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# Editorial
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# Query Data With Fuzzy Information In Object-Oriented Databases An Approach Interval Values

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***Abstract*— In this paper, we propose methods of handling attributive values of object classes in object oriented database with fuzzy information and uncertainty based on quantitatively semantics based hedge algebraic. In this approach we consider to attributive values (as well as methods) object class is interval values and the interval values are converted into sub interval in [0, 1] respectively. That its the fuzziness of the elements in the hedge algebra is also sub interval in [0,1]. So, we present an algorithm allows the comparison of two sub interval [0,1] helping the requirements of the query data.**

## I. INTRODUCTION

In recent years, the information about the objects in the real world are often fuzziness, uncertain, incomplete. So the traditional object-oriented database model inconsistent in reality. Solving this problem, fuzzy object-oriented database modeling has suggested to represent and process the objects that the information its can be fuzziness and uncertainty.

The attributive value of the object in the fuzzy object-oriented database is complex. It includes: linguistic values, number values, interval values, reference to objects (this object may be fuzzy), collections,… Thus, when query data in object-oriented database with fuzzy and uncertaintyty information the most important problems is how to find a method of handle the fuzzy values and then we build a methods comparising them. There are many approaches on handling fuzzy values that researchers interests as: graph theory [4], fuzzy logic and theory of ability [2], probability theory [3], logical basis [1],… Each approach has advantages and disadvantages.

In 2006, Nguyen Cat Ho and al have proposed an hedge algebraic model. Approached in hedge algebra, linguistic semantics can be represented by an neighborhood intervals defined by the fuzzy measure and linguistic values of attribute it considered as linguistic variable. On this basis, in this paper considered domain of fuzzy attribute is hedge algebra and transformer interval values into subsegment [0, 1], and then querying and handling the data of objescts with fuzzy information and uncertainty become effective.

The paper is organized as follows: Section 2 presents the basic concepts relevant to hedge algebraic as the basis for the next sections; section 3 proposed two SFTVA and SFTVM algorithms for searching data fuzzy conditions for both attributes and methods; section 4 presents examples for seraching data with fuzzy information, and finally conclusion.

## II. HEDGE ALGEBRAS

Builting on approach to hedge algebra, we present some overview of basics of hedge algebra and the ability to represent the semantics based on the structure of hedge algebra [6].

Consider the domain of the linguistic variable Truth: *Dom*(TRUTH) = {*true, false, very true, very false, more-or-less true, more-or-less false, possibly true, possibly false, approximately true, approximately false, little true, little false, very possibly true, very possibly false*.....}, where *true, false* is primary terms, mordifier terms *very, more-or-less, possibly, approximately true, little* is hedges. Meanwhile linguistic domain T = *Dom*(TRUTH) can be considered as a linear hedge algebra $\underline{X} = (X, C, H, \leq)$, where $C$ is a set of primary term considered as a generator term. H is a set of hedge considered as a one-argument operations, ≤ relation on terms (fuzzy concepts) is a relation order "induced" from natural semantics. Example based on semantics, relation order following are true: *false ≤ true, more true ≤ very true nhưng very false ≤ more false, possibly true ≤ true nhưng false ≤ possibly false, ...* Set X is generated from C by means of one-argument operations in H. Thus, a term of X represented as $x = h_n h_{n-1}.....h_1 x$, $x \in C$. Set of terms is generated from the an X term denoted by H(x). If C has exactly two fuzzy primary term, then one term called positive term denoted by $c^+$, other term called negative denoted by $c^-$ and we have $c^- < c^+$. In the above example, ***True*** is positive and ***False*** is negative.

Thus, let $X = (X, G, H, \leq)$ with $G = \{c^-, W, c^+\}$, $H = H^- \cup H^+$, where $H^+ = \{h_1,..., h_p\}$ *and* $H^- = \{h_{-1}, ..., h_{-q}\}$ are linearly ordered, with $h_1 < .. . < h_p$ *and* $h_{-1} < .. . < h_{-q}$, where $p, q > 1$, we have the following definitions related:

**Definition 2.1 [6]**. $f: X \to [0,1]$ is quantitative semantic function of X if ∀h, k ∈ $H^+$ or ∀ h, k ∈ $H^-$, ∀x, y ∈ X, we have:

$$\frac{|f(hx) - f(x)|}{|f(kx) - f(x)|} = \frac{|f(hy) - f(y)|}{|f(ky) - f(y)|}$$

For hedge algebra and quantitative semantic function, we can define *fuzziness* of fuzzy concept. Given quantitative

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semantic function f of X, consider any $x \in X$. Fuzziness of x when it is measured by the diameter of the set $f(H(x)) \subseteq [0,1]$.

**Definition 2.2 [6]**: An $fm : X \to [0,1]$ is said to be a fuzziness measure of terms in X if:

(1) fm is called complete, that is $\forall u \in X$, $\sum_{-q \le i \le p, i \ne 0} fm(h_i u) = fm(u)$.

(2) if x is precise, that is H(x) = {x} then $fm(x) = 0$. Hence $fm(0)=fm(W)=fm(1)=0$.

(3) $\forall x,y \in X, \forall h \in H, \frac{fm(hx)}{fm(x)} = \frac{fm(hy)}{fm(y)}$, *This proportion is called the fuzziness measure of the hedge h and denoted by* $\mu(h)$.

**Definition 2.3 [6]:** Invoke *fm* is fuzziness measure of hedge algebra X, *f*: X -> [0, 1]. $\forall x \in X$, denoted by $I(x) \subseteq [0, 1]$ and |I(x)| is measure length of I(x).

A family J = {I(x):x∈X} called the partition of [0, 1] if:

(1): $\{I(c^+), I(c^-)\}$ is partition of [0, 1] so that |I(c)| = *fm*(c), where c∈ $\{c^+, c^-\}$.

(2): If I(x) defined and |I(x)| = fm(x) then {I(hix): I = 1...p+q} is defined as a partition of I(x) so that satisfy conditions: $|I(h_i x)| = fm(h_i x)$ and $|I(h_i x)|$ is linear ordering.

Set $\{I(h_i x)\}$ called the partition associated with the terms x. We have

$$\sum_{i=1}^{p+q} |I(h_i x)| = |I(x)| = fm(x)$$

**Definition 2.4 [6]:** Set $X_k = \{x \in X : |x| = k\}$, consider $P^k = \{I(x) : x \in X_k\}$ is a partition of [0, 1]. Its said that u equal v at k level, denoted by $u =_k v$, if and only if *I(u)* and *I(v)* together included in fuzzy interval k level. Denote $\forall u, v \in X$, $u =_k v \Leftrightarrow \exists \Delta^k \in P^k : I(u) \subseteq \Delta^k$ and $I(v) \subseteq \Delta^k$.

## III. FUZZY OBJECT-ORIENTED DATABASE AND DATA SEARCH METHOD

Based on fuzzy object-oriented database model given by Zongmin Ma[11], fuzzy class C includes a set of attributes and methods.

C = ({$a_1$, $a_2$, …, $a_k$}, {$M_1$, $M_2$, …, $M_m$})

Where $a_i$ is imprecise attribute (precise), $M_j$ is method.

Attribute $a_i$ = <*n, t*> *with* n is name and t is value attribute. Attribute value can be one of the four following cases:

- **Precise values**: This category of values involves all the primary values that usually appear in an object-oriented data model (e.g., numeric classes, string classes, etc.). Domain value in this case we can easily manipulate with the use of the operations ( $\le, \ge, =$ ) in the conditional expression of queries; or we can build the fuzzy conditions fuzzy to implement query data, example "*show all objects employees who is low income than the average salary"*.
- **Imprecise values (or fuzzy)**: The cases with imprecise values (or fuzzy) are complex, linguistic labels [10] are usually used to represent this kind of values. Different types of imprecise values must be considered on the semantics of the imprecise value. For example, a plant is named *thyme*, it developer on humus land biet the levels of low or average lighting is uncertainly; or His height is about 2 meters; approximately [18, 35] to represent young people's concepts.
- **Objects**: The attribute value may be a reference to another objects (complex object). Objects that it references may be fuzzy.
- **Collections**: The attribute may be conformed by a set of values or even by a set of objects. Imprecision in this kind of attributes appears at two levels:
  - The set may be fuzzy.
  - The elements of the set may be fuzzy values or fuzzy objects.

A method defined in class is as following description:

$M_j(N, I, R) \Rightarrow (u, v, g)$

Where:

N: name method.

I: set of input parameters; {<name, type>}.

R: set of attributes that its value is read by the method.

u: set of output parameters include the return value type {<name, type>}.

v: set of attributes that its value is changed by the method.

g: the set of message given by the method of the form {[o, msg, p]}, o is the place to receive notifications, msg is message and p is the set of parameters in the message {<n, t>}.

Similar the model of object-oriented database, a fuzzy object oriented database is data model, in which attribute of data is fuzzy (or clear) and methods operate on the attributes that are packaged in structures called objects (fuzzy).

### *A. Convert the attribute value to interval values*

In this paper, we only interested in handling of interval values. So, all attribute values are transferred to interval value and then manipulating easily. The description of transferable method follows as:

- If attribute value is a then converted into [a, a].
- If attribute value is about a then converted into [a-$\varepsilon$, a+$\varepsilon$], $\varepsilon$ is the radius with center x.
- If attribute value from a to b then converted into [a, b].

### *B. Convert the interval values to subsegment [0, 1]*

Set $Dom(A_i)$ = [min, max] is domain object attribute values, where min and max stand for min and max values of $Dom(A_i)$.

**Definition 3.1 [9]:** *f: Dom($A_i$)* $\rightarrow$ [0, 1] and determined:

$$f(a) = \frac{a - \min}{\max - \min} \forall a \in Dom(A_i)$$

*C. Algorithm search data approach to interval value*

The query language model object-oriented databases are several authors research interest and extend the model fuzzy object-oriented database. The structure of fuzzy OQL queries are considered as: *select* <attributes>/<methods> *from* <class> *where* <*fc*>, where <*fc*> are fuzzy conditions or combination of fuzzy condition that allow using of disjunction or conjunction operations.

Important issues in the fuzzy OQL query is determine truth value of the <*fc*> and associated truth values. In this paper, we use approaching to interval values for determinating the truth value. Example, we consider query following "*show all students are possibly young age*". To answer this query, we perform finding the intersection parts of two subsegment [0, 1]:

+ *First subsegment*: As we have shown the attribute value has 4 cases, we focus on considering the attribute values in the second case and special interval value. In the above query, *age* is attribute of student objects and attribute value are considered interval value. We use definition 3.1 to convert this interval into the subsegment [0, 1].

+ *Second subsegment*: In the above query, *possibly young* is fuzzy condition and fuzzy condition is considered fuzziness on complete linear hedge algebra. So, fuzzy condition is also subsegment [0, 1] (fuzziness of linear hedge algebra is subsegment [0, 1]).

Without loss of generality, we consider on cases multiple fuzzy conditions with notation follow as:

- $\theta$ is AND or OR operation.
- $fz^k value_i$ is fuzzy values of the i attribute.

**SFTVA algorithm:** *search data in cases multiple fuzzy conditions for attribute with $\theta$ operation.*

**Input**: A class C consists of a set of attributes and methods.
C = {$o_i$ | i = 1..n}.
$o_i$=<{$a_1$, $a_2$, .., $a_p$}, M>.
where $a_i$ is attribute, M is set methods.

**Output**: $\forall$ o $\in$ C satisfy condition $\overset{p}{\underset{i=1}{\theta}}$ ($o.a_i$= $fz^k value_i$) (where $o.a_i$ is attribute value i of object).

**Method**

Initialization.

(1) **For** i = 1 to p **do**

(2) **Begin**

(3) Set $G_{a_i}$ = { $\mathbf{0}$, $c_{a_i}^-$, $\mathbf{W}$, $c_{a_i}^+$, $\mathbf{1}$}, $H_{a_i} = H_{a_i}^+ \cup H_{a_i}^-$.

Where $H_{a_i}^+ = \{h_1, h_2\}$, $H_{a_i}^- = \{h_3, h_4\}$, with $h_1 < h_2$ and $h_3 > h_4$. Select the fuzzy measure for the generating element and hedge.

(4) $D_{a_i} = [\min_{a_i}, \max_{a_i}]$ // $\min_{a_i}$, $\max_{a_i}$ : min and max value of domain $a_i$.

(5)**End**

(6) **For** each o $\in$ C **do**

(7) **For** i = 1 to p **do**

(8) Convert $o.a_i$ into interval [$a_t$, $b_t$] respective;

// *used function f to convert interval [a, b] into subsegment [0, 1]*

(9) **For** each object o $\in$ C **do**

(10) **For** i = 1 to p **do**

(11) $o.a_i$ = [$f$($a_t$), $f$($b_t$)];

// *Construct fuzzy measure* $I_{a_i}^k(x_j)$ *keep partition k level.*

(12) $k$ = 1;

(13) **While** $k \leq 4$ **do** // *level partition largest with* $k$ = 4

(14) **Begin**

(15) **For** i = 1 to p **do**

(16) **For** j = 1 to $2^5(k-1)$ **do**

(17) Construct fuzzy measure $k$ level: $I_{a_i}^k(x_j)$;

(18) $k = k + 1$;

(19) **End**

//*Determine partition k level of* $fz^k value_i$

(20) **For** i = 1 to p **do**

(21) **Begin**

(22) t=0;

(23) **Repeat**

(24) t=t+1;

(25) **Until** $fz^k value_i \in I_{a_i}^k(x_t)$;

(26) $X_i^k = X_i^k \cup I_{a_i}^k(x_t)$;

(27) **End**

(28) **For** each o $\in$ C **do**

(29) **If** $\overset{p}{\underset{i=1}{\theta}}$ ($o.a_i \subseteq X_i^k$) **then** $\overset{p}{\underset{i=1}{\theta}}$ ($o.a_i$= $X_i^k$);

**SFTVM algorithm:** *search data cases single fuzzy conditions for method.*

In the object-oriented database model, class is defined as a set of characteristics, including attributes and methods determine objects of this class. Each method is performed as a function operation on attribute values of objects. So, finding the data in this case, we convert interval values of attribute which handling on it with the corresponding domain into subsegment [0, 1], corresponder. Further, we choose the function combination of hedge algebras that are consistent with method that its operation. Then, domain of method is subsegment [0, 1].

At last, we perform finding the intersection parts of two subsegment [0, 1] this.

**Input**: A class C consists of a set of attributes and methods.
C = {$o_i$ | i = 1..n}.
$o_i$=<{$a_1$, $a_2$, …, $a_p$}, {$M_1$, $M_2$, …, $M_m$}>.
where $a_i$ is attribute, $M_j$ is method.

**Output**: $\forall$ o $\in$ C satisfy condition $o.M_i$= $fzp^k value$ ($o.M_i$ is the return value of method).

**Method**

Initialization.

(1) **For** i = 1 to p **do**
(2) $D_{a_i} = [\min_{a_i}, \max_{a_i}]$ // $\min_{a_i}$, $\max_{a_i}$ : min and max value of domain $a_i$.
(3) **For** each object o ∈ C **do**
(4) **For** i = 1 to p **do**
(5) Convert $o.a_i$ into interval $[a_t, b_t]$ respective;
*// used function f to convert interval [a, b] into subsegment [0, 1]*
(6) **For** each object o ∈ C **do**
(7) **For** i = 1 to p **do**
(8) $o.a_i = [f(a_t), f(b_t)]$;
(9) Determine function combination of hedge algebras
*// Determine domain for method*
(10) **For** i = 1 to m **do**
(11) $o.M_i = [f(\underline{x}), f(\underline{y})]$;
(12) **For** i = 1 to m **do**
(13) Set $G_{h_i} = \{ \mathbf{0}, c_{h_i}^-, \mathbf{W}, c_{h_i}^+, \mathbf{1}\}$, $H_{h_i} = H_{h_i}^+ \cup H_{h_i}^-$. Where $H_{h_i}^+ = \{h_1, h_2\}$, $H_{h_i}^- = \{h_3, h_4\}$, with $h_1 < h_2$ and $h_3 > h_4$. Select the fuzzy measure for the generating element and hedge.
*// Construct fuzzy measure* $I_{h_i}^k$ *keep partition k level.*
(14) $k = 1$;
(15) **While** $k \le 4$ **do** *// level partition largest with k = 4*
(16) **Begin**
(17) **For** i = 1 to m **do**
(18) **For** j = 1 to $2^5(k-1)$ **do**
(19) Construct fuzzy measure *k* level: $I_{h_i}^k(x_j)$;
(20) $k = k + 1$;
(21) **End**
*// Determine partition k level of fvalue*
(22) **For** i = 1 to m **do**
(23) **Begin**
(24) t=0;
(25) **Repeat**
(26) t=t+1;
(27) **Until** $fzpvalue \in I_{h_i}^k(x_t)$;
(28) $Y_i^k = I_{h_i}^k(x_t)$;
(29) **End**
(30) **For** each o ∈ C **do**
(31) **For** i = 1 to m **do**
(32) **If** $(o.M_i \subseteq Y_i^k)$ **then** $(o.M_i = Y_i^k)$;

**Theorem:** SFTVA algorithm and SFTVM algorithm always stop and correct.
*Proof*:
1. *The Stationarity*: Algorithm will stop when all objects completed the approved
2. *The corrective maintenance*: algorithm always checks the two subsegments are intersecting or not.

Indeed, to find the intersection of the two subsegments [0, 1], with $[I_a, I_b]$ is the first subsegment and $[I_{x1}, I_{x2}]$ is the second subsegment. We have the following cases:

First case: If $[I_a, I_b] \cap [I_{x1}, I_{x2}] = \varnothing$ then $[I_a, I_b] \not\subset [I_{x1}, I_{x2}]$.

Second case: If $[I_a, I_b] \cap [I_{x1}, I_{x2}] \neq \varnothing$ then three cases occurred following:

a. If $I_{x1} <= I_a$ and $I_b <= I_{x2}$ then $[I_a, I_b] \subseteq [I_{x1}, I_{x2}]$.
b. If $I_a < I_{x1}$ and $I_{x1} < I_b <= I_{x2}$ then $[I_a, I_b] \not\subset [I_{x1}, I_{x2}]$.
c. If $I_{x1} <= I_a < I_{x2}$ and $I_b > I_{x2}$ then $[I_a, I_b] \not\subset [I_{x1}, I_{x2}]$.

Algorithm is always check subsegment $[I_a, I_b]$ contained in subsegment $[I_{x1}, I_{x2}]$.

Computational complexity of **SFTVA** algorithm evaluation follows as: step (1)-(5) complexity is $O(p)$, step (6)-(8) is $O(n*p)$, step (9)-(11) is $O(n*p)$, step (12)-(19) is $O(p)$, (step (20)-(27) is $O(p)$, step (28)-(29) is $O(n*p)$. So, the **SFTVA** algorithm can computational complexity $O(n*p)$.

Computational complexity of **SFTVM** algorithm evaluation follows as: step (1)-(2) complexity is $O(p)$; step (3)-(5) is $O(n*p)$; step (6)-(8) is $O(n*p)$; step (10)-(11) is $O(m)$; step (12)-(13) is $O(m)$; step (14)-(21) is $O(m)$; step (22)-(29) is $O(m)$; step (30)-(31) is $O(n*m)$. So, the **SFTVM** algorithm can computational complexity is $\max(O(n*p), O(n*m))$.

## IV. EXAMPLE

we consider a database with six rectangular object as follows:

| rectangular | | | | |
|---|---|---|---|---|
| iDhcn | name | length of edges | width of edges | area() |
| iD1 | hcn1 | [1.65, 1.68] | [1.3, 1.4] | |
| iD2 | hcn2 | 1.72 | [1.48, 1.5] | |
| iD3 | hcn3 | [1.7, 1.75] | 1.72 | |
| iD4 | hcn4 | 1.67 | [1.2, 1.3] | |
| iD5 | hcn5 | [1.2, 1.3] | 1.4 | |
| iD6 | hcn6 | 1.6 | [1.36, 1.48] | |

**Query 1:** List of rectangles have length "*less long*" and width "*possibly short*".
To answer queries 1 we do the following:
**Step (1)-(5)**:

Let consider a linear hedge algebra of *length*, $\underline{X}_{length}$ = ( $\underline{X}_{length}$, $G_{length}$, $H_{length}$, ≤), where $G_{length}$ = *{S, L}*, with S, L stand for *short and long*, $H^+_{length}$ = *{M, V}*, $H^-_{length}$ = *{P, L}*, where *P*, *L*, *M* and *V* stand for *Possibly*, *Little*, *More* and *Very.*

Suppose that $W_{length}$ = 0.6, *fm(short)* = 0.6, *fm(long)* = 0.4, *fm(V)* = 0.35, *fm(M)* = 0.25, *fm(P)* = 0.2, *fm(L)* = 0.2.

Dom(LENGTH) = [1.0, 2.0].

**Step (6)-(11)**:

| rectangular | | | | |
|---|---|---|---|---|
| iDhcn | name | length of edges | width of edges | area() |
| iD1 | hcn1 | [0.65, 0.68] | [0.3, 0.4] | |
| iD2 | hcn2 | [0.72, 0.72] | [0.48, 0.5] | |
| iD3 | hcn3 | [0.7, 0.75] | [0.72, 0.72] | |
| iD4 | hcn4 | [0.67, 0.67] | [0.12, 0.13] | |
| iD5 | hcn5 | [0.12, 0.13] | [0.12, 0.12] | |
| iD6 | hcn6 | [0.6, 0.6] | [0.38, 0.48] | |

**Step (12)-(19)**: so *less long* and *possibly short* at two levels of partitioning, we only built two levels of partitioning.

We have *fm(VL)* = 0.14, *fm(ML)* = 0.1, *fm(LL)* = 0.08, *fm(PL)* =0.08.

By *LL* < *PL* < *L* < *ML* < *VL* so we have *I(VL)* = [0.86, 1], *I(ML)* = [0.76, 0.86], *I(PL)* = [0.68, 0.76], *I(LL)* = [0.60, 0.68].

We have *fm(VS)* = 0.21, *fm(MS)* = 0.15, *fm(LL)* = 0.12, *fm(PS)* = 0.12.

By *VS* < *MS* < *S* < *PS* < *LS* so we have *I(VS)* = [0, 0.21], *I(MS)* = [0.21, 0.36], *I(PS)* = [0.36, 0.48], *I(LS)* = [0.48, 0.6].

**Step (20)-(27)**: determine the partitioning of *less long* and *possibly short*.

$X_k$ = I(*LL*) = [0.60, 0.68] and $Y_k$ = I(*PS*) = [0.36, 0.48].

**Step (28)-(29)**: according to conditions:

- The length is "*less long*" so we have three objects satisfied is iD1, iD4, iD6.
- The width is "*possibly short*" so we have three objects satisfied is iD1, iD6.

So there are two objects iD1, iD6 satisfies a query with the operation *and*.

**Query 2:** List of rectangles have area is "*less small*".

To answer queries 2 we do the following:

**Step (1)-(2)**: Dom(LENGTH) = [1.0, 2.0].

**Step (9)**: Method calculates the area of a rectangle is *length x width* so in this case we select the function combined hedge algebra functions as follows:

$$f(\underline{x}) = f(a_1) \text{ x } f(a_2)$$
$$f(\underline{y}) = f(b_1) \text{ x } f(b_2)$$

Where:- $f(\underline{x})$, $f(\underline{y})$ is lower and upper bound of the domain method *area()*.

- $f(a_1)$, $f(a_2)$, $f(b_1)$, $f(b_2)$ is lower and upper bound of length and width attribute.

**Step (3)-(8), (10)-(11)**:

| rectangular | | | | |
|---|---|---|---|---|
| iDhcn | name | length of edges | width of edges | area() |
| iD1 | hcn1 | [0.65, 0.68] | [0.3, 0.4] | [0.2, 0.27] |
| iD2 | hcn2 | [0.72, 0.72] | [0.48, 0.5] | [0.35, 0.36] |
| iD3 | hcn3 | [0.7, 0.75] | [0.72, 0.72] | [0.5, 0.54] |
| iD4 | hcn4 | [0.67, 0.67] | [0.12, 0.13] | [0.08, 0.09] |
| iD5 | hcn5 | [0.12, 0.13] | [0.12, 0.12] | [0.01, 0.02] |
| iD6 | hcn6 | [0.6, 0.6] | [0.38, 0.48] | [0.23, 0.29] |

**Step (12)-(13):**

Let us consider a linear hedge algebra of size, $\underline{X}_{size}$ = ( $\underline{X}_{size}$, $G_{size}$, $H_{size}$, ≤), where $G_{size}$ = {S, L}, with S and L stand for *small* and *large*, $H^+_{size}$ = *{M, V}*, $H^-_{size}$ = *{P, L}*, where *P*, *L*, *M* and *V* stand for *Possibly*, *Little*, *More* and *Very.*

Suppose that $W_{size}$ = 0.6, *fm(S)* = 0.6, *fm(L)* = 0.4, *fm(V)* = 0.35, *fm(M)* = 0.25, *fm(P)* = 0.2, *fm(L)* = 0.2.

**Step (14)-(21)**: so *less small* at two levels of partitioning, we only built two levels of partitioning.

We have *fm(VL)* = 0.14, *fm(ML)* = 0.1, *fm(LL)* = 0.08, *fm(PL)* = 0.08.

By *LL* < *PL* < *L* < *ML* < *VL* so we have *I(VL)* = [0.86, 1], *I(ML)* = [0.76, 0.86], *I(PL)* = [0.68, 0.76], *I(LL)* = [0.60, 0.68].

We have *fm(VS)* = 0.21, *fm(MS)* = 0.15, *fm(LL)* = 0.12, *fm(PL)* = 0.12.

By *VS* < *MS* < *S* < *PS* < *LS* so we have *I(VS)* =[0, 0.21], *I(MS)* = [0.21, 0.36], *I(PS)* = [0.36, 0.48], *I(LS)* = [0.48, 0.6].

**Step (22)-(29)**: determine the partitioning of *less small*.

$X_k$ = I(*LS*) = [0.48, 0.60].

**Step (30)-(31)**: according to conditions, rectangular area is *less small* so there is a satisfying object ID3.

## V. CONCLUSION

In this paper, we propose a new method for manipulating data with interval values in object-oriented database that its information is fuzzy and uncertainty. This approach is quantitative semantics based hedge algebras. With this approach, the data manipulation is easy because interval values are converted into sub interval in [0, 1]. The fuzziness of the term in the hedge algebras is also sub interval in [0, 1]. So the comparison interval values with a fuzziness measures in hedge algebras become the comparison on the two segments [0, 1]. We proposed a computational method of the class by using a combination of hedge algebras and computing on it. Basins on comparising interval values, we proposed two algorithms SFTVA and SFTVM for searching data with fuzzy conditions for both attributes and methods.

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# An Information System for controlling the well trajectory

## Information Systems

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***Abstract*—: The well drilling process became very boring, requires a choice of the justified solution from a set possible. Because of major bulk received and treated data, originating vastness of problem situations. The relevant value thus has information supply of drilling process for a possibility of effective human-engine acceptance of a solution. The complexity of operations at boring inclined, horizontal, sectional, on shelf of ocean - all this requires adequate reacting at operating (on-Line) control by well-studying process. The realization of computer-Aided control systems in many aspects depends on progress the applicable computer for conducting conversation in an interactive system of automated control.**

***Keywords- Decision-Making, drilling process, inclinometric data, automated control, Information System, well trajectory, azimuth and zenith angles, Plane Projection.***

## I. INTRODUCTION

The work describes methods and means for processing, presentation, interpretation of On-line inclinometric data of drilling. But it should be noted that the problems of inclinometric data processing are not directly provided with methods of recognition [1]. However, introduction of these problems follows, on the one hand, from a wish of a more complete coverage of drilling problems and importance in connection with a growing interest particularly to slant and horizontal drilling. On the other hand, evaluation of the results of actual drilling is also qualification, an appraisal of a situation as a very important part in decision-making.

## II. DISCUSSION

In view of the above and applying basic methods and mathematical relationships for estimation of ultimate values of azimuth and zenith angles there were proposed methods and means for plotting the design and actual paths of wells in space, in vertical and horizontal planes, their viewing from different sides, change of data for variation in a real time, and, consequently, for prediction of a path and On-line decision-making.

A process of getting data on a spatial location of a bore-hole includes two stages: obtaining of initial inclinometric information with the help of various technical means and processing of this information; and the role of processing is rather high. The main objective of processing is determination of a location of a bore-hole, and by applying an appropriate calculation method we can obtain more accurate results with the same number of measurement points. Different mathematical methods for plotting of a bore-hole path by the results of inclinometric measurements are available. However the problems of processing are much wider.

The problems of On-line control are closely connected with the problems of design of an optimal profile, and also with the problems of On-line management of slant hole drilling. In fact, control and management can be considered as two subsystems of a single system of control and management of a drilling process [2].

The methods and means described in this paper enable resolution of the following problems of processing of inclinometric information and design problems:

- introduction of parameters of a design profile;
- calculation of a design profile of a bore-hole;
- introduction, arrangement and merging of data base obtained in multiple measurements;
- accumulation of information on wells;
- control of a current location of a well bottom;
- plotting of horizontal and vertical views of a well;
- plotting of a bore-hole path in spatial coordinates (*x, y, z*);
- comparison of an actual bore-hole path with the design one and revealing of dangerous deviations from a project;
- recommendations on a zenith angle and an azimuth for connection by a straight line of the actual bore-hole bottom with the design one;
- Preparation of reports.

For fulfilling of a project assignment for construction of a well, i.e., for drilling of a bore-hole along a design path with hitting the set point of penetration of a producing formation with minimum deviations the technologist should have a



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possibility of continuous monitoring of a bore-hole path and revealing any deviations. Using such possibility a technologist can take timely management decisions and on their basis make necessary alterations in a controlled object [3] – a drilling process.

The developed program in the Delphi environment makes it possible to show the actual and design bore-hole paths both projected on a vertical and horizontal plane and axonometrically (a spatial representation), to estimate parameters necessary for monitoring a bore-hole drilling, to collect, store and present information.

A module for interpretation of inclinometric data "Fig. 1" consists of three modules: an initial data input module; a module for algorithmic calculations "Fig. 2"; an information output module "Fig. 3".

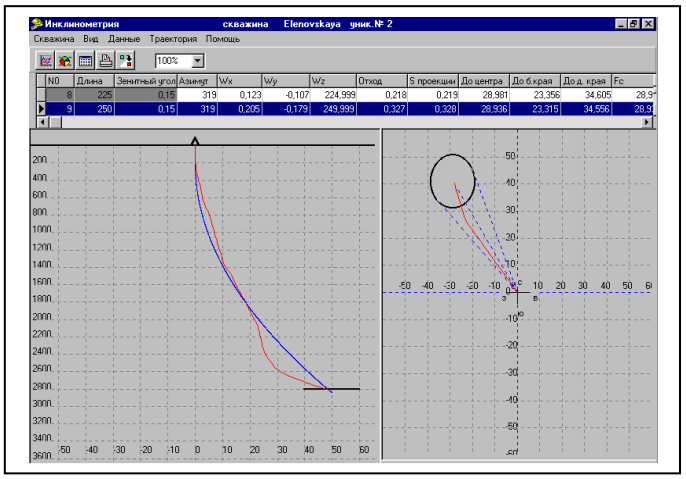


Figure 1 Graphic interpretation of inclinometric data

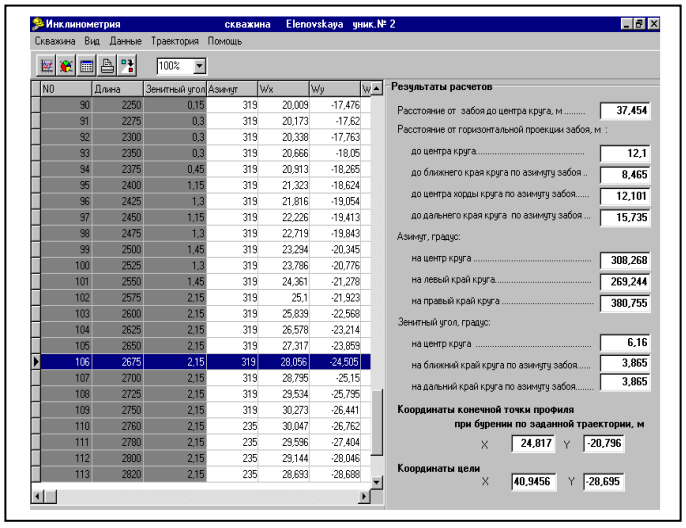


Figure 2 Module for Algorithmic Calculations (initial and estimated Parameters of spatial location of a well)

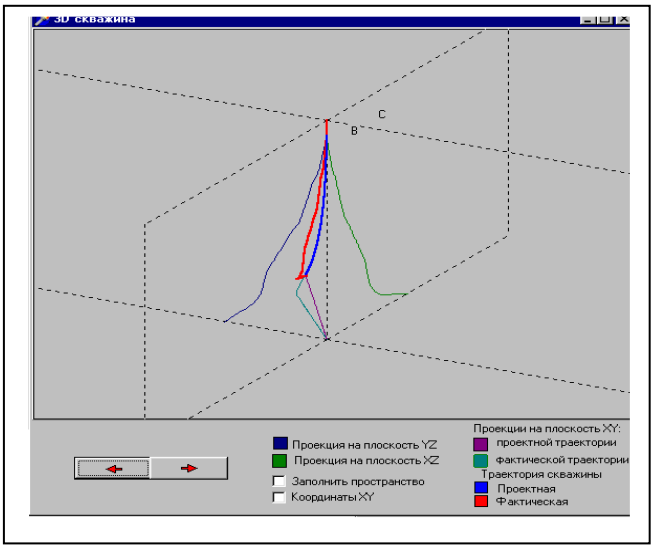


Figure 3 an Information Output Module (3D Well Trajectory Plane Projection)

In the next future the work will be continued to develop an information system for processing geology-technological data [4].

## III. CONCLUSION

In this paper the following results were obtained:

Developed, on the basis of the available mathematical software for processing of inclinometric data, is a program for showing on a display of axonometric paths (Trajectory) of a design and actual well, their turning around the vertical, selection of projections to horizontal and vertical planes, scaling of selected parts of paths, changes of azimuth and zenith angles, prediction of these changes in relation to an assumed zone of hitting the assigned area of a path.

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# Behavioral Analysis on IPv4 Malware in both IPv4 and IPv6 Network Environment

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***Abstract* - Malware is become an epidemic in computer network nowadays. Malware attacks are a significant threat to networks. A conducted survey shows malware attacks may result a huge financial impact. This scenario has become worse when users are migrating to a new environment which is Internet Protocol Version 6. In this paper, a real Nimda worm was released on to further understand the worm behavior in real network traffic. A controlled environment of both IPv4 and IPv6 network were deployed as a testbed for this study. The result between these two scenarios will be analyzed and discussed further in term of the worm behavior. The experiment result shows that even IPv4 malware still can infect the IPv6 network environment without any modification. New detection techniques need to be proposed to remedy this problem swiftly.**

***Keywords-IPv6, malware, IDS.***

## I. INTRODUCTION

IPv6 is a new network protocols which is meant to overcome IPv4 problems. Many advantages offered by this new protocol including 1) A large number of address flexible addressing scheme 2) Offers packet forwarding more efficient 3) Support for secure communication 4) Better support for mobility and many more [1]. Although IPv6 offers a lot of benefits, people are still reluctant to totally migrate from IPv4 to IPv6 network. This is because even IPv6 have been deployed for many years, this protocol is still considered in its infancy [2]. Many researchers have spent ample of time to enhance the IPv6 services to become at least at par with IPv4 addresses. Since IPv4 addresses are facing depletion, migrating to IPv6 is inevitable eventually [3-5]. Some studies claimed that IPv6 cause many security issues [6-9]. Unfortunately, researchers pay little attention on IPv6 security issues[10]. Thus, some culprits are really eager to fully utilities all the vulnerabilities occur during this transition period. Producing malware is one of the most popular techniques to be used. Studies show that new age malwares can survive in new network environment [11, 12]. Hence, researchers agree that further studies have to be conducted to remedy the malware infection issues [13-16].

Malware is software which rapidly invented to manipulate vulnerabilities of computer networks. Based on [17], 250 new malware variants were introduced everyday from all over the world. These so called new age malwares were not new genuine ones but rather innovated from the existing malware. These malwares were modified and some modules were added to it to avoid being detected from the anti-virus software which is using signature patterns to detect malwares.

Malware is become an epidemic in computer network nowadays[18]. Malware attacks are a significant threat to networks. A conducted survey shows malware attacks may result a huge financial impact[19]. This scenario is becoming worse when users are migrating to a new environment which is Internet Protocol Version 6.

The objectives of this study are to determine whether an IPv6 network is totally safe from attacks which were intended for IPv4 network and to identify malware behavior in different network environments.

In the following chapters, we will explain about some related works to this study and followed by the methodology used in this experimental research. The experimental design will be explained and some result and analysis will be discussed. Finally, the conclusion for the overall study will be stated in the end of this paper.

## II. RELATED WORK

### A. Malware

Malware are represented by several forms namely virus, Trojan, spyware, adware and worms [20, 21]. Each of them has different characteristics to attack their victims. Their method of propagation also varied including sharing memory sticks, downloading files, peer-to-peer applications, sharing file and many more.

### B. Malware Propagation Methods

Many activities can help these malware propagate more easily. Unfortunately, most of end-users are not fully aware of it due to lack of knowledge about this issue. We have classified this propagation in two categories namely 1) human intervention and 2) self-propagation.

Most of malware are spreading involving human intervention. These activities including transferring virus via


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memory sticks, installing peer-to-peer applications, downloading files which contain malware and sending/forwarding malware emails. Malwares fall in this category are virus, Trojan, spyware and adware. Since its propagation based on human intervention, the spreading rate cannot be determined cause the key value of spreading the virus is very subjective. If those malware transferred rapidly by victims, then the spreading rate is very high. However, if it just left without any execution in the computer, the malware will stay dormant and the spreading rate will be low.

The other propagation category is self-propagation. The only malware falls in this category is worm. This is because the spreading method has been pre-defined and hardcoded in the worm software so that it can launch the attack by itself without needed any intervention by human. Worms normally will scan for victims before it initiate the first attack. Therefore, this worm spreading can be determined technically. However, it is not easy to determine it because each of them is using different scanning method to search for their victims.

### C. *Malware Scanning Methods*

The worm scanning methods can be divided into three categories as defined by [22] 1) naïve random scanning, 2) sequential scanning and 3) localized scanning. The first scanning method already defined the target regardless the information about the victim's network. The example worm which is using this technique is Slammer. The second scanning method will search for vulnerable hosts through their closeness in IP address space based on host configuration. Blaster worm is an example uses this technique to attack its victim. Finally, the last scanning method preferentially searches for vulnerable hosts in the local subnetwork. It uses the victim's network information to initiate the attack. Nimda worm is an example uses this technique to attack its victim.

We believe the localized scanning method is very dangerous since its will use the information about the current network to launch its attack and the result will be disastrous. What is more, this worm can survive in a new network environment for example in IPv6 network environment. This paper has used Nimda variant E to be released in both IPv4 and IPv6 network environment to see how this worm works and how it will affect the network performance.

## III. METHODOLOGY

In this study, we have planned some work flow in order to get our expected result. The methodology used for this study as depicted in the Figure 1.

In order to test the IPv4 worm behavior in both IPv4 and IPv6 network environment two testbeds have been implemented. The computer setup and configuration are identical except for the protocol used to communicate between computers are different. The testbed design for this study can be found in Figure 2.

Before the worm released, a clean testbed need to be ready. Some worms will remain in the memory even after the virus was cleaned by the antivirus software. Therefore, each computer will be cleaned thoroughly including format all computers involve to ensure no other factors will affect the result later on. The original configuration for computers, router and switch involve will be restored.

After the clean testbed ready, the packet sniffer node will be activated to capture all packets through the gateway router. The reason the gateway router involves in this experiment is because to simulate as if this environment is accessible to the other networks. Therefore, this will stimulate the worm to launch its attack to broader scale rather than local area network only.

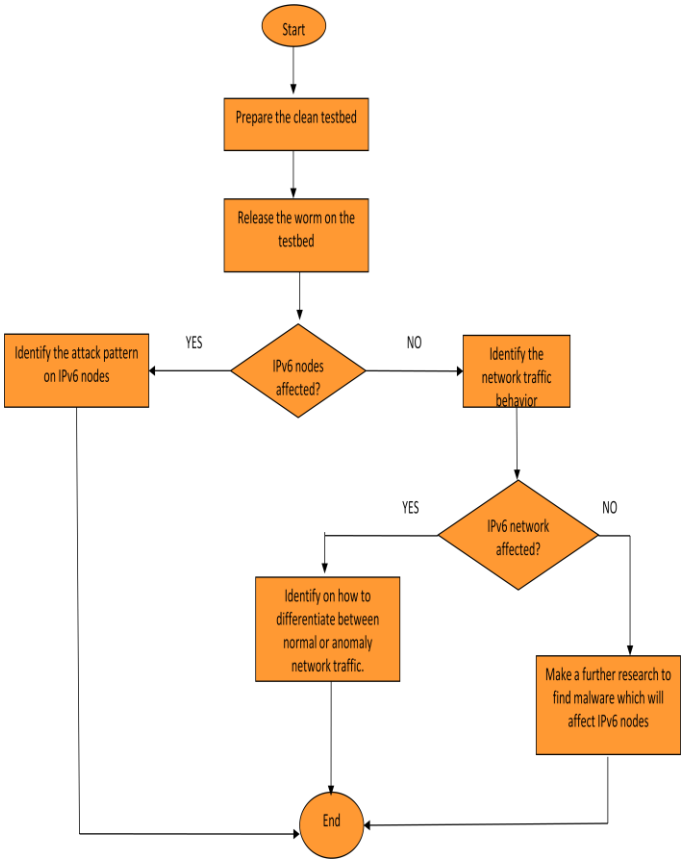


Figure 1: Research Methodology

Since worm in IPv6 is still new, we are expecting two different results will occur based on the worm behavior. The first one, the worm will survive in IPv6 network environment and attack IPv6 nodes directly. If this is the case, then the attack pattern can easily be determined based on changes happened in the affected nodes. However, if the


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worm is not affecting the IPv6 then we will see whether the worm probably affect the network bandwidth. Then, if the worm is consuming the bandwidth consumption, the anomaly pattern needs to be determined later on. Otherwise, the worm can be considered totally dormant in IPv6 network.

## IV. Experiment Design

In this experiment, we used the network layout as depict in Figure 2:

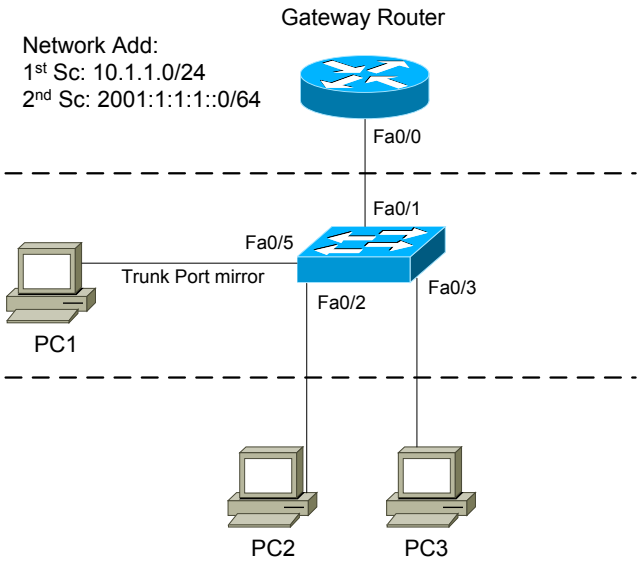


Figure 2: Testbed Network Layout

Based on Figure 2, three computers had been setup in this testbed namely PC1, PC2 and PC3. PC1 was installed a packet sniffer software to capture all traffic through the gateway router trunk. PC2 and PC3 work as nodes in the same network where PC2 as the source who release the worm. These computers used Windows XP SP1 as their operating system and Nimda variant E will be used as the worm in the experiment.

The procedure of this experiment is as the following:

*S1: Ready all computers, router and switch. Restore all default configurations into those computers, router and switch.*
*S2: Activate the packet capture software on PC1 to start capture the ideal network pattern.*
*S3: Leave the computers for a few minutes to ensure the network traffic has become stable.*
*S4: Start releases the Nimda.E worm from PC2.*
*S5: Wait for a few seconds until we can saw the worm started infected the network.*
*S6: Leave the computer for a few minutes to ensure the worm fully infected the network.*
*S7: Plug out all cables connected to computer to stop the simulation and save the network traffic log from PC1 for further analysis.*
*S8: Before starts the next experiment session, all computers must be formatted to ensure it is free from worm infection in operating system and in its memory.*

## V. Result & Analysis

### A. The First Scenario

In this scenario, IPv4 network protocol will be used. The network address used for this scenario is 10.1.1.0/24. Before the worm was released, the ideal network traffic pattern was captured as a benchmark. Figure 3 shows the benchmark of an ideal network traffic pattern.

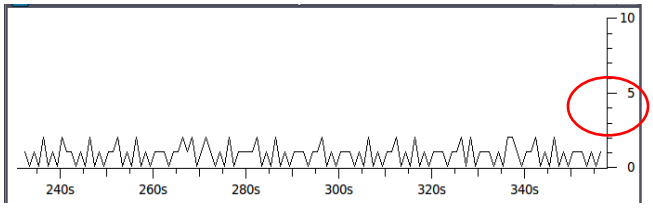


Figure 3: Ideal Network Traffic Pattern for IPv4 network

Figure 3 shows the graph about number of packets captured through the gateway router in seconds. For an ideal network, the traffic through the gateway router interface is less than 3 packets per second as depict in Figure 3. These packets were released for the network information convergence.

After the network stable, the worm was released in the network. After the worm was released, the number of packet received by the gateway router was increased exponentially as depicted in Figure 4. The sample of the captured packet is depicted in Figure 5.

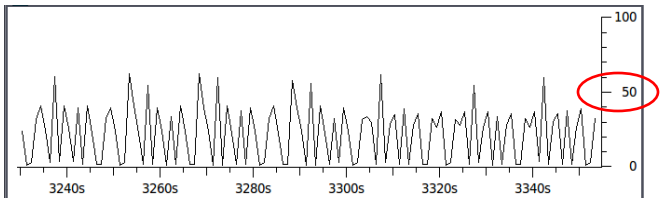


Figure 4: Network Traffic pattern after Nimda.E worm released in IPv4 network


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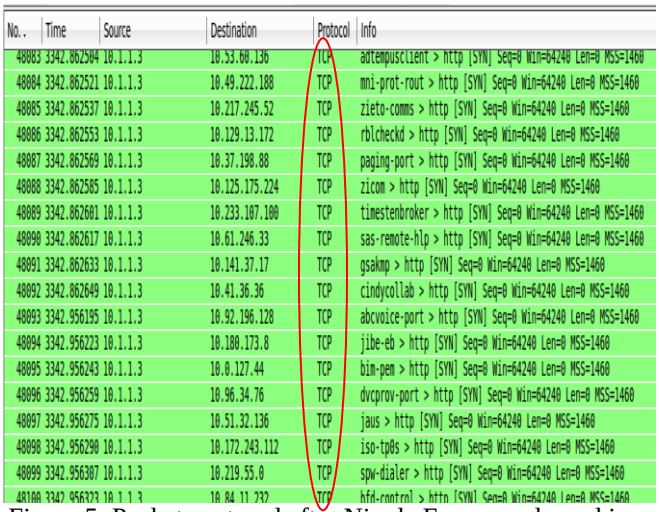


Figure 5: Packet captured after Nimda.E worm released in IPv4 network

Figure 4 shows the graph about number of packets captured through the gateway router in seconds. After the worm was released, it shows that the number of packets through the gateway router was dramatically increased up to almost 55 packets per seconds as depicted in Figure 4. Meanwhile, Figure 5 show the sample of packets captured after the worm was released. It seems that the worm released TCP flooding those packets were generated by one IP address which it is belong to the infected computer based on the IP address. We conclude after a computer was infected by Nimda.E worm, it will release a massive number of TCP connections to connect to its potential victims based on the network address information from the infected computer.

### *B. The Second Scenario*

In this scenario the network layout and the computers setup were identical with the previous scenario. The only different in this scenario was the computers were using IPv6 network protocol instead of IPv4. The network address for this scenario is 2001:1:1:1::0/64. Same as in previous scenario, the ideal network traffic pattern was captured as a benchmark in it is depicted in Figure 6:

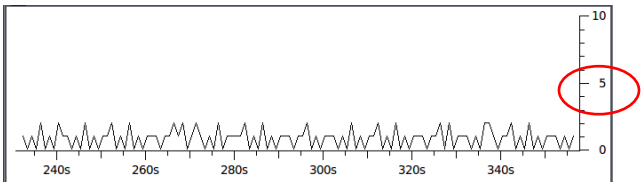


Figure 6: Ideal Network Traffic Pattern for IPv6 network

Figure 6 shows the graph about the number of packet through the gateway router in seconds. Same as in previous scenario, in an ideal network the traffic through the gateway router is less than 3 packets per seconds which were used for the network information convergence.

After the network stable, the worm was released in the network. After the worm was released, the number of packet received by the gateway router was increased exponentially as depicted in Figure 7. The sample of the captured packet is depicted in Figure 8.

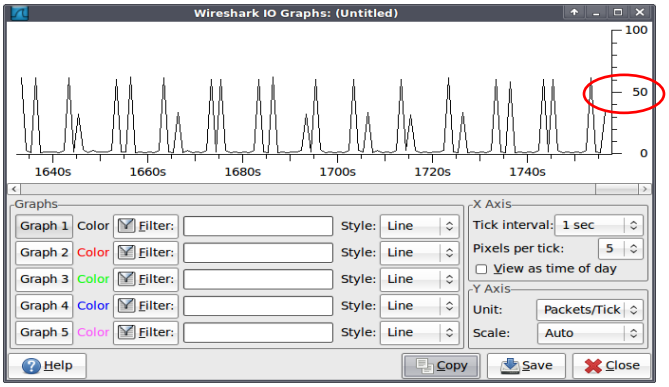


Figure 7: Network Traffic pattern after Nimda.E worm released in IPv6 network

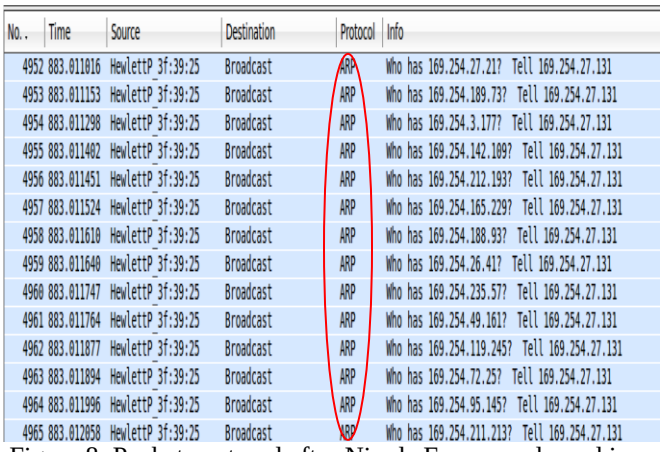


Figure 8: Packet captured after Nimda.E worm released in IPv6 network

Figure 7 shows the graph about number of packets captured through the gateway router in seconds. After the worm was released, the number of packets through the gateway router way severely increased to almost 55 packets per seconds as shown in Figure 7. Figure 8 shows the sample of packets captured after the worm was released. If in IPv4, the worm released the TCP flooding but in IPv6 it released ARP flooding instead. We believe this is because the worm was trying to attack its victim in IPv4 network even the worm was released in IPv6 network environment. We realized the infected computer is not using

### *C. The Experiment Result Analysis*

After all the experiments done, we gathered all the information for further analysis. Figure 9 shows the comparison between numbers of packet released based on different scenarios.



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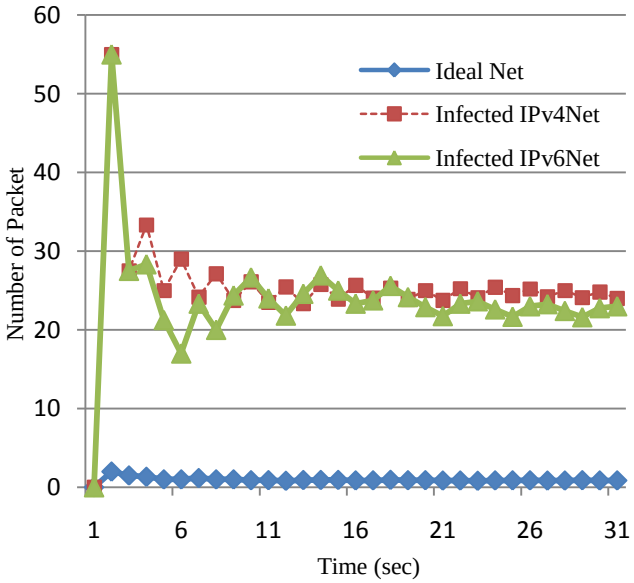


Figure 9: The average packet released based on different scenarios

Figure 9 shows the comparison of numbers of packets released based on three different scenarios. The first line is about the average number of packets released in second after the worm infected in IPv4 network. The second line is about the average number of packets released in second after the worm infected in IPv6 network. The last line is about the average number of packets released on an ideal network. Since the number of packet released in ideal network are identical between IPv4 and IPv6 network, then this information is represented by one scenario only.

From the Figure 9, we can see that the numbers of packets are exponentially increased after the worm was released compares to an ideal network regardless the network protocol used whether it is in IPv4 or IPv6 protocol. However, the number of packets released in IPv4 is slightly higher compares in IPv6 and the type of packets released in each network are also different. This is probably because the router need more time to process the address information in IPv6 due to its long ip addressing scheme. Moreover, the type of packet released was also different in IPv4 compares to IPv6 where in IPv4 the worm was released TCP connections to its victim whereby in IPv6 the worm was released ARP packet to connect to its victim as depicted in Figure 5 and Figure 8. The comparison is compiled in Table 1.

Table 1: Comparison Between Different Scenarios

| | **Ideal Network** | **Infected IPv4 Net** | **Infected IPv6 Net** |
|---|---|---|---|
| Maximum number of packets released (per sec) | 3 | 55 | 55 |
| Average packet released per second | Low | Slightly Higher | High |
| Type of packet | Network Discovery | ND & TCP | ND & ARP |
| | (ND) | | |
| Type of attack | None | TCP Flooding | ARP Flooding |

### D. *The Experiment Findings*

After two different scenarios executed and analyzed, we compiled our conclusions for this study as the following:

- Even IPv6 node infected, it still look for its victim in IPv4 network. This shows that IPv4 malware still can survive in IPv6 network environment without any modification made on the existing worm.

- In IPv4 network, the nimda worm will release TCP flooding attacks whereas in IPv6 network, the worm will behave differently by releasing ARP flooding attacks.

- IPv4 worm will not directly infect the IPv6 nodes, but it will totally consume the IPv6 network. IPv6 seem not totally invincible from attack even the attack was intended for IPv4 network. This scenario will become worse if the network is using transition mechanism to communicate between IPv4 and IPv6 network protocol.

## VI. CONCLUSION

Migrating from IPv4 to IPv6 is inevitable. Many researchers put a lot of effort to ensure the IPv6 services and stability to be much better compares to IPv4. However, not many researchers pay enough attention on security issues. The malware give severe impact on the network which cause a lot of trouble to end users. This paper shows that malware which was invented for IPv4 network still can penetrate and survive in IPv6 network without any modification made on the existing malware. This issue will be worse if the organization is using transition mechanism to communicate both their IPv4 and IPv6 nodes.

For further research, a more realistic testbed need to be used to represent the real network environment. A study on how this worm behaves in transition mechanism such as dual-stack need to be conducted to further understand how it works. Finally, a new detection technique needs to be proposed to cater this issue.

## VII. ACKNOWLEDGEMENTS

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# Molecular Dynamics Simulation on Protein Using Gromacs

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***Abstract*—Development of computer technology in chemistry brings many applications of chemistry, not only the application to visualize the structure of molecule but also to molecular dynamics simulation. One of them is Gromacs. Gromacs is an example of molecular dynamics application developed by Groningen University. This application is a non-commercial and able to work in the operating system Linux. The main ability of Gromacs is to perform molecular dynamics simulation and minimization energy. In this paper, the author discusses about how to work Gromacs in molecular dynamics simulation. In the molecular dynamics simulation, Gromacs does not work alone. Gromacs interacts with Pymol and Grace. Pymol is an application to visualize molecule structure and Grace is an application in Linux to display graphs. Both applications will support analysis of molecular dynamics simulation.**

***Keywords-molecular dynamics; Gromac; Pymol; Grace***

## I. INTRODUCTION

Computer is necessary for life of society, especially in chemistry. Now, many non-commercial application of chemistry is available in Windows version and also Linux. The applications are very useful not only in visualization molecule structure but also to molecular dynamics simulation.

Molecular dynamics is a simulation method with computer which allowed representing interaction molecules of atom in certain time period. Molecular dynamics technique is based on Newton law and classic mechanics law. Gromacs is one of application which able to do molecular dynamics simulation based on equation of Newton law. Gromacs was first introduced by Groningen University as molecular dynamics simulation machine.

This paper is focused at usage of Gromacs application. In this paper, we tell about how to install Gromacs, Gromacs concepts, file format in Gromacs, Program in Gromacs, and analysis result of simulation.

## II. THEORIES

### A. Protein

Protein is complex organic compound that has a high molecular weight. Protein is also a polymer of amino acid that has been linked to one another with a peptide bond.

Structure of protein divided into three, namely the structure of primary, secondary, tertiary and quaternary. Primary structure is amino acid sequence of a protein linked to it through a peptide bond.

Secondary structure is a three-dimensional structure of local range of amino acids in a protein stabilized by hydrogen bond.

Tertiary structure is a combination of different secondary structures that produce three-dimensional form. Tertiary structure is usually a lump. Some of the protein molecule can interact physically without covalent bonds to form a stable oligomer (e.g. dimer, trimer, or kuartomer) and form a Quaternary structure (e.g. rubisco and insulin).

### B. Molecular Dynamics

Molecular dynamics is a method to investigate exploring structure of solid, liquid, and gas. Generally, molecular dynamics use equation of Newton law and classical mechanics.

Molecular dynamics was first introduced by Alder and Wainwright in the late 1950s, this method is used to study the interaction hard spheres. From these studies, they learn about behavior of simple liquids. In 1964, Rahman did the first simulations using realistic potential for liquid argon. And in 1974, Rahman and Stillinger performed the first molecular dynamics simulations using a realistic system that is simulation of liquid water. The first protein simulations appeared in 1977 with the simulation of the bovine pancreatic trypsin inhibitor (BPTI) [8].

The main purposes of the molecular dynamics simulation are:

- Generate trajectory molecules in the limited time period.
- Become the bridge between theory and experiments.
- Allow the chemist to make simulation that can't bo done in the laboratory

### C. The Concepts of Molecular Dynamics

In molecular dynamics, force between molecules is calculated explicitly and the motion of is computed with integration method. This method is used to solve equation of Newton in the constituents atomic. The starting condition is the position and velocities of atoms. Based on Newton's perception, from starting position, it is possible to calculate the next position and velocities of atoms at a small time interval and force in the new position. This can be repeated many times,


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even up to hundreds of times. Molecular dynamics procedure can be described with the flowchart as follows:

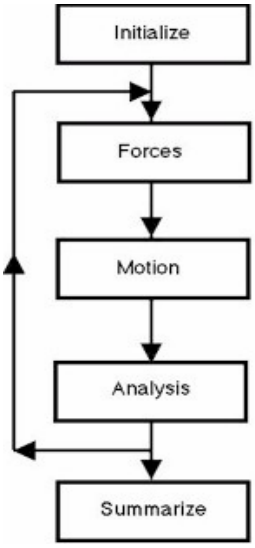


Figure 1. Flowchart molecular dynamics [13]

From The figure above can be seen the process of molecular dynamics simulation. The arrow indicates a path sequence the process will be done. The main process is calculating forces, computing motion of atoms, and showing statistical analysis the configuration for each atom.

## III. GROMACS

### A. Gromacs Concepts

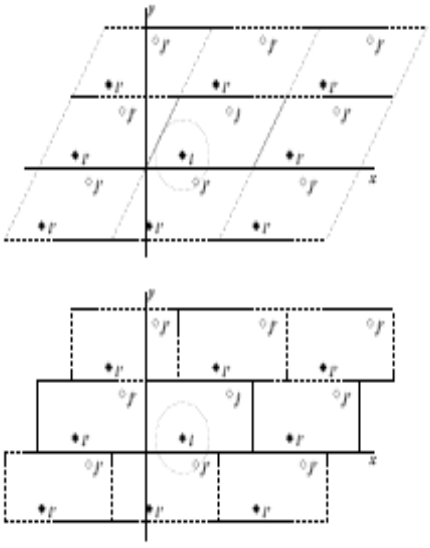

Figure 2. Periodic boundary condition In Two Dimensions [7]

Gromacs is an application that was first developed by department of chemistry in Groningen University. This application is used to perform molecular dynamics simulations and energy minimization. The concept used in Gromacs is a periodic boundary condition and group. Periodic boundary condition is classical way used in Gromacs to reduce edge effect in system. The atom will be placed in a box, surrounded by a copy of the atom.

In Gromacs there are some model boxes. That is triclinic, cubic, and octahedron. The second concept is group. This concept is used in Gromacs to show an action. Each group can only have a maximum number of 256 atoms, where each atom can only have six different groups.

### B. Install Gromacs

Gromacs applications can run on the operating system Linux and windows. To run Gromacs on multiple computer, then the required MPI (Message Passing Interface) library for parallel communication.Gromacs applications can be downloaded in http://www.gromacs.org.

How to install Gromacs is as follows:

1. Download FFTW in http://www.fftw.org
2. Extract file FFTW

```
% tar xzf fftw3-3.0.1.tar.gz
% cd fftw3-3.0.1
```

3. Configuration

```
%./configure --prefix=/home/anas/fftw3 -
-enable-float
```

4. Compile fftw

```
% make
```

5. Installing fftw

```
% make install
```

6. After fftw installed then install Gromacs. Extract Gromacs.

```
% Tar xzf gromacs-3.3.1.tar.gz
% cd gromacs-3.3.1
```

7. Configuration

```
% Export CPPFLAGS =-
I/home/anas/fftw3/include
% export LDFLAGS=-L/home/anas/fftw3/lib
% Export LDFLAGS =-
L/home/anas/fftw3/lib
%. /configure –prefix=/home/anas/gromacs
%. / Configure-prefix = / home / Anas /
gromacs
```

8. Compile and install gromacs

```
% make & make install
```

### C. Flowchart of Gromacs

Gromacs need several steps to set up a file input in the simulation. The steps can be seen in flowchart below. Flowchart illustrates how to do molecular dynamics simulation of a protein. The steps are divided into:


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1. Conversion of the pdb file

   At this step pdb is converted to gromos file (gro) with pdb2gmx. Pdbgmx also created topology file (.top)

2. Generate box

   At this step, the editconf will determine the type of box and the box size that will be used in the simulation. on Gromacs there are three types of box, namely triclinic, cubic, and octahedron.

3. Solvate protein

   The next step is solvate the protein in box. The program genbox will do it. Genbox will generate a box defined by editconf based on the type. Genbox also determined the type of water model that will be used and add number of water molecule for solvate protein the water model commonly used is SPC (Simple Point Charge).

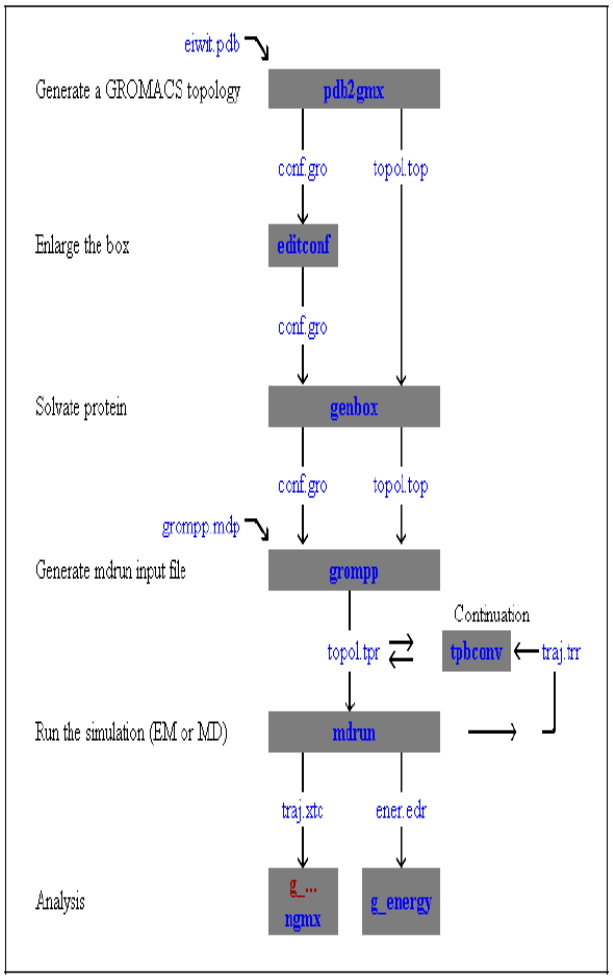


Figure 3. Flowchart Gromacs [16].

4. Energy minimization

   The process of adding hydrogen bond or termination may cause atoms in protein too close, so that the collision occurred between the atoms. The collision between atoms can be removed by energy minimization. Gromacs use mdp file for setup parameters. Mdp file specified number of step and cut-off distance. Use grompp to generate input file and mdrun to run energi minimization. The energy minimization may take some time, depending on the CPU [21].

5. Molecular dynamics simulation

   The process of molecular dynamics simulation is the same as energy minimization. Grompp prepare the input file to run mdrun. Molecular dynamics simulations also need mdp file for setup parameters. Most option of mdrun on molecular dynamics is used in energy minimization except –x to generate trajectory file.

6. Analysis

   After the simulation has finished, the last step is to analyze the simulation result with the following program:

   - Ngmx to perform trajectory
   - G_energy to monitor energy
   - G_rms to calculated RMSD (root mean square deviation)

### *D. File Format*

In Gromacs, there are several types of file format:

- Trr: a file format that contains data trajectory for simulation. It stores information about the coordinates, velocities, force, and energy.
- Edr: a file format that stores information about energies during the simulation and energy minimization.
- Pdb: a form of file format used by Brookhaven protein data bank. This file contains information about position of atoms in structure of molecules and coordinates based on ATOM and HETATM records.
- Xvg: a form of file format that can be run by Grace. This file is used to perform data in graphs.
- Xtc: portable format for trajectory. This file shows the trajectory data in Cartesian coordinates.
- Gro: a file format that provides information about the molecular structure in format gromos87. The information displayed in columns, from left to right.
- Tpr: a binary file that is used as input file in the simulation. This file can not be read through the normal editor.
- Mdp: a file format that allows the user to setup the parameters in simulation or energy minimization.

### *E. Gromacs Programs*

#### *1) Pdb2gmx*


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Pdb2gmx is a program that is used to convert pdb file. Pdb2gmx can do some things such as reading file pdb, adding hydrogen to molecule structure, and generate coordinate file a topology file.

2) *Editconf*

Editconf is used to define box water that will be used for simulation. This program not only defines the model, but also set the relative distance between edge of box and molecules. There are 3 types of box such as

- Triclinic, a box-shaped triclinic
- Cubic, a square-shaped box with all four side equal
- Octahedron, a combination of octahedron and dodecahedron.

3) *Grompp*

Grompp is a pre-processor program. Grompp have some ability that is:

- Reading a molecular topology file
- Check the validity of file.
- Expands topology from the molecular information into the atomic information.
- Recognize and read topology file (*. top), the parameter file (*. tpr) and the coordinates file (*. gro).
- Generate *. tpr file as input in the molecular dynamics and energy of contraction that will be done by mdrun.

Grompp copies any information that required on topology file.

4) *Genbox*

Genbox can do 3 things:

- Generate solvent box
- Solvate protein
- Adding extra molecules on random position

Genbox removes atom if distance between solvent and solute is less then sum of Van der Walls radii of each atom.

5) *Mdrun*

Mdrun is main program for computing chemistry. Not only performs molecular dynamics simulation, but it can also perform Brownian dynamics, Langevin dynamics, and energy minimization. Mdrun can read tpr as input file and generate three type of file such as trajectory file, structure file, and energy file.

## IV. Result of Simulation

The testing is carried out on different types of protein. Each protein has different structure and number of atom. Testing is based on flowchart of Gromacs. This testing do two process, the first is energy minimization and the second is molecular dynamics simulation. Number of step for energy minimization is 200 numstep and molecular dynamics is 500 numstep. (numstep = 1ps)

From the testing that was made on 4 different types of protein it can be seen the difference form of molecule before and after simulation. In molecular dynamics simulation, it is occurs change-mechanisms of protein structure from folded state to unfolded state. Its mechanism is as seen in Figure 4.1.

In the molecular dynamics simulation above, each protein has a different velocity simulation. From the data above we see the differences long simulations of each protein. Length of time the simulation is depicted with a non-linier graph. Length of time simulation is not only influenced by the number of atoms but also the number of chain and water blocks. In the case of protein Ribonuleoside-Diphosphate Reductase Alpha 2, although the number of atom is greater than the protein 1gg1 FV-d1.3 Kappa (Light Chain) but the simulation time is more quickly. Because the number of blocks and the chain of water in this protein are lower than the protein 1gg1 FV-d1.3 Kappa (Light Chain).

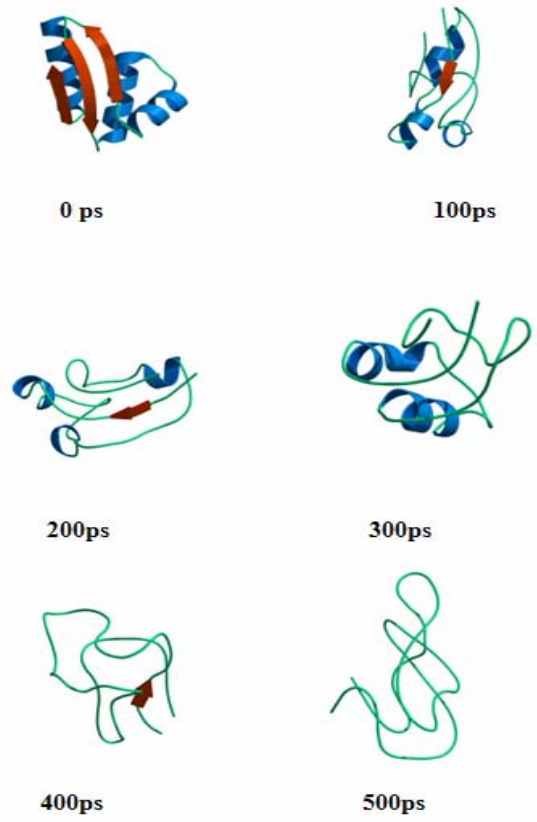


Figure 4. Figure 4.1 Mechanism Unfolded State [16]


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TABLE I. SIMULATION TIME FOR 500 PICOSECOND

| Protein | Number of Atom | Simulation Time for 500 ps (minute:second) |
|---|---|---|
| Alpha-Lactalbulmin | 7960 | 34:07 |
| 1gg1-kappa d1.3 fv (Light Chain) | 2779 | 20:07 |
| Ribonuleoside-Diphosphate Reductase 2 Alpha | 5447 | 3:30 |
| Lysozyme C | 1006 | 1:02 |

## V. CONCLUSION

This paper introduces Gromacs as one of the applications that are able to perform molecular dynamics simulation, especially for protein. At this writing, the testing is carried out on four different types of protein. From The results of testing, it can be seen that each protein has a different long time.

At the protein Alpha-Lactalbulmin with number of atom 7960, long simulation time is 34 minutes 7 seconds. 1gg1 FV-d1.3 Kappa (light chain) with number of atom 2779, long simulation time is 20 minutes 7 seconds. Ribonuleoside-Diphosphate Reductase Alpha 2 with number of atom 5447, long simulation time is 3 minutes 30 seconds. And Lysozyme C with the number of atom 1006, long simulation time is 1 minute 2 seconds. In addition Gromacs also help understand the mechanisms Folding and unfolding of protein.

## ACKNOWLEDGMENT

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# Examining the Linkage between Information Security and End-user Trust

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*Abstract*- **The main purpose of information security is to protect information and specifically, the integrity, confidentiality, and availability of data through an organization's network and telecommunication channels. Although information security is critical for organizations to survive, a number of studies continue to report incidents of critical information loss. To this end, there is still an increasing interest to study information security from a non-technical perspective. In doing so, this research focuses on the linkage between information security and end-user trust as a way to better understand and more efficiently manipulate the information security management process. That is, manipulating more effectively information security among end-users. Achieving the required level of information security within organizations usually requires security awareness and control but also a better understanding of end-user behavior in which security measures are tailored, too. In effect, organizations may have a clearer insight into how to behave more effectively to such security measures.**

**Keywords- Information Security, End-user Trust, Information Technology**

## I. INTRODUCTION

The reliance by every organization upon information technology (IT) has increased dramatically, as technology has developed and evolved. Over recent decades, organizations have come to depend on IT for operations, external transactions, and mediated communications (e.g., e-mail, fascimile). Similarly, information has developed into a strategic asset, while the computerized information systems have become ultimate strategic tools for both government and organizations [1,2]. Due to globalization and competitive economic environments, efficient information management is critical to business survival and effective decision making activities. Although, as connectivity to devices has increased, so has the likelihood of unauthorized intrusion to systems, theft, defacement, and other forms of information resource loss.

In a similar vein, as the society and its economic patterns have evolved from the heavy- industrial era to that of information society, in terms of providing new products and services to satisfy people's needs, organizational strategies have changed too. In effect, corporations have altered their organizational and managerial structures as well as work patterns in order to leverage technology to its greatest advantage. Economic and technology phenomena such as downsizing, outsourcing, distributed architecture, client/server and e-banking, all include the goal of making organizations leaner and more efficient. However, information systems are deeply exposed to security threats as organizations push their technological resources to the limit in order to meet organizational needs [3,4].

A number of major studies recently conducted [5,6,7] have indicated that security threats continue to rise. While security attacks are either internal or


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external, 66% of computer attacks in Greece come from employees within organizations [8]. To this end, the success of information security appears to depend, in part, upon the effective behavior and understanding of the individuals involved in its use. Constructive behavior by end users and system administrators can improve the effectiveness of information security. Human behavior is complex and multi-faceted, and this becomes more complicated in organizations whereas their culture defies the expectations for control and predictability that developers routinely assume for technology. In support of this, the [9] Guidelines for the Security of Information Systems, also state that: "*The diversity of system user- employees, consultants, customers, competitors or the general public- and their various levels of awareness, training and interest compound the potential difficulties of providing security*".

The present research takes a different perspective on this issue by focusing on behavioral information security: the values and beliefs held by end-users that influence the confidentiality, availability, and integrity of data through the organizations' information systems. To this end, this research examines the extent to which information security behaviors relate to end-users trust, that is: opening to the efficient communication of security risk messages. The main research assumption is that end-users trust would relate positively to the enactment of information security behaviors such as following new security policies and communicating security messages that are in effect of the organizations' business objectives. Hence, information security should support the mission of the organizations, it must be cost effective and must be in sync with end-users behavior seamlessly; that is, integrate technology, processes and people.

## II. BRIEF INFORMATION SECURITY BACKGROUND

Although a number of IS security approaches have been developed over the years that reactively minimize security threats such as checklists, risk analysis and evaluation methods, there is a need to establish mechanisms to proactively manage IS security. That said, academics' and practitioners' interest has turned on social and organizational factors that may have an influence on IS security development and management. For example, Reference [10] have emphasized the importance of understanding the assumptions and values of different stakeholders to successful IS implementation. Such values have also been considered important in organizational change [11], in security planning [12] and in identifying the values of internet commerce to customers [13]. Reference [4] have also used the value-focused thinking approach to identify fundamental and mean objectives, as opposed to goals, that would be a basis for developing IS security measures. These value-focused objectives were more of the organizational and contextual type.

A number of studies investigated inter-organizational trust in a technical context. Some of them have studied the impacts of trust in an e-commerce context [14,15,16] and others in virtual teams [17,18]. Reference [19] studied trust as a factor in social engineering threat success and found that people who were trusting were more likely to fall victims to social engineering than those who were distrusting. Reference [20] used a goal setting approach to identify weaknesses in security management procedures and found that different political agendas influenced the level of goal security goal setting negatively.

Reference [21, p. 1551] also reviewed 1043 papers of the IS security literature for the period 1990-2004 and found that almost 1000 of the papers were categorized as 'subjective-argumentative' in


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terms of methodology with field experiments, surveys, case studies and action research accounting for less than 10% of all the papers. That said, this research adopts a survey approach to study the linkage between information security and end-user trust as no prior research has studied these specific contexts and their interrelationship.

## III. INFORMATION SECURITY BEHAVIOR

Information security behavior is part of the corporate culture and defines how employees see the organization [22]. Most of the literature on organizational culture focuses on the hypothesis that strong cultures enhance organizational performance [23,24]. This hypothesis is based on the notion that having widely shared and commonly held strong organizational norms and values leads to higher performance through at least three ways. First, a strong culture enhances coordination and control within the organization. Second, it improves goal alignment between the organization and its members. Third, a strong corporate culture improves employee efforts.

Similarly, organizational culture is a system of learned behavior which is reflected on the level of end-user awareness and can have an effect on the success or failure of the information security process. Reference [25] found that users considered a user-involving approach to be much more effective for influencing user awareness and behavior in information security. Reference [26] studied influences that affect a user's security behavior and suggested that by strengthening security culture organizations may have significant security gains. Reference [27] investigated security information management as an outsourced service and suggested augmenting security procedures as a solution, while [28] suggested a model based on the Direct-Control Cycle for improving the quality of policies in information security governance. Reference [29] discussed the importance of gaining improvements from software developers during the software developing phase in order to avoid security implications. Reference [30] advanced a new model that explains employees' adherence to IS policies and found that threat appraisal, self-efficacy and response efficacy have an important effect on intention to comply with information security policies.

Behavior, in terms of information security, is the perception of organizational norms and values associated with information security and so it exists within the organizations, not in the individual. To this end, individuals with different backgrounds or at different levels in the organization tend to describe the organization in similar way [31]. Security culture is used to describe how members perceive security within the organization. Since security and risk minimization are embedded into the organizational culture, all employees, managers and end-users must be concerned of security issues in their planning, managing and operational activities. In order to ensure effective and proactive information security, all staff must be active participants rather than passive observers of information security. In doing so, staff must strongly held and widely share the norms and values of the organizational culture in terms of information security behavior and perception.

## IV. END-USER TRUST

Organizational researchers began to study the concept of trust in inter-organizational relationships and between organizations [32]. A variety of trust models have been applied to various research streams [33,34] to explain inter-organizational trust in different contexts. For instance, a number of studies investigated inter-organizational trust in a technical context. Some of them have studied the impact of trust in e-commerce [14,15,16] and others in virtual teams [17,18].


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However, trust determines the performance of a society's institutions and is a propensity of people in a society to co-operate to produce socially efficient outcomes [35]. Reference [36] defined trust as a habit formed over centuries long history of horizontal networks of association between people covering both commercial and social activities. Reference [37] defined trust as a "psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behavior of another" (p. 395).

Reference [38] defined trust as a four place predicate in terms that someone has trust in someone, in something, in some respect and under some conditions. That means the agent trusting (someone), the agent being trusted (respect) and the (conditions) under which trust is given. Hence, this research supports that in information security there is need to trust one another in communicating efficiently information security risk messages. Specifically, the end-users will provide, and not hide, valuable information among other people in order to keep awareness, control and a better understanding of security issues within organizations.

According to [33], individuals' beliefs about another's ability, benevolence and integrity lead to willingness to risk, which in turn leads to risk-taking in a relationship, as manifested in a variety of behaviors. Therefore, a higher level of trust in a work partner, increases the likelihood that one will take the risk with a partner e.g., to co-operate, share information, communicate. In doing so, risk-taking behavior is expected to lead to positive outcomes, e.g., individual performance, while in social units such as work groups, co-operation and information sharing are expected to lead to higher group performance [39,40].

However, other studies that examined the main effect of trust on workplace behaviors and outcomes found partial or no support. Some studies reported a significant main effect and other did not. More specifically, [41] found that trust within groups has a positive effect on openness in communication while [42] found that trust between negotiators mediated the effects of social motives and punitive capability on information exchange. Reference [43] proposed that trust is necessary, but not sufficient, condition for co-operation. This terminology suggests that rust may act as a moderator although the model does not specifically consider how trust might operate in this manner.

However, since high levels of trust within organizations have positive effect on openness to communication [33], then high levels of trust among end-users would improve the communication of security messages in the context of information security. In respect, this research examines the linkage between information security and end-users trust as a holistic approach to information security, that is: integrate technology, people and processes.

## V. SURVEY OF PERCEPTIONS

Three hundred and twenty seven (143 women and 184 men) employees of a large sized bank in Greece took part in the survey. The respondents ranged from junior staff to senior management and were between the ages of 22 and 65. They completed an anonymous survey questionnaire that was circulated personally by the principal researcher and consisted by 18 items. The questions were designed to solicit a response on the participant's perception of risk, their trust of the likelihood of others behaving to organizational norms and values and their trust of others in communicating efficiently security messages within the organization. Table 1 below shows an example of questions.

For the trust behaviour based questions, respondents evaluated their likelihood of engaging in risk behaviours (i.e., '…indicate the likelihood of engaging in each activity) on a five point rating scale raging from 'Very likely' (1) to Very unlikely' (5).


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For the security perception questions, respondents rated their perception of the risk presented by each risky behaviour (i.e., …indicate how risky you perceive each activity to be) on a five point scale ranging from 'Very significant' (1) to 'Very insignificant' (5).

| |
|---|
| 15. In your opinion what is the likelihood of people in the organization participating in the following activities:<br>Share their passwords with other employees.<br>Access files they are not authorized for. |
| 16. For each of the following activities, please indicate how risky you perceive each activity to be:<br>Share your password with another employee.<br>Access files you are not authorised for. |
| 17. Please indicate your perception of others in communicating efficiently in the following security related activities:<br>Challenge the knowledge of another employee on security related tasks.<br>Hide information from a co-employee in order to prove your skills. |
| 18. For each of these activities, please indicate the likelihood of others to behave to organizational norms and values:<br>Do not meet expiration dates on given tasks.<br>Do not share your knowledge with others due to competitive reasons. |

Table 1. Example of Questions

For the trust in communicating efficiently security messages based questions, respondents rated their perception of the likelihood of other people in the organization communicating in activities (i.e., …your opinion what is the likelihood of people in the organization participating and communicating in the following activities) on a five point rating scale raging from 'Very likely' (1) to 'Very unlikely' (5).

The information in this report is based on the initial response of the three hundred and twenty seven participants. Using a variation of [44] formula to determine sample sizes necessary for given combinations of precision, confidence levels and variability, this survey should have a confidence level of 95% with a precision level of greater that $\pm$4%.

The main purpose of the survey was to find out mainly the following: What is the individual's perception of the risk involved with certain activities? What are the individuals' levels of trust of the likelihood of others in the organization behaving to certain organizational norms and values with regard to certain security activities? What are the individuals' levels of trust in communicating efficiently information security risk messages within the organization?

The intended outcome of this research is to develop a strategy to improve organizational information security and an enhancement of trust levels to communicating efficiently security messages within the organizations. The questions analyze the different components relating to information security: 1) individual perception of risk, 2) individual perception of trust that others will behave according to organizational norms and values, 3) individual perception of trust in communicating efficiently within information security activities.

Table 2 below, shows the responses in percentages of the individual perception of risks for certain activities (perceived values), the individual perception of trust that others are determined to communicate efficiently in security-related activities (communication), and the individual perception of behaving to organizational norms and values (end-user trust). The results give interesting insights and


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reveal gaps in the individual's perception of information security and trust in the context of organizational norms and values. Male and female respondents don't differ significantly in their perceptions of risk in all activities with the exception of challenging another's knowledge on security tasks where 62% of females perceived very significant risk in undertaking this activity. It would appear that generally female respondents are less likely to engage in risky behaviour. Surprisingly 38% of both male and female respondents perceive that it is likely or very likely that people within the organization are sharing passwords with other people. In addition, 84% of male and 78% of female respondents perceive it to be a significant risky activity. While 11% of male and 13% of female respondents implied that they would share a password with other people. Thus, it appears that while sharing passwords with others is considered risky, organizational norms and values ignore such behaviour.

In the context of others communicating efficiently security risk messages, 23% of male and 33% female respondents perceive hiding information from a co-employee as a risky activity yet 82% of male and 73% of female respondents said it was unlikely or very unlikely they would participate in the activity. This may imply that while individuals don't perceive this as a very risky activity, they intent to share information with others which means that the organization's norms and values enable cooperation and overall communication among the employees.

Of the total respondents 42% said that they would reuse the same password many times and in terms of information security project communication 53% said that they would ask for clarity of goal achievement in case they are confused. Finally, 53% said that project communication initiates from top-executives and that trust in top-management provides better understanding and control of security issues. In effect, communication is improved. The questionnaires were taken anonymously to enhance true value, although there is an uncertainty of answers that conform to what the security policy state as well as the employee's actual behaviour.


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| All figures are shown as percentage (%) | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female |
|---|---|---|---|---|---|---|---|---|---|---|
| **Perception of risks for these activities** | Very Significant | | Significant | | Neutral | | Insignificant | | Very Insignificant | |
| Share password with others | 50 | 47 | 34 | 31 | 14 | 14 | 12 | 10 | 7 | 5 |
| Challenge new employee in work place | 20 | 24 | 38 | 38 | 17 | 12 | 11 | 13 | 6 | 4 |
| Allow another to use ID pass/card | 38 | 47 | 33 | 32 | 16 | 16 | 21 | 19 | 7 | 3 |
| View or download prohibited material | 32 | 47 | 31 | 33 | 20 | 10 | 7 | 11 | 5 | 4 |
| Forge someone's signature | 26 | 34 | 45 | 39 | 19 | 6 | 5 | 9 | 3 | 6 |
| Access unauthorised files | 37 | 31 | 41 | 34 | 17 | 17 | 19 | 13 | 4 | 3 |
| Challenge another's knowledge on security tasks | 40 | 62 | 30 | 22 | 12 | 11 | 32 | 29 | 12 | 5 |
| Hide information from other employees | 19 | 21 | 22 | 19 | 12 | 14 | 12 | 21 | 11 | 12 |
| **Trust of others in communicating efficiently security messages** | **Very Likely** | | **Likely** | | **Neutral** | | **Unlikely** | | **Very Unlikely** | |
| Share password with others | 18 | 21 | 22 | 19 | 12 | 13 | 29 | 30 | 21 | 22 |
| Challenge new employee in work place | 16 | 14 | 12 | 11 | 13 | 18 | 24 | 21 | 11 | 22 |
| Allow another to use ID pass/card | 6 | 7 | 3 | 10 | 17 | 13 | 33 | 21 | 19 | 21 |
| View or download prohibited material | 3 | 1 | 3 | 12 | 11 | 10 | 32 | 29 | 51 | 14 |
| Forge someone's signature | 1 | 1 | 2 | 6 | 5 | 3 | 33 | 21 | 59 | 26 |
| Access unauthorised files | 2 | 3 | 5 | 4 | 15 | 13 | 20 | 19 | 50 | 61 |
| Challenge another's knowledge on security tasks | 25 | 31 | 24 | 21 | 12 | 11 | 21 | 19 | 48 | 72 |
| Hide information from other employees | 21 | 20 | 19 | 24 | 11 | 19 | 34 | 25 | 29 | 26 |
| **Perception of trust of the likelihood of others behaving to organizational norms and values** | **Very Likely** | | **Likely** | | **Neutral** | | **Unlikely** | | **Very Unlikely** | |
| Share password with others | 6 | 4 | 7 | 9 | 11 | 14 | 21 | 18 | 49 | 50 |
| Challenge new employee in work place | 30 | 21 | 32 | 28 | 16 | 11 | 29 | 19 | 46 | 10 |
| Allow another to use ID pass/card | 7 | 3 | 3 | 2 | 17 | 12 | 23 | 18 | 33 | 30 |
| View or download prohibited material | 3 | 2 | 9 | 11 | 1 | 5 | 37 | 31 | 7 | 23 |
| Forge someone's signature | 4 | 1 | 8 | 2 | 1 | 6 | 11 | 9 | 43 | 56 |
| Access unautorised files | 3 | 2 | 8 | 4 | 11 | 5 | 12 | 9 | 77 | 56 |
| Challenge another's knowledge on security tasks | 35 | 31 | 23 | 21 | 16 | 10 | 19 | 21 | 44 | 43 |
| Hide information other employees | 32 | 29 | 31 | 28 | 17 | 22 | 33 | 41 | 49 | 32 |

Table 2. Risk perception, perception of trust and likelihood ratings by gender.



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## VI. LIMITATIONS AND FURTHER RESEARCH

There are opportunities to undertake further intensive research to identify more critical behavioural and psychological factors and their relation in the context of information security. Although high levels of end-user trust goal setting plan seems to positively influence information security development and management, we cannot be sure as to how an these high levels of end-user trust could always lead to information security success. Future research on information systems security, especially research based on surveys, should therefore examine the role of other possible factors at the level of security planning in addition to end-user trust. Likewise, another issue interesting to investigate would be the role and type of feedback in communication and end-user trust in the context of security design, e.g., whether the type of feedback (outcome or process feedback) provided affects the communication- end-user trust relationship.

However, there were some biases during the collection of data mainly due to the suspicious attitude of the IT employees towards the researchers. That is, the IT employees through the survey might be careful in answering questions with regard to security because the issue of information systems security is highly confidential and sensitive. To this end, open-ended questions were of useful to some extend.

Moreover, the research findings may be influenced by political games that different banking units wish to play. As the participation in a research survey can help organizational members to voice their concerns and express their views they can use this opportunity to put forward those views that they wish to present to other members of the organization.

## VII. CONCLUSIONS

There was a belief that information technology and security were difficult issues to be understood by non-IT staff. Nowadays, it is believed that people make the difference to information technology and security and that training on the ethical, legal and security aspects of information technology usage should be ongoing at all levels within organizations (Nolan, 2005). Since people react differently to poorly constructed security messages, communication will broken down and may confuse task knowledge and security risk awareness among the employees. Thus, the main implication for information security management is to focus on changing attitudes and human behaviour which are parts of the organizational norms and values in order to enhance awareness among the employees about information security related tasks. In doing so, efficient communication of security risk messages among end-users will increase since it is important to realize that awareness is one of the first steps to obtain active employee's participation in the information security process and vice versa. That is, a well established security awareness will ensure security project communication though active participation of employees to security related tasks.

The more organizations rely on information systems to survive in competitive markets, the more increasing becomes the need to maintain the confidentiality, availability, and integrity of data through the organization's network and telecommunication channels. However, the technology advancement rate for the use and management of these information systems is more radical than the development of means for ensuring the confidentiality, availability, and integrity of data through them. That is, as organizations become aware of security issues, security threats remain high.


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Although achieving the required level of information security among end-users requires also security awareness and control, a better understanding of the organization's norms and values in which security measures are tailored to, is also important. In this way, organizations may have a clearer insight into how to communicate more efficiently to such security measures.

This research examined the linkage between information security and end-user trust as part of behavior to organizational norms and values. The main research assumption was that end-user trust in terms of others communicating security messages efficiently, would overall relate positively to the enactment of information security behaviors such as following new security policies and new technologies that are in effect of the organization's business objectives. Information security needs to be embedded in organizational norms and values so that satisfactory security levels can be achieved through a clearer insight into the security measures and objectives of the organization. High end-user trust levels and well trained end-users can address the security planning and management of information within an organization. Overall, information security should support the mission of the organizations, it must be cost effective and fit into the organizations' culture seamlessly, that is integrate technology, processes and people.

Future research should focus on the perception and development of communication strategies and how they could be applied to different organizational structures as well as security measures and policies according to structure organizational size that improve end-user awareness on information security. That said, different structured organizations may have different business objectives and therefore, security needs.

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# A New Approach of Probabilistic Cellular Automata Using Vector Quantization Learning for Predicting Hot Mudflow Spreading Area

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*Abstract*— **In this letter, we propose a Cellular Automata using Vector Quantization Learning for predicting hot mudflow spreading area. The purpoe of this study is to determine inundated area in the future. Cellular Automata is an easy approach to describe the complex states of hot mudflow disaster that have some characteristics such as occurring on the urban area, levees and surface thermal changing. Furthermore, the Vector Quantization learning determines mass transport in the surrounding area in accordance with equilibrium state using clustering of landslide. Evaluating of prediction result uses ASTER/DEM and SPOT/HRV imaging. Comparison study shows that this approach obtains better results to show inundated area in this disaster.**

***Keywords: Probabilistic cellular automata, vector quantization, hot mudflow spreading, prediction, mass transport Introduction***

## I. INTRODUCTION

Simulating hot mudflow in the plane and urban area requires understanding how the surface changing properties vary with time and space. In order to generate complex flow about interactions between natural and human made topography, we need the model of the main mechanical features of hot mud depending on landscape data. Another difficulty is to compute the simulation of hot mudflow at acceptable rates. However, they are difficult to apply in general conditions.

Argentini [1] introduced a CA approach to simulate fluid dynamic with some obstacles and fluid flow parameters. This approach used basic rules in the two-dimensional spaces. Vicari [2] introduce CA approach to simulate lava flow. This approach used Newtonian fluid dynamic concept. Combination of both approach obtained a discrete approach for predicting hot mudflow [3]. This approach yielded correct location and direction of hazardous area, but the intersection area between prediction area and real area of hazardous area is around 36.44%. This approach is a deterministic approach based on Cellular Automata to estimate the areas potentially exposed to hot mudflow inundation, concentrate mudflow characteristics, combine fluid flow and lava flow properties, and neglect difficulty to describe a model of complex human made landscape data and random behavior of state changing. The previous approach assumes that hot mudflow has similar characteristics to lava flow such as thermal changing, fluid mass transport rules and material mixing.

It is difficult to describe some physical phenomena caused by complex human made landscape objects such as levees, buildings, and other environmental properties. Avolio et al. [4] have proposed an alternative Cellular using minimization differences to simulate lava flow. This approach has stochastically state changing. The key-point of this approach is easy to develop. Recently, D'Ambrossio et al. [5] and Del Negro et al. [6] have applied the stochastic approach to simulate soil erosion. This approach also uses minimization differences based on Cellular Automata for other fluid flow phenomena. The idea of the use of the stochastic approach makes the alternative approach describe complex landscape object problems on the hot mudflow disaster [7]. The problem of this idea is how to fix probability value of mass transport on each neighbor-cell.

The aim of this letter is a new approach of cellular automata model for predicting hazardous area in the hot mudflow disaster. This approach uses some ideas such as minimization difference model and vector quantization to make cluster of mass transport possibility depend on altitude, height of mud and plant [8]. Because of cluster continuity by vector quantization, it looks like the statistical behavior of landscape object in the urban area. Vector Quantization determines cluster of inundated area [9] that makes flow difference in neighborhood area easy to define in probability values. A similar approach has not yet been undertaken for mudflow and lava flow in any other place, which appeared in the landslide area. However, a simple cellular automata approach is considered there.

Simulation results use the landscape map using ASTER DEM, and initial parameters of hot mudflow. This paper shows some simulation result on map view in the varying time and percentage of predicting performances. We also show the comparison of predicting on inundated area and direction with the other previous approach.


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## II. Overview of Fluid Dynamic Cellular Automata

Most numerical approaches to modeling landscape evolution simulate the physical flow such as mass transport of fluid particles, erosive effects of water discharge, infiltration and absorption by solving complex differential equations. CA is an alternative approach to simulate fluid flow using a simple approach. The current implementation is primarily based on D'Ambrossio et al. [5] because it uses "very simple approximations intended to describe complex geographical effect" and it able to offer "insight into how thermal and viscous fluid parameter affects the evolution of landscapes" despite its simplicity.

The CA algorithm simulates first-order processes associated with fluvial erosion by iteratively applying a set of simplified rules to individual cells of a digital topographic grid [10]. The state represents a number of fluid particles in the topographic grid, and the subsequent movement and behavior (diffusion, and erosion) of the cell is controlled by the rules and a few parameters of the current cell and its surrounding neighbors [11]. The same rules are applied to all grid cells, i.e., there is no outside-imposed distinction between slope and channel; the model forms its own channels [11].

Figure 1 illustrates how the algorithm works. For example, fluid particles move to lower elevations, simulating fluid flow in the landslide grid. There are two varying flows; erosion and diffusion. The amount of erosion and diffusion each produces is proportional to the local slope, simulating speedier erosion of steeper slopes and lesser erosion of hard rock surfaces.

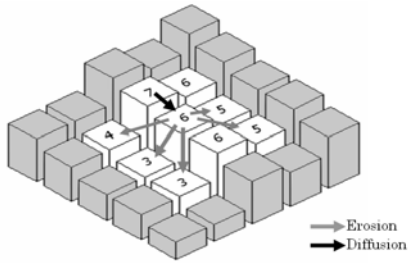


Figure 1. Schematic diagram showing how CA model works

Xiaoming Wei [12] introduced the simple CA approach for highly viscous fluid. Its movement is mainly a result of gravity, viscosity damping and friction. This approach uses four variables to indicate the expanding potential of a liquid cell; there is solid, liquid, amount of material and energy. Setting a certain threshold for this variable enables to control the expanding behavior of the liquid. For each liquid cell, if its energy is higher than a certain threshold, it has the potential to spread along its horizontal neighboring cells [17]. This approach uses four nearest neighbors and four second nearest neighbors.

Another CA approach to simulate fluid flow uses the minimization difference approach that was introduced by Avolio [4] and D'Ambrossio [5]. This approach is one alternative approach to solve fluid dynamic without sophisticated mathematical formulation. It obtains a satisfactory model to simulate the lava flow with various parameters such as viscosity and surface thermal changing. This approach is powerful to simulate fluid flow and easy to develop.

## III. Proposed Approach

### A. General Characteristic of Hot Mudflow Disaster

On 29 May 2006, the gas exploration operation had caused cauldron of hot mud in 6.3 km depth spray out hot mud to surrounding areas on Sidoarjo, East Java, Indonesia (7.530553°S; 112.709684° E) [13][14]. This disaster located at the urban area near Sidoarjo (Figure 2-top). Hot mud had spilled over 5000 m3 per-day. It increased over 170,000 $m^3$ per-day as reported by Cyranoski [15] and over 150,000 $m^3$ as reported by Harsaputra [16].


Figure 2. The location of hot mudflow disaster

Hot mudflow had an immense impact on environment, economic and human resource in the future if no countermeasure is conducted (Figure 2-bottom) [17]. Within the first two years, the mud flow disaster destroy some villages, farm lands, factories and public facilities such as schools, markets, roads, water pipes and gas pipes. Over 17,000 people had lost their houses and jobs. If facts, approximately mud blows out 150,000 m3 per-day with the assumption that contains 70% by water. This implies that water come out by 687,000 barrel a day. This situation is different from some disaster areas where the previously occurred other locations because it has overmuch mud [18].


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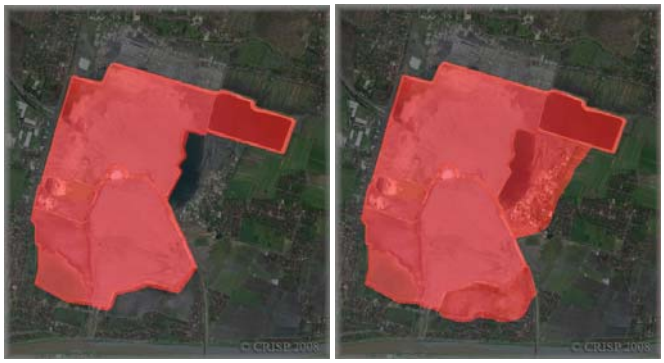
Although one possible solution is spillway to Porong River, it does cost and takes a long time and vast human resource. Therefore, strong demands on prediction of mudflow spreading volume and mudflow disaster area as well as on how to evacuate from the area of which the levee that was constructed to prevent mudflow spillover are there for people who are living in the disaster areas. If inundated area are predicted before the mud comes, the Indonesia government makes countermeasures to reducing the impact.

This simulation uses map on February 2008 (Figure 3a) as initial map and map on August 2008 as target map (Figure 3b). This map is landscape approximation using ASTER/DEM and the height data on the some observation points. The map size is approximate 3.705km×4.036km. The red area is mud inundated area. In this simulation, mud blows from the main crater (big hole) that has a diameter around 20m [8], and mud moves to other locations depend on slope difference and mudflow parameters. The key process is mass transport that defines the amount of mud moving.



(a) (b)

Figure 3. (a) Initial map on February 2008, (b) target map on August 2008

### B. Model Definition

This model is 2D CA model. It uses two-dimensional grids to describe set of cells. The state of cell $S$ is floating point value that shows the amount of mud and soil particles. In this research, we define two-type variables of state; the amount of mud $s_t(x,y)$ and the amount of soil $h_t(x,y)$. Mud is moving material. It moves from one cell to its neighbors using probability of move $p_{mov}$. The other hand, the small part of mud also changes into the soil using probability of deposition $p_{vis}$. The model state is as shown in Figure 4.

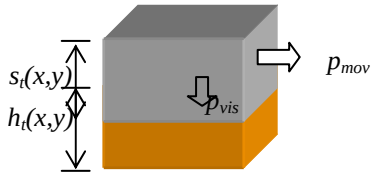



Figure 4. Mud and soil states.

### C. Model Definition

In this research, we use probability Cellular Automata based on Minimization Differences [5][7] as the main approach. The algorithm of Minimizatin Differences is as follow:

(a) A is the set of cell not eliminated. Its initial value is set to the number of its neighbors. Each cell on position (i,j) has two components such as soil and mud. The height of them are $g_{ij}$ and $s_{ij}$. Total height of this cell is: $h_{ij} = g_{ij} + s_{ij}$. There is dynamic soil $u_{ij}$, but it is the small portion of soil and we adjust on normal distribution of $p_m$.

(b) The average height is found for the set of A of non-eliminated cells:

$$m = \frac{h_c + \sum_{i \in A} c_i . h_i}{n_A + 1} \quad (1)$$

Where:
$h_c$ is height of the center cell.
$h_i$ is height of the non-eliminated neighbor cells.
$n_A$ is number of non-eliminated neighbor cells.
$c$ is current mass-transport weighting from the learning process.

(c) The cells with height larger than average height are eliminated from A.

(d) Go to step (b) until no cell is to be eliminated.

(e) The flows, which minimize the height differences locally, are such that the new height of the non-eliminated cell is the value of the average weighting height.

$$h_i = \frac{\sum_{A} c_i . h_i}{n_A} \quad (2)$$

When we used probability adjustment depend on height differences in the previous research, we use Vector Quantization learning to make cluster space of mass transport as a probability adjustment in the neighborhood area. We select some points in the previous map and the nearest points in the current map as paired point. We use standard competitive learning to determine height of points around the surrounding area.

$$c^{new} = c^{old} + \tau\left(c^{pair} + c^{old}\right) \quad (3)$$

Where:
$c^{new}$ is a new inundated point in the surrounding area.
$c^{old}$ is an inundated point in the previous map.
$c^{pair}$ is an inundated point in the current map.
$\tau$ is a learning rate.

In each point, there are some parameters that influence of mass transport on simulation process such as altitude (ground height), mud height and landslide [8]. Because of the discontinuous distribution of abrupt mass movement hazards [19], VQ obtains an alternative method to quickly assess the degree of hazard for each unit. It creates groups without considering whether or not the units in the same group are continuously distributed. Figure 5 shows the processing schema of hot mudflow spreading simulation. The learning process using vector quantization determines a cluster space that describes the probability of mass transport. The probability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values add some weighting under flow process in minimization differences approach.

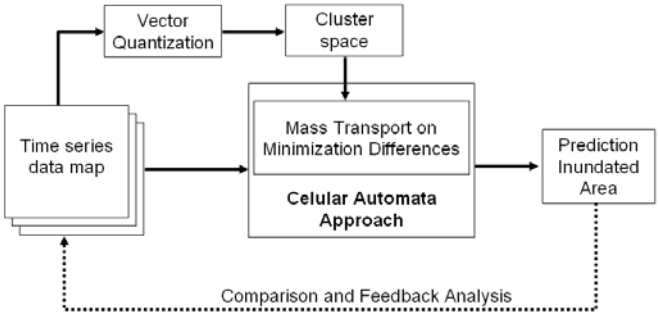


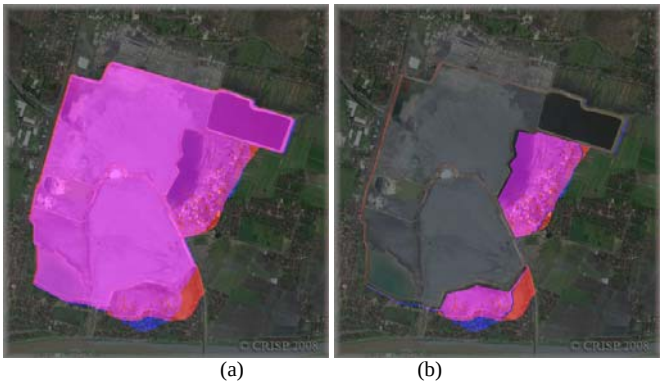

Figure 5. The schematic of hot mudflow spreading simulation

## IV. Simulation Results

In this simulation, we use the current resolution of ASTER/DEM (30m×30m). The mud blow volume is around 150.000 $m^3$ per day using Gaussian random number around this volume. The mixing particle is 70% water and 30% solid material.

### A. Simulation Results

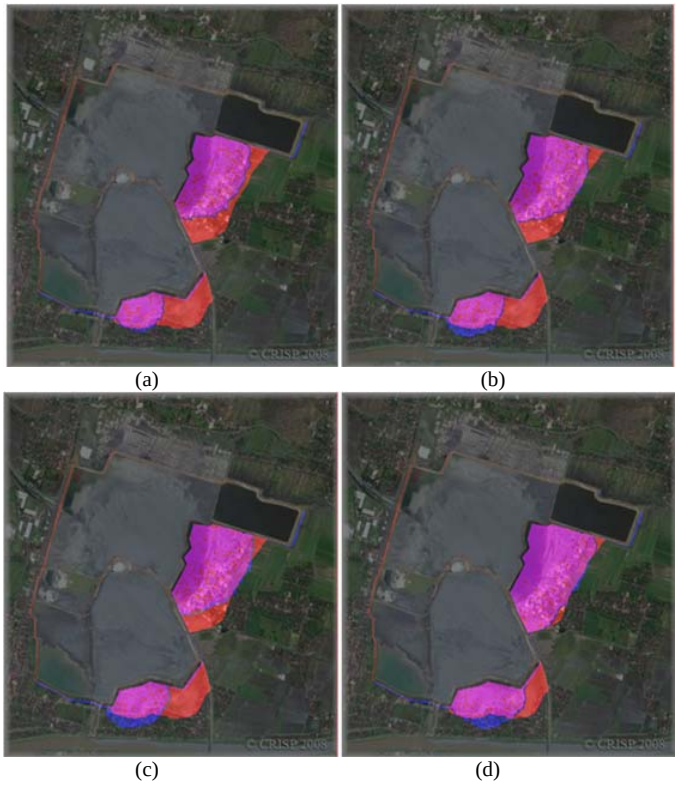
The simulation result is shown as Figure 6. In this figure, we show the total inundated area (Figure 6a) and the new inundated area (Figure 6b). The red area is the real inundated area, the blue area is the predicted area, and the pink area is intersection between real area and predicted area. In Figure 7a, the intersection area is above 95% that show this approach yield a good result of prediction. It is not fair because the prediction accuracy is only for new inundated area. Therefore, we compare the predicted area and the real area in new inundated area only. Figure 7b shows that the intersection area in new inundated area is 71.85%. This result is better that the previous result that uses minimization difference approach (56.44%) [7]. Figure 7 shows the comparison between this approach and other approach.



(a) (b)

Figure 6. The simulation result: (a) total inundated area, (b) new inundated area using this approach

Figure 8 shows combination of CA approach and online clustering using vector quantization obtain better performance to predict new inundated area (54.13-69.13%) than previous methods in 3x3 Von-Newmann neighborhood system in all resolution; minimization differences algorithm (48.15%-65.67%) in our previous research, Avolio's approach (45.75%-63.34%) and Vicari's approach (43.25%-60.25%). Comparison of these methods is shown in figure 8.



(a) (b)

(c) (d)

Figure 7. Comparison of (a) Vicari's approach, (b) Avolio's approach, (c) CA using Minimum Difference approach, (d) CA using VQ approach

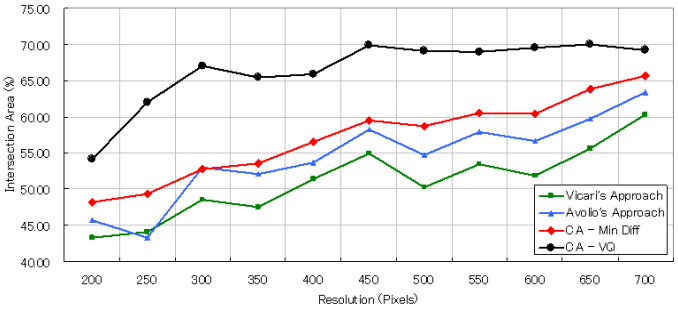



Figure 8. Comparison with the other approaches

### B. Resolution Influences

This simulation runs in some resolution. In normal size, we use ASTER/DEM map that has resolution 30m and image size 300x300 pixels. The minimum resolution is 200 pixels (map resolution is 45m). The maximum resolution is 700 pixels (map resolution is 12.9m). The prediction performance increases by increasing resolution and become stable on higher resolution as shown in Fig. 9. This figure shows there are two peak points of intersection area; in resolution 30m and in resolution 20m. They occur because the resolution of our ASTER/DEM data is 30m, and we use another data (height data on critical points) that have resolution 20m.



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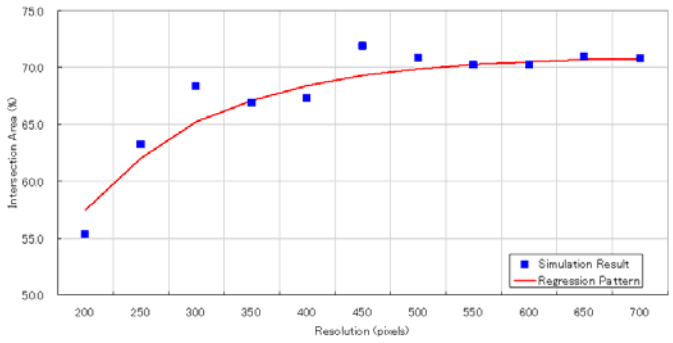


Figure 9. Prediction performance for each resolution

## V. CONCLUSION REMARKS

Through the simulation study with the proposed model based on Cellular Automata, we may conclude the following,

(1) The using vector quantization learning in CA approach obtain much better performance to predict new inundated area in hot mudflow disaster.
(2) The prediction performances depend on resolution. Increasing resolution will increase the prediction performance and become stable in the higher resolution.
(3) The dangerous levee location for spillover can be found with the proposed method.
(4) Cell size effect is clarified. By considering the resolution of data sources, the resolution of ASTER derived DEM (Digital Elevation Model) is 30m, the most appropriate number of cells of CA is determined with these resolutions.

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# A Linux Kernel Module for Locking Down Applications on Linux Clients

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***Abstract*—Preventing the installation and execution of unauthorized software should be a high priority for any organization. Allowing users to install and execute unauthorized software can expose an organization to a variety of security risks. In this paper we present a graylisting solution to control application execution on Linux clients using a loadable kernel module. Our developed kernel based solution, Locking Applications on Linux Clients or LALC is a new Linux subsystem which adds a graylisting application lockdown capability to Linux kernel. The restriction policy applied by LALC to specific client is based on the preconfigured security level of the client's group and on the application the client desire to execute or to install. LALC is flexible enough to support the business needs as well as new applications and new versions of existing applications. And it is so secure that no end user can circumvent its configuration.**

***Keywords-Application Lockdown; Linux Kernel Module; Restriction Policy; Whitelisting; Blacklisting; Graylisting.***

## I. INTRODUCTION

The rising number of computer security incidents since 1988 [3][4] suggests that malware is an epidemic.

Malware is referred to by numerous names. Examples include malicious software, malicious code and malcode. Many definitions have been offered to describe malware. For instance, [7] describe a malware instance as a program whose objective is malevolent. Malicious codes defined in [6] as "any code added, changed, or removed from a software system in order to intentionally cause harm or subvert the intended function of the system."

Nowadays, in many organizations, employees can peruse web sites, send and receive email, download software, and install applications whenever they want. On one hand, such openness helps business flow by empowering workers to use information freely; on the other, it can risk the security and integrity of both computers and data as it opens a wide window for malware and malicious attacks.

Often the first defensive step is to run an anti-virus and anti-malware protection software. These programs perform a thorough cleaning of existing virus and malware infections, returning the systems to a relatively stable state. However, they are typically just behind the hacker curve. Computers are vulnerable to newly released viruses or attacks until the malware code is identified and the anti-virus agents are updated on every machine.

Using these methods makes a "zero day attack" almost impossible to prevent using anti-virus software. And due to this failure of anti-malware, organizations take the choice of locking down their entire networking environments.

Locking down a network client can mean a lot of different things. In this paper we refer to a client as being locked down if it is configured in such a way that prevents unauthorized applications from being installed or executed.

It is obvious that locking down clients will stop users from installing or executing an application that contains spyware, a Trojan, a virus, or some other form of malware. This will result in a tremendous security improvement and business continuity.

Locking down client machines can be done using different methods. The problem with many of these methods, however, is that they are either impractical, costly or places a heavy burden on the network administrators.

In this paper, we develop a kernel based solution for Locking Application on Linux Clients (LALC) applying a graylisting approach. LALC uses a central server that controls applications running on clients. The server was configured to define client's security levels and their associate allowable and disallowable applications. Clients are configured to request server permission on executing an application. The server permits or denies client requests by comparing the hash value of the requested application to those pre-stored values. For flexibility and ease of use, the solution provides a Server Configuration Utility for managing clients groups, their security levels and their associate restriction lists.

This paper is organized as follows. In Section II, we revise the basic locking down approaches, and we discuss the design of LALC in Section III. In Section IV we show how we implement and test LALC and we conclude the paper in Section V.


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## II. LOCKING DOWN APPROCHES

Basically, there are three major approaches for locking down client applications; blacklisting, whitelisting and graylisting.

### A. Blacklisting Approach

This approach applies the security premise "what is not expressly defined to be prohibited must be allowed". So in this approach only those applications that have been defined to be unwanted, the blacklist, will not be executed, all other applications will be allowed to run. Clearly this approach will not defend against malicious applications not previously identified in the blacklist.

### B. Whitelisting Approach

This is the reverse approach to blacklisting, it applies the security premise "what is not expressly defined to be allowed must be prohibited". Application whitelisting is emerging as the security technology that gives a true defense-in-depth capability, filling in the gaps that anti-virus was never designed to cover. Application whitelisting is characterized by the ability to identify authorized executables and associated files and to treat as an attack any program or file that is not on the authorized whitelist. Recent advances in application whitelisting, including automatically approving files from trusted sources to reduce administrative overhead or allowing end-users to personalize their endpoint for greater user acceptance, has made application whitelisting an attractive choice.

Application whitelisting is a technique gathering momentum in commercial security systems. Most implement additional access controls within the operating system to stop unauthorized programs from running. Products from companies such as CoreTrace [5], SolidCore [10] and Bit9 [2] all use application whitelists to create a safer working environment.

### C. Graylisting Approach

This approach combines the previous two approaches; it uses three lists, while, black and a gray. This approach works by focusing on valid whitelisting applications and allow only those applications to run. All the applications in the blacklist are not allowed to run. When an application is not in the white list or in the black list, it will be placed in the gray list for further justification. This approach uses software authentication to reduce the problem of malware and other unwanted software [9].

## III. LOCKING APPLICATIONS ON LINUX CLIENTS (LALC)

LALC is a graylisting solution that restricts application execution on network Linux clients. The solution maintains three lists, a white list for applications that are authorized to run, a black list for applications that are solely prohibited and a gray list for applications that are neither white nor black.

LALC deploys client group restriction policy which allow establishment of different client groups that have different security levels. For system flexibility LALC implements three security levels, namely, Lockdown, Block-and-Ask and Monitor. In Lockdown level, only whitelisted applications are allowed to run. In Block-and-Ask a confirmation message for executing the application is sent to the user when the application is gray. In the Monitor level the gray applications are allowed to be executed without user confirmation. In all security levels, the gray applications are added to the gray list for later administrator analyses.

### A. LALC Components

LALC is a client/server application. On the client side, we build two components, a Loadable Kernel Module (LKM) to intercept client attempts to execute applications, and an Agent program which was designed to calculate the hash value of the desired application file using MD5 algorithm and to communicate with the server. Although the Agent Module employs MD5 algorithm but any other hashing algorithm can be used instead.

On the server side we build a Server program to receive client's requests and to generate responses, and a Server Configuration Utility to allow administrators to manage client groups, security levels and application lists.

*1) Client Components:* Two components are deployed on each client; the Loadable Kernel Module (LKM) and the Agent.

*a) The Loadable Kernel Module (LKM):* The LKM is built based on the facts that; a loadable kernel module is a piece of code that can be dynamically loaded or unloaded from the Linux kernel, and once it loaded it becomes a part of the kernel [8]. And Linux kernel dedicates a specific system call, namely execve, to handle client request to the kernel for executing a program file [1].

LKM was designed to intercept client requests on behalf of the original execve, and to invoke the Agent. Based on the return value LKM may or may not allow original execve to handle the client application.

LKM comprises four functions; initialization(), custom_execev(), write() and read().

- Initialization() :When LKM is loaded into the kernel it executes the initialization(). This function redirects client calls from the original execve system call to the custom_execve function inside the LKM. Initialization() performs redirection by replacing the execve address in the kernel table by the address of the custom_execve(), and saving the original execve address. Also the initialization() prepares a communication channel to the Agent process via a /proc file. It creates a /proc file and connect its read/write operations with read() and write() inside the LKM. Also it creates two buffers to be used by LKM other functions, namely, Request Buffer and Response Buffer. Generally, /proc file system is a method used for communication between the kernel and user processes [9]. Fig. 1 shows how LKM initialization function works.


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- custom_execve(): The purpose of this function is to replace the original execve system call, and therefore it will be executed whenever a client process desires to execute an application file. It saves the name of the application file to be executed in the Request Buffer and sets a flag to indicate that a request to execute an application file is pending (Request_Pending = 1). After that it wakes up the Agent to handle the pending request, and it renders itself in awaiting state. After custom_execve wakes up by the write(), it reads the Request Buffer and resets the pending flag. Based on the value in the buffer, custom_execve either allows the execution of the application or denies it. On allowing execution custom_execve executes the original execve system call, and on denying, it returns an error code on behalf of the original execve system call. Fig.2 shows how the custom execve function works.

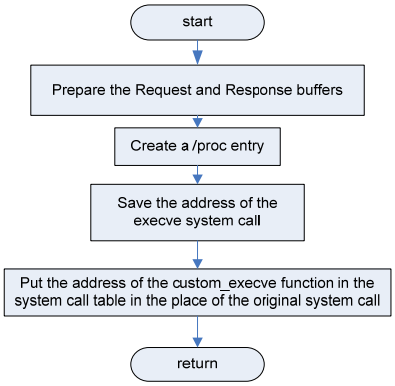


Figure 1. KLM Initialization Function

- read(): When the Agent tries to read the /proc file this function is executed. It waits until the variable Request_Pending is set. Once the variable is set, it returns the contents of the Request Buffer - which is the application file name- to the Agent module.
- write(): When the Agent tries to write to the /proc file this function is executed. The purpose of write() is to write to Response Buffer the message that the Agent desire to write to the /proc file and then it call upon custom_execve function.

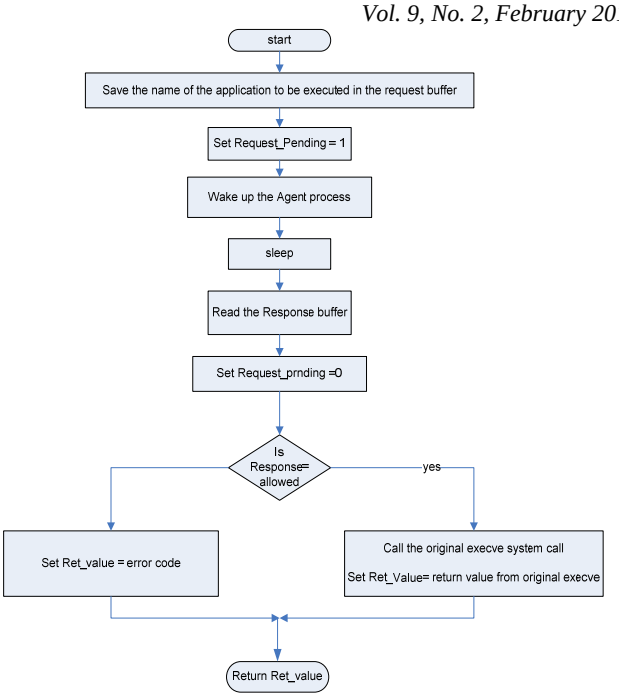


Figure 2. LKM custom_execve function

*b) The Agent:* The Agent program is a user level program that runs in the client machine. Its purpose is to calculate the hash value for the application file content, and to forward it to the server combined with the requesting client hostname and the application file name. Later, the Agent has to forward back the server's response to the LKM custom_execve function through writing to /proc file. Fig.3 shows how Agent works.

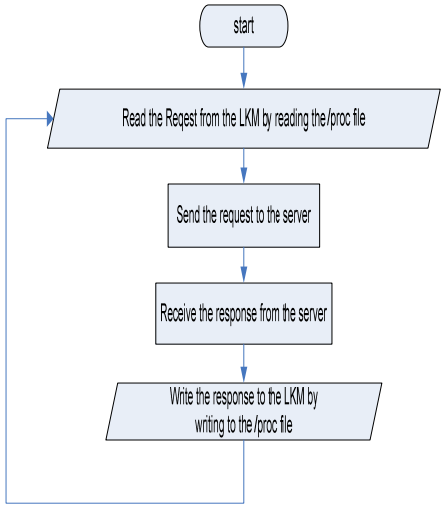


Figure 3. Agent program main loop

*2) Server Components:* Two components are deployed on the server side; the Server program and the Server Configuration Utility.


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*a) Server Program:* The main task of the Server program is to receive client requests via Agent programs and to respond to those requests. The request's hash value and the requested client host name are used by the server to generate the permission response, and it uses the application file name to identify the client in its log file.

The server generates the response by manipulating a database which stores information about client groups, group's security levels and application lists. The server waits for Agents connections on a specific TCP port, and when an Agent connects to that port, the server receives the request and sends back a response. Fig.4 shows how the server works.

*b) Server Configuration Utility:* The Server Configuration Utility is a friendly graphical user interface for enterprise administrators to configure the Server to enforce enterprise restriction policy. They can use it to manage clients, clients groups, group's security levels and application lists.

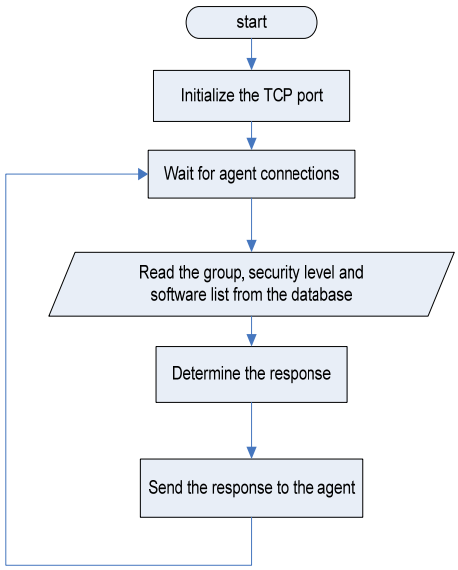


Figure 4. Server program loop

The database manipulated by the configuration utility consists of three tables that stores information about clients, client groups, and restriction rules.

The clients table contains information about each client, which includes; the client host name and its corresponding group ID. The client groups table is where group information is stored, which includes; group ID, group-name and the group security level. The restriction rules table stores information about rules applied to each group. A rule specifies the applied list (white or black) to a specific application for a particular group.

## IV. IMPLEMENTATION AND TESTING

### A. Implementation

Many tools have been used to implement the system. Open source tools have been chosen for implementation. Linux ubuntu 7.04 have been chosen as an operating system for client and server machines. The LKM is written in C language. The Agent, Server and the Server Configuration Utility are written in C++ with Qt4 library. Qt is a library that helps in building GUI C++ programs. The database management system used was SQLite. SQLite is a self-contained, serverless SQL database engine. The hashlib++ library was used to generate the hash of executable files in the agent program.

### B. Testing

To test LALC, LKM and the Agent program have been compiled in the client side. A shell script has been written to load the LKM and to run the Agent at startup. When the client machine comes up the LKM and the Agent are ready.

The Server and the Server Configuration Utility have been compiled in the server machine and the Server was started. Groups have been added using the Server Configuration Utility and clients have been added to each group. The lock-down security level has been chosen for the group and applications have been added to the whitelist.

We test the system by attempting to launch two programs form the client machine, one is a white listed and the other is not. The system performs exactly as expected; the whitelisted program is executed while the other one is prohibited.

## V. CONCLUSIONS

LALC brings an easy-to-use, kernel integrated solution for locking applications on Linux clients. Its simplicity makes extending it fairly easy, while its integration into Linux kernel allows it to improve Linux security features that support enterprise needs.

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# MULTIRESOLUTION WAVELET AND LOCALLY WEIGHTED PROJECTION REGRESSION METHOD FOR SURFACE ROUGHNESS MEASUREMENTS

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***Abstract*--This paper presents the benefits of using coiflet wavelet for feature extraction from the surface roughness image. The features extracted are learnt by the Locally weighted projection regression network (LWPR) method. The image captured through Charge coupled device (CCD) camera undergoes preprocessing to remove noise and enhance the quality of image to make the details of the pixels more clear. The image is decomposed by using coiflet wavelet. Four level of decomposition is done to obtain detailed information, Entropy measure is applied and subsequently Locally weighted projection regression network method (LWPR) is used for training the entropy calculated. The target values labeled are with surface roughness within the limits or not. The values are trained using LWPR and a set of final weights are obtained. Using this final weight values, different portion of the image is analyzed to verify, if the roughness is within the limit or not**

**Keywords- Locally weighted projection regression network method (LWPR), discrete wavelet (DWT)**

## 1. INTRODUCTION

Measuring a rough surface is based on grey levels corresponding to the surface texture. Deeper a valley, the darker the corresponding pixel, the higher a peak, the brighter the corresponding area in the image. Modern instruments can give a three-dimensional (3D) measure of a surface. There is no single technique that can be used to entirely characterize a texture. Image is analyzed at one single-scale; a limitation that can be removed by employing a multiscale representation of the textures similar to wavelet transform. Wavelets have already been applied successfully as a tool for characterizing engineered surfaces with one-dimensional (1D) profiles but also in 2D for characterizing some particular engineering applications. Industrial inspection is a very popular field for using wavelets. They are well suited to detect the defects like scratches on a uniform texture. It should be mentioned that for special monitoring tasks, images to be processed often come from a CCD camera.

Surface finish is an apparent witness of tool marks or - lack of same - on the machined surface of a work piece. Surface finish is a characteristic of any machined surface [1-5]. It is sometimes called surface texture or roughness. The design engineer is usually the person who decides what the surface finish of a work piece should be. They base their reasoning on what the work piece is supposed to do. Here are a few examples that the engineer considers when applying a surface finish specification:

- Good surface finishes increase the wear resistance of two work pieces in an assembly
- Good surface finishes reduce the friction between two work pieces in an assembly



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Surface finishes are usually specified with a "check mark" on the blueprint as shown in the Figure 1. Surface finishes are specified in micro inches and are located on the left side of the symbol above the check mark "V" shown Figure 1. The waviness requirement (if specified) is usually given in thousands of an inch and is located on the top right of the symbol. In the example it is the value ".0015". The roughness width requirement (if specified) is usually given in thousands of an inch and is located on the bottom right of the symbol. In the example it is the value ".002". The lay direction requirement (if specified) is usually represented by a symbol [6-10] and is located right below the roughness width requirement. In the example it is the symbol for perpendicularity. The graphic below show the rest of the symbols [11].

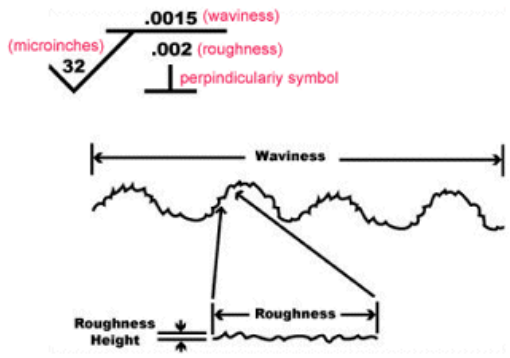


Fig.1 Surface finish representation

## 2. WAVELETS (WT)

The WT was developed as an alternative to the short time Fourier transform (STFT). A wavelet is a waveform with limited duration that has an average value of zero. Comparing wavelets with sine waves, sinusoids do not have limited duration, they extend from minus to plus infinity and where sinusoids are smooth and predictable [12]. Wavelet analysis is the breaking up of a signal into shifted and scaled versions of the original (or *mother*) wavelet. Mathematically, the process of Fourier analysis is represented by the *Fourier transfor*m:

$$F(\omega) = \int_{-\infty}^{\infty} f(t) e^{-j\omega t} dt \qquad (1)$$

which is the sum over all time of the signal f(t) multiplied by a complex exponential. The results of the transform are the Fourier coefficients, which when multiplied by a sinusoid of frequency, yield the constituent sinusoidal components of the original signal. Graphically, the process looks like:

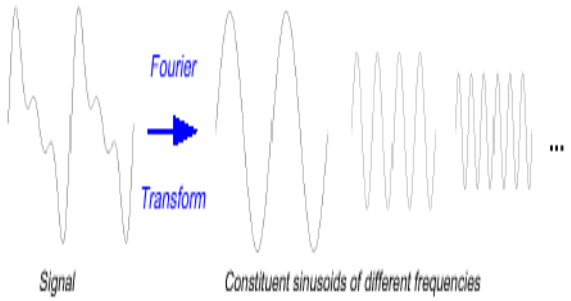


Fig.2 Wavelet

The continuous wavelet transform (CWT) (Figure 3) is defined as the sum over all time of the signal multiplied by scaled, shifted versions of the wavelet function:

$$C(scale, position) = \int_{-\infty}^{\infty} f(t)\psi(scale, position, t)\,dt \qquad (2)$$

The result of the CWT is many wavelet coefficients C, which are a function of scale and position. Multiplying each coefficient by the appropriately scaled and shifted wavelet yields the constituent wavelets of the original signal:

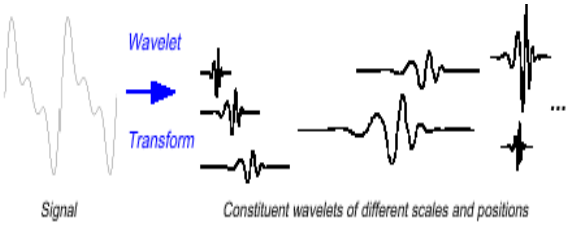


Fig.3 Continuous wavelet

### Scaling

Scaling a wavelet simply means stretching (or compressing) it. The scale factor works exactly the same with wavelets. The smaller the scale factor, the more "compressed" the wavelet.

### Shifting

Shifting a wavelet simply means delaying (or hastening) its onset. Mathematically, delaying a function by *k*

### Coiflet wavelet

Inspite of existing different wavelets, coiflet wavelet whose function has *2N* moments equal to 0 and the scaling function has *2*N-1 moments equal to 0 has


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been considered. The two functions have a support of length 6N-1.

The features are obtained from the Approximation and Details of the 4th level by using the following equations

$$V1=1/d \sum (\text{Approximation details}) \quad (3)$$

Where d = Samples in a frame and

V1 = Mean value of approximation

$$V2=1/d \sum (\text{Approximation or details} - V1)) \quad (4)$$

Where V2=Standard Deviation of approximation

$$V3=\text{maximum (Approximation or details)} \quad (5)$$

$$V4=\text{minimum (Approximation or details)} \quad (6)$$

$$V5=\text{norm (Approximation or Details)}^2 \quad (7)$$

Where V5 = Energy value of frequency

## 3. .LOCALLY WEIGHTED PROJECTION REGRESSION (LWPR)

LWPR achieves better results in nonlinear function approximation in high dimensional spaces. It is insensitive to redundant data. It uses linear models locally [13, 14]. Univariate regressions in selected directions are used in the input space. The nonparametric local learning system learns rapidly. It uses second order learning methods based on incremental training. Weight adjustments are done based on local information only. Training LWPR is done as follows,

The 5 features obtained are used as inputs for the LWPR and the target values for training each surface roughness type is based on labeling.

1. Input extracted features from wavelet.
2. Initialize LWPR using diagonal distance matrix α, norm, meta rate and initial_λ. Many other variables can be initialized or made constants depending upon the requirements.
3. Create random numbers.
4. Choose input and target output of a pattern
5. Find global mean and variance of the patterns.
6. Normalize input and output.
7. Compute the weight.
8. Check if new random field has to be added.
9. Find mean square errors between target and the estimated values.
10. Repeat steps 5 to 9 until all the patterns are presented.

## 4 SCHEMATIC DIAGRAM

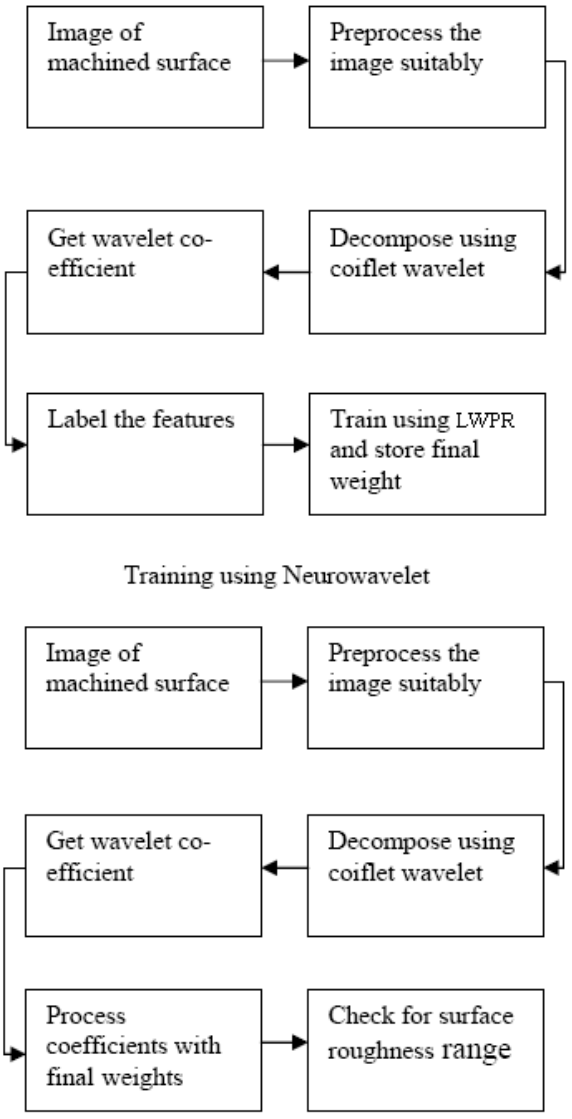


Fig.4 Training and testing



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## 5 IMPLEMENTATION

**Training**

1. Read each Image

2. Remove noise

3. Enhance image

4. Decompose by discrete wavelet (DWT) of type coiflet

5. Decompose by 4 levels

6. Find feature from the approximation matrix at the $4^{th}$ level decomposition

7. Label the features based on the type of surface roughness measured for the machined work piece using profilometer

8. Repeat step 1 to step 7 for different types of acceptable and unacceptable roughness values

9. Train the LWPR using input and corresponding labels obtained in previous steps.

11**.** Store the Final Weights in a File.

**Testing**

1. Read each Image

2. Remove noise

3. Enhance image

4. Decompose by discrete wavelet (DWT) of type coiflet

5. Decompose by 4 levels

6. Find feature from the approximation matrix at the $4^{th}$ level decomposition

7 process with final weights of LWPR

8. Classify the roughness.

## 6 . EXPERIMENT DETAILS

Milling machine has been used to machine flat specimen under the following condition

M1,F150,S800,.5DOC,49DIA CUTTER

M2,F150,S800,1DOC,49DIA CUTTER

M3,F150,S1000,.5DOC,49DIA CUTTER

M4,F150,S1000,.8DOC,49DIA CUTTER

M5,F200,S800,..5DOC,49DIA CUTTER

M6,F200,S800,.8DOC,49DIA CUTTER

M7,F200,S1000,.5DOC,49DIA CUTTER

M8,F200,S1000,.8DOC,49DIA CUTTER

## 7. RESULTS

Sample images

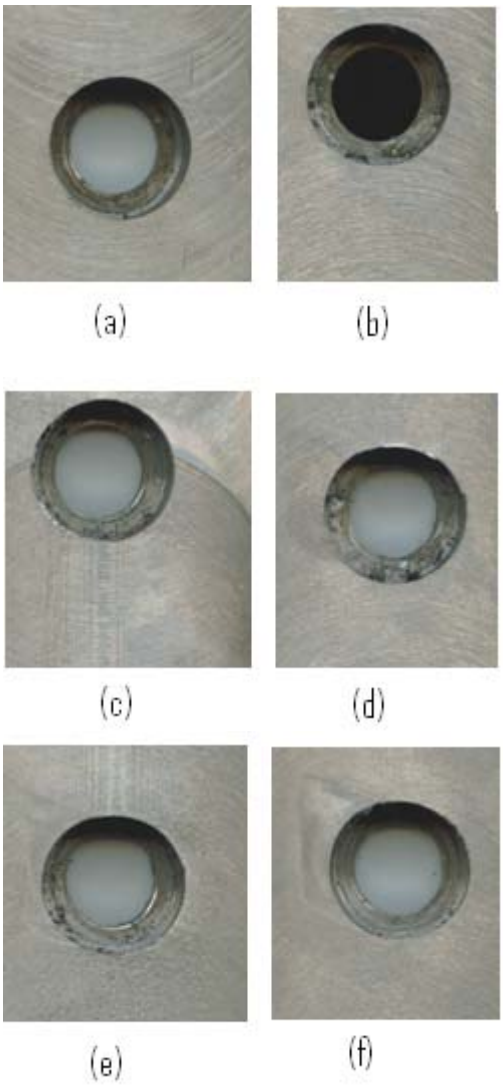


Fig. 5 Images used for training and testing LWPR



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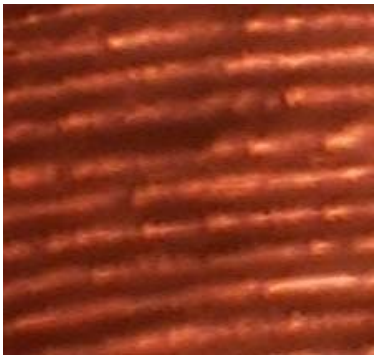

Fig.6 Surface roughness under magnification

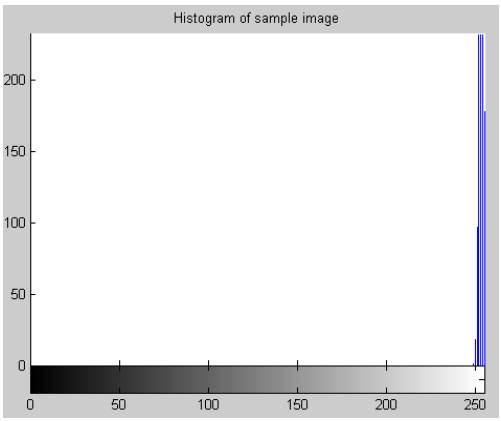


Fig.7 Histogram of an image with surface roughness

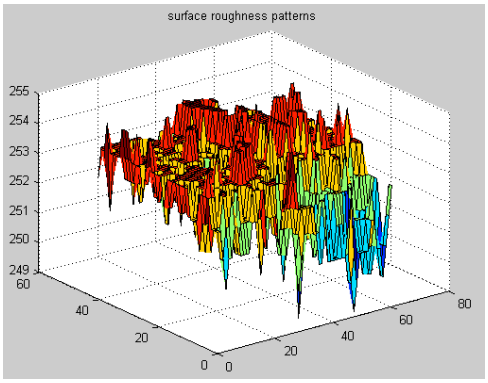


Fig 8 Surface roughness pattern

Feature patterns are developed from the surface roughness images obtained after machining. The patters are separated as training and testing patterns. The patterns are labeled with range of surface roughness values.

## 8. CONCLUSION

This work has been focused in estimating the surface roughness values from the image of machined surface in milling. Coiflet wavelet is used for image decomposition and radial basis function network for learning the training patterns to obtain final weights for finding roughness from new images. The performance of this work is only 95%. The performance has to be improved by changing the topology of the LWPR

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# PIFS CODES BASED FOR BIOMETRIC PALMPRINT VERIFICATION

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***Abstract* — This paper proposes a new technique to extract the palmprint features based on some fractal codes. The palmprint features representation is formed based on position of range blocks and direction between the position of range and domain blocks of fractal codes. Each palmprint representation is divided into a set n blocks and the mean value of each block are used to form the feature vector. The normalized correlation metrics are used to measure the degree of similarity of two feature vectors of palmprint images. We collected 1050 palmprint images, 5 samples from each of 210 persons. Experiment results show that our proposed method can achieve an acceptable accuracy rate with FRR = 1.754, and FAR= 0.699.**

***Keyword*; *biometrics, fractal codes, fractal dimension, feature extraction, palmprint recognition***

## I. INTRODUCTION

The personal verification becomes an important and highly demanded technique for security access systems in this information area. Traditional automatic personal recognition can be divided into two categories: token-based, such as a physical key, an ID card, and a passport, and knowledge-based, such as a password and a PIN. However these approaches have some limitations. In the token-based approach, the "token" can be easily stolen or lost. In the knowledge-based approach, the "knowledge" can be guessed or forgotten [21]. In order to reduce the security problem caused by traditional methods, biometric verification techniques have been intensively studied and developed to improve reliability of personal verification. Biometric-based approach use human physiological or behavioral features to identify a person. The most widely used biometric features are of the fingerprints and the most reliable are of the irises. However, it is very difficult to extract small minutiae features from unclear fingerprints and the iris input devices are very expensive [19]. Other biometric features such as of face, voice, hand geometries, and handwritten are less accurate. Faces and voices can be mimicked easily, hand geometries and handwritten can be faked easily.

Palmprint is the relatively new in physiological biometrics [18]. There are many unique features in a palmprint image that can be used for personal recognition. Principal lines, wrinkles, ridges, minutiae points, singular points and texture are regarded as useful features for palmprint representations [21]. A palmprint has several advantages compared to other available features: low-resolution images can be used, low cost capture devices can be used, it is very difficult or impossible to fake palmprints, and their characteristics are stable and unique [18].

Recently, many verification/identification technologies using palmprint biometrics have been developed [2],[3],[4],[5],[11],[12],[13],[18],[21]. Zhang *et al*. [21] applied 2-D Gabor filter to obtain the texture features of palmprints. Pang *at al*. [13] used the pseudo-orthogonal moments to extract the features of palmprint. LI *et al*. [12] transformed the palmprint from spatial to frequency domain using Fourier transform and then computed ring and sector energy features. Connie at al.[2] extracted the texture feature of palmprint using PCA and ICA. Wu *et al*.[18] extracted line feature vectors (LFV) using the magnitudes and orientations of the gradient of the points on palm-lines. Kumar *et al*.[11] combined the palmprints and hand geometries for verification system. Each palmprint was divided into overlapping blocks and the standard deviation value of each block was used to form the feature vector.

In this paper, we propose a new technique to extract the features of palmprint based on fractal codes. This technique is different with the method in [4] and [5].

## II. IMAGE ACQUISITION

All of palm images are captured using Sony DSC P72 digital camera with resolution of 640 x 480 pixels. Each persons was requested to put his/her left hand palm down on with a black background. There are some pegs on the board to control the hand oriented, translation, and stretching. A sample of the hand and pegs position on the black board is shown on Figure 1 (a).

## III. PALMPRINT EXTRACTION AND NORMALIZATION

This paper used new technique to extract the ROI (region of interest) of palmprint. This technique consists of two steps in center of mass (centroid) method. These steps can be explained as follow.

a. The gray level hand image is thresholded to obtain the binary hand image. The threshold value was computed automatically using the Otsu method. To avoid the white pixels (not pixel object) outside of the hand object is used median filter.


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b. Each of the acquired hand images needs to be aligned in a preferred direction so as to capture the same features for matching. The moment orientation method is applied to the binary image to estimate the orientation of the hand. In the method, the angle of rotation ($\theta$) is the difference between normal axis and major axis of ellipse that can be computed as follows.

$$\theta = \frac{1}{2}\tan^{-1}\left[\frac{2\mu_{1,1}}{\mu_{2,0}-\mu_{0,2}}\right] \quad (1)$$

$$\mu_{p,q} = \sum_m \sum_n (m-\overline{m})^p (n-\overline{n})^q \quad (2)$$

where $\mu_{p,q}$ represent the (p,q)$^{th}$ moment central, and ($\overline{m},\overline{n}$) represents center of area is defined as

$$\overline{m} = \frac{1}{N}\sum_m \sum_n m, \quad \overline{n} = \frac{1}{N}\sum_m \sum_n n, \quad (3)$$

where $N$ represents number of pixel object. Furthermore, the grayscale and the binary image are rotated about ($\theta$) degree.

c. Bounding box operation is applied to the rotated binary image to get the smallest rectangle which contains the binary hand image. The original hand image, binarized image, and the bounded image shown in Figure 1 (a), (b), and (c), respectively.

d. The centroid of bounded image is computed using equation (3) and based on this centroid, the bounded binary and original images are segmented with 200 x 200 pixels. The segmented image and its centroid position are shown in Figure 1 (d) and (e).

e. The centroid of the segmented binary image is computed and based on this centroid the ROI of grayscale palmprint image can be cropped with size 128 x 128 pixels. The first and the second positions of centroid in binary and gray level image are shown in Figure 1 (f) and (g).

This method is so simple. This method has been tested for 1050 palmprint images acquired from 210 persons, and the results show this method is reliable.

Before the feature extraction phase, the extracted ROI are normalized using normalization method in [11] to reduce the possible imperfections in the image due to non-uniform illumination. The method is as below:

$$I'(x,y) = \begin{cases} \phi_d + \lambda & if\ I(x,y) > \phi \\ \phi_d - \lambda & otherwise \end{cases} \quad (4)$$

$$\lambda = \sqrt{\frac{\rho_d \{I(x,y)-\phi\}^2}{\rho}} \quad (5)$$

where $I$ and $I'$ represents original grayscale palmprint image and the normalized image respectively, $\phi$ and $\rho$ represents mean and variance of the original image respectively, while $\phi_d$ and $\rho_d$ are the desired values for mean and variance respectively. This research use $\phi_d$ = 180 and $\rho_d$ = 180 for all experiments.

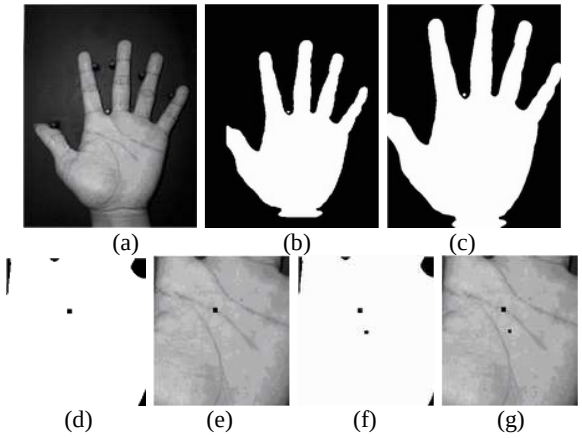


Figure 1. Extraction of palmprint, (a) original image, (b) binary image of (a), (c) object bounded, (d) and (e) position of the first centroid mass in segmented binary and gray level image, respectively, (f) and (g) position of the second centroid mass in segmented binary and gray level image, respectively.

## IV. FEATURES EXTRACTION

There are three main steps to extract the palmprint features based on fractal codes proposed in this paper. These steps can be explained as follows.

### *A. Extraction of fractal codes of palmprint images*

Fractal codes of palmprint images are obtained using the partitioned iterated function system (PIFS) method. In PIFS method, each image is partitioned into its range blocks and domain blocks. The size of the domain blocks is usually larger than the size of the range blocks. The relation between a pair of range block ($R_i$) and domain block ($D_i$) is noted as

$$R_i = w_i(D_i) \quad (6)$$

$w_i$ is contracted mapping that describes the similarity relation between $R_i$ and $D_i$, and is usually defined as an affine transformation as below:

$$w_i\begin{bmatrix} x_i \\ y_i \\ z_i \end{bmatrix} = \begin{bmatrix} a_i & b_i & 0 \\ c_i & d_i & 0 \\ 0 & 0 & s_i \end{bmatrix}\begin{bmatrix} x_i \\ y_i \\ z_i \end{bmatrix} + \begin{bmatrix} e_i \\ f_i \\ o_i \end{bmatrix} \quad (7)$$

where $x_i$ and $y_i$ represent top-left coordinate of the $R_i$, and $z_i$ is the brightness value of its block. Matrix elements $a_i$, $b_i$, $c_i$, and $d_i$, are the parameters of spatial rotations and flips of $D_i$, $s_i$ is the contrast scaling and $o_i$ is the luminance offset. Vector elements $e_i$ and $f_i$ are offset value of space. In this paper, we used the size of domain region twice the range size, so the values of $a_i$, $b_i$, $c_i$, and $d_i$ are 0.5. The actual fractal code $p_i$ below is usually used in practice[19].

$$f_i = \left((x_{D_i}, y_{D_i}), (x_{R_i}, y_{R_i}), size_i, \theta_i, s_i, o_i\right) \quad (8)$$


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where $(x_{R_i}, y_{R_i})$ and $(x_{D_i}, y_{D_i})$ represent top-left coordinate position of the range block and domain block, respectively, and *size* is the size of range block. The fractal codes of a palmprint image is denoted as follow:

$$F = \bigcup_{i=1}^{N} f_i \tag{9}$$

where *N* represents the number of the fractal code. The inequality expression below is used to indicate whether the range and the relevant domain block are similar or not.

$$d(R,D) \le \varepsilon, \tag{10}$$

where *d(R,D)* represents rmse value, and ϵ is the threshold (tolerance) value. The range and the relevant domain block is similar if *d(R,D)* is less or equal than ϵ. Otherwise, the block is regarded not similar.

*B. Palmprint features representation*

The first step of this method is the forming of angle image A as follows.

$$A(j,k) = \alpha_i,\ j = 1,2,3,\ldots M_1, k = 1,2,3,\ldots M_2 \tag{11}$$

$$\alpha_i = \arctan\left|\frac{y_D - y_R}{x_D - x_R}\right|_i \quad if \quad j = x_{R_i}\ and\ k = y_{R_i},$$

otherwise, $\alpha_i = 0$ (12)

where $(x_{D_i}, y_{D_i})$ represent top-left coordinate of the domain block (see formula (8)) and $d_i$ represent the angle between range and domain block. The angle image is not binary image representation. The criterion below are added to compute the direction $\alpha_i$.

$$\begin{aligned}
&if \quad x_R < x_D\ and\ y_R \ge y_D \quad then \quad \alpha_i = \alpha_i \\
&if \quad x_R > x_D\ and\ y_R \ge y_D \quad then \quad \alpha_i = 180 - \alpha_i \\
&if \quad x_R > x_D\ and\ y_R \le y_D \quad then \quad \alpha_i = 180 + \alpha_i \\
&if \quad x_R < x_D\ and\ y_R \le y_D \quad then \quad \alpha_i = 360 - \alpha_i \\
&if \quad x_R = x_D\ and\ y_R \ge y_D \quad then \quad \alpha_i = 90 \\
&if \quad x_R = x_D\ and\ y_R \le y_D \quad then \quad \alpha_i = 270
\end{aligned} \tag{13}$$

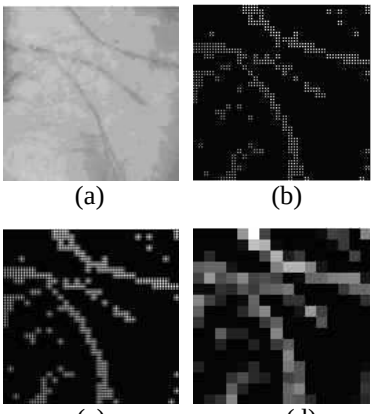
The criterion $size_i = \min(size)$ means the palmprint features representation is formed practically using the coordinate of the smallest size range block. Later, the representation is filtered as follow.

$$I'(x,y) = I(x,y) * h(x,y)_{m\,x\,n}, \tag{14}$$

*h(x,y)* is filter which all of its component are one. Figure 2(b) show the palmprint features image of Figure 2(a).

*C. Palmprint feature vector*

Palmprint feature vector (*V*) is obtained by dividing the palmprint image into 16 x 16 blocks, and for each block its mean value is computed, so obtained the feature vector $V = (v_1, v_2 \ldots, v_N)$, where N = 256,and $v_i$ is mean value of block *i*.



(a) (b) (c) (d)

Figure 2. Palmprint feature extraction, (a) original image, (b) Image *I*, (c) Image *I'*, (d) block feature representation

The Figure 2 (d) show the palmprint feature representation in 16 x 16 sub blocks. Figure 3 shows example of three groups of palmprints from the same palm and palms with similar/different line structures. The features of these palmprints are plotted in figure 4. The results show that the features of three palm images from the same person are close to each other than the features of three palm images from the different persons with similar or different line structures.

## V. PALMPRINT FEATURE MATCHING

The degree of similarity between two palmprint features is computed as follows:

$$d_{rs} = 1 - \frac{(x_r - \bar{x}_r)(x_s - \bar{x}_s)^T}{\left[(x_r - \bar{x}_r)(x_r - \bar{x}_r)^T\right]^{1/2}\left[(x_s - \bar{x}_s)(x_s - \bar{x}_s)^T\right]^{1/2}} \tag{15}$$

where $\bar{x}_r$ , $\bar{x}_s$ are the mean of palmprint feature $x_r$ and $x_s$ , respectively. The above equation computes one minus normalized correlation between palmprint feature vector $x_r$ and $x_s$. The values of $d_{rs}$ are between 0 – 2. The $d_{rs}$ will be close to 0 if $x_r$ and $x_s$ obtained from two image of the same palmprint. Otherwise, the $d_{rs}$ will be far from 0.

Figure 4 shows comparison of feature component of those palmprint shown in figure 3, and their score are listed in Table 1. The matching score of group A are close to 0, and the matching score of group B and C are far from 0. The average score of group A, B, and C are 0.1762, 0.5057, and 0.6452, respectively. It is easy to distinguish group A from group B and C using these scores.

(a1) (a2) (a3)

Group A: palmprints from the same person



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(b1) (b2) (b3)

Group B: palmprints from different person with similar line structure

(c1) (c2) (c3)

Group 3: palmprints from different person with different line structure

Figure 3. Example of three groups of palmprint

Table 1 Matching Score of groups A, B, and C in figure 3

| | a1 | a2 | a3 | Average |
|---|---|---|---|---|
| a1 | 0 | 0.1957 | 0.1404 | 0,1762 |
| a2 | 0.1957 | 0 | 0.1925 | |
| a3 | 0.1404 | 0.1925 | 0 | |
| | b1 | b2 | b3 | Average |
| b1 | 0 | 0.5352 | 0.3056 | 0,5057 |
| b2 | 0.5352 | 0 | 0.6763 | |
| b3 | 0.3056 | 0.6763 | 0 | |
| | c1 | c2 | c3 | Average |
| c1 | 0 | 0.6900 | 0.6177 | 0,6452 |
| c2 | 0.6900 | 0 | 0.6280 | |
| c3 | 0.6177 | 0.6280 | 0 | |

## VI. EXPERIMENTS AND RESULTS

We collected palm image from 210 persons from both sexes and different ages, 5 samples from each person, so our database contains 1050 images. The resolution of hand image is 640 x 480 pixels. The palmprint images, of size 128 x 128 pixels, were automatically extracted from hand image as described in the Section 3. The averages of the first three images from each user were used for training and the rest were used for testing.

The performances of the verification system are obtained by matching each of testing palmprint images with all of the training palmprint images in the database. A matching is noted as a correct matching if the two palmprint images are from the same palm and as incorrect if otherwise.

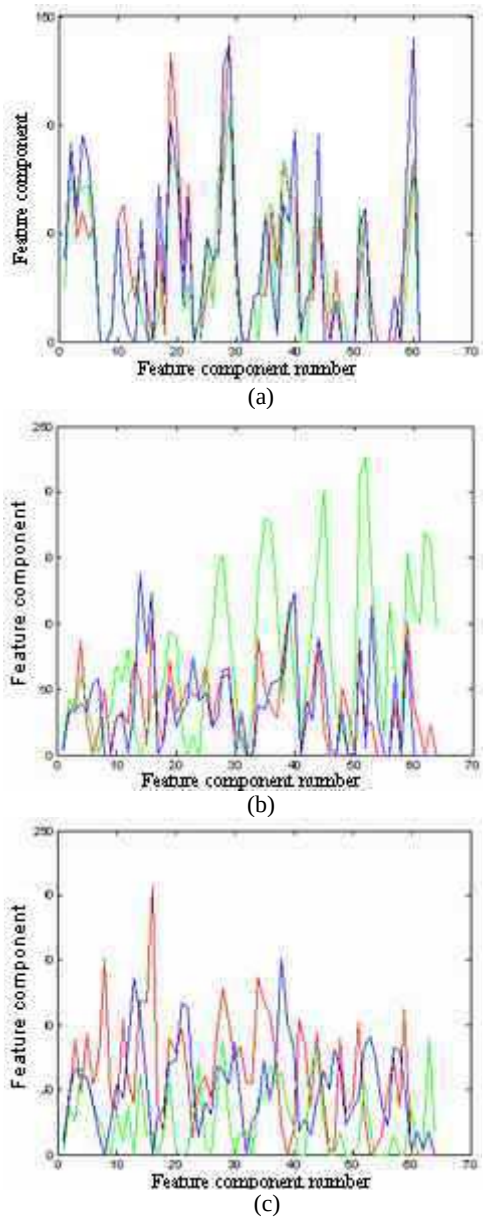


Figure 4. Comparison of feature component of the palmprint group shown in figure 2. (a),(b),(c) are feature component of group A, B, and C, respectively. Red, green, blue color are the first, second, and third palmprint in each group, respectively.

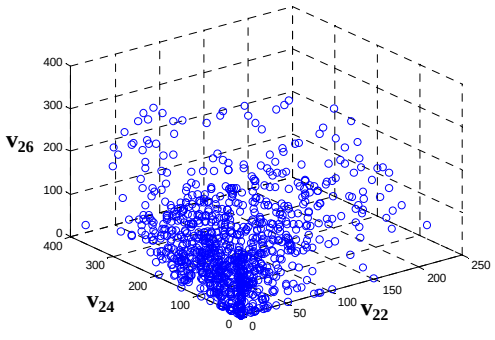


Figure 5. Distribution of three feature components of 1050 palmprints in feature space



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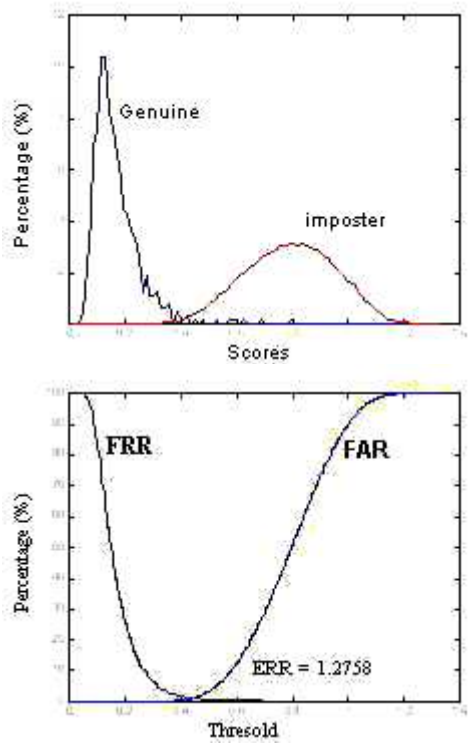


(a) (b)

Figure 6. Performance of verification system,(a) genuine and imposter distribution, (b) FAR/FRR/EER with various threshold

Table 2. FRR/FAR with various threshold value

| Threshold | FRR | FAR |
|---|---|---|
| 0.4386 | 2.0734 | 0.4734 |
| 0.4586 | 1.9139 | 0.5158 |
| **0.4626** | **1.7544** | **0.6998** |
| 0.4746 | 1.4354 | 0.9160 |
| 0.4786 | 1.2759 | 1.3552 |
| 0.4986 | 1.1164 | 2.1480 |
| 0.5386 | 1.1164 | 2.2881 |

Figure 6 (a) shows the probability distributions of a genuine and imposter parts with tolerance value = 3, and feature vector length = 256 (16 x 16 blocks). The genuine and imposter parts are estimated from correct and incorrect matching scores, respectively. The result with various threshold and false acceptance rates (FAR)/false rejection rates (FRR) are shown in figure 6 (b). The equal error rate (EER) of the verification system is 1.2758. Table 2 show the performance (FAR/FRR) system with some threshold values.

The main advantage by using PIFS code in this paper is both palmprint feature and palmprint image can be obtained directly from compressed domain (fractal code).

## VII. CONCLUSIONS AND FUTURE WORK

In this paper, we introduced a fractal characteristics based feature extraction and representation method for palmprint verification. The experiment results show that the proposed method can achieve an acceptable accuracy rate with FRR = 1.7544, and FAR= 06998. In the future, we will combine the proposed method with wavelet transformation to extract the feature of palmprint to retain the block operation.

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# Breast Contour Extraction and Pectoral Muscle Segmentation in Digital Mammograms

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***Abstract*— Breast cancer is one of the major causes of fatality among women aged above 40. Digital mammography is used by radiologists for analysis and interpretation of cancer. Visual reading and interpretation of mammograms is a very demanding and expensive job. Even well-trained experts may have an interobserve variation rate of 65-75 percent. Extraction of the breast contour and pectoral muscle segmentation is necessary in order to limit the search for abnormalities by Computer Aided Diagnosis (CAD). A new technique for breast border extraction and pectoral muscle segmentation is explored in this paper. The technique is applied to 250 MIAS mammograms. This method has given about 98% in segmenting the pectoral muscle**.

***Keywords –Image Processing, mammography, morphology, filter, edge detection.***

## I. INTRODUCTION

One of the leading causes of death among women is the breast cancer. Early diagnosis and subsequent treatment can significantly improve the chance of survival for patients with breast cancer. Most effective method for the detection of early breast cancer is mammography. Mammograms are among the most difficult radiological images to interpret by radiologists. Studies have shown that radiologists do not detect all breast cancers that are retrospectively detected on the mammograms. Detection is the ability to identify potential abnormalities, such as microcalcification, masses, and architectural distortions. Diagnosis is the ability to characterize or classify a detected abnormal entity as being either benign or malignant. However, before CADe algorithms can perform their task of identifying suspicious regions in a mammogram, a series of pre-processing steps must be taken. These include: mammogram orientation, label and artifact removal, mammogram enhancement, breast contour detection and pectoral muscle segmentation

Many computer algorithms [1, 2, 3] have been proposed for automating various aspects of detecting the presence of cancer in mammograms. While detection rates for automatic systems are quite high, the false positive detection rates are also high. Accordingly, work continues on improving all aspects of computer-aided detection (CAD) for mammography. Implementation of breast border detection, because of some factors such as the low contrast near the borders, image noise and artifacts is complicated.

In mammogram, image processing [27-31] and computer-aided diagnosis of breast cancer breast segmentation is an important pre-processing step. The accuracy and efficiency of processing algorithms will be increased if the processing is limited to a specific target region in an image.

Extracting the pectoral muscle [23, 24, 25] is particularly important in automated mammogram image assessment. Segmentation of the pectoral muscle is a non-trivial, complex and demanding task. It is also complicated further by a number of factors. Foremost thing is, the muscle edge is not a straight line, but can be convex, concave or a mixture of both. Secondly muscle edge though may appear to be visually continuous; the edge exhibits variations in texture and sharpness. This paper describes a new technique for extracting the breast border and segmenting the pectoral muscle of digital mammograms.

The remainder of this paper is organized as follows. In Section 2, the approaches to extraction of breast border and segmentation of pectoral muscle are described. The theory and proposed techniques are presented in Section 3. Experimental results are given and discussed in Section 4. Finally, the paper is summarized in Section 5.

## II. PREVIOUS APPROACHES TO BREAST BORDER EXTRACTION AND PECTORAL MUSCLE SEGMENTATION

There have been various approaches to the task of isolating the breast region.


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M. Wirth et al. developed an algorithm [1] that uses morphological preprocessing and fuzzy rule-based algorithm for breast region extraction. Kostas Marias et al. [2] used the boundary extraction technique based on a combination of the Hough transform followed by image gradient operators and morphology in order to make coherent the breast region part of the image. Histogram equalization and thresholding process are employed by Barba J. Leiner et al. [3] to extract only the region of the image that corresponds to the breast. Segmentation of the breast region in mammograms has traditionally been achieved using methods besides active contours [4]. Semmlow et al. [5] used a spatial filter and Sobel edge detector to locate the breast boundary on xeromammograms. Global thresholding has been used in many cases to segment the breast region from the background [6-7]. The major problem with using global thresholding is the nonuniform background region, although efforts, such as that of Masek et al. [8] using local thresholding have shown more promise.

A system of masking images with different thresholds to find the breast edge is developed by Abdel-Mottaleb et al. [9]. Gradient based method is proposed by Méndez et al. [10] to find the breast contour. They used a two level thresholding technique to isolate the breast region of the mammogram. The smoothed mammogram is divided into three regions and then a tracking algorithm is applied to the mammogram to detect the border. Bick et al. [11] proposed a global segmentation approach that incorporates aspects of thresholding, region growing and morphological filtering. Lou et al. [12] proposed a method based on the assumption that the trace of intensity values from the breast region to the air-background is a monotonic decreasing function.

One of the inherent limitations of these methods is the fact that very few of them preserve the skin or nipple. The most promising method of extracting the breast contour focuses on modeling the non-breast region of a mammogram using a polynomial method, as described by Chandrasekhar and Attikiouzel [13, 14].

Maysam Shahedi et al. proposed a new algorithm [15] for automatic breast border detection in digital mammograms based on local adaptive thresholding method. Roshan Dharshana Yapa et.al. presented a new algorithm [16] for estimating skin-line and breast segmentation using fast marching algorithm. They introduced some modifications to the traditional fast marching method, specifically to improve the accuracy of skin-line estimation and breast tissue segmentation.

The method proposed in [17] initially determines intensity value of the background to be able to find pixels that create the border line. Then breast centre has been taken as the starting point for a simple region growing algorithm. H. Mirzaalian et al. proposed an algorithm [18] based on polynomial modeling to detect breast contour. Two methods [19] are implemented on a number of mammogram images by Ayman et.al. The segmentation outputs of these methods were very efficient and excellent. Method proposed in [20] applies the meta-heuristic methods such as Ant Colony Optimization (ACO) and Genetic Algorithm (GA) for identification of suspicious region in mammograms.

There have been various approaches to the task of segmenting the pectoral muscle.

A histogram-based thresholding technique is used by K. Thangavel and M. Karnan [23] to separate the pectoral muscle region. For selecting the threshold value the global optimum is considered. The intensity values smaller than global optimum threshold are changed to zero, and the gray values greater than the threshold are changed to one. To better preserve the pectoral muscle region erosion and dilation operations are applied. To segment the pectoral muscle region the gray level mammogram image is converted to binary image. The white pixels in the lower left corner of the mammogram image indicate the pectoral muscle region.

Kwork et al. [24] developed a method for automatic pectoral muscle segmentation on mammograms by straight line estimation and cliff detection. A straight line estimates the muscle edge and cliff detection refines the detected edge by surface smoothing and edge detection in a restricted neighborhood.

H. Mirzaalian et al. developed [25] a new method for the identification of the pectoral muscle in MLO mammograms. The developed method is based on nonlinear diffusion algorithm. They compared their results by those recognized by two expert radiologists. To evaluate the accuracy of proposed method, HDM (Hausdorff Distance Measure) and MAEDM (Mean of Absolute Error Distance Measure) were used.

R.J. Ferrari proposed [26] a new method for the identification of the pectoral muscle in MLO mammograms based upon a multiresolution technique using Gabor wavelets. This new method overcomes the limitation of the straight-line representation considered in their initial investigation. The results of the Gabor-filter-based method indicated low Hausdorff distances with respect to the hand-drawn pectoral muscle edges.

Mario Mustra et al. [17] uses wavelet decomposition, image blurring and edge detection using the Sobel filter for breast border detection and pectoral muscle segmentation. N. Nicolau et al. [34] proposed the use of Independent Component Analysis (ICA) for identification and subsequent removal of the pectoral muscle.

## III. PROPOSED BREAST BORDER EXTRACTION AND PECTORAL MUSCLE SEGMENTATION TECHNIQUE


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The block diagram for pectoral muscle segmentation is shown in Fig. 1. Short description of each block is given.

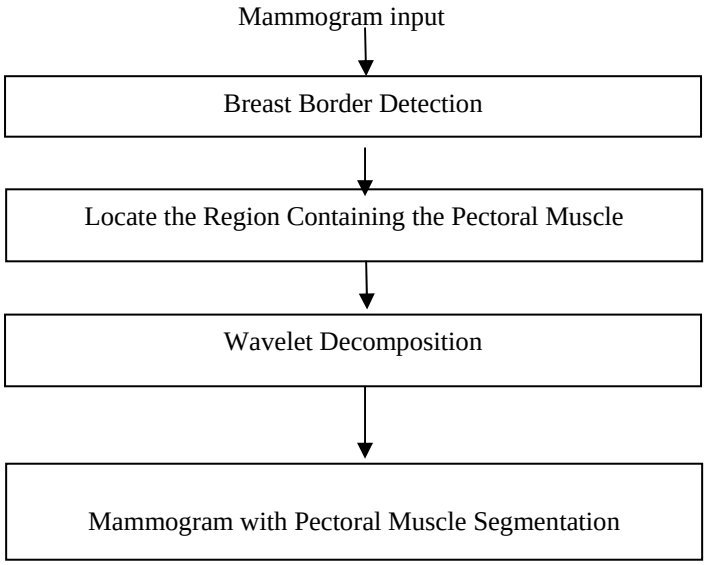


Figure 1: Steps carried out for pectoral muscle segmentation.

3.1 *Breast Border Detection*

We explored a new technique for breast region segmentation using morphological and filtering techniques. The steps followed to detect the breast border involves: - Removal of noise by median filter, Artifacts removal by morphological operation, Edge detection using Sobel method, filtering, finding the perimeter of the binarized image and thus detect the breast border.

*Removal of Noise*

Median filter is used to remove the noise. It is the nonlinear filter used to remove the impulsive noise from an image. Median filter is a spatial filtering operation. In the proposed median filter output pixel contains the median value in the 3X3 neighborhood around the corresponding pixel in the input image.

*Artifacts Removal*

The original mammogram is opened by using a suitable structuring element. After the opening of mammogram it is reconstructed. Next step is to threshold the difference image with 102, which is experimentally obtained. Finally morphological operators are applied to smooth irregularities and expand region. Fig. 2 shows the results of these steps on MIAS image mdb003.


Figure 2: Results for MIAS image mdb003 (a). Original image; (b). Artifacts removed in the mdb003

*Edge Detection and Filtering Techniques*

This step uses the Sobel edge detector followed by dithering and 2-D order statistic filtering. The Sobel method finds edges using the Sobel approximation to the derivative. Edge detection is followed by dithering. A logical OR operation is done on dithered and edge detected image. A 2-D order static filtering is applied on the image obtained as a result of the previous steps. The result for mdb003 is shown in Fig. 3 after applying these steps.

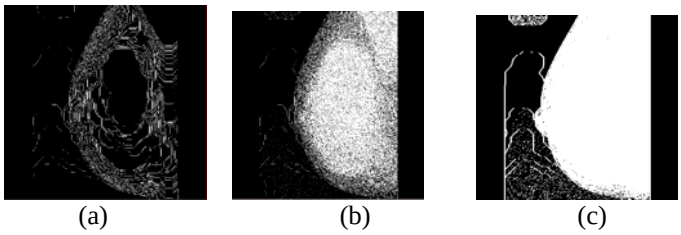


Figure 3: Results for MIAS image mdb003 (a). Edge detection; (b). Dithering ; (c). 2-D statistic filtering

*Multidimensional image filtering*

This step removes the noises using a multidimensional image filtering. A rotationally symmetric Gaussian low pass filter filters the image. After that the image is converted to binary image and erosion is carried out. Fig. 4 shows the results for MIAS image mdb003 after applying these steps.

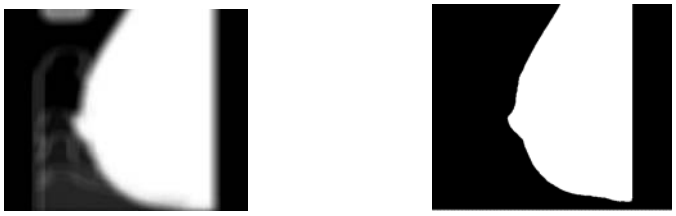

Figure 4: Results for MIAS image mdb003

*Find perimeter pixels in binary image and superimpose on the original image*

Finally the perimeter pixels in binary image are found. This perimeter is the boundary of the breast image. Fig. 5


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shows the results. A pixel is the part of the perimeter if it is nonzero and it is connected to at least one zero-valued pixel. The connectivity used is 8.

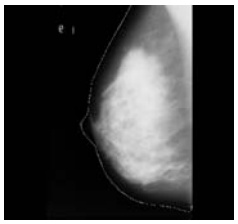

Figure 5: Contour superimposed on original image mdb003.

3.2 *Locate the region containing the pectoral muscle*

Pectoral muscle detection is a challenging task in the breast segmentation process. The algorithm for pectoral muscle segmentation proposed in this paper consists of few steps. Technique for segmenting pectoral muscle presented in this paper uses wavelet decomposition, and edge detection using the Canny filter.

The region of interest containing pectoral muscle is determined by two steps. First a rectangle which encloses the pectoral muscle is determined and then a refinement/reduction to this rectangle is done so that the processing time for pectoral muscle segmentation can be still reduced. The initial rectangle is formed by three points A B and C. For example, if the image shows MLO view of the right breast, the first point A is top left corner of the image with coordinates (1,1). The second point B is determined by the contour of skin-air interface. The third point C is chosen to be approximately at half of image height. By those three points a rectangle is determined. Fig. 7 shows the breast contour superimposed on the image mdb016 and the rectangle ABCD determined.

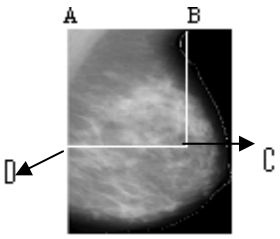


Figure 7: Breast contour superimposed on the image mdb016 and the rectangle ABCD determined.

The reason to reduce the size of the rectangle is to reduce the processing time for pectoral muscle segmentation and is done in the following way. A new point E is determined on the breast contour in such a way that point E on the breast contour has a maximum distance from the line BD towards point A. Now a line FG is drawn parallel to the line BD through E. It can be seen that for all the 250 images the reduced rectangle AFGD still include the pectoral muscle. Fig. 8 shows this result for mdb016.

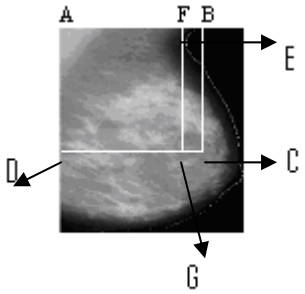


Figure 8: The reduced area that containing the pectoral muscle region is enclosed in AFGD.

*3.3 Wavelet decomposition*

Wavelet decomposition of fourth level is being done. Fourth level wavelet decomposition gives the best results for detecting larger structures, such as pectoral muscle. The fourth level decomposition gives the best results because it preserves enough rough details while at the same time remove fine details like noise and granulation. In this paper, a Daubechies filter has been used. Daubechies wavelets are a family of orthogonal wavelets defining a discrete wavelet transform and characterized by a maximal number of vanishing moments for some given support. With each wavelet type of this class, there is a scaling function which generates an orthogonal multiresolution analysis. Fig 9 shows a Daubechies 20 2-d wavelet.

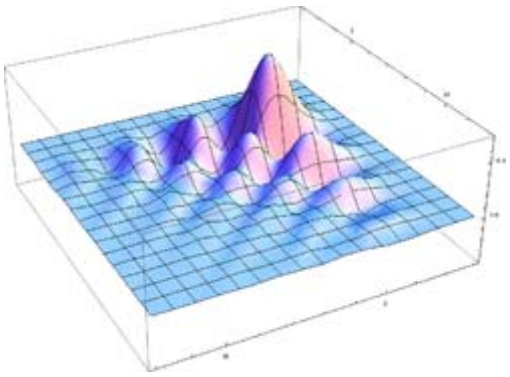

Figure 9 : Daubechies 20 2-d wavelet

After the wavelet decomposition edges that were detected by the Canny filter inside the pectoral muscle region are removed by approximating muscle boundary with a straight line that connects upper right corner and lower left corner of muscle region in the case of the right breast image.



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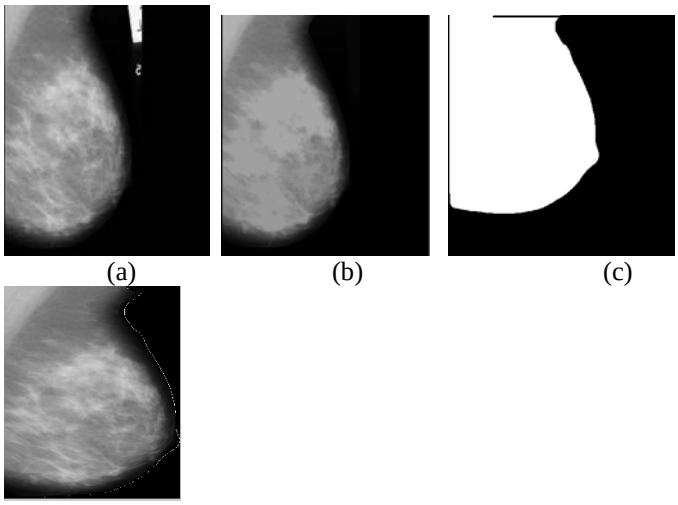
## IV. EXPERIMENTAL RESULTS

The proposed method applied to 250 mammograms from Mammography Image Analysis Society (MIAS) database [21]. The various results obtained are discussed below. Evaluation of breast contour detected in the mammograms was performed by the Hausdorff Distance Measure (HDM) [22] and also the Mean of Absolute Error Distance Measure (MAEDM). Evaluation is based on a distance transforms and image algebra between the edges identified by radiologists and by proposed method. The accuracy of contour detection is 99.06.

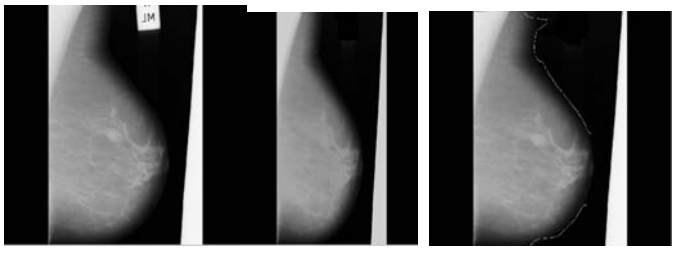
Some of the results of the proposed method for breast contour extraction are explained below. Fig. 10 shows the successful results of the proposed method. Fig. 11 shows the failure case.



(a) (b) (c)

(d)

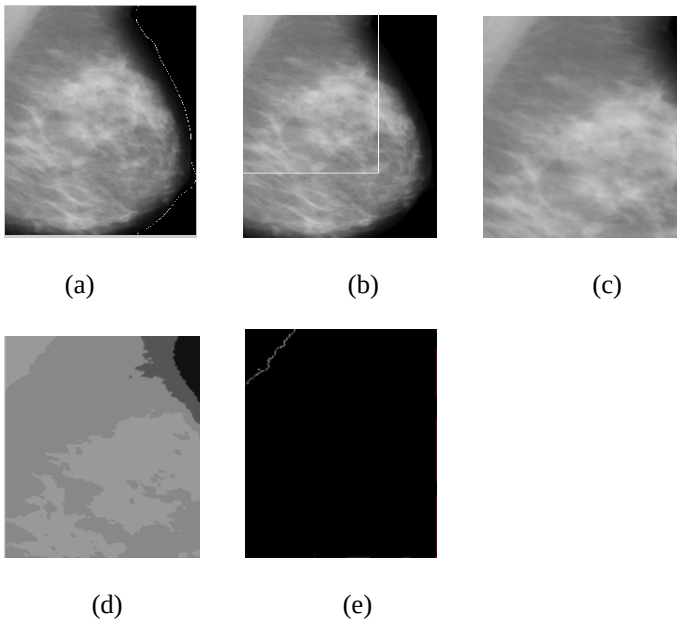
Figure 10: Mammogram segmentation results for MIAS image mdb016. (a). Original Mammogram; (b). Noise & Artifacts removal after filtering and morphological operation. (c). Binary Image; (d). Contour superimposed on original.



(a) (b) (c)

Figure 11: Mammogram segmentation results for MIAS mdb012. (a). Original Mammogram; (b). Image after removal of artifacts; (c) Contour superimposed on original image.

Some of the results of the proposed method for pectoral muscle identification is explained below. Fig. 12 shows the successful results of the proposed method.



(a) (b) (c)

(d) (e)

Figure 12: Pectoral muscle identification results for MIAS image mdb016. (a).Breast contour superimposed on original image; (b). The region of interest that contain the pectoral muscle; (c). Segmented area that contain the pectoral muscle; (d). Wavelet decomposed image; (e). Pectoral muscle edge identified on image.

## V. CONCLUSION.

In this paper a method for the detection of the breast contour and pectoral muscle segmentation is presented. The proposed method for detecting the breast border contour is tested on the 250 MIAS datasets. This method gave 99.06 successes in detecting the correct skin-air interface. The proposed method fails in detecting the correct skin-air interface for very few mammograms because of the noise (big size artifacts). Advantage of this method is low algorithm complexity and therefore short processing time. Our further development concerns smoothing of the breast border and pectoral muscle segmentation line. The proposed technique is fully autonomous, and is able to preserve the skin and nipple.

Pectoral muscle detection is a challenging task because it is not very well differenced from the surrounding breast tissue. There is different intensity variation of the pectoral muscle and the surrounding tissue for each mammogram images. The method proposed in this paper uses wavelet decomposition. This approach works well with an accuracy of 98% because pectoral muscle is rather large object for detection. Future work will focus on smoothening the breast contour and pectoral muscle edge.



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# Improved Shape Content Based Image Retrieval Using Multilevel Block Truncation Coding

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***Abstract*— This paper presents improved content based image retrieval (CBIR) techniques based on multilevel Block Truncation Coding (BTC) using multiple threshold values. Block Truncation Coding based feature is one of the CBIR methods proposed using shape features of image. The shape averaging methods used here are BTC Level – 1, BTC Level – 2, BTC Level – 3 and BTC Level – 4. Here the feature vector size per image is greatly reduced by using mean of each plane and finding out the threshold value. Then divide each plane using the threshold value. In order to find out the performance of the algorithm, shape averaging is applied to calculate precision and recall values. Instead of using all pixel data of image as feature vector for image retrieval these six, twelve, twenty – four and forty – eight feature vectors for BTC Level – 1, Level – 2, Level – 3 and Level – 4 respectively, can be used. This results in better performance. The proposed CBIR techniques are tested on generic image database having 1000 images spread across 11 categories. For each proposed CBIR technique 55 queries (5 per category) are fired on the generic image database To compare the performance of image retrieval techniques average precision and recall are computed of all queries. The results have shown the performance improvement (higher precision and recall values) with proposed methods compared to BTC Level-1.**

**Keywords- Content Based Image Retrieval (CBIR), BTC Level-1, BTC Level-2, BTC Level-3, BTC Level - 4.**

## I. INTRODUCTION

Information retrieval (IR) is the science of searching for documents, for information within documents, and for metadata about documents, as well as that of searching relational databases and the World Wide Web. There is overlap in the usage of the terms data retrieval, document retrieval, information retrieval, and text retrieval, but each also has its own body of literature, theory and technologies. IR is interdisciplinary, based on computer science, mathematics, cognitive psychology, linguistics, statistics, and physics. Automated information retrieval systems are used to reduce what has been called "information overload". Many universities and public libraries use IR systems to provide access to books and journals. Web search engines are the most visible IR applications. Images do have giant share in this information being stored and retrieved.

### *A. Image Retrieval*

Image search is a specialized data search used to find images. User may give a keyword, sketch or an image to image search engine for retrieving the relatively similar images from the image databases. The similarity used for search criteria could be meta tags, color distribution in images and region/shape attributes. Most traditional methods of image retrieval utilize some method of adding metadata such as captioning, keywords, or descriptions to the images so that retrieval can be performed over the annotation words[23]. The limitations of text-based approach are that it is subject to human perception and the problem of annotation of images. Annotating every image is a cumbersome and expensive task.

### *B. Content-based image retrieval*

Content-based image retrieval (CBIR) is the application of computer vision to the image retrieval problem, that is, the problem of searching for digital images in large databases. The term 'content' in this context might refer to color, shapes and textures. The color aspect can be achieved by the techniques averaging and histograms [4, 5, 7]. The texture aspect can be achieved by using transforms [12] or vector quantization [9, 11, 15]. Finally the shape aspect can be achieved by using gradient operators or morphological operators. Some of the major areas of application are: Art collections, Medical diagnosis, Crime prevention, the military, Intellectual property, Architectural and engineering design and Geographical information and remote sensing systems.

## II. EDGE EXTRACTION

Edge detection is very important in image analysis. The edges give idea about the shapes of objects present in the image. Hence they are useful for segmentation, registration, and identification of objects in a scene. The problem with edge extraction using gradient operators is that detection of edges is either in horizontal or in vertical directions, as the gradient operators take only the first order derivative of image. Shape feature extraction in image retrieval requires the extracted edges to be connected in order to reflect the boundaries of objects present in the image. Slope magnitude method[1] is used along with the gradient operators (Sobel, Prewitt, Robert and Canny)[1] to extract the shape features in form of connected boundaries. The process of applying the slope magnitude method is given as follows. First the image needs to be convolved with the Gx mask to get the x gradient and Gy mask to get the y gradient of the image. Then the individual squares of both these gradients are taken. Square


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root of addition of the two squared terms gives the extracted connected edges from the image as given in equation 1.

$$G = \sqrt{G_x^2 + G_y^2} \quad (1)$$

## III. BLOCK TRUNCATION CODING

Block truncation coding (BTC) is a simple image coding technique developed in the early years of digital imaging. BTC has played an important role in the history of digital image coding in the sense that many advanced coding techniques have been developed based on BTC or inspired by the success of BTC.

This method first divides the image to be coded into small non-overlapping image blocks typically of size 4× 4 pixels to achieve reasonable quality. The small blocks are coded one at a time. For each block, the original pixels within the block are coded using a binary bit-map the same Upper Mean Color (UM) size as the original blocks and two mean pixel values. The method first computes the mean pixel value of the whole block and then each pixel in that block is compared to the block mean. If a pixel is greater than or equal to the block mean, the corresponding pixel position of the bitmap will have a value of 1 otherwise it will have a value of 0. Two mean pixel values one for the pixels greater than or equal to the block mean and the other for the pixels smaller than the block mean are also calculated. At decoding stage, the small blocks are decoded one at a time. For each block, the pixel positions where the corresponding bitmap has a value of 1 is replaced by one mean pixel value and those pixel positions where the corresponding bitmap has a value of 0 is replaced by another mean pixel value.

It was quite natural to extend BTC to multi - spectrum images such as color images. Most color images are recorded in RGB space, which is perhaps the most well-known color space. As described previously, BTC divides the image to be coded into small blocks and code them one at a time. For single bitmap BTC of color image, a single binary bitmap the same size as the block is created and two colors are computed to approximate the pixels within the block. To create a binary bitmap in the RGB space, an inter band average image (IBAI) is first created and a single scalar value is found as the threshold value. The bitmap is then created by comparing the pixels in the IBAI with the threshold value.

### *A. Bit Calculation*

Let X={R(i,j),G(i,j),B(i,j)} where i=1,2,….m and j=1,2,….,n; be an m×n color image in RGB space. The interband average image could be computed as IA={IB(i,j) } where i=1,2,---,m and j=1,2,-----,n and where

$$IB(i,j) = \frac{1}{3}[(R(i,j) + G(i,j) + B(i,j))] \quad (2)$$

The Threshold(T) is computed as the mean of IB(i,j).

$$T = \frac{1}{mXn}\sum_{i-1}^{m}\sum_{j=1}^{n} IB(i,j) \quad (3)$$

The Binary bitmap {BM(i,j)} with i=1,2,...,m and j=1,2,…,n is computed as

$$BM(i,j) = \begin{cases} 1, if\ IB(i,j) \geq 1 \\ 0, if\ IB(i,j) < 0 \end{cases} \quad (4)$$

### *B. Upper mean and Lower mean calculation*

After the creation of the bitmap, two representative (mean) colors are then computed. The two mean colors, Upper Mean and Lower Mean. The Upper Mean UM=(Rm1, Gm1, Bm1) is computed as following equations.

$$R_{m1} = \frac{1}{\sum_{i=1}^{m}\sum_{j=1}^{n} BM(i.j)}[\sum_{i=1}^{m}\sum_{j=1}^{n} BM(i,j)XR(i,j)] \quad (5)$$

$$G_{m1} = \frac{1}{\sum_{i=1}^{m}\sum_{j=1}^{n} BM(i.j)}[\sum_{i=1}^{m}\sum_{j=1}^{n} BM(i,j)XG(i,j)] \quad (6)$$

$$B_{m1} = \frac{1}{\sum_{i=1}^{m}\sum_{j=1}^{n} BM(i.j)}[\sum_{i=1}^{m}\sum_{j=1}^{n} BM(i,j)XB(i,j)] \quad (7)$$

The Lower Mean LM= (Rm2, Gm2, Bm2) is computed as following equations:

$$R_{m2} = \frac{1}{mxn - \sum_{i=1}^{m}\sum_{j=1}^{n} BM(i.j)}[\sum_{i=1}^{m}\sum_{j=1}^{n}(-BM(i,j)XR(i,j))] \quad (8)$$

$$G_{m2} = \frac{1}{mxn - \sum_{i=1}^{m}\sum_{j=1}^{n} BM(i.j)}[\sum_{i=1}^{m}\sum_{j=1}^{n}(-BM(i,j)XG(i,j))] \quad (9)$$

$$B_{m2} = \frac{1}{mxn - \sum_{i=1}^{m}\sum_{j=1}^{n} BM(i.j)}[\sum_{i=1}^{m}\sum_{j=1}^{n}(-BM(i,j)XB(i,j))] \quad (10)$$

Now these Upper Mean and Lower Mean together will form a feature vector or signature of the image. For every image stored in the database these feature vectors are computed and stored in feature vector table. Whenever a query image is given to CBIR, again the feature vector for query image will be computed and then it will be matched with feature vector table entries for best possible matches at given accuracy rate. Here we have used Direct Euclidean Distance as a similarity measure to compute the similarity measures of images for Content Based Image Retrieval applications.

## IV. MULTILEVEL BTC

Image As seen above in section 2.4, the image data is divided into 6 parts using the 3 means calculated for each of the planes (R, G and B). This is called BTC - Level 1. Similarly, if the image data is divided into 12 parts using the 6 means


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calculated of each of the 6 parts in Level 1, we obtain BTC Level 2 data[21].

Here the bitmap are prepared using upper and lower mean values of individual colour components. For Red colour component, the bitmap "BMUR" and "BMLR" are generated as given in equations 17 and 18. Similarly for Green colour component "BMUG" & "BMLR" and for Blue colour components "BMUB" & "BMLB" can be generated.

$$BMUR(i,j) = \begin{cases} 1, if\ R(i,j) \geq UR \\ 0, if\ R(i,j) < UR \end{cases} \quad (11)$$

$$BMLR(i,j) = \begin{cases} 1, if\ R(i,j) \geq LR \\ 0, if\ R(i,j) < LR \end{cases} \quad (12)$$

Using this bitmap the two mean colours per bitmap, one for the pixels greater than or equal to the threshold and the other for the pixels smaller than the threshold are calculated. The upper mean color UM (UUR, ULR, UUG, ULG, UUB, ULB) are given as follows.

$$UUR = \frac{1}{\sum_{i=1}^{m}\sum_{j=1}^{n} BMUR(i.j)}[\sum_{i=1}^{m}\sum_{j=1}^{n} BMUR(i,j)Iur(i,j)] \quad (13)$$

$$ULR = \frac{1}{\sum_{i=1}^{m}\sum_{j=1}^{n} BMLR(i.j)}[\sum_{i=1}^{m}\sum_{j=1}^{n} BMLR(i,j)Ilr(i,j)] \quad (14)$$

And the first two components of Lower Mean LM= (LUR, LLR, LUG, LLG, LUB, LLB) are computed using following equations.

$$LUR = \frac{1}{\sum_{i=1}^{m}\sum_{j=1}^{n} BMUR(i.j)}[\sum_{i=1}^{m}\sum_{j=1}^{n} \{1 - BMUR(i,j)\} * Iur(i,j)] \quad (15)$$

$$LLR = \frac{1}{\sum_{i=1}^{m}\sum_{j=1}^{n} BMLR(i.j)}[\sum_{i=1}^{m}\sum_{j=1}^{n} \{1 - BMLR(i,j)\} * Ilr(i,j)] \quad (16)$$

These Upper Mean and Lower Mean together will form a feature vector for BTC – Level 2. For every image stored in the database these feature vectors are computed and stored in feature vector table.

Similarly the feature vector for BTC – Level 3 can be found by extending the BTC – Level 2 till as shown in figure 20. Hence the image is divided into 24 parts using 12 means generated from Level 2. Each plane will give the 6 elements of feature vector. For example for the Red plane we get ( UUUR, LUUR, ULUR, LLUR, UULR, LULR, ULLR, LLLR ).

## V. PROPSED CBIR TECHNIQUES

The problem of having all the database images with same size for image retrieval can be resolved using proposed Mask Shape BTC based CBIR methods. Here firstly, the shape features of the image are extracted by applying slope magnitude method on gradients of the image in vertical and horizontal directions and then the BTC is applied on obtained Mask Shape images to have a shape feature vector with constant size irrespective of size of the image considered. Even in Mask shape BTC based image retrieval four variations are considered using different gradient operators.

## VI. IMPLEMENTATION

The discussed image retrieval methods are implemented using MATLAB 7.0 on Intel Core 2 Duo processor T8100(2.1 GHz) with 2 GB of RAM. To check the performance of proposed technique a database of 1000 variable sized images spread across 11 categories has been used[3]. Five queries were selected from each category of images. Mean Squared Error (MSE) is used as similarity measure for comparing the query image with all the images in the image database. Let Vpi and Vqi be the feature vectors of image P and Query image Q respectively with size n, then the MSE can be given as shown in equation 17.

$$MSE = \sum_{i=1}^{n}(Vpi - Vqi)^2 \quad (17)$$

To assess the retrieval effectiveness, we have used the precision and recall as statistical comparison parameters for our proposed technique of CBIR. The standard definitions of these two measures are given by following equations.

$$\text{Precision} = \frac{Number\_of\_relevant\_images\_retrieved}{Total\_number\_of\_images\_retrieved} \quad (18)$$

$$\text{Recall} = \frac{Number\_of\_relevant\_images\_retrieved}{Total\_number\_of\_relevent\_images\_in\_database} \quad (19)$$

## VII. RESULTS AND DISCUSSION

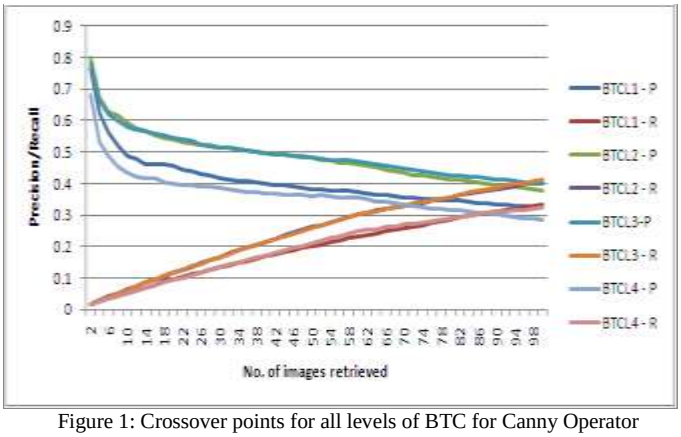


Figure 1: Crossover points for all levels of BTC for Canny Operator

Figure 1 shows a comparison between all the four levels of BTC by applying Canny operator. To get a better understanding of the results figure 2 shows a zoomed version of the same graph. From figure 2 we can see that level 3 gives the best performance in comparison to the other levels. But we see a drop in performance for level 4 due to the formation of null sets. Figure 3 shows a bar graph comparing the results of


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all four levels of BTC for the Canny Operator. The same performance is given by the other Gradient Operators as well.

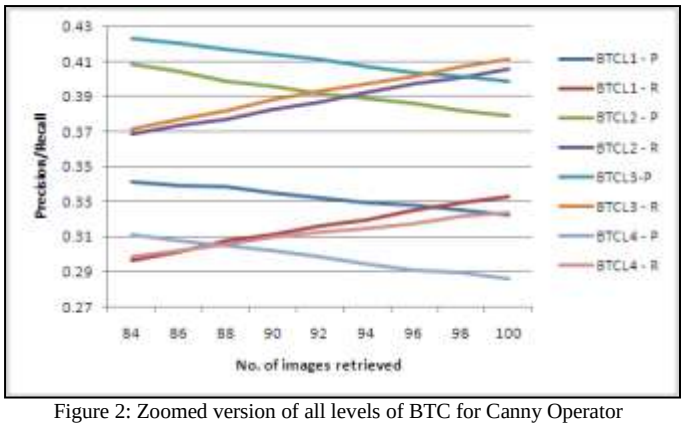


Figure 2: Zoomed version of all levels of BTC for Canny Operator

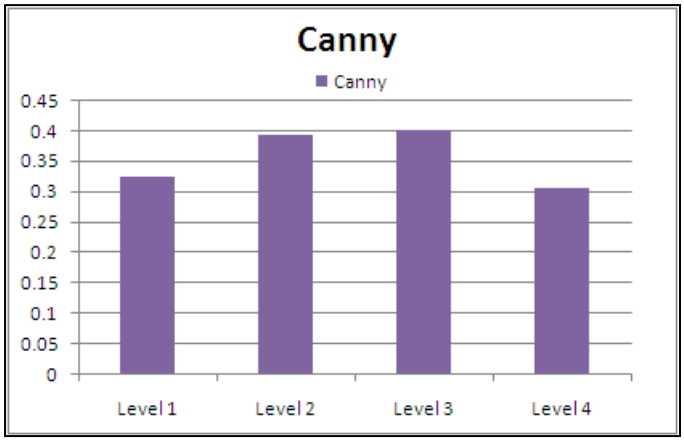


Figure 3: Comparison between all levels of BTC for Canny Operator

The performance of all the operators with all the four levels of BTC has been shown in figures 4a and 4b. Figure 4a shows comparison between all Gradient Operators with respect to BTC levels and figure 4b shows comparison between all BTC levels with respect to Gradient Operators.

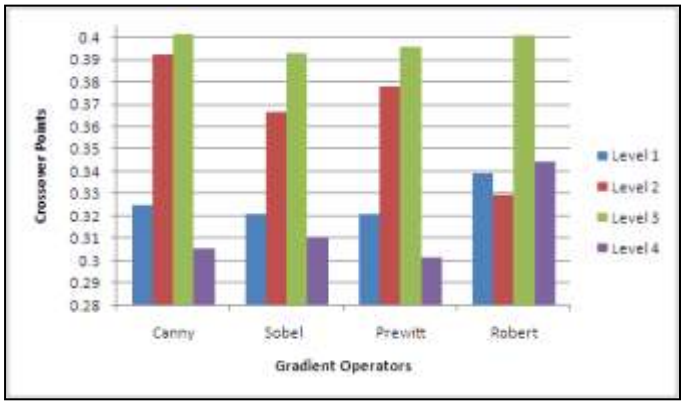


Figure 4a: Comparison between all operators based on BTC Levels

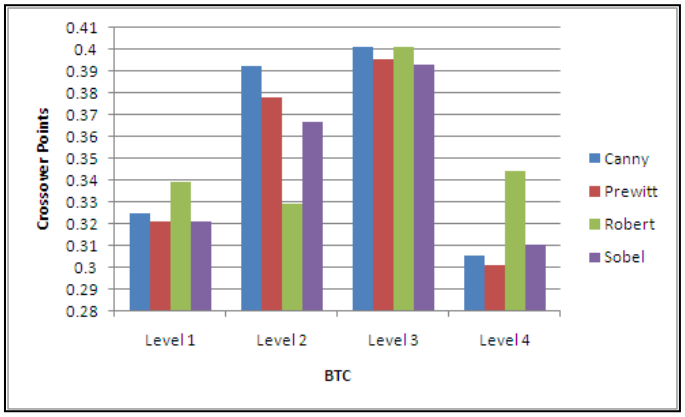


Figure 4b: Comparison between all BTC levels based on Gradient Operators

The performance of all the operators with all the four levels of BTC has been shown in figures 4a and 4b. Figure 4a shows comparison between all Gradient Operators with respect to BTC levels and figure 4b shows comparison between all BTC levels with respect to Gradient Operators.

## VIII. CONCLUSION

From the experimental analysis and results, it is evident that out of the four Gradient Operators, Canny Gradient Operator gives best performance in proposed shape based image retrieval techniques using BTC level 2 and BTC level 3. Robert Gradient Operator gives best performance for BTC level 3 and BTC level 4. Sobel and Prewitt Gradient Operators give an average performance for all 4 levels of BTC based CBIR methods. The BTC level 3 gives best performance for all Gradient Operators based CBIR as compared to other levels of BTC, with BTC level 4 showing the lowest performance..

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# An Enhanced Time Space Priority Scheme to Manage QoS for Multimedia Flows transmitted to an end user in HSDPA Network

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*Abstract*— **When different type of packets with different needs of Quality of Service (QoS) requirements share the same network resources, it became important to use queue management and scheduling schemes in order to maintain perceived quality at the end users at an acceptable level. Many schemes have been studied in the literature, these schemes use time priority (to maintain QoS for Real Time (RT) packets) and/or space priority (to maintain QoS for Non Real Time (NRT) packets). In this paper, we study and show the drawback of a combined time and space priority (TSP) scheme used to manage QoS for RT and NRT packets intended for an end user in High Speed Downlink Packet Access (HSDPA) cell, and we propose an enhanced scheme (Enhanced Basic-TSP scheme) to improve QoS relatively to the RT packets, and to exploit efficiently the network resources. A mathematical model for the EB-TSP scheme is done, and numerical results show the positive impact of this scheme.**

***Keywords: HSDPA; QoS; Queuing; Scheduling; RT and NRT packets; Markov Chain.***

## I. INTRODUCTION

In recent years, the performance of mobile cellular telecommunication networks have been growing continuously by increasing the hardware capacity, and new generation of mobile networks offer more bandwidth resources. With this development, new services with high bandwidth demand and different QoS requirements have been incorporated and its effect needs to be taken in consideration.

Despite of the efforts taken on the infrastructures to improve network services, the disturbing impact of the wireless transmission may lead to a degradation of the perceived quality at the end users. It becomes important to take additional measures on the networks.

Hence, two ways are possible. The first is to adapt the contenent to the current network conditions at the end user. This is the end to end QoS control [15]. The most well known mechanisms to achieve this adaptation are Random Early Detection (RED) [8] and its variants [7]. The second way is to manage network resources to offer network support for content; it is a network centric approach. One of the most important representatives of this second way is queue management and packet scheduling which have impact on the QoS attributes. When different type of packets with different needs of QoS standards share the same network resources, such as buffers and bandwidth, a priority scheme from the second way has to be used. The priority scheme can be defined in terms of a policy determining [13]**:**

- Which of the arriving packets are admitted to the buffer and how it is admitted
  And/or
- Which of the admitted packets is served next

The former priority service schemes referred to as space priority schemes and attempt to minimize the packet loss of non real time (NRT) applications (www browsing, e-mail, ftp, or data access) for which the loss ratio is the restrictive quantity. The latter priority service schemes are referred as time priority schemes and attempt to guarantee acceptable delay boundaries to real time (RT) applications (voice or video) for which it is important that delay is bounded.

Many priority schemes have been studied in literature, and have focused on space priority or time priority.

Authors in [14**]** present a modeling for a multimedia traffic in a shared channel, but they take in consideration system details rather the characteristics of the flows composing the traffic.

Works in [1], [4], [12] study priority schemes and try to maximize the QoS level for the RT packets, without taking into account the effect on degradation of the QoS for NRT packets.

In HSDPA (High-Speed Downlink Packet Access) technology, it is possible to implement Packet scheduling algorithms that support multimedia traffic with diverse concurrent classes of flows being transmitted to the same end


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user [9]. Therefore, Suleiman and all present in [16] a queuing model for multimedia traffic over HSDPA channel using a combined time priority and space priority (TSP priority) with threshold to control QoS measures of the both RT and NRT packets.
The basic idea of TSP priority [2] is that, in the buffer, RT packets are given transmission priority (time priority), but the number accepted of this kind of packets is limited. Thus, TSP scheme aims to provide both delay and loss differentiation.
Authors in [16], [17] studied an extension of TSP scheme incorporating thresholds to control the arrival packets of NRT packets (Active TSP scheme), and show, via simulation (using OPNET), that TSP scheme achieves better QoS measures for both RT and NRT packets compared to FCFS (First Come First Serve) queuing.

To model the TSP scheme, mathematical tools have been used in [18] and QoS measures have been analytically deducted, but some given results are false, ([5],[6],[9]) corrected this paper and used MMPP and BMAP processes to model the traffic sources.
When the basic TSP scheme is applied to a buffer in Node B (in HSDPA technology) arriving RT packets will be queued in front of the NRT packets to receive priority transmission on the shared channel. A NRT packet will be only transmitted when no RT packets are present in the buffer, this may the RT QoS delay requirements would not be compromised [2].
In order to fulfil the QoS of the loss sensitive NRT packets, the number of admitted RT packets, is limited to R, to devote more space to the NRT flow in the buffer.

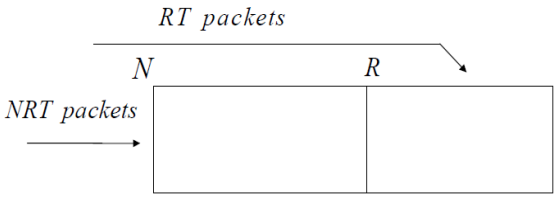


*Figure :. the B-TSP scheme applied to a buffer*

.

This scheme has in important drawback; as the number of NRT packets can not exceed a threshold R, this will result in RT packet drops even when capacity is available in the section reserved to NRT packets in the buffer that implies bad QoS management for RT packets, and bad management for buffer space.
Hence, in this paper, we propose an algorithm to enhance the basic TSP scheme (Enhanced Basic TSP: EB-TSP). The priority function is modified for packets to overcome the drawback cited above, in order to improve QoS for RT packet by reducing the loss probability of RT packets, and to achieve a better management for the network resources.
The rest of this paper is organized as follows: section 2 introduces the proposed buffer management scheme, which is termed as *EB-TSP* vs. *Basic-TSP*. Subsequently, in section 3 the mathematical model is presented and studied. The QoS measures related to the proposed scheme are analytically presented in section 4. Section 5 presents the numerical results and shows the effect that the proposed scheme has on the performance of traffic. Finally, section 6 provides the concluding remarks.

## II. EB-TSP SCHEME DESCRITION

The Basic-TSP (B-TSP) buffer management scheme for multimedia QoS control in HSDPA Node B, proposed by authors in [3] is defined to maintain inter-class prioritization for end-users with multiple flows. It consists on putting a buffer, for each user, where RT and NRT flows are queued according to the following scheme priority.
The RT flow packets are queued ahead of the NRT flow packets of the same user, for priority scheduling/transmission on the shared channel (time priority). At the same time, the NRT flow packets get space priority in the user's buffer queue. B-TSP scheme queuing uses a threshold *R* to restrict the maximum number of queued RT packets (fig.1).
In [18] authors have shown B-TSP to be an effective queuing mechanism for joint RT and NRT QoS compared to conventional priority queuing schemes.
To overcome the drawback of B-TSP scheme cited in section I, we propose to use the following control mechanism:
When an RT packet arrives at the buffer, either it is full or there is free space. In the first case, if the number of RT packets is less than *R*, then an NRT packet will be rejected and the arriving RT packet will enter in the buffer. Or else, the arriving RT packet will be rejected. In the second case, the arriving RT packet will enter in the buffer.
The same, when an NRT packet arrives at the buffer, either it is full or there is free space. In the first case, if the number of RT packets is less than *R*, then the arriving NRT packet will be rejected. Or else, an RT packet will be rejected and the arriving NRT packet will enter in the buffer. In the second case, the arriving NRT packet will enter in the buffer.

**Remark:** In the buffer, the RT packets are placed all the time in front of the NRT packets.

## III. MATHEMATICAL MODEL

### A. Arrival and Sevice Processes

The arrival processes of RT and NRT packets are assumed to be poissonian with rates $\lambda_{RT}$ and $\lambda_{NRT}$ respectively.
The service times of RT and NRT packets are assumed to be exponential with rate $\mu_{RT}$ and $\mu_{NRT}$ respectively.
We also assume that the arrival processes and the service times are mutually independent between them.
The state of the system at any time t can be described by the process $X(t) = (X_1(t), X_2(t))$,
where $X_1(t)$ (respectively $X_2(t)$ ) is the number of RT (respectively of NRT) packets in the buffer at time t.
The state space of *X(t)* is *E={0,…., N}x{0,…., N}.*


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### B. Stability

Since the arrival processes are Poisson (i.e the inter-arrivals are exponential), the service times are exponential and these processes are mutually independent between them, then *X(t)* is a Markov process.

We can prove easily that *X(t)* is irreducible, because all the states communicate between them.

Moreover, E is a finite space, then *X(t)* is positive recurrent.

Consequently, *X(t)* is an ergodic process and the equilibrium probability exists.

### C. Equilibrium Probability

We denote the equilibrium probability of *X(t)* at the state *(i,j)* by $\{p(i,j)\}$, where:

$$p(i,j) = \lim_{t\to\infty} P(X_1(t) = i, X_2(t) = j)$$

It is the solution of the following balance equations:

$$(\lambda_{NRT} + \lambda_{RT})\, p(0,0) = \mu_{NRT}\, p(0,1) + \mu_{RT}\, p(1,0)$$

$$(\lambda_{RT} + \mu_{NRT})\, p(0,N) = \lambda_{NRT}\, p_2(0,N-1)$$

$$(\lambda_{NRT} + \mu)\, p(N,0) = \lambda_{RT}\, p(N-1,0)$$

For *i =1, ……, N-1*

$$(\lambda_{NRT} + \mu_{RT} + \lambda_{RT})\, p(i,0) = \lambda_{RT}\, p(i-1,0) + \mu_{RT}\, p(i+1,0)$$

For *j=1, ….., N-1*

$$(\lambda_{RT} + \lambda_{RT} + \mu_{NRT})\, p(0,j) = \mu_{RT}\, p(1,j) + \lambda_{NRT}\, p(0,j-1) + \mu_{NRT}\, p(0,j+1)$$

For *i= R+1,….., N-1*

$$(\mu_{RT} + \lambda_{NRT})\, p(i,N-i) = \lambda_{RT}\, p(i,N-i-1) + \mu_{RT}\, p(i-1,N-i)$$

For *i =1, ……., N-1*

$$(\mu_{RT} + \lambda_{RT})\, p(i,N-i) = +\lambda_{NRT}\, p(i,N-i-1) + \lambda_{RT}\, p(i-1,N-i)$$

For *i =1, ……., N-2, j=1,…. , N-i-1*

$$(\lambda_{NRT} + \mu_{RT} + \lambda_{RT})\, p(i,j) = \lambda_{RT}\, p(i-1,j) + \lambda_{NRT}\, p(i,j-1) + \mu_{RT}\, p(i+1,j)$$

The equilibrium probability must verify the normalization equation given by: $\sum_{i=0}^{N}\sum_{j=0}^{N-i} p(i,j) = 1$.

## IV. QoS Measures

In this section, the loss probability and the delay for each class of traffic are analytically presented.

### A. Loss Probability

With the EB-TSP scheme, an RT packet is lost either when the buffer is full and the number of RT packets is more than *R* at the time of its arrival or when an NRT packet arrives and finds the buffer full and the number of RT packets is more than *R*.

Then the loss probability of RT packets is given by:

$$P_{L-RT} = \lim_{t\to\infty} \frac{\int_0^t 1_{(X_1(s)+X_2(s)=N,\, X_1(s)\geq R)}(s)\, A^1(s)\, ds}{N_1(t)} + \lim_{t\to\infty} \frac{\int_0^t 1_{(X_1(s)+X_2(s)=N,\, X_1(s)\succ R)}(s)\, A^2(s)\, ds}{N_1(t)}$$

Where:

$N_1(t)$ is the number of arriving RT packets in the buffer during the time interval [0,t]

$A^1(s)$ (respectively $A^2(s)$) is the RT (respectively NRT) arriving flow in the buffer at time *s*.

$$1_{(s)}(t) = \begin{cases} 1 & if\ \ s = t \\ 0 & else \end{cases}$$

Since *X* is ergodic, we show that:

$$P_{L-RT} = \sum_{i=R}^{N} p(i,N-i) + \frac{\lambda_{NRT}}{\lambda_{RT}} \sum_{i=R+1}^{N} p(i,N-i)$$

Using the same analysis, we can show that the loss probability of NRT packets is:

$$P_{L-NRT} = \sum_{i=0}^{R} p(i,N-i) + \frac{\lambda_{RT}}{\lambda_{NRT}} \sum_{i=0}^{R-1} p(i,N-i)$$

### B. Average Number of Packets in the Buffer

The average number of RT packets in the buffer at the steady state is:

$$N_{RT} = \lim_{t\to\infty} \frac{N_1(t)}{t}$$

We can show that:

$$N_{RT} = \sum_{i=0}^{N}\sum_{j=0}^{N-i} p(i,j)$$

We show also that the average number of NRT packets in the buffer at the steady state is:

$$N_{NRT} = \sum_{j=0}^{N}\sum_{i=0}^{N-j} p(i,j)$$

### C. Mean Delay

Using Little's Formula [10], we deduct that the average delays of RT and NRT packets respectively are given:

$$D_{RT} = \frac{N_{RT}}{\lambda_{RT}(1-P_{L-RT})}$$



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$$D_{NRT} = \frac{N_{RT} + N_{NRT}}{\lambda_{NRT}(1 - P_{L-NRT})}$$

## V. NUMERICAL RESULTS

In this section we present the numerical results of EB-TSP scheme. We use the Maple software to solve numerically the system of equations given in III-C and to evaluate the QoS measures. The numerical results for the EB-TSP scheme are compared to the same value for basic-TSP scheme. In the simulations, we use the following parameters:

| | |
|---|---|
| Total queue length | 60 |
| Threshold for number of RT packets | 15 |
| Arrival rate of NRT packets | 8 |
| Rate service of RT packets | 30 |
| Rate service of NRT packets | 25 |

*Table 1 : Simulation parameters*

Figure.2 plots the loss probability for the RT packets in both B-TSP and EB-TSP schemes. This figure shows that the proposed scheme has a significant impact on the performance of the system relatively to the RT packet loss, this effect is more important when the arrival rate of RT packets is growing. Which leads to the better quality for audio and video calls received by the end user in HSDPA cell using EB-TSP scheme.

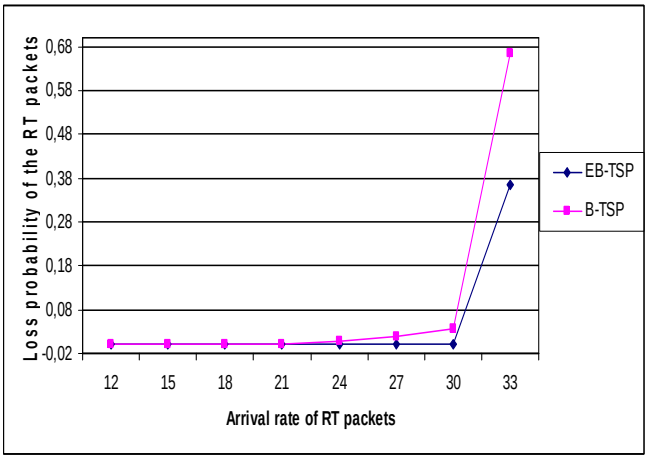


*Figure2: Variation of the loss probability of RT packets according to arrival rate of RT packets*

As expected, Figures 3, 4 and 5 show that EB-TSP scheme keeps the same level of other QoS measures: dropping probability for NRT packets and average delays for RT and NRT packets, compared to basic-TSP scheme.

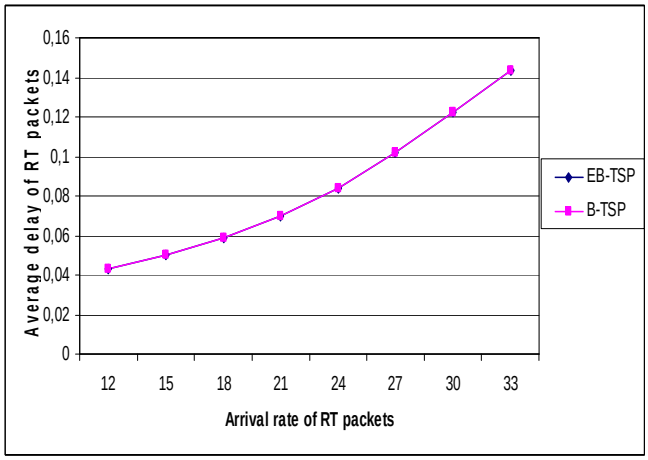


*Figure 3: Variation of the average delay of RT packets according to arrival rate of RT packets*

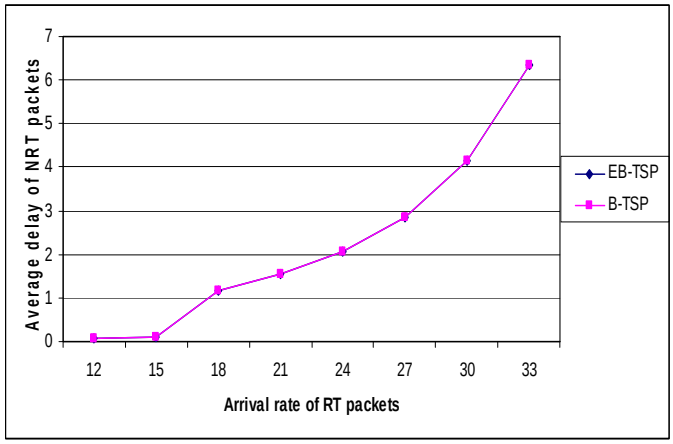


*Figure 4: Variation of the average delay of NRT packets according to arrival rate of RT packets*

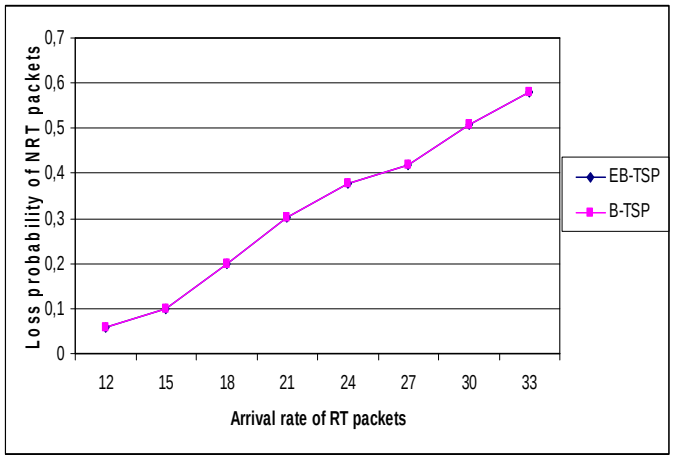


*Figure 5: Variation of the loss probability of NRT packets according to arrival rate of RT packets*


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## VI. CONCLUSION

In this paper we have applied a new time space priority scheme (Enhanced Basic-TSP) in HSDPA where multiple flows exist for an end user. This scheme overcomes a limitation of the Basic-TSP scheme previously studied in the literature, and achieves a better management for buffer space.

We devise an ergodic continuous-time Markov chain CTMC to characterize the transition of the system. The QoS measures in the proposed scheme are analytically given for both flows. Numerical results show that the EB-TSP have a significant impact on the RT packet dropping, and keep the RT delay and NRT packet dropping in the same level compared to Basic-TSP scheme. This implies an enhancement of the QoS relatively to the received RT flow at the end users

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# HS-MSA: New Algorithm Based on Meta-heuristic Harmony Search for Solving Multiple Sequence Alignment

## Survey and Proposed Work

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**Abstract—Aligning multiple biological sequences such as in protein or DNA/RNA is a fundamental task in bioinformatics and sequence analysis. In the functional, structural and evolutionary studies of sequence data the role of multiple sequence alignment (MSA) cannot be denied. It is imperative that there is accurate alignment when predicting the RNA structure. MSA is a major bioinformatics challenge as it is NP-complete. In addition, the lack of a reliable scoring method makes it harder to align the sequences and evaluate the alignment outcomes. Scalability, biological accuracy, and computational complexity must be taken into consideration when solving MSA problem. The harmony search algorithm is a recent meta-heuristic method which has been successfully applied to a number of optimization problems. In this paper, an adapted harmony search algorithm (HS-MSA) methodology is proposed to solve MSA problem. In addition, a hybrid method of finding the conserved regions using the Divide-and-Conquer (DAC) method is proposed to reduce the search space. The proposed method (HS-MSA) is extended to a parallel approach in order to exploit the benefits of the multi-core and GPU system so as to reduce computational complexity and time.**

***Keyword: RNA, Multiple sequence alignment, Harmony search algorithm.***

### I. INTRODUCTION

Living organisms are related to each other throughout evolution. A pair of organisms sometimes has a common ancestor in the past from which they were evolved. MSA tries to discover the similarities among the sequence and recover the mutations that took place.

A sequence is an ordered list of symbols from a set of letters of the alphabet, S (20 amino acids for protein and 4 nucleotides for RNA/DNA). In bioinformatics, a RNA sequence is written as s = AUUUCUGUAA. It is a string of nucleotides symbols comprising adenine (A), cytosine (C), guanine (G) and uracil (U): S = {A, C, G, U}.

Alignment is a method to arrange the sequences one over the other to show the match and mismatch between the residues. A column which has match residues shows that no mutation has occurred whereas a column with mismatch symbols indicates that several mutation events are happening. To improve the alignment score, the character "–" is used to correspond to a space introduced in the sequence. This space is usually called a gap. The gap is viewed as an insertion in one sequence and deletion in the other. A score is used to measure the alignment performance. The highest score of one indicates the best alignment.

For clarity's sake, the generic MSA problem is expressed using the following declaration: "Insert gaps within a given set of sequences in order to maximize a similarity criterion"[1]. Finding an accurate MSA from the sequences is very difficult. It is a time consuming and computationally NP-hard problem[2, 3]. The MSA problem can be divided into three difficulties, that is, scalability, optimization, and objective function.

In fact, the complexity that arises from all the three problems must be solved simultaneously. The first problem, scalability, is about finding the alignment of many long sequences. The second problem, optimization, deals with finding the alignment with the highest score based on a given objective function among the sequences. Optimization of even a simple objective function is an NP-hard problem. The third problem, the objective function (OF), involves speeding up the calculation in order to measure the alignment.

MSA covers two closely related problems: global MSA and local MSA. Global MSA aligns sequences across their whole length while local MSA aligns certain parts of the sequences, and locates conserved regions along with them as shown in Figure 1.

Figure 1. Global and local MSA



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In bioinformatics, MSA is a major interesting problem and constitutes the basis for other molecular biology analyses. MSA has been used to address many critical problems in bioinformatics. Studying these alignments provides scientists with information needed to determine the evolutionary relationships between them, find the sequences of the family, detect the structure of protein/DNA, reveal the sequence homologies, predict the functions of protein/DNA sequences, and predict the patient's diseases or discover drug-like compounds that can bind to the sequences.

In general, the primary step in the secondary structure prediction is through MSA, particularly in the prediction of the structure of RNA sequences. The RNA structure prediction method is extremely affected by the quality of the alignment[4]. Indeed, prediction of an accurate RNA secondary structure relies on multiple sequence alignments to provide data on co-varying bases[5]. MSA significantly improves the accuracy of protein/RNA structure prediction. For example, current RNA secondary structure prediction methods using aligned sequences have been successful in gaining a higher prediction accuracy than those using a single sequence[6]. Nucleic acid sequences are of primary concern in our proposed method to evaluate and improve the influence of the alignment tools on RNA secondary structure prediction.

Many different approaches have been proposed to solve the MSA problem. Dynamic programming, progressive, iterative, consistency and segment-based approaches are the most commonly used approaches[7]. Although many MSA algorithms are available, a solution has yet to been found that is applicable to all possible alignment situations[7].

It is well-known fact that the MSA problem can be solved by using the dynamic programming (DP) algorithm[8, 9]. Unfortunately, such an approach is notorious for its large consumption of processing time. DP methods with the sum-of-pairs score have been shown to be a NP-complete problem[10],[11]. Algorithms that provide the optimal solution is time consuming and have a running time that grows exponentially with the increase in the number of sequences and their lengths.

In essence, all widely used MSA tools seek an alignment with a high sum-of-pairs score. This optimization problem is NP-complete[2, 3] and thus motivates the research into heuristics. Over the last decade, the evolutionary and meta-heuristic approaches are one of the most recent approaches that have been used to solve the optimization problem. Evolutionary and meta-heuristic algorithms have been used in several problem domains, including science, commerce, and engineering. Consequently, most of the practical MSA algorithms are based on heuristics to obtain a reasonably accurate MSA within a moderate computational time and that which usually produces quasi-optimal alignment. Although many algorithms are now available, there is still room to improve its computational complexity, accuracy, and scalability.

In this paper, a novel algorithm (HS-MSA), that is, a meta-heuristic technique known as harmony search algorithm, is proposed to solve the old MSA problem. The MSA problem is viewed as an optimization problem and can be resolved by adapting a harmony search algorithm. Since the search space in HS is wide, a modified algorithm is proposed (MHS-MSA) to find the conserved blocks using well-known regions, and then align the mismatch regions between the successive blocks to form a final alignment. HS-MSA is extended to include the divide-and-conquer (DCA) approach in which DCA is used to cut and combine the sub-sequence to form the final MSA. Another proposed technique is to use the harmony search algorithm as an MSA improver (HSI-MSA) in which the initial alignment can be obtained from the conventional algorithms or their combinations. HS-MSA can be extended to the parallel algorithm (PHS-MSA) in order to exploit the benefits of the multi-core and GPU system to reduce computational complexity and time.

This paper is organized as follows: Section 2 reviews the related literature and describes the state-of-the-art MSA approaches. Section 3 explains the proposed algorithm. The evaluation and analysis methodology that is used to assess our proposed algorithm is explained in Section 4. Lastly, Section 5 provides the conclusion and summary of the paper.

## II. LITERATURE REVIEW

There are several MSA algorithms reported in the literature review. For a deeper understanding about the MSA algorithms, the basic concepts of MSA alignment representation, gap penalty, alignment scores, dataset benchmarks, MSA approaches, and harmony search algorithm need to be understood. As such subsection 2.1 briefly reviews the representation of MSA alignment followed by the details about gap penalty in subsection 2.2. The alignment scores, RNA datasets and benchmarks, and current MSA approaches are explained in subsections 2.3, 2.4 and 2.5 respectively. Subsection 2.6 provides a summary of the MSA algorithms and concludes with the harmony search algorithm in subsection 2.7.

### *A. Representation of MSA Alignment*

There are several ways to represent a multiple sequence alignment. Usually, the final sequences are an aligned listing of the entire sequence of one over the other. However, during the alignment process, it is helpful to represent the alignment of the sequences in a manner known as a representation. Some of the representations that have been used in previous algorithms include a bit matrix as used in[12], a matrix of gaps position as used in[13], multiple number-strings as used in[14],[15],[16],[17], string representation[18],[19],[20] as used in SAGA[18], four parallel chromosomes as used in[21], directed acyclic graph (DAG) as used in[22, 23], A-Bruijn graph as used in[24-26] , and dispersion Graph as used in[27].

### *B. Gaps Penalty*

A negative score or a penalty can be assigned to a set of gaps. Two types of gaps which were mentioned in the previous reviews[28] are defined as follows:

- Linear gap model – in this model a Gap is always given the same penalty wherever it is placed in the alignment. The penalty is proportional to the length of the gap and is


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given by gap = n×go, where go < 0 is the opening penalty of a gap and n is the number of consecutive gaps.

- Affine gap model – in this model both the new gap and extension gap are not given the same penalty. The insertion of a new gap has a greater penalty than the extension of an existing gap and is given by gap = go + (n − 1) × ge, where go < 0 is the gap opening penalty and ge < 0 is the gap extension penalty and are such that |ge| < |go|.

### C. Alignment Score

The MSA objective function is defined for assessing the alignment quality either explicitly or implicitly. An efficient algorithm is used to find the optimal or a near optimal alignment according to the objective function. Matches, mismatches, substitutions, insertions, and deletions need to be scored in the scoring function. The scoring function can be divided into two parts: substitution matrices and gap penalties. The former provides a numerical score for matches and mismatches while the latter allows for numerical quantification of insertions and deletions. All possible transitions between the 20 amino acids, or the 4 nucleic acids are represented in a substitution matrix which is an array of two dimensions of 20 x 20 for amino acid and 4 x 4 for nucleic acids.

Usually a simple matrix used for DNA or RNA sequences involves assigning a positive value for a match and a negative value for a mismatch[20]. Meanwhile, the scores for protein aligned residues are given as log-odds[29] substitution matrices such as PAM[30], GONNET[31], or BLOSUM[32].

There are several models for assessing the score of a given MSA. Many MSA tools have adopted the score method. A brief review of the score method that has been used to calculate the alignment score is as follows:

- Sum-of-Pairs (SP): It was introduced by Carrillo and Lipman[10]. More details about the sum-of-Pairs will be presented later.
- Weighted sum-of-pairs score[33],[34]: The weighted sum-of-pairs (WSP) score is an extension of the SP score so that each pair-wise alignment score contributes differently to the whole score.
- Maximal expected accuracy (MEA)[35]: The basic idea of MEA is to maximize the expected number of "correctly" aligned residue pairs[36]. It has been used in PRIME[37], and ProbCons[38] algorithms.
- Consistency-based Scoring: This consistency concept was originally introduced by Gotoh [9] and later refined by Vingron and Argos[39]. Consistency-based scoring is used in T-Coffee[40], MAFFT[41], and Align-m[42] algorithms.
- Probabilistic consistency Scoring function: This scoring function is introduced in ProbCons[38]. It is a novel modification of the traditional sum-of-pairs scoring system. This promising idea is implemented and extended in the PECAN[43], MUMMALS[44], PROMALS[45], ProbAlign[46] , ProDA[47], and PicXAA[48] programs.
- Segment-to-segment objective function: It is used by DIALIGN[49] to construct an alignment through comparison of the whole segments of the sequences rather than the residue-to-residue comparison.
- NorMD[50] objective function: It is a conservation-based score which measures the mean distance between the similarities of the residue pairs at each alignment column. NorMD is used in RASCAL[51] and AQUA[52].
- Muscle profile scoring function: MUSCLE[53] uses a scoring function which is defined for a pair of profile positions. In addition to PSP, MUSCLE uses a new profile function which is called the log-expectation (LE) score.

### D. RNA Database and Benchmarks

Typically, a benchmark of reference alignments is used to validate the MSA program. The accurate score is given by comparing the aligned sequence (test sequences) produced by the program with the corresponding reference alignment. Most alignment programs have been extensively investigated for protein. To date, few attempts have been made to benchmark nucleic acid sequences.

RNA reference alignments exist in several databases. It must be noted that although these databases provide a substantial amount of information to the specialist, they do differ in the file formats used and the data obtained. Herein, a brief review of the benchmarks and database that have been used for multiple RNA sequence alignment is explained in Table 1.

TABLE I. DATABASE AND BENCHMARKS

| RNA Database | Description | Website |
|---|---|---|
| Rfam[54],[55] | It is a compilation of alignment and covariance models including many regular non-coding RNA families[55] | http://rfam.sanger.ac.uk/ http://rfam.janelia.org/index.html. |
| BRAliBase[56],[57] | It is a compilation of RNA reference alignments especially designed for the benchmark of RNA alignment methods[57]. | http://www.biophys.uni-duesseldorf.de/bralibase/ http://projects.binf.ku.dk/pgardner/bralibase/ |
| Comparative RNA Website (CRW)[58] | It has alignments for rRNA (5S / 16S / 23S), Group I Intron, Group II intron, and tRNA for various organisms[58] | http://www.rna.ccbb.utexas.edu/ |
| European Ribosomal RNA Database[59],[60] | It is a collection of all complete or nearly complete SSU (small subunit) and LSU (large subunit) ribosomal RNA sequences available from public sequence databases[60]. | http://bioinformatics.psb.ugent.be/webtools/rRNA/ |
| The Ribonuclease P Database[61] | It contains a collection of sequence alignments, RNase P sequences, three dimensional models, secondary structures, and accessory information[61]. | http://www.mbio.ncsu.edu/RnaseP/ |
| 5S Ribosomal RNA | It is a collection of the large subunit of most organellar ribosomes and all | http://biobases.ibch.poznan.pl/5SData/ |


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| | | |
|---|---|---|
| Database[62] | cytoplasmic. This database is intended to provide information on nucleotide sequences of 5S rRNAs and their genes[62]. | |
| tmRNA[63] | tmRNA (also known as 10Sa RNA or SsrA) contains a compilation of sequences, alignments, secondary structures and other information. It shows secondary structure, together with careful documentation[63]. | http://www.indiana.edu/~tmrna/ |
| The tmRDB( tmRNA database)[64] | tmRDB provides aligned, secondary and tertiary structure of each tmRNA molecule. The alignment is available in several formats. | http://www.ag.auburn.edu/mirror/tmRDB/ |
| RNAdb[65],[66] | It provides sequences and annotations for tens of thousands of non-coding RNAs. | http://research.imb.uq.edu.au/rnadb/default.aspx |
| Noncoding RNA (ncRNA) database[67] | It provides information of the non-coding RNA sequences and functions of transcripts, (the non-coding RNA does not code for proteins, but performs regulatory roles in the cell) | http://biobases.ibch.poznan.pl/ncRNA/ |

### *E. Current MSA Approaches*

Many research on MSA algorithms have been published in the last thirty years and reviewed by a few researchers such as[7],[68],[69],[70]. The published algorithms vary in the way the researchers choose the specified order to do the alignment, and in the procedure used to align and score the sequences. Existing algorithms can be classified into one or combinations of the following basic approaches: exact, progressive, iterative algorithms, group alignment, block-based, consistency-based, probabilistic, computational intelligence, and heuristic. The following subsections provide a brief overview of the consistency-based, block-based and heuristic optimization approaches. These approaches are related in one way or the other to our proposed work. The consistency-based approach is explained in subsection 2.5.1 followed by the block-based approach in subsection 2.5.2. Finally, the heuristic optimization approach is explained in subsection 2.5.4.

#### *1) Consistency-based Approach*

The "consistency-based" approach is one of the strategies that has been proposed to improve the MSA scoring function. This approach tries to reduce the chance of early errors when constructing the alignment instead of correcting the existing errors via post processing[40],[38]. This is typically achieved by improving the pair-wise sequence quality based on other sequences in the alignment so as to obtain pair-wise alignments that are consistent with one another. This consistency strategy was originally described by Gotoh[9] and later refined by Vingron and Argos[39]. This strategy has been modified by several methods since then.

SAGA[18] incorporated the optimization of alignment with COFFEE based on a consistency measure called the consistence-based objective function.

Later, Dialign2[71] represented the consistency-based method incorporating the segment-by-segment approach.

Similarly, Align-m[42] used a local alignment as a guide to a global alignment non-progressive problem. Align-m used the pair-wise alignment consistency to find the parts that are consistent with each other.

T-Coffee[40] also implemented this idea by using a consistency-based alignment measure based on a library of pair-wise alignments. This method was later brought into a probabilistic framework by ProbCons[38], MUMMALS[44], ProbAlign[46], PROMALS[45], and MSAProbs[72].

Nonetheless, a combination of different strategies can be used. For instance, PCMA[73] (profile consistency multiple sequence alignment) combined two different alignment strategies, that is, progressive and consistency approaches.

#### *2)* Block-based Approach

Block-based MSA is a method in which an alignment is constructed by first identifying the conserved regions into what is called "blocks". Then, the regions between the successive blocks are aligned to form a final alignment[74]. Block-based methods can be included in the consistency or probability-based[75] approach. A block can be referred to a sub-sequence, a segment, a region, or a fragment[76]. A fragment is defined as pairs of ungapped segments of the input sequences[77]. A weight score is assigned to each possible fragment to find the consistent fragments with high overall sum of fragment scores. Those fragments are integrated from a pair-wise alignment into a multiple alignment.

Searching for these conserver blocks in many blocked-based methods is very time-consuming. Therefore, the key issue is how to construct the possible set of blocks efficiently[75].

Some of the previous algorithms such as those undertaken by Boguski et al.,[78]; Miller,[79]; Miller et al.,[80] construct blocks either by pair-wise alignment or by those not matched by all the N sequences. Instead of starting from pair-wise alignments, Match-Box[81] aims to identify conserved blocks (or boxes) among the sequences without performing a pair-wise alignment. Similarly, Zhao and Jiang [74] introduced the BMA algorithm which allows for internal gaps and some degree of mismatch in the method used to identify the blocks.

Based on a combination of local and global alignment, Dialign[71],[82],[83] involves an extensive use of the segment-by-segment methods. It combines the local and global alignment features by identifying and adding the conserve regions (block) shared between the sequences based on their consistency weights.

Based on the anchored alignment, CHAOS[84] used fast local alignments as "seeds" for a slower global-alignment. CHAOS is used to improve DIALIGN[71] and LAGAN[85].

Recently, Wang et al.[75] produced a block-based algorithm called BlockMSA. It combined the biclustering and divide-and-conquer approaches to align the sequences.

#### *3)* Heuristic Optimization Approaches

Many optimization problems from various fields have been solved by using diverse optimization algorithms. Computational intelligence (CI) plays an important role in solving the sequence alignment problem. Recently,


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Evolutionary Algorithms have the advantage of operating on several solutions simultaneously, combining an exploratory search through the solution space with the exploitation of current results[15]. There are no restrictions on the sequence numbers or their length. It is very flexible in optimizing the solution with low complexity. Many efforts have attempted to solve the MSA problem using evolutionary programming[86], [87]. Since MSA has computational difficulty, there is no best method that can solve MSA professionally.

Heuristic optimization approaches include genetic algorithm, ant colony, swarm intelligence, simulating annealing, tabu search, and combinations thereof. In the following subsections, the several techniques of heuristic optimization approaches are explained to show how these techniques are applied to solve the MSA problems.

*a) Genetic Algorithm*

Genetic Algorithm (GA) is a heuristic search that performs an adaptive search to find optimal solutions of large-scale optimization problems with multiple local minima[15] using techniques that simulate natural evolution.

GA is well suited for solving some NP-complete problems such as MSA. Sequence Alignment by Genetic Algorithm (SAGA)[18] is the earliest GA to be used to solve MSA problems. With the GA approach there are different methods that can be applied to solve the MSA problem such as the one used in[13], [12],[17],[88],[19],[20].

Some methods are a hybrid with other approaches. Zhang and Wong[89] presented a method that used pair-wise dynamic programming (DP) technique based on GA. Similarly, utilizing GA in a progressive approach has been presented in[90]. Later, Wang and Lefkowitz[91] produced the GenAlignRefine algorithm which uses a genetic algorithm to improve local region alignment which leads to improving the overall quality of global multiple alignments. In[92] GA is used as an iterative method to refine the alignment score obtained by the progressive method. The use of GA to find the cut-off point in the divide-and-conquer approach is presented in[93]. Using similar combinations, a novel algorithm of genetic algorithm with ant colony optimization GA-ACO was presented by Lee et al.[94]. Chen et al.[95] reported a method which employs a new selection scheme to avoid premature convergence in GAs. Taheri and Zomaya[96] presented RBT-GA using a combination of the Rubber Band Technique (RBT) and the Genetic Algorithm (GA). Jeevitesh et al.[97] proposed the PASA algorithm which used the alignment outputs of two MSA programs – MCoffee and ProbCons – and combined them in a genetic algorithm model.

*b) ANT* Colony

Ant colony optimization algorithm (ACO) is a probabilistic technique for solving computational problems. It is one of the swarm intelligence families. The ACO algorithm is used as a new cooperative search algorithm in solving optimization problems. ACO was inspired from the observation of the activities of real ants[98],[99],[100]. Recently, ACO is used to solve the NP-complete problems.

It shows efficiency in solving the MSA problems such as those reported in[101],[102] where each proposed algorithm was based on the ant colony optimization and divide-and-conquer technique. Other researchers such as[103],[104],[27],[105] relied on the ant colony to solve the MSA problem in their research work.

*c)* Particle Swarm Optimization

Particle swarm optimization (PSO) is a swarm intelligence technique for numerical optimization. It simulates the behaviour of bird flocking or fish schooling. PSO was presented by Kennedy and Eberhart[106] in 1995. The simplicity of implementation, quick convergence, and few parameters have resulted in PSO gaining popularity.

Many researchers have made modifications to the PSO idea and utilized this technique widely in solving MSA problems. Rasmussen and Krink[107] used a combination of particle swarm optimization and evolutionary algorithms to train HMMs for protein sequences alignment. Meanwhile, Pedro et al.[108] presented an algorithm based on PSO to improve a sequence alignment previously obtained using ClustalX. Juang and Su[109] produced an algorithm which combined the pair-wise DP and particle swarm optimization (PSO) to overcome the local optimum problems. Xu and Chen[110] designed an improved particle swarm optimization to solve MSA. Based on the idea of chaos optimization Lei et al.[111] produced chaotic PSO (CPSO) to solve MSA. A novel algorithm of mutation-based binary particle swarm optimization (M-BPSO) was presented by Hai-Xia et al.[112] for solving MSA.

*d)* Simulated Annealing

Simulated annealing (SA) was described by Kirkpatrick[113]. Simulated annealing is an algorithm that attempts to simulate the physical process of annealing. The basic concept of simulated annealing algorithms is based on observing the change of energy in which materials solidify from the liquid state to the solid state[114].

Several SA algorithms have been used to solve MSA problem. Kim et al.[115] used simulated annealing to develop the MSASA algorithm for solving MSA. Uren et al,[116] presented MAUSA that used simulated annealing to perform a search through the space of possible guide trees. Meanwhile, Keith et al.[117] described a new algorithm for finding a consensus sequence by using the SA method. Omar et al.[118] produced a combination of Genetic Algorithm and Simulated Annealing to solve MSA problems. Roc[114] presented a method for multiple DNA sequence alignment in which an optimal cut-off point is chosen by the genetic simulated annealing (GSA) techniques. Joo et al.[119] presented a new method called MSACSA for MSA, which is based on the conformational space annealing (CSA). CSA combines three traditional global optimization methods, that is, SA, genetic algorithm (GA), and Monte Carlo with minimization (MCM).

*e)* Tabu Search

Tabu search is a meta-heuristic approach used to solve combinatorial optimization problems. Tabu search (TS) and simulated annealing are similar in that both traverse the solution space by testing mutations of an individual solution. However, they differ in the number of generated solutions.


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While simulated annealing generates only one mutated solution, tabu search generates many mutated solutions and moves to the solution with the lowest energy of those generated. TS has been used to solve MSA problems. Riaz at el.[120] has implemented the adaptive memory features of tabu search to refine MSA. Lightner[121] used a tabu search approach to obtain multiple sequence alignment and explored iterative refinement techniques such as the hidden Markov model and the intensification heuristic approach to further improve the alignment.

### F. Summary of Related Algorithms for MSA

Table 2 lists the most current algorithms that are in use. This list is incomplete but includes the most related algorithms explained above. Online availability is the link to the online server or the site which can download and access the particular algorithm.

TABLE II. CURRENT MSA ALGORITHMS

| Algorithm | Approach | RNA | Online Availability | Reference |
|---|---|---|---|---|
| MAFFT | Consistency | Y | http://mafft.cbrc.jp/alignment/server/ | [122] |
| MUSCLE | Progressive/ refinement | Y | http://www.ebi.ac.uk/Tools/msa/muscle/ | [123] |
| Dialign2 | Consistency/ segment | Y | http://bibiserv.techfak.uni-bielefeld.de/cgi-bin/dialign_submit | [71] |
| Align-m | Consistency | N | http://bioinformatics.vub.ac.be/software/software.html | [42] |
| BlockMSA | 3-way consistency/ Block/DCA | Y | http://aug.csres.utexas.edu/msa/ | [75] |
| MAUSA | SA | N | http://eprints.utas.edu.au/208/ | [116] |
| SAGA | Iterative/Stochastic/GA | Y | http://www.tcoffee.org/Projects_home_page/saga_home_page.html | [18] |
| Mishima | k-tuple | Y | http://esper.lab.nig.ac.jp/study/mishima/ | [124] |
| MSAProbs | Pair-HMM and partition function | Y | http://sourceforge.net/projects/msaprobs/ | [72] |
| pecan | Consistency/ progressive | - | http://www.ebi.ac.uk/~bjp/pecan/ | [43] |
| PicXAA | posterior probability/ consistency | Y | http://www.ece.tamu.edu/~bjyoon/picxaa/ | [48] |
| PRIME | GROUP-TO-GROUP/ ANCHOR | Y | http://prime.cbrc.jp/ | [37] |
| ProAlign | HMM/ progressive | Y | http://applications.lanevol.org/ProAlign/ | [125] |
| PROBCONS | posterior probability pair-hmm | N | http://probcons.stanford.edu/index.html | [38] |
| ProDA | repeated and shuffled elements | Y | http://proda.stanford.edu/ | [47] |
| Probalign | posterior probabilities | Y | http://probalign.njit.edu/probalign/login | [46] |
| REFINER | Refinement/ Block | - | ftp://ftp.ncbi.nih.gov/pub/REFINER | [126], [127] |
| AIMSA | Region | - | - | [128] |
| PRALINE | Profile/iterative /progressive | - | http://www.ibi.vu.nl/programs/pralinewww/ | [129] |
| T-COFFEE | Consistency/ Progressive | Y | http://www.tcoffee.org/ | [40] |
| MUMMALS | Probability HMM | N | http://prodata.swmed.edu/mummals/mummals.php | [44] |
| PROMALS | *k*-mer/ Pair-HMM consistency | Y | http://prodata.swmed.edu/promals/promals.php | [45] |
| PCMA | *k*-mer/ Profile/consistency | - | ftp://iole.swmed.edu/pub/PCMA/pcma/ | [73] |
| BMA | Conserve block | Y | - | [74] |
| GA-ACO | GA and Ant colony | - | - | [94] |
| PASA | Refine by GA | - | - | [97] |

### G. Harmony Search Algorithm

Harmony search algorithm (HS) is developed by Geem[130]. HS is a meta-heuristic optimization algorithm based on music.

HS simulates a team of musicians together trying to seek the best state of harmony. Each player generates a sound based on one of the three options (memory consideration, pitch adjustment, and random selection). This is the equivalent of finding the optimal solution in an optimization process.

Geem et al.[130] models HS components into three quantitative optimization processes as follows:


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- The Harmony memory (HM): It is used to keep good harmonies. A harmony from HM is selected randomly based on the parameter called harmony memory considering (or accepting) rate, HMCR Є [0,1]. It typically uses HMCR = 0.7 ~ 0.95.
- The pitch adjustment: It is similar to a local search. It is used to generate a slightly different solution from the HM depending on the pitch-adjusting rate (PAR) values. PAR controls the degree of the adjustment by the pitch bandwidth (brange). It usually uses PAR = 0.1~0.5 in most applications.
- The random selection: A new harmony is generated randomly to increase the diversity of the solutions. The probability of randomization is Prandom = 1- HMCR , and the actual probability of the pitch adjustment is Ppitch = HMCR × PAR.

The pseudo code of the basic HS algorithm with these three components is summarized in Figure 2.

**Harmony Search Algorithm**

```
Begin
    Declare the objective function f(x), x =(x1,x2, …,xn)
    Initialize the harmony memory accepting rate (HMCR)
    Initialize pitch adjusting rate (PAR) and other parameters
    Initialize Harmony Memory with random harmonies
    While (t<max number of iterations )
            If (rand<HMCR),
              Choose a value from HM
                 If (rand<PAR), Adjust the value by adding certain amount
                 End if
            Else choose a new random value
            End if
        End while
        Calculate the objective function
        Accept the new harmony (solution) if better
        Update HM
    End while
    Find the current best solution in HM
End
```

Figure 2. Pseudo Code of the Harmony Search Algorithm[131]

Later, Geem[132] proposed an ensemble harmony search (EHS) where a new ensemble consideration operation is added to the original HS structure. The new operation takes into account the relationship among the decision variables, and the value of each decision variable can be chosen based on the other variables.

Thereafter, Mahdavi et al.[133] produced an improved harmony search (IHS), in which the parameter PAR and pitch bandwidth are adjusted dynamically in the improvisation step.

So far, Omran and Mahdavi[134] have proposed a global-best harmony search (GHS) in which the performance of HS is improved by borrowing the concepts from swarm intelligence to modify the pitch-adjustment step such that the new harmony is assigned by the best harmony in the HM.

Meanwhile, Pan at el.[135] produced a local-best harmony search algorithm with dynamic subpopulations (DLHS) for solving continuous optimization problems. The DLHS algorithm differs from the existing HS in that a whole harmony memory (HM) is divided into many sub-HMs and the independent processes are performed in each sub-HM. A periodic regrouping schedule is used to exchange information between the sub-HMs, so that the population diversity and the improvement in the accuracy of the final solution are maintained. In addition, the parameters are adjusted using a new developed adaptive strategy to enable it to be used with a particular problem or phase of the search process.

Recently, Zou at el.[136] proposed a novel algorithm known as a global harmony search algorithm (NGHS) to solve reliability problems.

NGHS modifies the improvisation step of the HS. Position updating and genetic mutation are new operations included in NGHS. Position updating enables the worst harmony of HM to move toward the global best harmony rapidly while genetic mutation prevents NGHS from becoming trapped into the local optimum.

## III. THE PROPOSED ALGORITHM

Herein, in this article several algorithms are proposed to solve the MSA problem by using the adapted harmony search algorithm (HS). Adaptive HS for MSA is explained in the next subsection 3.1. A modified HS algorithm for reducing search space is explained in subsection 3.2. Subsection 3.3 describes the HS Improver. Finally, in subsection 3.4 a parallel HS-MSA is introduced which can be implemented in different parallel platforms such as the Multi-core and GPU. Figure 3 shows the stages of the proposed research framework.

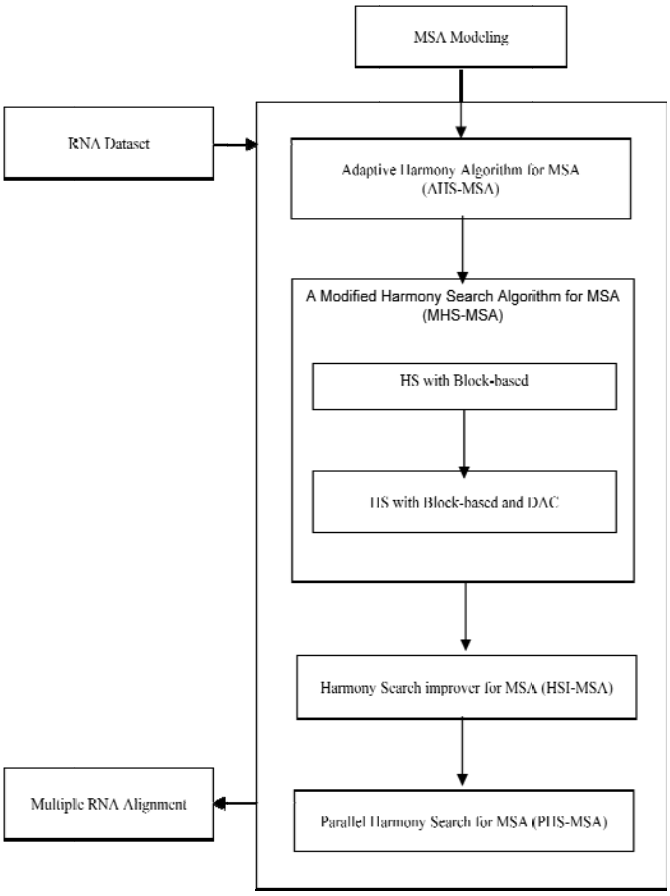


Figure 3. Research Framework.


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### A. Proposed Harmony Search Algorithm for MSA

The main goal of the MSA algorithms is to detect and align the homologous regions across the different sequences. This is achieved by optimizing an objective function that measures the quality of the alignment. The harmony search is a new meta-heuristic optimization algorithm which has a history in solving NP-complete problems[137]. This subsection explains the ability of the harmony search algorithm in solving MSA problem. Herein alignment representation, objective function, harmony memory initialization, and adaptive harmony search algorithm for MSA are explained in greater details.

*1)* Alignment Representation

Alignment of N sequences with different lengths from $L_1$ to $L_N$, are represented as a matrix N x W where each row contains gap positions encoded for each sequence. The length of the rows in the matrix is W = [αLmax], where Lmax = max $\{L_1,L_2,..,L_N\}$, and [x] is the smallest integer greater than or equal to x, and the parameter α is a scaling factor[86]. The value α is chosen according to the probability distribution. The value of α can be 1.2 as used in[94] or 1.5 as used in[138],[13],[20]. The choice of 1.2 is to allow the aligned sequences to be 20% longer than the longest sequence. Meanwhile the selection of 1.5 is to allow the alignment to be 50% longer than the longest sequence in the test as in [138].

*2)* Objective Function

To find the optimal solution in the HS-MSA, the sum-of-pairs (SP) score described in[139],[140],[10],[107] will be used to calculate the Objective Function (OF) where there is no prior knowledge of the reference alignment. The general form of the OF score of alignment n sequences which consists of M columns is:

$$OF = \sum_{i=1}^{l} \{S_n(m_i) - G_n(m_i)\},$$

where $S_n(m_i)$ is the similarity score of the column mi, $G_n(m_i)$ is the gap penalty of the column mi and l is the sequence length. The similarity score of the column mi can be measured by the sum-of-pairs (SP). The SP-score S(mi) for the i-th column mi is calculated as follows:

$$S(mi) = \sum_{j=1}^{n-1} \sum_{k=j+1}^{n} s(m_i^j, m_i^k),$$

where $m_i^j$ is the j-th row in the i-th column. For aligning two residues x and y, the substitution matrix s(x,y) is used to give the similarity score.

*3)* Harmony Memory Initialization

For a given 5 sequences, the procedure to initialize the harmony memory is as follows: Maximum sequence length is MaxS = 7, minimum sequence length is MinS = 4, maximum length of alignment is W = [1.2 * 7] = 9, maximum gaps in sequence Si is (W – $L_i$) where Li is the length of sequence i, maximum number of gaps is Gs = 9 – 4 = 5.

| Sequence | | | | | | | Length $L_i$ | Generate Gap Positions (W-$L_i$) | Gap positions in Sort ascending (W-$L_i$) |
|---|---|---|---|---|---|---|---|---|---|
| A | U | C | A | A | | | 5 | 4187 | 1478 |
| U | A | A | U | C | A | A | 7 | 32 | 23 |
| A | U | C | A | | | | 4 | 34789 | 34789 |
| U | A | A | U | C | A | U | 7 | 62 | 26 |
| A | U | G | A | U | U | | 6 | 729 | 279 |

A. Gaps Position

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| - | A | U | - | C | A | - | - | A |
| U | - | - | A | A | U | C | A | A |
| A | T | - | - | C | A | - | - | - |
| U | - | A | A | U | - | C | A | U |
| A | - | U | G | A | U | - | U | - |

B. Aligned sequence

Figure 4. Harmony memory initialization

The initial harmony memory is randomly generated and the rows are initialized in the following way: First, a random permutation number W-Li of gap positions is generated from a range of values (1 – W) for each sequence Si with length $L_i$. Second, those numbers (W-$L_i$) are sorted and used to indicate where the corresponding gaps are placed in the matrix. Finally, the positions in the matrix rows which are not associated by gaps are filled with the base symbols taken from the original sequence.

The random initialization procedure that produces the initial Harmony memory is illustrated in Figure 4. This is similar to the procedure used in [94]. The difference in our procedure is that the gap positions are generated and not the residue positions as in[94]. The generation gap positions are less than the generation residue positions for each sequence. The second difference is related to the first step in that the number of permutations are (W-$L_i$) and not W as in[94].

*4)* Adaptive Harmony Search Algorithm for MSA (AHS-MSA)

The purpose of AHS-MSA is to aid scientists in producing a high quality of MSAs that may lead to a better RNA structure prediction (Figure 5) as well as other issues in molecular biology. To date in reviewing the approaches to solving the MSA problem or in predicting the multiple RNA secondary structure, we have found that no studies have incorporated the use of the harmony search algorithm. The only research that


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has involved HS in bioinformatics is that of Mohsen et al.[141] which predicted the secondary structure for a single RNA sequence based on Minimum Free Energy.

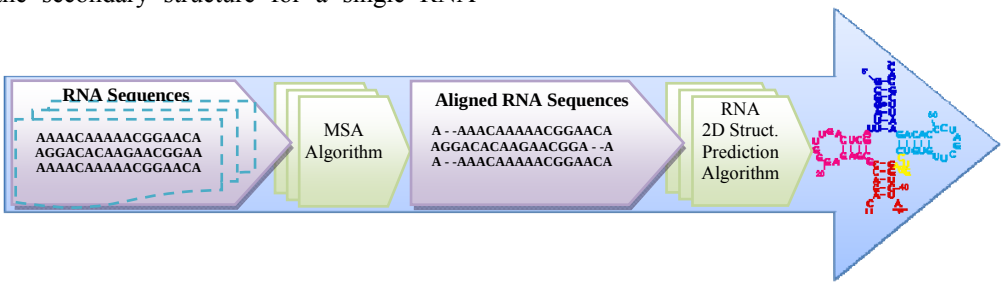


Figure 5. The impact of MSA in RNA secondary structure prediction

The HS algorithm has been successfully applied to several optimization problems[142]. As such this study aims to investigate the use and adaption of the HS algorithm in finding solutions to the MSA problems. The MSA problem can be considered as an optimization problem with minimal disruption of the accuracy, complexity, and speed rules. MSA can be resolved by adapting the harmony search algorithm. Moreover, HS possesses several advantages over conventional optimization techniques[143] such as:

1. HS does not require initial value settings for decision variables;
2. HS is a population-based meta-heuristic algorithm, which means that a group of multiple harmonies can be used simultaneously. Proper parallelism usually leads to better performance with higher efficiency and speed;
3. HS uses stochastic random searches which explore the search space more widely and efficiently;
4. HS does not need derivation information;
5. HS is less sensitive to chosen parameters;
6. HS can solve various NP-complete problems[137];
7. The structure of the HS algorithm is relatively easier;
8. HS is a very successful meta-heuristic algorithm due to its way of handling intensification and diversification.
9. HS is very versatile being able to combine with other meta-heuristic algorithms[134]

These characteristics increase the reliability and flexibility of the HS algorithm in producing better solutions.

The AHS-MSA algorithm as described in Figure 6 combines and adapts the HS idea to solve the MSA problem. The steps of the AMS-MSA algorithm are as follows:

1. Initialize the harmony parameters (HMCR, PAR, NI, and HMS).
2. Initialize the harmony memory with random harmonies by HMS solution. Each solution is an alignment.
3. Calculate the objective function (OF) for each harmony.
4. Improvise the new harmony.
5. Accept/reject the new harmony
6. Update the harmony memory.

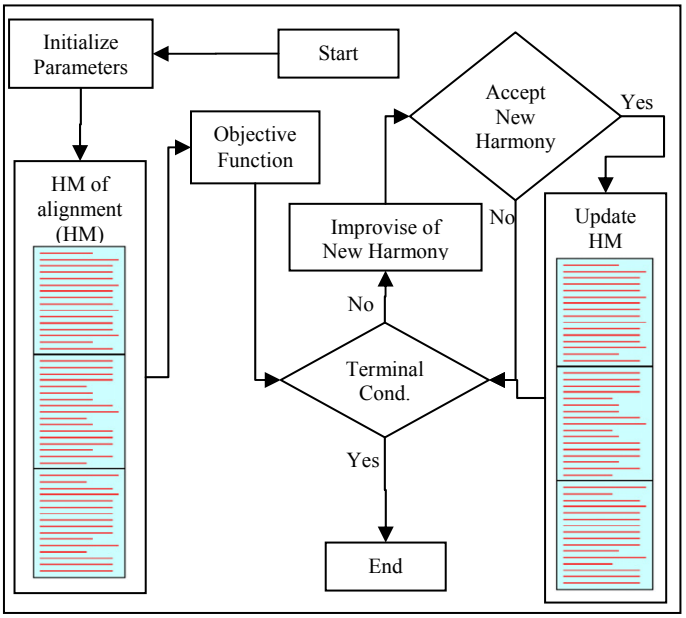


Figure 6. The flowchart of the proposed HS-MSA algorithm

### *B. A Modified Harmony Search Algorithm for MSA (MHS-MSA)*

To reduce the search space, a combination of methods is proposed. A hybrid method of HS and a segment-based approach is proposed and explained in the next subsection 3.2.1. In subsection 3.2.2, a hybrid method of HS and a combination of segment-based and divide-and-conquer approaches are proposed and explained.

#### *3.2.1 A Harmony Search algorithm with a Segment-based Approach*

Lately identifying areas of local conservations before finding the global alignment is gaining popularity among researchers. Conserved regions can be a helpful guide in identifying the homology of sequences and assisting the process of MSA. This idea is not new and has been implemented in other algorithms such as DIALIGN[49], MLAGAN[85], CHAOS[84], align-m[42], and MAFFT[144] where blocks are first detected from the pair-wise sequence alignment and that information is then used to detect MSA. The other algorithm, such as MISHIMA[124], also used this idea in


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which k-tuple is explored and analyzed from the original sequence. In the same way, well-aligned regions were seen in RASCAL[51],[128] where a consistency-based objective function called NorMD[50] was used.

Herein, this proposed method in our research is to reduce the search space in the previous AHS-MSA algorithm by combining pair-wise alignments into multiple alignments. It works by finding the conserved blocks through all the sequences before starting the MSA process. It explores all possible regions, which is more correct and consistent. All matched blocks are used to guide the MSA alignment. The idea is first to detect the conserved blocks in the sequences pair-wise and then to apply HS to identify MSA from those conserved columns.

The multiple alignment search space can be narrowed down to a number of possible regions per sequence pair. If parts of these residue pair are consistent within each other, they are considered as acceptable. For consistency it means that if symbol $A_i$ (residue i of sequence A) is aligned correctly with symbol $B_j$ , and $B_j$ with $C_k$, then $A_i$ and $C_k$ should also be aligned. Therefore, this property can be used to define the consistent parts among all the pair-wise alignments which can be considered as acceptable, and the gap positions can be defined at the rest of the aligned residue pairs.

The ability to determine the well-aligned regions has at least two advantages. It prevents the same region from being changed in the later process. Additionally, it speeds up the optimization process. The modified steps of the HS-MSA algorithm can be summarized as follows:

1. Find all possible residue pairs in each sequence pair using the pair-wise algorithm.
2. By using the consistency concept, find all possible blocks or columns that are acceptable.
3. Calculate the score value for each block by using the sum-of-pairs objective function.
4. Identify and analyze the potentially useful blocks, and select those that are more consistent with each other.
5. Apply the HS algorithm to initialize the final alignment from these blocks and find the optimal alignment.

#### *3.2.2 A Harmony Search algorithm with Segment-based and Divide-and-conquer Approaches*

The previous proposed method can be extended where the divide-and-conquer (DAC)[145] method can be combined.

Sammeth at el.[146], and Kryukov and Saitou[124] used the DCA approach in solving MSA. Kryukov and Saitou[124] produced the adapted DCA in which k-tuple is used to find the segments and align these segments by CLUSTALW and MAFFT. Sammeth at el.[146], on the other hand, integrated the global divide-and-conquer approach with the local segment-based approach as in DIALIGN.

A set of consistent columns can form segments in the alignment. The DCA protocol is to cut the sequences at a point and repeat that cutting procedure until it is no longer exceeded. Then the obtained sub-sequences are aligned independently and the results are combined to form a complete MSA alignment. The method proceeds as follows:

1. Find all possible residue pairs in each sequence pair using the pair-wise algorithm.
2. By using the consistency concept, find all the possible blocks or columns that are acceptable.
3. Calculate the score value for each column by using the sum-of-pairs objective function.
4. Identify and analyze the potentially useful columns, and select those that are more consistent with each other.
5. Add these conserve blocks/fragments to the fragments set F and they can be considered as cutting points.
6. Divide the sequence into sub-sequence based on these cutting points.
7. Apply the HS algorithm to construct the final alignment from these regions and find the optimal one.

### *C. A Harmony Search Algorithm Improver for MSA (HSI-MSA)*

Another proposed method in our research work is the use of HSI-MSA to combine many multiple alignments into one improved alignment. Any conventional MSA program or a combination of them can initialize the Harmony memory. Then the Harmony algorithm can be applied as an iterative method to refine/combine the alignment to find the best alignment result. Here HS takes on the role of an improver of the accuracy of the current alignment. The goal of this study is to investigate whether this approach is going to improve the accuracy of the different alignments or not. This improver idea is similar to the PASA algorithm[97] which was used a genetic algorithm model to combine the alignment outputs of two MSA programs – M-Coffee and ProbCons. It has also been used in ComAlign[147], M-Coffee[148] and AQUA[52] . The proposed method can be summarized as follows:

1. Initialize the harmony memory by using well-known MSA algorithms including our alignment gained from the previous step.
2. Calculate the score for each alignment.
3. Apply the HS algorithm to improve and find the optimal alignment.

This will combine all the alignment parts from the different alignments to find the optimal alignment within them and not just to select the best of them.

### *D. A Parallel Harmony Search Algorithm for MSA (PHS-MSA)*

In addition to the foregoing proposed methods, another way to reduce the computational complexity and time consumed is to parallel the HS-MSA algorithm using multi-core and multi-GPU platforms.

CUDA (Compute Unified Device Architecture) is an extension from C/C++ developed by NVIDIA to run thousands of threads parallelly[149] and to execute on the GPUs[150]. GPUs' architectures are "manycore" with


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hundreds of cores[149]. GPUs were implemented as a streaming processor.

It is a good alternative for high performance computing and it will become even more excellent in the near future. Furthermore, availability, low price, and easy installation are the main advantages[151] of the GPUs compared to other architecture.

Re-developing the algorithm and the data structure based on computer graphic concepts is the main obstacle facing the use of the GPUs[151],[152]. Moreover, other limitations are based on the streaming architecture which have to be taken into consideration (i.e. memory random access, cross fragment, persistent state)

Many researchers have shown the design and implementation of bioinformatics algorithms using GPUs. Examples that use GPU to parallel sequence alignment algorithm in bioinformatics are[153], [154], [151], [155], [156], [157].

Our approach is motivated by the rapidly increasing power of GPU. Our proposed approach is to implement the proposed HS-MSA algorithm using NVIDIA's GPUs, to explore and develop high performance solutions for multiple sequence alignment. To program the GPU, the HS-MSA will be implemented in NVIDIA GeForce 9400 GT CUDA. The computation will be conducted on NVIDIA GPUs installed in a 2.66 GHz intel Core 2 Quad CPU computer equipped with 3 GB RAM, running on Microsoft Windows XP Professional.

Moreover, to utilitize multiple CPU threads to incorporate GPU devices into one single program, the proposed method can be extended to use a hybrid multi-core and GPU codes by CUDA and OpenMP. This can lead to quicker implementation and greater efficiency on both GPU and multi-core CPU[158].

## IV. Evaluation and Analysis

To evaluate and analyse the performance of the proposed HS-MSA algorithm in greater depth there is a need for an objective criterion to assess the quality of the aligned sequences. The quality attained can be evaluated by comparing the results of the test alignment with the reference alignment[139].

The comparison can use some scores that may be dependent on the alignment itself (e.g, Sum-of-Pairs, Total Column Score) or independent from it (structure sensitivity and selectivity). This subsection describes in detail the benchmark dataset, the reference comparison, the alignment comparison and the structure comparison, which can be investigated to evaluate the test alignments.

### A. Benchmark Dataset

The proposed algorithm will be tested using the following datasets: Rfam, BRAliBase 2.1, Comparative RNA website (CRW), the Ribonuclease P database, 5S Ribosomal RNA database, tmRNA , tRNA , SRPDB, RNAdb, and ncRNA as explained in section 2.6. Different RNA datasets will be used from a variety of families and lengths such as 5S (5S.B.alphaproteobacteria, 5S.B.betaproteobacteria, 5S.B.actinobacteria), 16S (16S.B.fibrobacteres, 16S.E.entamoebidae, 16S.E.perkinsea) ribosomal RNA.

### B. Reference Comparison

To assess the quality of the aligned sequence, it requires a reference alignment from the database benchmark. The comparison is between the test alignment and the reference alignment.

Sum-of-pairs (SPS) and column Score (CS) are two different score functions that can be used to estimate this comparison. The SPS score is the percentage of the correct aligned residue pairs in the test alignment that occurred in the reference alignment[159]. The CS score is the percentage of the entire columns in the test alignment that occurred completely in the reference alignment[159].

In a given test alignment consisting of M columns, the ith column is denoted by $A_{i1}, A_{i2}, \ldots, A_{iN}$ where N is the number of sequences. For each pair of residues $A_{ij}$ and $A_{ik}$, $p_i(j,k)$ is defined such that $p_i(j,k) = 1$ if residues $A_{ij}$ and $A_{ik}$ from the test alignment are aligned with each other in the reference alignment, otherwise $p_i(j,k) = 0$. The Score of the $i^{th}$ column can be calculated as follows:

$$Si= \sum_{j=1}^{N} \sum_{k=1,k\neq j}^{N} P_i(j,k).$$

Then, the sum-of-pairs score for a given test alignment can be calculated as follows:

$$\text{Sum-of-Pairs (SPS)} = \frac{\sum_{i=1}^{M} S_i}{\sum_{i=1}^{Mr} S_{ri}},$$

where Mr is the number of columns in the reference alignment and Sri is the score Si for the ith column in the reference alignment.

Column score (CS): Using the same symbols as shown above, the score Ci of the ith column is equal to 1 if all the residues in that column are aligned in the reference alignment, otherwise it is equal to 0. Therefore, the column score is:

$$CS = \sum_{i=1}^{M} \frac{C_i}{M}$$

To compare the test alignment with the corresponding reference alignment, the sum-of-pairs function and column score are used as described in[139],[107],[160],[161],[162].

### C. Alignment Comparison

This comparison is to evaluate the performance of the proposed algorithm with respect to the other MSA aligners. Typically, the MSA aligners are validated by using a benchmark data set of reference alignments.

The Sum-of-pairs (SPS) and column scores (CS) of every produced alignment of each aligner program including our proposed algorithm are used to compare with the reference alignment.

The proposed algorithm HS-MSA can be compared to the commonly used MSA programs on the above reference alignment benchmark.


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### D. Structure Comparison

It might be expected that a more accurate alignment would lead to a more accurate RNA secondary structure. The proposed method is to investigate the impact of alignment accuracy on the accuracy of the RNA secondary structure using standard benchmarks and comparing them with the common well-known MSA algorithms.

Both the alignment process and the prediction process can affect the accuracy of the secondary structure prediction, but here only the alignment process is investigated.

The evaluation is performed in respect to sensitivity, selectivity or positive predictive value (PPV), and Mathews correlation coefficient (MCC) of the RNA secondary structure as used by Gardner and Giegerich[163]. The secondary structure of the test alignment produced by the proposed algorithm will be compared with that of others. The sensitivity and selectivity of the alignment process will be studied to investigate the effect of the proposed aligner on the accuracy of the structure as shown in Figure 7.

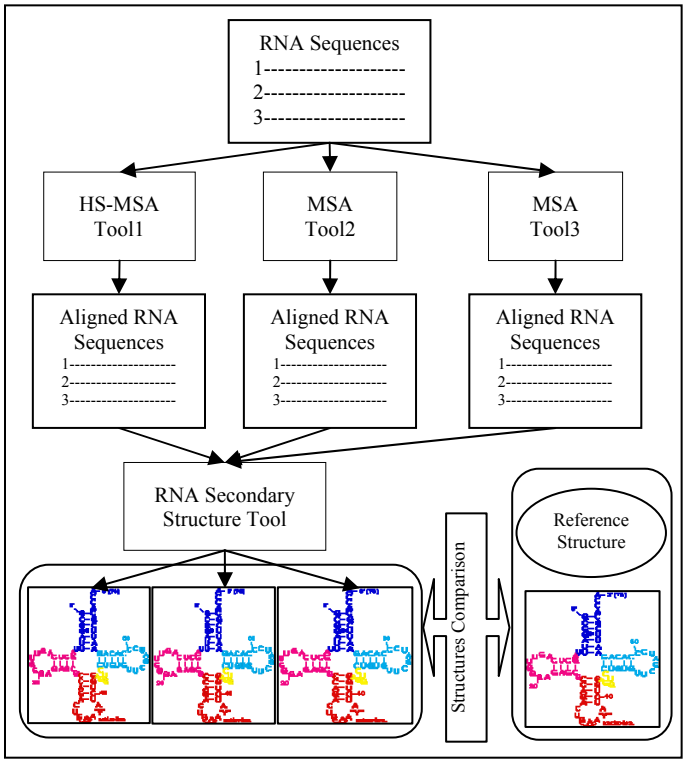


Figure 7. Structure comparison

## V. CONCLUSION

Multiple sequence alignment is a fundamental technique in many bioinformatics applications. Many algorithms have been developed to achieve optimal alignment. Some programs are exhaustive in nature; some are heuristic. Because exhaustive programs are not feasible in most cases, heuristic programs are commonly used. These include progressive, iterative, and block-based approaches.

This paper describes briefly the basic concepts of MSA and reviews the common approaches in MSA. To this end, this paper proposes a novel meta-heuristic method to solve the MSA problem. A meta-heuristic algorithm (HS-MSA), which has not been used up to now, is proposed for multiple sequence alignment that promises to greatly speed up the alignment process and improve its accuracy. The optimization method introduced herein is inspired by the so-called harmony search algorithm (HS). A new optimization algorithm for the combination of HS-MSA with segment-based multiple-alignment problem is also proposed and extended to include the parallel techniques.

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# HS-MSA: New Algorithm Based on Meta-heuristic Harmony Search for Solving Multiple Sequence Alignment

## Survey and Proposed Work

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**Abstract—Aligning multiple biological sequences such as in protein or DNA/RNA is a fundamental task in bioinformatics and sequence analysis. In the functional, structural and evolutionary studies of sequence data the role of multiple sequence alignment (MSA) cannot be denied. It is imperative that there is accurate alignment when predicting the RNA structure. MSA is a major bioinformatics challenge as it is NP-complete. In addition, the lack of a reliable scoring method makes it harder to align the sequences and evaluate the alignment outcomes. Scalability, biological accuracy, and computational complexity must be taken into consideration when solving MSA problem. The harmony search algorithm is a recent meta-heuristic method which has been successfully applied to a number of optimization problems. In this paper, an adapted harmony search algorithm (HS-MSA) methodology is proposed to solve MSA problem. In addition, a hybrid method of finding the conserved regions using the Divide-and-Conquer (DAC) method is proposed to reduce the search space. The proposed method (HS-MSA) is extended to a parallel approach in order to exploit the benefits of the multi-core and GPU system so as to reduce computational complexity and time.**

***Keyword: RNA, Multiple sequence alignment, Harmony search algorithm.***

### I. INTRODUCTION

Living organisms are related to each other throughout evolution. A pair of organisms sometimes has a common ancestor in the past from which they were evolved. MSA tries to discover the similarities among the sequence and recover the mutations that took place.

A sequence is an ordered list of symbols from a set of letters of the alphabet, S (20 amino acids for protein and 4 nucleotides for RNA/DNA). In bioinformatics, a RNA sequence is written as s = AUUUCUGUAA. It is a string of nucleotides symbols comprising adenine (A), cytosine (C), guanine (G) and uracil (U): S = {A, C, G, U}.

Alignment is a method to arrange the sequences one over the other to show the match and mismatch between the residues. A column which has match residues shows that no mutation has occurred whereas a column with mismatch symbols indicates that several mutation events are happening. To improve the alignment score, the character "–" is used to correspond to a space introduced in the sequence. This space is usually called a gap. The gap is viewed as an insertion in one sequence and deletion in the other. A score is used to measure the alignment performance. The highest score of one indicates the best alignment.

For clarity's sake, the generic MSA problem is expressed using the following declaration: "Insert gaps within a given set of sequences in order to maximize a similarity criterion"[1]. Finding an accurate MSA from the sequences is very difficult. It is a time consuming and computationally NP-hard problem[2, 3]. The MSA problem can be divided into three difficulties, that is, scalability, optimization, and objective function.

In fact, the complexity that arises from all the three problems must be solved simultaneously. The first problem, scalability, is about finding the alignment of many long sequences. The second problem, optimization, deals with finding the alignment with the highest score based on a given objective function among the sequences. Optimization of even a simple objective function is an NP-hard problem. The third problem, the objective function (OF), involves speeding up the calculation in order to measure the alignment.

MSA covers two closely related problems: global MSA and local MSA. Global MSA aligns sequences across their whole length while local MSA aligns certain parts of the sequences, and locates conserved regions along with them as shown in Figure 1.

Figure 1. Global and local MSA



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In bioinformatics, MSA is a major interesting problem and constitutes the basis for other molecular biology analyses. MSA has been used to address many critical problems in bioinformatics. Studying these alignments provides scientists with information needed to determine the evolutionary relationships between them, find the sequences of the family, detect the structure of protein/DNA, reveal the sequence homologies, predict the functions of protein/DNA sequences, and predict the patient's diseases or discover drug-like compounds that can bind to the sequences.

In general, the primary step in the secondary structure prediction is through MSA, particularly in the prediction of the structure of RNA sequences. The RNA structure prediction method is extremely affected by the quality of the alignment[4]. Indeed, prediction of an accurate RNA secondary structure relies on multiple sequence alignments to provide data on co-varying bases[5]. MSA significantly improves the accuracy of protein/RNA structure prediction. For example, current RNA secondary structure prediction methods using aligned sequences have been successful in gaining a higher prediction accuracy than those using a single sequence[6]. Nucleic acid sequences are of primary concern in our proposed method to evaluate and improve the influence of the alignment tools on RNA secondary structure prediction.

Many different approaches have been proposed to solve the MSA problem. Dynamic programming, progressive, iterative, consistency and segment-based approaches are the most commonly used approaches[7]. Although many MSA algorithms are available, a solution has yet to been found that is applicable to all possible alignment situations[7].

It is well-known fact that the MSA problem can be solved by using the dynamic programming (DP) algorithm[8, 9]. Unfortunately, such an approach is notorious for its large consumption of processing time. DP methods with the sum-of-pairs score have been shown to be a NP-complete problem[10],[11]. Algorithms that provide the optimal solution is time consuming and have a running time that grows exponentially with the increase in the number of sequences and their lengths.

In essence, all widely used MSA tools seek an alignment with a high sum-of-pairs score. This optimization problem is NP-complete[2, 3] and thus motivates the research into heuristics. Over the last decade, the evolutionary and meta-heuristic approaches are one of the most recent approaches that have been used to solve the optimization problem. Evolutionary and meta-heuristic algorithms have been used in several problem domains, including science, commerce, and engineering. Consequently, most of the practical MSA algorithms are based on heuristics to obtain a reasonably accurate MSA within a moderate computational time and that which usually produces quasi-optimal alignment. Although many algorithms are now available, there is still room to improve its computational complexity, accuracy, and scalability.

In this paper, a novel algorithm (HS-MSA), that is, a meta-heuristic technique known as harmony search algorithm, is proposed to solve the old MSA problem. The MSA problem is viewed as an optimization problem and can be resolved by adapting a harmony search algorithm. Since the search space in HS is wide, a modified algorithm is proposed (MHS-MSA) to find the conserved blocks using well-known regions, and then align the mismatch regions between the successive blocks to form a final alignment. HS-MSA is extended to include the divide-and-conquer (DCA) approach in which DCA is used to cut and combine the sub-sequence to form the final MSA. Another proposed technique is to use the harmony search algorithm as an MSA improver (HSI-MSA) in which the initial alignment can be obtained from the conventional algorithms or their combinations. HS-MSA can be extended to the parallel algorithm (PHS-MSA) in order to exploit the benefits of the multi-core and GPU system to reduce computational complexity and time.

This paper is organized as follows: Section 2 reviews the related literature and describes the state-of-the-art MSA approaches. Section 3 explains the proposed algorithm. The evaluation and analysis methodology that is used to assess our proposed algorithm is explained in Section 4. Lastly, Section 5 provides the conclusion and summary of the paper.

## II. LITERATURE REVIEW

There are several MSA algorithms reported in the literature review. For a deeper understanding about the MSA algorithms, the basic concepts of MSA alignment representation, gap penalty, alignment scores, dataset benchmarks, MSA approaches, and harmony search algorithm need to be understood. As such subsection 2.1 briefly reviews the representation of MSA alignment followed by the details about gap penalty in subsection 2.2. The alignment scores, RNA datasets and benchmarks, and current MSA approaches are explained in subsections 2.3, 2.4 and 2.5 respectively. Subsection 2.6 provides a summary of the MSA algorithms and concludes with the harmony search algorithm in subsection 2.7.

### *A. Representation of MSA Alignment*

There are several ways to represent a multiple sequence alignment. Usually, the final sequences are an aligned listing of the entire sequence of one over the other. However, during the alignment process, it is helpful to represent the alignment of the sequences in a manner known as a representation. Some of the representations that have been used in previous algorithms include a bit matrix as used in[12], a matrix of gaps position as used in[13], multiple number-strings as used in[14],[15],[16],[17], string representation[18],[19],[20] as used in SAGA[18], four parallel chromosomes as used in[21], directed acyclic graph (DAG) as used in[22, 23], A-Bruijn graph as used in[24-26] , and dispersion Graph as used in[27].

### *B. Gaps Penalty*

A negative score or a penalty can be assigned to a set of gaps. Two types of gaps which were mentioned in the previous reviews[28] are defined as follows:

- Linear gap model – in this model a Gap is always given the same penalty wherever it is placed in the alignment. The penalty is proportional to the length of the gap and is


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given by gap = n×go, where go < 0 is the opening penalty of a gap and n is the number of consecutive gaps.

- Affine gap model – in this model both the new gap and extension gap are not given the same penalty. The insertion of a new gap has a greater penalty than the extension of an existing gap and is given by gap = go + (n − 1) × ge, where go < 0 is the gap opening penalty and ge < 0 is the gap extension penalty and are such that |ge| < |go|.

### C. Alignment Score

The MSA objective function is defined for assessing the alignment quality either explicitly or implicitly. An efficient algorithm is used to find the optimal or a near optimal alignment according to the objective function. Matches, mismatches, substitutions, insertions, and deletions need to be scored in the scoring function. The scoring function can be divided into two parts: substitution matrices and gap penalties. The former provides a numerical score for matches and mismatches while the latter allows for numerical quantification of insertions and deletions. All possible transitions between the 20 amino acids, or the 4 nucleic acids are represented in a substitution matrix which is an array of two dimensions of 20 x 20 for amino acid and 4 x 4 for nucleic acids.

Usually a simple matrix used for DNA or RNA sequences involves assigning a positive value for a match and a negative value for a mismatch[20]. Meanwhile, the scores for protein aligned residues are given as log-odds[29] substitution matrices such as PAM[30], GONNET[31], or BLOSUM[32].

There are several models for assessing the score of a given MSA. Many MSA tools have adopted the score method. A brief review of the score method that has been used to calculate the alignment score is as follows:

- Sum-of-Pairs (SP): It was introduced by Carrillo and Lipman[10]. More details about the sum-of-Pairs will be presented later.
- Weighted sum-of-pairs score[33],[34]: The weighted sum-of-pairs (WSP) score is an extension of the SP score so that each pair-wise alignment score contributes differently to the whole score.
- Maximal expected accuracy (MEA)[35]: The basic idea of MEA is to maximize the expected number of "correctly" aligned residue pairs[36]. It has been used in PRIME[37], and ProbCons[38] algorithms.
- Consistency-based Scoring: This consistency concept was originally introduced by Gotoh [9] and later refined by Vingron and Argos[39]. Consistency-based scoring is used in T-Coffee[40], MAFFT[41], and Align-m[42] algorithms.
- Probabilistic consistency Scoring function: This scoring function is introduced in ProbCons[38]. It is a novel modification of the traditional sum-of-pairs scoring system. This promising idea is implemented and extended in the PECAN[43], MUMMALS[44], PROMALS[45], ProbAlign[46] , ProDA[47], and PicXAA[48] programs.
- Segment-to-segment objective function: It is used by DIALIGN[49] to construct an alignment through comparison of the whole segments of the sequences rather than the residue-to-residue comparison.
- NorMD[50] objective function: It is a conservation-based score which measures the mean distance between the similarities of the residue pairs at each alignment column. NorMD is used in RASCAL[51] and AQUA[52].
- Muscle profile scoring function: MUSCLE[53] uses a scoring function which is defined for a pair of profile positions. In addition to PSP, MUSCLE uses a new profile function which is called the log-expectation (LE) score.

### D. RNA Database and Benchmarks

Typically, a benchmark of reference alignments is used to validate the MSA program. The accurate score is given by comparing the aligned sequence (test sequences) produced by the program with the corresponding reference alignment. Most alignment programs have been extensively investigated for protein. To date, few attempts have been made to benchmark nucleic acid sequences.

RNA reference alignments exist in several databases. It must be noted that although these databases provide a substantial amount of information to the specialist, they do differ in the file formats used and the data obtained. Herein, a brief review of the benchmarks and database that have been used for multiple RNA sequence alignment is explained in Table 1.

TABLE I. DATABASE AND BENCHMARKS

| RNA Database | Description | Website |
|---|---|---|
| Rfam[54],[55] | It is a compilation of alignment and covariance models including many regular non-coding RNA families[55] | http://rfam.sanger.ac.uk/ http://rfam.janelia.org/index.html. |
| BRAliBase[56],[57] | It is a compilation of RNA reference alignments especially designed for the benchmark of RNA alignment methods[57]. | http://www.biophys.uni-duesseldorf.de/bralibase/ http://projects.binf.ku.dk/pgardner/bralibase/ |
| Comparative RNA Website (CRW)[58] | It has alignments for rRNA (5S / 16S / 23S), Group I Intron, Group II intron, and tRNA for various organisms[58] | http://www.rna.ccbb.utexas.edu/ |
| European Ribosomal RNA Database[59],[60] | It is a collection of all complete or nearly complete SSU (small subunit) and LSU (large subunit) ribosomal RNA sequences available from public sequence databases[60]. | http://bioinformatics.psb.ugent.be/webtools/rRNA/ |
| The Ribonuclease P Database[61] | It contains a collection of sequence alignments, RNase P sequences, three dimensional models, secondary structures, and accessory information[61]. | http://www.mbio.ncsu.edu/RnaseP/ |
| 5S Ribosomal RNA | It is a collection of the large subunit of most organellar ribosomes and all | http://biobases.ibch.poznan.pl/5SData/ |


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| | | |
|---|---|---|
| Database[62] | cytoplasmic. This database is intended to provide information on nucleotide sequences of 5S rRNAs and their genes[62]. | |
| tmRNA[63] | tmRNA (also known as 10Sa RNA or SsrA) contains a compilation of sequences, alignments, secondary structures and other information. It shows secondary structure, together with careful documentation[63]. | http://www.indiana.edu/~tmrna/ |
| The tmRDB( tmRNA database)[64] | tmRDB provides aligned, secondary and tertiary structure of each tmRNA molecule. The alignment is available in several formats. | http://www.ag.auburn.edu/mirror/tmRDB/ |
| RNAdb[65],[66] | It provides sequences and annotations for tens of thousands of non-coding RNAs. | http://research.imb.uq.edu.au/rnadb/default.aspx |
| Noncoding RNA (ncRNA) database[67] | It provides information of the non-coding RNA sequences and functions of transcripts, (the non-coding RNA does not code for proteins, but performs regulatory roles in the cell) | http://biobases.ibch.poznan.pl/ncRNA/ |

### *E. Current MSA Approaches*

Many research on MSA algorithms have been published in the last thirty years and reviewed by a few researchers such as[7],[68],[69],[70]. The published algorithms vary in the way the researchers choose the specified order to do the alignment, and in the procedure used to align and score the sequences. Existing algorithms can be classified into one or combinations of the following basic approaches: exact, progressive, iterative algorithms, group alignment, block-based, consistency-based, probabilistic, computational intelligence, and heuristic. The following subsections provide a brief overview of the consistency-based, block-based and heuristic optimization approaches. These approaches are related in one way or the other to our proposed work. The consistency-based approach is explained in subsection 2.5.1 followed by the block-based approach in subsection 2.5.2. Finally, the heuristic optimization approach is explained in subsection 2.5.4.

#### *1) Consistency-based Approach*

The "consistency-based" approach is one of the strategies that has been proposed to improve the MSA scoring function. This approach tries to reduce the chance of early errors when constructing the alignment instead of correcting the existing errors via post processing[40],[38]. This is typically achieved by improving the pair-wise sequence quality based on other sequences in the alignment so as to obtain pair-wise alignments that are consistent with one another. This consistency strategy was originally described by Gotoh[9] and later refined by Vingron and Argos[39]. This strategy has been modified by several methods since then.

SAGA[18] incorporated the optimization of alignment with COFFEE based on a consistency measure called the consistence-based objective function.

Later, Dialign2[71] represented the consistency-based method incorporating the segment-by-segment approach.

Similarly, Align-m[42] used a local alignment as a guide to a global alignment non-progressive problem. Align-m used the pair-wise alignment consistency to find the parts that are consistent with each other.

T-Coffee[40] also implemented this idea by using a consistency-based alignment measure based on a library of pair-wise alignments. This method was later brought into a probabilistic framework by ProbCons[38], MUMMALS[44], ProbAlign[46], PROMALS[45], and MSAProbs[72].

Nonetheless, a combination of different strategies can be used. For instance, PCMA[73] (profile consistency multiple sequence alignment) combined two different alignment strategies, that is, progressive and consistency approaches.

#### *2)* Block-based Approach

Block-based MSA is a method in which an alignment is constructed by first identifying the conserved regions into what is called "blocks". Then, the regions between the successive blocks are aligned to form a final alignment[74]. Block-based methods can be included in the consistency or probability-based[75] approach. A block can be referred to a sub-sequence, a segment, a region, or a fragment[76]. A fragment is defined as pairs of ungapped segments of the input sequences[77]. A weight score is assigned to each possible fragment to find the consistent fragments with high overall sum of fragment scores. Those fragments are integrated from a pair-wise alignment into a multiple alignment.

Searching for these conserver blocks in many blocked-based methods is very time-consuming. Therefore, the key issue is how to construct the possible set of blocks efficiently[75].

Some of the previous algorithms such as those undertaken by Boguski et al.,[78]; Miller,[79]; Miller et al.,[80] construct blocks either by pair-wise alignment or by those not matched by all the N sequences. Instead of starting from pair-wise alignments, Match-Box[81] aims to identify conserved blocks (or boxes) among the sequences without performing a pair-wise alignment. Similarly, Zhao and Jiang [74] introduced the BMA algorithm which allows for internal gaps and some degree of mismatch in the method used to identify the blocks.

Based on a combination of local and global alignment, Dialign[71],[82],[83] involves an extensive use of the segment-by-segment methods. It combines the local and global alignment features by identifying and adding the conserve regions (block) shared between the sequences based on their consistency weights.

Based on the anchored alignment, CHAOS[84] used fast local alignments as "seeds" for a slower global-alignment. CHAOS is used to improve DIALIGN[71] and LAGAN[85].

Recently, Wang et al.[75] produced a block-based algorithm called BlockMSA. It combined the biclustering and divide-and-conquer approaches to align the sequences.

#### *3)* Heuristic Optimization Approaches

Many optimization problems from various fields have been solved by using diverse optimization algorithms. Computational intelligence (CI) plays an important role in solving the sequence alignment problem. Recently,


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Evolutionary Algorithms have the advantage of operating on several solutions simultaneously, combining an exploratory search through the solution space with the exploitation of current results[15]. There are no restrictions on the sequence numbers or their length. It is very flexible in optimizing the solution with low complexity. Many efforts have attempted to solve the MSA problem using evolutionary programming[86], [87]. Since MSA has computational difficulty, there is no best method that can solve MSA professionally.

Heuristic optimization approaches include genetic algorithm, ant colony, swarm intelligence, simulating annealing, tabu search, and combinations thereof. In the following subsections, the several techniques of heuristic optimization approaches are explained to show how these techniques are applied to solve the MSA problems.

*a) Genetic Algorithm*

Genetic Algorithm (GA) is a heuristic search that performs an adaptive search to find optimal solutions of large-scale optimization problems with multiple local minima[15] using techniques that simulate natural evolution.

GA is well suited for solving some NP-complete problems such as MSA. Sequence Alignment by Genetic Algorithm (SAGA)[18] is the earliest GA to be used to solve MSA problems. With the GA approach there are different methods that can be applied to solve the MSA problem such as the one used in[13], [12],[17],[88],[19],[20].

Some methods are a hybrid with other approaches. Zhang and Wong[89] presented a method that used pair-wise dynamic programming (DP) technique based on GA. Similarly, utilizing GA in a progressive approach has been presented in[90]. Later, Wang and Lefkowitz[91] produced the GenAlignRefine algorithm which uses a genetic algorithm to improve local region alignment which leads to improving the overall quality of global multiple alignments. In[92] GA is used as an iterative method to refine the alignment score obtained by the progressive method. The use of GA to find the cut-off point in the divide-and-conquer approach is presented in[93]. Using similar combinations, a novel algorithm of genetic algorithm with ant colony optimization GA-ACO was presented by Lee et al.[94]. Chen et al.[95] reported a method which employs a new selection scheme to avoid premature convergence in GAs. Taheri and Zomaya[96] presented RBT-GA using a combination of the Rubber Band Technique (RBT) and the Genetic Algorithm (GA). Jeevitesh et al.[97] proposed the PASA algorithm which used the alignment outputs of two MSA programs – MCoffee and ProbCons – and combined them in a genetic algorithm model.

*b) ANT* Colony

Ant colony optimization algorithm (ACO) is a probabilistic technique for solving computational problems. It is one of the swarm intelligence families. The ACO algorithm is used as a new cooperative search algorithm in solving optimization problems. ACO was inspired from the observation of the activities of real ants[98],[99],[100]. Recently, ACO is used to solve the NP-complete problems.

It shows efficiency in solving the MSA problems such as those reported in[101],[102] where each proposed algorithm was based on the ant colony optimization and divide-and-conquer technique. Other researchers such as[103],[104],[27],[105] relied on the ant colony to solve the MSA problem in their research work.

*c)* Particle Swarm Optimization

Particle swarm optimization (PSO) is a swarm intelligence technique for numerical optimization. It simulates the behaviour of bird flocking or fish schooling. PSO was presented by Kennedy and Eberhart[106] in 1995. The simplicity of implementation, quick convergence, and few parameters have resulted in PSO gaining popularity.

Many researchers have made modifications to the PSO idea and utilized this technique widely in solving MSA problems. Rasmussen and Krink[107] used a combination of particle swarm optimization and evolutionary algorithms to train HMMs for protein sequences alignment. Meanwhile, Pedro et al.[108] presented an algorithm based on PSO to improve a sequence alignment previously obtained using ClustalX. Juang and Su[109] produced an algorithm which combined the pair-wise DP and particle swarm optimization (PSO) to overcome the local optimum problems. Xu and Chen[110] designed an improved particle swarm optimization to solve MSA. Based on the idea of chaos optimization Lei et al.[111] produced chaotic PSO (CPSO) to solve MSA. A novel algorithm of mutation-based binary particle swarm optimization (M-BPSO) was presented by Hai-Xia et al.[112] for solving MSA.

*d)* Simulated Annealing

Simulated annealing (SA) was described by Kirkpatrick[113]. Simulated annealing is an algorithm that attempts to simulate the physical process of annealing. The basic concept of simulated annealing algorithms is based on observing the change of energy in which materials solidify from the liquid state to the solid state[114].

Several SA algorithms have been used to solve MSA problem. Kim et al.[115] used simulated annealing to develop the MSASA algorithm for solving MSA. Uren et al,[116] presented MAUSA that used simulated annealing to perform a search through the space of possible guide trees. Meanwhile, Keith et al.[117] described a new algorithm for finding a consensus sequence by using the SA method. Omar et al.[118] produced a combination of Genetic Algorithm and Simulated Annealing to solve MSA problems. Roc[114] presented a method for multiple DNA sequence alignment in which an optimal cut-off point is chosen by the genetic simulated annealing (GSA) techniques. Joo et al.[119] presented a new method called MSACSA for MSA, which is based on the conformational space annealing (CSA). CSA combines three traditional global optimization methods, that is, SA, genetic algorithm (GA), and Monte Carlo with minimization (MCM).

*e)* Tabu Search

Tabu search is a meta-heuristic approach used to solve combinatorial optimization problems. Tabu search (TS) and simulated annealing are similar in that both traverse the solution space by testing mutations of an individual solution. However, they differ in the number of generated solutions.


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While simulated annealing generates only one mutated solution, tabu search generates many mutated solutions and moves to the solution with the lowest energy of those generated. TS has been used to solve MSA problems. Riaz at el.[120] has implemented the adaptive memory features of tabu search to refine MSA. Lightner[121] used a tabu search approach to obtain multiple sequence alignment and explored iterative refinement techniques such as the hidden Markov model and the intensification heuristic approach to further improve the alignment.

### F. Summary of Related Algorithms for MSA

Table 2 lists the most current algorithms that are in use. This list is incomplete but includes the most related algorithms explained above. Online availability is the link to the online server or the site which can download and access the particular algorithm.

TABLE II. CURRENT MSA ALGORITHMS

| Algorithm | Approach | RNA | Online Availability | Reference |
|---|---|---|---|---|
| MAFFT | Consistency | Y | http://mafft.cbrc.jp/alignment/server/ | [122] |
| MUSCLE | Progressive/ refinement | Y | http://www.ebi.ac.uk/Tools/msa/muscle/ | [123] |
| Dialign2 | Consistency/ segment | Y | http://bibiserv.techfak.uni-bielefeld.de/cgi-bin/dialign_submit | [71] |
| Align-m | Consistency | N | http://bioinformatics.vub.ac.be/software/software.html | [42] |
| BlockMSA | 3-way consistency/ Block/DCA | Y | http://aug.csres.utexas.edu/msa/ | [75] |
| MAUSA | SA | N | http://eprints.utas.edu.au/208/ | [116] |
| SAGA | Iterative/Stochastic/GA | Y | http://www.tcoffee.org/Projects_home_page/saga_home_page.html | [18] |
| Mishima | k-tuple | Y | http://esper.lab.nig.ac.jp/study/mishima/ | [124] |
| MSAProbs | Pair-HMM and partition function | Y | http://sourceforge.net/projects/msaprobs/ | [72] |
| pecan | Consistency/ progressive | - | http://www.ebi.ac.uk/~bjp/pecan/ | [43] |
| PicXAA | posterior probability/ consistency | Y | http://www.ece.tamu.edu/~bjyoon/picxaa/ | [48] |
| PRIME | GROUP-TO-GROUP/ ANCHOR | Y | http://prime.cbrc.jp/ | [37] |
| ProAlign | HMM/ progressive | Y | http://applications.lanevol.org/ProAlign/ | [125] |
| PROBCONS | posterior probability pair-hmm | N | http://probcons.stanford.edu/index.html | [38] |
| ProDA | repeated and shuffled elements | Y | http://proda.stanford.edu/ | [47] |
| Probalign | posterior probabilities | Y | http://probalign.njit.edu/probalign/login | [46] |
| REFINER | Refinement/ Block | - | ftp://ftp.ncbi.nih.gov/pub/REFINER | [126], [127] |
| AIMSA | Region | - | - | [128] |
| PRALINE | Profile/iterative /progressive | - | http://www.ibi.vu.nl/programs/pralinewww/ | [129] |
| T-COFFEE | Consistency/ Progressive | Y | http://www.tcoffee.org/ | [40] |
| MUMMALS | Probability HMM | N | http://prodata.swmed.edu/mummals/mummals.php | [44] |
| PROMALS | *k*-mer/ Pair-HMM consistency | Y | http://prodata.swmed.edu/promals/promals.php | [45] |
| PCMA | *k*-mer/ Profile/consistency | - | ftp://iole.swmed.edu/pub/PCMA/pcma/ | [73] |
| BMA | Conserve block | Y | - | [74] |
| GA-ACO | GA and Ant colony | - | - | [94] |
| PASA | Refine by GA | - | - | [97] |

### G. Harmony Search Algorithm

Harmony search algorithm (HS) is developed by Geem[130]. HS is a meta-heuristic optimization algorithm based on music.

HS simulates a team of musicians together trying to seek the best state of harmony. Each player generates a sound based on one of the three options (memory consideration, pitch adjustment, and random selection). This is the equivalent of finding the optimal solution in an optimization process.

Geem et al.[130] models HS components into three quantitative optimization processes as follows:


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- The Harmony memory (HM): It is used to keep good harmonies. A harmony from HM is selected randomly based on the parameter called harmony memory considering (or accepting) rate, HMCR Є [0,1]. It typically uses HMCR = 0.7 ~ 0.95.
- The pitch adjustment: It is similar to a local search. It is used to generate a slightly different solution from the HM depending on the pitch-adjusting rate (PAR) values. PAR controls the degree of the adjustment by the pitch bandwidth (brange). It usually uses PAR = 0.1~0.5 in most applications.
- The random selection: A new harmony is generated randomly to increase the diversity of the solutions. The probability of randomization is Prandom = 1- HMCR , and the actual probability of the pitch adjustment is Ppitch = HMCR × PAR.

The pseudo code of the basic HS algorithm with these three components is summarized in Figure 2.

**Harmony Search Algorithm**

```
Begin
    Declare the objective function f(x), x =(x1,x2, …,xn)
    Initialize the harmony memory accepting rate (HMCR)
    Initialize pitch adjusting rate (PAR) and other parameters
    Initialize Harmony Memory with random harmonies
    While (t<max number of iterations )
            If (rand<HMCR),
              Choose a value from HM
                 If (rand<PAR), Adjust the value by adding certain amount
                 End if
            Else choose a new random value
            End if
        End while
        Calculate the objective function
        Accept the new harmony (solution) if better
        Update HM
    End while
    Find the current best solution in HM
End
```

Figure 2. Pseudo Code of the Harmony Search Algorithm[131]

Later, Geem[132] proposed an ensemble harmony search (EHS) where a new ensemble consideration operation is added to the original HS structure. The new operation takes into account the relationship among the decision variables, and the value of each decision variable can be chosen based on the other variables.

Thereafter, Mahdavi et al.[133] produced an improved harmony search (IHS), in which the parameter PAR and pitch bandwidth are adjusted dynamically in the improvisation step.

So far, Omran and Mahdavi[134] have proposed a global-best harmony search (GHS) in which the performance of HS is improved by borrowing the concepts from swarm intelligence to modify the pitch-adjustment step such that the new harmony is assigned by the best harmony in the HM.

Meanwhile, Pan at el.[135] produced a local-best harmony search algorithm with dynamic subpopulations (DLHS) for solving continuous optimization problems. The DLHS algorithm differs from the existing HS in that a whole harmony memory (HM) is divided into many sub-HMs and the independent processes are performed in each sub-HM. A periodic regrouping schedule is used to exchange information between the sub-HMs, so that the population diversity and the improvement in the accuracy of the final solution are maintained. In addition, the parameters are adjusted using a new developed adaptive strategy to enable it to be used with a particular problem or phase of the search process.

Recently, Zou at el.[136] proposed a novel algorithm known as a global harmony search algorithm (NGHS) to solve reliability problems.

NGHS modifies the improvisation step of the HS. Position updating and genetic mutation are new operations included in NGHS. Position updating enables the worst harmony of HM to move toward the global best harmony rapidly while genetic mutation prevents NGHS from becoming trapped into the local optimum.

## III. THE PROPOSED ALGORITHM

Herein, in this article several algorithms are proposed to solve the MSA problem by using the adapted harmony search algorithm (HS). Adaptive HS for MSA is explained in the next subsection 3.1. A modified HS algorithm for reducing search space is explained in subsection 3.2. Subsection 3.3 describes the HS Improver. Finally, in subsection 3.4 a parallel HS-MSA is introduced which can be implemented in different parallel platforms such as the Multi-core and GPU. Figure 3 shows the stages of the proposed research framework.

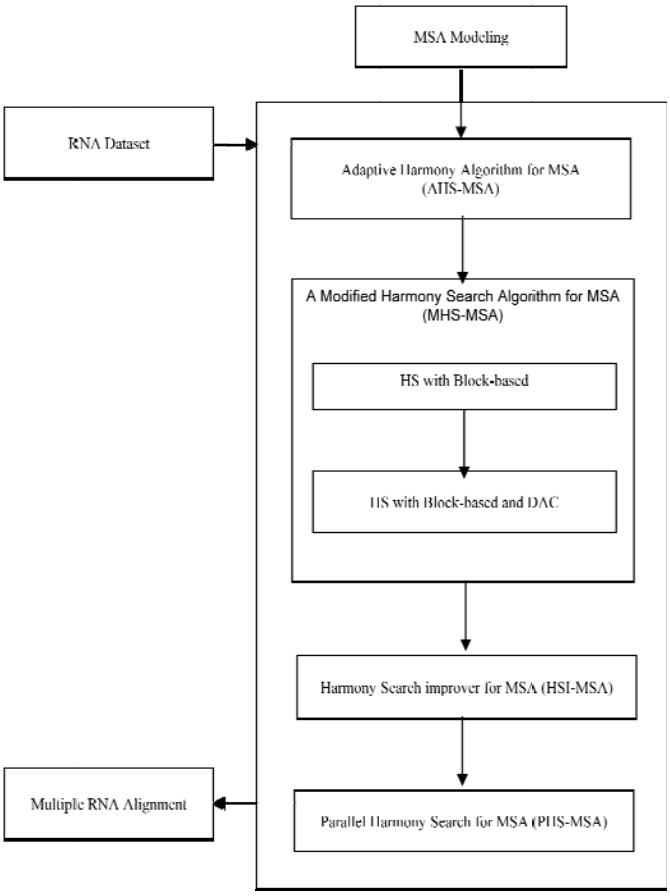


Figure 3. Research Framework.


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### A. Proposed Harmony Search Algorithm for MSA

The main goal of the MSA algorithms is to detect and align the homologous regions across the different sequences. This is achieved by optimizing an objective function that measures the quality of the alignment. The harmony search is a new meta-heuristic optimization algorithm which has a history in solving NP-complete problems[137]. This subsection explains the ability of the harmony search algorithm in solving MSA problem. Herein alignment representation, objective function, harmony memory initialization, and adaptive harmony search algorithm for MSA are explained in greater details.

*1)* Alignment Representation

Alignment of N sequences with different lengths from $L_1$ to $L_N$, are represented as a matrix N x W where each row contains gap positions encoded for each sequence. The length of the rows in the matrix is W = [αLmax], where Lmax = max $\{L_1,L_2,..,L_N\}$, and [x] is the smallest integer greater than or equal to x, and the parameter α is a scaling factor[86]. The value α is chosen according to the probability distribution. The value of α can be 1.2 as used in[94] or 1.5 as used in[138],[13],[20]. The choice of 1.2 is to allow the aligned sequences to be 20% longer than the longest sequence. Meanwhile the selection of 1.5 is to allow the alignment to be 50% longer than the longest sequence in the test as in [138].

*2)* Objective Function

To find the optimal solution in the HS-MSA, the sum-of-pairs (SP) score described in[139],[140],[10],[107] will be used to calculate the Objective Function (OF) where there is no prior knowledge of the reference alignment. The general form of the OF score of alignment n sequences which consists of M columns is:

$$OF = \sum_{i=1}^{l} \{S_n(m_i) - G_n(m_i)\},$$

where $S_n(m_i)$ is the similarity score of the column mi, $G_n(m_i)$ is the gap penalty of the column mi and l is the sequence length. The similarity score of the column mi can be measured by the sum-of-pairs (SP). The SP-score S(mi) for the i-th column mi is calculated as follows:

$$S(mi) = \sum_{j=1}^{n-1} \sum_{k=j+1}^{n} s(m_i^j, m_i^k),$$

where $m_i^j$ is the j-th row in the i-th column. For aligning two residues x and y, the substitution matrix s(x,y) is used to give the similarity score.

*3)* Harmony Memory Initialization

For a given 5 sequences, the procedure to initialize the harmony memory is as follows: Maximum sequence length is MaxS = 7, minimum sequence length is MinS = 4, maximum length of alignment is W = [1.2 * 7] = 9, maximum gaps in sequence Si is (W – $L_i$) where Li is the length of sequence i, maximum number of gaps is Gs = 9 – 4 = 5.

| Sequence | | | | | | | Length $L_i$ | Generate Gap Positions (W-$L_i$) | Gap positions in Sort ascending (W-$L_i$) |
|---|---|---|---|---|---|---|---|---|---|
| A | U | C | A | A | | | 5 | 4187 | 1478 |
| U | A | A | U | C | A | A | 7 | 32 | 23 |
| A | U | C | A | | | | 4 | 34789 | 34789 |
| U | A | A | U | C | A | U | 7 | 62 | 26 |
| A | U | G | A | U | U | | 6 | 729 | 279 |

A. Gaps Position

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| - | A | U | - | C | A | - | - | A |
| U | - | - | A | A | U | C | A | A |
| A | T | - | - | C | A | - | - | - |
| U | - | A | A | U | - | C | A | U |
| A | - | U | G | A | U | - | U | - |

B. Aligned sequence

Figure 4. Harmony memory initialization

The initial harmony memory is randomly generated and the rows are initialized in the following way: First, a random permutation number W-Li of gap positions is generated from a range of values (1 – W) for each sequence Si with length $L_i$. Second, those numbers (W-$L_i$) are sorted and used to indicate where the corresponding gaps are placed in the matrix. Finally, the positions in the matrix rows which are not associated by gaps are filled with the base symbols taken from the original sequence.

The random initialization procedure that produces the initial Harmony memory is illustrated in Figure 4. This is similar to the procedure used in [94]. The difference in our procedure is that the gap positions are generated and not the residue positions as in[94]. The generation gap positions are less than the generation residue positions for each sequence. The second difference is related to the first step in that the number of permutations are (W-$L_i$) and not W as in[94].

*4)* Adaptive Harmony Search Algorithm for MSA (AHS-MSA)

The purpose of AHS-MSA is to aid scientists in producing a high quality of MSAs that may lead to a better RNA structure prediction (Figure 5) as well as other issues in molecular biology. To date in reviewing the approaches to solving the MSA problem or in predicting the multiple RNA secondary structure, we have found that no studies have incorporated the use of the harmony search algorithm. The only research that


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has involved HS in bioinformatics is that of Mohsen et al.[141] which predicted the secondary structure for a single RNA sequence based on Minimum Free Energy.

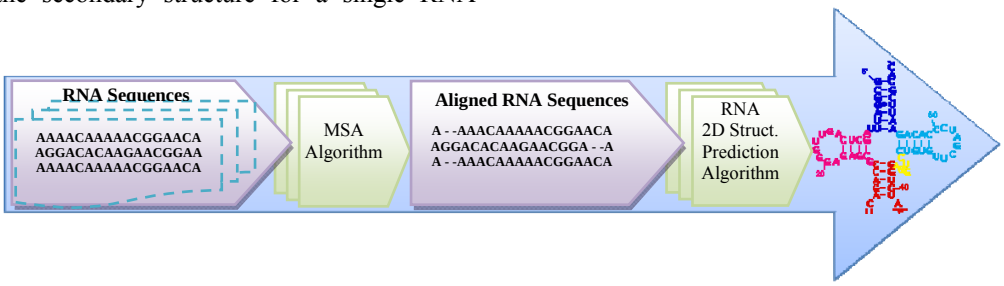


Figure 5. The impact of MSA in RNA secondary structure prediction

The HS algorithm has been successfully applied to several optimization problems[142]. As such this study aims to investigate the use and adaption of the HS algorithm in finding solutions to the MSA problems. The MSA problem can be considered as an optimization problem with minimal disruption of the accuracy, complexity, and speed rules. MSA can be resolved by adapting the harmony search algorithm. Moreover, HS possesses several advantages over conventional optimization techniques[143] such as:

1. HS does not require initial value settings for decision variables;
2. HS is a population-based meta-heuristic algorithm, which means that a group of multiple harmonies can be used simultaneously. Proper parallelism usually leads to better performance with higher efficiency and speed;
3. HS uses stochastic random searches which explore the search space more widely and efficiently;
4. HS does not need derivation information;
5. HS is less sensitive to chosen parameters;
6. HS can solve various NP-complete problems[137];
7. The structure of the HS algorithm is relatively easier;
8. HS is a very successful meta-heuristic algorithm due to its way of handling intensification and diversification.
9. HS is very versatile being able to combine with other meta-heuristic algorithms[134]

These characteristics increase the reliability and flexibility of the HS algorithm in producing better solutions.

The AHS-MSA algorithm as described in Figure 6 combines and adapts the HS idea to solve the MSA problem. The steps of the AMS-MSA algorithm are as follows:

1. Initialize the harmony parameters (HMCR, PAR, NI, and HMS).
2. Initialize the harmony memory with random harmonies by HMS solution. Each solution is an alignment.
3. Calculate the objective function (OF) for each harmony.
4. Improvise the new harmony.
5. Accept/reject the new harmony
6. Update the harmony memory.

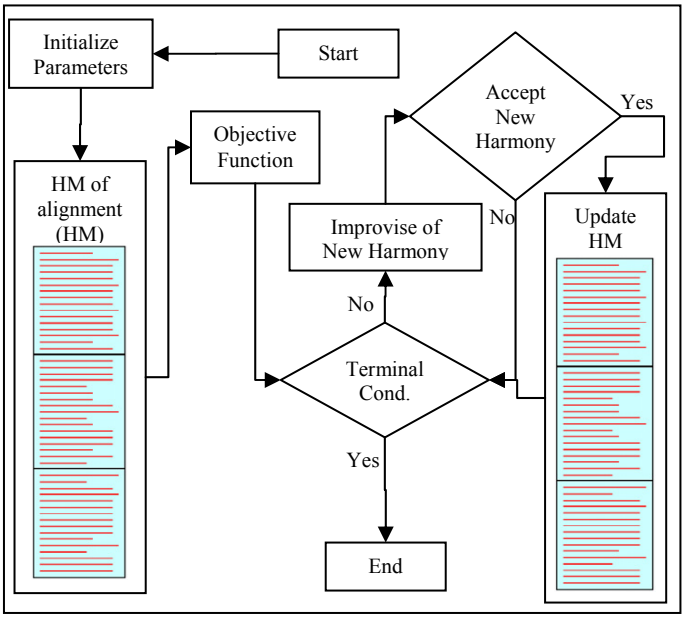


Figure 6. The flowchart of the proposed HS-MSA algorithm

### *B. A Modified Harmony Search Algorithm for MSA (MHS-MSA)*

To reduce the search space, a combination of methods is proposed. A hybrid method of HS and a segment-based approach is proposed and explained in the next subsection 3.2.1. In subsection 3.2.2, a hybrid method of HS and a combination of segment-based and divide-and-conquer approaches are proposed and explained.

#### *3.2.1 A Harmony Search algorithm with a Segment-based Approach*

Lately identifying areas of local conservations before finding the global alignment is gaining popularity among researchers. Conserved regions can be a helpful guide in identifying the homology of sequences and assisting the process of MSA. This idea is not new and has been implemented in other algorithms such as DIALIGN[49], MLAGAN[85], CHAOS[84], align-m[42], and MAFFT[144] where blocks are first detected from the pair-wise sequence alignment and that information is then used to detect MSA. The other algorithm, such as MISHIMA[124], also used this idea in


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which k-tuple is explored and analyzed from the original sequence. In the same way, well-aligned regions were seen in RASCAL[51],[128] where a consistency-based objective function called NorMD[50] was used.

Herein, this proposed method in our research is to reduce the search space in the previous AHS-MSA algorithm by combining pair-wise alignments into multiple alignments. It works by finding the conserved blocks through all the sequences before starting the MSA process. It explores all possible regions, which is more correct and consistent. All matched blocks are used to guide the MSA alignment. The idea is first to detect the conserved blocks in the sequences pair-wise and then to apply HS to identify MSA from those conserved columns.

The multiple alignment search space can be narrowed down to a number of possible regions per sequence pair. If parts of these residue pair are consistent within each other, they are considered as acceptable. For consistency it means that if symbol $A_i$ (residue i of sequence A) is aligned correctly with symbol $B_j$ , and $B_j$ with $C_k$, then $A_i$ and $C_k$ should also be aligned. Therefore, this property can be used to define the consistent parts among all the pair-wise alignments which can be considered as acceptable, and the gap positions can be defined at the rest of the aligned residue pairs.

The ability to determine the well-aligned regions has at least two advantages. It prevents the same region from being changed in the later process. Additionally, it speeds up the optimization process. The modified steps of the HS-MSA algorithm can be summarized as follows:

1. Find all possible residue pairs in each sequence pair using the pair-wise algorithm.
2. By using the consistency concept, find all possible blocks or columns that are acceptable.
3. Calculate the score value for each block by using the sum-of-pairs objective function.
4. Identify and analyze the potentially useful blocks, and select those that are more consistent with each other.
5. Apply the HS algorithm to initialize the final alignment from these blocks and find the optimal alignment.

#### *3.2.2 A Harmony Search algorithm with Segment-based and Divide-and-conquer Approaches*

The previous proposed method can be extended where the divide-and-conquer (DAC)[145] method can be combined.

Sammeth at el.[146], and Kryukov and Saitou[124] used the DCA approach in solving MSA. Kryukov and Saitou[124] produced the adapted DCA in which k-tuple is used to find the segments and align these segments by CLUSTALW and MAFFT. Sammeth at el.[146], on the other hand, integrated the global divide-and-conquer approach with the local segment-based approach as in DIALIGN.

A set of consistent columns can form segments in the alignment. The DCA protocol is to cut the sequences at a point and repeat that cutting procedure until it is no longer exceeded. Then the obtained sub-sequences are aligned independently and the results are combined to form a complete MSA alignment. The method proceeds as follows:

1. Find all possible residue pairs in each sequence pair using the pair-wise algorithm.
2. By using the consistency concept, find all the possible blocks or columns that are acceptable.
3. Calculate the score value for each column by using the sum-of-pairs objective function.
4. Identify and analyze the potentially useful columns, and select those that are more consistent with each other.
5. Add these conserve blocks/fragments to the fragments set F and they can be considered as cutting points.
6. Divide the sequence into sub-sequence based on these cutting points.
7. Apply the HS algorithm to construct the final alignment from these regions and find the optimal one.

### *C. A Harmony Search Algorithm Improver for MSA (HSI-MSA)*

Another proposed method in our research work is the use of HSI-MSA to combine many multiple alignments into one improved alignment. Any conventional MSA program or a combination of them can initialize the Harmony memory. Then the Harmony algorithm can be applied as an iterative method to refine/combine the alignment to find the best alignment result. Here HS takes on the role of an improver of the accuracy of the current alignment. The goal of this study is to investigate whether this approach is going to improve the accuracy of the different alignments or not. This improver idea is similar to the PASA algorithm[97] which was used a genetic algorithm model to combine the alignment outputs of two MSA programs – M-Coffee and ProbCons. It has also been used in ComAlign[147], M-Coffee[148] and AQUA[52] . The proposed method can be summarized as follows:

1. Initialize the harmony memory by using well-known MSA algorithms including our alignment gained from the previous step.
2. Calculate the score for each alignment.
3. Apply the HS algorithm to improve and find the optimal alignment.

This will combine all the alignment parts from the different alignments to find the optimal alignment within them and not just to select the best of them.

### *D. A Parallel Harmony Search Algorithm for MSA (PHS-MSA)*

In addition to the foregoing proposed methods, another way to reduce the computational complexity and time consumed is to parallel the HS-MSA algorithm using multi-core and multi-GPU platforms.

CUDA (Compute Unified Device Architecture) is an extension from C/C++ developed by NVIDIA to run thousands of threads parallelly[149] and to execute on the GPUs[150]. GPUs' architectures are "manycore" with


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hundreds of cores[149]. GPUs were implemented as a streaming processor.

It is a good alternative for high performance computing and it will become even more excellent in the near future. Furthermore, availability, low price, and easy installation are the main advantages[151] of the GPUs compared to other architecture.

Re-developing the algorithm and the data structure based on computer graphic concepts is the main obstacle facing the use of the GPUs[151],[152]. Moreover, other limitations are based on the streaming architecture which have to be taken into consideration (i.e. memory random access, cross fragment, persistent state)

Many researchers have shown the design and implementation of bioinformatics algorithms using GPUs. Examples that use GPU to parallel sequence alignment algorithm in bioinformatics are[153], [154], [151], [155], [156], [157].

Our approach is motivated by the rapidly increasing power of GPU. Our proposed approach is to implement the proposed HS-MSA algorithm using NVIDIA's GPUs, to explore and develop high performance solutions for multiple sequence alignment. To program the GPU, the HS-MSA will be implemented in NVIDIA GeForce 9400 GT CUDA. The computation will be conducted on NVIDIA GPUs installed in a 2.66 GHz intel Core 2 Quad CPU computer equipped with 3 GB RAM, running on Microsoft Windows XP Professional.

Moreover, to utilitize multiple CPU threads to incorporate GPU devices into one single program, the proposed method can be extended to use a hybrid multi-core and GPU codes by CUDA and OpenMP. This can lead to quicker implementation and greater efficiency on both GPU and multi-core CPU[158].

## IV. Evaluation and Analysis

To evaluate and analyse the performance of the proposed HS-MSA algorithm in greater depth there is a need for an objective criterion to assess the quality of the aligned sequences. The quality attained can be evaluated by comparing the results of the test alignment with the reference alignment[139].

The comparison can use some scores that may be dependent on the alignment itself (e.g, Sum-of-Pairs, Total Column Score) or independent from it (structure sensitivity and selectivity). This subsection describes in detail the benchmark dataset, the reference comparison, the alignment comparison and the structure comparison, which can be investigated to evaluate the test alignments.

### A. Benchmark Dataset

The proposed algorithm will be tested using the following datasets: Rfam, BRAliBase 2.1, Comparative RNA website (CRW), the Ribonuclease P database, 5S Ribosomal RNA database, tmRNA , tRNA , SRPDB, RNAdb, and ncRNA as explained in section 2.6. Different RNA datasets will be used from a variety of families and lengths such as 5S (5S.B.alphaproteobacteria, 5S.B.betaproteobacteria, 5S.B.actinobacteria), 16S (16S.B.fibrobacteres, 16S.E.entamoebidae, 16S.E.perkinsea) ribosomal RNA.

### B. Reference Comparison

To assess the quality of the aligned sequence, it requires a reference alignment from the database benchmark. The comparison is between the test alignment and the reference alignment.

Sum-of-pairs (SPS) and column Score (CS) are two different score functions that can be used to estimate this comparison. The SPS score is the percentage of the correct aligned residue pairs in the test alignment that occurred in the reference alignment[159]. The CS score is the percentage of the entire columns in the test alignment that occurred completely in the reference alignment[159].

In a given test alignment consisting of M columns, the ith column is denoted by $A_{i1}, A_{i2}, \ldots, A_{iN}$ where N is the number of sequences. For each pair of residues $A_{ij}$ and $A_{ik}$, $p_i(j,k)$ is defined such that $p_i(j,k) = 1$ if residues $A_{ij}$ and $A_{ik}$ from the test alignment are aligned with each other in the reference alignment, otherwise $p_i(j,k) = 0$. The Score of the $i^{th}$ column can be calculated as follows:

$$Si= \sum_{j=1}^{N} \sum_{k=1,k\neq j}^{N} P_i(j,k).$$

Then, the sum-of-pairs score for a given test alignment can be calculated as follows:

$$\text{Sum-of-Pairs (SPS)} = \frac{\sum_{i=1}^{M} S_i}{\sum_{i=1}^{Mr} S_{ri}},$$

where Mr is the number of columns in the reference alignment and Sri is the score Si for the ith column in the reference alignment.

Column score (CS): Using the same symbols as shown above, the score Ci of the ith column is equal to 1 if all the residues in that column are aligned in the reference alignment, otherwise it is equal to 0. Therefore, the column score is:

$$CS = \sum_{i=1}^{M} \frac{C_i}{M}$$

To compare the test alignment with the corresponding reference alignment, the sum-of-pairs function and column score are used as described in[139],[107],[160],[161],[162].

### C. Alignment Comparison

This comparison is to evaluate the performance of the proposed algorithm with respect to the other MSA aligners. Typically, the MSA aligners are validated by using a benchmark data set of reference alignments.

The Sum-of-pairs (SPS) and column scores (CS) of every produced alignment of each aligner program including our proposed algorithm are used to compare with the reference alignment.

The proposed algorithm HS-MSA can be compared to the commonly used MSA programs on the above reference alignment benchmark.


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### D. Structure Comparison

It might be expected that a more accurate alignment would lead to a more accurate RNA secondary structure. The proposed method is to investigate the impact of alignment accuracy on the accuracy of the RNA secondary structure using standard benchmarks and comparing them with the common well-known MSA algorithms.

Both the alignment process and the prediction process can affect the accuracy of the secondary structure prediction, but here only the alignment process is investigated.

The evaluation is performed in respect to sensitivity, selectivity or positive predictive value (PPV), and Mathews correlation coefficient (MCC) of the RNA secondary structure as used by Gardner and Giegerich[163]. The secondary structure of the test alignment produced by the proposed algorithm will be compared with that of others. The sensitivity and selectivity of the alignment process will be studied to investigate the effect of the proposed aligner on the accuracy of the structure as shown in Figure 7.

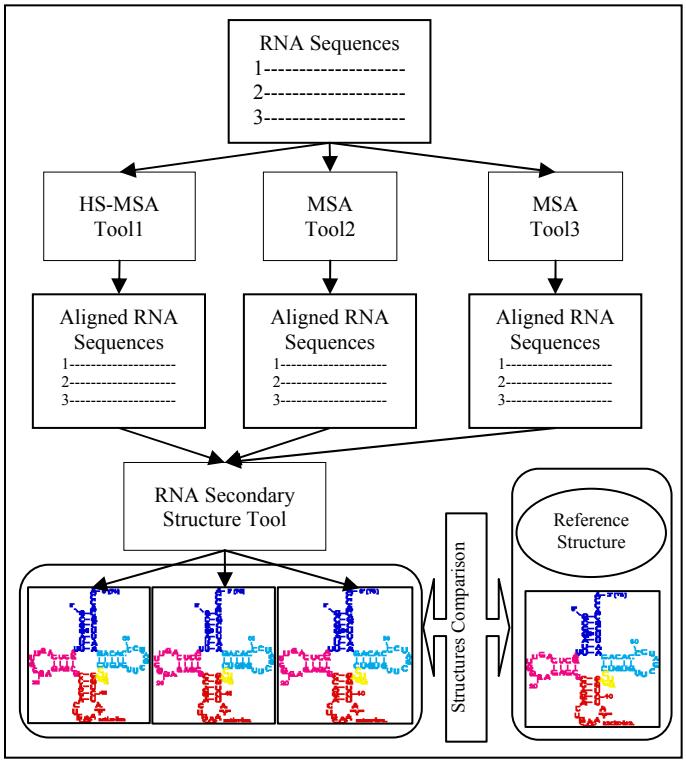


Figure 7. Structure comparison

## V. CONCLUSION

Multiple sequence alignment is a fundamental technique in many bioinformatics applications. Many algorithms have been developed to achieve optimal alignment. Some programs are exhaustive in nature; some are heuristic. Because exhaustive programs are not feasible in most cases, heuristic programs are commonly used. These include progressive, iterative, and block-based approaches.

This paper describes briefly the basic concepts of MSA and reviews the common approaches in MSA. To this end, this paper proposes a novel meta-heuristic method to solve the MSA problem. A meta-heuristic algorithm (HS-MSA), which has not been used up to now, is proposed for multiple sequence alignment that promises to greatly speed up the alignment process and improve its accuracy. The optimization method introduced herein is inspired by the so-called harmony search algorithm (HS). A new optimization algorithm for the combination of HS-MSA with segment-based multiple-alignment problem is also proposed and extended to include the parallel techniques.

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# A New Approach to Model Reference Adaptive Control using Fuzzy Logic Controller for Nonlinear Systems

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***Abstract*— The aim of this paper is to design a fuzzy logic controller- based model reference adaptive intelligent controller. It consists of fuzzy logic controller along with a conventional Model Reference Adaptive Control (MRAC). The idea is to control the plant by conventional model reference adaptive controller with a suitable single reference model, and at the same time control the plant by fuzzy logic controller. In the conventional MRAC scheme, the controller is designed to realize plant output converges to reference model output based on the plant which is linear. This scheme is for controlling linear plant effectively with unknown parameters. However, using MRAC to control the nonlinear system at real time is difficult. In this paper, it is proposed to incorporate a fuzzy logic controller (FLC) in MRAC to overcome the problem. The control input is given by the sum of the output of conventional MRAC and the output of fuzzy logic controller. The rules for the fuzzy logic controller are obtained from the conventional PI controller. The proposed fuzzy logic controller-based Model Reference Adaptive controller can significantly improve the system's behavior and force the system to follow the reference model and minimize the error between the model and plant output.**

***Keywords-Model Reference Adaptive Controller (MRAC), Fuzzy Logic Controller (FLC), Proportional-Integral (PI) controller***

## I. INTRODUCTION

Model Reference Adaptive Control (MRAC) is one of the main schemes used in adaptive system. Recently MRAC has received considerable attention, and many new approaches have been applied to practical processes [1], [2]. In the MRAC scheme, the controller is designed to realize plant output converges to reference model output based on the assumption that plant can be linearized. Therefore this scheme is effective for controlling linear plants with unknown parameters. However, it may not assure for controlling nonlinear plants with unknown structure. It is well known that fuzzy technique has been widely used in many physical and engineering systems, especially for systems with incomplete plant information [3]-[8]. In addition to fuzzy logic, it has been widely applied to controller designs for nonlinear systems [9]-[13].A learning approach of combining MRAC with the use of fuzzy systems as reference models and controllers for control dynamical systems can be found in [14]. A hybrid approach by combing fuzzy controller and neural networks for learning-based control is proposed in [15]. A problem of Fuzzy-Approximation-Based adaptive control for a class of nonlinear time-delay systems with unknown nonlinearities and strict-feedback structure is discussed in [16]. An Adaptive Network-Based Fuzzy Inference System (ANFIS) for speed and position estimation of permanent-magnet synchronous generator presented in [17].An adaptive fuzzy output feedback control approach is proposed for Single-Input-Single-Output (SISO) nonlinear systems without the measurements of the states. It is discussed in [18]. Gadoue et al. presented a fuzzy logic adaptation mechanisms and it is used in model reference adaptive speed-estimation schemes that are based on rotor flux[19].An adaptive fuzzy-based dynamic feedback tracking controller will be developed for a large class of strict-feedback nonlinear systems involving plant uncertainties and external disturbances and it is discussed in [20].Chang-Chun Hua et al. [21] presented an adaptive fuzzy-logic system and it is investigated for a class of uncertain nonlinear time-delay systems via dynamic output-feedback approach. A development of Adaptive Fuzzy Neural Network Control (AFNNC), including direct and indirect frameworks for an n-link robot manipulator, to achieve high-precision position tracking is discussed in [22]. An-Min Zou et al. [23] proposed a controller for the robust backstepping control of a class of nonlinear pure-feedback systems using fuzzy logic. A set of fuzzy controllers is synthesized to stabilize the nonlinear multiple time-delay large-scale system is presented in [24]

In this paper a proposal of designing a fuzzy logic controller- based model reference adaptive intelligent controller is designed from a fuzzy logic controller in parallel with a MRAC. From the designed PI controller, fuzzy rules are generated and it is used to design a fuzzy logic controller. The fuzzy controller is connected in parallel with an MRAC and its output is added and then given to the plant input. The fuzzy logic controller is used to compensate the nonlinearity of the plant and it is not taken into consideration in the conventional MRAC. The role of MRAC is to perform the model matching for the uncertain linearized system to a given reference model. Finally to confirm the effectiveness of proposed method, it is compared with the simulation results of the conventional MRAC.

## II. STATEMENT OF THE PROBLEM

To Consider a Single Input and Single Output (SISO), Linear Time Invariant (LTI) plant with strictly proper transfer function

$$G(s) = \frac{y_p(s)}{u_p(s)} = K_p \frac{Z_p(s)}{R_p(s)} \quad (1)$$

where $u_p$ is the plant input and $y_p$ is the plant output .Also, the reference model is given by


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$$G_m(s) = \frac{y_m(s)}{r(s)} = K_m \frac{Z_m(s)}{R_m(s)} \quad (2)$$

where r and ym are the model's input and output. To define the output error as

$$e = y_p - y_m \quad (3)$$

Now the objective is to design the control input u such as that the output error e goes to zero asymptotically for arbitrary initial condition, where the reference signal r(t) is piecewise continuous and uniformly bounded.

## III. STRUCTURE OF AN MRAC DESIGN

### *A. Relative Degree n =1*

As in Ref [1] the following input and output filters are used,

$$\dot{\omega}_1 = F\omega_1 + gu_p \quad (4)$$

$$\dot{\omega}_2 = F\omega_2 + gy_p$$

where F is an $(n-1)*(n-1)$ stable matrix such as that $\det(SI-F)$ is a Hurwitz polynomial whose roots include the zeros of the reference model and that (F,g) is a controllable pair. It is defined as the "regressor" vector

$$\omega = [\omega_1^T, \omega_2^T, y_p, r]^T \quad (5)$$

In the standard adaptive control scheme, the control u is structured as

$$u = \theta^T \omega \quad (6)$$

where $\theta = [\theta_1, \theta_2, \theta_3, C_0]^T$ is a vector of adjustable parameters, and is considered as an estimate of a vector of unknown system parameters θ* .

The dynamic of tracking error is

$$e = G_m(s) p^* \tilde{\theta}^T \omega \quad (7)$$

where $P^* = \frac{k_p}{k_m}$ and $\tilde{\theta} = \theta(t) - \theta^*$ represents parameter error. Now in this case, since the transfer function between the parameter error $\tilde{\theta}$ and the tracking error e is Strictly Positive Real (SPR) [1], the adaptation rule for the controller gain θ is given by

$$\dot{\theta} = -\Gamma e_1 \omega \operatorname{sgn}(p^*) \quad (8)$$

where $\Gamma$ is a positive gain.

### *B. Relative Degree n =2*

In the standard adaptive control scheme, the control u is structured as

$$u = \theta^T \omega + \dot{\theta}^T \Phi = \theta^T \omega - \theta^T \Gamma \phi e_1 \operatorname{sgn}(K_p / K_m) \quad (9)$$

where $\theta = [\theta_1, \theta_2, \theta_3, C_0]^T$ is a vector of adjustable parameters, and is considered as an estimate of a vector of unknown system parameters $\theta^*$ .

The dynamic of tracking error is

$$e = G_m(s)(s + p_0) p^* \tilde{\theta}^T \phi \quad (10)$$

where $P^* = \frac{k_p}{k_m}$ and $\tilde{\theta} = \theta(t) - \theta^*$ represents the parameter error. $G_m(s)(s+p_0)$ is strictly proper and Strictly Positive Real (SPR). Now in this case, since the transfer function between the parameter error $\tilde{\theta}$ and the tracking error e is Strictly Positive Real (SPR), [1] and the adaptation rule for the controller gain θ is given

$$\dot{\theta} = \Gamma \phi e_1 \operatorname{sgn}(K_p / K_m) \quad (11)$$

where e1= yp-ym and $\Gamma$ is a positive gain.

The adaptive laws and control schemes developed are based on a plant model that is free from disturbances, noise and unmodelled dynamics. These schemes are to be implemented on actual plants that most likely to deviate from the plant models on which their design is based. An actual plant may be infinite in dimensions, nonlinear and its measured input and output may be corrupted by noise and external disturbances. It is shown by using conventional MRAC that adaptive scheme is designed for a disturbance-free plant model and may go unstable in the presence of small disturbances.

## IV. PI CONTROLLER-BASED MODEL REFERENCE ADAPTIVE CONTROLLER

The disturbance and nonlinear component are added to the plant input of the conventional model reference adaptive controller, in this case the tracking error has not come to zero and the plant output is not tracked with the reference model plant output. The large amplitude of oscillations will come with the entire period of the plant output and the tracking error has not come to zero .The disturbance is considered as a random noise signal. To improve the system performance, the PI controller-based model reference adaptive controller is proposed. In this scheme, the controller is designed by using parallel combination of conventional MRAC system and PI controller.

The transfer function of PI Controller is generally written in the "Parallel form" given (12) by or the "ideal form'' given by (13)

$$G_{PI}(S) = \frac{U_{pi}(S)}{E(S)} = K_P + \frac{K_i}{S} \quad (12)$$

$$= K_P\left(1 + \frac{1}{T_i}\right) \quad (13)$$

where $U_{pi}(s)$ is the control signal, acting on the error signal $E(s)$,$K_p$ is the proportional gain, $K_i$ is the integral gain and $T_i$ is the integral time constant.

The block diagram of the PI controller-based model reference adaptive controller is shown in Fig. 1.

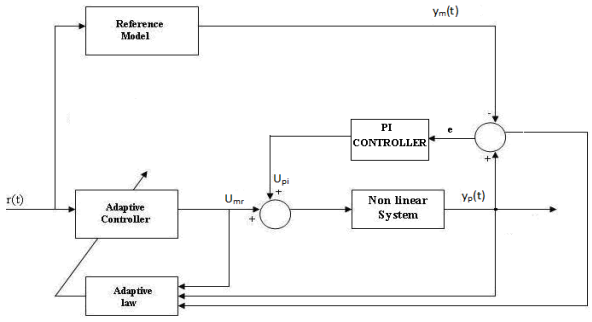


Fig. 1 PI controller-based MRAC

In the PI controller-based model reference adaptive controller, the value for the PI controller gains Kp and Ki are calculated by using the Ziegler–Nichols tuning method.



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The control input U of the plant is given by the following equation,

$$U = U_{mr} + U_{pi} \tag{14}$$
$$U_{mr} = \theta^T \omega$$

where Umr is the output of the adaptive controller and Upi is the output of the PI controller. The input of the PI controller is the error, in which the error is the difference between the plant output yp(t) and the reference model output ym(t). In this case also, the disturbance (random noise signal) and nonlinear component is added to the input of the plant .The PI controller- based model reference adaptive controller effectively reduces the amplitude of oscillations of the plant output. In this case the tracking error has not come to zero. The PI controller-based model reference adaptive controller improves the performance compared with the conventional MRAC.

## V. FUZZY LOGIC CONTROLLER-BASED MODEL REFERENCE ADAPTIVE CONTROLLER

To make the system adaptable to more quickly and efficiently than conventional MRAC system and PI controller-based MRAC system, a new idea is proposed and implemented. The new idea which is proposed in this paper is the fuzzy logic controller- based model reference adaptive controller. In this scheme, the controller is designed by using parallel combination of conventional MRAC system and fuzzy logic controller. The error and the change in error are given input to the fuzzy logic controller. The rules and membership function of fuzzy logic controller are formed from the input and output waveforms of PI controller of designed PI controller based MRAC scheme. The block diagram of fuzzy logic controller-based model reference adaptive controller is shown in Fig. 2.

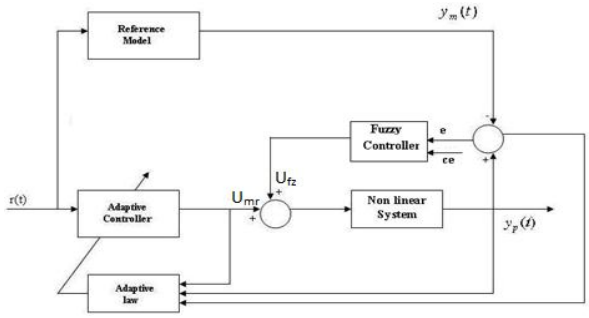


Fig. 2 Fuzzy logic controller-based MRAC system

The state model of linear time invariant system is given by the following form

$$X(t) = AX(t) + BU(t) \tag{15}$$
$$Y(t) = CX(t) + DU(t)$$

This scheme is restricted to a case of Single Input Single Output (SISO) control, noting that the extension to Multiple Input Multiple Output (MIMO) is possible. To keep the plant output yp converges to the reference model output ym, it is synthesized to control input U by the following equation,

$$U = U_{mr} + U_{fc} \tag{16}$$

where Umr is the output of the adaptive controller and Ufc is the output of the fuzzy logic controller

$$U_{mr} = \theta^T \omega$$
$$\theta = [\theta_1, \theta_2, \theta_3, C_0]^T \tag{17}$$
$$\omega = [\omega_1, \omega_2, y_p, r]^T$$

Stability of the system and adaptability are then achieved by an adaptive control law Umr tracking the system state x to a suitable reference model such as that the error e = yp-ym =0 asymptotically. The Fuzzy Logic Controller (FLC) provides an adaptive control for better system performance and solution for controlling nonlinear processes.

The plant output is compared with the model reference output. After comparison, the error and the change in error are calculated and are given as input to the fuzzy controller.

The error (e) and error change (ce) are defined as

$$e(k) = y_m(k) - y_p(k)$$
$$ce(k) = e(k) - e(k-1)$$

where ym(k) is the response of the reference model at kth sampling interval, yp(k ) is the response of the plant output at kth sampling interval, e(k) is the error signal at kth sampling interval, ce(k) is the error change signal at kth sampling interval.

FLC consists of three stages: fuzzification, rule execution, and defuzzification. In the first stage, the crisp variables e(kT) and ce(kT) are converted into fuzzy variables e and ce using the triangular membership functions. Each fuzzy variable is a member of the subsets with a degree of membership varying between '0' (non-member) and '1' (full member).In the second stage of the FLC, the fuzzy variables e and ce are processed by an inference engine that executes a set of control rules containing in a rule base. In this paper the control rules are formulated using the knowledge of the PI controller of designed PI controller-based MRAC system behavior and the experience of Control Engineers. The reverse of fuzzification is called defuzzification. The FLC produces the required output in a linguistic variable (fuzzy number). According to real-world requirements, the linguistic variables have to be transformed to crisp output. As the centroid method is considered to be the best well-known defuzzification method, it is utilized in the proposed method.

### *A. Construction of Fuzzy Rules:*

Consider an example of a PI controller input (error), change in error and PI controller output waveforms are given by Fig. 3.

By using the Fig.3, Fuzzy rules and membership for error (e) and change in error (ce) and output (Ufc ) are created

The developed fuzzy rules are

1. If error is 'A' and change in error is 'A' then the output is 'D'
2. If error is 'B' and change in error is 'B' then the output is 'F'
3. If error is 'C' and change in error is 'D' then the output is 'H'
4. If error is 'D' and change in error is 'F' then the output is 'J'
5. If error is 'E' and change in error is 'C' then the output is A


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6. If error is ‘F’ and change in error is ‘I’ then the output is ‘K’
7. If error is ‘G’ and change in error is ‘C’ then the output is B
8. If error is ‘H’ and change in error is ‘H’ then the output is ‘I’
9. If error is ‘I’ and change in error is ‘C’ then the output is ‘C’
10. If error is ‘J’ and change in error is ‘E’ then the output is E
11. If error is ‘K’ and change in error is ‘G’ then the output is ‘G’

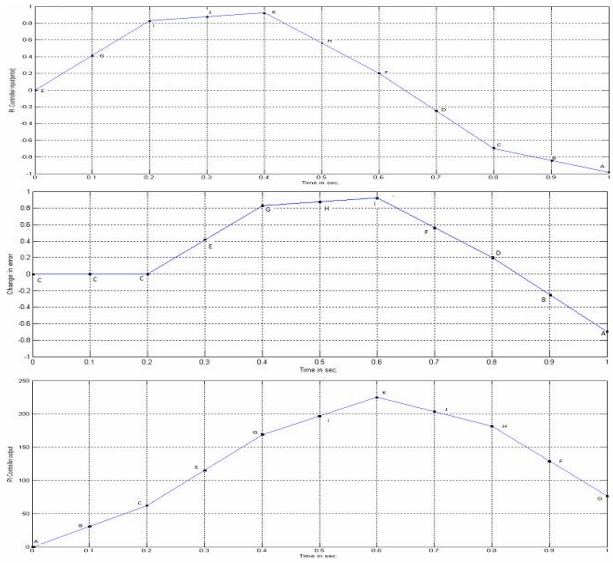

Fig. 3 PI controller input (error), change in error and PI controller output (Upi)

The FLC has two inputs: error e(kT) and change in error ce(kT) and one output Ufc(kT). The membership functions for fuzzy variable error (e), change in error (ce) and output (Ufc) are shown in Fig.4.

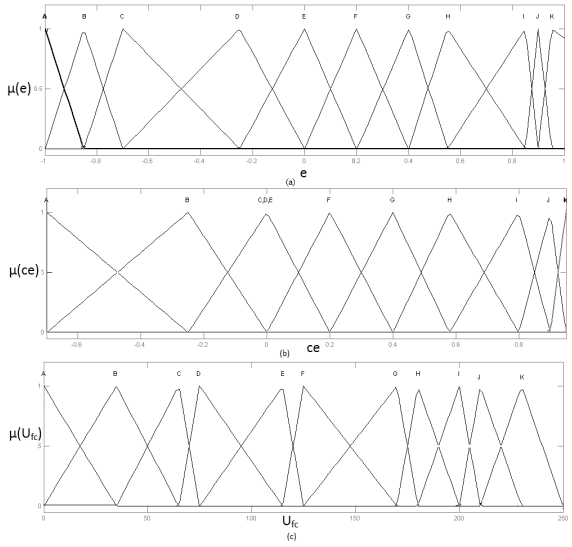


Fig. 4 (a) Membership functions of the fuzzy variables error (e), (b) change in error (ce), and output (Ufc)

In this proposed fuzzy logic controller- based MRAC method, tracking error became zero within 6 seconds and no oscillation has occurred. The plant output has tracked with the reference model output. This method is better than conventional MRAC system and PI controller -based MRAC system

## VI. RESULTS AND DISCUSSION

In this section, the results of computer simulations for conventional MRAC, PI controller-based MRAC and fuzzy logic controller-based MRAC system are reported. The results show the effectiveness of the proposed fuzzy logic controller-based MRAC scheme and reveal its performance superiority to the conventional MRAC technique.

*Example 1:*

In this example, the nonlinearity of backlash which is followed by linear system is shown in Fig. 5

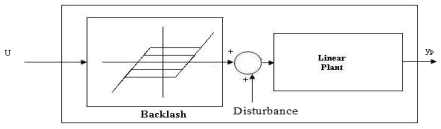


Fig. 5 Nonlinear System

The disturbance (random noise signal) is also added to the input of the plant

As an example, the system taken for the simulation is the Lateral Dynamic Model of a Boeing 747 airplane.

The transfer function for the Lateral Dynamic Model of a Boeing 747 airplane System is given by

$$G(s) = \frac{-0.5s^3 - 0.2608s^2 - 0.1223s - 0.05832}{s^4 + 0.6358s^3 + 0.9389s^2 + 0.5116 + 0.003674}$$

and the reference model are given by,

$$G_m(s) = \frac{1}{(s+3)}$$

The simulation was carried out with MATLAB and the input is chosen as r(t)= 55sin0.7t.The initial value of the conventional MRAC scheme controller parameters are chosen as θ(0) = [0.5, 0, 0, 0]T . The conventional model reference adaptive controller is designed by using the equations (6) and (8).

The simulations are done for the conventional MRAC, PI controller- based MRAC and fuzzy logic controller-based MRAC system with random noise disturbance and nonlinear component are added to the plant.

In the PI controller-based model reference adaptive controller, the value of the PI controller gains Kp and Ki are equal to 10 and 75 respectively. In the fuzzy logic controller- based model reference adaptive controller, each universe of discourse is divided into six fuzzy sets: NH (Negative High), NL (Negative Large), ZE (Zero), PS (Positive Small), PM (Positive Medium) and PH (Positive High).

The fuzzy variables e and ce are processed by an inference engine that executes a set of control rules which are contained in a (6x6) rule base as shown in Fig.6. The control rules are formulated using the knowledge of the PI controller of designed PI controller based MRAC scheme behavior and the experience of Control Engineers.


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| e \ ce | NH | NL | ZE | PS | PM | PH |
|---|---|---|---|---|---|---|
| NH | NH | ZE | ZE | PS | NL | PH |
| NL | NH | PS | ZE | PS | NH | NL |
| ZE | PS | ZE | ZE | PS | PS | PM |
| PS | NH | PS | ZE | PS | PS | NH |
| PM | NH | ZE | ZE | PS | PM | PH |
| PH | NL | ZE | ZE | NL | NH | PH |

Fig. 6 Fuzzy rules table

The membership functions for fuzzy variable error (e), change in error (ce) and output (Ufc) are shown in Fig. 7

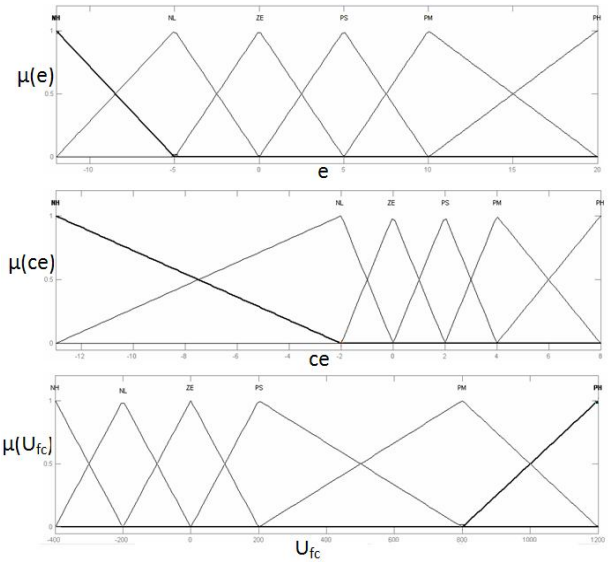
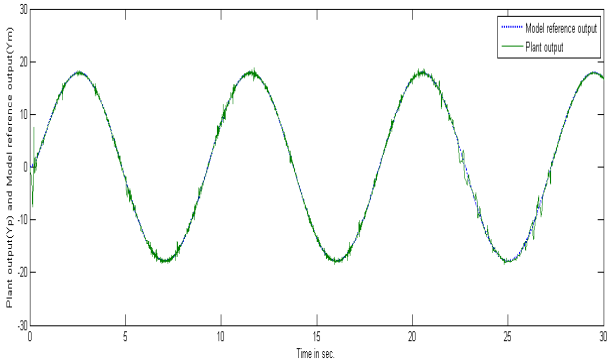
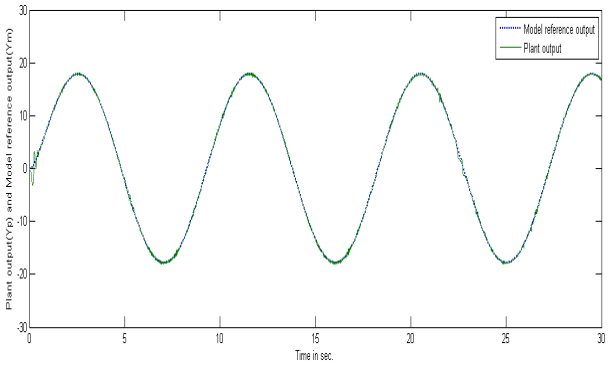



Fig. 7 Membership functions for fuzzy variable error (e), change in error (ce) and output (Ufc)

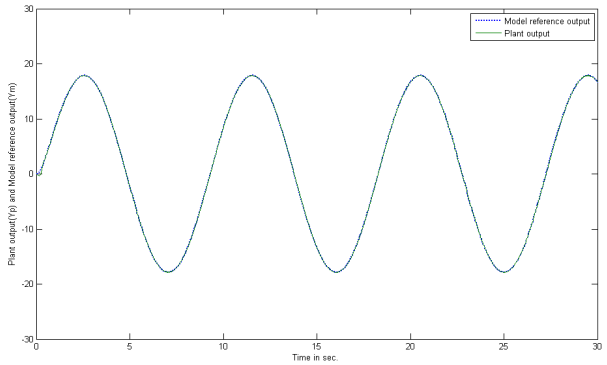
The results for the conventional MRAC, PI controller-based MRAC and fuzzy logic controller -based MRAC system are given in Fig. 8



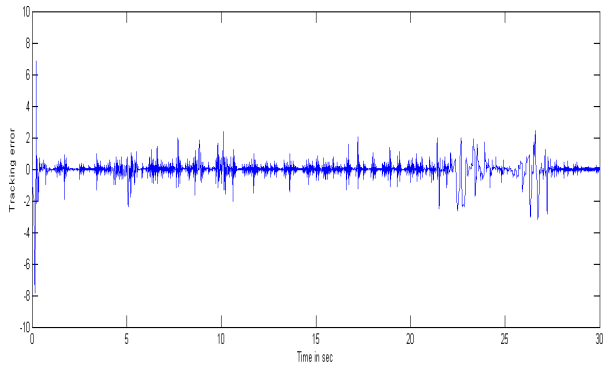

8(a)



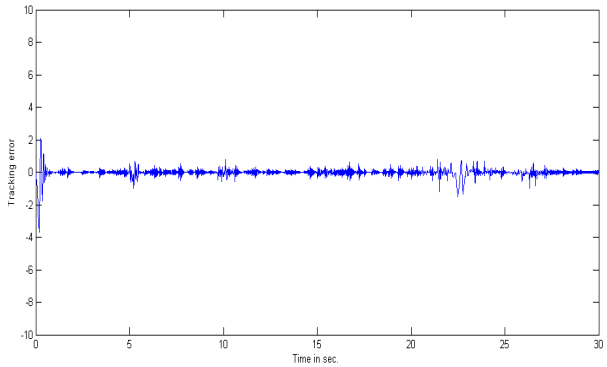

8(b)




8(c)




8(d)




8( e )



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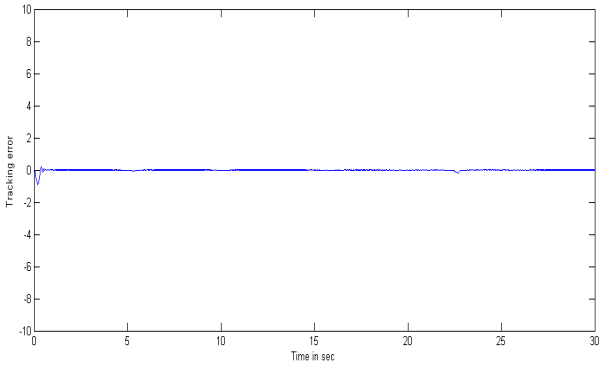



8(f)

Fig. 8 Simulation results:8(a).Plant output yp(t) (solid lines) and the Reference model output ym (t) (dotted lines) of the conventional MRAC system for the input r(t)= 55sin0.7t. 8(b).Plant output yp(t) (solid lines) and the Reference model output ym (t )(dotted lines) of the PI controller-based MRAC scheme for the input r(t)= 55sin0.7t. 8(c). Plant output yp(t) (solid lines) and the Reference model output ym (t )(dotted lines) of the fuzzy logic controller-based MRAC scheme for the input r(t)= 55sin0.7t. 8(d).Tracking error e for the conventional MRAC.8 (e).Tracking error e for the PI controller-based MRAC scheme and 8(f) Tracking error e for the fuzzy logic controller -based MRAC scheme.

*Example 2:*

In this example, the nonlinearity of Dead zone is followed by linear system.The disturbance (random noise signal) is also added to the input of the plant. A second order system with the transfer function is given below

$$G(S) = \frac{1}{S^2 + 3S - 10}$$

is used to study and the reference model is chosen as

$$G_M(S) = \frac{5}{S^2 + 10S + 25}$$

The initial value of conventional MRAC scheme controller parameters are chosen as θ(0) = [3, 18,-8, 3]T. The conventional model reference adaptive controller is designed by using the equations (9) and (11). The simulation was carried out with MATLAB and the input is chosen as r(t)= 20+5sin4.9t. In the PI controller based model reference adaptive controller, the value for the PI controller gains Kp and Ki are equal to 8 and 85 respectively.

In the fuzzy controller based model reference adaptive controller, seven linguistic variables are used for the input variable error and change in error.

They are Extremely Negative (EN), High Negative (HN), Medium Negative (MN), Small Negative (SN), zero (ZE), Medium Positive (MP) and High Positive (HP).

The seven linguistic variables are used for the output variable as Very Low(VL),Low(L),Nearly Low(NL), Medium(M),Medium High(MH),High(H) and Extremely positive(EP).

The control rules are formulated using the knowledge of the PI controller of designed PI controller-based MRAC scheme behavior and the experience of Control Engineers. The fuzzy variables e and ce are processed by an inference engine that executes a set of control rules which are containing in a (7x7) rule base as shown in Fig. 9. The membership functions for fuzzy inputs error (e), change in error (ce) and fuzzy output (Ufc) are shown in Fig. 10.

| e \ ce | EN | HN | MN | SN | ZE | MP | HP |
|---|---|---|---|---|---|---|---|
| EN | L | H | M | MH | MH | L | H |
| HN | H | M | M | MH | MH | H | H |
| MN | M | M | MH | MH | MH | M | H |
| SN | M | MH | MH | MH | MH | MH | L |
| ZE | M | MH | MH | MH | VL | M | EH |
| MP | H | H | M | MH | MH | H | L |
| HP | L | L | M | MH | MH | L | NL |

Fig. 9 Fuzzy rules table

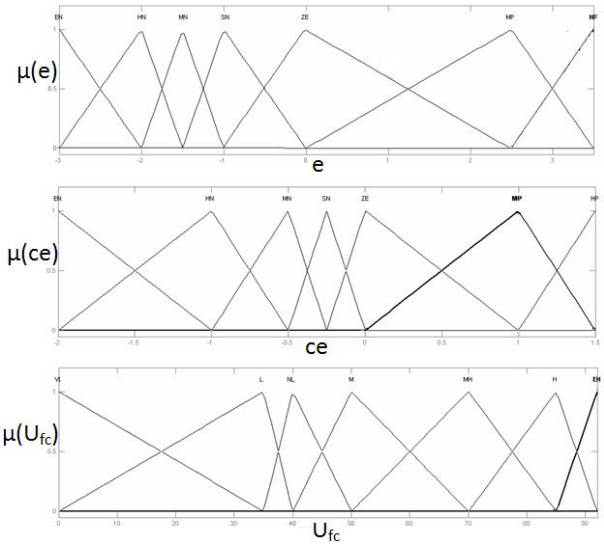
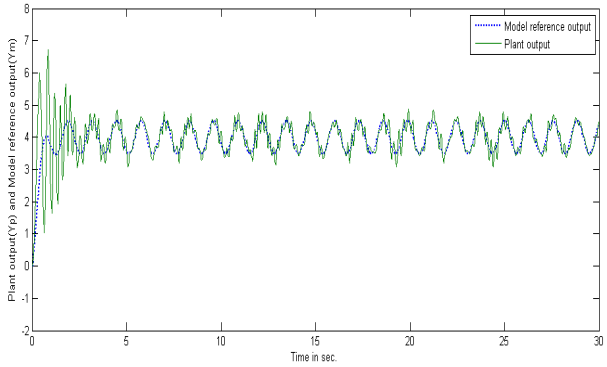



Fig. 10 Fuzzy memberships used for simulation

The results for the conventional MRAC, PI controller-based MRAC and fuzzy logic controller- based MRAC system are given in Fig .11.




11 (a)



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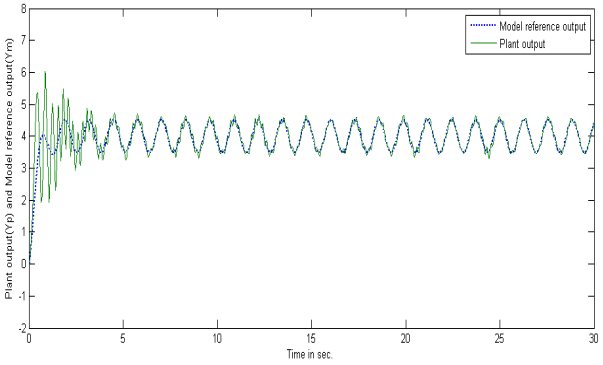
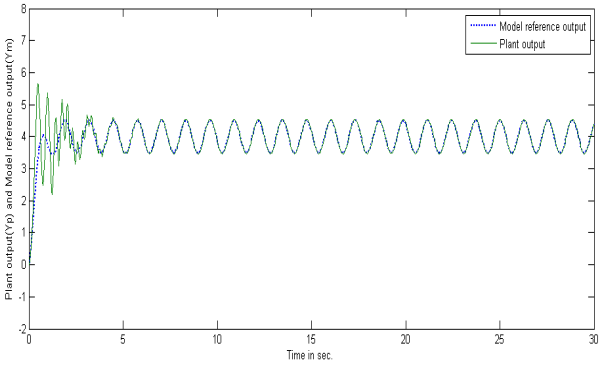
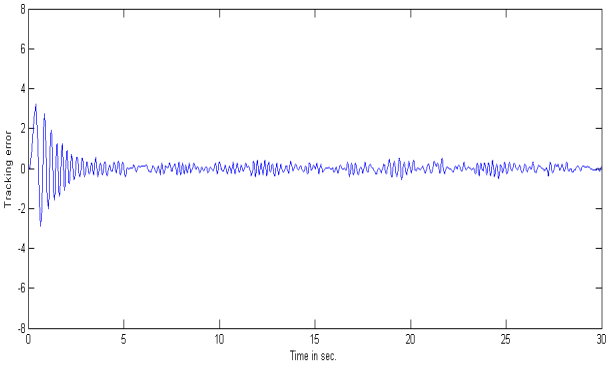


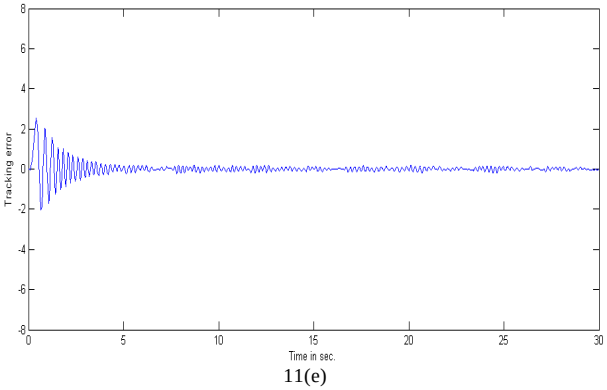

11(b)



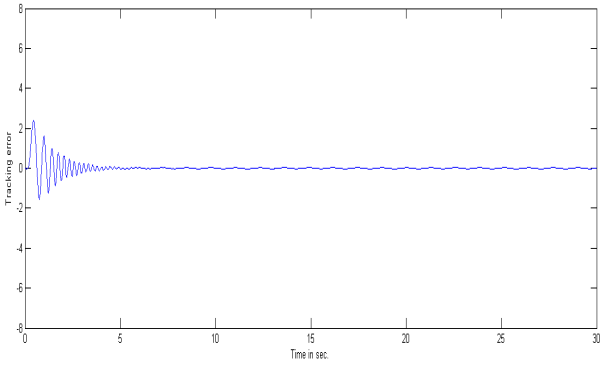

11(c)




11(d)




11(e)




11(f)

Fig. 11 Simulation results:11(a) Plant output yp(t) (solid lines) and the Reference model output ym (t) (dotted lines) of the conventional MRAC system for the input r(t)= 20+5sin4.9t. 11(b) Plant output yp(t) (solid lines) and the Reference model output ym (t )(dotted lines) of the PI controller-based MRAC scheme for the input r(t)= 20+5sin4.9t. 11(c) Plant output yp(t) (solid lines) and the Reference model output ym (t )(dotted lines) of the fuzzy logic controller-based MRAC scheme for the input r(t)= 20+5sin4.9t. 11(d) Tracking error e for the conventional MRAC. 11(e) Tracking error e for the PI controller-based MRAC scheme. 11(f) Tracking error e for the fuzzy logic controller- based MRAC scheme.

The nonlinear component and the disturbance (random noise signal) are added to the plant input of conventional MRAC. The plant output is not tracked with the reference model output and large amplitude of oscillations occur at the entire plant output signal as shown in Fig. 8(a) and 11(a) and also tracking error has not come to zero as shown in Fig. 8(d) and 11(d). But when the disturbance (random noise signal) and non linear component are added to the input of the plant of PI controller-based model reference adaptive controller and it improves the performance comparing to the conventional MRAC and also reduces the amplitude of oscillations of the plant output as shown in Fig. 8(b) and 11(b).In this case also plant output does not track the reference model output and the tracking error has not come to zero as shown in Fig. 8(e) and 11(e).When the disturbance (random noise signal) and nonlinear component are added to the input of the plant of the proposed fuzzy logic controller-based MRAC scheme, the plant output has tracked with the reference model output as shown in Fig. 8(c) and 11(c).The tracking error becomes zero within 6 seconds with less control effort as shown in Fig. 8(f) and 11(f) and no oscillations has occurred. From the plots, one can see clearly that the transient performance, in terms of the tracking error and control signal, has been significantly improved by the proposed MRAC using fuzzy logic controller. The proposed fuzzy logic controller-based MRAC schemes show better control results compared to those by the conventional MRAC and PI controller -based MRAC system. On the contrary, the proposed method has much less error than conventional method in spite of nonlinearities and disturbance.

## VII. CONCLUSION

In this section, the response of the conventional model reference adaptive controller is compared with the PI controller-based MRAC system and proposal model reference adaptive controller using fuzzy logic controller. The controller is checked with the two different plants. The proposed fuzzy logic controller -based MRAC controller shows very good tracking results when compared to the



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conventional MRAC and the PI controller- based MRAC system. Simulations and analyses have shown that the transient performance can be substantially improved by proposed MRAC scheme and also the proposed controller shows very good tracking results when compared to conventional MRAC. Thus the proposed intelligent parallel controller is found to be extremely effective, efficient and useful

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# Routing Approach with Immediate Awareness of Adaptive Path While Minimizing the Number of Hops and Maintaining Connectivity of Mobile Terminals Which Move from One to the Others

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***Abstract*— Wireless Ad-hoc Network (MANET) is a special kind of network, where all of the nodes move in time. The topology of the network changes as the nodes are in the proximity of each other. MANET is generally self-configuring no stable infrastructure takes a place, where each node should help relaying packets of neighboring nodes using multi-hop routing mechanism. This mechanism is needed to reach far destination nodes to solve problem of dead communication. This multiple traffic "hops" within a wireless mesh network caused dilemma. Network that contain multiple hops become increasingly vulnerable to problems such as energy degradation and rapid increasing of overhead packets. In recent years, many routing protocols have been suggested to communicate between mobile nodes. One proposed routing approach is to use multiple paths and transmit clone of the packets on each path (i.e., path redundancy). Another more efficient routing protocol is to selective path redundancy from the multiple paths and sends packets on appropriate path. It can improve delivery efficiency and cut down network overhead, although it also increases processing delays on each layer. This paper provides a generic routing framework that immediately adapts the broken of established main route. The fresh generated route search process is taking place immediately if topology changing is initialized while data is being transmitted. This framework maintains the route paths which consist of selected active next neighbor nodes to participate in the main route. At the time which the main route is broken, the data transmission starts immediately thus data is transmitted continuously through the new route and the broken route is recovered by the route maintenance process. We conduct extensive simulation studies to shows that proposed routing protocol provides the backup route at the time when the main route is loss and analyzed the behavior of packets transmission. Using the framework, the average of successfully generated data transmission at various hops is kept 4.5% higher than the other network without implemented it with about 22% of overhead packets increase. Related with average network speed, the proposed protocol has successfully improved the successful data transmission 10.94% higher (at average network speed between 10 and 40 km/h). In the future research, we will extend this framework in wide area of wireless network and compare it with other multipath routing protocols.**

***Multi-hop; route path; connectivity; metric (key words)***

## I. INTRODUCTION

MANET consists of mobile nodes platforms which are free to move in the area. Node is referred to a mobile device which equipped with built-in wireless communications devices attached and has capability similar to autonomous router. The nodes can be located in or on airplanes, ships, cars, rooms, or on people as part of personal handheld devices, and there may be multiple hosts among them. The system may operate in isolation, or have gateways to a fixed network. Every node is autonomous. In the future operational mode, multiple coverage of the network is expected to operate as global “mobile network” connecting to legacy “fixed network”.

The network has several characteristics, e.g. dynamic topologies, bandwidth-constrained, energy - constrained operation, and limited physical security. These characteristics create a set of underlying assumptions and performance considerations for protocol design which extend beyond static topology of the fixed network. The design should reacts efficiently to topological changes and traffic demands while maintain effective routing in a mobile networking context.

All nodes in MANET rely on batteries or other exhaustible energy modules for their energy. As a result of energy conservation or some other needs, nodes may stop transmitting and/or receiving for arbitrary time periods. A routing protocol should be able to accommodate such sleep periods without overly adverse consequences. Therefore, routing protocols for ad hoc network consider node mobility, stability and the reliability of data transmission. Broadcast is the dominant form of message delivery on the wireless network. Most of AODV protocol and its extensions use overhearing of broadcasted RREQ and RREP packets for discovering routes.

In this paper, we provide a framework that immediately adapts the loss of established main route. The main route can be broken because of either death nodes or metric calculation requirements. The network should capable to generate backup

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route search process immediately if topology changing is initialized while data is being transmitted. This framework takes care of the updated broken route which is selected active neighbor nodes to participate in the main route. At the time which the main route is broken, the broken route is recovered by the topology maintenance process then the data transmission starts immediately through the new route. It is expected to reduce the packet transmission delay by establishing the backup route while data is transmitted. We conduct extensive simulation studies to shows that proposed routing protocol provides the backup route at the time when the main route is broken off and analyzed the behavior of packets transmission. A comparison between similar network of Link State Routing and the generic framework is also conducted. Simulation results show that modified algorithms under different formation conditions are more efficient than the network without deployed that framework. The remainder of this paper is organized as follows: Section 2 gives preliminaries and our system model. Section 3 discusses the detail design of the simulation model, its notations, and assumptions. Simulation algorithm that suits mobile environment is presented in Section 4. A performance evaluation of generic algorithm and comparison to a similar network of Link State Routing are presented in Section 5. Section 6 concludes the paper.

## II. RELATED WORKS

Wireless network is generally set up with a centralized access point for provide high level of connectivity in certain area. The access point has knowledge of all devices in its area and routing to nodes is done in a table driven manner [1][2][5]. The Nemoto[2] introduced a technical review of wireless mesh network products that implemented IEEE802.11 standard through installation of fixed wireless mesh network nodes. In terms of review the network performance at this stage, it will be represented as the view of use and evaluation of outdoors Muni-WiFi devices in accordance to applying the legacy LAN technology inside the corporate network. Performance of network access layer, i.e. performance of voice and TCP data transmission in terms of throughput, response time between mesh nodes, and communication delay in multi-hop transmission are presented.

However, Nemoto[2] intended to operate in static topology network. With recent performance in computer and wireless communications technologies, advanced wireless mobile device is expected to see increasingly widespread use and application. The vision of future mobile ad hoc networking is to support robust and efficient operation in mobile wireless networks by incorporating routing functionality such that networks are capable to be dynamic, rapidly-changing with random, multi-hop topologies which are likely composed of relatively bandwidth-constrained wireless links. Supporting this form of host mobility requires address management, protocol interoperability enhancements and the likes.

In this dynamic network, broadcasting plays a critical role especially in vehicular communication where a large number of nodes are moving and at the same time sending a large size of packet. In wireless network where nodes communicate with each other using broadcast messages, the broadcast environment works as receivers collect information from all transmitting nodes within its coverage neighborhood, and then allowing receivers to aware of immediate surrounding respond before re-transmitting packet. Several transmissions may be redundant (overhead) during broadcast mechanism. These redundant causes the broadcast storm problem [8], in which redundant packets cause contention, collision, and consume a significant percentage of the available energy resources. Thus, routing protocols should be capable to respond these changes using minimum signaling and taking into account the energy as a parameter distributed in network.

Routing is one of the key network protocols in telecommunication networks. It selects the paths for traffic to flow from all the sources to their final destinations. Between sources and final destinations, there are nodes, areas, and active traffic. There are proposals to allow flexible multipath routing in the Internet and single-path routing primarily uses where one user (source-final destination pair) uses only one selected path from the source to the destination, with the exception that traffic may split evenly among equal cost paths e.g., the current routing protocol within an AS, Open Shortest Path First (OSPF) protocol.

In single-path routing protocols, route maintenance can be performed in concurrent with data transmission and take its role whenever routes fail or broken off. Therefore, data transmission will be stopped while the new route is established, causing data transmission delay. On the other hand, multipath routing protocols perform the route maintenance process even if only one route fails among the multiple routes. To perform the route maintenance process before all routes fail, the network must always maintain multiple routes. This can reduce data transmission delays caused by link failure. However, routing maintenance can lead to higher traffic of overhead. Several implementations of routing are based on AODV; typical examples are AOMDV, AODVM and AODV-BR protocols.

The AODV-BR [10] protocol maintains the main route rules when it is broken by using the neighbor nodes around the routes to bypass the main route. At this protocol, neighbor nodes overhear the RREP packets for establishing and maintaining the backup routes during the route initiation process. If part of the main route is broken, nodes broadcast RRER packets to neighbor nodes. When neighbor nodes receive this packet, they establish an alternate route using information contained in overheard RREP packets previously.

The AOMDV [7] protocol establishes link-disjoint paths in the network. When nodes receive the RREQ packet from the sender node, AOMDV protocol stores all RREQ packets. So, each node maintains a list of neighboring hops where RREQ packet contains information about neighbor node of the sender nodes. If first hop of received RREQ packet is duplicated from its own first hop, the RREQ packet is discarded. At the final destination, RREP packets are sent from each received RREQ packet. The multiple routes are made by RREP packets that follow the reverse routes to source node that have been set up already in intermediate nodes.


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For the AODVM [9] protocol, the intermediate nodes record all received RREQ packets in routing table. They do not discard the duplicate RREQ packets. The final destination node sends an RREP for all the received RREQ packets. An intermediate node forwards a received RREP packet to the neighbor in the routing table to reach source node. Each node cannot participate in more than one route.

## III. Simulation Model, Notations, And Assumption

In this paper, we propose framework of adaptive route protocol based on the AODV protocol and broadcast mechanism. AODV protocol is configured in the network with topology changed randomly because of the freely moving mobile nodes. In this circumstance, node failure occurs frequently. Therefore, AODV should capable to sense the path for nodes involved between source and final destination to prevent path breakthrough caused by node failure. This framework generates route search process immediately after the established main route is broken. It uses RREQ and RREP packets which are broadcasted to appropriate active neighbor nodes in order to incorporate in the main route on behalf of source-final destination path. Such this adaptive single hop routing may consume a lesser amount of energy in comparison to multi hop routing. In addition, this framework gets its advantage in the case transmission of larger packets where the fragmented packets should reach the final destination with higher successful transmission.

The proposed framework assumes that nodes are capable of dynamically adjusting their relay nodes on per move step base. This behavior is almost similar to MANET routing protocols (e.g., AODV, DSR and TORA). One common property of these routing protocols is that they discover routes using broadcast flooding protocols whose value of distance metric in order to minimize the number of relay nodes between any source and final destination pair.

### A. The Model

Simulation cover a single area of homogeneous nodes that communicate with each other using the broadcast services of IEEE 802.11. There are nodes with different roles simulated in this simulation, namely initiator node/source node, receiver node, sender node, destination node, and final destination node. Initiator node/source node is node that initiates transmission of packet. Packet can be either route discovery or data transmission. Like other nodes, initiator is always moving with random direction, speed, and distance. At the time it is moving, initiator node is always sensing its neighbor to maintain connectivity. Receiver node is node that can be reached by source/sender node. Nodes are defined as neighbors if it located within its distance radius range. At initial time, node senses its neighbors before packet data is required to be transmitted. Coverage neighbor nodes always receive packets that are broadcasted from sender. Destination node is selected receiver node in multi hop transmission that should relay packets to the next receiver node. Final destination node is node that became the end destination of packets.

Wireless link channel is assumed to have no physical noise; i.e., the errors in packet reception due to fading and other external interferences are not considered as a serious problem. Packets from sender to receiver will be transmitted as long as the bandwidth capacity is sufficient and the received signal to noise ratio (SNR) is above a certain minimum value. Thus each packet received is acknowledged at the link layer and de-encapsulate at the higher layer. Each node is capable of measuring the received SNR by analyzing overhead of packets. A constant bit error rate (BER) is defined for the whole network. Whenever a packet is going to be sent, a random number is generated and compared to the packet's CRC. If the random number is greater, the message is received, otherwise it is lost. The default value for the BER is 0, which means there is no packet loss due to physical link error.

The layered concept of networking was developed to accommodate changes in local layer protocol mechanism. Each layer is responsible for a different function of the network. It will pass information up and down to the next subsequent layer as data is processed. Among the seven layers in the OSI reference model, the link layer, network layer, and transport layer are 3 main layers of network. The framework is configured in those layers. Genuine packets are initiated at Protocol layer, and then delivered sequentially to next layer as assumed that fragmented packets to be randomly distributed. Simulation models each layer owned with finite buffers. Limited buffer makes packets are queued up according to the drop tail queuing principle. When a node has packets to transmit, they are queued up provide the queue contains less than K elements ($K \geq 1$). To increase the randomization of the simulation process, simulation introduces some delay on some common processes in the network, like message transmission delay, processing delay, time out, etc. This behavior will result that at each instance of a simulation would produce different results. The packets exchanged between sender and receiver is of a fixed rate transmission $\lambda$ based on a Poisson distribution. Nodes that have packet queued are able to transmit it out using in each available bi-directional link channel.

Energy is power kept in each node. The energy consumption required to transmit a packet between nodes A and B is similar to that energy required between nodes B and A if and only if the distance and the size of packet are same. The coverage distance range of the nodes is a perfect symmetric unit disk (omni-directional). If $d_{x,y} \leqslant r_x \rightarrow$ x and y can see each other. This assumption may be acceptable in the condition that interference in both directions is similar in space and time; which is not always the case. Usually interference-free Media Access Control (MAC) protocol such as Channel Sense Multiple Access (CSMA) may exist. Heinzelman et al. assumed that the radio dissipates $E_{elec}$ = 50 nJ/bit to run the transmitter or receiver circuitry and $\varepsilon_{amp}$ = 100 pJ/bit/m$^2$ for the transmit amplifier [5][6]. The radio model is shown in the Fig. 1 below.

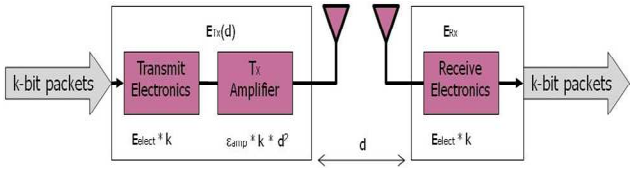


Figure 1: The radio model.


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Thus, to transmit a k-bit message a distance d using this radio model, the radio expends:

$$E_{TXBit}(k,d) = E_{elect}*k + \varepsilon_{amp}*k*d^2 \quad (1)$$

and to receive this message, the radio expends:

$$E_{RX}(k) = E_{elect}*k \quad (2)$$

The energy behaviors of node are defined as follow:

- During the idle time, a node does not spend energy. Even though this assumption has been proven untrue because being idle might be as costly as receiving data, this is still an assumption that can be done in most experiments, since the most important factor is the overhead in terms of message exchange and its associated cost.
- The nodes are assumed to have one radio for general messages. The main radio is used in all operations when the node is in active mode, and to send and receive control packets. When this radio is turned off, then no messages will be received and no energy will be used.
- Energy distribution among nodes can either be constant value, normally distributed, Poisson distributed, or uniformly distributed.

### *B. Immediate Awareness Routing Algorithm*

The core algorithm is developed from static mode (e.g., sensor networks). The enhancement for serving mobility then detailed in support of topology development and routing maintenance. We show our methodology on a tree network. The tree topology decomposes the paths between source and final destination into several route paths. The algorithm underestimates the interference among the route paths. The algorithm starts to operate with the network topology development. The routing maintenance is responsible to sense the broken of the main route path during data transmission.

Network topology is initiated using broadcast mechanism and propagated through node-to-node based on routing metrics approach. During propagation, it takes into account all topology development, route discovery, and data transmission. Each source injects single big packet which fragmented into multiple packets in the network, which traverse through the network until reach the final destination. Packets, which are waited for an opportunity to be transmitted, are queued at each node in its path. This model is not only applicable in direct communication (one hop transmission) but it can also work in multi-hop transmission. In this situation, when the source and final destination nodes are located outside the maximum transmission range, source node is capable to discover multiple hops routing while keep the data being transmitted.

Topology development is proactive; it discovers and disseminates link state information. It involves transmit and receives of HELLO packets, REPLY packets, CONFIRM packets, and so on; mostly redundant. These packets which successfully received by link layer, will update an entry in the neighbor table which cache information about surrounding nodes exists. HELLO packets and corresponding REPLYs have contents of [ID, hop, energy, time, throughput, direction], where ID is a unique neighbor node (IP address), hop is a number which increment each time packet reach at relay node, energy is current available energy level needed to ensure the communication with the neighbor node, time is current time at which this event is executed, throughput is total of bits that can be pushed through this available link having bandwidth and latency, and direction is the way node will move to reach its distance.

The routing maintenance is responsible for performing the route optimization operation that leads to the discovery of routes changes. The algorithm performs two basic operations: initiate packets, which compute whether a route optimization between two nodes is needed and sets up broadcast mechanism; and determine when to transmit routing maintenance packets. The framework optimizes routes through sequence of steps to converge to an optimum route.

When a node first starts, it only knows of its immediate neighbors, and the direct cost involved in reaching them. (This information, the list of destinations, the total cost to each, and the next hop to send data to get there, makes up the routing table, or distance table.) Each node, on a regular basis, sends broadcast packets to neighbors to get all costs of destinations. The neighboring node(s) examine this information, and compare it to what they already know, thus update their own routing table(s). Over time, all the nodes in the network will discover the best next hop for all destinations, and the best total cost. When one of the nodes involved are changed, those nodes which used it as their next hop for certain destinations discard those entries, and create new routing-table information. They then pass this information to all adjacent nodes, which then repeat the process. All the nodes in the network receive the updated information, and discover new paths to all the destinations which they can still reach.

During this sequence, relay node is determined by relevant information gathered from neighbor nodes. After omitted redundant packets and based on calculation metric value, relay node is set (i.e., a small set of nodes that potentially forward the broadcast packet) to achieve high delivery ratio with certain metric consideration. It means that only selected neighbors able to forward the packet to the next neighbors. The selected neighbor or new relays added to a route during iteration are very much dependent on the relay found in the previous iteration. This set can be selected dynamically (based on both topology and broadcast state information). In order to simulate this proposed routing, the relay node set forms a connected dominating set (CDS) and achieves full coverage of connected network. It is possible that the first iteration, which seemed as most optimum value of metric value is not the route achieving the optimum topology with optimum delay path.

Several relay nodes may exist between source and final destination, thus source node must choose the one providing a highest metric value in the path lead to final destination. Multiple packets are sent to that single (next) relay node. Transmission of multiple route-redirect packets will waste bandwidth and network resources (overhead packets increased). For sparsely populated networks, this may not be a problem. However, this is an issue in the case of densely


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populated networks where several potential nodes can be chosen. [4] The simulation creates dense environment. Densely populated nodes are desired to make alternate routing possible.

Routing maintenance is part of the framework that addresses this immediate awareness path change by giving priority for the execution of an update routing maintenance packet to the potential neighbor node that computes highest route metric energy-distance values first. After receiving an update routing maintenance packet, a node modifies its routing table, putting the source of the received packet as the next hop node for the specific sender-destination route path. To execute preferential event in sequentially distributed events, we apply a different time-event execution after the triggering event takes place. The lower and upper bound of the queuing interval are set such that events do not interfere with predefined timers used by the other events for layers and modification events.

The proposed scheme for routing maintenance is as follow. First, when main route failure is detected, the RouteERROR packet sent back to a source and nodes participating in the path to allow detecting the disconnection of the main route. When the node receives the RouteERROR packet it checks the level flag in the routing table and determines whether it belongs to stay near or far from first relay of the main route. After received RouteERROR packet, the closest node reinitiates the route discovery process for the main route, and at the same time keeps the packets (already) received and reconfigures its path configuration. The dying node (i.e. node caused the route path breakthrough) stops to receive new packets. It has responsibility to transmit packets (already) received to destination node before steady silent (and OFF). Immediately after the breakthrough path is successfully re-connected, the closest node starts data transmission through the backup route.

In AOMDV and AODVM, data transmission is started after the path is found.[4] It cause overhead at the first route discovery and delay the first data transmission. The proposed framework solved these problems by starting a data transmission immediately after route discovery process starts at some interval of initialTime. To establish a main route, a source node broadcasts an HELLO packet with the level value of zero to neighbor nodes. When intermediate nodes receive the packet, they store the level value and information about the source node in the neighbor table. Neighbor nodes transmit the corresponding REPLY packet, which is sent back to the source node along with information owned through the reverse path. Intermediate nodes that receive the REPLY packet increment the level value in the neighboring table. By incrementing the level value, the protocol ensures that a node will be used as (considerably) the selected route paths. When a source node receives the REPLY packet, the main route is established. Source node then broadcast confirmation packets about this selection to neighbor nodes again. Each source node does broadcasts HELLO packets with the certain level value to surrounding nodes. Consequently, nodes belonging to the main route keep different level values. Nodes belonging to the main route always have a level value one higher if located under several relays from source node. A value of zero for level flag indicates the source node of main route, and a value of one indicates the next relay in the main route.

After two hops iterations, the source node starts data transmission. When receiver receives a packet data from other nodes, it de-encapsulates the packet, check packet's destination, and searches the routing table to see if a route toward the destination node may exist. If this is not the case, the node searches the neighbor table to see if information regarding the destination node is available. If this is not the case, the node will give up and makes information about this to its gateway. Otherwise, the node will process the received packet. The iteration will follows as described previously. When nodes are mobile and no data packets are available for transmission, a source node required to transmit explicit signaling packets to maintain a topology.

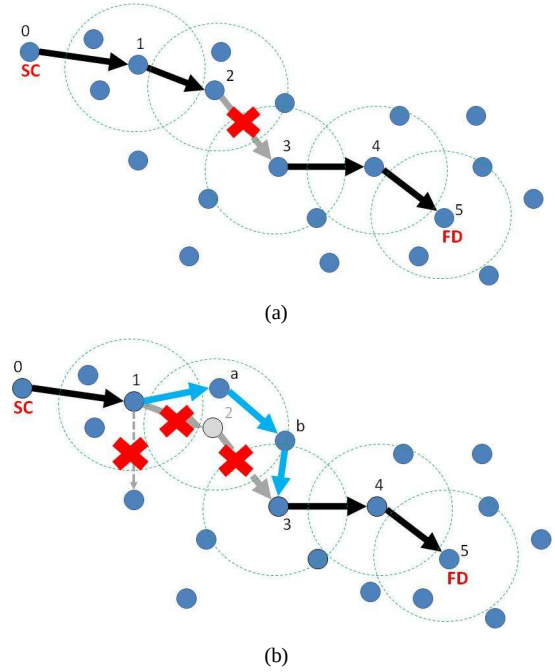


Figure 2. Route path maintenance steps. (a) At the time path is broken off. (b) The re-paired path (backup route) is established.

Fig. 2 shows the example that the route is maintained when a new source node SC performs the route discovery process to the destination node FD as the final destination node of source node SC (a route is already established between source node SC and final destination node FD). A main route (SC →1→ 2→ 3→ 4→ FD) between SC and FD is disconnected by the recently, then the backup route is established (SC→ 1→ a→ b→ 3→ 4→ FD) between SC and FD.

We built a JAVA network simulator to evaluate this framework. The simulator supports physical, link and network layers for single/multi hop ad-hoc networks. We assume that IEEE 802.11 Distributed Coordination Function (DCF) or MAC protocol which uses Channel Sense Multiple Access with Collision Avoidance (CSMA/CA) already deployed. Successfully received packet by receiver's interface is packet whose SNR is above a certain minimum value otherwise the packet cannot be distinguished from background noise/interference. Packets are transmitting through physical layer in accordance with Poisson distribution. Communication between two nodes in IEEE 802.11 uses RTS-CTS signaling


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before the actual data transmission takes place. Simulation simulates this with random hearing to link's condition. The simulator uses two-steps propagation model to simulate interactive propagation in the operation of the protocol in dynamic environment. The propagation model is appropriate for outdoor environments where a line of sight communication existed between the transmitter and receiver nodes and when the antennas are omni-directional.

The packets are simulated either fragmented or not fragmented, flow through layers at every time-slot. The length of the active periods (denoted by random variable) is distributed randomly according to Mersenne Twister algorithm. The mean of transmission rate and arrival rate of packets can be controlled by changing the value of "p" (a Poisson distribution value). The arrival process is defined as the arrival packets stream at each node is a series of active and idle periods. The received packet is then processed by the layering module with the result that one of the following actions is taken: (i) the packet is passed to the higher layers if both MAC and IP addresses match; (ii) the packet is dropped if neither MAC nor IP addresses match; or (iii) the packet is forwarded to another node when only the MAC address matches. In the latter case, it searches the routing table to find the next route node with the higher metric calculation to reach next destination node.

## IV. PERFORMANCE EVALUATION

Our simulation modeled a network of 50 nodes placed randomly with a uniform distribution within an area of 300 X 300 meter square. Each node randomly selects a new position and moves towards that location with a certain speed. The average network speed is selected from value between 5 and 50m/s respectively. Once nodes reach the position, they become stationary for a predefined pause time and then select another position after a delay. This process continues until the end of simulation. The sources were determined, while final destination nodes were selected randomly over the network. Traffic was modeled using CBR (constant-bit-rate) sources with 1500-byte data packets and a traffic rate of Poisson distribution value at five packets per second is selected. Scenarios for simulation are batched with variables of number initiators/sources and speed. We compare the framework and similar LSR network to best understand the various tradeoffs and limitations of the algorithm. The similar LSR network is selected because it is simple to deploy and can be used for analyzing a large scale of packets processes using known network topology.

A similar (LSR) network would generate full routing tables in advance where, all nodes in the network would be aware of distance level and routes to all other nodes in the network. This network can compute the optimum metric with shortest distance to a next relay node by listening replies of topology construction and topology maintenance packets transmitted by the neighbors. This network operation requires each node in the network to broadcast a routing packet. The broadcast packets contain information about the distance metric of all known destinations. Each node floods the network with information about what other nodes it can connect to, and the received packets may require to be forwarded by other nodes to propagate the entire network. After collecting packets from all nodes of the network, any node should be capable of computing optimum routes to any other node in the network. Each node then independently assembles this information into a tree. Using this tree, each node then independently determines the least-cost path from itself to every other node using a standard shortest paths (distance) algorithm. The iteration of propagation events to be entirely flooded mainly depends on the density of nodes in the network. The result is a tree rooted at the source node such that the path through the tree from the root to any other node is the least-cost path to that node. This tree then serves to construct the routing table, which specifies the best next hop to get from the current node to any other node.

Measurements of the experiment comprise the successful data transmission rate from source to destination nodes and the control packet overhead for route discovery and route maintenance. The graphs represent the results of experiments for various pause times.

Successful packet transmission rates indicate that the destination node received all packets sent from the source node. Using the framework, there is improvement of successful data transmission about 4.5% higher than the network without implement it. The successful packet transmission rate is shown in Fig. 3.

The proposed protocol provides higher data transmission rates than AODV protocols. When the route fails in the AODV protocol, the protocol performs the route discovery process again from the source node. In this research, routes are repaired from intermediate nodes (connected to the failed link) which participating in the path leads to the destination node. The proposed protocol has a higher packet transmission rate than AODV protocol (because the proposed protocol can reduce the packet loss rate that occurs during the route research process) and need to wait at short delay for the route to be reinitiated.

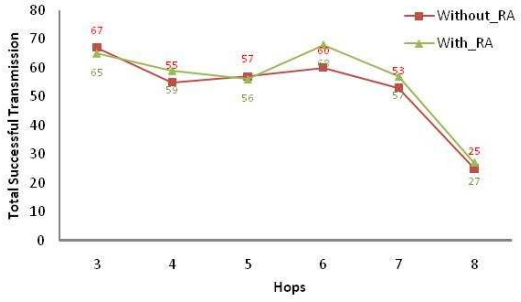


Figure 3. The successful packet transmission rates.


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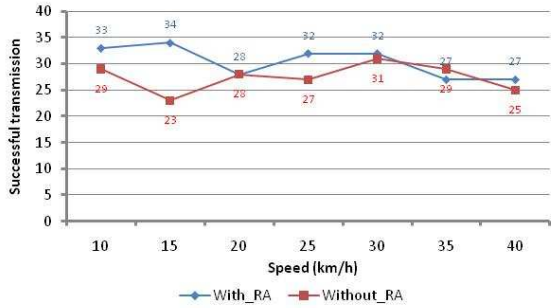


Figure 4. Establishment of backup route in data transmission at different network speed.

Fig. 4 shows the comparison of the successful data transmission at different speed when the main route is broken between the networks with implement the framework and the other without implemented it. As a result, proposed protocol has successfully improved the successful data transmission (or backup the main route) 10.94% higher.

When the main route in network is broken off, the proposed protocol finds the new route by starting a route discovery process at the closest victim node and delays data transmission for a while. At this time, it causes the routing overhead of main route and backup route discovery processes. Control packets are packets used for establishing routes. In addition, data packets indicate the actual packets used for data transmission. Routing overheads is shown in Fig. 5. About 22% increase of overhead packets at the network which implement the routing framework.

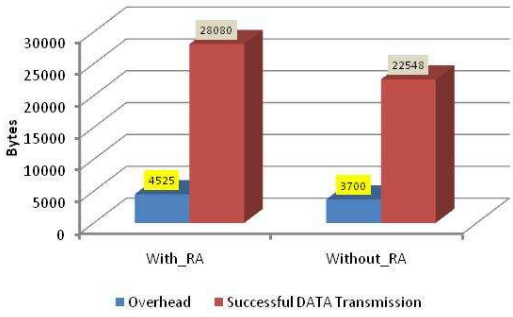


Figure 5. Routing packet overhead.

## V. Conclusion And Future Work

In this paper, we proposed a routing protocol that establishes routes which is capable to adapt the broken off path between source and final destination nodes based on the AODV protocol for MANETs. The new protocol has not too high overhead to conventional AODV protocol. Also this protocol sends the data immediately after the main route is successfully recovered to reduce he data transmission delay. During execution, besides discovering the backup routes when the main route is broken off, the framework always maintains the route using the topology maintenance process. The main difficulty however is in identifying the bottlenecks in the network. The result obtained in this simulation is compared against the similar LSR network with AODV protocol. It is interesting to note that the routing policy, which was designed primarily for achieving higher successful data transmission in the single wireless network area, can also be engineered to achieve good delay performance in multiple wireless network area. In the future research, we will simulate this framework in wide area of wireless network and compare it with other multipath routing protocols such as AOMDV and AODVM.

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# Mining Maximal Dense Intervals from Temporal Interval Data

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***Abstract*- Some real life data are associated with duration of events instead of point events. The most common example of such data is data of cellular industry where each transaction is associated with a time interval. Mining maximal fuzzy intervals from such data allows the user to group the transactions with similar behavior together. Earlier works were devoted to mining frequent as well as maximal frequent non-fuzzy intervals. We propose here a method of mining maximal dense fuzzy intervals where density of an interval quite similar to the frequency of an interval.**

***Keywords- Frequent intervals, Maximal frequent intervals, Density of a fuzzy interval, Minimum density, Contribution (vote) of a transaction on a fuzzy interval, join of two fuzzy intervals.***

## I INTRODUCTION

Among the various types of data mining applications, analysis of transactional data has been considered important. One important extension of this mining problem is to include a temporal dimension. Most of the earlier works done in this area do not take into account the time factor. By taking into account the time aspect, more interesting patterns that are time dependent can be extracted. Recently data mining in temporal data sets has arisen as an important data mining problem [[2], [10]].

Many real life problems are associated with duration events instead of point events. In this paper we are considering such datasets i.e. dataset having time intervals. Such datasets are called as temporal interval datasets. A record in such data typically consists of the starting time and ending time (or the length of the transaction) in addition to other fields. In [5] an algorithm for mining maximal frequent intervals from such data sets has been given

In practice however most of the time people make statements using vague terms like the early morning, late evening etc instead of mentioning strict time intervals. There is no strict boundary for separating early morning from morning. To represent such vague terms, fuzzy sets are required. In this paper we discuss the problem of mining dense intervals using a fuzzy concept. The objective of this paper is three fold. First we propose the definition of density of a fuzzy interval over a transactional (where each transaction is associated with a time duration) dataset. Secondly, we propose to define a join operation on the fuzzy intervals and lastly we propose an algorithm to mine maximal dense fuzzy intervals. In such cases, we define the amount of contribution (also called vote) of a transaction t associated with time interval $[t_1, t_2]$ for a given fuzzy interval $A$ as the ratio of the area bounded by the membership function $A(x)$ (associated with the fuzzy interval) and the real line included within the interval $[t_1, t_2]$ to the total area covered by $A(x)$ and the real line. If the total average of the votes of all the transactions in a fuzzy interval $A$ exceeds a pre-defined threshold, then the fuzzy interval is called a dense fuzzy interval. Similarly a dense fuzzy interval will be maximal if no dense fuzzy interval contains it. The well-known A-priori algorithm cannot be used here directly as the downward and upward closure property of frequent sets does not hold in this case (it is proved with an example). We propose a variation of the A-priori algorithm that works in this situation and gives us the maximal dense fuzzy intervals.

## II. RELATED WORKS

One of the very useful extensions of conventional data mining is temporal data mining. In recent times it has been able to attract a lot of researcher to work in this area. Considering the time dimension in the conventional data mining problem, more interesting patterns can be extracted that are time dependent. There are mainly two broad directions of temporal data mining [7]. One concerns the discovery of causal relationships among temporally oriented events. Ordered events from sequences and the cause of an event always occur before it. The other concerns the discovery of similar patterns within the same time sequence or among different time sequences. The underlying problem is to find frequent sequential pattern in the temporal databases.

Wong *et al* [9] introduced the fuzzy concept into the association rule mining to deal with quantitative attributes. Quantitative attributes are normally handled by partitioning the attribute domains and then combining adjacent partitions [8]. Although this method can solve problems introduced by finite domain, it causes the sharp boundary problem. To soften the affect of soft boundaries, fuzzy sets are used. Here each quantitative attribute is associated with several fuzzy sets. A fuzzy association rule looks like if $X$ is $A$ then $Y$ is $B$, where $X$ and $Y$ are attributes and $A$ and $B$ are fuzzy sets which describe $X$ and $Y$ respectively. Prade *et al* [6] defined support and confidence of a fuzzy association rule.


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In [2], Rossi and Ale extended the well-known A-priori algorithm for mining association rules to temporal data and described a technique to find interesting patterns on the data that are time bounded.

In [5], the problem of mining maximal frequent intervals is discussed. They define a maximal frequent interval as an interval that is frequent which means that it is present in sufficient number of transactions and no other frequent interval contains it. Using a pre-fix traversal algorithm, the maximal frequent intervals have been found and it was also found experimentally that pre-order traversal algorithm outperforms the A-priori based algorithm.

Our approach is different from the above approaches. We are taking into account the fact that the intervals of time are of fuzzy nature. By calculating density of the fuzzy intervals in a particular transactional dataset where transactions are associated with time intervals (non-fuzzy) as mentioned in the next section, we first compute the dense fuzzy time intervals by using some user defined minimum density value and then apply a join operation to join neighboring intervals to find maximal dense fuzzy intervals. The fuzzy intervals and their membership functions are provided by domain experts.

## III PROBLEM DEFINITION

### *A. Some basic definitions related to fuzziness*

Let $E$ be the universe of discourse. A fuzzy set $A$ in $E$ is characterized by a membership function $A(x)$ lying in [0,1]. $A(x)$ for $x \in E$ represents the grade of membership of x in $A$. Thus a fuzzy set $A$ is defined as

$A=\{(x, A(x)), x \in E\}$

A Fuzzy set $A$ is said to be normal if $A(x) =1$ for at least one $x \in E$.

An $\alpha$-cut of a fuzzy set is an ordinary set of elements with membership grade greater than or equal to a threshold $\alpha$, $0 \le \alpha \le 1$. Thus an $\alpha$-cut $A_\alpha$ of a fuzzy set $A$ is characterized by

$A_\alpha=\{x \in E; A(x) \ge \alpha\}$ [see *e.g.* [3]]

A fuzzy set is said to be convex if all its $\alpha$-cuts are convex sets.

A fuzzy number is a convex normalized fuzzy set $A$ defined on the real line $R$ such that

1. there exists an $x_0 \in R$ such that $A(x_0) =1$, and
2. $A(x)$ is piecewise continuous.

Thus a fuzzy number can be thought of as containing the real numbers within some interval to varying degrees.

Fuzzy intervals are special fuzzy numbers satisfying the following.

1. there exists an interval $[a, b] \subset R$ such that $A(x_0) =1$ for all $x_0 \in [a, b]$, and
2. $A(x)$ is piecewise continuous.

A fuzzy interval can be thought of as a fuzzy number with a flat region. A fuzzy interval $A$ is denoted by $A = [a, b, c, d]$ with $a < b < c < d$ where $A(a) = A(d) = 0$ and $A(x) = 1$ for all $x \in [b, c]$. $A(x)$ for all $x \in [a, b]$ is known as left reference function and $A(x)$ for $x \in [c, d]$ is known as the right reference function. The left reference function is non-decreasing and the right reference function is non-increasing [see *e.g.* [4]]. The area of a fuzzy interval is defined as the area bounded by the membership function of the fuzzy interval and the real line.

### *B. Contribution (vote) of a transaction to a fuzzy interval*

We define vote of a transaction t associated with the time interval $[t', t'']$ for the fuzzy interval $A= [a, b, c, d]$ as follows:

$$vote_t A = \frac{\int_{t'}^{t''} A(x)dx}{\int_a^d A(x)dx}$$

where $A(x)$ is the membership function associated with the fuzzy interval.

Here $\int_{t'}^{t''} A(x)dx$ is the portion of the area bounded by $A(x)$ and the real line included in the time interval $[t', t'']$. $\int_a^d A(x)dx$ is the total area bounded by $A(x)$ and the real line.

Obviously $vote_t A$ lies in [0,1] and if $A \subseteq [t', t'']$, then $vote_t A = 1$ and if $A \cap [t', t''] = \Phi$, then $vote_t A = 0$.

### *C. Density of a fuzzy time interval in a data set*

The density of a fuzzy interval over a given temporal interval dataset $D$ is computed by summing up the votes of all the transactions of $D$ for the corresponding fuzzy time interval and dividing it by the total number of transactions in $D$. Each record contributes a vote, which falls in [0, 1].

$$density_D A = \sum_{t \in D} vote_t A / |D|$$

A fuzzy interval is dense if its density is more than a user specified threshold called *min_density*.

### *D. Join of two fuzzy intervals*

The fuzzy intervals are given by the user as input. Two fuzzy intervals A and B are called neighbors or adjacent to each other if $supp(A \cap B) \neq \Phi$ where $supp(A \cap B) = \{x; (A \cap B)(x) > 0\}$ [see *e.g.*[4]]. We assume that the input fuzzy intervals are such that if the intervals are arranged in the ascending order according to their starting time then each fuzzy interval has a unique left neighbor and a unique right neighbor. Let $A = [a_1, b_1, c_1, d_1]$ and $B = [a_2, b_2, c_2, d_2]$ be two adjacent fuzzy intervals. Without loss of generality we can assume that $a_1 < a_2$. Also we assume that for any two adjacent fuzzy intervals such as $A$ and $B$ above $c_1 = a_2$ and $d_1 = b_2$ and for $c_1 \le x \le d_1$ $A(x) = 1 - B(x)$. Our assumption is natural since otherwise some points will be given more emphasis and some less emphasis. We define the join of $A$ and $B$ denoted by $A \hat{} B$ is defined as

$A \hat{} B = [a_1, b_1, c_2, d_2]$


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Where $(A \hat{} B)(x) = \begin{cases} A(x), & a_1 \le x \le b_1 \\ A(x) + B(x) = 1, & b_1 \le x \le c_2 \\ B(x) \text{ for } & c_2 \le x \le d_2 \end{cases}$

To explain the joining operation we again consider two fuzzy intervals $[a_1,b_1,c_1,d_1]$ and $[a_2,b_2,c_2,d_2]$ whose membership functions are shown in the figure1. Here $c_1 = a_2$ and $b_2 = d_1$. Any point in between $c_1$and $d_1$ will have a membership value of $A(x)$ corresponding to $A$ and corresponding to $B$ it will have a membership value of $B(x) = 1 - A(x)$ so that $A(x) + B(x) = 1$. Thus our joined fuzzy interval will be $[a_1, b_1, c_2, d_2]$ (shown in fig.2).

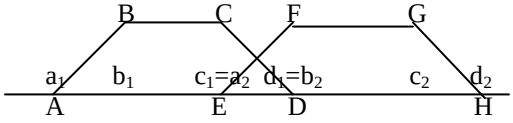


**Fig 1: Join of two fuzzy intervals**

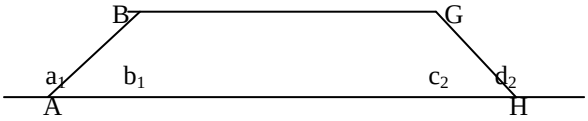


**Fig 2: Joined interval**

A dense fuzzy interval is maximal if no super set of it is dense. However a subset of it may not be dense because the downward and upward closure property for dense sets may not hold in this case.

*E. Theorem*

The join of two fuzzy intervals is not dense if both of the fuzzy intervals are not dense and dense if at least one of the fuzzy intervals is dense.

Proof. To prove the above result we consider a data set $D$ with 8 transactions. The time-intervals associated with the transactions are shown below.

| Transaction id | $t_1$ | $t_2$ | $t_3$ | $t_4$ | $t_5$ | $t_6$ | $t_7$ | $t_8$ |
|---|---|---|---|---|---|---|---|---|
| Time-interval $[t_i, t_j]$ | **[1,3]** | **[1,6]** | **[3,6]** | **[2,6]** | **[5,7]** | **[6,7]** | **[1,2]** | **[5,7]** |

Table1: Transaction datasets

Consider the fuzzy intervals $A$ = [1, 3, 4, 6] and $B$ = [4, 6, 7, 9] where the membership functions of $A$ and $B$ are respectively

$$A(x) = \begin{cases} 0, & x \le 1 \text{ and } x \ge 6 \\ (x-1)/2, & 1 \le x \le 3 \\ 1, & 3 \le x \le 4 \\ (6-x)/2, & 4 \le x \le 6 \end{cases}$$

and

$$B(x) = \begin{cases} 0, & x \le 4 \text{ and } x \ge 9 \\ (x-4)/2, & 4 \le x \le 6 \\ 1, & 6 \le x \le 7 \\ (9-x)/2, & 7 \le x \le 9 \end{cases}$$

$$vote_{t_1} A = \frac{\int_1^3 A(x)dx}{\int_1^6 A(x)dx} = 1/3$$

$$vote_{t_2} A = \frac{\int_1^6 A(x)dx}{\int_1^6 A(x)dx} = 1$$

$$vote_{t_3} A = \frac{\int_3^6 A(x)dx}{\int_1^6 A(x)dx} = 2/3$$

$$vote_{t_4} A = \frac{\int_2^6 A(x)dx}{\int_1^6 A(x)dx} = 2.75/3$$

$$vote_{t_5} A = \frac{\int_5^7 A(x)dx}{\int_1^6 A(x)dx} = .25/3$$

$$vote_{t_6} A = \frac{\int_6^7 A(x)dx}{\int_1^6 A(x)dx} = 0$$

$$vote_{t_7} A = \frac{\int_1^2 A(x)dx}{\int_1^6 A(x)dx} = .25/3$$

$$vote_{t_8} A = \frac{\int_5^7 A(x)dx}{\int_1^6 A(x)dx} = .25/3$$

Therefore,

$$Density(A) = \frac{vote_{t_1}A + vote_{t_2}A + vote_{t_3}A + vote_{t_4}A + vote_{t_5}A + vote_{t_6}A + vote_{t_7}A + vote_{t_8}A}{8}$$

$$= 3.1666666/8$$

$$= 0.395833325$$

Similarly

$$vote_{t_1} B = \frac{\int_1^3 B(x)dx}{\int_4^9 B(x)dx} = 0$$

$$vote_{t_2} B = \frac{\int_1^6 B(x)dx}{\int_4^9 B(x)dx} = 1/3$$



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$$vote_{t_3}B = \frac{\int_3^6 B(x)dx}{\int_4^9 B(x)dx} = 1/3$$

$$vote_{t_4}B = \frac{\int_2^6 B(x)dx}{\int_4^9 B(x)dx} = 1/3$$

$$vote_{t_5}B = \frac{\int_5^7 B(x)dx}{\int_4^9 B(x)dx} = 1.75$$

$$vote_{t_6}B = \frac{\int_6^7 B(x)dx}{\int_4^9 B(x)dx} = 1/3$$

$$vote_{t_7}B = \frac{\int_1^2 B(x)dx}{\int_4^9 B(x)dx} = 0$$

$$vote_{t_8}B = \frac{\int_5^7 B(x)dx}{\int_4^9 B(x)dx} = 1.75/3$$

Therefore,

$$Density(B) = \frac{vote_{t_1}B + vote_{t_2}B + vote_{t_3}B + vote_{t_4}B + vote_{t_5}B + vote_{t_6}B + vote_{t_7}B + vote_{t_8}B}{8}$$

$= 2.5/8 = 0.3125$

Now, $(A \hat{} B) = [1, 3, 7, 9]$

$$(A \hat{} B)(x) = \begin{cases} 0, & x \le 1 \text{ and } x \ge 9 \\ (x-1)/2, & 1 \le x \le 3 \\ 1, & 3 \le x \le 7 \\ (9-x)/2, & 7 \le x \le 9 \end{cases}$$

$$vote_{t_1}(A \hat{} B) = \frac{\int_1^3 (A \hat{} B)(x)dx}{\int_1^9 (A \hat{} B)(x)dx} = 1/6$$

$$vote_{t_2}(A \hat{} B) = \frac{\int_1^6 (A \hat{} B)(x)dx}{\int_1^9 (A \hat{} B)(x)dx} = 4/6$$

$$vote_{t_3}(A \hat{} B) = \frac{\int_3^6 (A \hat{} B)(x)dx}{\int_1^9 (A \hat{} B)(x)dx} = 3/6$$

$$vote_{t_4}(A \hat{} B) = \frac{\int_2^6 (A \hat{} B)(x)dx}{\int_1^9 (A \hat{} B)(x)dx} = 2.75/6$$

$$vote_{t_5}(A \hat{} B) = \frac{\int_5^7 (A \hat{} B)(x)dx}{\int_1^9 (A \hat{} B)(x)dx} = 2/6$$

$$vote_{t_6}(A \hat{} B) = \frac{\int_6^7 (A \hat{} B)(x)dx}{\int_1^9 (A \hat{} B)(x)dx} = 1/6$$

$$vote_{t_7}(A \hat{} B) = \frac{\int_1^2 (A \hat{} B)(x)dx}{\int_1^9 (A \hat{} B)(x)dx} = .25/6$$

$$vote_{t_8}(A \hat{} B) = \frac{\int_5^7 (A \hat{} B)(x)dx}{\int_1^9 (A \hat{} B)(x)dx} = 2/6$$

Therefore,

$$Density(A \hat{} B) = \frac{vote_{t_1}A + vote_{t_2}A + vote_{t_3}A + vote_{t_4}A + vote_{t_5}A + vote_{t_6}A + vote_{t_7}A + vote_{t_8}A}{8}$$

Therefore $Density(A \hat{} B) = 2.83333/8$

$= 0.35416625$

So if we take *min_dense* = 0.35 then we see that *A* is dense but *B* is not dense whereas (*A*^*B*) is dense. This establishes that the downward as well as upward closure property is not satisfied for dense fuzzy intervals.

## IV. PROPOSED ALGORITH

The algorithm is a level wise algorithm similar to the A-priori algorithm used for frequent item set mining [1]. Input to the algorithm is a temporal interval data set say *D*, n fuzzy intervals (called basic fuzzy intervals here) satisfying both the assumptions made in ***definition of join of fuzzy intervals*** defined on the time period covered by the dataset and with a value of *min_density* (minimum density value). The algorithm first finds the dense basic fuzzy intervals by going through the dataset once and using the ***definition C*** given in section ***III***. They are dense fuzzy intervals at level 1 we denote this set of dense intervals by $L_1$. Next each dense fuzzy interval at level 1 is joined with its left neighbour and right neighbour both of which are basic intervals (may not be dense) using the join operation defined ***definition D*** in section ***III***. They are the candidates $C_2$ at level 2. Using the same technique, going through the data set once more the dense fuzzy intervals at level 2 say $L_2$ are obtained. These are kept and the others removed. If any of the intervals obtained by joining a dense interval say *A* with its neighbours turn out to be dense then *A* is removed from the list of dense intervals maintained at the previous level. This level wise extraction goes on till a particular level becomes empty. Then the intervals kept at each level are the maximal dense fuzzy intervals. It is mentioned here that at any level the dense intervals are joined with their neighbors from the basic fuzzy intervals only. This is done because two new fuzzy intervals obtained by joining basic intervals although


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neighbors may not satisfy our second assumption (***Definition D***) for being conformable for the join operation. When two intervals *A* and *B* are joined where *A* is the left neighbor of *B*, then the left neighbor of *A* becomes the left neighbor of *A*^*B* and the right neighbor of *B* becomes the right neighbor of *A* ^*B*.

- *Algorithm 1*

Input $C_1 = \{ A_i ; i = 1, 2,\ldots n\}$ /* set of fuzzy intervals */
Set Density[i]=0;for i = 1,2,…,n /* Density[i] stores the Density of $A_i$ */
for each transaction t in *D*
{
Compute $vote_t(A_i)$ for i = 1, 2, ….n
Density[i] += $vote_t(A_i)$
}
for(i = 1, 2,….,n) do
{
if( ( Density[i])/ $|D| \geq min\_density$ )
Add $A_i$ to $L_1$
}
k = 1
$L_1$= [Dense fuzzy intervals at level 1]
for (k = 2 ; $L_k \neq \phi$ ; k++)
{
do
{
$C_k$ = candidate-gen ($L_{k-1}$)
Compute $L_k$ by going through the transactions in the dataset
k = k + 1
}
}

Candidate-gen($L_{k-1}$, $C_k$)
{
for all $A \in L_{k-1}$
form *A*^L and *A*^R where L and R are the left and right neighbours of *A* respetively in case these exists.
/* For the extreme intervals both the neighbours may not exist */
$C_k = C_k \cup \{A^L, A^R\}$
}

To illustrate the above algorithm we again consider the example given in the section-III. For the sake of convenience, consider the basic fuzzy interval as fuzzy number with triangular membership function, which will be the input intervals for the first level i.e. $C_1 = \{A, B, C, D, E, F\}$, where $A = [1, 2, 3]$, $B = [2, 3, 4]$, $C = [3, 4, 5]$, $D = [4, 5, 6]$, $E = [5, 6, 7]$ and $F = [6, 7, 8]$ and *min_density* = 0.4.
After the first pass we have, *Density*(*A*) = 0.375, *Density*(*B*) = 0.375, *Density*(*C*) = 0.375, *Density*(*D*) = 0.5, *Density*(*E*) = 0.5, *Density*(*F*) = 0.1875.
Thus the set of first level dense fuzzy number is
$L_1 = \{D, E\}$
Candidates for the second pass are
$C_2 = \{C^D, D^E, E^F\}$
where each members of $C_2$ are formed by joining the members of $L_1$ with their left right neighbor of $C_1$ using the definition of join and $C^D = [3, 4, 5, 6]$, $D^E = [4, 5, 6, 7]$. $E^F = [5, 6, 7, 8]$
After the second pass, we get *Density*(C^*D*) = 0.4375, *Density*(*D*^*E*) = 0.5, *Density*(*E*^*F*) = 0.34375.
Thus the second level dense sets are
$L_2 = \{C^D, D^E\}$
Joining with their left and right neighbors from the basic fuzzy numbers we obtain the candidates for the third pass as
$C_3 = \{B^C^D, C^D^E, D^E^F\}$
After third pass, we get *Density(B^C^D)* = 0.458333333, *Density(C^D^E)* = 0.458333333, *Density (D^E^F)* = 0.3958333333.
Thus the third level dense sets are
$L_3 = \{B^C^D, C^D^E\}$
Similarly candidates for the fourth pass as
$C_4 = \{A^B^C^D, B^C^D^E, C^D^E^F\}$
After the fourth pass, we get *Density(A^B^C^D)* = 0.40625, *Density(B^C^D^E)* = 0.0.4375, *Density(C^D^E^F)* = 0.390625.
Thus the fourth level dense sets are
$L_4 = \{A^B^C^D, C^D^E^F\}$
Candidates for the fifth pass as
$C_5 = \{A^B^C^D^E, B^C^D^E^F\}$
After the fifth pass, we get *Density(A^B^C^D^E)* = 0.425, *Density(B^C^D^E^F)* = 0.3875.
Thus the fifth level frequent sets are
$L_5 = \{A^B^C^D^E\}$
Candidates for the sixth pass are
$C_6 = \{A^B^C^D^E^F\}$
After the sixth pass *Density(A^B^C^D^E^F)* = 0.385416666, which is less than *min_ density*.
Thus the sixth level is empty which is empty. So the algorithm terminates giving the following maximal dense sets *A^B^C^D^E*.

## CONCLUSIONS

In this paper, we have introduced the concept of fuzziness in mining maximal dense intervals. In our datasets each transaction has associated with it a time interval of the form [start_time, end_time]. It is a level-wise method of generating dense fuzzy intervals. At the bottom level we have the basic dense fuzzy intervals. In subsequent levels the already obtained dense fuzzy intervals are expanded by joining them with their neignbours from the basic fuzzy intervals and their density counted by going through the dataset to check whether they are frequent or not. The process continues till no candidate is generated or some level is empty. The algorithm finally gives only the maximal dense fuzzy intervals. This algorithm although looks like A-priori algorithm, has a slight variation in the sense that it has to take into account the fact that the downward and upward closure properties of dense interval do not hold here.


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# Image Processing: The Comparison of the Edge Detection Algorithms for Images in Matlab

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*Abstract*—**Edge detection is the first step in image segmentation. Image Segmentation is the process of partitioning a digital image into multiple regions or sets of pixels. Edge detection is one of the most frequently used techniques in digital image processing. The goal of edge detection is to locate the pixels in the image that correspond to the edges of the objects seen in the image. Filtering, Enhancement and Detection are three steps of Edge detection. Images are often corrupted by random variations in intensity values, called noise. Some common types of noise are salt and pepper noise, impulse noise and Gaussian noise. However, there is a trade-off between edge strength and noise reduction. More filtering to reduce noise results in a loss of edge strength. In order to facilitate the detection of edges, it is essential to determine changes in intensity in the neighborhood of a point. Enhancement emphasizes pixels where there is a significant change in local intensity values and is usually performed by computing the gradient magnitude. Many points in an image have a nonzero value for the gradient, and not all of these points are edges for a particular application. Therefore, some method should be used to determine which points are edge points. Four most frequently used edge detection methods are used for comparison. These are: Roberts Edge Detection, Sobel Edge Detection, Prewitt Edge Detection and Canny Edge Detection. One the other method in edge detection is spatial filtering. This Paper represent a special mask for spatial filtering and compare throughput the standard edge detection algorithms (Sobel, Canny, Prewit & Roberts) with the spatial filtering.**

Keywords-***Spatial Filtering, Median Filter, Edge Detection, Image Segmentation.***

## I. INTRODUCTION

Over the years, several methods have been proposed for the image edge detection which is the method of marking points in a digital image where luminous intensity changes sharply for which different type of methodology have been implemented in various applications like traffic speed estimation [5], Image compression [6], and classification of images [7]. Most of the traditional edge-detection algorithms in image processing typically convolute a filter operator and the input image, and then map overlapping input image regions to output signals which lead to considerable loss in edge detection [8,9].

Edge and feature points are basic low level primitives for image processing. Edge and feature detection are two of the most common operations in image analysis. An edge in an image is a contour across which the brightness of the image changes abruptly. In image processing, an edge is often interpreted as one class of singularities. In a function, Singularities can be characterized easily as discontinuities where the gradient approaches Infinity. However, image data is discrete, so edges in an image often are defined as the Local maxima of the gradient. This is the definition we will use here. Operations in image processing, This topic has attracted many researchers and many achievements have been made [11-18].

For Such as: Rooms et al proposed to estimate the out-of focus blur in wavelet domain by examining the sharpness of the sharpest edges [11]. Hanghang Tong et al proposed new blur detection schemes which can determine whether an image is blurred or not and to what extent an image is blurred. Which raises the demand for image quality assessment in terms of blur Based on the edge type and sharpness analysis using Harr wavelet transforms [12]. X. Marichal, proposed using DCT information to qualitatively characterize blur extent [13] Berthold K., ET AL describes the processing performed in the course of producing a line drawing from an image obtained through an image dissector camera. The edgemarking phase uses a non-linear parallel line-follower [14]. Lixia Xue et al proposed An edge detection algorithm for multispectral remote sensing image, they extended the onedimensional cloud-space mapping model to the multidimensional model [15].Mike Heath etal, presented a paradigm based on xperimental psychology and statistics, in which humans rate the output of low level vision algorithms. They demonstrate the proposed experimental strategy by comparing four well-known edge detectors: Canny, Nalwa–Binford, Sarkar–Boyer, and Sobel [16], Hoover *etal* at USF have recently conducted such a comparison study based on manually constructed ground truth for range segmentation tasks [17]. Krishna Kant Chintalapudi et al showed that such localized edge detection techniques are non-trivial to design in an arbitrarily deployed sensor network. They defined the notion of an edge and develop performance metrics for evaluating localized edge detection algorithms [10,18].

Usage of specific linear time-invariant (LTI) filters is the most common procedure applied to the edge detection problem, and the one which results in the least computational


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effort. In the case of first-order filters, an edge is interpreted as an abrupt variation in gray level between two neighbor pixels. The goal in this case is to determine in which points in the image the first derivative of the gray level as a function of position is of high magnitude. By applying the threshold to the new output image, edges in arbitrary directions are detected.

In other ways the output of the edge detection filter is the input of the polygonal approximation technique to extract features which to be measured. A very important role is played in image analysis by what are termed feature points, pixels that are identified as having a special property. Feature points include edge pixels as determined by the well-known classic edge detectors of PreWitt, Sobel, Roberts, Canny and Spatial Filtering. Classical operators identify a pixel as a particular class of feature point by carrying out some series of operations within a window centered on the pixel under scrutiny. The classic operators work well in circumstances where the area of the image under study is of high contrast. In fact, classic operators work very well within regions of an image that can be simply converted into a binary image by simple thresholding[1].

This paper is organized as follows. Section II is for the purpose of providing some information about edge detection. Section III is focused on simulation results and also focused on comparison of various Edge Detection Methods. Section IV presents the conclusion.

## II. EDGE DETECTION

Edge detection techniques transform images to edge images benefiting from the changes of grey tones in the images. Edges are the sign of lack of continuity, and ending. As a result of this transformation, edge image is obtained without encountering any changes in physical qualities of the main image. Objects consist of numerous parts of different color levels. In an image with different grey levels, despite an obvious change in the grey levels of the object, the shape of the image can be distinguished in Fig.1.

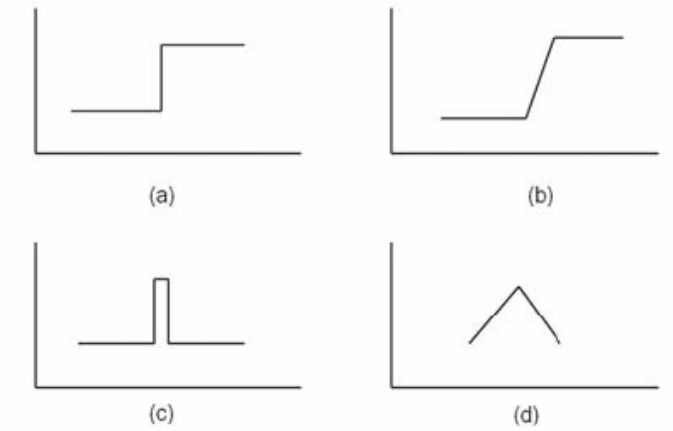


Figure 1. Type of Edges (a) Step Edge (b) Ramp Edge (c) Line Edge (d) Roof Edge

An Edge in an image is a significant local change in the image intensity, usually associated with a discontinuity in either the image intensity or the first derivative of the image intensity. Discontinuities in the image intensity can be either Step edge, where the image intensity abruptly changes from one value on one side of the discontinuity to a different value on the opposite side, or Line Edges, where the image intensity abruptly changes value but then returns to the starting value within some short distance. However, Step and Line edges are rare in real images. Because of low frequency components or the smoothing introduced by most sensing devices, sharp discontinuities rarely exist in real signals. Step edges become Ramp Edges and Line Edges become Roof edges, where intensity changes are not instantaneous but occur over a finite distance. Illustrations of these edge shapes are shown in Fig.1.

### A. Steps in Edge Detection

Edge detection contain three steps namely Filtering, Enhancement and Detection. The overview of the steps in edge detection are as follows.

*1) Filtering:* Images are often corrupted by random variations in intensity values, called noise. Some common types of noise are salt and pepper noise, impulse noise and Gaussian noise. Salt and pepper noise contains random occurrences of both black and white intensity values. However, there is a trade-off between edge strength and noise reduction. More filtering to reduce noise results in a loss of edge strength.

*2) Enhancement:* In order to facilitate the detection of edges, it is essential to determine changes in intensity in the neighborhood of a point. Enhancement emphasizes pixels where there is a significant change in local intensity values and is usually performed by computing the gradient magnitude.

*3) Detection:* Many points in an image have a nonzero value for the gradient, and not all of these points are edges for a particular application. Therefore, some method should be used to determine which points are edge points. Frequently, thresholding provides the criterion used for detection.

### B. Edge Detection Methods

Three most frequently used edge detection methods are used for comparison. These are (1) Roberts Edge Detection, (2) Sobel Edge Detection, (3) Prewitt edge detection and (4) Canny edge detection. One the other method in edge detection is spatial filtering. The details of methods as follows:

*1) The Roberts Detection:* The Roberts Cross operator performs a simple, quick to compute, 2-D spatial gradient measurement on an image. It thus highlights regions of high spatial frequency which often correspond to edges. In its most common usage, the input to the operator is a grayscale image, as is the output. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point. Fig.2. shows Roberts Mask.


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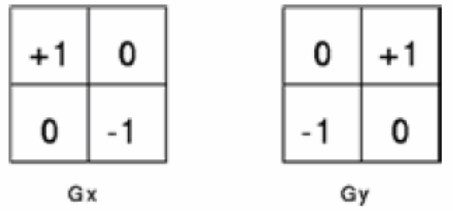


Figure 2. Roberts Mask

*2) The Prewitt Detection:* The prewitt edge detector is an appropriate way to estimate the magnitude and orientation of an edge. Although differential gradient edge detection needs a rather time consuming calculation to estimate the orientation from the magnitudes in the x and y-directions, the compass edge detection obtains the orientation directly from the kernel with the maximum response. The prewitt operator is limited to 8 possible orientations, however experience shows that most direct orientation estimates are not much more accurate. This gradient based edge detector is estimated in the 3x3 neighbourhood for eight directions. All the eight convolution masks are calculated. One convolution mask is then selected, namely that with the largest module. Fig.3. shows Prewitt Mask.

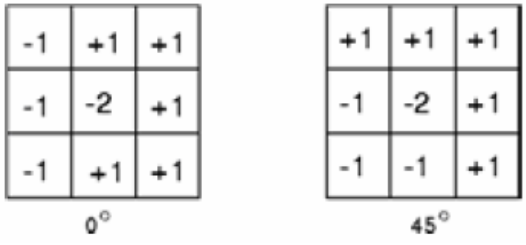


Figure 3. Prewitt Mask

*3) The Sobel Detection:* The Sobel operator performs a 2-D spatial gradient measurement on an image and so emphasizes regions of high spatial frequency that correspond to edges. Typically it is used to find the approximate absolute gradient magnitude at each point in an input grayscale image. In theory at least, the operator consists of a pair of 3x3 convolution kernels as shown in Figure 4. One kernel is simply the other rotated by 90o.This is very similar to the Roberts Cross operator. The convolution masks of the Sobel detector are given in Fig.4. Fig.5. shows Edge patterns for Sobel edge detector.

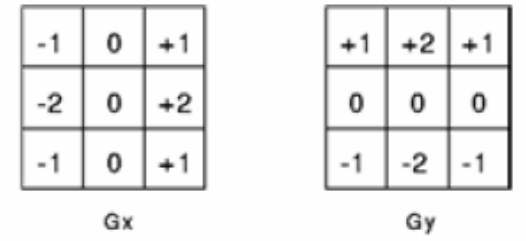


Figure 4. Sobel Mask

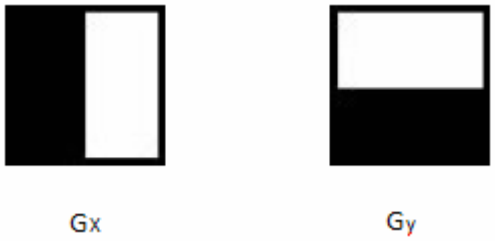


Figure 5. Edge patterns for Sobel edge detector

*4) The Canny Detection:* Canny edge detection is an important step towards mathematically solving edge detection problems. This edge detection method is optimal for step edges corrupted by white noise. Edge detection with low probability of missing true edges, and a low probability of detecting false edges. [2] The Canny algorithm uses an optimal edge detector based on a set of criteria which include finding the most edges by minimizing the error rate, marking edges as closely as possible to the actual edges to maximize localization, and marking edges only once when a single edge exists for minimal response.[3]

Canny used three criteria to design his edge detector. The first requirement is reliable detection of edges with low probability of missing true edges, and a low probability of detecting false edges. Second, the detected edges should be close to the true location of the edge. Lastly, there should be only one response to a single edge. To quantify these criteria, the following functions are defined:

$$SNR(f) = \frac{A}{n_0} \cdot \frac{\left| \int_{-\infty}^{0} f(x)dx \right|}{\left[ \int_{-\infty}^{\infty} f^2(x)dx \right]^{\frac{1}{2}}} \quad (1)$$

$$SNR(f) = \frac{A}{n_0} \cdot \frac{\left| f'(0) \right|}{\left[ \int_{-\infty}^{\infty} f'^2(x)dx \right]^{\frac{1}{2}}} \quad (2)$$

where A is the amplitude of the signal and n20 is the variance of noise. SNR(f) defines the signal-to-noise ratio and Loc(f) defines the localization of the filter f(x).

The Canny edge detection algorithm runs in 5 separate steps:

1. Smoothing: Blurring of the image to remove noise.
2. Finding gradients: The edges should be marked where the gradients of the image has large magnitudes.
3. Non-maximum suppression: Only local maxima should be marked as edges.
4. Double thresholding: Potential edges are determined by thresholding.
5. Edge tracking by hysteresis: Final edges are determined by suppressing all edges that are not connected to a very certain (strong) edge.[19]

*5) The Spatial Filtering Detection:* we implement image edge detection so that we can identify the boundary of object


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in an image. For this, we apply a spatial mask. Fig.6. shows Spatial Mask.

$$\begin{bmatrix} -1 & -2 & -1 \\ -2 & 0 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

Figure 6. Spatial Mask

The mechanics of spatial filtering are illustrated in the Fig.7. The process consists simply of moving the center of the filter mask ω from point to point in an image, f. at each point (x, y), the response of the filter at that point is the sum of the products of the filter coefficients and the corresponding neighborhood pixels in the area spanned by the filter mask.[4]

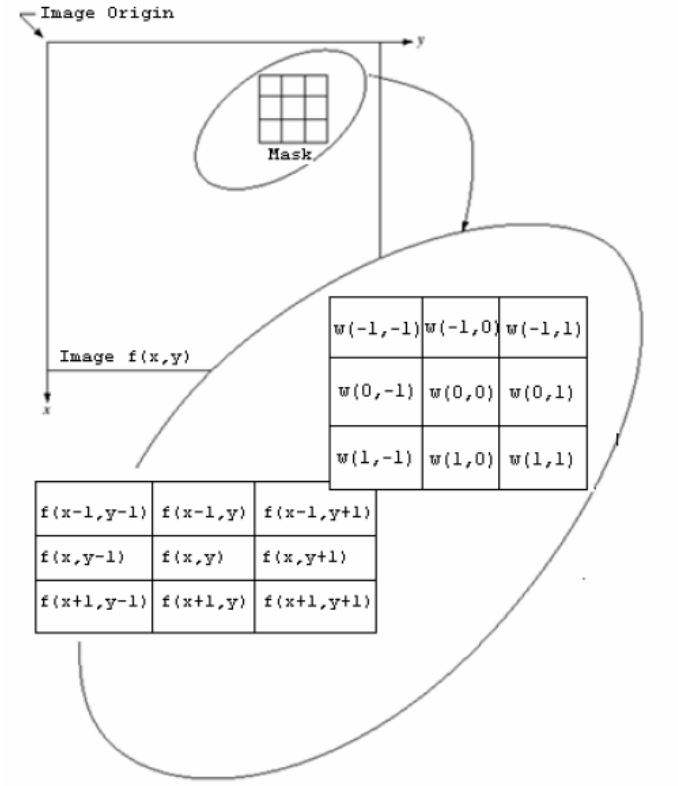


Figure 7. The Mechanics of Spatial Filtering.

## III. SIMULATION RESULTS

The algorithm for image edge detection was tested for various images and the outputs were compared to the existing edge detection algorithms and it was observed that the outputs of this algorithm provide much more distinct marked edges and thus have better visual appearance than the ones that are being used. The sample output shown below in Fig.8 compares the "Sobel", "Roberts", "Prewitt" and "Canny" Edge detection algorithms together and with the "Spatial Filtering" algorithm in Fig.9. It can be observed that the output that has been generated by the "Spatial Filtering" has found out the edges of the image more distinctly as compared to the ones that have been found out by Any one of the standard edge detection algorithms (Sobel, Canny, Prewit & Roberts). On the other hand, by the "Spatial Filtering" more of the edges will be traced and the outputs of this algorithm provide much more distinct marked edges and thus have better visual appearance than the standard existing.

Thus the "Spatial Filtering" Edge Detection algorithm provides better edge detection and helps to extract the edges with a very high efficiency and specifically establishes to avoid double edges results in obtaining an image with single edges.

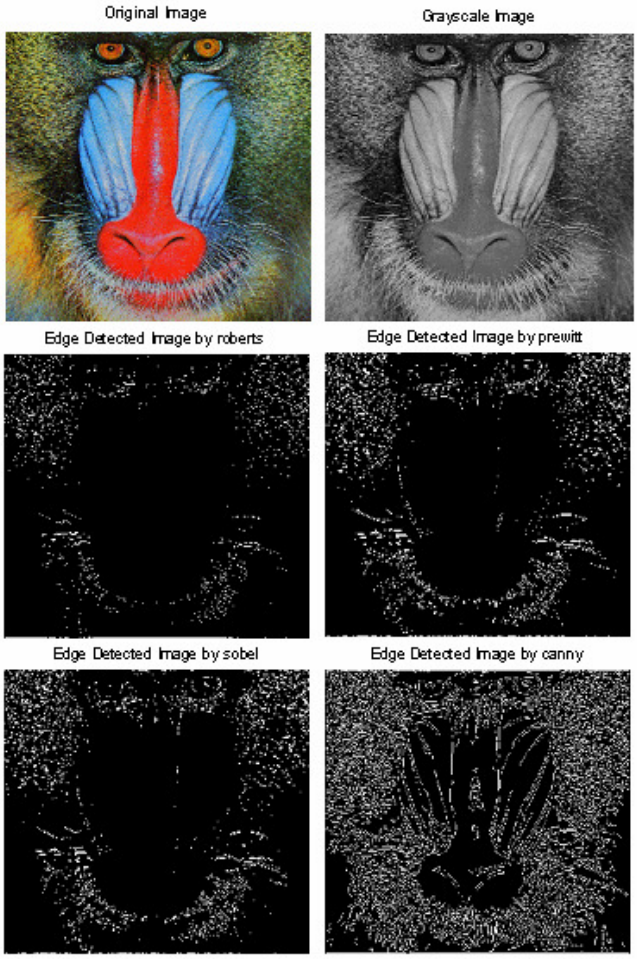


Figure 8. Results of our algorithm compared with standard edge detection algorithms(Sobel, Canny, Prewit & Roberts)

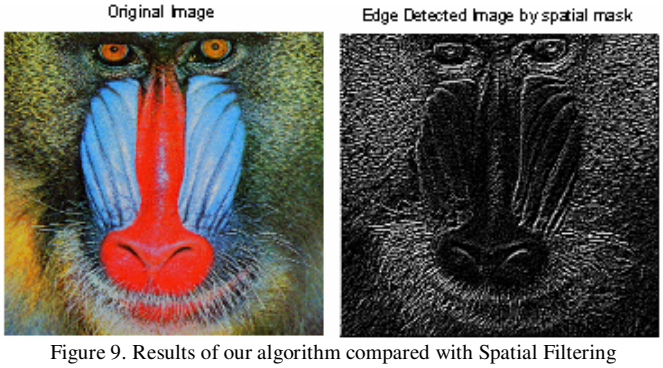


Figure 9. Results of our algorithm compared with Spatial Filtering


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## IV. CONCLUSION

This paper proposed 2 methods for edge detection. In the first method the standard edge detection algorithms (Sobel, Canny, Prewitt & Roberts) has been used for edge detection and the second method is the special Spatial Filtering method is used for edge detection. It can be observed that the output that has been generated by the "Spatial Filtering" has found out the edges of the image more distinctly as compared to the ones that have been found out by Any one of the standard edge detection algorithms (Sobel, Canny, Prewit & Roberts). On the other hand, by the "Spatial Filtering" more of the edges will be traced and the outputs of this algorithm provide much more distinct marked edges and thus have better visual appearance than the standard existing. Thus the "Spatial Filtering" Edge Detection algorithm provides better edge detection and helps to extract the edges with a very high efficiency and specifically establishes to avoid double edges results in obtaining an image with single edges.

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# Improving Cathodic Protection System using SMS-based Notification

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***Abstract*—Mobile service has produced significant impact in various industries. It has also gained growing demands for not only in telecommunication sector, but also numerous other sectors such as banking, business, entertainment, education and many others. The objective of this paper is to present yet another mobile system development to enhance current cathodic protection (CP) system. The developed system is able to send notification to technicians via SMS if there is any fault occurs in gas pipeline. The system has been developed in three-tier architecture and tested with functional testing. It is connected with CP system which functions to monitor CP measurements upon gas pipeline. If there is any fault detected by CP system, it will send instruction to the developed system, which will then invoke SMS notification delivery to technicians. The system has successfully been developed and believed can improve current CP system that requires human to manually perform the monitoring process. This study implies effectiveness and time saving as responsible personnel or technicians will be notified of any faults anytime and anywhere through mobile phones. For future work, it is recommended that the system will also be equipped with proactive notification delivery in which technicians will be notified if any faults are expected to occur.**

***Keywords-SMS;notification system; SMS-based system; cathodic protection***

## I. INTRODUCTION

The explosion in development of mobile applications and services has given a significant impact to the mobile phone industry. This industry has gained growing demands in numerous sectors such as business [1], banking [2] and gaming [3]. It is reported that in May 2010 alone, there were 92 countries generated over ten million mobile advertisement requests [4]. Benefits gained from mobile services are not only meant for customers but for service providers too. It provides a broad range of business opportunities to service providers with potential streams of revenue. It is forecasted that mobile services such as m-commerce will gain more significant growth globally in future [5]. The main factor of this great acceptance towards mobile service is believed to be its anytime and anywhere accessibility. Besides, another factor that plays a big role is its flexibility to meet users' expectations. For instance, advertisement has long been regarded negatively as garbage by customers. However, with new advancements in mobile service, advertisers may now provide more diversified and personalized advertisements to customers. This personalized m-advertisement is effective in a way that it allows appropriate message to reach the most potential customers at the best time in the right place [6].

This paper focused on yet another mobile service development. It enhanced cathodic protection (CP) system through SMS notification feature. CP system is elementary to pipeline integrity management, and broadly used in gas, petrochemical and water transmission and distribution. Cathodic protection is implemented to protect pipelines, in which measurements of CP data are required to be reported regularly for monitoring purposes. Two important measurements are level of protection applied to the pipeline at the source and along the pipeline itself [7]. In this study, a system was developed to notify technicians of any faults occur regarding CP measurement upon pipelines. The notification is sent to technicians via SMS. The implementation of SMS in this system was believed to be very important mainly because it required less human intervention in monitoring processes. The developed system had exploited the significant advantages offered by mobile solutions. As known, mobile solution has become a popular choice to provide improvements in customer-oriented systems. The work done in [8] shows that mobile solution improves tourism industry. The system enables users to receive new tourist contents with minimal user intervention. Besides, the work done in [9] presents that the notification system has changed from conventional notice board to SMS. Their work focused on implementing SMS-based notification in e-parcel management system. Moreover, SMS-based notification is also implemented in asset management system [10]. In this system, the assets' locations are tracked using RFID and GIS technology. It also contains a feature that gives automated notification of asset movement and malfunction alarm via SMS to users. Furthermore, the work done in [11] shows the development of a mobile notification system in university. The system sends notification to students through mobile instant messaging application installed on their mobile phones [12]. This system implies benefits as students do not need to log on to e-learning system to retrieve announcements made by their lecturers. These all systems show that mobile solution has provided significant benefits to users specifically in providing real-time notification. Real-time notification is believed to become an efficient way of


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diminishing the work process cycles and increase in information flow [13].

In a nutshell, the objective of this paper was to present the improvement of CP system through the implementation of SMS-based alarm notification. The system will notify technicians or responsible personnel of any faults that occur via SMS. The developed system was named as SMS-based Cathodic Protection (SMS-CP) system.

## II. METHODOLOGY

This study began with literature study and data gathering works. Results produced from this initial works were then used in analysis process to produce system requirements. The study then continued with system design activities in which system architecture, system flow, use case diagram and database were designed. These designs were then used in the implementation process in which the system was developed and tested iteratively until it evolved as final product. In every iteration, a prototype was produced to be evaluated based on system requirements. Lastly, the final version of the developed system was tested with functional testing. The testing outcomes showed that the objective of this study had been successfully achieved.

### A. Development Tools

A Microsoft Windows XP personal computer was used in this study for system development. It was also then used as a server to be installed with the developed system and the SMS gateway software. Besides, a Global System for Mobile Communications (GSM) modem was also used in this study to support the SMS sending functionality.

PHP and MySQL were used as the development language and database respectively. They were chosen as to ensure interoperability with the current PHP-based CP system. Apart from that, Joomla! was used as to develop CP system manager. Moreover, Ozeki NG SMS gateway software was used in this system to manage and perform the SMS sending functionality.

### B. System Architecture

Fig. 1 shows the system architecture of the developed system. The system was developed in three-tier architecture. The data of CP value measurement is retrieved from measuring apparatus installed in gas pipeline. The data are sent to CP system manager system for further processing and to be stored in database. This study was conducted based on the real case study of a gas company in Malaysia. However, due to confidentiality issue and restriction in system authorization imposed by the company, the actual CP system manager could not be used in this study. Instead, a prototype system named as MANTAU was developed and used. MANTAU is a web-based system developed using PHP scripting language.

The developed system, SMS-CP is installed on server. It contains a PHP script module that performs continuous checking procedure to check for CP measurement data from CP system manager. If there are any fault data found, the SMS-CP system will produce an instruction message to invoke Ozeki NG SMS gateway software for sending SMS. The details of the fault data which are the area (location) with its reference number, date, time and CP measurement will be sent to Ozeki NG SMS gateway software. Besides, phone numbers of technicians will also be forwarded by SMS-CP system to the Ozeki NG SMS gateway software. This software will then create an SMS message to be sent to technicians. There is also a database installed on server for SMS-CP system to store details about fault occurrence, and phone numbers of technicians.

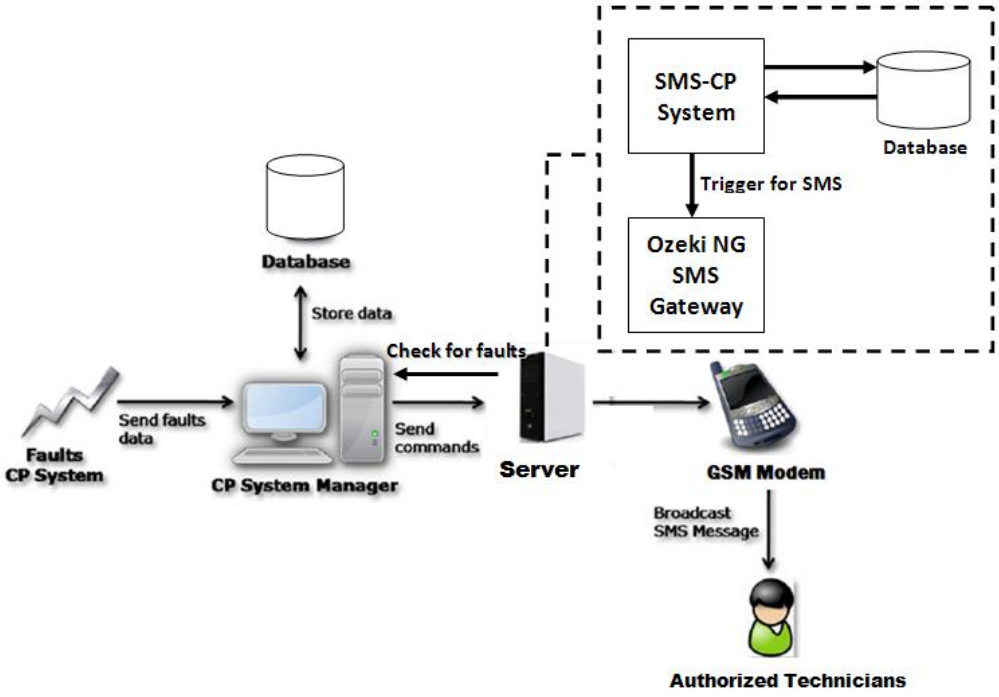


Figure 1. System Architecture.


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Ozeki NG SMS gateway will forward the created SMS message to GSM modem. The GSM modem will then complete the notification sending process by forwarding the message to all authorized technicians via SMS. Fig.2 and Fig. 3 below show the use case diagram and sequence diagram of the developed system respectively.

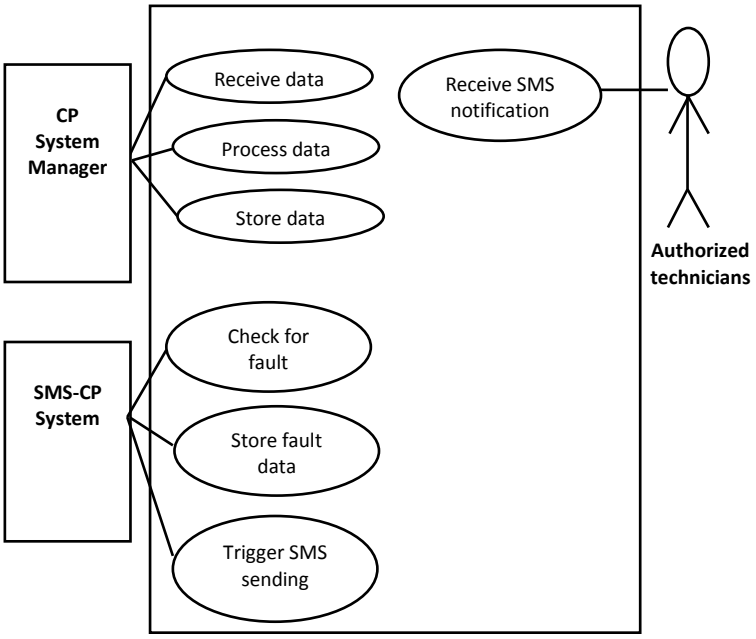


Figure 2. Use Case diagram.

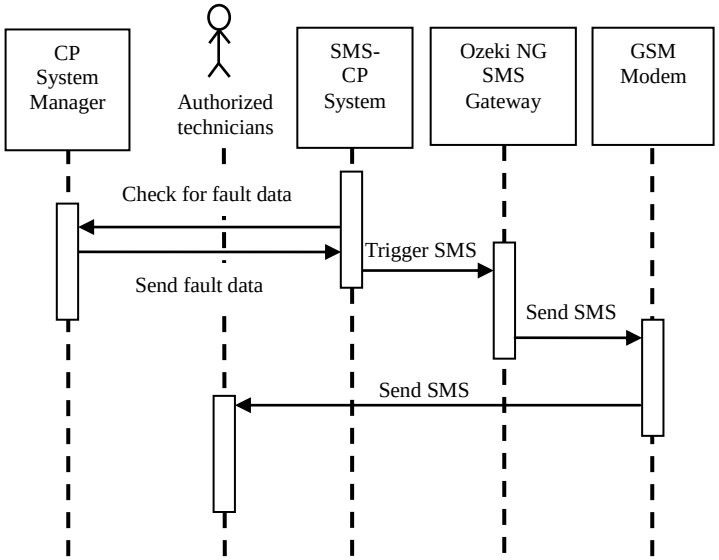


Figure 3. Sequence diagram.

## III. Results and Discussion

### A. System Prototype

The CP system manager was developed as a web-based system. This system was named as MANTAU and its functionalities among others were to receive, process and store CP measurement data. Fig. 4 shows the interface of MANTAU system that displays a graft of data for 2007.


Figure 4. Interface of MANTAU system (CP system manager).

The data retrieved from CP measuring apparatus contained five values which were pipeline location, location code, date, time, and Transformer Rectifier (TR). These data are represented as follow:

*{location, code, date {day, month, year}, time {hour, minute, second}, TR }*

These data were stored in MANTAU database for further processes as well as for future reference.

The SMS-CP system which was located on server contained a PHP script module to perform continuous check on fault CP measurement data from MANTAU database. In this study, the time gap was set to 30 seconds, which means SMS-CP system will check for CP measurement data for every half a minute. If there was a fault occurred, the data will be retrieved by SMS-CP system and stored in its database. At the same time, it will trigger another PHP script module to instruct Ozeki NG SMS gateway software to send SMS notification message to authorized technicians. In this case, SMS-CP system will forward the whole fault data along with technicians' phone numbers to Ozeki NG SMS gateway software. These data are represented as follow:

*{location, code, date {day, month, year}, time {hour, minute, second}, TR, phone}*

Fig. 5 shows the notification message received by technician's mobile phone via SMS. In this example, the data received are as follow:


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*{CP13 Ulu Pauh, 0008005, {23, 9, 2008}, {2, 43, 25}, TR: 5.90V}*


Figure 5. Notification message via SMS.

### *B. System Testing*

The developed system was tested using functional testing method. A set of test cases was created based on the system requirements. Table 1 show the test cases used in this testing process.

TABLE I. TEST CASES FOR FUNCTIONAL TESTING

| Test Case | Expected Outcome |
|---|---|
| 1. The data set contains NO fault data. | The reciever should not get SMS message. |
| 2. The data set contains ONE fault data. | The reciever should get ONE SMS message. |
| 3. The data set contains ONE fault data. | The correct data should be displayed in SMS message. |
| 4. The data set contains ONE fault data. | The SMS message should be received within acceptable time duration. |
| 5. The data set contains MORE THAN ONE fault data. | The reciever should get the right number of SMS messages. |
| 6. The data set contains MORE THAN ONE fault data. | All received SMS messages should contain correct data. |
| 7. The data set contains MORE THAN ONE fault data. | The SMS message should be received within acceptable time duration. |

Since the developed system was not linked to the real CP measurement apparatus, three data sets were created to become input for the CP system manager. The three data sets were: 1) without fault data; 2) contains one fault data; and 3) contains more than one fault data. Each data set contains 30 lines of data, in which each line contains data as follow:

*{location, code, date {day, month, year}, time {hour, minute, second}, TR}*

It is also important to note that fault data means TR value (in Volts) contains value 10.00 or below.

In the functionality test that had been performed, all test cases in Table 1 had produced positive (success) outcomes. Regarding the time taken for receiver to receive notification message, it was in between 30 seconds to 1.5 minutes. This duration was considered as acceptable.

## IV. CONCLUSION

The developed system enables technicians in gas company to receive notification of any faults occurred in pipeline via SMS. The received notification contains important information namely location, date, time and the measurement value. The system implies benefit in terms of effectiveness and time saving, as technicians will be notified anytime and anywhere through mobile phone.

The system consists of CP system manager, SMS-CP system and Ozeki NG SMS gateway software. The CP system manager functions as measurement data retriever and processer. These data are then stored in its database. Besides, SMS-CP system contains checking module which continuously performs the task to check for fault data from CP system manager. If there is a fault occurred, this system will trigger an instruction to ask Ozeki NG SMS gateway software to create SMS message. This gateway software will insert all data received from SMS-CP system and forward them through GSM modem to technicians.

For future works, it is recommended that the system will also contain a functionality that can give notification proactively. That means a notification message will be sent to technicians when fault is expected to occur.

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# Content Based Image Retrieval using Dominant Color and Texture features

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***Abstract*— Nowadays people are interested in using digital images. So the size of the image database is increasing enormously. Lot of interest is paid to find images in the database. There is a great need for developing an efficient technique for finding the images. In order to find an image, image has to be represented with certain features. Color and texture are two important visual features of an image. In this paper we propose an efficient image retrieval technique which uses dominant color and texture features of an image. An image is uniformly divided into 8 coarse partitions as a first step. After the above coarse partition, the centroid of each partition ("color Bin" in MPEG-7) is selected as its dominant color. Texture of an image is obtained by using Gray Level Co-occurrence Matrix (GLCM). Color and texture features are normalized. Weighted Euclidean distance of color and texture features is used in retrieving the similar images. The efficiency of the method is demonstrated with the results.**

***Keywords- Image retrieval, dominant color, Gray level co-occurrence matrix.***

## I. INTRODUCTION

Content-based image retrieval (CBIR) [1] has become a prominent research topic because of the proliferation of video and image data in digital form. Increased bandwidth availability to access the internet in the near future will allow the users to search for and browse through video and image databases located at remote sites. Therefore fast retrieval of images from large databases is an important problem that needs to be addressed.

Image retrieval systems attempt to search through a database to find images that are perceptually similar to a query image. CBIR is an important alternative and complement to traditional text-based image searching and can greatly enhance the accuracy of the information being returned. It aims to develop an efficient visual-Content-based technique to search, browse and retrieve relevant images from large-scale digital image collections. Most proposed CBIR [2,3,4] techniques automatically extract low-level features (e.g. color, texture, shapes and layout of objects) to measure the similarities among images by comparing the feature differences.

Color is one of the most widely used low-level visual features and is invariant to image size and orientation [1]. As conventional color features used in CBIR, there are color histogram, color correlogram, and dominant color descriptor (DCD).

Color histogram is the most commonly used color representation, but it does not include any spatial information. Color correlogram describes the probability of finding color pairs at a fixed pixel distance and provides spatial information. Therefore color correlogram yields better retrieval accuracy in comparison to color histogram. Color autocorrelogram is a subset of color correlogram, which captures the spatial correlation between identical colors only. Since it provides significant computational benefits over color correlogram, it is more suitable for image retrieval. DCD is MPEG-7 color descriptors [4]. DCD describes the salient color distributions in an image or a region of interest, and provides an effective, compact, and intuitive representation of colors presented in an image. However, DCD similarity matching does not fit human perception very well, and it will cause incorrect ranks for images with similar color distribution [5, 6]. In [7], Yang et al. presented a color quantization method for dominant color extraction, called the linear block algorithm (LBA), and it has been shown that LBA is efficient in color quantization and computation. For the purpose of effectively retrieving more similar images from the digital image databases (DBs), Lu et al. [8] uses the color distributions, the mean value and the standard deviation, to represent the global characteristics of the image, and the image bitmap is used to represent the local characteristics of the image for increasing the accuracy of the retrieval system.

In [3,12] HSV color and GLCM texture are used as feature descriptors of an image. Here HSV color space is quantized with non-equal intervals. H is quantized into 8-bins, S into 3-bins and v into 3-bins. So color is represented with one dimensional vector of size 72 (8X3X3). Instead of using 72 color feature values to represent color of an image, it is better to use compact representation of the feature vector. For simplicity and with out loss of generality the RGB color space is used in this paper.

Texture is also an important visual feature that refers to innate surface properties of an object and their relationship to the surrounding environment. Many objects in an image can be distinguished solely by their textures without any other information. There is no universal definition of texture. Texture


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may consist of some basic primitives, and may also describe the structural arrangement of a region and the relationship of the surrounding regions [5]. In our approach we have used the texture features using gray-level co-occurrence matrix (GLCM).

Our proposed CBIR system is based on Dominant color [21] and GLCM [17] texture. But there is a focus on global features. Because Low level visual features of the images such as color and texture are especially useful to represent and to compare images automatically. In the concrete selection of color and texture description, we use dominant colors, Gray-level co-occurrence matrix. The rest of the paper is organized as follows. The section II outlines proposed method in terms of Algorithm. The section III deals with experimental setup. The section IV presents results. The section V presents conclusions.

## II. PROPOSED METHOD

Only simple features of image information can not get comprehensive description of image content. We consider the color and texture features combining not only be able to express more image information, but also to describe image from the different aspects for more detailed information in order to obtain better search results. The proposed method is based on dominant color and texture features of image.
Retrieval algorithm is as follows:
**Step1**: Uniformly divide each image in the database and the target image into 8-coarse partitions as shown in Fig.1.
**Step2**: For each partition, the centroid of each partition is selected as its dominant color.
**Step3**: Obtain texture features (Energy, Contrast, Entropy and inverse difference) from GLCM.
**Step4**: construct a combined feature vector for color and texture.
**Step5**: find the distances between feature vector of query image and the feature vectors of target images using weighted and normalized Euclidean distance.
**Step6**: sort the Euclidean distances.
**Step7**: retrieve first 20 most similar images with minimum distance

### *A. Color feature representation*

In general, color is one of the most dominant and distinguishable low-level visual features in describing image. Many CBIR systems employ color to retrieve images, such as QBIC system and Visual SEEK. In theory, it will lead to minimum error by extracting color feature for retrieval using real color image directly, but the problem is that the computation cost and storage required will expand rapidly. So it goes against practical application. In fact, for a given color image, the number of actual colors only occupies a small proportion of the total number of colors in the whole color space, and further observation shows that some dominant colors cover a majority of pixels. Consequently, it won't influence the understanding of image content though reducing the quality of image if we use these dominant colors to represent image.

In the MPEG-7 Final Committee Draft, several color descriptors have been approved including number of histogram descriptors and a dominant color descriptor (DCD) [4, 6]. DCD contains two main components: representative colors and the percentage of each color. DCD can provide an effective, compact, and intuitive salient color representation, and describe the color distribution in an image or a region of interesting. But, for the DCD in MPEG-7, the representative colors depend on the color distribution, and the greater part of representative colors will be located in the higher color distribution range with smaller color distance. It is may be not consistent with human perception because human eyes cannot exactly distinguish the colors with close distance. Moreover, DCD similarity matching does not fit human perception very well, and it will cause incorrect ranks for images with similar color distribution. We will adopt a new and efficient dominant color extraction scheme to address the above problems [7,8].

According to numerous experiments, the selection of color space is not a critical issue for DCD extraction. Therefore, for simplicity and without loss of generality, the RGB color space is used. Firstly the image is uniformly divided into 8 coarse partitions, as shown in Fig. 2. If there are several colors located on the same partitioned block, they are assumed to be similar. After the above coarse partition, the centroid of each partition is selected as its quantized color. Let X=(XR, XG,XB) represent color components of a pixel with color components Red, Green, and Blue, and Ci be the quantized color for partition i.

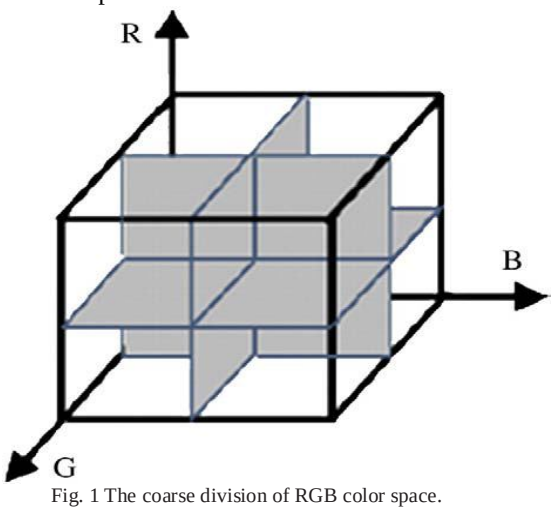

Fig. 1 The coarse division of RGB color space.

### *B. Extraction of dominant color of an image*

The procedure to extract dominant color of an image is as follows:

According to numerous experiments, the selection of color space is not a critical issue for DCD extraction. Therefore, for simplicity and without loss of generality, the RGB color space is used. Firstly, the RGB color space is uniformly divided into 8 coarse partitions, as shown in Fig. 2. If there are several


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colors located on the same partitioned block, they are assumed to be similar. After the above coarse partition, the centroid of each partition ("color Bin" in MPEG-7) is selected as its quantized color.

Let X=(XR, XG,XB) represent color components of a pixel with color components Red, Green, and Blue, and Ci be the quantized color for partition i. The average value of color distribution for each partition center can be calculated by

$$\bar{X}_i = \frac{\sum_{X \in C_i} X}{\sum_{X \in C_i} 1}$$

After the average values are obtained, each quantized color can be determined by using

$$C_i = \left(\bar{X}_i^R, \bar{X}_i^G, \bar{X}_i^B\right)(1 \le i \le 8)$$

In this way, the dominant colors of an image will be obtained.

### C. Extraction of texture of an image

Most natural surfaces exhibit texture, which is an important low level visual feature. Texture recognition will therefore be a natural part of many computer vision systems. In this paper, we propose a texture representation for image retrieval based on GLCM.

GLCM [11, 13] is created in four directions with the distance between pixels as one. Texture features are extracted from the statistics of this matrix. Four GLCM texture features are commonly used which are given below:

GLCM is composed of the probability value, it is defined by $P(i, j|d, \theta)$ which expresses the probability of the couple pixels at $\theta$ direction and d interval. When $\theta$ and d is determined, $P(i, j|d, \theta)$ is showed by $P_{i,j}$. Distinctly GLCM is a symmetry matrix and its level is determined by the image gray-level. Elements in the matrix are computed by the equation shown below:

$$P(i, j|d, \theta) = \frac{P(i, j|d, \theta)}{\sum_i \sum_j P(i, j|d, \theta)} \qquad (4)$$

GLCM expresses the texture feature according the correlation of the couple pixels gray-level value at different positions. It quantificationally describes the texture feature. In this paper, four texture features are considered. They include energy, contrast, entropy, inverse difference.

$$\text{Energy} \quad E = \sum_x \sum_y P(x,y)^2 \qquad (5)$$

It is a texture measure of gray-scale image represents homogeneity changing, reflecting the distribution of image gray-scale uniformity of weight and texture.

$$\text{Contrast} \quad I = \sum \sum (x-y)^2 P(x,y) \qquad (6)$$

Contrast is the main diagonal near the moment of inertia, which measures how the values of the matrix are distributed and number of images of local changes reflecting the image clarity and texture of shadow depth. Large Contrast represents deeper texture.

$$\text{Entropy} \quad S = -\sum_x \sum_y P(x,y) \log P(x,y) \qquad (7)$$

Entropy measures randomness in the image texture. Entropy is minimum when the co-occurrence matrix for all values is equal. On the other hand, if the value of co-occurrence matrix is very uneven, its value is greater. Therefore, the maximum entropy implied by the image gray distribution is random.

$$\text{Inverse difference} \quad H = \sum_x \sum_y \frac{1}{1+(x-y)^2} P(x,y) \qquad (8)$$

It measures number of local changes in image texture. Its value in large is illustrated that image texture between the different regions of the lack of change and partial very evenly. Here p(x, y) is the gray-level value at the Coordinate (x, y).

The texture features are computed for an image when d=1 and $\theta = 0^0, 45^0, 90^0, 135^0$. In each direction four texture features are calculated. They are used as texture feature descriptor. Combined feature vector of Color and texture is formulated.

## III. EXPERIMENTAL SETUP

### A. Data set

Wang's [15] dataset comprising of 1000 Corel images with ground truth. The image set comprises 100 images in each of 10 categories. The images are of the size 256 x 384 or 384X256. But the images with 384X256 are resized to 256X384.

### B. Feature set

The feature set comprises color and texture descriptors computed for an image as we discussed in section 2.

### C. Computation of similarity

The similarity between query and target image is measured from two types of characteristic features which includes dominant color and texture features. Two types of characteristics of images represent different aspects of property. So during the Euclidean similarity measure, when necessary the appropriate weights to combine them are also considered. Therefore, in carrying out Euclidean similarity measure we should consider necessary appropriate weights to combine them. We construct the Euclidean calculation model as follows:

$$D(A, B) = \omega_1 D(F_{CA}, F_{CB}) + \omega_2 D(F_{TA}, F_{TB}) \qquad (13)$$


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Here $\omega_1$ is the weight of color features, $\omega_2$ is the weight of texture features, $F_{CA}$ and $F_{CB}$ represents the normalized 72-dimensional color features for image A and B. For a method based on GLCM, $F_{TA}$ and $F_{TB}$ on behalf of 4- dimensional normalized texture features correspond to image A and B. Here, we combine color features and texture features. The value of $\omega$ through experiments shows that at the time $\omega_1=\omega_2=0.5$ has better retrieval performance.

## IV. EXPERIMENTAL RESULTS

The experiments were carried out as explained in sections II and III. The results are benchmarked with some of the existing systems using the same database [15]. The quantitative measure is given below

$$p(i)=\frac{1}{100}\sum_{1\le j\le 1000, r(i,j)\le 100, ID(j)=ID(i)}1$$

Where p(i) is precision of query image I, ID(i) and ID(j) are category ID of image I and j respectively, which are in the range of 1 to 10. The r(i, j) is the rank of image j. This value is percentile of images belonging to the category of image i, in the first 100 retrieved images.

The average precision $p_t$ for category **t**$(1\le t\le 10)$ is given by

$$p_t=\frac{1}{100}\sum_{1\le i\le 1000, ID(i)=t} p(i)$$

The comparison of proposed method with other retrieval systems is presented in the Table 1. These retrieval systems are based on HSV color, GLCM texture and combined HSV color and GLCM texture. Our sub-blocks based retrieval system is better than these systems in all categories of the database.

The experiments were carried out on a Core i3, 2.4 GHz processor with 4GB RAM using MATLAB. Fig. 2 shows the image retrieval results using HSV color, GLCM texture, HSV color and GLCM texture and the proposed method. The image at the top left- hand corner is the query image and the other 19 images are the retrieval results.

The performance of a retrieval system can be measured in terms of its recall (or sensitivity) and precision (or specificity)**.**Recall measures the ability of the system to retrieve all models that are relevant, while precision measures the ability of the system to retrieve only models that are relevant. They are defined as

$$Recall=\frac{\text{Number of relevant images retrieved}}{\text{Total Number of relevant images}}$$

$$precision=\frac{\text{Number of relevant images retrieved}}{\text{Total Number of images retrieved}}$$

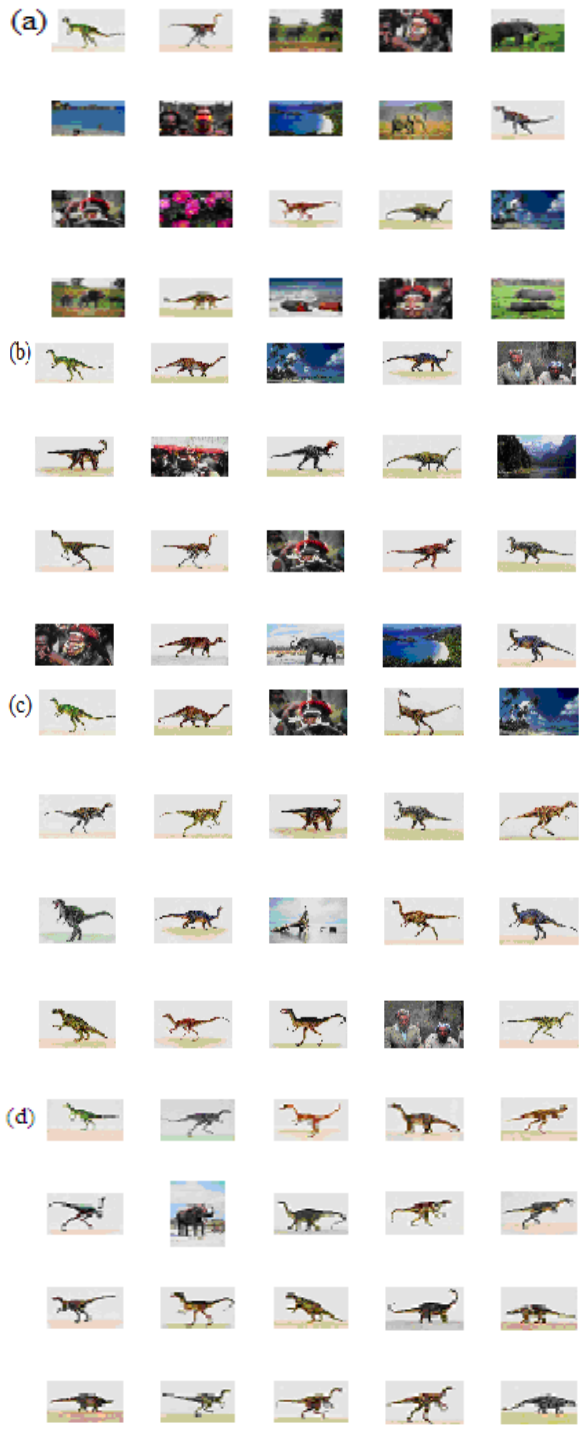


Fig. 3 The image retrieval results(dinosaurs) using different techinques (a) retrieval based on HSV color (b) retrieval based on GLCM texture (c) retrieval based on HSV color and GLCM texture (d) retrieval based on proposed method



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Table1. Comparison of average precision obtained by proposed method with other retrieval techniques.

| Class | Average Precision | | | |
|---|---|---|---|---|
| | HSV color | GLCM Texture | HSV color +GLCM Texture | Dominant color +GLCM Texture (proposed method) |
| Africa | 0.26 | 0.21 | 0.25 | 0.27 |
| Beaches | 0.27 | 0.35 | 0.21 | 0.36 |
| Building | 0.38 | 0.5 | 0.24 | 0.25 |
| Bus | 0.45 | 0.22 | 0.51 | 0.52 |
| Dinosaur | 0.26 | 0.29 | 0.6 | 0.91 |
| Elephant | 0.3 | 0.24 | 0.26 | 0.38 |
| Flower | 0.65 | 0.73 | 0.81 | 0.89 |
| Horses | 0.19 | 0.25 | 0.28 | 0.47 |
| Mountain | 0.15 | 0.18 | 0.2 | 0.3 |
| Food | 0.24 | 0.29 | 0.25 | 0.32 |
| Average | 0.315 | 0.326 | 0.361 | 0.467 |

The following graph showing the Comparison of average precision obtained by proposed method with other retrieval systems.

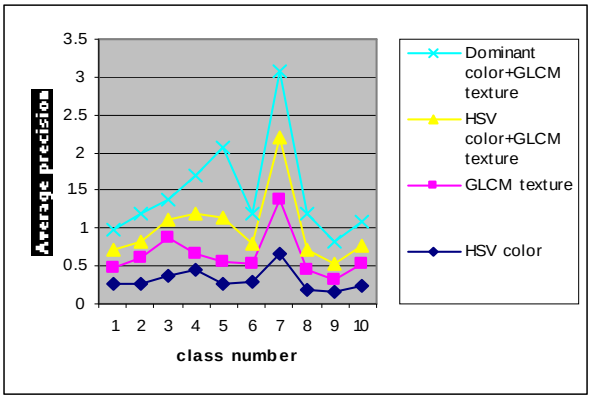


Fig. 3 Average precision of various image retrieval methods for 10 classes of Corel database.

The graph in Fig.4 showing the Comparison of average precision obtained by proposed method with other retrieval systems. And the graph in Fig.5 showing the Comparison of average recall obtained by proposed method with other retrieval systems.

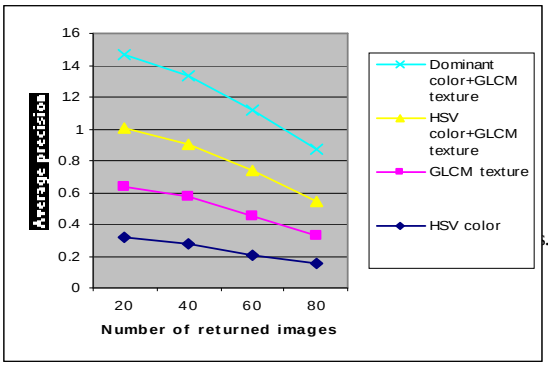


Fig. 4 Average Precision of various image retrieval methods.

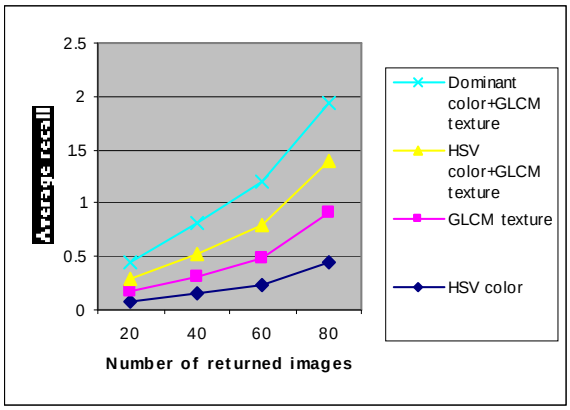


Fig. 5 Average recall of various image retrieval methods.

## V. CONCLUSION

CBIR is an active research topic in image processing, pattern recognition, and computer vision. In this paper, a CBIR method has been proposed which uses the combination of dynamic dominant color, GLCM texture descriptor. Experimental results showed that the proposed method yielded higher average precision and average recall with reduced feature vector dimension. In addition, the proposed method almost always showed performance gain of average retrieval time over the other methods. As further studies, the proposed retrieval method is to be evaluated for more various databases.

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# AN IMPROVED MULTIPERCEPTRON NEURAL NETWORK MODEL TO CLASSIFY SOFTWARE DEFECTS

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***Abstract*:** Predicting software defects in modules not only helps in maintaining legacy systems but also helps the software development process and ensures higher reliability. Advantage includes planning of resources for the projects and minimization of budget. Research has been carried out using statistical methodology and machine learning techniques which are generic in nature. The dependability on legacy Software systems to meet current demanding requirements is a major challenge for any IT administrator and estimation of costs to maintain the same is a huge challenge. In this paper, it is proposed to modify the existing multi layer perceptron Neural Network which is a popular supervised classification algorithm to predict defects in a given module based on the available software metrics.

***Keywords— Legacy software, Software metrics, Software reliability, Classification, Multilayer Perceptron Neural network, Fault-proneness.***

## I. INTRODUCTION

Software reliability and Software quality assurance are two major areas in software engineering which ensures high quality software. Both these concepts are drawn in throughout the development and maintenance process. The notable major activities used are performance analysis, functional tests, quantifying time and budget along with measurement of metrics[1]. In addition; code reviews, key personnel assignment and automatic test-case generation are the other strategies that are applied to reach the high reliability [2].

Software quality can be viewed from different perspectives including time, budget and mean time to failure. Alpha and Beta testing help to improve the quality of software but does not ensure zero defects and is a very expensive proposition if not planned properly.

Software quality modeling becomes an important criterion to ensure that the software not only meets the desired quality but also within time and budget lines. Defect prediction based on quantifiable metrics though in controversy, has been used successfully to predict defects in modules. Defect prediction models have independent variables captured in the form of product and process metrics and one dependent variable which indicates whether there could be a fault or no fault in the module. Typically researchers have used product metrics extensively to predict fault in the modules. The independent variables used for prediction of defects can be parameters captured in previous projects which is available in the configuration management system or can be computed from the current project.

Predicting module defects also finds application in legacy systems where it may not be possible to replace legacy systems through the practice of application retirement. Defect prediction provides a cost effective process to enhance them.

The previous work carried out by the author [3] investigates the KC1 for defect classification using Decision Tree induction and Bayesian networks. Various pre-processing techniques were also investigated [4]. The results obtained are tabulated in table 1 and 2.


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TABLE-I. CLASSIFICATION ACCURACY ON KC1 DATASET

| KC1 Dataset | Correctly classified % | Incorrectly classified % | Mean Absolute error |
|---|---|---|---|
| Ramdom tree | 81.86 | 18.14 | 0.1924 |
| CART | 84.91 | 15.09 | 0.2095 |
| Bayesian logistic regression | 86.03 | 13.97 | 0.1397 |

TABLEII. CLASSIFICATION ACCURACY AFTER PREPROCESSING IN KC1 DATA SET

| | % correctly classified | % Incorrectly Classified |
|---|---|---|
| Random Tree | 94.5531 | 5.4469 |
| Logistic regression | 95.6704 | 4.3296 |
| CART | 96.7877 | 3.2123 |

In this paper, the efficacy of neural network for defect prediction using available model and our proposed model is verified.

This paper is organized into the following sections. Section II describes software metrics, Section III describes data mining techniques for classification, Section IV gives an introduction to Neural Network used, Section V describes the dataset used in the work, Section VI includes the improved neural network technique and output obtained. The last section analyses and concludes the paper.

## II. SOFTWARE METRICS

Software metrics are collected at various phases of the software development process. These metrics contain information of software and can be used to predict software quality in the early stages of software life cycle.

Software reliability engineering is one of the most important aspects of software quality. Recent studies show that software metrics can be used in software module fault-proneness prediction. A software module has a series of metrics, some of which are related to fault-proneness. Multiple research works on the software quality prediction using the relationship between software metrics and software module's fault-proneness have been done in the last decades. There are several techniques proposed to classify the modules for identifying fault-prone modules

## III. DATA MINING TECHNIQUES

Data Mining (DM) aims to establish something new from the facts recorder in the databases. Originally, data mining is a statistician's term for overusing data to draw in legitimate inferences. DM is the use of powerful tools to sift out important or significant traits that are previously unknown from databases or data warehouses.

Software is prone to have errors and bugs. The process of software testing is to assess the quality of computer software and verify whether the software complies with software specification and customer needs. There are two ways to find errors in software testing: manual and automated. Manually debugging is laboured intensive and costly while automated debugging can classify and locate the software defect automatically. Data mining based software debugging is becoming more and more accepted and it can significantly reduce the amount of labour cost in software debugging.

Data Mining extracts useful information and knowledge from huge amount of data. DM methods can be applied to the data generated in every stage of software life cycle such as design, development, testing, deployment and maintenance, and extract potential errors in the software.

## IV. NEURAL NETWORKS

Neural networks consist of multiple layers of computational units, usually interconnected in a feed-forward way. Each neuron in one layer has directed connections to the neurons of the subsequent layer. In many applications the units of these networks apply a sigmoid function as an activation function.

The feed forward neural network was the first and arguably simplest type of artificial neural network devised. As the majority of faults are found of its modules, there is a need to investigate the modules that are affected severely as compared to other modules and proper maintenance to be done on time especially for the critical applications Ebru Ardil et. al (2009).

Algorithms based on neural networks have a lot of applications in knowledge engineering. In data mining, the following neural network architectures are used:


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- Multilayered feed forward neural networks
- Kohenen's self-organizing maps.

### A) Multilayered feed forward neural networks

Multilayered feed forward neural networks (ANNs) are non-parametric regression methods, which approximate the underlying functionality in data by minimizing the loss function. The common loss function used for training and ANN is quadratic error function. ANN is used for adaptation supervised learning. Database form a training set. During training, specified items of data records are put as the input of neural network and its weights are changed in such a way that its output would approximate the values in the data set. After finishing learning process, the learned knowledge is represented by the values of neural network weights. For training, the algorithm of back propagation of error is often used.

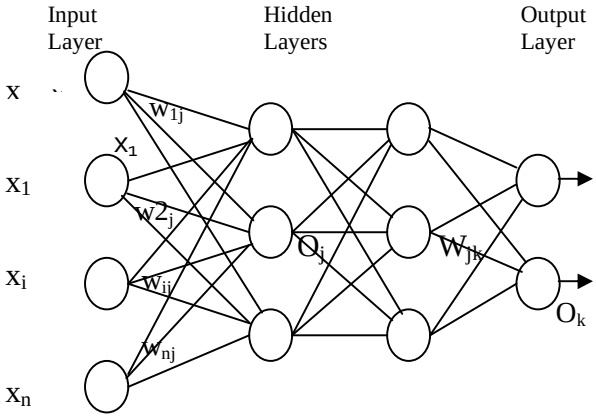


**Fig. 1. Multilayaer Neural Network**

### B) Kohenen's self-organizing maps

Kohenen's self-organizing maps (SOMs) have become a promising technique in cluster analysis. They are adapted by unsupervised learning. In data mining, Kohenen's self-organizing maps based cluster techniques have the following advantages over standard statistical methods.

DM typically deals with high-dimensional data. A record in a database typically consists of a large number of items. The data do not have regular multivariate distribution and thus the traditional statistical methods have their limitations and they are not effective. SOMs work with high-dimensional data efficiently.

Kohenen's self-organizing maps provide means for visualization of multivariate data, because two clusters of similar members activate output neurons with small distance in the output layer. In other words, neurons that share a topological resemblance will be sensitive to inputs that are similar. This property has no other algorithm of cluster analysis.

SOM is a dynamic system, which learns abstract structure in high-dimensional input space using low-dimensional space for representation.

## V. DATA SET

Data from the NASA's Metric Data Program (MDP) data repository is made use of. The KC1 dataset used contains LOC measure, cyclomatic complexity, Base Halstead Measures, Derived Halstead measures from various software modules.

The attributes used in this work is described briefly below

LOC_BLANK - The number of blank lines in a module.
LOC_CODE_AND_COMMENT - The number of lines which contain both code & comment in a module.
LOC_COMMENTS - The number of lines of comments in a module.
CYCLOMATIC_COMPLEXITY - The cyclomatic complexity of a module.
DESIGN_COMPLEXITY - The design complexity of a module.
ESSENTIAL_COMPLEXITY - The essential complexity of a module.
LOC_EXECUTABLE - The number of lines of executable code for a module (not blank or comment)
HALSTEAD_CONTENT - The Halstead length content of a module.
HALSTEAD_DIFFICULTY - The Halstead difficulty metric of a module.
HALSTEAD_EFFORT - The Halstead effort metric of a module.
HALSTEAD_ERROR_EST - The Halstead error estimate metric of a module.
HALSTEAD_LENGTH - The Halstead length metric of a module.
HALSTEAD_LEVEL - The Halstead level metric of a module.
HALSTEAD_PROG_TIME - The Halstead programming time metric of a module.
HALSTEAD_VOLUME - The Halstead volume metric of a module.
NUM_OPERANDS - The number of operands contained in a module.


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NUM_OPERATORS - The number of operators contained in a module.
NUM_UNIQUE_OPERANDS - The number of unique operands contained in a module.
NUM_UNIQUE_OPERATORS - The number of unique operators contained in a module.
LOC_TOTAL - The total number of lines for a given module.

## VI. PROPOSED METHODOLOGY & EXPERIMENTAL INVESTIGATION

The Multilayer Perceptron is an example of a supervised learning artificial neural network that is used extensively for the solution of a number of different problems, including classification, pattern recognition and interpolation. The algorithm for Perceptron Learning is based on the back-propagation rule. The hidden layer typically consists of either sigmoid or tanh function. The algorithm for multi layer perceptron neural network is given below.

i. Present input and desired output

Present input Y*p = y0 ,y1 ,y2 ,...,yn-1* and target output ***C****p = c0 ,c1 ,...,cm-1* where n is the number of input nodes and m is the number of output nodes.

ii. Calculate the actual output

*Each layer calculates the following:*
*fxpj = f* [*w0y0 + w1y1 + .... + wyn*]
jThis is then passed to the next layer as an input. The final layer outputs values *opj*.

iii. Adapts weights, starting from the output we now work backwards.

*wij(t+1) = wij(t) + ñþpjopj* , where *ñ* is a gain term and *þpj* is an error term for pattern *p* on node *j*.

For output units
*þpj = kopj*(*1 - opj*)(*t - opj*)

For hidden units
*þpj = kopj*(*1 - opj*)[(*þp0wj0 + þp1wj1 + ....+þpkwjk*)]

where the sum is over the *k* nodes in the layer above node *j*.

In this paper, a fuzzy bell hidden layer is proposed, that uses a bell shaped curve as its fuzzy member in the hidden layer and is given by

$$: \frac{1}{1+\left|\frac{x-w_2}{w_0}\right|^{2w_1}}$$

Where y is the input and w is the weight. L2 Criterion is used to compute the cost function desirable. The error computed to the supervised learning procedure is the squared Euclidean distance between the network's output and the desired response.

65 percent of the data was used as the training set and the remaining used as the test set. The classification accuracy obtained on KC1 dataset is 98.2%.

The proposed fuzzy based neural model was able to classify better than Random Tree by 14.66%, CART by 11.41% and Bayesian logistic regression by 10.50%. However the proposed method needs to be evaluated with other datasets to better test the performance in terms of consistency.

The results obtained by our proposed methodology is improved over the regular multilayer perceptron model with sigmoidal hidden function by 3.92%. Figure 2 displays the accuracy obtained by various classification methods carried out.

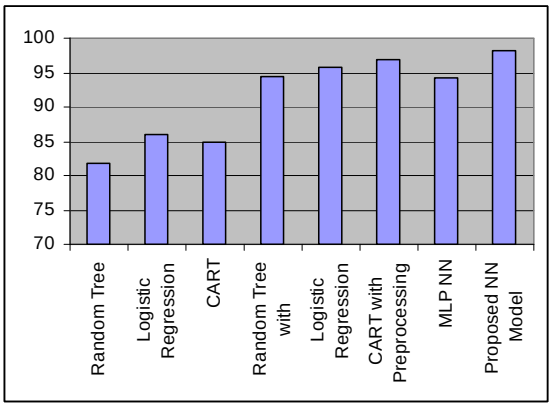


FIG.2. CLASSIFICATION ACCURACY ON KC1 DATA SET

## CONCLUSION

In this paper, it has been observed that the proposed Bell fuzzy based neural network model performs better than existing neural network model and other classification algorithms. Thus it can be very decisively said that Bell fuzzy function used in multi-perceptron neural network improves the classification accuracy of software defect prediction..


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# AN INTERACTIVE VISUALIZATION METHODOLGY FOR ASSOCIATION RULES

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***Abstract*- The task of the knowledge discovery and data mining process is to extract knowledge from data such that the resulting knowledge is useful in a given application. Obviously, only the user can determine whether the resulting knowledge satisfies this requirement. Moreover, what one user may find useful is not necessarily useful to another user. Visual data mining tackles the data mining tasks from this perspective enabling human involvement and incorporating the perceptivity of humans. The objective of this paper is to present the students performance through visualization mining method on data coming from educational institute. Such method together with the novel visualization technique described here allows the analyst to explore data and view significant differences among performance values of students. The results are immediately presented in a graphical form and the user is allowed to change settings in order to allow him or her to iteratively explore the data and find some useful knowledge.**

## I. INTRODUCTION

For data mining [1] to be effective, it is important to include the human in the data exploration process and combine the flexibility, creativity, and general knowledge of the human with the enormous storage capacity and the computational power of today's computers. Visual data exploration aims at integrating the human in the data exploration process, applying its perceptual abilities to the large data sets available in today's computer systems. The basic idea of visual data exploration is to present the data in some visual form, allowing the human to get insight into the data, draw conclusions, and directly interact with the data. Visual data mining techniques have proven to be of high value in exploratory data analysis and they also have a high potential for exploring large databases. These huge databases contain a wealth of data and constitute a potential goldmine of valuable information. As new courses and new colleges emerges, the structure of the educational database changes. Finding the valuable information hidden in those databases and identifying and constructing appropriate models is a difficult task. Data mining techniques play an important role at each stop of the information discovery process and visual data exploration usually allows a faster data exploration and often provides better results, especially in cases where automatic algorithms fail. In addition, visual data exploration techniques provide a much higher degree of confidence in the findings of the exploration. This fact leads to a high demand for visual exploration techniques and makes them indispensable in conjunction with automatic exploration techniques.

The main contribution in this study is addressing the capabilities and strengths of data mining technology in identifying placement of students and to guide the teachers to concentrate on appropriate attribute associated and counsel the students or arrange for suitable placement to them. In this work, we propose a dynamical framework for association rule mining that integrates interactive visualization techniques in order to allow users to drive the association rule finding process, giving them control and visual cues to ease understanding of both the process and its results.

## II. ASSOCIATION RULE MINING (ARM)

Association Rules Mining (ARM) [2] can be divided into two sub problems: the generation of the frequent itemsets lattice and the generation of association rules. The complexity of the first sub problem is exponential. Let |I|=m the number of items, the search space to enumerate all possible frequent itemsets is equal to $2^m$, and so exponential in m [2]. Let $I = \{a_1, a_2, \ldots, a_m\}$ be a set of items, and let $T = \{t_1, t_2, \ldots, t_n\}$ be a set of transactions establishing the database, where every transaction $t_i$ is composed of a subset $X \subseteq I$ of items. A set of items $X \subseteq I$ is called itemset A transaction $t_i$ contains an itemset X in I, if $X \subseteq t_i$. Several ARM published papers are based on two main indices which are support and confidence [2]. The support of an itemset is the percentage of transactions in a database where this itemset is one subgroup. The confidence is the conditional probability that a transaction contains an itemset knowing that it contains another itemset. An itemset is frequent if support (X) $\geq$ minsup, where minsup is the user-specified minimum support. An association rule is strong if confidence(r) $\geq$ minconf, where minconf is the user-specified minimum confidence. Left part of an association rule is called antecedent and right part is called conclusion. Our motivations are described hereafter.


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## III. MOTIVATION

The number of generated rules is a major problem on association rules mining. This number is too significant and leads to another problem called Knowledge mining. The human cycles spent in analyzing knowledge is the real bottle neck in datamining. This issue can limit the final user's expertise because of a strong cognitive activity. To solve it, visual datamining became an important research area. Indeed, extracting relevant information is very difficult when it is hidden in a large amount of data. Visual data mining attempts to improve the KDD process by offering adapted visualization tools which allow tackling various known problems. Those tools can use several kinds of visualization techniques which allow simplifying the acquisition of knowledge by the human mind. It can handle more data visually and extract relevant information quickly.

Indeed, in most real life databases, thousands and even millions of high-confidence rules are generated, among which many are redundant. In this paper, we are interested in the most used kind of visualization categories in data mining, i.e., use visualization techniques to present the information catched out from the mining process. Visualization tools became more appealing when handling large data sets with complex relationships, since information presented in the form of images is more direct and easily understood by humans. Visualization tools allow users to work in an interactive environment with ease in understanding rules. In a based tabular view of association rules, all strong rules are represented as in a tabular representation format (rule table), in which each entry corresponds to a rule. All rules can be displayed in different order, such as order by premise, conclusion, support or confidence. This helps users to have a clearer view of the rules and locate a particular rule more easily.

## IV. VISUAL DATA MINING

The rise of KDD revealed new problems as knowledge mining. These large amounts of knowledge must be explored with specific advanced tools. Indeed, expertise requires an important cognitive work, a fortiori, a harmful waste of time for industrial. Extracting nuggets is a difficult task when relevant information is hidden in a large amount of data. In order to tackle this issue, visual datamining was conceived to propose visual tools adapted to several well-known KDD tasks. These tools contribute to the effectiveness of the processes implemented by giving understandable representations while facilitating interaction with experts. Visual data mining is present during all KDD process: upstream to apprehend the data and to carry out the first selections, during the mining, downstream to evaluate the obtained results and to display them. Visual tools became major components because of the increasing role of the expert within KDD process. Visual datamining integrates concepts resulting from various domains such as visual perception, cognitive psychology, visualization metaphors, information visualization, etc.

We focus on visualization during the post processing stage and we are interested by ARM. Independently of both context and task, ARM has a main drawback which is the high number of generated rules. Several works on filtering rules were proposed and a state of the art was presented in [3]. Although reducing the whole of generated rules significantly, this number remains however important. Expert must be able to easily interact with an environment of datamining in order to more easily understand the displayed results. This point is essential for the global performance of the system. Visual tools for association rules were proposed to reduce this cognitive analysis but they remain limited [3].

## V. VISUAL ASSOCIATION RULE MINING

Various works already exist to help expert analysis in text-mode [4]. Several works on visual rules exploration were published [2], [5], [6], [7]. The main beliefs of our interactive ARM are described hereafter. All these tools use several methods which are textual, 2D or 3D way. The choice of one of them proves to be a difficult work. Moreover, their interpretations can vary according to the expert. Each one of these techniques presents advantages and drawbacks. It is necessary to take them into account for the initial choice of the representation. The effectiveness of these approaches is dependent on the input data files. These representations are understandable for small quantities of data but become complex when these quantities increase. Indeed, particular information can not be sufficiently perceptible in the mass. The common limitation of all the representations is that if they are global, they quickly become unreadable (size of the objects in 2D, occlusions in 3D) and if they are detailed, they do not provide an overall picture on these data to the expert.

## VI. RELATED WORK

Traditionally, many simple methods are designed to render small amount of data or statistical features of big data sets, such as histogram, pie, tree, etc. To visualize more complex data, modern scientific visualization utilizes more advanced techniques. Visualization techniques, such as EXVIS [8], Chernoff Faces [9], icons [10] and m-Arm Glyph [11], are often called glyph-based methods. Glyphs are graphical entities whose visual features, such as shape, orientation, color and size, are used to encode attributes of an underlying dataset, and glyphs are often used for interactive exploration of data sets [12]. Glyph-based techniques range from representation via individual icons to the formation of texture and color patterns through the overlay of many thousands of glyphs [13]. Chernoff used facial characteristics to represent information in a multivariate dataset [14]. Each dimension of the data set encodes one facial feature, such as nose, eyes, eyebrows, mouth, or jowls. Glyphmaker proposed by Foley and Ribarsky visualize multivariate datasets in an interactive fashion [14]. Levkowitz described a prototype system for combining colored squares to produce patterns to represent an underlying multivariate dataset [15]. In [10] an icon encodes six dimensions by six lines of different colors within a square icon. In [13] Levkowitz describes the combination of textures


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and colors in a visualization system. The m-Arm Glyph by Pickett and Grinstein [11] consists of a main axis and m arms, and the length and thickness of each arm and the angles between each arm and main axis are used to encode different dimensions of a data set. [6] describes a glyph-based system for large high dimensional datasets. These techniques are incapable of visualizing large amount of high dimensional data because:

- Lack of human computer interaction.
- Lack of integration with other data mining and knowledge discovery (KDD) tools.

## VII. PROPOSED WORK

Nowadays, higher educational organizations are facing a very high competitive environment and are aiming to get more competitive advantages over the other business competitions. These organizations should improve the methodology of teaching, placement and counseling of students. They consider students and teachers as their main assets and they want to improve their key process indicators by effective and efficient use of their assets

Students' academic performance is critical for educational institutions because strategic programs can be planned in improving or maintaining students' performance during their period of studies in the institutions. The academic performance in this study is measured by certain attribute as indicated in Table 1. This study presents the work of data mining in predicting the final placement of students. This study applies association rule mining technique to choose the best prediction and analysis. The list of students who are predicted as likely to drop from the selection criterion by data mining is then turned over to teachers and management for direct or indirect intervention.

For example, let us consider the transaction database of few students from Students' repository of institute which shows the students general and academic grades in different courses they enrolled for during their years of attendance in the institution. Student performance score is basically determined by the sum total of the continuous assessment and the examination scores. In most institutions the continuous assessment which includes various assignments, class tests, group presentations is summed up to weigh 30% of the total score while the main semester examination is 70%. To differentiate different students' performances we have selected different attributes as attendance, Mark, Activity etc. .as shown in table 1.

Educational institutions with Association rule mining can predict the student's performance more accurately, which in turn can result in quality education.

### *A. Student Level Analysis*

Successfully training the student requires analyzing the data at the student level. Using the associated discovery data mining technique, educational institutions can more accurately select the kind of training to offer to different kinds of students. With the help of this technique, educational institutions can.

i. Segment the student database to create student profiles.

ii. Conduct analysis on a single student segment for a single factor. For example, the institution can perform in-depth analysis of the relationship between attendance and academic achievement.

iii. Analyze the student segments for multiple factors using group processing and multiple target variables. For example, ―What are the characters shared by students who drop out from colleges?

iv. Perform sequential (over time) basket analysis on student segments. For example, ―What percentage of high attendance holders also achieved in academic side also?

### *B. Developing new strategies*

Teachers can increase the placement percentage by identifying the most lucrative student segments and organize the training sessions accordingly. The results may be affected, if teachers do not offer the right kind of training to the right student segment at the right time. With data mining operations such as segmentation or association analysis, institutions can now utilize all of their available information for betterment of students.

TABLE I ATTRIBUTE LIST

| **ATTRNAME** | **ATTR** | **Possible Values** |
|---|---|---|
| Enrolment No. | ENR | Yes, No |
| Attendance | ATT | Poor, Good, Average |
| 10+2 Grade | INT | A, B, C |
| Area of expertise | EXP | M,C,E |
| Gender | G | M, F |
| Fund | F | P, S, F |
| Student Department | STD | ME, CS, IT |
| Activities performed by the student | ACT | A, B, C |
| Percentage of practical session | PSA | A, B, C |
| Exercise given by teacher | ET | A, B, C |
| Average mark of the experience report | ER | A, B, C |
| Final mark | MARK | A, B, C |
| Evaluation | EVL | A, B, C |


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## VIII. SYSTEM ARCHITECTURE

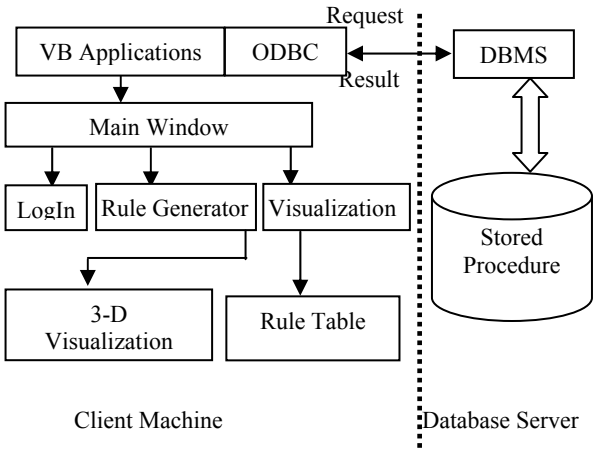


Figure 1. System Architecture

The system architecture is shown in Figure. The database resides in the server machine. The stored procedures (Oracle) reside in the server side. Our VB application runs in the client machine. It consists of several modules: LogIn, Rule Generator, and Visualization module. LogIn module is used to connect to the database server. Rule Generator is used to mining the association rules given the information provided by the user. Visualization module consists of two sub-modules Rule table and 3-D visualization. These modules can be accessed using the Main window.

*Knowledge Extraction Stage*

Rendering millions of icons is computationally expensive, and interpretation and analysis to be performed by the user is even harder. A visualization system has to provide not only a "loyal" picture of the original dataset, but also an "improved" picture to a viewer for easier interpretation and knowledge extraction. Integration of analysis functionality is important and necessary to help the viewer to extract knowledge from the display. The basic requirement about a visualization system as:

> "Different data values should be visualized differently, and the more different the data values are, the more different they should look".

But what a viewer wants to find with a visualization system is not data values themselves, instead, it is the information or knowledge represented by data values. So, the above requirement can be better stated as:

> "Different information should be visualized differently, and the more different the information is, the more different it should look".

To help a viewer on knowledge extraction a visualization system has to deal with the problem of non-uniform knowledge/information distribution. It is common in some data sets or fields that a small difference of a value could mean a big difference, which means the knowledge and information is not distributed uniformly within data values. A user would like a visualization system to be able to show these knowledge differences clearly. To be specific, two differences of same amount in data values may not necessarily be rendered by the identical difference in visual elements on the screen. Instead the difference representing more information should be displayed more significantly to get attention from a viewer.

*Interactive Visualization Model*

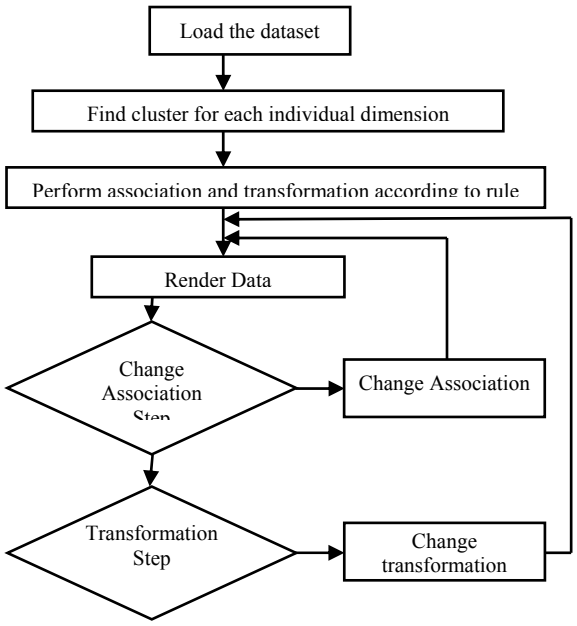


Figure 2. Visualization Model

In Figure 2 we give an interactive visualization model which has the following properties:

1) Interaction: It is clear that integration of domain knowledge to a visualization system is very important due to the problem of non-uniform knowledge distribution. To a visualization system integration of domain knowledge can be achieved by choosing proper association function and transformation function during visualization process. However, there is no universal technique for all fields, data sets or users, and a visualization system should be interactive and provide a mechanism for views to adjust or change association and transformation functions during visualization process. And each data set or field has to be studied individually and visualized interactively before its important information can be revealed, which can only be performed by viewers or domain experts. By interaction a viewer can guide a visualization system step by step to display what he is interested in more and more clearly.
2) Correctness: We propose the following criteria for "correct" visualization:
    a) If possible a visualization system should show different dimensions of a data set differently


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through different visual objects or visual elements of one visual object.

b) The more different the values are, the more differently they should be rendered. Since we may not know the distribution of a dataset, assigning data values to visual elements/properties may not make full usage of available visual elements/properties, a clustering step is preferred.

c) The more different the information represented by data values are, the more differently they should be rendered. A distinguished visual difference between different information can help viewers better, which can be achieved by interaction between a visualization system and viewers. In this interaction process, viewers can fine tune the transformation between data values and visual elements, and domain knowledge is obtained and reflected through a more customized display.

3) "Maximizing" rule: To optimize the rendering quality, the maximal range of visual objects/elements should be used as default settings.

## IX. IMPLEMENTATION METHODOLOGY

At the beginning of any mining task, the system acquires the support for each attribute category defined at discretization step during preprocessing phase of a generalized composite record in the corresponding cluster. Figure 3 depicts the user interface screens that acquire these supports. In order to show how our technique has enhanced the rule generated, we conducted the following experiment steps: Run the system and give variable support for each attribute category based on the user interest.

1) Count the number of rules generated and the number of used premises in these rules.

2) Rerun the system and give equal support for all attributes categories.

3) Count the number of rules and the premises used in these rules.

4) Examine the quality of rules generated in each case by comparing the number of rules and premises used.

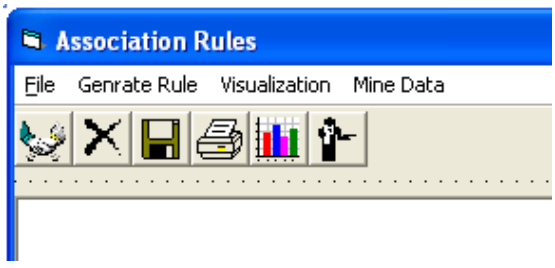


Figure 3. Interface Screen

The main window consists of the menu, toolbar, and a text area. The user can connect to different databases, here Oracle through the *connect* sub-menu and disconnect from the same through the *disconnect* sub-menu. Under the *Generate Rule* menu, the user can choose *generate rules*. The operations of rule generation and rule visualization are mainly done through the menu.

We use VB standard EXE as the software development tool to implement our project. VB provides an Integrated Development Environment (IDE), which makes interface design, program debugging very efficiently. The menu can be implemented using the Menu Editor. All the objects in the main window can be designed visually.

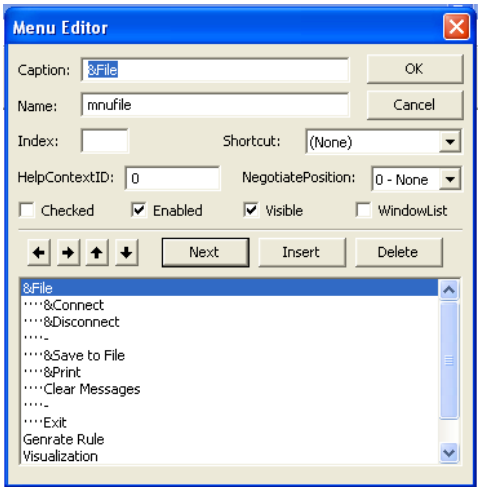


Figure 4. Menu Editor

After the user chooses "Connect" menu item, a Login window will be brought up. Login module of Association Rule Software is described in fig. 5. After the user provided all the needed information, the user can choose to "Connect" to the DBMS

```
Private Sub cmdOK_Click()
a.connect txtUserName.Text, txtPassword.Text
If Loginsucceeded Then
Form1.mnuconn.Enabled = Not Loginsucceeded
Form1.mnudisc.Enabled = Loginsucceeded
Form1.Toolbar1.Buttons(1).Enabled=Not Loginsucceeded
Unload Me
Form1.Show
End If
End Sub
```

Figure 5. Login Module



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*Rule Generator*

For each input data set, some parameters have to be specified by the user for the association rule generation. This kind of information can be arranged in the concerned table, because the data is not always in the same table, and sometimes it is needed to obtain the data from two or more different tables, the user should have the ability to select multiple tables as the data source in the procedure. The user may also want to specify the lowest support and confidence value to get the interested association rules. The value of stop level is used to let the user decide that after how much passes that the user wants the rule generation needs to be canceled. The information is taken from the transaction table and the user can click the "Generate Rules" menu button to begin to merge the data from different tables. Then the association rule generation algorithm will be called to generate the rules.

*1- Select the mining task and consequently the appropriate cluster*
*2- Get the confidence threshold for generating a rule (this means that the rule will only be generated if the number of occurrences of records described by this rule divided by the total number of records in the cluster greater than the given confidence threshold)*
*3- Construct a matrix (calculated relative weight) with number of rows equal to the number of attributes (m) and number of columns (n) equal to the maximum number of categories of a certain attribute*
*4- Using the appropriate cluster, fill in the calculated relative matrix with the relative weight of each attribute category in this cluster*
*5- Compare the calculated relative weight with the user given support and mark irrelevant attributes categories.*
*6- For each generalized composite record do*
*7- For each generalized composite record attribute do { if the attribute category is irrelevant then mark it as irrelevant copy relevant attributes category into a new table}*
*8- Group similar rows in the new table and calculate a confidence value for this grouped records*
*9- Generate rules*

Proposed algorithm

The algorithm is based on well known existing techniques to obtain association rules as Apriori algorithm. This algorithm is modified to enable a user to control and impose his area of focus during knowledge discovery steps in order to overcome the loss of information problem and to enable him/her to generate rules that he/she is interested in. The proposed algorithm solved this problem by allowing the user to define the relative weight or support of each attribute interval category such that the mining algorithm could generate rules using this attribute interval category only if this support is satisfied.

The generated rules can be visualized in either the table format or 2D, 3D format by selecting the appropriate *visualization* Menu Item. As we execute the program the title screen comes into action which is shown in fig. 3.

Further we click on the Visualization Menu to get different graph related to Association rules. We can further select the graph of our choice by clicking on any of the option button available in the visualization effect window, as shown in the figure 6.

Some of the generated rules are given in Table 2 in a form that is understandable by humans. In Table 2, the first column represents the rule number, the generated rules are presented in the second column, the number of the students who successfully satisfy the rules is given in the third column, and the number of attributes contained in the rule is given in the last column. The table shows the rules in a descending order depending on the number of the students who successfully have satisfied the rule. This ordering helps in determining the most significant rule. For the generated rules, the longest rule consists of 10 attributes while the shorter rule contained only 3 attributes.

TABLE 2 GENERATED RULES

| Rule # | Rules | # Obj | # Attrib |
|---|---|---|---|
| 7 | IF ENR = Y, ATT = A, INT=A, G = M, STD=IT, ACT=A, PSA=A, ET=A, ER=B, MARK=A THEN EVL = A | 13 | 10 |
| 3 | IF ENR = Y, ATT = B, INT=A, G = F, STD=IT, ACT=A, PSA=A, ET=A, ER=B, MARK=A THEN EVL = A | 9 | 10 |
| 11 | IF ENR = Y, ATT = B, INT=A, G = M, STD=CS, ACT=A, PSA=C, ET=C, ER=B, MARK=B THEN EVL = B | 9 | 10 |
| 17 | IF ENR = Y, ATT = C, INT=A, G = M, F=SC, STD=ME, ACT=A, PSA=B, MARK=B THEN EVL = A | 8 | 9 |
| 9 | IF ENR = Y, ATT = A, INT=B, G = F, ACT=A, PSA=A, ET=A, ER=B, MARK=B THEN EVL = B | 5 | 8 |
| 14 | IF ENR = Y, ATT = C, G = M, ACT=B, PSA=A, ER=B, MARK=A THEN EVL = A | 4 | 7 |
| 3 | IF ENR = Y, ATT = C, MARK=C THEN EVL = C | 3 | 3 |

We implemented the mapping of intermediate rule table into the format that the user can understand easily. A visualization module that includes rule table and 2-D, 3-D graphics was developed to help the user get the interested information easier through sorting, and filtering functions. Besides the performance our software can access the data stored in multiple data tables through ODBC such as Oracle. Our visualization module uses 'rule-item' relationship so that it can display more rules at one time. In additional, the rule sorting and filtering ability of our visualization module gives the user more flexibility and efficiency in managing and understanding the association rule. In our implementation, we store the generated rules in the database. Once the rules are


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stored in database, they can be easily handled because of the SQL capabilities.

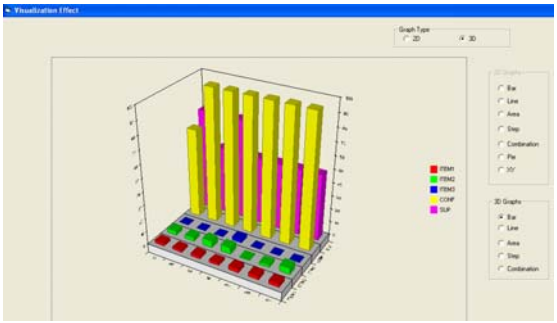

Figure 6. Visualization effect

## X. CONCLUSION

The framework proposed will ease the task of association rule mining by giving users greater control over the mining task and by improving their ability to interpret the rules, evaluate their relevance and obtain insight on the knowledge mined from large datasets. We rely on interactive visualizations as an efficient approach to bridge the gap between task automation and user control in mining tasks.

This study has bridge the gap in educational data analysis and shows the potential of the association rule mining algorithm for enhancing the effectiveness of academic planners and level advisers in higher institutions of leaning. The analysis reveals some hidden patterns of students' which could serve as bedrock for academic planners in making academic decisions and an aid in the curriculum re-structuring and modification with a view to improving students' performance. To adopt this approach a larger number of students should be considered from the first year to the final year in the institution. This will surely reveal more interesting patterns. With all these observations, if academic planners can make use of the extracted hidden patterns from students' performances using association rule mining approach, it will surely help in curriculum re-structuring and also, help in monitoring the students' ability. This will enable the academic advisers to guide students properly on courses they should enroll for. This, eventually, tends to increase the student placement rate.

## XI. FUTURE

We conclude by remarking that visualization of association mining results in particular and data mining results in general is a promising area of future work. Educational, research, government and business institute can benefit significantly from the symbiosis of data mining and information visualization disciplines.

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### AUTHORS PROFILE

Mohammad Kamran is a Software Developer. His primary interests lay in the areas of data mining and association rules. Nowadays, he is a research scholar in Computer Science at Integral University. His paper summarizes the current state of his thesis work on the field of "study of association rules in large database.



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# Video Delivery based on Multi-Constraint Genetic and Tabu Search Algorithms

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***Abstract*— The rapid growth of wireless communication and networking protocols, such as H802.11 and cellular mobile networks, is bringing video into our lives anytime and anywhere on any device. The video delivery over a wireless network faces several challenges going forward such as limitation, bandwidth variation, and high error rate so on. This paper proposed a new approach to improve the performance of video delivery, called Video Delivery based on Multi-Constraint Genetic and Tabu Search algorithms. In this paper, GA is used to find the faceable paths and Tabu search is used to select the best path from those paths that help to enhance the bandwidth delay and to improve the packet loss for wireless video content delivery.**

***Keywords-; GA, Tabu Search, Multi-hop network, and Video delivery.***

## I. INTRODUCTION

In recent years, one of the real time applications is video conference systems that are widely used. In additions, real-time embedded systems are found in many diverse application areas including automotive electronics, avionics, telecommunications, space systems, medical imaging, and consumer electronics. The transport of real time video streams over the Internet by using wired and wireless multimedia delivery faces several challenges such as random channel variation, bandwidth scarcity and limited storage capacity [1]. The quality of service (QoS) of the video should have assurance of low bit rate. In addition, there are different applications have various QoS requirements to achieve users' satisfaction. QoS depends on some of the parameters such as: throughput, bandwidth, delay, error rate control, and packet loss [2][3][4][5]. According to those parameters, the transportation paths are chosen. Nowadays, optimal path routing algorithms do not support alternate routing. If the existing path is the best path, and it cannot accept a new flow, the associated traffic cannot be transmitted, even if the appropriate alternative path is existing. Hence, clearly the quality of service routing algorithms must be adaptable, flexible, and intelligent enough to make a fast decision. To achieve this, a Genetic Algorithm (GA) based on the computational strategies that inspired by natural processes is used. GA is a global optimization technique derived from the principle of nature selection and evolutionary computing or technique [6][7][8][9]. GA- theoretically and empirically- has been proven to be a robust search technique. Each possible point in the search space of the problem is encoded into a suitable representation for applying GA. In GA, each population of individual solutions with fitness value is transformed to a new generation of the population, depending on the Darwinian principle of the survival of the fitness. By applying genetic operators, such as crossover and mutation, GA produces better approximations to the solutions. Many routing algorithms based on GA have been proposed [2][10][11]. Selection and reproduction processing at each iteration produces a new generation of approximations. The outline of the basic GA is shown in Figure 1.

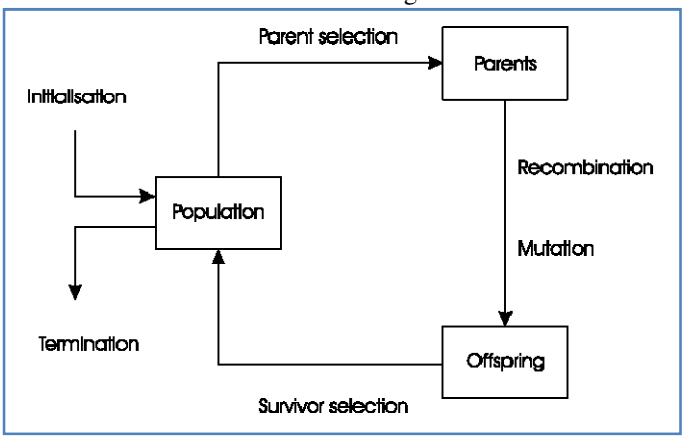


Figure 1. Outline of the basic GA [12]

Genetic representation is considered the encoding of the solutions as arrays of integers.
The stages of a GA are:
1. Select initial population
2. Determine the fitness of all initial individuals of the population
3. Do
   1. Select the best-ranking individuals to reproduce.
   2. Breed a new generation through crossover and mutation (genetic operations) and give birth to offspring.
   3. Evaluate the individual fitness of the offspring.
   4. Replace the lowest ranked part of population with offspring.
4. While (not terminating condition).

In this paper, we propose a new approach based on genetic algorithm combined with Tabu search technique to get the ability to use the past experiences to improve current decision-making to choose the efficiency paths.
Tabu search is a global heuristic technique which attempts to prevent from falling into local optimum by making a special


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list called Tabu. Every solution has been recently chosen is assigned in a Tabu list that is called "taboo" for a short period of time depending on this list length. This decreases the probability of repeating in the same solution and so that it makes more opportunities for enhancement by moving into the unexplored areas of the search space. In 1997, Glover and Laguna give in their work a comprehensive description of Tabu search technique [13]. In addition, many algorithms based on Tabu Search has been done and gotten much better improvements [14][15][16]. The basic idea of the Tabu search technique is shown in Figure 2.

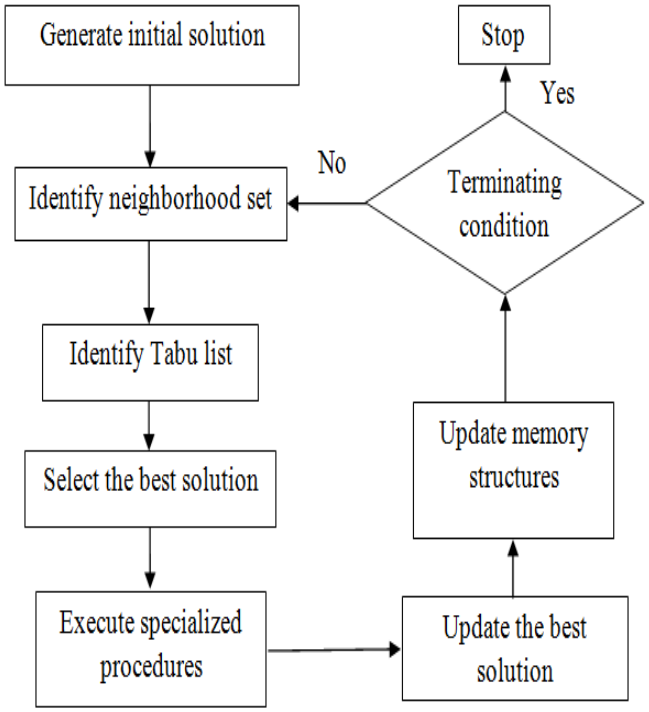


Figure 2. Tabu search technique

## II. PROBLEM STATEMENTS

There are several basic challenges should be solved to provide high quality of multimedia delivery on multi-hop wireless networks.

- It is familiar that the rate of the error bit (BER) of wireless network is much higher than that in the links of the wired line. The shared wireless media and contention from neighbor traffic increase the exacerbation the restrictions of bandwidth and then attend the error of the channel in the multi-hop network. The compressed bit stream is fragile in the face of the loss of the channel while video coder can compress video efficiently such as MPEG and H.26x.

- The congestion in the wireless network is not the only reason for losses of the packet which there are many packet losses come as a consequence of the random channel error that can be measured over multi-hope network [17]. On other hands, routing change/ break that frequently occurred in multi-hop networks is considered another reason of packet losses. These packet losses should be awarded because it is critical to perform correct error control and resource allocation, especially for multimedia streaming applications.

- The need for increasing QoS support mechanisms in multi-hop wireless networks which the standard multi-hope networks- IEEE 802.11- has a serious shortcoming in the environment of a multi-hop because of contention from a neighbor traffics and hidden terminal effects.

-Routing layer, MAC layer, and physical layer together compete for the network resource in a wireless network. For wireless networks, the traditional "layered" protocol stack is not sufficient because of the direct connecting between the physical layer and the upper layers [18].

Multimedia video applications have diverse QoS requirements. The QoS requirements are expressed by the QoS parameters. The QoS parameters are: delay, hop count, Jitter delay, bit rate error, and bandwidth.

Consider a Network *G (N, E)*, where *N* is the set of nodes, and *E* is the set of edges in which each link $(u \rightarrow v) \in E$ that is associated with link weights $wi\ (u \rightarrow v) \geq 0$, for all $i = 1, \ldots l$. Given *l* constraint *Ki*, where $i = 1, \ldots l$, the multiple constraint problem is to find a path p from the source (initial node, *i*) to destination node *t* as shown in Figure 3.

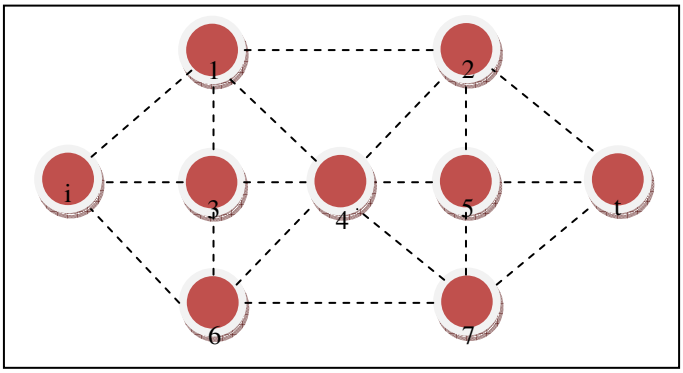


Figure 3. A sample Network

## III. PROPOSED METHOD

The flowchart of the proposed method as shown in Figure 4 represents how to solve the problem by getting a faceable path *p* from source node *i* to destination node *t* such that:

$$w_i(\mathrm{p}) = \sum_{(u \rightarrow v) \in p} (w_i(u \rightarrow v) \leq K_i \text{ for all } i = 1, \ldots, l) \quad \ldots(1)$$

Where,

*Population* - is all available paths.

*Parent Selection*- is a selection strategy that selects two individuals from the population with the lowest fitness value.

*Recombination*- is basically Crossover and Mutation.

*Survivor Selection*- replaces two individuals from the population with the lowest offspring.



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*Termination*- means the termination by time iterations or the condition is achieved.

*Representation and Encoding*- Encoding is one of the problems that are found when GA is used for getting a solution. Encoding depends on the problem that GA is applied. In this paper, the genes are represented by the tree junction, and the network is represented by a tree network [19]. The length of every chromosome is the same using this coding method and the genetic operations are achieved in the tree junction. The encoding procedure represents in Figure 3 as a sample network which node *i* is the source node and t is the destination node.

*Initial Population*- is generated randomly by choosing feasible points in the gene coding that forms a path. Population size refers to the number of chromosomes that identified in one generation. GA has a few probabilities to execute the crossover when there are a few chromosomes which a small part of the search is observed. Moreover, GA will slow down if there are numerous chromosomes. In our proposal, the size of the initial population depends on the number of the outgoing links from the source.

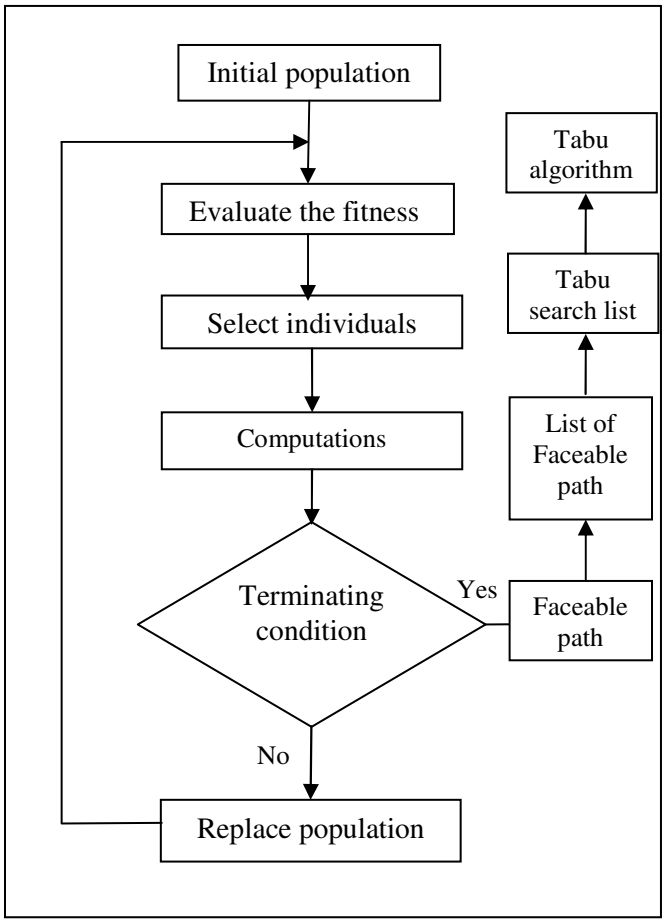


Figure 4. Proposed Algorithm flowchart

*Fitness function Evaluation*- The correlation of fitness value to every solution is accomplished during of a fitness function. The fitness function that is utilized in this paper to find the faceable paths is given in equation 2.

$$F = \max\left(\frac{\sum_{i=1}^{l} w_i(p)}{K_i}\right) \ldots\ldots \qquad (2)$$

Where, $l$ is the total number of constraints presumed, $p$ is the path, $Ki$ is the maximum compatible constraint value identified for the application, and $wi$ is the link weights which is static and depends on the physical proprieties of the link.

The initial population with the fitness value will compute for each chromosome.

*Chromosome Selection*- Chromosomes are chosen from the initial population to be parents. Depending on Darwin's evolution theory, the best Chromosomes should be alive and generate offspring. Many methods are available for selecting the chromosomes such as elitism selection, steady state selection, tournament selection, roulette wheel selection, etc. In this paper, we prefer to use the elitism selection method. Elitism is the method which copies the best chromosomes to new population. The operation of genetic is done by selecting the chromosomes, sorting them depend on the fitness value in the initial population, and then choosing the first two at the top of the list.

*Crossover and Mutation*- are two fundamental factors of GA, which is considered the main performance of GA. These operations will be implemented by encoding that depends on the problem that will be solved by GA [2]. We prefer in this paper to use a single point crossover at the tree junction to generate new offspring. The mutation point chosen is the points that cause the infringement of satisfaction of constraint.

The proposed method is divided into two parts: Preprocessing part and processing part as the following:

**Preprocessing part**: In this part, a short message sends through the faceable (available) paths from the initial point (client) to the target point (server), including the time and the length of a message. A wireless network is connected by multi-hops and routers as shown in Figure 3. Then, genetic algorithm is used to find the available paths to the server that is considered the central point for communications. After that, those paths will store in Tabu list, which determines the efficient paths by Tabu search technique in the processing part.

**Processing part**: The efficient path will be chosen from Tabu list in this part. After receiving the message, the information that is included in the message will be used as attributes and restrictions in the fitness function to decide the efficient path, using the fitness function in equation 2.

## Fitness

We need fitness to select and evaluate the parent and child to know what the best path for the next generation and to exclude the worst one. Fitness function will depend on the count of hops, delay, bandwidth chromosome, and Jitter delay. The most common parameters that used in the fitness function are path number, hop number, delay, Jitter delay, bandwidth, and efficient path, which denoted by *I*, *P*, *C*, *RC*, *dp*, and *lp*,


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respectively. Efficient path value (*lp*) is set 0 if all constraints are achieved, otherwise it is set to 1.

For more efficient, we will give every constraint weight percentage according to the most important constraint. For example, constraint 1, constraint 2, constraint 3, constraint 4 are given 75%, 50%, 25%, and 5% of weight percentage respectively.

Depending on the number of constraints, we can calculate the value F in the next equation:

$F$ = Max (round (Σ (count($P$) + (constraint value *constraint weight)) + (constraint value * constraint weight) – (($dp/I$) * 100))) . .... (3)

The value of $F$ from the equation 3 will be used to select the maximum fitness value as the best solution.

## IV. SUMMARY

The proposed method based on the Genetic Algorithm and Tabu search algorithm. GA is used to find the faceable paths by using equation 1 and equation 2 and get the best path according to the number of constraints that is concentrated on. There are some constraints are more important and better to satisfy than others. By using Tabu algorithm with a given weight percentage for each constraint to evaluate the fitness function (equation 3), we can get the efficient paths with mixed multi constraints.

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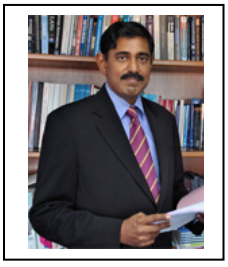

Professor Dr.SureswaranRamadass**:** is a Professor and the Director of the National Advanced IPv6 Centre (NAV6) at Universiti Sains Malaysia. Dr. Sureswaran obtained his BsEE/CE (Magna Cum Laude) and Masters in Electrical and Computer Engineering from the University of Miami in 1987 and 1990 respectively. He obtained his PhD from Universiti Sains Malaysia (USM) in 2000 while serving as a full time faculty in the School of Computer Sciences.

Dr. Sureswaran's recent achievements include being awarded the AnugerahTokoh Negara (National Academic Leader) for Innovation and Commercialization in 2008 by the Minister of Science and Technology. He was also awarded the Malaysian Innovation Award by the Prime Minister in


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2007. Dr. Sureswaran is also the founder and headed the team that successfully took Mlabs Systems Berhad, a high technology video conferencing company to a successful listing on the Malaysian Stock Exchange in 2005. Mlabs is the first, and so far, only university based company to be listed in Malaysia.



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# An Efficient Hybrid Honeypot Framework for Improving Network Security

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***Abstract*–Honeypots provide a system that can lure the attackers and hackers and response to various security frameworks to control the globe and its environment and examine and analysis network activities. We try to employ and develop a honeypot framework to propose a hybrid approach that improves the current security.**

**In this paper, we proposed hybrid honeypots based network assuming initiative and enterprise security scheme strategies. The proposed model has more advantages that can response accurately and swiftly to unknown attacks and lifetime safer for the network security.**

***Keywords-Intrusion Detection System; User Datagram Protocol; Simple Mail Transfer Protocol; De-Militarized Zone; Secure Shell; Secure Sockets Layer; Internet Protocol Security; Network Traffic Monitoring; Network Address Translation; Dynamic Host Configuration Protocol***

## I. INTRODUCTION

A honeypot can be implemented in network security to discover latest assail actions that might not detect by Intrusion Detection Systems or network firewalls conformity with the old static defense rule system. It is important to take into account of the enterprise defense rules to go through the honeypot when IDS (Intrusion Detection Systems) and Firewall are designed.

Computer networks are well vulnerable to different exploit that can make network unsecure or comprise their signify operation. Intruders and attackers have become provoke rapidly on security of networks and their challenges. To have a better and improved security, enterprises, organization and more important finance departments have an essay solution to implement various hardware and software for network security providers such as firewalls, variant of the intrusions detector[18], Virtual Private Networks. However, these solutions act without interruption to depart from proprietary information approachable by deciding intruders, and ensue to warn approaches while new attacks take a place.

## II. BACKGROUND

Since 2001, the prevalence of Internet worms and inoculation serious damage in tens of millions of computers around the world and aimed at damaging the system hundreds of thousands of individuals and organizations was initiated. Code Red worm [2], the prevalence of this type of injury for the first time as the Internet was born and today after the Morris Worm [15] [5], in 1988 that led to the compromised Internet hosts and 360 thousands vulnerable server and deliver the web service attacks and distributed launched on the administration of web servers, various types of worms have born. Blaster worm [25], which was among the very destructive worms, which its incidence could use a service running to millions of personal computers and damage easily put them to work, was another type. Worm Slammer [2], using only UDP (User Datagram Protocol) packets and in only 10 minutes of time could cause pollution to the population, these worms also can use single UDP.

The Witty [3], using a UDP packet for extensive contamination of the infection of the mention. Conceptual basis of their defense and technology projects meant to defend the attacks to not utilizing, in other words, in order to prevent them from attacks already have occurred strategy is used. Defend and attack behavior projects classified with their common feature and extraction of them. We can conduct relevant strategies to prevent to these attacks.

There are various types of intrusion detections with different analyze and the detection concepts even to monitor the network traffic [18]. However, a few have the capability of chasing these intruders by deploying mobile agents as well [17]. Implementation of a solo intrusion detection system cannot perform as a full mechanism attack responder; nevertheless, they are the best immune component to trace the incoming intruders.

Many administrators how are working on security of production systems apply honeypots to research the network action. In 2002 another honeypot classification has been introduced [20], by the level of interaction this classification is conduct on honeypot architecture and the objective which it has to apply for. A complex honeypot can be created to confer the invader entire operating system with which to interact. On the contrary, for detecting any un-ruled activity like port scanning and system explosion a honeypot that merely emulates different services in operation can be designed, and try to gather the fingerprint of invaders.

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## III. ANALYSIS OF PROPOSED MODEL

### A. Low Interaction Honeypots

Low-interaction honeypots in an aggressive expansion are simple but can be less work because of simply detection by intruders, and with certain commands the interaction honeypot emulate can get down. An example of a low-interaction [20], honeypot is honeyd.

Taking the advantages of low interaction honeypot provides limited interaction with invaders to let them emulate with services. The intention of this type of honeypot is to collect data of a first step of assail, and data about the threat's motivation is rarely captured, and it is because of low level of interaction and effectively system compromise.

A virtual honeypot software process requires having an IP address. Multiple virtual honeypots typically use several IP addresses and network interfaces to share a single run. Hence, the virtual honeypot setup on one physical machine as network address translation runs on a firewall or in other ways. Most high-interaction honeypots allow completely compromised the production system while the low-interaction honeypots emulate virtual because of their ability is limited.

Honeyd important work is to provide warnings, which most of them are right and real attack alert. By default, honeyds can detect any activity on any User Datagram Protocol (UDP) port or Transmission Control Protocol (TCP), and also writes some of the activities in ICMP (Internet Control Message Protocol). Besides, they can deceive the attacker through its ability to simulate factors that are used. The system response packets are suitable for fingerprinting, which by implementing a tool like Nmap that can point to run scan network packets. A honeyd's attacker also interacts with services, such as Telnet, FTP, HTTP, POP3, SMTP (Simple Mail Transfer Protocol) server named. Moreover, they can have backdoors for viruses, including the viruses that can be pointed Kuang2 and Mydoom likes.

### B. High Interaction Honeypots

In this paper, we deploy honeynet with developing the variety of tools to support our research for deploying and examining suspicious network traffic. In our particular design, we provide a web interface to monitor the information gathering and also in backend a firewall to control outgoing connection from potentially comprised honeypot. Implementing a high interaction honeypot host is a cost effective procedure which mostly in mid range scale organization, they used virtual environment to approach the advantage of easier to monitor and safe and clean successful compromise. Various virtual machine solutions to this environment are virtual PC [22], virtual box [23], XEN [19], VM ware [24], user mode Linux [9].

In approach to have high interaction honeypot to grant a real network information gathering and facing different scans, buffer over flows and various analyses, we associate with a few real machines to support our production server and collaboration with low interaction honeypot zone to reach the bases and real experiment result.

Many recent research studies to explore the deployment of honeypots to enhance network security has been done, and it could be named between [4] [10] [11] [12] [13] [21] [26] [28] [29]. In Weiler proposed [26], honeypots are assigned as a shield in the network, whereby all incoming traffic that is imported directed to them. After that about disconnection of that connection or legally allowed to connect is given. This solution may not work as an ideal, because honeypots employ to attract attackers and being destroyed and not as prevent or defense mechanism to serve. Teo [21], give another solution framework called Japonica, which has presented the main target of early and rapid response to unknown attacks through dynamic orchestration in detection, prevention, and reaction mechanisms to particular attacks. However, always wrong false alarm probability is a very important issue and until the person directly and professionally tries to access production services instead of Honeypots attack.

To conclude these methods we can mention that many of the above proposed used honeypot as a defense mechanism to block the attacker from attacking the network. In this paper, that provided the hybrid honeypot proposed architecture with having of both low-interaction and high-interaction honeypots and provide a framework to not blocking or defensive system but be as interactive and a lure design with minimization of the traditional mistakes.

### C. Hybrid Honeypots

The call for assembled details assailed processes on number of IP domiciles urged researcher of this topic and network security providers to pursue more intelligent and scalable architectures. These research guides into the large scale category architecture which called hybrid honeypot architecture.

## IV. APPROACHED MODEL

### A. Worms Activity

In a network view, a worm can be a software or program that due to run on a honeypot can intention other honeypots to modify administration sufficiently which they start to make a link and generate connection or pair connection requests. This delimitation helps to have a method to distinguish and infection, which takes place non self distributing network action from self spreading, that take system down and configure by its particular code. However, it doesn't intention to automatically continue the method. Almost all types of worms have their own executable codes, which indicate that the captured worms have multiple links and had system buffer overflow or password generation from their viable. Even though most of these viable or executables have a nickname which is contributed mostly directly with them, and because they are available as files by the worms initial utilize. The following Table I. give us the various worm's model and shown the number of captured on our particular network.

The proposed work offers the best architecture that most focus on the decoy the best lure architecture which absorbed by internal network attacks through the hybrid honeypot which able to capture and record all the incoming and existing data and provide us the data


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control. In proposed honeynet captures all the activities and operations of intruders, and send them to the log for the further application.

### B. Data Analyzing Module

Data analyzing module does analysis of the collected data from original data. The honeynet record data through internal honeypots and forward them for analyzing. In this between also we are using an appropriate firewall which to get more information about captured data, furthermore we direct the firewall logs to our analyzer.

In the proposed architecture, the use, a firewall module to work as a logger to capture all the traffic and their situation in our back end design, which provide the accessibility of our production systems.

### C. Honeynet Activity

As previously mentioned, the honeynet has two main activities, which are information control and information seizure or data recording. The primary idea of information control is to foreclose invaders abusing the honeynet feature to direct them to access the other host. Information seizure is to capture all the functionality of invaders. It is arduous to gather information as still as imaginable, nevertheless, not to be recognize by intruders.

Most of the invaders try to spread out to encipher channels like SSL (Secure Sockets Layer), IPSec, SSH (Secure Shell) and other related channel. In such activities, the encryption must be accomplished with a particular account by the data collector mechanism. In addition to this matter, we employ seizer tools with this similar functionality on the honeypot to reach a multi record level way of recording [1]. In this way not only may connect the various intruders' activity steps together, on the contrary, as well can keep the way from the default of a single mechanism.

Logs, the information which recorded and system activity recorded by tools in honeypot are transfer to analyzing module. The information is saved as obtain information consistent with the feature of network connection and its contents. The recorded information by honeynet has less amount size, on the contrary, with more fidelity and fatal.

By taking the beneficent of virtual technology, which also use in honeynet, we have the ability to set up the virtual honeypot [14], on a host. This plan helps to deduct and minimize the cost development of the honeynet. Nevertheless, the performance needed to deploy of a host is still higher.

### D. De-Militarized Zone

De-Militarized Zone (DMZ) is not network hardware device affection a router or a bridge [8], so it does not pass through altered packets. De-Militarized-Zone is designed to provide secure communication with servers before packets entering to a firewall without needing any inbound firewall gapes between the internal LAN or network and the deployed DMZ.

The policy establishes facts security needs for networks and the machines and peripherals employed within the DMZ. The traditional De-Militarized-Zones admit machines which located behind the firewall to comment's requests outgoing to the DMZ. Machines in DMZ reply, try to forward or reissue queries outside the internet or public network.

Many DMZ employs in the event to utilize a server (such as proxy server) or other servers as the machines deployed within the DMZ. The deployed firewall in after trying to prevent the machines situated in DMZ from initiating inbound requests. For the DMZ configuration, most of the machines conducted on the internal network or in a typical LAN run behind the firewall which through that they are able to connect to an external network or the internet. To deploying the secure zone a few machines or servers as well employed outside the firewall in the DMZ, those machines on the external part intercept traffic and agent queries for other parts of network, and they provide an extra layer of protection for the behind firewall zone machines.

A DMZ most often includes servers which provide various services to the clients from the internet. These services are included FTP, for e-mail services, SMTP, IMAP4 and POP3, and also DNS server. Even though these servers must be direct to limited access from the internet, and besides, they could protect the firewall as well. Here we indicate that the servers and honeypots reside could be the DMZ or inside the network, however DMZ is suggested. The best structure we are looking for that has been shown in Fig. 1.

### E. Proposed Hybrid Honeypot Framework

The proposed advance introduces a pliable honeypot based network security system that adopted to alter, in particular, organizational, financial and important conducted server zone network based on the energetic dynamic implementation and configuration of hybrid honeypots.

The primary concept is for the low interaction honeypots is to conduct using free ready unused IP addresses which available through operating systems or distributed ones and their services. They imitate simulation of the distributed operating systems and their services of the deployed production hosts in a particular network. In the mass of cases the going network traffic to honeyds will be directed to high interaction honeypot where attackers face with certain services. The deployment of the half-breed or hybrid in order approach the technology of honeypot in two main categorizes:

Employing minimum administrative interferes on account of the number of honeyds and their particular service setups automatically based on the authority of the network. Focusing on the needed of the honeynets or high interaction honeypots in the network by the redirection of traffic scenario from the low interaction honeypot shows the affection of honyds as real systems to attackers.

### F. Proposed Honeynet

By the availability of fake machines in the network, firstly, the system administrator requires assigning the IP addresses of the physical honeypot or essential host in the honeynet, then authorized traffic redirection from low interaction honeypots and log the activities of attackers. The locution redirection does not intend to simply change communication direction from different machines. However, rather, it pertained reformatting the entering


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network packets predetermine to a particular honeyd and returning them back on the network. By deploying this way they have the ability to discover their means to the real honeypot. Afterwards, replies to the interloper and next gives the delusion to him which invader is engaging with a certain real machine.

We try to show an example of typical Local Area Network conduct for our approach to a hybrid honeypot. Fig. 1 illustrates the deployment and shows the position. This figure illustrates a low interaction honeypot server which is directly connected to the main switch, and it is with other production systems. It is as well showing the physical honeypot in the architecture honeynet which are ready to receive network direct traffic or redirected coming through low interaction honeypot. As it has been shown in the architecture, the low interaction honeypots machines are seemed like a physical or production system but in actual purpose they are just born as virtual machines in advanced.

In our architecture, we may use Network Address Translation (NAT). This employ aim to not requiring of reconfiguring each honeypot to be dynamically in internal domicile for external domiciles, which come through NTM (Network Traffic Monitoring). Accordingly, we should mention by setting up the honeypot to support dynamic address reconfiguration, we can skip this part also.

The low interaction honeypot server which has been illustrating in this figure, which has three main functionalities, that imply in different threads. The first honeyd server interfaces network scanning application to gain information near by the various available operating systems in the network, their particular direct or administer ports and their running services and finally collect and save these data in the file. The next thread receives the above mentioned data from the file and adjusts the require configuration of low interaction honeypots. Hence, it includes the operating system, their services, and port and network assistance distribution in the real network part. The last thread analyzes the low interaction honeypot log traffic data and save it in a particular file. Furthermore, the servers wait for arriving traffic, which going to unused IP addresses and finally presume to identity those IPs while invaders are engaged.

To construct the proposed system which is shown in Fig. 1, a programming language, network scanning tools, and operating system need to be chosen. Even though the approach architecture framework in general advanced and is not limited to a particular preference. The operating system which has been selected for the honeyd server needed to conduct open source due to the suppleness it availability to deploy the security application. For this purpose, we conducted Linux Fedora 12.0 version that has the require feasibility due to our framework. For the programming language, the functionality for the network library availability language and its skill of simply integrating Fedora tools was needed. For such cases, we select Python language, which gives us the needed library of avail networking.

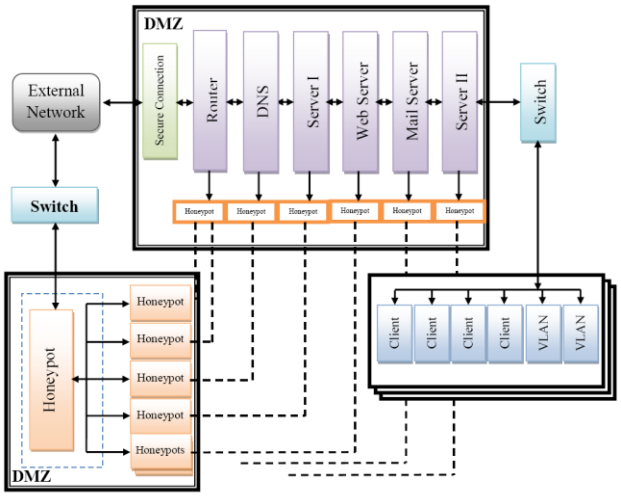


Figure 1. Hybrid honeypot architecture.

In the next step, a network scanning tool needed to resolve the sort of operating system conducted in the network and the various ports in the production network and provide such required information.

The Nmap for a particular purpose was chosen to be a part of our experiment. This network tool can be conducted in two dissimilar active modes to gather data about various available distributed operating systems as well as conduct ports and assumed operating services of them in the network. These two folded are, normal mode that this tool gathered the information in the precise time. In this mode Nmap tries by parallelizing the port scans, even though information can be collected in minimum time in this case, on the contrary, the server might be overloaded with input or output information, and the network traffic might expand accordingly. The second mode of Nmap tool is the polite mode that gathers the information with time consuming. In this mode, the tool serializing port scans with hesitating among sequential scans. This case is applicable to the machine and the network amicable at time consumption and taking an extensive time to finish the scans. Even so, we will have an accurate scan over the network.

As you can see in Fig. 2, the process of Nmap scans is sending a ping to establish all the devices on the network and gather their IP addresses but not permanently in a particular file. This file may be used to next scan which will be operating system or port scans for given located IP addresses. The out coming of the scans logged into the particular file which generally now a day using the property of XML file that is analyzed every time until scan is finalized. Once the tool scans finished and stopped, an analyzer is starting and conduct in a thread to extract the collected data from the file which automatically build a profile to store these data.

### *G. Deployment of Honeyds*

The elementary opinions to propose the hybrid honeypot is to create employ of unused IP addresses, nevertheless, there is a task which helps to solve how to separate them amid the running operating system and accordingly minimize the likelihood of revealing the real and production host in the network and let them to be


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attacked by intruders. A straight forward advance was deployed according to taking near to be a constant continuation after including the virtual systems to the production system by distribution of the operating system, and it should be while extinguish the physical honeypots.

## V. EVALUATION AND EXPERIMENTS

### A. Redirection

In our architecture, we try to take the beneficiary of redirection load. By refering to redirection tasks; the method begins by retrieving the IP addresses which are redirecting from the file data, which is based on ports number and operating system employed by the honeyds. Each product honeypot is adjusted with a supreme number of potential configurable connections which is situated at deciding the maximum limit number of honeyds which able to redirect. Afterwards, the honeyds ports and productive honeypots which have the access for redirection to assign connections are compared. However, the number of honeypot applicable to give the productive honeypot system which runs the operating system is upon to the limitation connection number which may be handled by the system.

For example, in redirection of a TCP port number 139 of the low interaction honeypot which refers to IP domicile 172.16.16.7 to the productive honeypot and to the same port as well that the physical honeypot is working with IP domicile 172.16.16.77 there will be requiring to use set command and release that by the honeyd to emulate hosts and guide traffic to a certain productive honeypot.

*set Comp172.16.16.7 port 139 tcp proxy:172.16.16.77:139*

Additionally, the conductive traffic network, monitors and loges the honeynet traffics, lastly in the sort kind. The specified imitation of the system abilities shows actively while the system's skill to redirect network traffic and log the information and conceder for relative warning. The distinguished property of the propose architecture is, it's competent to divert the vindictive traffic from the production host. It is considerable which the protection ranking is depended upon the availability of free IP domicile and also honeyds. However, this protection extremely increases as operate of unused IP domicile and therefore, can much have the influence to deduct the deficient against to the production systems.

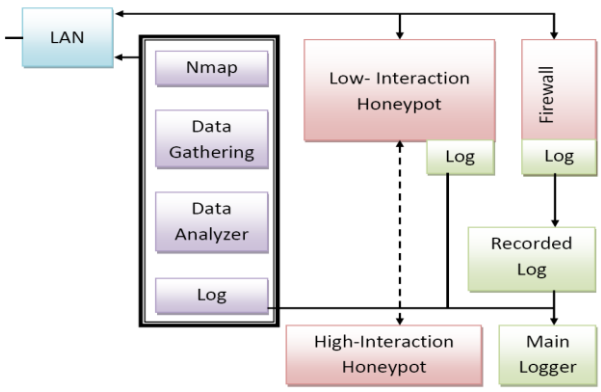


Figure 2. Functionality of Low and High Interaction Honeypots.

Let us here to clarify the ability of redirection to another honeypot, which means by, we are able to directly fined a worm's self disseminate activity which in a first touch the advance new target honeypot conducted the activity of the network. Nevertheless, there are the number of malicious, which are infecting in several level of the vulnerable process which the first infection neglect to fully setup, so in this case, they will fail to indicate their self broadcasting ability, and if we don't admit some explorative out going connection. Since any honeypot, we may detect later to pass on the connection which would not have any information of the exact serial numbers, that cannot provide the proxy for the unset of the connection.

In the proposed architecture that tryed to take the beneficiary of redirection load. By refering to redirection tasks; the method begins by retrieving the IP addresses which are redirecting from the file data, which is based on ports number and operating system employed by the honeyds. Each product honeypot is adjusted with a supreme number of potential configurable connections which is situated at decide the maximum limit number of honeyds which able to redirect.

Afterwards, the honeyds ports and productive honeypots which have the access for redirection to assign connections are compared. However, the number of honeypot applicable to give a productive honeypot system which runs the operating system is upon to the limitation connection number which may be handled by the system.

In another condition, the destination request is addressing of Dynamic Host Configuration Protocol (DHCP), in such cases the request diverted it to the DNS honeypot or either DHCP. As earlier we have mentioned always in case of availability of a new born honeypot we send the outgoing request to them, but we should consider that in this level for detecting self issuing behavior is important and saturation or either capacity of employed honeypot is considerable.

In other cases the outgoing request always should deny, and the established should drop. By implementing these conditions, we faced several apartness activities: A vulnerable activity was detected by observing the checked logs of the honeyds. The hacker used an initiate address of 172.16.16.105 that was known to us, and it was one of our systems, which was not used and under task at the time, so that IP address was spoofed and implement to cover the origin.

### B. Free IP

When the network scans tool initiate on the network, server provides data regarding the network IP addresses and deployed operating systems. As Fig. 3 shows the distributed of IP domicile between the unused IP domicile and production systems, this figure advocates that the network is capable of an epochal number of virtual systems to conduct.


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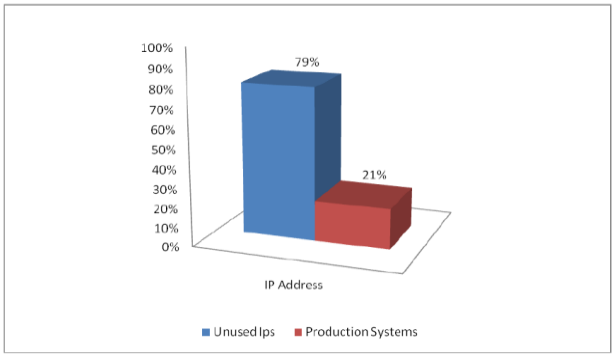


Figure 3. The distributed of IP domicile between the unused IP domicile and production systems.

### C. Protection of Free IP

By considering the free IP domiciles on the network, it means that by undertaking rare free IP addresses the system can be much protected to the production system. For this case, there is a condition that if the number of IP domiciles is equal to production host, the likelihood of an invader aggress a production host is minimum 50% if no hybrid honeypot conducted there.

### D. Nmap

The Nmap tool is to impact on the network for the idea of conducting a tool on a particular network to measure and garnering component of the system [27]. The measuring of Nmap is conducted how; in the first step, it is starting the scanning through the normal option which on the various operating systems it may take different time consumption. As we have tested in windows XP SP2 in our testing machine, we got the average of 3 to 4 seconds which in the conducted Linux Fedora we got the result of 49 seconds.

In the first normal testing, multiple threads run to get the information of aggregate ports in the same time. Here we should mention that the analysis and evaluation of the machine to machine are varied, and it depends on the communication situation over the network and the status of traffic and system position, which some times in case of an amount of entering in traffic tools need to re-communicate with that particular system.

To shun extravagant output or input traffic and for reducing the time consumption and scanning the network the scans were divided into the parallel run until every establish get executes. Consequently, the system tries to the next step which starts measuring with the polite mode. In the polite mode as earlier we discussed, the tool conducted serialized the independent port under scan for every IP domicile. Here, two cases are come out for the measuring of the time which are time consumption for each port and retard between finalizing a scan and starting the next one.

In the polite mode, the time consumption is so high and evens the retard between scans also is approximately near to 480 milliseconds, so our honeypot system and over the network, we face the overhead. To give the solution for this particular case it needs to allot the various IP domicile to aggregate threads so the system is able to get run different IP scans by the aim of parallel perform. So conducting the scan in polite mode let the system consumption much less time in average. In comparing to windows based machine Linux based system have the more average respectively.

### E. Experiment Conditions

In our experiment work, different policy in order can be implementing and conditionally used, such as:

If an outgoing request to the remote area transcends, prepared honeypot has the limitation, and it will be dropped. This feature of general safety harness which is independent of complement safety.

If an outbound DNS request source is from the Domain Name Service or DHCP servers which had the honeypot, it may give the permission to connect. We set our honeypots address of DNS or DHCP server which auto configured itself and runs. We permit a node to communicate to DNS requests outbound.

If an outgoing request is for DNS and the source is the standard or normal honeypot request, divert it to the DNS honeypot or DHCP and In addition, a request like this is questionable, since they must first send through DNS honeypot or DHCP considering how to configure them.

If there is an outgoing service from a source honeypot which has not penetrated, this request should be abounded. Here, another condition is if a honeypot try to make an activity like be updates automatically, we simply prevent this activity. This causes as our network accuracy behavior of the honeypot.

If the requests for out-bounding direct the address of origin that can initial a honeypot, the request is passed on. In such a condition usually let communication initiate to the origin of the attack to permit it multilevel vulnerable and interfere to the honeypot, so this type is always validated.

### F. Logs Assessment

The logs which collected by honeyd provided a glance of possible attacks after revealing un implement connections IPs were being made as a consequence of a random scan. It has been revealed that the vulnerable tried by employing Nmap. It has been discovered that a system with the IP of 172.16.16.225 tried to connect to a honeyd with different IP, which was 172.16.16.123 and through the ports 135, 139, and 445. For this case, the network administrator warns that, and we consequently discovered that the origin system was a system which infected by the Natche virus to make this type of interconnection.

The analyzing after around two weeks on different traffics on the network has stored during honeypots operation. We discover a large activity in the background. Fig. 4 and Fig. 5 highlight the TCP, UDP, FTP and other port scans per day which recorded and provided by NTM. The total IP observation of the conducted machines before employing any honeypot has shown in Fig. 4.

To prior conduction of our security architecture, the wide ranges of IP scan happened on the various machines which mean by any port scans through any internal or external IP scanner simply can get placed. Let is here look into to post implementation of our proposal model. As


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Fig. 5 shown, in case of port and IP address activity of the machines, we have much less activity of port auditing.

The success of proposed architecture in best recorded case shows less than 6 ports auditing in total which in a same day we had around 24 activities. In worth case of conduction, the Fig. 5 shows, the 96 ports activity which on the same day report in Fig. 4 we have 488 ports scanning.

TABLE I. CAPTURED WORMS/TROJANS/INTRUDERS ACTIVITY WITH A FEW SYSTEMATIC REPORTS BY OUR PROPOSED ARCHITECTURE WHILE THE NAMES EXTRACT FROM PANDA ANTIVIRUS

| Name | Worm Name | Size | Port | Connections | Alias |
|---|---|---|---|---|---|
| Conficker.C | W32/Conficker.C.worm | 167,765 | | 10 | W32.Downadup |
| Blaster | W32/Blaster | 6,176 | TCP 135 | 5 | WORM_MSBLAST |
| Gaobot.BKE | W32/Gaobot.BKE.worm | 6,176 | TCP 135 | 3 | |
| Sasser.E | W32/Sasser.E.worm | 15,872 | TCP 445, ICMP | 4 | WORM_SASSER.E |
| P2PShared.AV | W32/P2PShared.AV.worm | 643,072 | Email | 7 | P2PShared.AV |
| Bobax.D | W32/Bobax.D.worm | 19,456 | TCP 5000 | 2 | Bobax.D |
| Piggi.B | W32/Piggi.B.worm | 73,216 | | 1 | Piggi |
| IRCBot.CNK | W32/IRCBot.CNK.worm | 75,188 | 445 | 3 | IRCBot.CNK |
| Sasser.B | W32/Sasser.B.worm | 15,872 | TCP 9996 | 4 | W32/Sasser.worm.b |
| Xorer.O | W32/Xorer.O.worm | 95,744 | | 3 | AUTORUN.INF |
| Blaster | W32/Blaster | 6,176 | UDP 69 | 4 | W32/Lovsan.worm |
| Yahmail.A | Trj/Yahmail.A | 213,093 | | 3 | Infostealer.Yahmali |
| Lina.D | Trj/Lina.D | 102,400 | FTP, IRC | 3 | .doc |
| Sdbot.ftp | W32/Sdbot.ftp.worm | | FTP | 5 | Sdbot |
| Conficker.C | W32/Conficker.C.worm | 167,765 | | 4 | WORM_DOWNAD.AD |
| Sdbot.COP | W32/Sdbot.COP.worm | | FTP | 6 | |
| IrcBot.AIV | W32/IrcBot.AIV.worm | 91,132 | FTP | 1 | IrcBot.AIV |
| Nugache.A | W32/Nugache.A.worm | 177,152 | TCP 8 | 2 | MSTC |
| Nugache.A | W32/Nugache.A.worm | 177,152 | TCP 8, 207 | 3 | MSTC.EXE |
| Nugache.A | W32/Nugache.A.worm | 177,152 | TCP 157 | 3 | MSTC.EXE |
| Chasnah.A | W32/Chasnah.A.worm | 77,824 | | 4 | Chasnah.A |
| Blaster | W32/Blaster | 6,176 | TCP 4444 | 5 | WORM_MSBLAST.H |
| Sasser.A | W32/Sasser.A.worm | 15,872 | TCP 5554 | 2 | W32.Sasser.Worm |
| MakeSnake.A | W32/MakeSnake.A.worm | 390,656 | FTP | 4 | MakeSnake.A |
| Radulambu.C | Radulambu.C | 131,072 | | 3 | Local Security, DoS |
| MS09-059 | MS09-059 | | | 2 | Local Security, DoS |
| Bobax.D | W32/Bobax.D.worm | 19,456 | TCP 445,135 | 4 | Send Spam, LSASS |
| Lovgate.C | W32/Lovgate.C | 78.848 | TCP 10168 | 5 | Lovgate.C |
| P2PShared.AV | W32/P2PShared.AV.worm | 643,072 | UAC | 2 | P2PShared.AV |
| Mofei.G | W32/Mofei.G.worm | 33,169 | | 5 | W32.Femot.Worm |
| Poxdar.A | W32/Poxdar.A.worm | 18,432 | FTP | 2 | Poxdar |
| Spybot.AKB | W32/Spybot.AKB.worm | 419,328 | | 3 | Spybot.AKB |
| Mofei.G | W32/Mofei.G.worm | 70,604 | FTP | 4 | Worm.Win32.Mofeir |
| Femot | W32.Femot.Worm | 40,504 | | 3 | Femot |
| WinVNC.A | Bck/WinVNC.A | 2,539,520 | | 3 | WinVNC.A |
| Malicious URL | Malicious URL | | | 4 | URL |

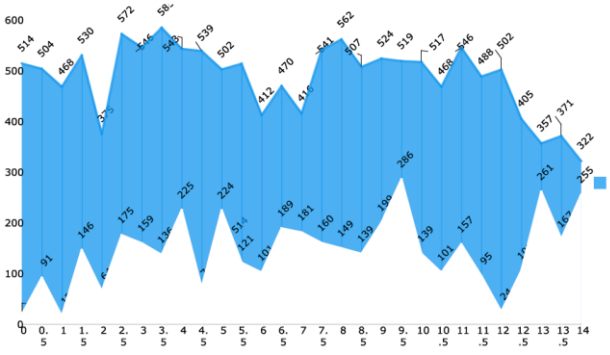

Figure 4. Various IP ports scans activity, before implementation of our proposed architecture.

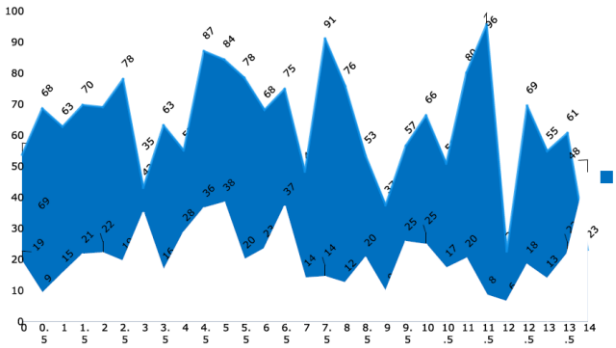

Figure 5. Various IP ports scans activity, after implementation of our proposed architecture.

As engaging a hacker takes time, and as we have mentioned before, in such conditions the system needs to restart the honeypot and a new born after this process, the honeypot is always filled up. Checking the number of honeypots needed in unemployed of further filtering, we try to do trace to analysis using different meaning of honeypot cycles. So as the life cycle contents of the attack engagement time additionally the restart time as well. We have the different life cycle between seven seconds and up to approximately four minutes, and here we should add that virtual machine's conductor has different performance to recreate and on some may take only a few seconds [16] (while to restart the machine totally, may consume a full minute).

Here to clarifying the Table I. and to identify the different worms which infected, we imported the executables malicious toward a virtual machine on which we previously conduct Panda Antivirus [7] and while identifying of all is really incomplete perform because some names reveal like unknown one, and since we don't have good access to a large worm database we brought and mention those unidentified completeness names as well.

Our recorded is not only for buffer-overflow worms but also is included the weakness of passwords as well. Almost the worm attacks needed multiple connections/interconnection to complete their loop and make a life-cycle , for example, as our system recorded, we discovered 72 for BAT.Boohoo.Worm , which listed in the table and tried to make a data transmission channel differentiating it from the connection/ interconnection to send the executable worms to infect the system. This case and its behavior shows the debilitated of employing techniques to filter known attacks from running system background. Nevertheless, in same condition we have discovered a large number of known worms and exploit which after their first activity in our lure machine got unveiled.

Table I. also notes us minimum detection time for each of these worms. For this purpose, our measurement detection time is as between the time which the system received the initial scanned packet at the honeypot, to when next honeypot get infected and redirect and try to create an outgoing connection attempt, can be a proof for that we have recorded codes of self broadcastings.

This Detection consumes time is reckoned assuming of various factors, which could be the delay of final host



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response, stability of network, execution time for each worm within the honeypot, and availability of honeypot which the consumption time calculation is not a matter of this paper.

## VI. SCALABILITY AND FUNCTIONALITY

High integrity: Design and the proposed system should be a fully functional and accurate server for known vulnerabilities and new attack is diagnosed.

Scalability: The system should be able at least possible to analyze the actual scanning probe and pay a lot of URLs.

Isolation: The network communication system must separately establish each honeypot. Precise control: The system must somehow be designed to host a possible external attack honeypots exist.

Wide coverage: The system must be able to honeypots settings with a variety of models and operating systems to implement their services.

This structure allows us those honeypot systems to remain independent. This feature is desirable to cover the area and prevent the honeypot discovered by attackers and to ensure visibility to a wide range of the Internet addresses space, as in previous work exploring major changes in different places can be seen the network is shown [6].

Due to architecture scalability, the system can be spread out via including physical machines (Production machines), production honeypots and honeyds that can prepare a stronger protection and security level, which carried out by decreasing the likelihood of vulnerability to production systems. Another matter which could be considered is our architecture structural.

Our proposed system will consider deploying in various subnets in order for serious and greater protection of all the subnets. Now we have the resetting terms that the scans permit the system to reconfigure the different distributed operating systems and their different services that the honeyds imitate to demonstrate the contemporary merge in the production network.

So, we have the advantage of this architecture that it does not require to moderate, this is due to be the ability to discovering immoderate activities of network, the compression between various security defense models and our proposed model is shown in Table II. Another issuing, which previously also mentioned is loading balancing of the current architecture, and it will be getting done our proposed redirection ability. The physical (production) honeypots receive redirections coming from the honeyds which is based on the operating system, and they try to run and give the distribution operating system between the honeyds moderate which in the production network, it is anticipated that the honeypots will be loaded by considering and assuming the distribution of the operating systems in the particular network.

TABLE II. COMPARISSION OF VARIOUS SECURITY DEFENSE FRAMEWORKS

| | Normal Firewall | Firewall and Anti-virus | Firewall Integrated IDS | Honeypot plus Firewall |
|---|---|---|---|---|
| **Fast Response** | Normal | High | Low | Normal |
| **Performance** | Low | Low | Normal | High |
| **Difficulty in Implementation** | Low | Low | Normal | High |
| **False Alarm** | Normal | Normal | High | Low |
| **Discover Unknown Thread** | Low | Low | Normal | High |
| **Internal Security** | Normal | Normal | Normal | High |
| **High Integrity** | Low | Low | Normal | High |
| **Scalability** | Normal | Normal | Normal | High |
| **Isolation** | Low | Low | Low | High |
| **Wide Coverage** | Low | Low | Normal | High |

## VII. CONCLUSIONS

The proposed hybrid honeypot architecture system provides a partial protection to the production systems. It fulfills this by decreasing the likelihood of activity of the hacker and is targeting our production systems by employing the lure systems in the network which the hacker cannot come to know about these systems, their status and his fingerprint and consider the fake system as real systems. This cannot complete our goal without employing the redirection capability, and the production system will remain vulnerable to attack for direct assail that do not pass through the conducted honeypot system.

In the proposed design, the production honeypots can play only as a passive duty in which they only can log different activities of the attackers, so the system administrator can extract and analyzed them due to data mining. This could play a more active role by analyzing the attacker's activities and decreasing the different attack's type by use of signatures file or a signature database which has the capability of the development and mine the data. As we have shown, the honeypots will be an ability of adding and releasing the warnings, and they can send notice to the administrator, the intruder type and various feasible suggestions to block the attack propagation.

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# Optimization of ACC using Soft Computing Technique

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*Abstract*— **The important feature of the Adaptive Cruise Control (ACC) system is the ability to maintain a proper inter-vehicle gap based on the speed of leading vehicle and the desired distance. Adaptive Cruise Control operates in two modes (i) Velocity Control mode, (ii) Distance Control mode. ACC acts like a conventional Cruise Controller (CC) under velocity control mode. In the case of the distance control mode, the speed of the host vehicle is reduced according to the surrounding environment to maintain the safe distance between the leading vehicle and the host vehicle. 25 rules have been used in Fuzzy logic Controller (FLC) with the knowledge base of the system. The inputs of the FLC are distance error and the speed error. The host vehicle adapts to the lead vehicle speed changes and tries to maintain a proper distance between them. The performance of the FLC based ACC is improved by Genetic Algorithm to tune the fuzzy rule base. Genetic Programming is used to select the best rule out of the 25 for a corresponding input. The result showed a better improvement over the Fuzzy Controlled System.**

***Keywords - Adaptive Cruise Control; Genetic Algorithm; Fuzzy Logic Control***

## I. INTRODUCTION

Researches on Intelligent Vehicle (IV) Systems have been devoted to solve problem such as driver burden reduction, accident prevention, traffic flow smoothing. Mentally, driving is a highly demanding activity - a driver must maintain a high level of concentration for long periods and be ready to react within a split second to changing situations. In particular, drivers must constantly assess the distance and relative speed of vehicles in front and adjust their own speed accordingly. A Cruise Control (CC) system has been developed to assist the driver for driving in long distance on highway when there is no vehicle present before the host vehicle. Adaptive Cruise Control (ACC) supports the driver in longitudinal control of vehicles by operating in two modes of control, (i.e.,) Velocity Control mode and Distance Control mode. In Velocity Control mode ACC maintains the vehicle's preset velocity set by the driver. The stability of the ACC system is disturbed when a lead vehicle or an obstacle is present in the way of the vehicle fitted with ACC. Such a drawback is rectified by switching over to Distance Control. In this mode ACC automatically adjusts the host vehicle velocity in order to maintain a safe distance between the two vehicles. These systems are characterized by a moderately low level of throttle and brake authority. The limitation of conventional ACC systems is that they do not manage speeds under 30 km/h and, consequently, are not useful in traffic jams or urban driving, situation. At congested traffic, the ACC system becomes less useful. Now, ACC systems are made capable of maintaining controlled vehicle's position relative to the leading vehicle even in congested traffic by using stop and go features while maintaining a safe distance between leading and following vehicles autonomously. The conventional CC system operates only in one mode of control i.e., velocity control mode, on the other hand, ACC has two both velocity and distance control modes. In this paper the different inter vehicle distances and speed levels have been considered. Simulation results obtained from ACC system using Fuzzy Logic Controller (FLC) and genetically tuned FLC have been compared to validate the objective of this paper.

## II. FLC BASED ACC

Fuzzy Logic Controller is designed on the basis of fuzzy logic, which does not require any mathematical models but mainly depends on the experience. Fuzziness describes event ambiguity. It measures the degree to which an event occurs, not whether it occurs. Fuzzy theory is a powerful tool in the exploration of complex problems because of its ability to determine outputs for a given set of inputs without using a conventional, mathematical model. Fuzzy theory becomes easily understood because it can be made to resemble a high level language instead of a mathematical language. To


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describe a universe of discourse, fuzzy sets with names such as “hot” and “cold” are used to create a membership function. By determining the degree of membership of an input in the fuzzy sets of this membership function, the role of membership functions play in decoding the linguistic terminology to the values a computer can use [7]. Fuzzy Logic controller is represented by a set of rules represented in the form of if-then rules [3]. The fuzzy rule consists of antecedent and consequent. Antecedent is a condition in its application domain and consequent is a control action for the system under control. The fuzzy inference engine employs the fuzzy knowledge base to simulate human decision making and infer fuzzy control actions. Finally, the defuzzifier module is used to translate the processed fuzzy data into the crisp data suited to real world applications [4].

### *A. Frame work of the Fuzzy Logic Controller*

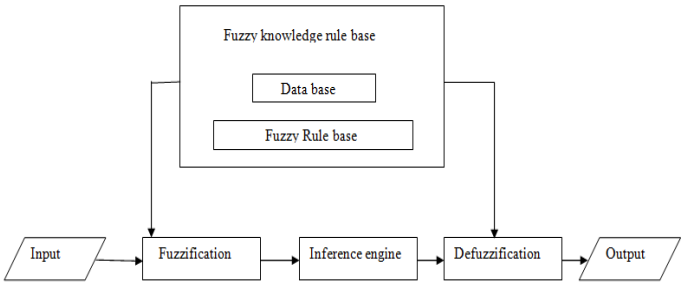


Figure. 1. Framework of Fuzzy Logic Controller

Fuzzify the inputs according to the input membership Functions. The rule strength is found out by combining the fuzzified inputs according to the Fuzzy rules. The consequence of the rule is found out by combining the rule strength and the output membership function. The Fuzzified output has to defuzzified to convert the Fuzzified value to a crisp value. Defuzzifying method is the weighted average of all rule outputs[8].

### *B. Inputs of the Fuzzy logic controller*

Two input and a single output Fuzzy logic controller is used. The inputs of the Fuzzy Logic Controller are distance error (Xerror) and the speed error (Serror). The distance error (1) is the difference between the actual distance (Inter-vehicle Distance, Xactual) and the desired distance (Xdesired). Three different distance levels are considered for simulation purpose which is shown in Fig.2. (Fig 2 (a) – distance varies from 7 to 13.3m, Fig 2 (b) – distance varies from 5 to 6m, Fig 2 (c) – distance varies from 2 to 4.4m) The actual distance can be measured using an ultrasonic sensor. The desired distance is the distance which required to be maintained between the vehicles to avoid the rear end collision. Desired distance changes in direct proportion to the vehicle speed.

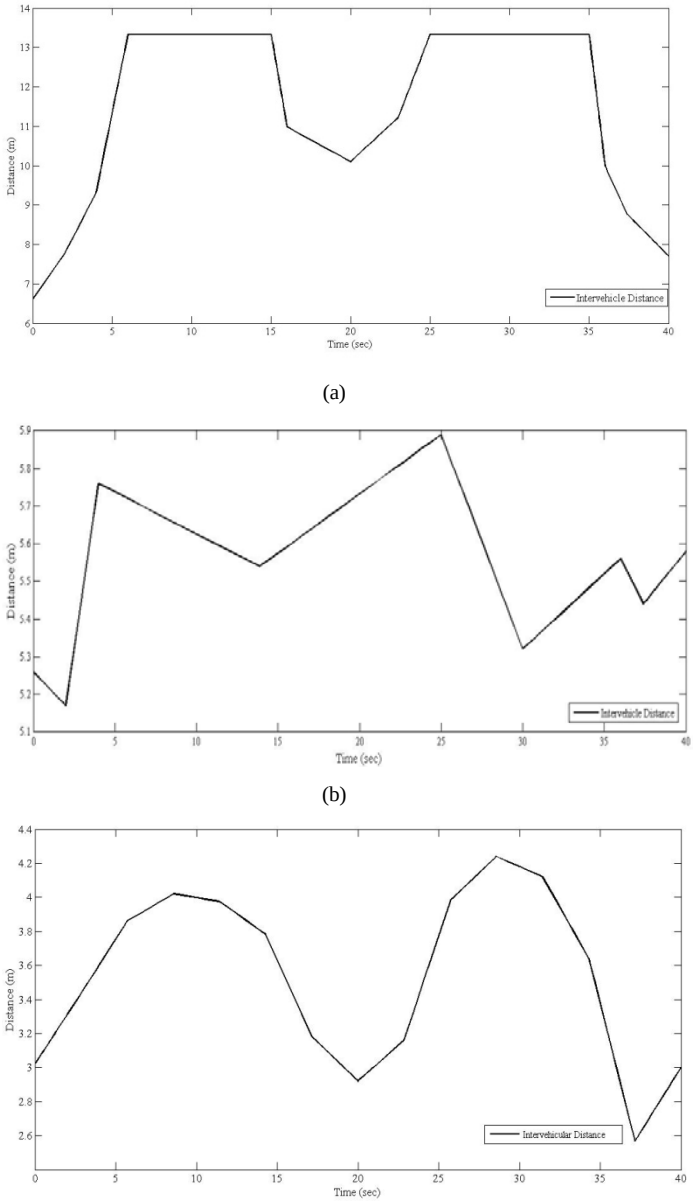


Figure 2. Actual Distance

The Speed error is obtained by the difference between the leading vehicle speed (Slead) and the host vehicle speed (Shost) according to (4).

$$X_{error} = X_{actual} - X_{desired} \quad (1)$$

$$X_{desired} = X_{safe} + THW.V_h \quad (2)$$

$$THW = \frac{clearance}{lead\ vehicle\ velocity} \quad (3)$$

The velocity of the leading vehicle is found out by sum of the host vehicle and the distance error according to (5).



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$$S_{error} = S_{lead} - S_{host} \quad (4)$$

$$S_{lead} = S_{host} + X_{error*3.6} \quad (5)$$

The output of the Fuzzy Controller determines acceleration or braking which drives the vehicle.

### C. Fuzzification of Inputs

Mamdani Fuzzy inference method is used in this case. The Fuzzy sets are represented by using the linguistic variables namely (i) Negative Medium (NM) (ii) Negative Small (NS) (iii) Zero Error (iv) Positive Small (v) Positive Medium [10]. Xerror and Serror are the two inputs for the Fuzzy Logic Controller. The output is the firing on ACC which gives the desired braking and acceleration. The input and output of the Fuzzy Logic Controller are represented triangular membership functions. The output is the acceleration or Braking command according to the current input. The positive side of the output represents the acceleration command and the negative side represents the braking command. 25 rules have been generated with the knowledge base of the system. Table 1 gives the relation between the input and the fuzzy output

TABLE.1. FUZZY RULE BASE

| | | **Speed error** | | | | |
|---|---|---|---|---|---|---|
| **Distance error** | | **NM** | **NS** | **ZE** | **PS** | **PM** |
| | **NM** | PM | PM | PM | PS | PS |
| | **NS** | PS | PM | PS | ZE | PS |
| | **ZE** | PM | ZE | ZE | NS | NM |
| | **PS** | PM | PS | NS | NS | NS |
| | **PM** | PS | NS | NS | NM | NS |

This system is modeled based upon the equations. The value of X desired depends on the Speed of the host vehicle. The desired distance varies proportional to the speed of the host vehicle. The value of X error is negative when X actual is less than the X desired, therefore the Speed of the host vehicle has to be reduced. The value of X error is positive when the X actual is greater than the X desired; therefore the speed of the host vehicle has to be increased. Thus this controls the output of the ACC vehicle. The host vehicle is adapted to the lead vehicle with minimum error.

### D. Output of FLC Based ACC

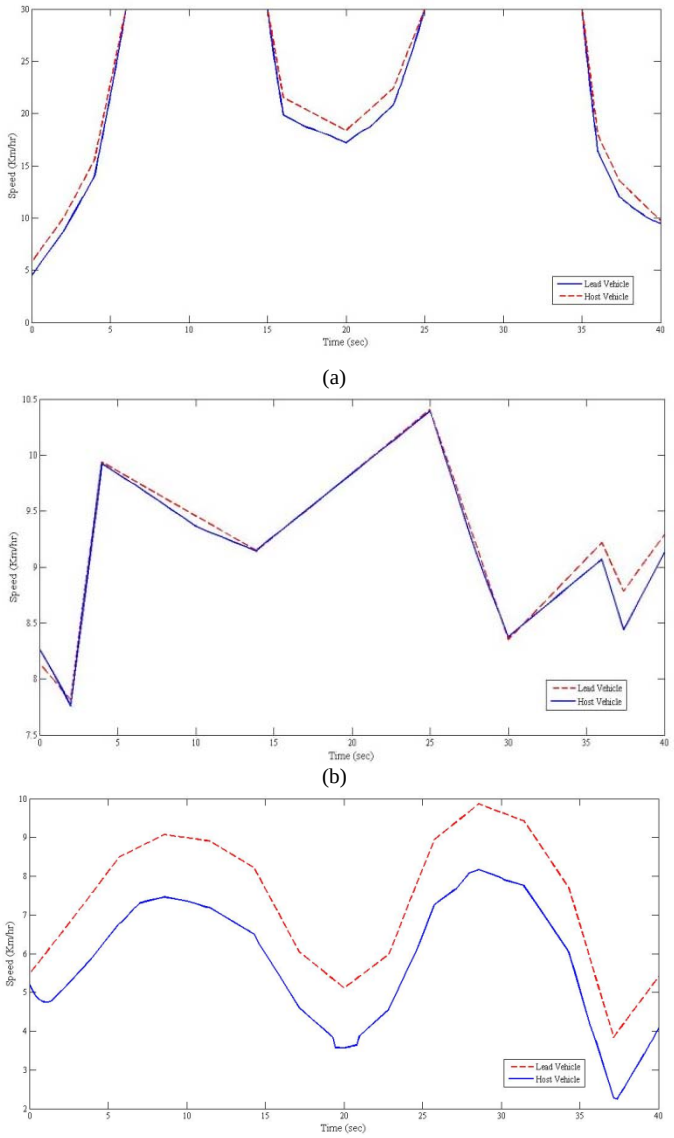


Figure 3. Output of the fuzzy controlled ACC for the given conditions

The host vehicle is getting adapted to the lead vehicle for various inter-vehicle distances considered and shown in Fig 2. For the third case the level of adaptation was very poor.

## III. GA BASED FUZZY CONTROLLED ACC

Genetic Algorithms are computing algorithms to solve optimization problems by making use of evolutionary principles as known from biology. Evolution is a process that operates on chromosomes (organic devices for encoding the structure of living beings) rather than on living beings. The processes of natural selection cause those chromosomes that encode successful structures to reproduce more often than those that do not. Recombination processes create different chromosomes in offspring by combining genes from the chromosomes of the two parents. Mutation may cause the


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chromosomes of children to be different from those of their parents [7]. Genetic algorithms are used to maximize the performance of a fuzzy logic controller through the search of a rule from a given knowledge base to achieve the goal of minimizing the number of rules required.GA will eliminate all the unnecessary rules which have no significant contribution to improve the system performance [5].

### A. *Optimization of Fuzzy rule base*

X actual is the difference between the leading vehicle and the host vehicle for which the simulation is done. Xerror and S error are the two inputs for the GA based fuzzy controlled ACC. Fuzzification is a process which converts the crisp value into a fuzzy value. X error and Serror are the two inputs given.25 rules have been generated with the knowledge base of the system. The membership function of the linguistic statement is converted to a binary string by assigning a binary number [12].

Negative medium :000
Negative small :001
Zero error :010
Positive small :011
Positive medium :100

10 random rules are obtained from the fuzzy rule base. The rule strength is calculated with respect to the antecedent and consequent of the fuzzy rule. The selection of the chromosome is done and the GA operators such as Crossover and Mutation take place and the next generation is formed

### B. *Crossover*

Crossover is a process by which the systematic information exchanges between two chromosomes and is implemented by using probabilistic decisions. Cross over is done with crossover probability. Two parents are randomly selected and let the parents be 1 & 3. A random number is generated to split the chromosome and to form the next generation. If the generated random number is less than the crossover probability Crossover has to be done by selecting the crossover site randomly by Interchange the bits

Parent=10000010
00110100
Crossover offspring= 10000100
00110010

### C. *Mutation*

Mutation is a process in which the occasional alteration of a value at a randomly selected bit position.Mutation is done with mutation probability (pc=0.6).Two parents are randomly selected and let the parent be 3. A random number is generated and if the generated random number is less than the mutation probability mutation has to be done by selecting the mutation site randomly by flipping the bit[11].

Parent=10000100
offspring=10000110

### D. *Simulation output*

The new generation has been formed after crossover and mutation. The generated 25 rules have been reduced to 2 rules using the Genetic Algorithm. The surface view of the optimized rule is shown in Fig.4

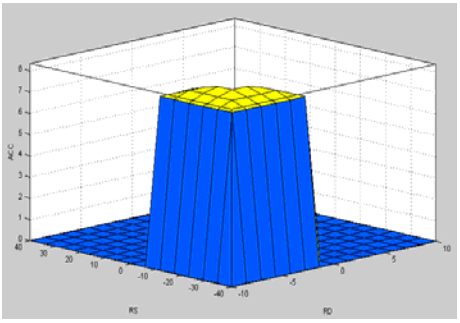
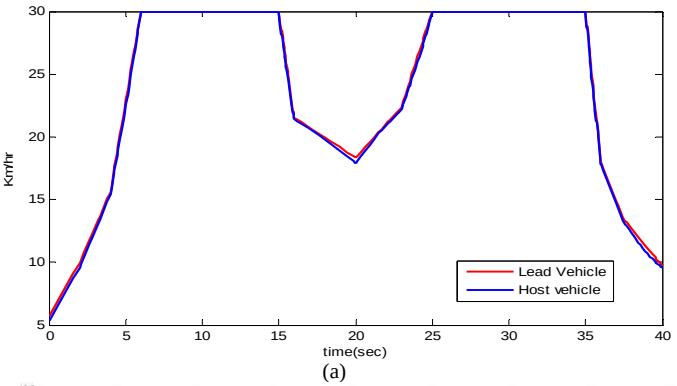
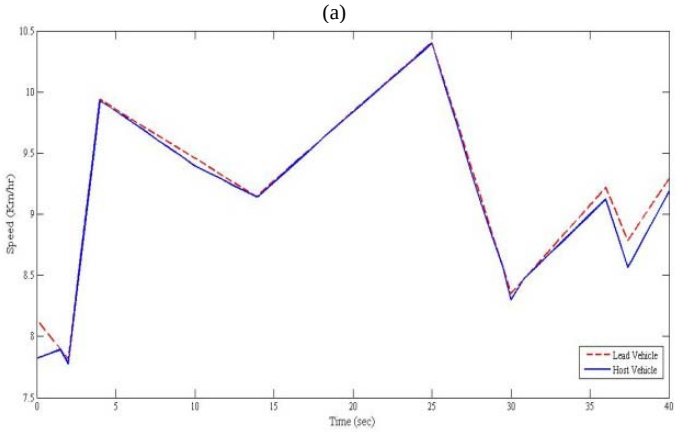


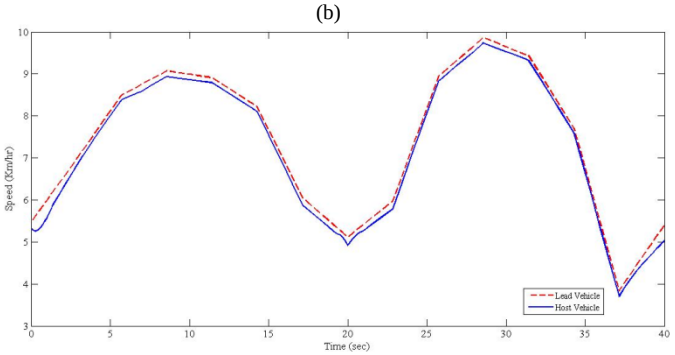
Figure. 4. Surface view of optimized rules




(a)




(b)




(c)



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Figure. 5. GA based Fuzzy Controller Output for the given scenarios

## IV.CONCLUSION

Adaptive Cruise Control has been designed using Fuzzy Logic Control. 25 rules have been generated with the knowledge base of the system. The host vehicle tried to maintain the distance so that the Xerror remains almost zero. FLC based ACC system developed much error when the distance was less than 5m. In order to reduce this error, Genetic Algorithm is used to optimize the Fuzzy rule base. Host Vehicle adapts to the change in lead vehicle speed more efficiently.

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# A Fuzzy Approach to Prevent Headlight Glare

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**Abstract: This paper proposes a fuzzy rule based design approach to prevent the Headlight glare emitted by the oncoming vehicles on the Highways. This gradually reduces accidents on the Highways as the driver of the oncoming vehicle is put on a comfortable zone which might otherwise blind the oncoming driver's visibility. In the conventional vehicles the illumination is adjusted manually by the driver. This fuzzy based approach has the fuzzy sensor and the controller embedded inside the windshield or fit on to it, generates ambient illumination to the oncoming driver, there by not ruining the vision of the driver during night. This setup has to be embedded on to all the vehicles, so that it prevents the happening of accidents. Fuzzy sensor and the controller makes use of the fuzzy rules. The light intensity emitted by the oncoming vehicle received by the fuzzy sensor, is fuzzified using triangular membership function and checked for the tolerance limit. If not of acceptable limit; the fuzzy sensor forwards it to the fuzzy controller which converts the light intensity to an ambient light source thereby defuzzifying the output.**

***Key words- Fuzzy logic; fuzzy rules; fuzzy sensor; fuzzy controllers; fuzzification; defuzzification; Headlight glare***

## I. INTRODUCTION

Around the world more than 1.2 million people lose their life in Road Accidents, every year. 3 to 4 % of Gross National Product is lost in Road Accidents. One person is killed in Road Accidents, every three minutes in the World. Total number of annual road accident deaths is more than the total population of Mauritius.

Headlight glare is the main challenge, when driving at night to the drivers. During night the drivers are affected by the dazzling high intensity headlights, which puts off their vision and results in accidents. The blinding effect may be nearly total, if the lights have not been switched from high beam, but even on low beam there is significant discomfort and reduced visibility. This paper proposes a Fuzzy based approach to reduce the headlight glare. The fuzzy sensor and the fuzzy controllers embedded in the windshield during its lamination process or fit on to the windshield, gives a solution to the headlight glare. The Sensor includes the operation of checking the light source, if of over tolerance/under tolerance. There by the controller converting it in to low intensity if of high intensity and vice versa, providing ambient light source.

The light intensity(I) measured in Volts and the distance(D) in metres are received by the fuzzy sensor. The input parameters received by the fuzzy sensor are crisp input values (Numerical value). These crisp sets are converted in to fuzzy sets using the process of fuzzification and are evaluated using the fuzzy rules. The output light intensity(OI) calculated using the fuzzy rules is checked for the tolerance limit by the fuzzy sensor. If beyond the tolerance limit, the fuzzy sensor defuzzifies using Centroid of Area and then sends it to the fuzzy controller which converts it to ambient light source. The process of fuzzification and defuzzification is also repeated in the fuzzy controller.

In [1] a fuzzy controller that controls the brake rate of the vehicle has been stated. The speed of the vehicle for which the brake has to be applied and distance of the vehicle from the point at which it has to stop are passed as the input parameters to a fuzzifier. The controller compares these inputs with the rule base and gives the desired output.


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In [2] automatic fuzzy controller which controls the switching of headlight intensity of automobiles has been proposed..

[3,5,6,8,9,11,12] gives basic understanding of Crisp set, its conversion to Fuzzy sets, concepts of fuzzy controller, and the knowledge about Fuzzy Expert system. This paper gives the Methodology used in the fuzzy sensor, fuzzification of input variables, rule evaluation and defuzzification in section II, Implementation in section III and conclusion in section IV.

## II. METHODOLOGY

The fuzzy sensor with its input parameters I(input intensity), D(distance) and the output parameter OI(Sensor output) is clearly shown in Fig. 1. The figures below indicate the demonstrations derived using MATLAB.

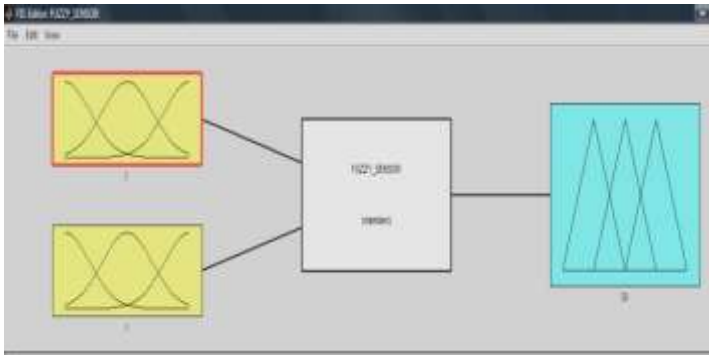

Fig. 1. The structure of the fuzzy sensor

### *A. Fuzzy inference process*

Fuzzy inference process defines a set of fuzzy "if – then "rules. Most fuzzy logic based system uses rule bases to represent the relation among the linguistic variables and to derive actions from sensor input.
The fuzzy inference process is performed in four steps:

1. Fuzzification of the input variables.
2. Defining Membership functions.
3. Rule evaluation.
4. Defuzzification.

*1) Fuzzification:* Fuzzification is the process of converting the crisp input variables to fuzzy variables. It is the mapping of the range of input to set membership values of each fuzzy variable. The crisp values got for the input parameters I and D are converted in to fuzzy sets. For fuzzification of these parameters, linguistic variables are used (Table I, II, III). The input Intensity(I) consists of 6 fuzzy sets, Distance(D) has 10 fuzzy sets and the output parameter ouput Intensity consists of 6 fuzzysets.

TABLE I. LINGUISTIC VARIABLES FOR INPUT INTENSITY I(V) AND THEIR NUMERICAL RANGE

| Linguistic value | Notation | Numerical range |
|---|---|---|
| JustNoticeable | JN | 0-3.50 |
| Noticeable | N | 3.00-6.50 |
| Satisfactory | S | 5.00-8.50 |
| JustAcceptable | JA | 7.00-10.50 |
| Disturbing | D | 9.00-12.50 |
| UnBearable | UB | 11.00-14.50 |

TABLE II. LINGUISTIC VARIABLES FOR DISTANCE D(MTS) AND ITS NUMERICAL RANGE

| Linguistic value | Notation | Numerical range |
|---|---|---|
| VeryClose | VC | 0-25 |
| Close | CL | 12-50 |
| VeryNear | VN | 37-75 |
| Near | N | 62-100 |
| ModeratelyNear | MN | 87-125 |
| ModeratelyFar | MF | 110-150 |
| Far | F | 135-175 |
| VeryFar | VF | 160-200 |
| PrettyVeryFar | PVF | 185-225 |
| BoundaryZone | BZ | 210-250 |

TABLE III. LINGUISTIC VARIABLES FOR SENSOR OUTPUT LIGHT SOURCE OI(V) AND ITS NUMERICAL RANGE

| Linguistic value | Notation | Numerical range |
|---|---|---|
| JustNoticeable | JN | 0-3.50 |
| Noticeable | N | 3.00-6.50 |
| Satisfactory | S | 5.00-8.50 |
| JustAcceptable | JA | 7.00-10.50 |
| Disturbing | D | 9.00-12.50 |
| UnBearable | UB | 11.00-14.50 |

*2) Defining Membership functions:* After fuzzification is done, the next process is to define the membership


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functions in the fuzzy sets for the input and output parameters. The Triangular membership function is used for constructing the fuzzy sets. The membership function of the input parameters is shown by the figures (2-3). The membership function of the output parameter is shown in figure.4. Fuzzy membership expressions for the input Intensity(I) and Distance(D) is given by (Eq.(1-2)).

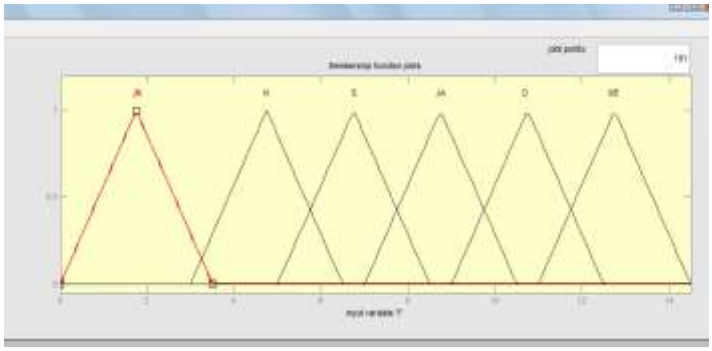

Fig.2. The membership function of I(inputIntensity)

$$\mu_{JN}(x) = \begin{cases} 0; & x \le 0 \\ \frac{x-0}{1.75}; & 0 \le x \le 1.75 \\ \frac{3.50-x}{1.75}; & 1.75 \le x \le 3.50 \\ 0\ ; & 3.50 \le x \end{cases}$$

$$\mu_{N}(x) = \begin{cases} 0; & x \le 3.00 \\ \frac{x-3}{1.75}; & 3.00 \le x \le 4.75 \\ \frac{6.50-x}{1.75}; & 4.75 \le x \le 6.50 \\ 0\ ; & 6.50 \le x \end{cases}$$

$$\mu_{S}(x) = \begin{cases} 0; & x \le 5.00 \\ \frac{x-5}{1.75}; & 5.00 \le x \le 6.75 \\ \frac{8.50-x}{1.75}; & 6.75 \le x \le 8.50 \\ 0\ ; & 8.50 \le x \end{cases}$$

$$\mu_{JA}(x) = \begin{cases} 0; & x \le 7.00 \\ \frac{x-7}{1.75}; & 7.00 \le x \le 8.75 \\ \frac{10.50-x}{1.75}; & 8.75 \le x \le 10.50 \\ 0\ ; & 10.50 \le x \end{cases}$$

$$\mu_{D}(x) = \begin{cases} 0; & x \le 9.00 \\ \frac{x-9}{1.75}; & 9.00 \le x \le 10.75 \\ \frac{12.50-x}{1.75}; & 10.75 \le x \le 12.50 \\ 0\ ; & 12.50 \le x \end{cases}$$

$$\mu_{UB}(x) = \begin{cases} 0; & x \le 11.00 \\ \frac{x-11.00}{1.75}; & 11.00 \le x \le 12.75 \\ \frac{14.50-x}{1.75}; & 12.75 \le x \le 14.50 \\ 0\ ; & 14.50 \le x \end{cases} \quad (1)$$



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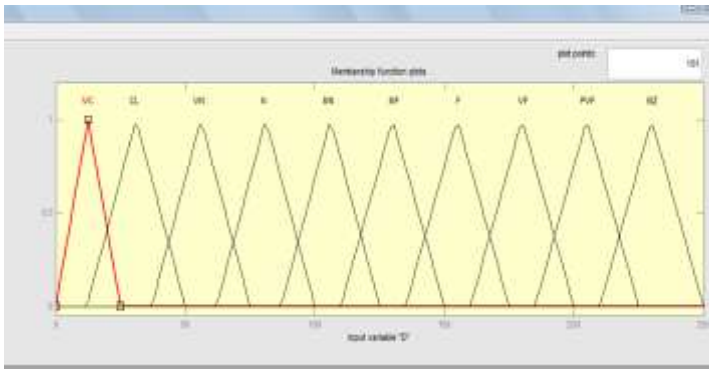

Fig. 3. The membership function of D(Distance)

$$\mu_{VC}(x) = \begin{cases} 0; & x \le 0 \\ \frac{x-0}{12.5}; & 0 \le x \le 12 \cdot 5 \\ \frac{25-x}{12.5}; & 12 \cdot 5 \le x \le 25 \\ 0\ ; & 25 \le x \end{cases}$$

$$\mu_{CL}(x) = \begin{cases} 0\,; & x \le 12 \\ \frac{x-12}{19}\ ; & 12 \le x \le 31 \\ \frac{50-x}{19}\ ; & 31 \le x \le 50 \\ 0\ ; & 50 \le x \end{cases}$$

$$\mu_{VN}(x) = \begin{cases} 0\,; & x \le 37 \\ \frac{x-37}{19}\ ; & 37 \le x \le 56 \\ \frac{75-x}{19}\ ; & 56 \le x \le 75 \\ 0\ ; & 75 \le x \end{cases}$$

$$\mu_{N}(x) = \begin{cases} 0\,; & x \le 62 \\ \frac{x-62}{21}\ ; & 62 \le x \le 81 \\ \frac{100-x}{19}\ ; & 81 \le x \le 100 \\ 0\ ; & 100 \le x \end{cases}$$

$$\mu_{MN}(x) = \begin{cases} 0\,; & x \le 87 \\ \frac{x-87}{19}\ ; & 87 \le x \le 106 \\ \frac{125-x}{19}\ ; & 106 \le x \le 125 \\ 0\ ; & 125 \le x \end{cases}$$

$$\mu_{MF}(x) = \begin{cases} 0\,; & x \le 110 \\ \frac{x-110}{20}\ ; & 110 \le x \le 130 \\ \frac{150-x}{20}\ ; & 130 \le x \le 150 \\ 0\ ; & 150 \le x \end{cases}$$

$$\mu_{F}(x) = \begin{cases} 0\,; & x \le 135 \\ \frac{x-135}{20}\ ; & 135 \le x \le 155 \\ \frac{175-x}{20}\ ; & 155 \le x \le 175 \\ 0\ ; & 175 \le x \end{cases}$$

$$\mu_{VF}(x) = \begin{cases} 0\,; & x \le 160 \\ \frac{x-160}{20}\ ; & 160 \le x \le 180 \\ \frac{200-x}{20}\ ; & 180 \le x \le 200 \\ 0\ ; & 200 \le x \end{cases}$$



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$$\mu_{PVF}(x) = \begin{cases} 0; & x \le 185 \\ \frac{x-185}{20}; & 185 \le x \le 205 \\ \frac{225-x}{20}; & 205 \le x \le 225 \\ 0; & 225 \le x \end{cases}$$

$$\mu_{BZ}(x) = \begin{cases} 0; & x \le 210 \\ \frac{x-210}{20}; & 210 \le x \le 230 \\ \frac{250-x}{20}; & 230 \le x \le 250 \\ 0; & 250 \le x \end{cases} \quad (2)$$

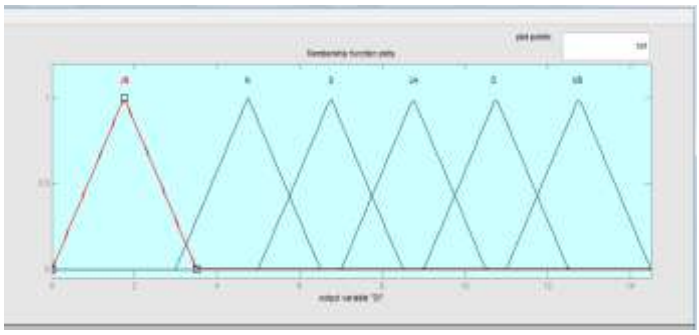

Fig. 4. The membership function of OI(Output Intensity of sensor )

3) *Rule evaluation*: The fuzzy input values are processed using the set of rules. The rules in fuzzy control consist of a condition, IF, followed by a control action, THEN. Each rule processes the information using different input parameters; the output of each rule is different. In order to construct the fuzzy rules we construct rule matrix (Table IV) and rule bases.

TABLE IV. RULE MATRIX REPRESENTATION

| D/I | JN | N | S | JA | D | UB |
|---|---|---|---|---|---|---|
| BZ | JN | JN | JN | S | JA | D |
| PVF | JN | JN | N | S | D | D |
| VF | JN | JN | N | S | D | D |
| F | JN | N | S | S | D | D |
| MF | JN | N | S | JA | D | D |
| MN | N | N | S | JA | D | D |
| N | S | S | S | JA | D | UB |
| VN | S | S | S | D | D | UB |
| CL | JA | JA | D | D | UB | UB |
| VC | JA | D | D | UB | UB | UB |

From the rule matrix we are able to arrive at the rule bases. We have 10*6 rules for the fuzzy sensor. The rule base consists of antecedent part and the consequent part. Antecedent part consists of input linguistic variables that may be combined using AND operators. Consequent part contains the output of the fuzzy rule. The figure below (Fig. 5) shows the rule base for the sensor. In the figure below, the value of I=13.9, D=250 and OI=7.25. This implies that the output light intensity is moderate; the sensor judges it to be of the acceptable limit and it need not send it to the controller.

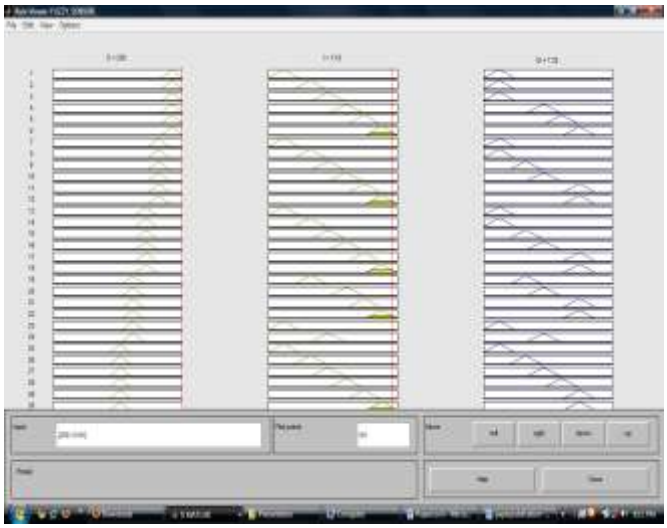

Fig. 5. Computing the value of OI for I=13.9 and D=250

If the output light intensity I is higher(9.00 and above), the sensor sends it to the controller and the fuzzy controller (Fig. 6) converts it into an ambient light source.



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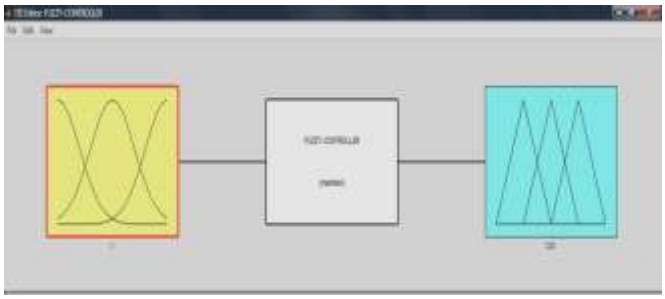

Fig. 6. The structure of the Fuzzy Controller

The Fuzzy controller accepts the OutputIntensity(OI), if it is of either Disturbing(D),or UNBEARABLE(UB) it converts it to an ambient light source. The Fuzzy controller's ouput is the ControllerOutputIntensity(COI)(Table V)

TABLE V. THE LINGUISTIC VARIABLES FOR COI AND ITS NUMERICAL RANGE

| **Linguistic value** | **Notation** | **Numerical range** |
|---|---|---|
| ReduceLightSource | RLS | 9.00-14.50 |
| AmbientLightSource | ALS | 0-9.00 |

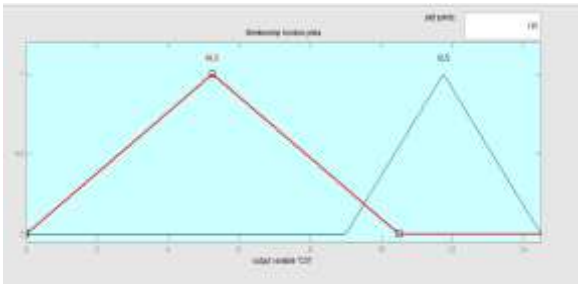

Fig. 7. The membership function for the ControllerOutputIntensity(COI)

The rule bases for the fuzzy controller(Table VI) is as shown below.

TABLE VI. THE RULE BASES FOR THE FUZZY CONTROLLER

| **Rule** | **OI** | **COI** |
|---|---|---|
| 1 | JN | ALS |
| 2 | N | ALS |
| 3 | S | ALS |
| 4 | JA | ALS |
| 5 | D | RLS |
| 6 | UB | RLS |

The figure below (Fig. 8) shows the rule base for the sensor. In the figure below, the value of OI=9.5 and that of COI=7.45 . This implies that the output light intensity is moderate; the sensor judges it not to be of the acceptable limit and it sends it to the controller.

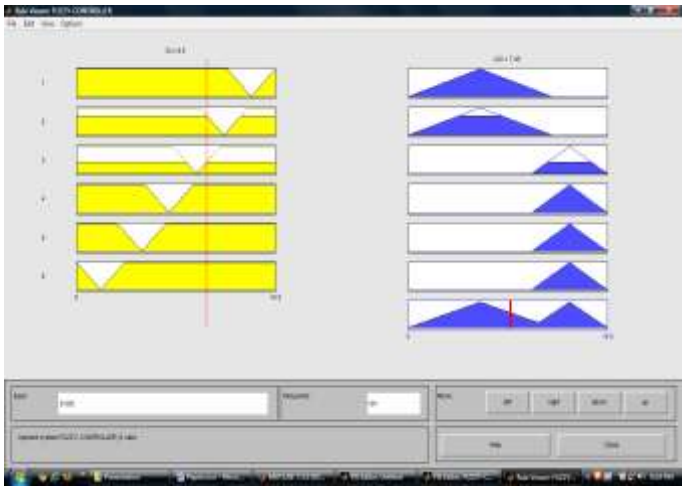

Fig. 8. Computing the value of COI for OI=9.5

*4) Defuzzification:* The fuzzy sets are converted to crisp values. Here the fuzzy sets represented by OI(Sensors output) and ols(fuzzy controllers output) are converted to crisp sets(Numerical values). Centre of Area method has been used. General formula for COA is (Eq:3)

$$z^* = \frac{\int \mu_c(z) z dz}{\int \mu_c(z) dz} \qquad (3)$$

## III. IMPLEMENTATION

The MATLAB Fuzzy Logic Toolbox has been used to encode fuzzy sets, membership functions, fuzzy rules and to perform inference process for both the fuzzy sensor and the fuzzy controller.

## IV. CONCLUSION

This paper has proposed a fuzzy rule based approach to prevent the headlight glare which in turn minimizes the Accidents. The fuzzy sensor and the controller uses the fuzzy rule bases to control the intensity of light. The conventional controllers would not be very efficient in controlling the headlight glare as there would be discrete values either high/low beam but the fuzzy controller has the continuous light intensities rather than high/low beam. The


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fuzzy sensor and the controller has to be embedded inside the windshield or fit on to it, during the windshield lamination process. This fuzzy system comprising the sensor and the controller reduces the headlight glare and therefore reduces the accidents on the highways during the travel at night. This fuzzy system would be of greater boon to the drivers as the driving becomes comfortable without ruining the vision of the driver at both the ends. This setup comprising the fuzzy sensor and the fuzzy controller, has to be put up on all the vehicles in order to prevent the happening of accidents.

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# WEB-OBJECT RANK ALGORITHM FOR EFFICIENT INFORMATION COMPUTING

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***Abstract* - In recent years there has been considerable interest in analyzing relative trust level of the web objects. As the web contain facts and the assumptions on the global scale resulting on various criterions for trusting web page. In this paper an algorithm is proposed which assigns a rank to every web object like a requested document on the web that specify the quality of that object or the relative level of trust one can make on that web page. It is used for object level information extraction for ranking search results and is implemented in C++. In this paper the behavior of object rank for different values of moister factor in a domain is analyzed. The results emphasize that the moister factor can be useful in rank computation and further explore more web pages in alignment with the user's requirements.**

***Keywords- Random Surfer Model, Information Computing, Web Objects, Information Retrieval System, Web Graph, Ranking, Object Rank.***

## I. INTRODUCTION

Information computing in various web domains is broadly extracting the web objects of unstructured nature like text objects that convince information need from within large collections using document-level ranking and therefore the structured information about real-world objects which is embedded in static web pages. Online databases exist on the web in huge amounts which are of unstructured nature. Unstructured data refers to the data which does not have clear, semantically obvious structure [7]. In other words information computing constitutes process of searching, recovering, and understanding information, from huge amounts of stored data. The information from the web can be retrieved by implementing searching techniques as Keyword based Searching, Concept-based Searching, Hybrid Search, and Knowledge Base Search. In case of object level information computing, domain based search is required. Every commercial information retrieval systems try to facilitate a user's access to information that is relevant to his information needs. This paper highlights ranking problem for domain based information retrieval, which states that every owner of the document wants to improve ranking of its document for that it can do many manipulations on its document like increasing number of links to the page by the dummy pages [1]. Object based information computing maintain the integrity of the search results based upon various lexicons. As the web contains the contradictions and hypothesis on a huge scale, therefore finding the relevant information using search engines is a tedious job. With the help of object level ranking [22], various objects on a domain independent of the query that describes the relative trust of the web page can be prioritized. The object rank of a page depends upon various factors associated with the web object.

The organization of the paper is as follows. Related work is presented in section 2. Section 3 discusses the challenges of high quality search results. In section 4, Web_Object_Rank algorithm is proposed and discussed. The algorithm is implemented in section 5. Finally Section 6 concludes the paper on the basis of the results obtained.

## II. RELATED WORK

Google is a prototype of a large-scale search engine that makes heavy use of the structure present in hypertext [1]. Google is designed to crawl and index the web efficiently and produce much more satisfying search results than existing systems. Link Analysis Ranking [16] emphasize that hyperlink structures are used to determine the relative authority of a web page and produce improved algorithms for the ranking of search results. The prototype with a full text and hyperlink database of web pages is available at [8]. In the current era there is much concern in using random graph models for the web. The Random Surfer model [9] and the Page Rank-based selection model [11] are described as two major models [10]. Page Rank-based selection model tries to capture the effect that the search engines have on the growth of the web by adding new links according to Page Rank. The Page Rank algorithm is used in the Google search engine [12] for ranking search results. PageRank is a link analysis algorithm used by the Google Internet search engine that assigns a numerical weighting to each element of a hyperlinked set of documents, such as the World Wide Web (WWW), with the purpose of "measuring" its relative importance within the set. Google is designed to be a scalable search engine with primary goal to provide high quality search results over a rapidly growing WWW [18]. The PageRank theory suggests that even an imaginary surfer who is randomly clicking on links will eventually stop clicking. The probability, at any step, that the surfer will continue is a damping factor *d* [2]. The


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*damping factor (α)* is eminently empirical, and in most cases the value of α can be taken as 0.85 [1]. Page Rank is the stationary state of a Markov chain [2, 7]. The chain is obtained by perturbing the transition matrix induced by a web graph with a damping factor that spreads uniformly over the rank. The behavior of Page Rank with respect to changes in α is useful in link-spam detection [3]. The mathematical analysis of Page Rank with change in α show that contrary to popular belief, for real-world graphs values of α close to 1 do not give a more meaningful ranking [2,21]. The order of displayed web pages is computed by the search engine Google as the PageRank vector, whose entries are the Page Ranks of the web pages [4]. The Page Rank vector is the stationary distribution of a stochastic matrix, the Google matrix. The Google matrix in turn is a convex combination of two stochastic matrices: one matrix represents the link structure of the web graph and a second, rank-one matrix, mimics the random behavior of web surfers and can also be used to fight web spamming. As a consequence, Page Rank depend mainly the link structure of the web graph, but not on the contents of the web pages. Also the Page Rank of the first vertex, the root of the graph, follows the power law [10]. However, the power undergoes a phase-transition as parameters of the model vary.

Link-based ranking algorithms rank web pages by using the dominant eigenvector of certain matrices--like the co-citation matrix or its variations [17]. Distributed page ranking on top of structured peer-to-peer networks is needed because the size of the web grows at a remarkable speed and centralized page ranking is not scalable [5].

Page ranking can be propagation rates depending on the types of the links and user's specific set of interests [6]. Page filtering can be decided based on link types combined with some other information relevant to links. For ranking, a profile containing a set of ranking rules to be followed in the task can be specified to reflect user's specific interests [20]. Similarities of contents between hyperlinked pages are useful to produce a better global ranking of web pages [19].

## III. CHALLENGES

The primary focus of Web Information Retrieval Support System (WIRSS) is to address the aspects of search that consider the specific needs and goals of the individuals conducting web searches [15]. The major goal is to provide high quality search results over a rapidly growing World Wide Web. Google employs a number of techniques to improve search quality including page rank, anchor text, and proximity information. Decentralized content publishing is the main reason for the explosive growth of the web. Corresponding to a user query there are many documents that can be retrieve by search engine. And every owner of the document wants to improve the ranking of its document. Commercial search engine have to maintain the integrity of there search results and this is one reason for the unavailability of the efforts made by them publicly. Democratization of content creation on the web generates new challenges in WIRSS. This gives rise to the question on integrity of web pages. In a simplistic approach, one might argue that only some publishers are trustworthy and others not. One more challenge is fast crawling technology is needed to gather the web objects and keep them up to date.

## IV. WEB_OBJECT_RANK ALGORITHM AND IMPLEMENTATION

Page Rank of a web object can be defined as the fraction of time that the surfer spends on an average on that object. The probability that the random surfer visits a web page is its Page Rank [1]. Evidently, web objects that are hyperlinked by many other pages are visited more often. The random surfer gets bored and restarts from another random web object with a probability termed as the ***moister factor (m).*** The probability that the surfer follow a randomly chosen outlink is ***(1-m)***.

The Markov Chain is a *discrete-time stochastic process:* a process that occurs in a series of time-steps in each of which a random choice is made [7]. There is one state corresponding to each web object. Hence, a Markov chain consists of *N states if there are N numbers of Web Objects in the collection.* A Markov chain is characterized by an *N × N Probability Transition Matrix P* each of whose entries is in the interval [0, 1]; the entries in each row of *P* add up to 1. Markov Property states that each entry *Pij* is the transition probability that depends only on the current state *i.* A Markov chain's probability distribution over its states may be viewed as a *Probability Vector*: a vector all of whose entries are in the interval [0, 1], and the entries add up to 1. According to [7, 14] the problem of computing bounds on the conditional steady-state Probability Vector of a subset of states in finite, discrete-time Markov chains is considered.

### A. Web_Object_Rank Algorithm: Features

Features of Object Rank Algorithm are as follow:

- Query independent algorithm (assigns a value to every document independent of query).
- Content independent Algorithm.
- Concerns with static quality of a web page.
- Object Rank value can be computed offline using only web graph.
- Object Rank is based upon the linking structure of the whole web.
- Object Rank does not rank website as a whole but it is determined for each web page individually.
- Object Rank of web pages $T_i$ which link to page A does not influence the rank of page A uniformly.
- More are the outbound links on a page T, less will page A benefit from a link to it.
- Object Rank is a model of user's behavior.

### B. Web_Object_Rank Algorithm: Assumptions

If there are multiple links between two web objects, only a single edge is placed.

- No self loops allowed.
- The edges could be weighted, but we assume that no weight is assigned to edges in the graph.
- Links within the same web site are removed.
- Isolated nodes are removed from the graph.


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### C. Web_Object_Rank Algorithm

This algorithm is basically a query independent algorithm that takes a web graph as an input and assigns a rank to every object which can specify the relative authorization of that web page. In the proposed algorithm, following is the list of variables

- moist_fact (m) is the moister factor: the probability of random surfer to restart search from another web object
- 1-m is the probability of the random surfer to search web objects from randomly chosen outlinks
- outlinks is the number of web objects linked with a particular page
- N is the number of objects in the domain
- prob[i][j] is the Probability Transition Matrix for all i ,j € 1 to N
- adj[i][j] is the Adjacency Matrix for all i ,j € 1 to N
- x is the Probability Vector
- itr is Iteration

### D. Web_Object_Rank Algorithm

| | |
|---|---|
| Step 1. | Create a web graph of various objects in a domain. |
| Step 2. | Set prob[i][j]=adj[i][j] |
| Step 3. | Compute number of out links from a particular node say counter.<br>IF outlinks of web objects = NULL<br><br>THEN prob[i][j] is equally distributed for all i ,j<br><br>ELSE prob values are distributed according to number of outlinks<br>For all i,j IF (counter = 0)<br>THEN<br>prob[i][j]=1/N<br>ELSE<br>IF (prob[i][j] =1)<br>THEN<br>prob[i][j] =1.0/counter |
| Step 4. | Multiply the resulting matrix by 1 − m. |
| Step 5. | Add m/N to every entry of the resulting matrix, to obtain *Probability Transition Matrix*.<br>For all i , j Do<br>prob[i][j]=(prob[i][j]*(1- m))+((m/N); |
| Step 6. | Randomly select a node from 0 to N-1 to start a walk say s_int . |
| Step 7. | Initialize Random surfer and itr to keep account of number of iterations required to 0. |
| Step 8. | Try to reach at steady state with in 200 iterations otherwise toggling occur |
| Step 9. | Multiplying Probability Transition Matrixes with Probability Vector to get steady state |
| Step 10. | Check either system enters in steady state or not |
| Step 11. | Print the ranks stored in Probability Vector x and EXIT. |

## V. IMPLEMENTATION

This implementation is based upon random surfer model [7] and Markov chain [13, 14]. The random surfer visit the objects in the web graph according to distribution based on which random surfer can be in one of the following four possible states at any time.

*Initial state* is state of the system from where it will start its walk. The system is set in the random state by randomly selecting an object using random function and value corresponding to that web object in the Probability Vector is set to unity. Rest of the values in the Probability Vector is zero. *Steady state* is that state of the system when the Probability Vector of random surfer fulfills the properties of irreducibility and aperiodicity's. To check either the system get the steady state or not, two successive values of the Probability Vector must be same. *Ideal state* is that state of the random surfer when the system achieves the steady state but at the same time web object ranks are distributed uniformly to all documents. Toggling state is achieved by the random surfer when the system is not able to reach at steady state and just toggle between two set of object ranks.

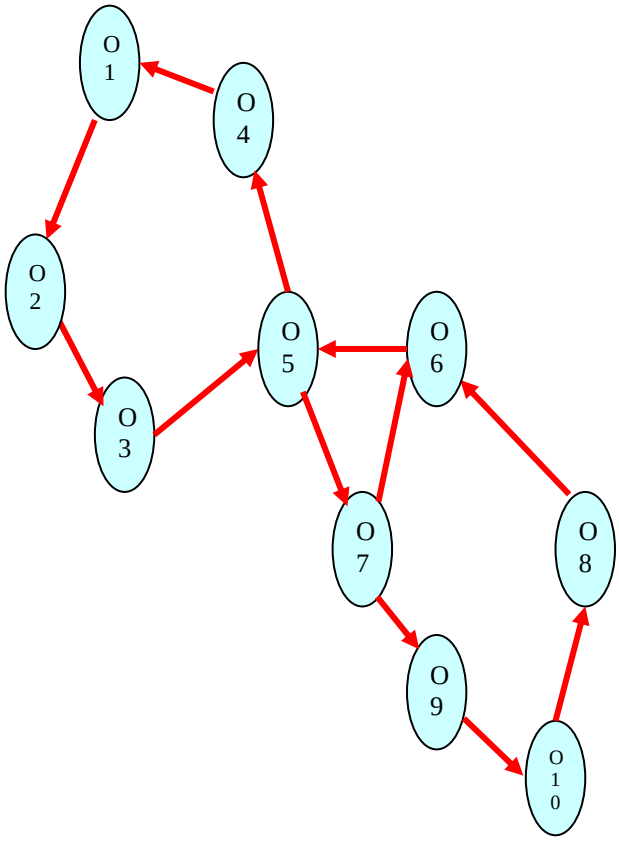


**Fig. 1. Web Graph**


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### C. *Results and Discussion*

The web graph shown in Fig 1 is used for analyzing various factors of the proposed algorithm. Variation in graph structures used for analysis change the performance of the algorithm. The graph shows 10 web objects in a domain that are interlinked as strongly connected graph. Every two nodes of the graph have a path with less number of links. $O_i$ is the $i^{th}$ web object in the domain where i vary from 1 to 10. The adjacency matrix for web graph of Fig 1 is shown in Fig 2.

$$\begin{pmatrix} 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \end{pmatrix}$$

Fig.2. Adjacency Matrix for all i ,j € 1 to 10

To analyze the convergence speed, number of iterations required by random surfer to reach at a steady state is recorded in Table 1 and the corresponding graph is shown in fig 3. In fig. 3 infinity value is shown by a large number of iterations (200 or more). It clearly shows that as the moister factor approaches 1, the number of iterations is reduced.

**Table 1: Moister Factor Vs No. of Iterations**

| Moister Factor | No. of Iterations |
|---|---|
| 0 | Infinity |
| 0.05 | Infinity |
| 0.1 | Infinity |
| 0.15 | Infinity |
| 0.2 | 83 |
| 0.25 | 73 |
| 0.3 | 62 |
| 0.35 | 46 |
| 0.4 | 41 |
| 0.45 | 33 |
| 0.5 | 35 |
| 0.55 | 39 |
| 0.6 | 24 |
| 0.65 | 21 |
| 0.7 | 20 |
| 0.75 | 22 |
| 0.8 | 16 |
| 0.85 | 12 |
| 0.9 | 11 |
| 0.95 | 10 |
| 1 | 2 |

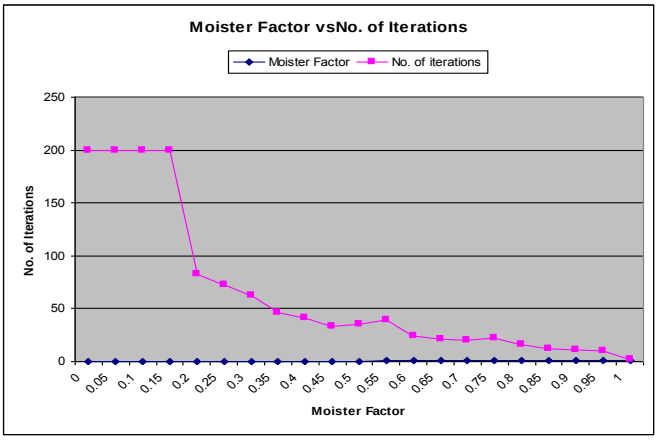


**Fig. 3 . Moister Factor vs Number of Iterations**

It is further analyzed that as the Moister Factor is equal to 1, random Surfer enters into the Ideal state and the corresponding rank values of the web objects is same as in table 2. The graph for the ideal state is shown in Fig 4.

**Table 2: Ranks of objects at moister factor 1**

| Object | Computed Rank |
|---|---|
| $O_1$ | 0.1 |
| $O_2$ | 0.1 |
| $O_3$ | 0.1 |
| $O_4$ | 0.1 |
| $O_5$ | 0.1 |
| $O_6$ | 0.1 |
| $O_7$ | 0.1 |
| $O_8$ | 0.1 |
| $O_9$ | 0.1 |
| $O_{10}$ | 0.1 |

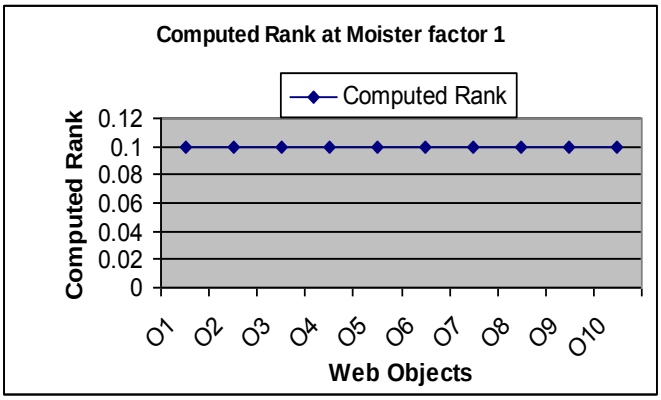


**Fig.4. Random Surfer Ideal State**

Figure 5 shows that for the Moister Factor less than 0.2, no rank is provided to any web object and system enters into the toggling state with large number of



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iterations for the given domain. Also, the ranks computed by the proposed algorithm for moister factor values from 0.2 to 1 are shown.

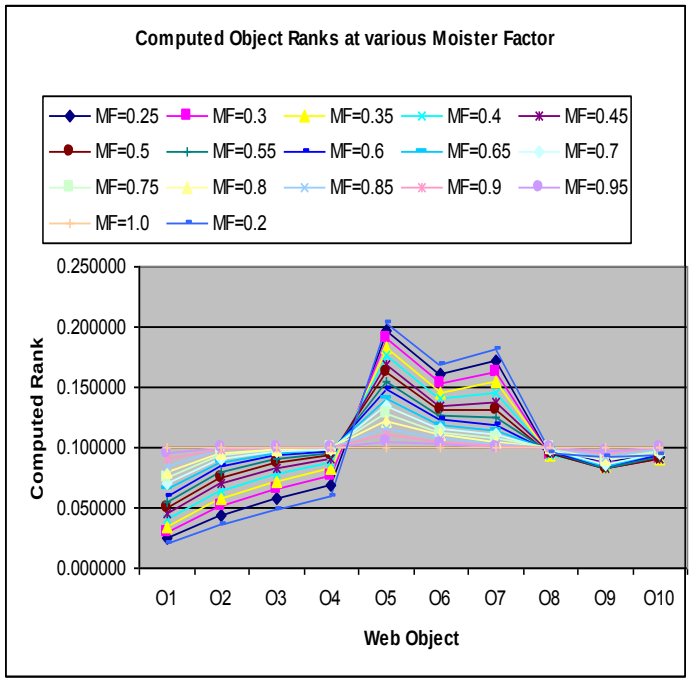


**Fig. 4. Moister factor (>.2) to different documents**

From the above graphs and analysis, we can say that the moister factor plays a main role in this algorithm and performance of algorithm can be improved if this factor is selected properly. The value of moister factor can vary from 0 to 1 but in most of the cases system enter into the toggling state if value selected is less than 0.2 and at the value 1 system enter into ideal state giving insignificant results. Value must be closer to 1 but can not be 1. As shown in Fig. 2 systems achieve a steady state in less number of iterations if moister factor value is closer to 1.

## CONCLUSION

The current study was conducted to demonstrate how the link structure of the web can be used to provide the ranking to various documents. This ranking can be provided offline. With the help of this approach one can prioritize the various documents on the web independent of the query. However a complete score computation is based on various other factors. In the proposed algorithm a damping factor is used that play a very important role on the analysis of the algorithm. After the analysis it is concluded that damping factor must not be selected closer to zero. At the damping factor one, the system enters into the ideal state and the ranking provided is insignificant. As per evaluation the damping factor must be selected greater than or equals to 0.5. However, if we consider convergence speed as only factor to evaluate the performance than the best moister factor will be .95. The proposed algorithm is query independent algorithm and does not consider query during ranking.

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# CONCURRENCY CONTROL IN CAD USING FUNCTIONAL BACK PROPAGATION NEURAL NETWORK

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***ABSTRACT*--This paper presents artificial neural network method using functional back propagation algorithm (FUBPA) for implementing concurrency Control while developing dial of a fork using Autodesk inventor 2008. Initially, the various parts are decided and the sequence in which they have to be drawn. While implementing concurrency control, this work ensures that associated parts cannot be accessed by more than one person due to locking. The FUBPA learns the objects and the type of transactions to be done based on which node in the output layer of the network exceeds a threshold value. Learning stops once all the objects are exposed to FUBPA. During testing performance, metrices are analyzed.**

Keywords: ***Concurrency Control, Functional Back Propagation* Network, T*ransaction Locks, Time Stamping.***

## I. INTRODUCTION

Maintaining consistency in transactions of objects during drawing huge computer aided object is the result of efficient concurrency Control. In computer aided design (CAD), many persons will be accessing different parts of same objects according to the type work allotted to engineers. As all the parts of the same objects are stored in a single file, at any point of time, there should not be corruption of data, inconsistency in storage and total loss of data.

Locks are used for accessing objects. In a database operation lock manager plays an important role whether one or more transactions are reading or writing any part of 'I' where 'I' is an item. It is the part of that record, for each item I. Gaining access to I is controlled by manager and ensure that there is no , access (read or write) would cause a conflict. The


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lock manager can store the current locks in a lock table which consists of records with fields (<object>, <lock type>, <transaction>) the meaning of record (I, L, T) is that transaction T has a lock of type L on object I [1-4].

The process of managing simultaneous operations on the database without having them interfere with one another is called concurrency.[5-8] When two or more users are accessing database simultaneously concurrency prevents interference.. Interleaving of operations may produce an incorrect result even though two transactions may be correct. Some of the problems that result in concurrency are lost update, inconsistent analysis and uncommitted dependency.

## II. PROBLEM DEFINITION

There is inability to provide consistency in the database when long transactions are involved. It will not be able to identify if there is any violation of database consistency during the time of commitment. It is not possible to know, if the transaction is with undefined time limit. There is no serializability when many users work on shared objects. During long transactions, optimistic transactions and two phase locking will result in deadlock. Two phase locking forces to lock resources for long time even after they have finished using them. Other transactions that need to access the same resources are blocked. The problem in optimistic mechanism with Time Stamping is that it causes repeated rollback of transactions when the rate of conflicts increases significantly. Artificial neural network [9] with Functional Back Propagation Network (FUBPA) has been used to manage the locks allotted to objects and locks are claimed appropriately to be allotted for other objects during subsequent transactions.

Inbuilt library drawing for the dial of fork (Figure 1) are available in AutoCAD. The fork is used in the two wheeler front structure. Due to customer requirements, the designer edits the dial of fork in the central database by modifying different features. Consistency of the data has to be maintained during the process of modifications of different features. Following sequences of locking objects have to be done whenever a particular user accesses a specific feature of the dial of fork. Each feature is treated as an object. The features are identified with numbers and corresponding feature names. In this explanation, $O_1$ refers to an object / feature marked as 1.

In general, the following sequences are formed when creating dial of fork. The major parameters involved in creating the dial of the fork are hollow cylinder, wedge and swiveling plate. The various constraints that have to be imposed during modifications of features by many users on this dial of fork are as follows:

- During development of features, hollow cylinder details should not be changed
- External rings are associated with hollow cylinder.
- The circular wedge has specific slope and associated with hollow cylinder.

This dial of fork has following entities.

1) Features 1, 2, (set 1)
2) Features 10, 11,12,13,14 (set 2)
3) Features 5,6,7,8 (set 3)
4) Features 3, 4 (set 4)


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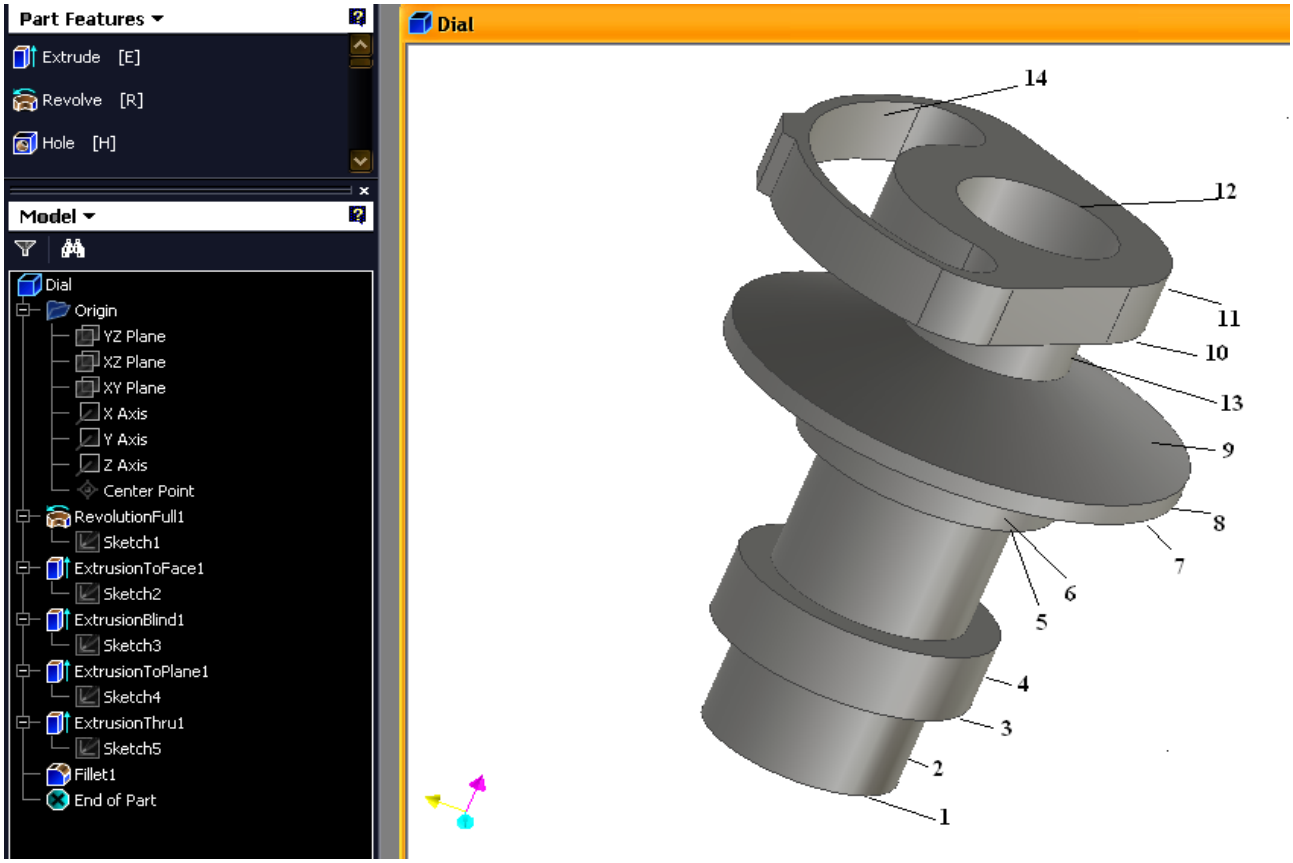


Figure 1. Dial of fork

1 Lower end, 2 height of the end part, 3 external support, 4 Height of the external support, 5 support for the wedge, 6 height of the support for the wedge, 7 wedge, 8 thickness of the wedge, 9 slope of the wedge, 10 Wedge lock, 11 Height of the wedge lock, 12 Concentric hole, 13 separator, 14 Guideway

Set 1, set 2, set 3, set 4 can be made into individual drawing part files (part file 1, part file 2, part file 3 and part file 4) and combined into one assembly file (containing the part files 1,2 3 and 4 which will be intact). When the users are accessing individual part files, then transactions in part file 1 need not worry about the type of transactions in part files 2,3,4 and vice versa among them. When the part files 1 2, 3 and 4 are combined into a single assembly file, then inconsistency in the shape and dimension of the set 1, set 2, set 3 and set 4, during matching should not occur. Provisions can be made in controlling the dimensions and shapes with upper and lower limits confirming to standards. At any time when a subsequent user is trying to access locked features, he can modify the features on his system and store as an additional modified copy of the features with Time Stamping and version names (allotted by the user / allotted by the system).


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## III. FUNCTIONAL UPDATE METHOD

When the network is trained with analog data, the number of iterations is large for the objective function (J) to reach the desired mean squared error (MSE). The objective function does not reach the desired MSE due to some local minima, whose domains of attractions are as large as that for the global minimum. The network converges to one of those local minima, or the network diverges. The updating of the weights will not stop, unless every input is outside the significant update region (0.1 to 0.9), and the outputs of the network will be approaching either 0 or 1. This requires much iteration for the network to converge. To overcome these difficulties, a functional criterion, which results in faster convergence of the network, is used.

The main idea of this method is that the weights of this network are updated only when any one of the nodes in the output layer of the network is misclassified. Even if one of the nodes in the output layer is not misclassified, no updating of weights is done. A node in the output layer is misclassified, if the difference between the desired output and the network is greater than 0.5.

The number of layers and the number of nodes in the hidden layers are decided. The weights among layers are initialized. A training pattern is presented to the input layer of the network, and the difference between the network's output and the target output is calculated for each node in the output layer. If the difference obtained for each node is greater than the value of a functional criterion, a counter is incremented and the weights are updated. If the difference of not even one node is greater than 0.5, no updating for the weights is done. The MSE of the network for each pattern is calculated only when at least one node in the output of the network is misclassified. Remaining training patterns are presented to the network. Training of the network is stopped when a performance index of the network is reached.

The algorithm for the functional update is as follows:

Step 1: The weights and thresholds of the network are initialized.

Step 2: The inputs and outputs of a pattern are presented to the network.

Step 3: The output of each node in the successive layers is calculated by:

$$O_{(\text{output of a node})} = 1/ (1+\exp (-\sum w_{ij}\, x_i)) \quad (1)$$

Step 4: The number of nodes in the output layer, which are misclassified, are denoted by 'nm'. A node is misclassified, if it does not satisfy the equation:

$$1-\varepsilon > D \geq 0.5 \quad (2)$$


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Where ε is the value fixed by the programmer, and

D = | Desired output-Network output | … **(3)**

If 'nm' is empty, i.e., not even one node satisfies equation 2, step 2 is adopted.

Step 5: If 'nm' is not empty, the objective function 'j' is computed by:

$$J = \frac{1}{2}\sum \sum_{Xi \in nm} D^2 \quad (4)$$

Step 6: The weights and thresholds are updated.

Step 7: The steps (2 to 6) are adopted, until the total MSE of all the patterns is below a specified value.

## IV. RESULTS AND DISCUSSION

Let us assume that there are two users editing the dial of the fork. User1 edits $O_1$ and hence $O_2$ will be locked sequentially (Table 1). Immediately user2 wants to edit $O_2$, however he will not get transaction as already $O_2$ is locked. However, user2 or any other user can try to access $O_3$ to $O_{14}$

**Table 1: Shape and dimension consistency management**

| Group | First feature | Remaining feature to be locked |
|---|---|---|
| G1 | 1 | 2 |
| G2 | 10 | 11,12,13,14 |
| G3 | 5 | 6,7,8 |
| G4 | 3 | 4 |

The variables used for training the ANN about locks assigned to different objects are transaction id, object id, lock mode (Table 2).

Transaction id represents the client or any other intermediate transactions

Object id represents the entire feature or an entity in the file. Mode represents type of lock assigned to an object.

In Table 2, column 1 represents the lock type. column 2 represents the value to be used in the input layer of the FUBPA. Column 3 gives binary representation of Lock type to be used in the output layer of FUBPA. The values are used as target outputs in the module during lock release on a data item.

**Table 2: Binary representation of lock type**

| Lock type | (Input layer representation numerical value). | Binary representation in target layer of the FUBPA |
|---|---|---|
| Object Not locked | 0 | 000 |
| S | 1 | 001 |
| X | 2 | 010 |
| IS | 3 | 011 |
| IX | 4 | 100 |

Initially, user 1 and user 2 have opened the same dial of fork file from the common database. The following steps shows sequence of execution and results

$T_1$ edits $O_1$ with write mode. Table 4 shows pattern formed for the training.

**Table3: First time pattern used for training FUBPA**

| Object number | Input pattern | Target output pattern |
|---|---|---|
| $O_1$ | [ 1 1] | [ 0 1 0] |

**Step 1:** The transaction manager locks objects mentioned in the third column of Table 1. Repeat step 1 with the patterns given in Table 4.


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| Table 4: Additional patterns used for training OML FUBPA | | |
|---|---|---|
| **Object number** | **Input pattern** | **Target output pattern** |
| $O_1$ | [ 1 1] | [ 0 1 0] |
| $O_2$ | [ 2 1] | [ 0 1 0] |

**Step 2:** A new transaction $T_2$ access $O_2$. A pattern is formed to verify if lock has been assigned to $O_2$ and its associated objects $O_1$. Only when the locks are not assigned to $O_2$ and $O_1$ then $T_2$ is allowed.

The following input patterns are presented to the testing module to find if the output [0 0 0] is obtained in the output layer. During testing, the final weights obtained during training will be used. Otherwise it means that lock has been assigned to either $O_2$. In such case, transaction is denied for $T_2$. Else the following Table 5 is presented in step 1

| Table 5: Additional patterns used for training FUBPA | | |
|---|---|---|
| **Object number** | **Input pattern** | **Target output pattern** |
| $O_1$ | [ 1 1 ] | [ 0 1 0] |
| $O_2$ | [ 2 1] | [ 0 1 0] |
| $O_3$ | [ 3 1 ] | [ 0 1 0] |
| $O_4$ | [ 4 1 ] | [0 1 0 ] |
| $O_5$ | [5 1] | [0 1 0] |
| $O_6$ | [6 1] | [0 1 0] |
| $O_7$ | [7 1] | [0 1 0] |
| $O_8$ | [8 1] | [0 1 0] |

**Step 3:** To know the type of lock value assigned to an object and for a transaction, testing is used. Testing uses the final weights created by training. The proposed FUBPA for lock state learning and lock state finding have been implemented using Matlab 7

## V. CONCLUSION

An artificial neural network with FUBPA has been implemented for providing concurrency control to maintain consistency in the CAD database. A dial of fork has been considered that contains 14 objects. The 14 objects have categorized into 4 groups. The transaction behavior and concurrency control by the two users on the 14 objects have been controlled using FUBPA network. The neural network method requires memory based on the topology used for storing objects and its transactions when compared with conventional method.

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# Computer Modelling of 3D Geological Surface

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*Abstract*— **The geological surveying presently uses methods and tools for the computer modeling of 3D-structures of the geographical subsurface and geotechnical characterization as well as the application of geoinformation systems for management and analysis of spatial data, and their cartographic presentation. The objectives of this paper are to present a 3D geological surface model of Latur district in Maharashtra state of India. This study is undertaken through the several processes which are discussed in this paper to generate and visualize the automated 3D geological surface model of a projected area.**

***Keywords-component; 3D Visualization, Geographical Information System, Digital Terrain Data Processing, Cartography.***

## I. INTRODUCTION

Traditional geological maps which illustrate the distribution and orientation of geological structures and materials on a two-dimensional (2D) ground surface are no longer sufficient for the storing, displaying, and analysing of geological information. It is also difficult and expensive to update traditional maps that cover large areas. Many kinds of raster and vector based models for describing, modelling, and visualizing 3D spatial data have been developed. At the mean time, with the fast development of sensor techniques and computer methods, several types of airborne or close range laser scanners are available for acquisition of 3D surface data in real or very fast time. A few more type of digital photogrammetry workstations are also available for semi-automatic interpretation of the complicated man made 3D surfaces. However due to image noises and limited resolution of current laser range data, so many existing techniques still need to be extended to fit real application.

This paper presents a fast and efficient method to automate the generation of 3D geological surfaces from 2D geological maps. The method was designed to meet the requirement in creating a three-dimensional (3D) geologic map model of Latur district in Maharashtra state of India. The LULC (Land Use and Land Cover) database [11] of National Remote Sensing Centre, ISRO, India, for Latur district has been used for visualization experiments. The elevation data pertaining to Latur district is obtained from USGS (United State Geological Survey) Seamless server database [10] of United States and is used for digital elevation modelling (DEM) experiments.

## II. STUDY AREA

Latur District is in the south-eastern part of the Maharashtra state in India. It is well known for its Quality of Education, Administration, food grain trade and oil mills. Latur district has an ancient historical background. The King 'Amoghvarsha' of Rashtrakutas developed the Latur city, originally the native place of the Rashtrakutas. The Rashtrakutas who succeeded the Chalukyas of Badami in 753 A.D called themselves the residents of Lattalut. Latur is a major city and district in Maharashtra state of India. It is well known for its quality of education, administration, food grain trade and oil mills. The district is divided into three sub-divisions and 10 talukas (sub-districts) [1].

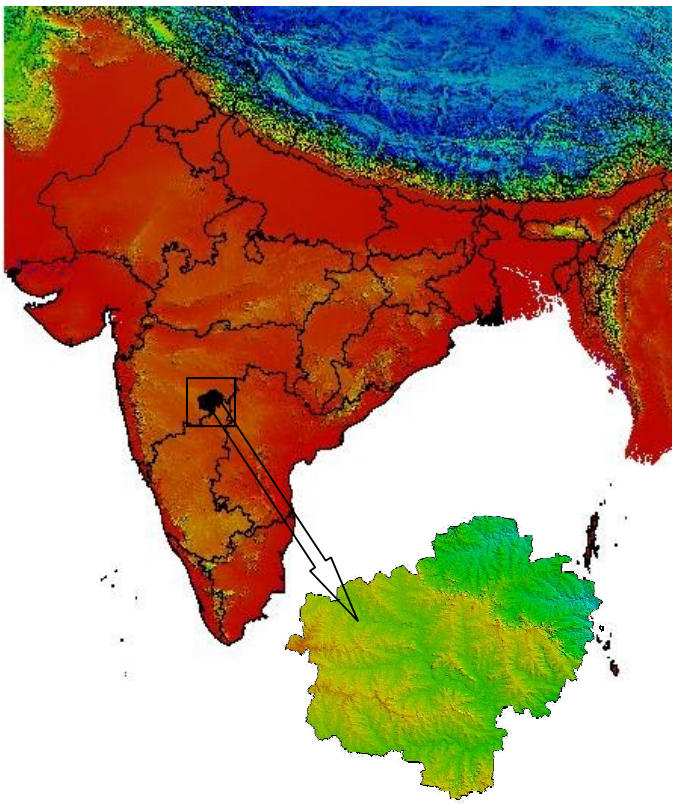

Figure 1. A false color composite imagery of India acquired by SPOT & IKONOS, the location of Latur district (Courtesy NRSA Hyd.).



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Latur is located at 18°24′N 76°35′E / 18.4°N 76.58°E / 18.4; 76.58 as shown in Fig.1. It has an average elevation of 631 meters (2070 feet). It is situated 636 meter above mean sea level. The district is situated on Maharashtra-Karnataka boundary. On the eastern side of the Latur is Bidar district of Karnataka, whereas Nanded is on the Northeast, Parbhani district on the northern side, Beed on the Northwest and Osmanabad on the western and southern side. The entire district of Latur is situated on the Balaghat plateau, 540 to 638 meters from the mean sea level.

## III. AUTOMATED 3D SURFACE MODEL

3D geological information systems provide a means to capture, model, manipulate, retrieve, analyse, and present geological situations. Traditional geological maps which illustrate the distribution and orientation of geological materials and structures on a 2D ground surfaces provide vast amounts of raw data. It is thus vital to develop a set of intelligent maps that shows features of geological formations and their relationships[2].

### *A. Digital Elevation Model of Latur district*

DEM is a representation of the terrain surface by coordinates and numerical descriptions of altitude. DEM is easy to store and manipulate, and it gives a smoother, more natural appearance of derived terrain features. Therefore, the created DEM is the foundation of 3D geological maps when the z-coordinates of the vertices of geological formations can be interpolated. The data consists of 4 topographical map sheets, with 3D coordinates of terrain, contour lines, and other information. The maps are in GEOTIFF format at a scale of 1:150000 (Fig.2). These DEMs were then integrated into a whole DEM of Latur using a DEM Global Mapper. The final gridded DEM data with 5-metre intervals for Latur district was obtained (Fig.2). The file size is about 4.83MB.

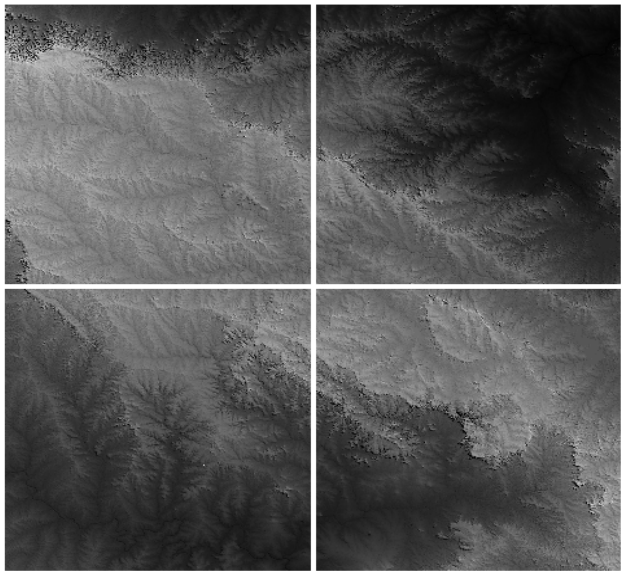

Figure 2. Tiled DEM of Latur District (courtesy USGS).

### *B. Cropping DEMs using Latur district base map shape file.*

After integrating DEMs tiles, the next process is to extract (crop) the required region of Latur district from integrated DEMs using the latur district base map shape file. For this process, we use the software GLOBAL MAPPER 11v to crop the DEMs with only required region's terrain data. The remaining area is considered as null data as shown in Fig.3.

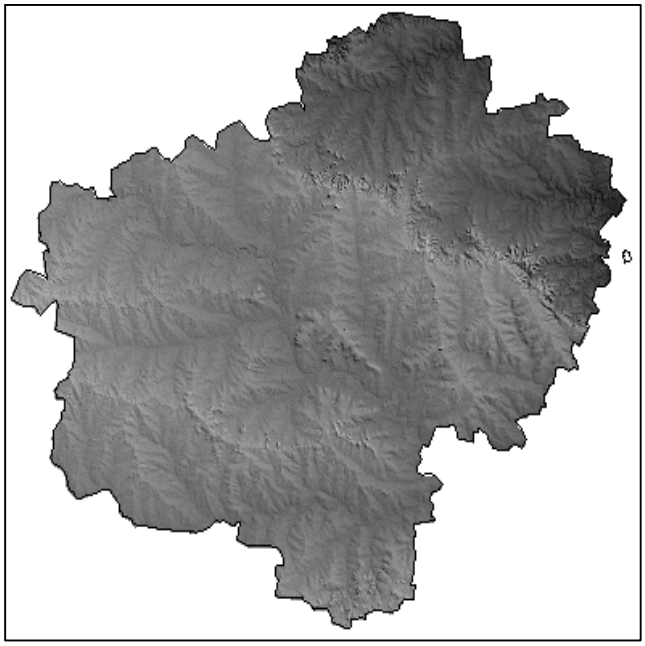

Figure 3. Cropped DEM using Latur district base map.

### *C. Accessing and concatenating DEMs in MATLAB*

After the successful cropping of all the DEM data sheets (tiles), we import them in MATLAB for further processes. The DEMs can be converted in to DTED (Digital Terrain Elevation Data) version 0,1,2.. any format, and import them in MATLAB. The DTED0 files have 120-by-120 points. DTED1 files have 1201-by-1201. The edges of adjacent tiles have redundant records.

Acquiring all the data sheets with their specified location (projection) and sequence of data sheets are very important here.

Concatenation of the DEM tiles with respect to their locations needs horizontal and vertical concatenation.

#### *1) Horizontal Concatenation*

First, we concatenate the matrices of top-left and top-right tiles (Fig.2), i.e. Horizontal concatenation.

$$H1 = TL \text{ (horzcat) } TR . \quad (1)$$

where H1 is a concatenated matrix of top-left (TL) and top-right (TR) matrices.


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Next, we concatenate the matrices of Bottom-Left and Bottom-Right tiles, i.e. again Horizontal concatenation.

H2=BL (horzcat) BR (2)

where H2 is a concatenated matrix of Bottom-left (BL) and Bottom-right (BR) matrices.

*2) Vertical Concatenation*

Next, we need to concatenate H1 and H2 matrices vertically, i.e.

H = H1 (vertcat) H2 (3)

where H is a complete concatenated matrix of H1 and H2.

### *D. Visualizing 3D geographical surface model*

A workflow was chosen, on the one hand, by applying GIS methods using ESRI shape files and global mapper software for data acquisition, maintenance, and presentation and on the other hand, by applying three-dimensional spatial modelling with a interactive 3D modelling in MATLAB. Based on Non-Uniform Rational data, any geometric shape can be modelled. Besides surfaces of the different engineering geological units, solids using boundary representation techniques were modelled [3]. In MATLAB it is one of the easiest way to visualize the well defined projected data sets in 3D view using mathematical functions surf() and mesh(). To visualize the acquired projected data set over a rectangular region, we need to create colored parametric surfaces specified by X, Y, and Z, with color specified by Z.

A parametric surface is parameterized by two independent variables, i and j, which vary continuously over a rectangle; for example, 1<=i<=m and 1<=j<=n. The three functions x(i,j), y(i,j), and z(i,j) specify the surface. When i and j are integer values, they define a rectangular grid with integer grid points. The functions x(i,j), y(i,j), and z(i,j) become three m-by-n matrices, X, Y, and Z. Surface color is a fourth function, c(i,j), denoted by matrix C. Each point in the rectangular grid can be thought of as connected to its four nearest neighbours [6].

$$\begin{array}{c} i-1,j \\ | \\ i,j-1 - i,j - i,j+1 \\ | \\ i+1,j \end{array} \qquad (4)$$

Surface color can be specified in two different ways: at the vertices or at the centers of each patch. In this general setting, the surface need not be a single-valued function of x and y. Moreover, the four-sided surface patches need not be planar. For example, one can have surfaces defined in polar, cylindrical, and spherical coordinate systems [8].

The shading function sets the shading. If the shading is interpolates, C must be of the same size as X, Y, and Z; it specifies the colors at the vertices. The color within a surface patch is a bilinear function of the local coordinates. If the shading is faceted (the default) or flat, C(i,j) specifies the constant color in the surface patch:

$$\begin{array}{c} (i,j) \quad - \quad (i,j+1) \\ | \quad C(i,j) \quad | \\ (i+1,j) \quad - \quad (i+1,j+1) \end{array} \qquad (5)$$

In this case, C can be the same size as X, Y, and Z and its last row and column are ignored. Alternatively, its row and column dimensions can be one less than those of X, Y, and Z.

### *E. Assigning axes to 3D model*

MATLAB automatically creates an axes, if one does not already exist, when you issue a command that creates a graph, but the default axes assigned by MATLAB doesn't match with real coordinate systems of this projected area.

This existing model is built with 3 axes data x, y and z respectively. The X and Y axis represents the latitude and longitude values for this model i.e.

UPPER LEFT X=76.2076079218
UPPER LEFT Y=18.8385493143
LOWER RIGHT X=77.2934412815
LOWER RIGHT Y=17.8677159574

WEST LONGITUDE=76° 12' 27.3885" E
NORTH LATITUDE=18° 50' 18.7775" N
EAST LONGITUDE=77° 17' 36.3886" E
SOUTH LATITUDE=17° 52' 3.7774" N

The above shown values are associated with all four tiles of DTED files. The Z axis itself represents the terrain (height) values of ground surface objects. Here in this model the elevation data is assigned in feet scale format i.e. 0 to 3000 feets.

## IV. RESULTS

With reference to the processes discussed above, the 3D visualization experimental results are shown in the Figs. 4, 5 and 6 for 3D model of Latur district geological surface.


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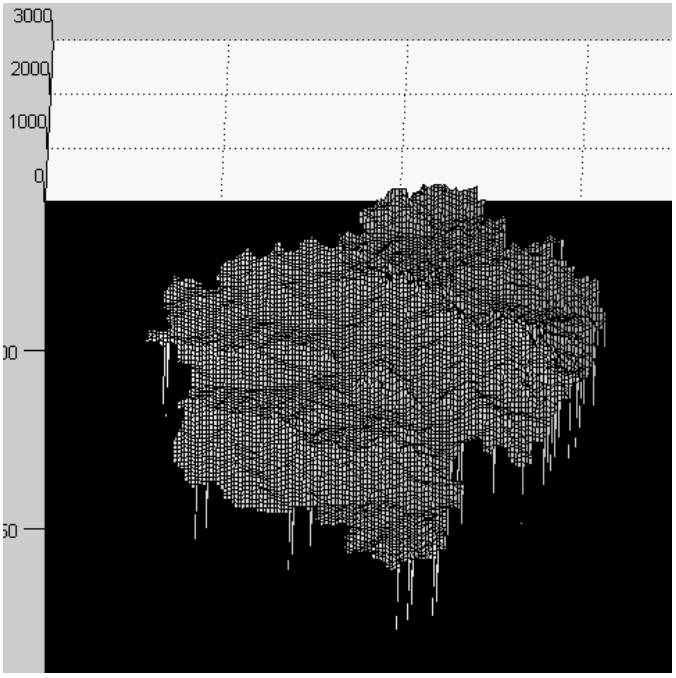


Figure 4. A 70o camera view point of surface model with gray color scheme.

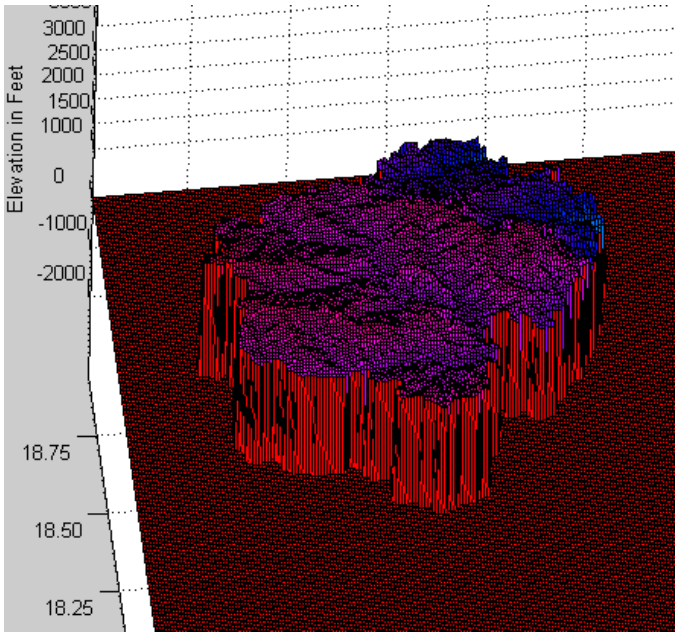


Figure 5. A 45o camera view point of surface model with HSV color scheme.

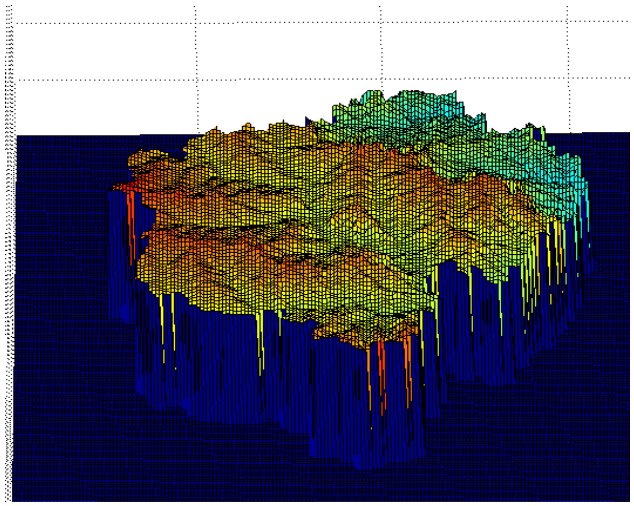

Figure 6. A true color composite scheme (Atlas shader) 3D model.

## V. CONCLUSIONS AND FUTURE WORK

Some key processes for automated 3D geological surface modeling such as data acquisition, concatenation, 3D surface modeling and axes data managing have been presented.
The visualization experiments are done using data for Latur district. In the future work, we attempt to overlay real time map layers on this 3D surface model.

## ACKNOWLEDGEMENT

The authors are indebted to the National Remote Sensing Centre (NRSC), ISRO, India, for providing LULC digital data of Latur district, and to United States Geological Survey (USGS) for providing access to elevation data for Latur district.

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# Sectorization of Haar and Kekre's Wavelet for Feature Extraction of color images in Image Retrieval

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***Abstract-*** **This paper presents the Innovative idea of Sectorization of Haar Wavelet transformed images and Kekre's Wavelet Transformed images to extract features for image retrieval. Transformed images have been sectored into 4,8,12 and 16 sectors. Each sector produces the feature vector component in particular sector size. Thus the feature vector size increases with the increase in the sector size. The experiment of augmenting the feature vectors with extra components performed .The performance of proposed method of sectorization checked with respect to increase in sector sizes, effect of augmentation of extra components in both Haar and Kekre's Wavelet sectorization .The retrieval rate checked with crossover of average precision and recall. LIRS and LSRR are calculated for average of randomly selected 5 images of all 12 classes and compared with the overall average of LIRS/LSRR. The work experimented over the image database of 1055 images and the performance of image retrieval with respect to two similarity measures namely Euclidian distance (ED) and sum of absolute difference (AD) are measured.**

***Keywords- CBIR, Haar Wavelet, Kekre's Wavelet Euclidian Distance, Sum of Absolute Difference, LIRS, LSRR, Precision and Recall.***

## I. INTRODUCTION

Digital world of the current era needs storage and management of bulky digital images. It is the need of the century to have better mechanism to store, manage and retrieve whenever needed digital images from the large database. Content-based image retrieval (CBIR), [1-4] is any technology that in principle helps to achieve this motive by their visual content. By this definition, anything ranging from an image similarity function to a robust image annotation engine falls under CBIR. This characterization of CBIR as a field of study places it at a unique juncture within the scientific community. It is believed that the current state-of-the-art in CBIR holds enough promise and maturity to be useful for real-world applications if aggressive attempts are made. For example, many commercial organizations are working on image retrieval despite the fact that robust text understanding is still an open problem. Of late, there is renewed interest in the media about potential real-world applications of CBIR and image analysis technologies, There are various approaches which have been experimented to generate the efficient algorithm for CBIR like FFT, DCT, DST, WALSH sectors [8-14][21][22], Transforms [16][17], Vector quantization[17], bit truncation coding [18][19].

The problem of CBIR still needs lots of research to achieve the better retrieval performance. It needs extensive experiments on all of its parameters i.e. Feature extraction, similarity measures, retrieval performance measuring parameters.

In this paper we have introduced a novel concept of Sectorization of Haar Wavelet and Kekre's Wavelet in both column wise and row wise transformed color images for feature extraction (FE).Two different similarity measures namely sum of absolute difference and Euclidean distance are considered. Average precision, Recall, LIRS and LSRR are used for performances study of these approaches.

## II. HAAR WAVELET [5]

The Haar transform is derived from the Haar matrix. The Haar transform is separable and can be expressed in matrix form

$$[F] = [H]\,[f]\,[H]^T$$

Where f is an NxN image, H is an NxN Haar transform matrix and F is the resulting NxN transformed image. The transformation H contains the Haar basis function hk(t) which are defined over the continuous closed interval $t \in [0,1]$.

The Haar basis functions are



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- When k=0, the Haar function is defined as a constant

  $\mathbf{h_k(t) = 1/\sqrt{N}}$
- When k>0, the Haar Function is defined as

$$h_k(t) = \frac{1}{\sqrt{N}} \begin{cases} 2^{p/2} & (q-1)/2^p <= t < (q-0.5)/2^p \\ -2^{p/2} & (q-0.5)/2^p <= t < q/2^p \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

$$\text{Where } 0 \le p < \log_2 N \text{ and } 1 \le q \le 2^p$$

## III. KEKRE'S WAVELET [5]

Kekre's Wavelet transform is derived from Kekre's transform. From NxN Kekre's transform matrix, we can generate Kekre's Wavelet transform matrices of size (2N)x(2N), (3N)x(3N),……, (N2)x(N2). For example, from 5x5.Kekre's transform matrix, we can generate Kekre's Wavelet transform matrices of size 10x10, 15x15, 20x20 and 25x25. In general MxM Kekre's Wavelet transform matrix can be generated from NxN Kekre's transform matrix, such that M = N * P where P is any integer between 2 and N that is, $2 \le P \le N$. Kekre's Wavelet Transform matrix satisfies $[K][K]_T = [D]$ Where D is the diagonal matrix this property and hence it is orthogonal. The diagonal matrix value of Kekre's transform matrix of size NxN can be computed as

$$D(x,y) = \begin{cases} 2 & , \text{if } x = y = N \\ N & , \text{if } x = y = 1 \\ 0 & , \text{if } x \neq y \\ D(x+1,y+1) + 2(N-x+1) & , \text{if } x=y=p \text{ and } p \neq 1 \text{ or } N \end{cases}$$

**(2)**

## IV. SECTORIZATION OF TRANSFORMED IMAGES [8-14]

### *A. 4 Sector Formation*

Even and odd rows/columns of the transformed images are checked for sign changes and the based on which four sectors are formed as shown in the Figure 1 below:

**Computation of 4 Sectors**

| Sign of Even row/column | Sign of Odd row/column | Quadrant Assigned |
|---|---|---|
| + | + | I (0 –90°) |
| + | - | II (90 – 180°) |
| - | - | III( 180- 270°) |
| - | + | IV(270–360°) |

Figure 1: Computation of 4 Sectors

### *B. 8 Sectors Formation*

The transformed image sectored in 4 sectors is taken into consideration for dividing it into 8 sectors. Each sector is of angle 45°. Coefficients of the transformed image lying in the particular sector checked for the sectorization conditions as shown in the Figur2.

**Computation of 8 Sectors**

| Sectors | Conditions |
|---|---|
| I,IV,V,VIII | \|A\| >= \|B\| |
| II,III,VI,VII | \|B\| >= \|A\| |
| Where<br>A = Even Row / Column of Transformed Image<br>B = Odd Row / Column of Transformed Image | |

Figure 2:Computation of 8 Sectors

### *C. 12 Sector Formation.*

Division each sector of 4 sectors into angle of 30° forms 12 sectors of the transformed image. Coefficients of the transformed image are divided into various sectors based on the inequalities shown in the Figure 3.

**Computation of 12 Sectors**

| Sectors | Conditions |
|---|---|
| I, IV, VII, X | $\|A\| >= \sqrt{3} * \|B\|$ |
| II, V, VIII, XI | $1/\sqrt{3} * \|A\| <= \|B\| <= \sqrt{3} * \|A\|$ |
| III, VI, IX, XII | Otherwise |
| Where<br>A = Even Row / Column of Transformed Image<br>B = Odd Row / Column of Transformed Image | |

Figure 3:Computation of 12 Sectors



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*D. 16 Sector Formation:*

Similarly we have done the calculation of inequalities to form the 16 sectors of the transformed image. The even/odd rows/ columns are assigned to particular sectors for feature vector generation

## V. EXPERIMENTAL RESULTS

We have used the augmented Wang image database [2] The Image database consists of 1055 images of 12 different classes such as Flower, Sunset, Barbie, Tribal, Cartoon, Elephant, Dinosaur, Bus, Scenery, Monuments, Horses, Beach. Class wise distribution of all images in the database has been shown in the Figure 4.

| | | | | | |
|---|---|---|---|---|---|
| **Class** |  |  |  |  |  |
| **No. of Images** | 45 | 59 | 51 | 100 | 100 |
| **Class** |  |  |  |  |  |
| **No. of Images** | 100 | 100 | 100 | 100 | 100 |
| **Class** |  |  | | | |
| **No. of Images** | 100 | 100 | | | |

Figure 4: Class wise distribution of images in the Image database

Figure5. Query Image

The query image of the class Horse has been shown in Figure 5. For this query image the result of retrieval of both Column wise and Row wise Haar and Kekre's wevlet transformed images for all sectors are checked. The Figure 6 shows the first 20 retrieval for the query image with respect to of Row wise Haar Wavelet Sectorization for its 16 Sectors with sum of absolute difference as similarity measure. It can be observed that the retrieval of first 20 images are of relevant class i.e. Horse; there are no irrelevant images till first 45 retrievals in both cases. The result of row wise Kekre's Wavelet shown in Figure 7; the retrieval of first 20 images is same as Kekre's Wavelet except the order of retrieval of images changes.

Figure 6: First 20 Retrieved Images of Row wise Haar wavelet (16 Sectors)

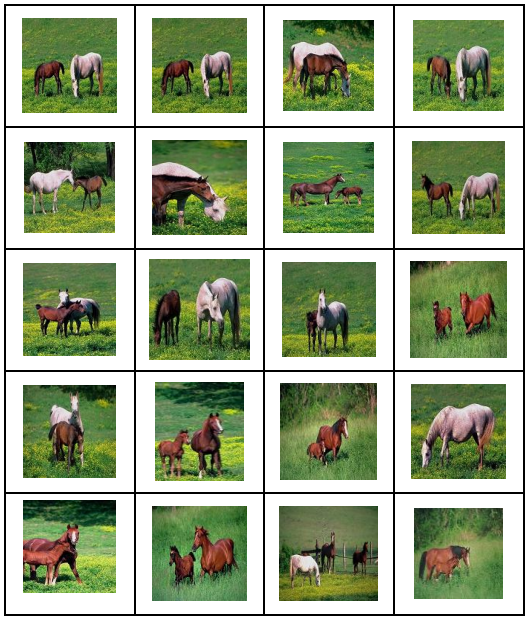

Figure 7: First 20 Retrieved Images of Row wise Kekre's Wavelet Sectorization (16 Sectors).

Once the feature vector is generated for all images in the database a feature database is created. 5 randomly chosen query images of each class is produced to search the database. The image with exact match gives minimum absolute difference and Euclidian distance. To check the effectiveness of the work and its performance with respect to retrieval of the images we have calculated the overall



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average precision and recall as given in Equations (3) and (4) below. Two new parameters i.e. LIRS and LSRR are introduced as shown in Equations (5) and (6).

$$\text{Precision} = \frac{\text{Number of Relevant images Retrieved}}{\text{Total Number of Images Retrieved}} \quad (3)$$

$$\text{Recall} = \frac{\text{Number of Relevant Images Retrieved}}{\text{Total Number of Relevant Images in the Database}} \quad (4)$$

$$\text{LIRS} = \frac{\text{Length of Initial Relevant string of Images}}{\text{Total Relevant Images Retrieved}} \quad (5)$$

$$\text{LSRR} = \frac{\text{Length of String to Recover all Relevant Images}}{\text{Total Images in the Database}} \quad (6)$$

All these parameters lie between 0-1 hence they can be expressed in terms of percentages. The newly introduced parameters give the better performance for higher value of LIRS and Lower value of LSRR [8-13].The class wise performance of the proposed algorithm with respect to average precision and recall cross over points in all sectors for both Haar Wavelet (Row wise and column wise) and Kekre's Wavelet (Row wise and column wise) with the consideration of two similarity measures namely Euclidean distance(ED) and sum of absolute difference (AD) has been shown in Figure 8- Figure 11.The average value of each method has been plotted as horizontal lines to compare the individual class performances .It is seen that sectorization of column wise performs better than row wise transformed images in both HAAR and Kekre's wavelet. The use sum of absolute difference gives better retrieval for in all sectors except 16 sectors compared to Euclidian distance for all classes of images. The retrieval performance for each classes vary as it is observed that Diana sour, flowers, sunset and horses have maximum of retrieval i.e. 80%, 70%,50% and 50% respectively.

The Figure 12 depicts the overall average performances of Haar and Kekre's wavelet. It shows that for sector sizes 4,8,12 Haar wavelet has retrieval performance than Kekre's wavelet. The sectorization of column wise transformed images is far better i.e. on average 45% than row wise i.e. on average 30%.The performance of the proposed algorithm is checked with respect to two new parameters i.e. LIRS and LSRR .The class wise performance of LIRS and LSRR shown in Figure 13-Figure 20.The class having maximum value of average precision and recall cross over point must have maximum LIRS and Minimum LSRR. Taking the example of Diana sour class which has cross over points as: 80% (Row wise and column wise Haar and Kekre's Wavelet), has maximum LIRS (see Figures 13,14,17 and Figure 18) and Minimum LSRR (see Figures 15,16,19 and 20).Similarly these parameters can be easily checked for other classes as well. Thus these parameters are very useful to check the performances of the retrieval in CBIR.

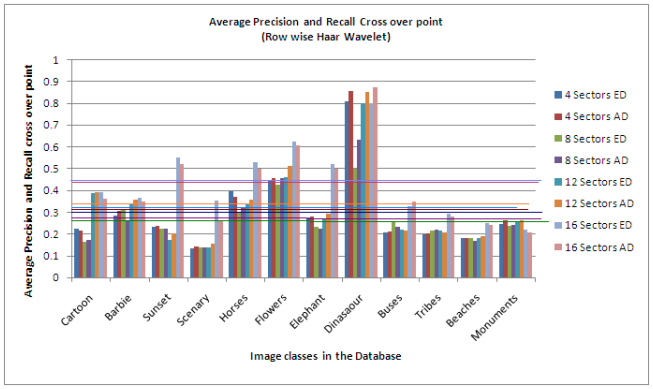


Figure 8: Overall Average Precision and Recall performance of Sectorization of Row wise Haar Wavelet. Absolute Difference(AD) and Euclidian Distance (ED) as similarity measures.

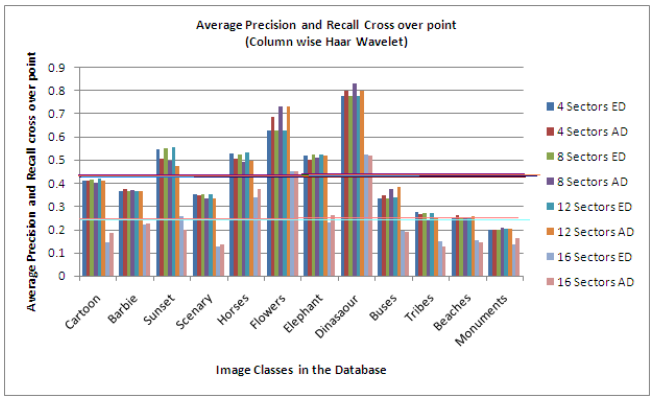


Figure 9: Overall Average Precision and Recall performance of Sectorization of Column wise Haar Wavelet. Absolute Difference (AD) and Euclidian Distance (ED) as similarity measures

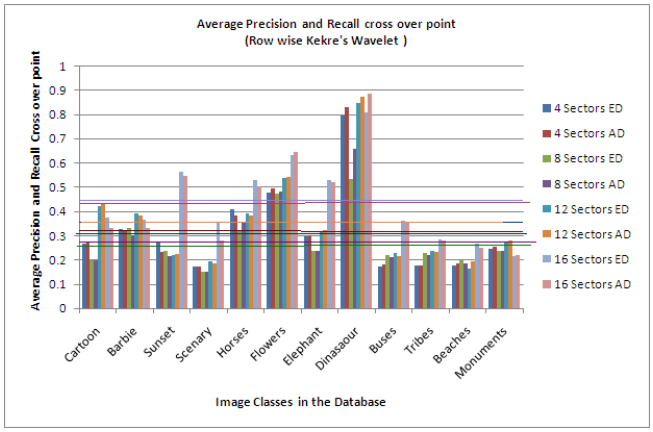


Figure 10: Overall Average Precision and Recall performance of Row wise Kekre's Wavelet Sectorization



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with Absolute Difference (AD) and Euclidian Distance (ED) as similarity measures

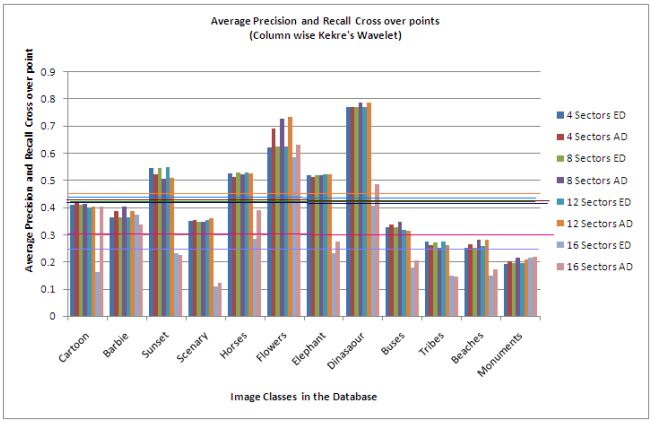


Figure 11 Overall Average Precision and Recall performance of Column wise Kekre's Wavelet Sectorization with Absolute Difference (AD) and Euclidian Distance (ED) as similarity measures

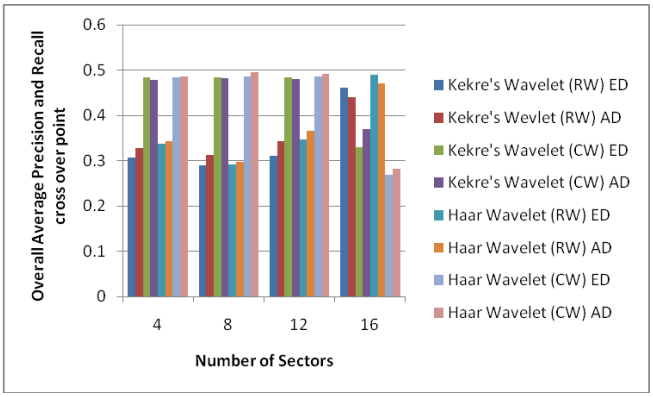


Figure 12: Comparison of Overall Precision and Recall cross over points of Kekre's Wavelet and Haar Wavelet with Absolute Difference (AD) and Euclidean Distance (ED) as similarity measure.

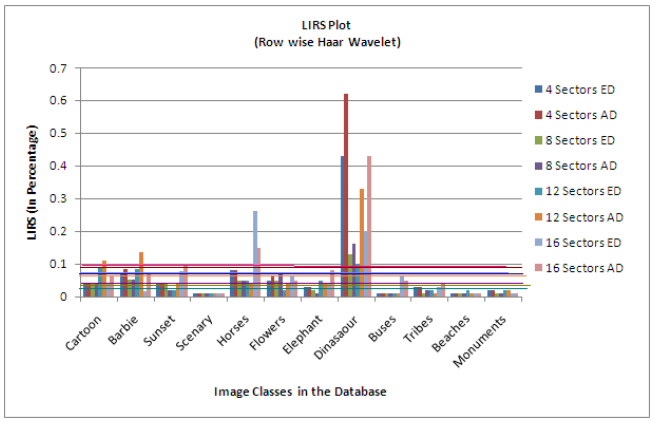


Figure 13: The LIRS Plot of Row wise Haar transformed images . Overall Average LIRS performances (Shown with Horizontal lines :0.068 (4 Sectors ED), 0.086 (4 Sectors AD), 0.036(8 Sectors ED), 0.038(8 Sectors AD), 0.040(12 Sectors ED), 0.066(12 Sectors AD), 0.068(16 Sectors ED), 0.088(16 Sectors AD) ).

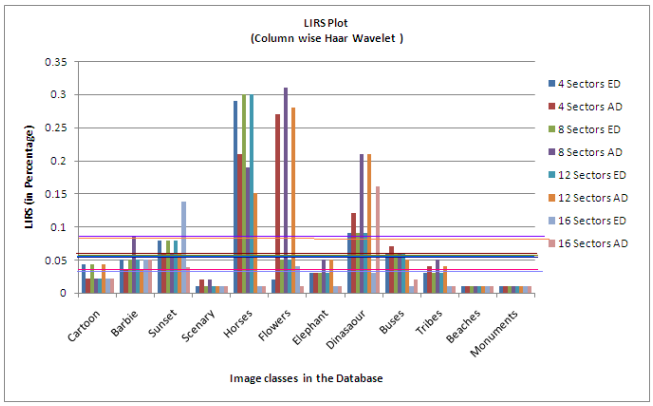


Figure 14: The LIRS Plot of Column wise Haar transformed images . Overal Average LIRS performances (Shown with Horizontal lines :0.060 (4 Sectors ED), 0.074 (4 Sectors AD), 0.063(8 Sectors ED), 0.089(8 Sectors AD), 0.061(12 Sectors ED), 0.078(12 Sectors AD), 0.029(16 Sectors ED), 0.030(16 Sectors AD) ).



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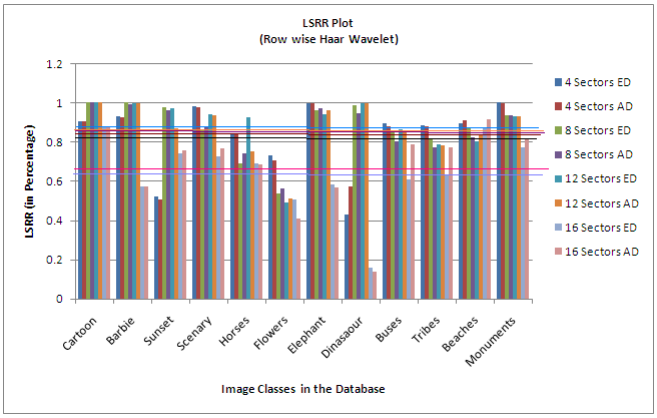


Figure 15: The LSRR Plot of Row wise Haar transformed images . Overall Average LSRR performances (Shown with Horizontal lines :0.83 (4 Sectors ED), 0.84 (4 Sectors AD), 0.87(8 Sectors ED), 0.86(8 Sectors AD), 0.88(12 Sectors ED), 0.86(12 Sectors AD), 0.64(16 Sectors ED), 0.67(16 Sectors AD) ).

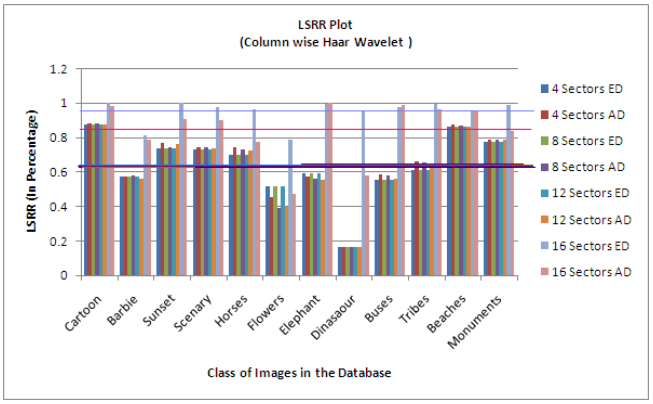


Figure 16: The LSRR Plot of Column wise Haar transformed images . Overall Average LSRR performances (Shown with Horizontal lines :0.63(4 Sectors ED), 0.65 (4 Sectors AD), 0.639(8 Sectors ED), 0.638(8 Sectors AD), 0.639(12 Sectors ED), 0.633(12 Sectors AD), 0.94(16 Sectors ED), 0.84(16 Sectors AD) ).

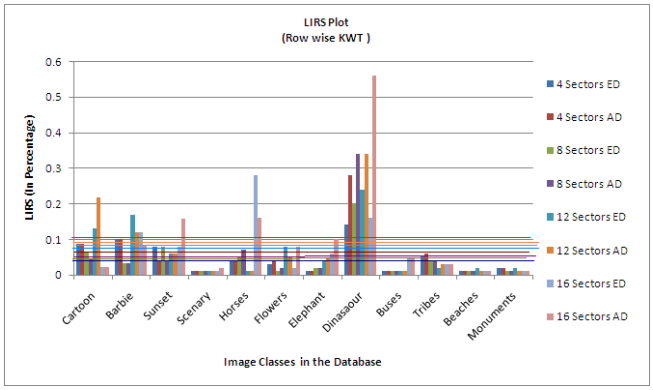


Figure 17: The LIRS Plot of Row wise KWT transformed images . Overall Average LIRS performances (Shown with Horizontal lines :0.048 (4 Sectors ED), 0.059 (4 Sectors AD), 0.044(8 Sectors ED), 0.053(8 Sectors AD), 0.067(12 Sectors ED), 0.076(12 Sectors AD), 0.070(16 Sectors ED), 0.10(16 Sectors AD) ).

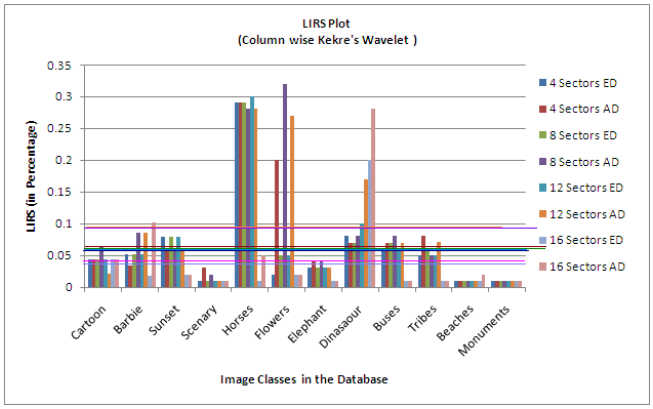


Figure 18: The LIRS Plot of Column wise KWT transformed images . Overall Average LIRS performances (Shown with Horizontal lines :0.061 (4 Sectors ED), 0.078 (4 Sectors AD), 0.064(8 Sectors ED), 0.091(8 Sectors AD), 0.066(12 Sectors ED), 0.090(12 Sectors AD), 0.030(16 Sectors ED), 0.048(16 Sectors AD) ).



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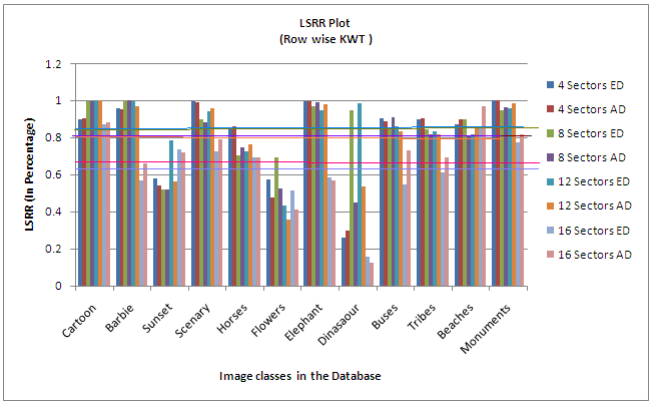


Figure 19: The LSRR Plot of Row wise KWT transformed images . Overall Average LSRR performances (Shown with Horizontal lines :0.813 (4 Sectors ED), 0.807 (4 Sectors AD), 0.085(8 Sectors ED), 0.80(8 Sectors AD), 0.85(12 Sectors ED), 0.80(12 Sectors AD), 0.63(16 Sectors ED), 0.67(16 Sectors AD) ).

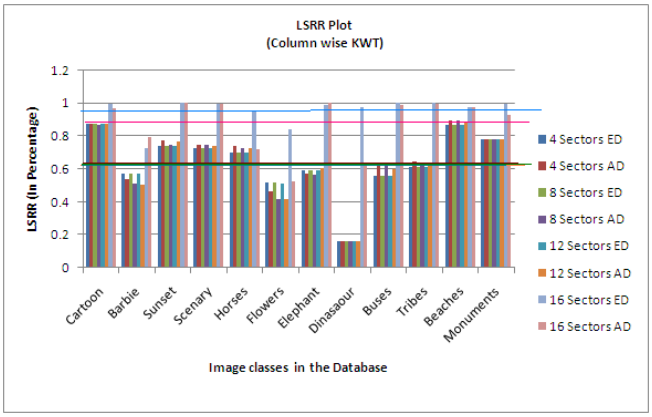


Figure 20: The LSRR Plot of Column wise KWT transformed images . Overall Average LSRR performances (Shown with Horizontal lines :0.639 (4 Sectors ED), 0.648 (4 Sectors AD), 0.639(8 Sectors ED), 0.637(8 Sectors AD), 0.639(12 Sectors ED), 0.637(12 Sectors AD), 0.950(16 Sectors ED), 0.873(16 Sectors AD) ).

## VI. CONCLUSION

The work experimented on 1055 image database of 12 different classes discusses the performance of sectorization of Haar wavelet and Kekre's wavelet transformed color images for image retrieval. The work has been performed with both approaches of column wise and row wise transformation. The performance of the proposed method is checked with respect to various sector sizes and similarity measuring approaches namely Euclidian distance and sum of absolute difference. It has been observed that the combination of column wise Haar wavelet sectorization with sum of absolute difference and augmented feature vector gives better performance as far as overall average precision and recall cross over point s concerned as compared to Kekre's Wavelet transform as shown in the Figure 12. The newly introduced parameter LIRS and LSRR gives good platform for performance evaluation to judge how early all relevant images is being retrieved (LSRR) and it also provides judgement of how many relevant images are being retrieved as part of first set of relevant retrieval (LIRS).The sum of absolute difference as similarity measure is recommended due to its lesser complexity and better retrieval rate performance compared to Euclidian distance.

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**Dhirendra Mishra** has received his BE (Computer Engg) degree from University of Mumbai. He completed his M.E. (Computer Engg) from Thadomal shahani Engg. College, Mumbai, University of Mumbai. He is PhD Research Scholar and working as Associate Professor in Computer Engineering department of Mukesh Patel School of Technology Management and Engineering, SVKM's NMIMS University, Mumbai, INDIA. He is life member of Indian Society of Technical education (ISTE), Member of International association of computer science and information technology (IACSIT), Singapore, Member of International association of Engineers (IAENG). His areas of interests are Image Processing, Operating systems, Information Storage and Management



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# A Survey on Joint and Distributed Routing for 802.16 WiMAX Networks

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***Abstract*---**The growing demand for last mile broadband access is resulted from the increased growth of speedy multimedia services for mobile, residential and little business customers. Technologies based on 802.16 WiMAX (Worldwide Interoperability Microwave Access) ensures to offer high data rates in long distance and afford multimedia services and are expected to act as key issue for high speed broadband services. The technique for building multi-hop mesh is provided by IEEE 802.16 WiMAX standard. This can be act as high speed wide-area wireless network and can afford better wireless coverage up to 5 miles with Line of Sight (LOS) transmission inside the bandwidth of around 70 Mbps. As the wireless environment varies unexpectedly, routing in wireless network is challenging work. There are several demands for IEEE 802.16 WiMAX routing like delay, long transmission scheduling, increasingly stringent Quality of Service (QoS) support, load balance and fairness restrictions. The aim of this survey is to analyze some of the routing protocols proposed by various authors for IEEE 802.16 WiMAX networks.

***Keywords*---**IEEE 802.16, Routing Algorithm, Wireless mesh networks, Scheduling.

## I. INTRODUCTION

IN present telecommunications, networking and services are varying in a rapid way to support next generation Internet user environment. Wireless networks will play a significant role in supporting next generation Internet. Wireless broadband networks are being increasingly deployed and used in the last mile for extending or enhancing Internet connectivity for fixed and/or mobile clients situated on the edge of the wired network.

WiMAX is considered as an important wireless technology and involved in several probable applications in case of high data rate, greater network coverage, strong QoS capabilities and cheap network deployment and maintenance costs. This is estimated to support many business applications which require the support of quality of service. WiMAX can be modified to apply in different modes such as point-to-multipoint (PMP) or Mesh mode based on applications and network investment.

The vast increasing user demand for faster connection in Web and VoIP services has lead to the progress of new broadband access technologies in the current days. In the year 2004, a IEEE 802.16 standard which is generally called as WiMAX is finalized in order to provide last-mile fixed wireless broadband access in the Metropolitan Area Network (MAN) with performance as good as to conventional cable, DSL or T1 networks.

The frequency required for the operation of IEEE 802.16 in case of Line-of-Sight (LOS) is 10 to 66 GHz, whereas, for non Line-of-Sight, operating frequency is 2 to 11 GHz. Orthogonal frequency division multiplexing (OFDM) is utilized in the physical layer in order to support adaptive modulation and coding. Based on the condition of channel, this can afford a data rate up to 134 Mbps per base station for each channel of 28 MHz. An IEEE 802.16 network contains Base Station (BS) and multiple Subscriber Stations (SSs). The Base Station acts as a gateway for the Subscriber Stations to the external network, and each SS acts as an access point that aggregates traffic from end users in a several geographical area.

Most of the nodes are either stable or minimally movable in case of community wireless networks. This lead to the focus of routing protocol in improving the capacity of network or the performance of individual transfer, rather than focusing on movement of nodes of decreasing the power consumption. The major problem faced by such network lies in the loss in the full capacity because of interference among multiple concurrent transmissions. There are also certain basic difficulties in routing in wireless networks. Routing model has to support in both short time scales and long time scales. A better wireless routing protocol has to support equally for stability in long term route and accomplish opportunistic performance for shore term route. The robustness against a wide spectrum of soft and hard failures should be attained by the Wireless routing which ranging from transient channel outages, links with intermediate loss rates, from several channel disconnections, nodes under denial-of-service (DOS) attacks, and failing nodes. So challenges in routing protocol are to deal with both these problems. At the same time, it should support large node population by modifying itself to necessary extent. The random routing is provided in IEEE 802.16 protocol in which parents are selected in random with the help of SSs while building the tree. This paper presents some of the routing techniques proposed by different author for 802.16 WiMAX networks.


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## II. LITERATURE SURVEY

Konark [1] proposed a routing and scheduling algorithm of IEEE 802.16 mesh backhaul network for radio resource management (RRM). The resource allocation concerned in IEEE 802.16 mesh backhaul network is investigated by the author. The multipath routing is the major issue considered here in order to utilize the resources of wireless radio efficiently and hence providing spectral efficiency. The main characteristic of scheduling technique is to permit the dynamic dispatching of data blocks. This is based on the condition of present buffer and the condition of route without knowing the demand in traffic. Hence it is helpful for heterogeneous traffic load which is supported by IEEE 802.16 Network which is a strong candidate in Wireless Networking characteristics. The load demand information of application layer and the interference information of PHY layer are utilized by routing protocol. The routing protocol is designed in order that the least mean path interference should be provided from the multiple hops. The scheduling technique is designed in order that it should find the maximum number of concurrent transmission which satisfies the Signal- to- interference plus noise ratio (SINR) limitations. In both the techniques, the iterative allocation continues until there is no unallocated capacity request.

Kaarthick *et al.,* [2] presented an adaptive routing algorithm to support distributed services in WiMAX. For stationary and mobile hosts, IEEE 802.16 is considered as a cost effective solution to Internet broadband access in the recent years. The WiMAX network can be enabled with distributed services in order to support several customers in the WiMAX network efficiently. An adaptive routing technique is proposed by the author for calculating the bandwidth guaranteed paths with the help of disciplined flooding and proxy setup to provide distributed services in IEEE 802.16e. The performance of the algorithm can be computed with the help of AODV technique which act as a benchmark algorithm. The evaluation of this technique is based on the following four metrics:

- Route discovery time
- Delay
- Total errors sent
- Total packets dropped

Susana *et al.,* [3] put forth hybrid WiFi-WiMAX network routing protocol. The growth of multihop routing protocols is supported by the proliferation of Wireless Local Area Networks (WLANs). In addition, the requirement to cover larger areas has led to the development of fresh standards for Wireless Metropolitan Area Networks (WMANs). A new routing technique is developed by the author in order to combine WLANs and WMANs which will results in better interconnectivity.

Kuran *et al.,* [4] given a Cross-Layer Routing-Scheduling in IEEE 802.16 mesh networks. For the Internet Protocol-based fourth-generation (4G) wireless communication systems, broadband wireless access networks will be a fundamental component that is a part convergent and pervasive networking architecture. One of the major active techniques for broadband wireless access is IEEE 802.16 Mobile WiMAX. There are several challenges for the mixing of WiMAX and next-generation broadband networks such as diverse operational environment, increasingly stringent QoS support, power/coverage limitations and capacity boundaries. The possible solution to this problem is the mesh operation mode of IEEE 802.16. A cross-layer routing-scheduling scheme in IEEE 802.16 mesh networks is proposed by the author in this work. This technique uses the distributed and centralized scheduling capabilities of IEEE 802.16 link layer in mesh mode and routing in network layer together in order to perform the operation optimally. This technique is based on the techniques of IEEE 802.16 protocol. The experimental results pointed out that this method can considerably progress the improvement in the network performance particularly in case of a congestion in the Internet part of the traffic at the cost of a minor burden on the intranet traffic in the form of a slight increase in the end-to-end delay.

Shiying [5] proposed a joint admission control and routing in IEEE 802.16-based mesh networks. In WiMAX-based metropolitan area mesh networks, the quality of service (QoS) provisioning techniques are considered in this paper. The connection admission control (CAC) and routing concern in the design and operation of wireless multihop mesh networks is studied by the author and proposes a joint connection admission control and the routing technique for various service classes with the intention to maximize the overall revenue from all agreed connections. Connection-level QoS limitations such as handoff connection dropping probability can be fixed within a threshold. By providing different reward rates, multiple service classes can be arranged according to their importance. Then the optimal CAC policies can be obtained by applying the optimization techniques. The optimality criterion is considered as the long-run average reward. The proposed technique can maximum revenue obtainable by the system under QoS constraints and the author shows that the optimal joint policy is a randomized policy. This indicates that the connections are admitted to the system with some prospect when the system is in definite states.

Wan [6] given an interference aware routing and scheduling in WiMAX Backhaul Networks with Smart Antennas. A smart adaptive antenna can be used for intended communications and interference suppression as it can offer multiple Degrees of Freedom (DOFs). Network throughput can be appreciably


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enhanced by more efficient spatial reuse by combining smart antennas in a WiMAX system. Routing and scheduling in WiMAX backhaul networks along with smart antennas are considered by the author. Full concern for interference impact and DOF availability is offered by the proposed method which properly defines the Interference-aware Tree Construction Problem (ITCP) for routing. Next, for resolving the problems in polynomial time the technique is proposed. In case of scheduling, the proposed technique initially provides a polynomial-time, optimal technique for a particular case in which the number of DOFs in every node is sufficient to neglect all potential secondary interference. Finally, for scheduling problem effective heuristic algorithm is proposed by the author.

Jin *et al.,* [7] put forth a routing and packet scheduling for throughput maximization in IEEE 802.16 Mesh Networks. The difficulty of maximizing the system throughput in IEEE 802.16 broadband access networks with mesh topology is considered in this paper and the results are provided. At first, the simplified linear network is taken in account with only uplink traffic and presents a optimal scheduling technique. The author initiates an analytical result on the length of the schedule. The difficulty in routing and packet scheduling in general topology is then taken into account by the author and provides its NP completeness. The proposed method also offers an ILP formation for this difficulty. The author proposes techniques that find routes and schedules of packet transmissions in general mesh topologies depend on the optimal algorithm for linear networks.

A Routing Metric and Algorithm for IEEE 802.16 Mesh Networks is provided by Ntsibane [8]. The high speed data rates over large distances and multimedia services are facilitated by the technologies that are based on 802.16. Also, this technology is likely to provide the high speed broadband delivery even beyond the current 3rd Generation wireless technologies. The mesh mode which utilizes this technique has the capability of escalating the coverage well beyond the cities and into the rural areas that are presently not served by conventional techniques. The author considers the potential of the mesh mode and provided a routing technique which is appropriate for coordinated distributed scheduling.

Nazari *et al.,* [9] proposed case for mobility- and traffic-driven routing algorithms for wireless access mesh networks. Here the author has presented a new technique in order to develop routing algorithms in which the author idea attempt to understand the characteristics of network (i.e. network connectivity, mobility and rate of modification of the topology) and the patterns of expected traffic for a specific mobile scenario before the start of the design algorithm, which deals with the optimization of routing performance. This paper mainly applied to approach Triton, a proposed 802.16-based (WiMAX) maritime wireless access mesh network. Most probably the trace-based analysis out shows that, while the stationary nodes are most commonly selected in the route selection, then the rate of change between the routes to the gateway nodes is seems to get reduced by 23.3% and the average time taken for which routes between a node and a gateway remains valid is gradually spikes to 31%. The author described that it is quite important to take the expected traffic patterns for designing the routing pattern for a specific system. The network topology will not affect the expected traffic, so that reduction of overheads is done.

Ben-Jye Chang *et al.,* [10] discussed about Adaptive competitive on-line routing algorithm for IEEE 802.16j WiMAX multi-hop relay networks. IEEE 802.16j is a relay based approach which is based on the IEEE 802.16e standard, and WiMAX has proposed this standard. This is mainly for widening the service area of Base Stations (BSs) and to improve the signal strength quality i.e., received signal strength (RSS) quality. The main advantages of IEEE 802.16j are the expense for building IEEE 802.16 WiMAX networks is comparably low and much compatible with existing WiMAX standards. Diverse features on mobility and relay range deliberately reveals that the, Relay Station (RS) can be grouped up into three types: Fixed RS (FRS), Nomadic RS (NRS) and Mobile RS (MRS). There are different types of RSs in relay-based WiMAX network. The routing path among a Mobile Station (MS) and the MR-BS are the two important factors to construct efficient relay-based WiMAX and find out an optimal solution. The author thus propose an IEEE 802.16j-conformed relay-based adaptive competitive on-line routing approach, in which the selection of a multihop optimal path is done in terms of link bandwidth, path length and channel condition. This proposed paper significantly outperforms other approaches in Fractional Reward Loss (FRL), which is deliberately shown in numerical results.

Al-Hemyari *et al.,* [11] stated a Centralized scheduling, routing tree in WiMAX mesh networks. IEEE 802.16 came into picture since there is a lot of demand for high speed internet access service in last few years. So IEEE 802.16 working group have provided a broadband wireless access (BWA) for developing the worldwide interoperability for microwave access. (WiMAX) standard is used for wireless metropolitan area networks (MANs) in order to provide a broadband wireless over a miles, easy deployment, and high speed data rate for large spanning area. Single channel single transceiver scheme in WiMAX mesh network is implemented here for obtaining an efficient routing and collision free centralized scheduling (CS) algorithms, which is used to introduce the cross layer concept between the network layer


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and media access controller (MAC) layer. The authors proposed method has improved the system performance with respect to scheduling length, channel utilization ratio (CUR), and the throughput of the system while compared to other system.

Qassem *et al.,* [12] had a look on Cross-layer routing and scheduling for IEEE 802.16 mesh network. In recent years, requiremant for high-speed internet access and multimedia service has increased greatly. The IEEE 802.16 defines the wireless broadband access technology called WiMAX (Worldwide Interoperability Microwave Access) which aspires to facilitate the broadband wireless network for wide range of distance, easy deployment, and high speed data rate for large spanning area. In this paper, the author propose an Energy/bit Minimization routing and centralized scheduling (EbM-CS) based algorithm to multi-transceiver in WiMAX mesh network (WMN), which introduces the cross-layer concept between the layers of MAC and network. The results show that the proposed algorithm has improved in terms of performance with aspect of system throughput.

Al-Hemyari *et al.,* [13] described the Constructing Routing Tree Centralized Scheduling using Multi-Channel System in 802.16. The IEEE 802.16 standard describes WiMAX (worldwide interoperability for microwave access) mesh network, using the base station (BS) as a coordinator for centralized scheduling. This paper mainly comprises of a centralized scheduling algorithm by building up a routing tree in WiMAX mesh network, this will introduces the cross-layer concept between the media access controller (MAC) and the network layers. Here consideration is done for interference, hop-count, spatial reuse and quality of services (QoS) guarantee. The author states that, each node has one transceiver and can be tuned between multiple channels for the user concern, which discard the secondary interference. This work greatly shows that this algorithm improves the length of scheduling, channel utilization ratio (CUR) and average transmission scheduling.

Al-Hemyari *et al.,* [14] explained about constructing routing tree for centralized scheduling using multi-channel single transceiver system in 802.16 mesh mode. To obtain centralized scheduling, The WiMAX mesh networks based on IEEE 802.16 standard was developed. Here base station act as a coordinator for obtaining scheduling. But mostly, interferences from transmission of the neighboring nodes within mesh network cannot be avoided. By constructing the routing tree with multi-channel single transceiver system in the network the interference can be reduced completely. In this algorithm, there is a facility so that each node has one transceiver that can be tuned to any of the channels, which user decides. This scheme is used for eliminating the secondary interference that occurs in the network. The parameters of interference, hop-count, and number of children for every node, spatial reuse, fairness, load balancing, quality of services (QoS) and node identifier (ID) are considered. The results of analysis obtained shows that this proposed algorithm significantly improves the length of scheduling and the channel utilization ratio (CUR).

Xiaohua Jia [15] illustrated a distributed algorithm of delay-bounded multicast routing for multimedia applications in wide area networks. The author considers the solution to attain the good route in a wireless network and for the performance measure for routing technique the spectral efficiency is applied. The merging of different perspectives from networking and information theory in the design of routing technique is considered as the main aim of this study. With the help of distributed manner, it is very hard to find the optimum route with the maximum spectral efficiency. The author presents two suboptimal alternatives such as approximately ideal- path routing (AIPR) technique and the distributed spectrum efficient routing (DSER) technique which is motivated by information-theoretic analysis. The approximately ideal- path routing technique needs the location information and it discovers the path to estimate an optimum regular path. The distributed spectrum efficient routing is based on Bellman-Ford or Dijkstras algorithms which are highly suitable for distributed implementations. The spectral efficiencies of approximately ideal- path routing technique and the distributed spectrum efficient routing for random networks approach is higher than that of nearest-neighbor routing in the low signal-to-noise ratio (SNR) regime and that of single-hop routing in the high SNR regime. In the temperate SNR regime, the spectral efficiency of distributed spectrum efficient routing technique is up to twice that of nearest-neighbor or single-hop routing.

Jilin Le *et al.,* [16] put fourth DCAR: Distributed Coding-Aware Routing technique in Wireless Networks. The usage of network coding is interested in recent year in order to enhance the performance of wireless networks. For example, the author proposed COPE which is a practical wireless coding system that illustrates the achievement of throughput gain by network coding. Still, COPE has two basic limitations:

- The coding opportunity is crucially reliable on the established routes
- COPE is restricted within a two-hop region in coding structure.

To overcome these limitations, the author proposes certain suitable techniques. Especially, the author proposes the distributed coding-aware routing (DCAR) technique that provides


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- The detection for existing paths between a given source and destination
- The detection for possible network coding opportunities over much extensive network region.

The capability to discover high throughput paths is very low in conventional techniques, whereas, the distributed coding-aware routing technique possesses the potential to discover high throughput paths with coding opportunities. The limitations of COPE technique is overcome by the DCAR technique which can detect the coding opportunities on the entire path. A new routing technique known as coding-aware routing metric (CRM) is proposed by the author in order to increase the performance comparison between coding-possible and coding-impossible paths.

Honggang Wang *et al.*, [17] given Interplay between Routing and Distributed Source Coding in Wireless Sensor Network. In applications like real time target tracking and environment monitoring, the coding for multiple correlated sensors are related by the mission-driven wireless sensor networks (WSN) with the advancement in distributed source coding (DSC). The major potential opportunities in association with sensor networks are offered by the features of these DSC applications. For enhancing the network performance, this technique makes use of multirate transmissions. The author studied the techniques for interplay optimization between routing and DSC in WSN. Then a new multirate based routing technique for mission-driven DSC applications is proposed that significantly extends the lifetime of network. The proposed technique implements the rate assignment depends on the residual energy. In order to satisfy the end-to-end transmission rate constraint, information precision requirement and the energy constraints in the network for DSC, the proposed technique utilizes a joint rate and energy scheduling mechanism. Experimental results show that the proposed multirate based routing scheme achieves significantly longer network lifetime when compared to the conventional techniques.

Wenjun Liu *et al.*, [18] proposed a Grid-Based Distributed Multi-Hop Routing Protocol for Wireless Sensor Networks. The main factors to consider while designing the wireless sensor network routing technique are high delivery ratio with low energy consumption and transmission delay. A grid-based distributed multi-hop routing protocol (GDRP) is proposed by the author for designing the wireless sensor network. At a time only one node is chosen as grid head per grid and the other nodes carry out grid head tasks by dynamically rotating them. The inter-grid communication utilizes the multi-hop routing pattern for reducing the consumption of energy by grid heads. According to the routing cost, distance and residual energy of neighboring grid heads, every grid head performs a distributed algorithm and chooses an optimal next h-hop routing path independently in grid-based distributed multi-hop routing protocol. Grid-based distributed multi-hop routing protocol balances energy consumption well, thus guides to a high data delivery ratio, low transmission delay and prolonged network lifetime that are shown in the simulation results.

Yamamoto *et al.*, [19] demonstrate the analysis of distributed route selection scheme in wireless ad hoc networks. The analyses are carried on the capacity region of ad hoc networks by means of optimal routing or scheduling. The network obtained will be scalable because the distributed network control techniques can be implemented without centralized information. Alternatively, the network performance can be highly degraded by selfish nodes. The network capacity will be the mainly affected performance factor. Depending on the distributed route selection by means of game theory, the author attempts to examine the acquired network capacity region. Experimental results shows that even with optimal routing every rational selfish node cannot find a unique route under the assumption that node know not only their own end-to-end throughput, but also of all other nodes as a result of their own.

Tzu-Chieh Tsai *et al.*, [20] shows Routing and Admission Control in IEEE 802.16 Distributed Mesh Networks. One of the challenging issues in wireless mesh networks is QoS. Here the author propose a new routing method by using SWEB as metrics system that is well-suited in IEEE 802.16 distributed, and coordinated mesh mode. Token bucket mechanism is proposed for the usage of an admission control algorithm. For controlling the traffic pattern in the information path, token bucket is used and this helps to estimate the bandwidth required by a connection. The hop count and delay requirements of real-time traffics are taken into account for estimating the bandwidth. Delay requirements of real-time traffics are the main concern for TAC designing, and avoid the starvations of low priority traffics. With the proposed routing techniques, the admission control algorithm and the inherent QoS support for the IEEE 802.16 mesh mode, a QoS-enabled environment can be established. At last, extensive simulations are performed to validate the algorithms, and show good performance results.

Yajun Li *et al.*, [21] projected a novel routing algorithm in distributed IEEE 802.16 mesh networks. The author had, proposed a novel distributed routing algorithm for IEEE 802.16/WiMAX based mesh networks. Here this algorithm is not designed to eradicate the traffic delay completely; instead this will provide routes for traffic flows with have minimum end-to-end delays, so that traffic can be avoided. It says that the proposed algorithm is incorporated into the medium access control (MAC) layer to avoid traffic in the path. Each node


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have a separate work to determines the next-hop nodes is free from traffic or not, if it finds the traffic in the path, then the information is allotted to next free path, else the information and attempts to forward packets in the very earliest slots. In addition to this algorithm, another one mechanism called loop cancelation is proposed to avoid being trapped in path loops and thus guarantees the accessibility of the author's algorithm. Thus the result reveals that the proposal system can considerably reduce the delay of traffic flows and also achieve load balance to a certain degree.

Saha *et al.,* [22] put an idea of routing in IEEE 802.16 based distributed wireless mesh networks. Now- a-days Wireless mesh networks play a vital role in the field of telecommunication and network. Due to dynamic channel condition and lack of infrastructure Routing in distributed wireless mesh networks is seems to be a challenging fact in the area of networking. Here the author has introduced a new technique which provides the traffic distribution over a multiple path which helps in avoiding the delay of data in transmission path. The transmission delay over multiple hops can be calculated by applying queuing analysis on the intermediate nodes over the routes, and the analytical model is proposed to calculate such transmission delay. Simulation is carried out to support the analytical results for reducing the delay in the network.

## III. CONCLUSION

This survey reviewed a lot of routing protocols for WiMAX based networks. Routing in WiMAX is an active area of research in which many techniques have been proposed that are facilitating to increase the throughput, minimizing the delay and offer further robustness over wireless channel. This survey presents the advantages and disadvantages of different routing algorithms for 802.16 WiMAX networks. This helps in choosing the best suited routing protocol for WiMAX networks. The various challenges for the routing in WiMAX are delay, long transmission scheduling, increasingly stringent Quality of Service (QoS) support and load balance and fairness limitations. All these challenges are not satisfied by many of the conventional routing techniques. With this analysis, the joint and distributed routing protocol can achieve all the qualities mentioned above. So the joint and distributed routing protocol can be utilized in 802.16 WiMAX network to improve better routing when compared to the conventional techniques.

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# A New Secure Approach for Message Transmission by Godelization and FCE

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***Abstract***

**In this paper, we devised a novel algorithmic approach for transmitting information through Fast Comparison Encryption (FCE) algorithm. The proposed scheme uses an algorithm name it as FCE which transforms the information into an encoded Godel Number Sequence (GNS) which results in a text. It will be reconstructed at the other end using the inverse process.**

***Key Words: GNS, FCE.***

## I. INTRODUCTION

In simple terms, authentication is identification plus verification. *Identification* is the process whereby an entity identity, rather than one-way authentication, whereby only one principal verifies the identity of the other principal, is usually required. There are three main types of authentication in a computing system [4]:

a. Message content authentication -verifying that the content of a received message is the same as when it was sent; in a computing environment.

b. Message origin authentication - verifying that the sender of a received message is the same one recorded in the sender field of a message; and

c. General identity authentication - verifying that a principal's identity is as claimed.

Lack of security may exist when a volume of data is transferred from its source to the destination if no measure is taken for its security. For one reason or the other, most of the data being transmitted must be kept secret from others [5]. A very important reason to encode data or messages is to keep them security. In this paper, a novel method for message authentication is proposed. This is an efficient encryption scheme by using Godel number sequence (GNS) [1] and Fast comparison encryption scheme (FCE) [2], FCE uses any block cipher to encrypt only a few bytes of random seeds in each page of the database, and uses lighter-weight computation to encrypt the actual data in a information. The low

overhead of FCE enables efficient comparison and, therefore, efficient indexing on the ciphertext. In this work, we specifically aim at encryption to ensure the security of on-disk data. FCE is specifically tailored to database systems in the following way, Comparison is fast, which facilitates the search of indices.

## II. GODEL NUMBER SEQUENCE

A mathematical concept termed as Godelization [1] is used as an encoding scheme. The scheme of Godelization is explained as follows: Prime factorization theorem states that every positive integer greater than one can be factored into multiplication of primes, and this factorization is unique except for difference in the order of the factors. To factor a number 'n' is to write it as a product of other prime numbers:

n=a x b x c

Factoring a number is relatively hard compared to multiplying the factors together to generate the number.

For any number 'n' of natural numbers, the Godel number sequence (GNS) is given by :

GNS (n) = (x0, x1, x2,…xk) where

$n = (2^{x0})*(3^{x1})*(5^{x2})\ldots((PrNo(k))^{xk})$ where PrNo(k) is the $k^{th}$ prime.

$90 = (2^1)*(3^2)*(5^1)$

GNS (90) = (1, 2, 1)

The Godel number sequence [1] will be encoded by using Fast comparison Encryption for improving the security of the information and reduce the complexity of the computation. Fast comparison encryption scheme is very light weight mechanism. This will be described in the following section.



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*A. Inverse Gödelization*

At the receiver side, there is a need to perform the inverse operations of Gödelization technique to obtain the original data. It is the process of decompressing the string by replacing alphabets with digits and any substring KX is decompressed with K occurrences of X. The string obtained is in the form of $GNS(i_1)\$GNS(i_2)\$.....\$GNS(i_n)$ which is the Gödel String of the image and inverse Gödelization is applied to the string to obtain the intensity values of the image which are calculated as $GNS(i) = (x_0,x_1,.....x_k)$ where $i= 2^{x0} * 3^{x1} * 5^{x3} \ldots P^{xk}$.

## III. FAST COMPARISION ENCRYPTION

Encrypt a plaintext by using FCE [2]. Let's consider size of GNS of the original information is 'P' bytes. Convert it into bits while computing. Let's denote the key by 'K'(1byte). It should be generate randomly from the input by using random permutation function (Perfun). |K| gives length of the Key.

*A. Key Generation:*

Perfun :

It is a random permutation function
$\{1,2,...P\} \rightarrow \{1,2,...P\}$

Step 1: Let $s_i$ is a starting bit of a key.
For j=1 to P
$s_j$ = Perfun(j) mod |K| . It is in the range of [0, |K|-1].

Step 2: Sj is the starting bit of the Key 'K'.

*B. Encryption Algorithm*

Input: Plain Text (P bytes), randomly generated key K (symmetric), and random permutation function.
Output: Cipher text (En)

Algorithm

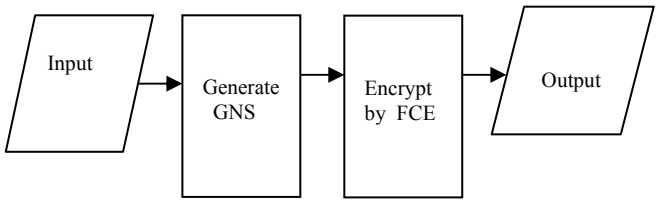
Step 1 : Generate GNS

Step 2 *:* Find $s_j$.

Step 2 : Find K.

Step 3: $En \leftarrow En_i = K \oplus P_i$.

Consider and generate the Godel number sequence (GNS) [1] to each byte of the plain text separately. Encrypt the GNS of the each byte by using fast comparison encryption scheme (FCE) [2] and send to the receiver. The cipher text byte ($E_n$) of the plaintext byte $P_i$ is simply the bitwise XOR of K. This process is shown in the figure 1.




figuare 1. Encryption Algorithm

*C. Decryption Algorithm*

Input : Ciphertext ($En_i$), K.
Ouput : PlainText

*Algorithm*

Step 1: Decrypt the data.
$P \leftarrow P_i = K \oplus En_i$

Step 2: Apply reverse Godelization on 'P'.
Consider and decrypt each byte of the Encrypted text by using FCE and get the original text by applying the reverse godelization. This is shown in the figure 2.

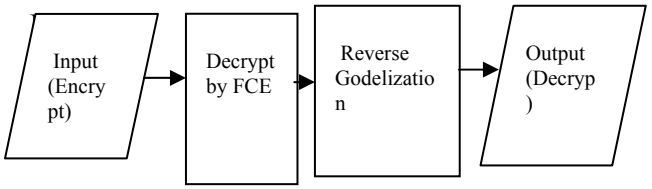



figure 2. Decryption Algorithm

## IV. Proposed Methodology

The main contribution of this paper is towards development of new algorithms which increase the data payload capacity than the regular methods and follows a layered approach for encoding and authenticity for more robustness. A technique termed as Godelization method [1] combined with FCE method [2, 3] is used as embedding technique. The proposed methodology is based on mathematical concept known as Gödelization which is used as one of the encoding schemes. Later another improved technique based on a new compression technique known as Fast Comparison Encryption technique. The implementation results of the proposed method are shown in Figure 3 and Figure 4.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## V. Results

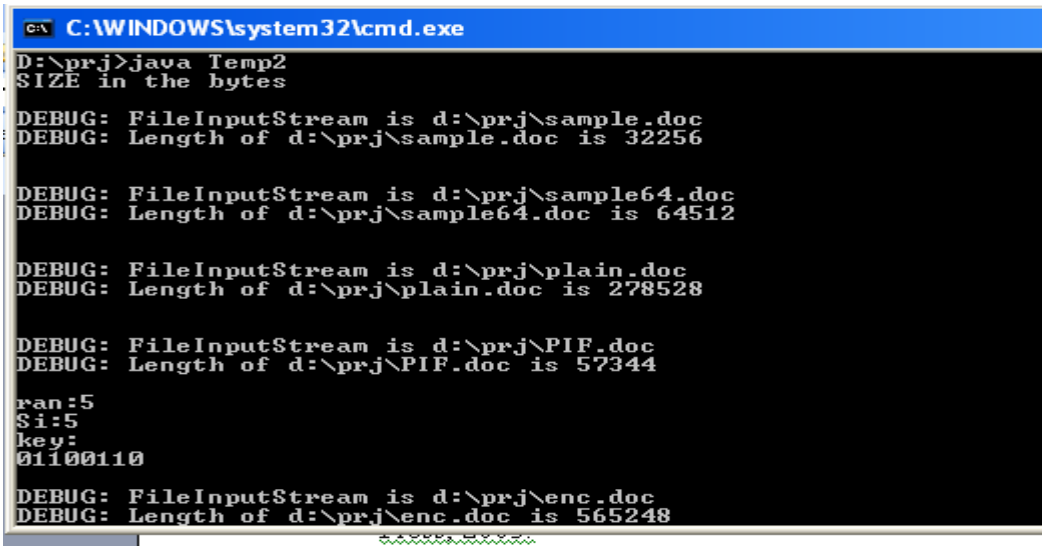


figure 3. Encryption by FCE with GNS

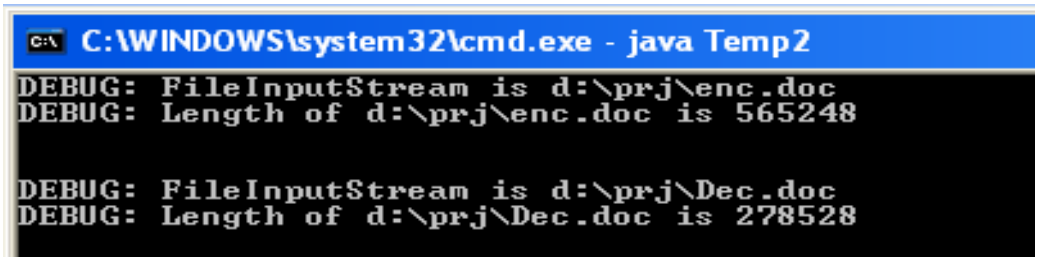


figure 4. Decryption by FCE with reverse GNS

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# Rapid Prototyping Model Coordinate Estimation Using Radial Basis Function.

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***ABSTRACT:*** **This paper discusses the methods for getting proper geometric coordinates of a sample object that has to be rapid prototyped. The coordinates of the objects is obtained by using Radial Basis Function (RBF). The training is done with many sample objects. It is expected to have minimum distance traveled by the Rapid prototyping machine when the software follows the geometric coordinates produced by the RBF.**

***Key words: Rapid Prototyping, Artificial Neural Network, Radial Basis Function.***

## 1. INTRODUCTION

Rapid prototyping (RP) refers to a variety of specialized equipment, software and materials capable of using 3D computer aided design (CAD)[5] data input to directly fabricate geometrically complex objects. RP technologies have emerged as a key element of time with their ability to shorten the product design and development process[2]. This highly innovative and cost efficient technology has found applications in automotive, aerospace and medical equipment manufacturing, replacing the commonly used slower and less accurate manual methods of fabricating prototypes[4]. With advances in established technologies, materials and the introduction of new methods, selecting the right RP machine has become much more difficult and is one of the most important decisions to be made when employing any RP technology. This is vital in minimizing built time, cost and achieving optimal accuracy. When making this decision, the designers and RP machine operators should consider a number of different processes and specific constraints. This may be a difficult and time consuming task.

The RP material flows through an orifice and comes out in the form of drops. The size of the drop is depending upon the speed of the wire comes out and solidification of material. For example, 1 mm size of drop is placed in 1 mm size cube cavity to get the same size of cube after solidification in fraction of seconds[1]. The sides of the cube should be flat in all respects. To achieve this focus has been made on a method which can inform that how to make the above things with critical path method (CPM)[6]. Some products have been chosen with their applications, particularly in medical area. By considering all the parameters in developing any kind of object is being able to produce in shorter time without any difficulty[3].

## 2. MATERIALS AND METHODS

### *2.1 Materials*

A schematic flow of the proposed work is presented in Figure 1.

*Rapid Model:* It is the end product that has to be rapid prototyped.

*Coordinates:* There are various Coordinates measured from the RP model either through CMM/Reverse Engineering/existing drawing details.



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*Sizes:* The length, width /thickness, breadth/height and other profiles are calculated from the coordinates.

*RBF:* Coordinates and sizes of sample RP models are used as data for training the RBF neural network to obtain final weights that will be used for testing.

*Obtain format to meet RP M/c:* The outputs of RBF are used as inputs for RP M/c converter where RP model will be developed.

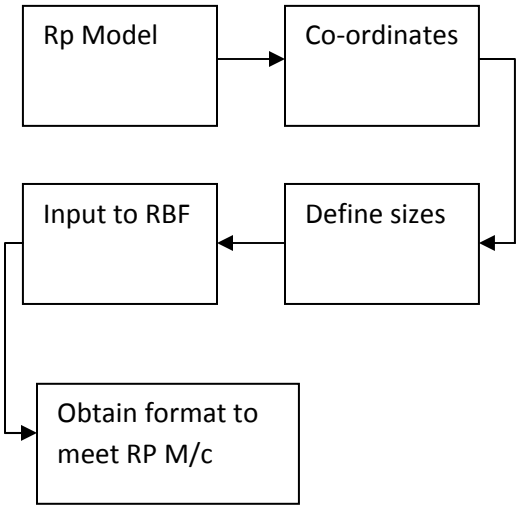


Fig.1 Schematic flow

*2.2 Methods*

The concept of distance measure is used to associate the input and output pattern values. Radial Basis Functions is capable of producing approximations to an unknown function 'f' from a set of input data abscissa. The approximation is produced by passing an input point through a set of basis functions, each of which contains one of the RBF centres, multiplying the result of each function by a coefficient and then summing them linearly.

For each function 't', the approximation to this function is essentially stored in the coefficients and centres of the RBF. These parameters are in no way unique, since for each function 't' being approximated, many combinations of parameter values exist. RBFs have the following mathematical representation:

$$F(x) = c_o + \sum_{i=0}^{N-1} c_i \, \Phi(\| x - R_i \|) \qquad (1)$$

where

c is a vector containing the coefficients of the RBF,

R is a vector containing the centres of the RBF, and

$\phi$ is the basis function or activation function of the network.

**Implementation**

**Step 1:** Apply Radial Basis Function.

No. of Input = 15

No. of Patterns = 6

No. of Centre = 6

Calculate RBF as

RBF = exp (-X)

Calculate Matrix as

G = RBF

$A = G^T * G$

Calculate

$B = A^{-1}$

Calculate

$E = B * G^T$

**Step 2:** Calculate the Final Weight.

F = E * D

**Step 3:** Store the Final Weights in a File.

## 3. EXPERIMENT SET UP

Six RP models have been considered as examples for testing the RBF network. Each RP model has been labeled with Cartesian coordinates. The models have been developed using CAD software. The models are defined with definite number of points. The distance between points are calculated internally by the program. During training RBF, only the point coordinates are input in the input layer. The number of centers used is 6. The targets used is 15.

Table 1 presents 6 sample RP models under consideration. Table 2 presents number of points considered in this analysis for each RP model. Table 3a-c presents actual coordinates in mm for each point. The total number of points considered is 15 in each object.


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**Table 1 Sample RP models**

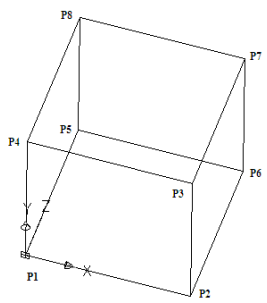

Fig 1

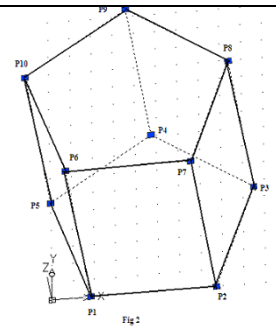

Fig 2

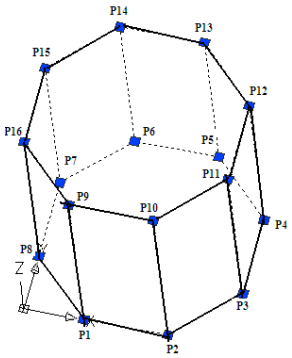

Fig 4

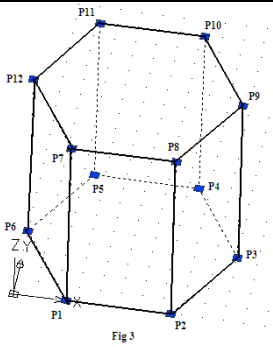

Fig 3

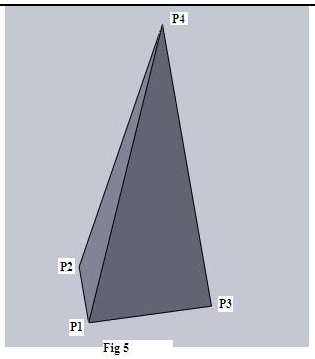

Fig 5

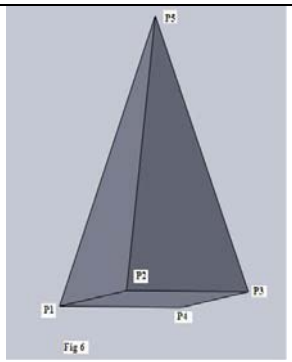

Fig 6

**Table 2 Number of points in the RP model**

| *RP* | *Number of points* |
|---|---|
| 1 | 8 |
| 2 | 10 |
| 3 | 12 |
| 4 | 15 |
| 5 | 4 |
| 6 | 5 |
| | |

**Table 3a Cartesian coordinate**

| | *P1* | | | *P2* | | | *P3* | | | *P4* | | | *P5* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **x** | **y** | **z** | **x** | **y** | **z** | **x** | **y** | **z** | **x** | **y** | **z** | **x** | **y** | **z** |
| 1 | 0 | 0 | 0 | 50 | 0 | 0 | 50 | 50 | 0 | 0 | 50 | 50 | 0 | 0 | 50 |
| 2 | 9.08 | 0 | 0 | 38.47 | 0 | 0 | 47.55 | 27.95 | 0 | 23.77 | 45.22 | 0 | 0 | 27.95 | 0 |
| 3 | 12.5 | 0 | 0 | 37.5 | 0 | 0 | 50 | 21.65 | 0 | 37.5 | 43.30 | 0 | 12.5 | 43.30 | 0 |
| 4 | 13.52 | 0 | 0 | 32.66 | 0 | 0 | 46.19 | 13.52 | 0 | 46.19 | 32.66 | 0 | 32.66 | 46.19 | 0 |
| 5 | 0 | 0 | 0 | 25 | 0 | 0 | 12.5 | 21.65 | 0 | 12.5 | 7.22 | 50 | x | x | x |
| 6 | 0 | 0 | 0 | 25 | 0 | 0 | 25 | 25 | 0 | 0 | 25 | 0 | 12.5 | 7.22 | 50 |

## 4 RESULTS AND DISCUSSION

The coordinates of the RP models are learnt by RBF. Table 4 presents the outputs of RBF for all the 6 RP models for the points p1, p2. Similar close outputs are obtained for points p3, p4, p5, p6, p7, p8, p9, p10, p11, p12, p13, p14, p15

**Conclusion:** This work has made an attempt to train RBF with RP model coordinates. During the actual implementation, the RP model coordinates are given as inputs to the RBF to obtain the actual coordinates that helps in RP modeling.


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| Table 3b Cartesian coordinate | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | P6 | | | P7 | | | P8 | | | P9 | | | P10 | | | |
| | *x* | *y* | *z* | *x* | *y* | *z* | *x* | *y* | *z* | *x* | *y* | *z* | *x* | *y* | *z* | |
| 1 | 50 | 0 | 50 | 50 | 50 | 50 | 0 | 50 | 50 | x | x | x | x | x | x | |
| 2 | 9.08 | 0 | 50 | 38.47 | 0 | 50 | 47.55 | 27.95 | 50 | 23.77 | 45.22 | 50 | 0 | 27.95 | 50 | |
| 3 | 0 | 21.65 | 0 | 12.5 | 0 | 50 | 37.5 | 0 | 50 | 50 | 21.65 | 50 | 37.5 | 43.30 | 50 | |
| 4 | 13.52 | 46.19 | 0 | 0 | 32.66 | 0 | 0 | 13.52 | 0 | 13.52 | 0 | 50 | 32.66 | 0 | 50 | |
| 5 | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | |
| 6 | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | |

| Table 3c Cartesian coordinate | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | P11 | | | P12 | | | P13 | | | P14 | | | P15 | | | |
| | *x* | *y* | *z* | *x* | *y* | *z* | *x* | *y* | *z* | *x* | *y* | *z* | *x* | *y* | *z* | |
| 1 | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | |
| 2 | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | |
| 3 | 12.5 | 43.30 | 50 | 0 | 21.65 | 50 | x | x | x | x | x | x | x | x | x | |
| 4 | 46.19 | 13.52 | 50 | 46.19 | 32.66 | 50 | 32.66 | 46.19 | 50 | 13.52 | 46.19 | 50 | 0 | 32.66 | 50 | |
| 5 | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | |
| 6 | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | |
| **X** **represents no coordinates** | | | | | | | | | | | | | | | | |

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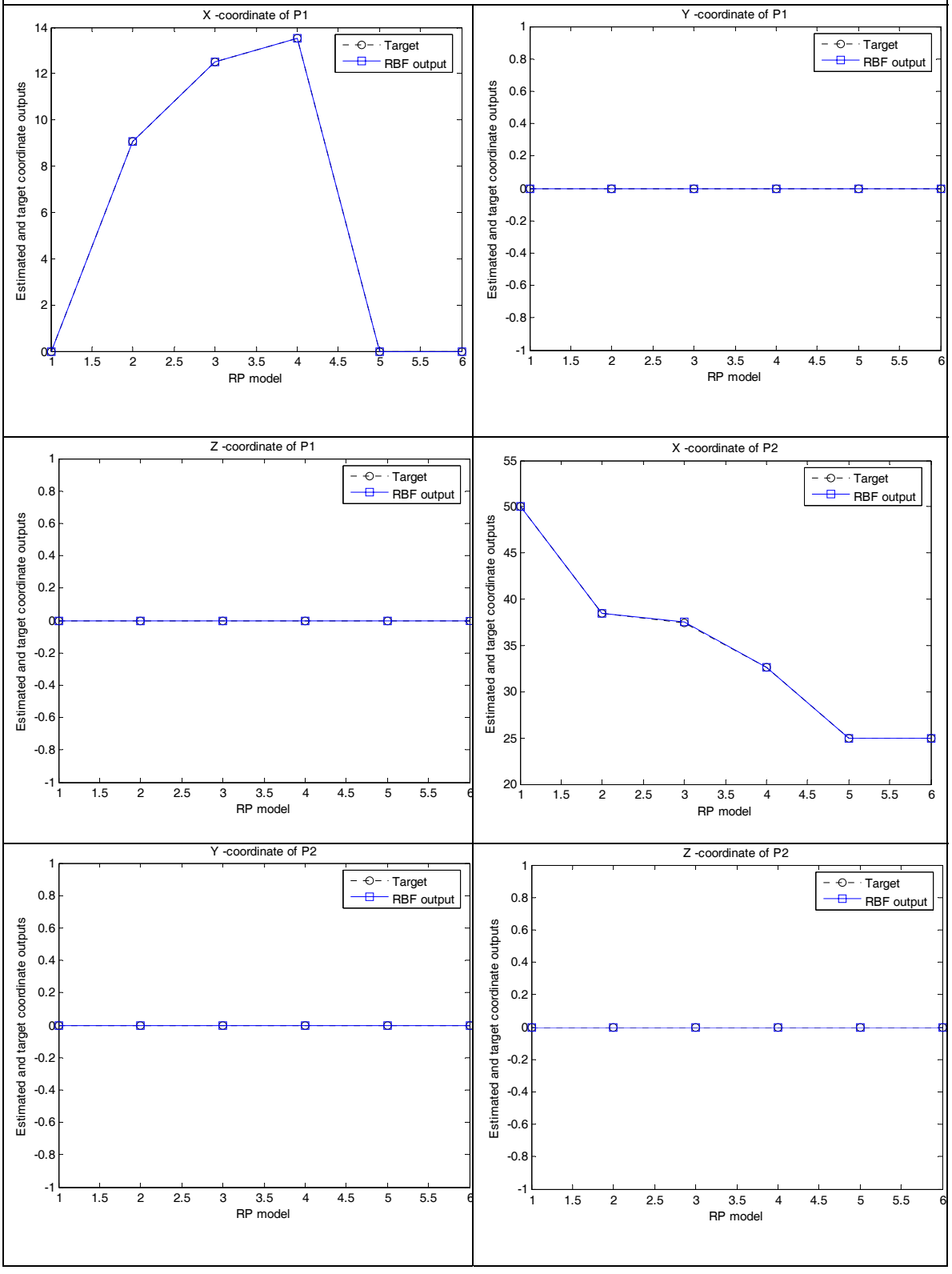
**Table 4 RBF outputs**



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# HESCHL'S GYRUS AUDITORY CORTEX SLICE REGISTRATION USING ECHO STATE NEURAL NETWORK (ESNN)

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***Abstract*—This paper presents Herschel's gyrus auditory cortex slice registration using Echo state neural network (ESNN). Training the network is done with translation and rotational values of the selective points (feature points) from two images at a time (source and target images). The input layer is given with coordinates of the selective points of the source image and in the output layer; the labeling is the translation and rotational values of the selective points of the target image. ESNN is an estimation network which estimates the required registration information from the selective points of target and source image. The output of ESNN is compared with radial basis function (RBF).**

***Keywords-Echo state neural network, functional magnetic resonance imaging (fMRI), Heschl's gyrus, auditory cortex***

## I. INTRODUCTION

The image registration [1] aims to find a transformation that aligns images of the same scene taken at different times, from different viewpoints. It has been studied in various contexts due to its significance in a wide range of areas, including medical image fusion, remote sensing, and computer vision. Medical image acquisition systems generate digital images that can be processed by a computer and transferred over computer networks. Digital imaging allows extracting objective, quantitative parameters from the images by image analysis. Medical image analysis exploits the numerical representation of digital images to develop image processing techniques that facilitate computer-aided interpretation of medical images. The continuing advancement of image acquisition technology and the resulting improvement of radiological image quality have led to an increasing clinical need and physician's demand for quantitative image interpretation in routine practice, imposing new and more challenging requirements for medical image analysis[2][3]. A fundamental problem in medical image analysis is the integration of information from multiple images of the same subject, acquired using the same or different imaging modalities and possibly at different time points. One essential aspect thereof is image registration, i.e., recovering the geometric between corresponding points in multiple images of the same scene. While various more or less automated approaches for image registration have been proposed in the field of medical imaging and image analysis, one strategy in particular, namely maximization of mutual information[4][5] , has been extremely successful at automatically computing the registration of 3-D multimodal medical images of various organs from the image content itself.

## II. MATERIALS AND METHODS

### *A. Neural Network Structures*

The Echo state neural network is used for learning the images. The number of neurons in the input layer is 4, and the number of neurons in the output layer is 6.

**Input layer description**

Node 1 = x coordinate of point in image 2(target image)
Node 2 = y coordinate of point in image 2(target image)
Node 3 = x coordinate of point in image 1(image to be registered with target image)
Node 4 = y coordinate of point in image 1(image to be registered with target image)

**Output layer description**

Node 1= vertical shift


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Node 2= upward (1) or downward (2)
Node 3=horizontal shift
Node 4= left (1) or right (2)
Node 5= angle with respect to axis passing through centre of the image
Node 6= left (1) or right (2)

The hidden layer has been trained with different number of nodes increasing from 2 neurons.

The target values corresponding to x, y values of image 1 and image2 are calculated as follows

```
TS=size (Directions, 1)
for i=1:TS-1%1
   I=Directions(i,:);
   F=Directions(i+1,:);
   X=F(1,1)-I(1,1);
   Y=F(1,2)-I(1,2);
   if X==0 & Y==1
      D(i)=1;
   elseif X==0 & Y==1
      D(i)=2;
      elseif X==-1 & Y==0
      D(i)=3;
      elseif X==1 & Y==0
      D(i)=4;
      elseif X==-1 & Y==-1
      D(i)=5;
      elseif X==1 & Y==1
      D(i)=6;
      elseif X==-1 & Y==1
      D(i)=7;
      elseif X==1 & Y==-1
      D(i)=8;
   end

end
```

Table 1 shows the direction of rotation among pixel coordinates of source and target image. The size of the image considered is 63 rows by 63 columns. The term 'T' refers to target image and 'S' refers to source image. Curved arrow to the right is the clockwise direction and the curved arrow to the left is the counter clockwise direction. Table 1 shows the possible rotation of the pixel of source image to different location in target image.

Table 2 presents 10 sample pixel coordinates that is used for training the network. For testing the network, the same sample points with another 10 points (total 20 points) are presented.

The description of Table is as follows.

Column 1 = pattern number
Column 2= x coordinate of points in target image
Column 3= y coordinate of points in target image
Column 4= x coordinate of points in source image
Column 5= y coordinate of points in source image
Column 6= shift in rows
Column 7= Upward or downward translation
Column 8= shift in columns
Column 9 = Horizontal translation
Column 10= Rotation of source pixel coordinate with respect to corresponding target pixel coordinate
Column 11= Clock wise or counterclockwise rotation

**Table 1 Rotation of source coordinates from Target image coordinates**

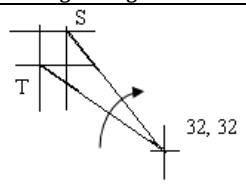
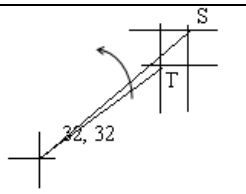
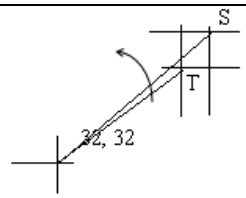
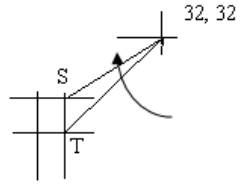
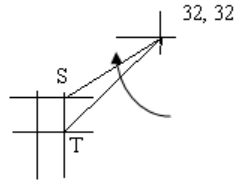
| | |
|---|---|
| 1 |   |
| 2 |   |
| 3 |   |
| 4 |   |
| 5 |   |

**Table 2 Patterns used for training and testing ESNN**

| | *Input pattern* | | *Target pattern* | |
|---|---|---|---|---|
| | *Target(actual)* | *Source(distorted)* | *Translation (pixel)* | *Rotation (degrees)* |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| *Pattern number* | *x* | *y* | *x* | *y* | *Vertical shift* | *Upward(1) Downward(2)* | *Horizontal shift* | *Left(1) Right(2)* | *Angle rotated* | *Direction CW(2) / CCW(1)* |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | 14 | 1 | 17 | 2 | 1 | 1 | 2 | 3.05 | 2 |
| 2 | 5 | 41 | 3 | 42 | 2 | 1 | 1 | 2 | 0.59 | 1 |
| 3 | 22 | 47 | 19 | 48 | 3 | 1 | 1 | 2 | 5.4 | 1 |
| 4 | 34 | 47 | 32 | 48 | 2 | 1 | 1 | 2 | 7.59 | 2 |
| 5 | 38 | 18 | 36 | 18 | 2 | 1 | 0 | 0 | 7.25 | 1 |
| 6 | 28 | 6 | 27 | 7 | 1 | 1 | 1 | 2 | 2.56 | 2 |
| 7 | 48 | 14 | 47 | 15 | 1 | 1 | 1 | 2 | 0.2 | 2 |
| 8 | 49 | 45 | 48 | 45 | 1 | 1 | 0 | 0 | 1.68 | 1 |
| 9 | 36 | 62 | 35 | 62 | 1 | 1 | 0 | 0 | 1.88 | 1 |
| 10 | 13 | 57 | 12 | 58 | 1 | 1 | 1 | 2 | 0.33 | 1 |

### *B ECHO STATE NEURAL NETWORK (ESNN)*

An Artificial Neural Network (ANN) is an abstract stimulation of a real nervous system that contains a collection of neuron units, communicating with each other via axon connections. Artificial neural networks are computing elements which are based on the structure and function of the biological neurons. These networks have nodes or neurons which are described by difference or differential equations.

Dynamic computational models require the ability to store and access the time history of their inputs and outputs. The most common dynamic neural architecture is the Time-Delay Neural Network (TDNN) that couples delay lines with a nonlinear static architecture where all the parameters (weights) are adapted with the back propagation algorithm. Recurrent Neural Networks (RNNs) implement a different type of embedding that is largely unexplored. RNNs are perhaps the most biologically plausible of the Artificial Neural Network (ANN) models. One of the main practical problems with RNNs is the difficulty to adapt the system weights. Various algorithms, such as back propagation through time and real-time recurrent learning, have been proposed to train RNNs; these algorithms suffer from computational complexity, resulting in slow training, complex performance surfaces, the possibility of instability, and the decay of gradients through the topology and time. The problem of decaying gradients has been addressed with special processing elements (PEs). ESNN possesses a highly interconnected and recurrent topology of nonlinear PEs that constitutes a reservoir of rich dynamics and contains information about the history of input and output patterns. The outputs of this internal PEs (echo states) are fed to a memory less but adaptive readout network (generally linear) that produces the network output. The interesting property of ESNN is that only the memory less readout is trained, whereas the recurrent topology has fixed connection weights. This reduces the complexity of RNN training to simple linear regression while preserving a recurrent topology, but obviously places important constraints in the overall architecture that have not yet been fully studied.

The echo state condition is defined in terms of the spectral radius (the largest among the absolute values of the eigenvalues of a matrix, denoted by (|| ||) of the reservoir's weight matrix (|| W || < 1). This condition states that the dynamics of the ESNN is uniquely controlled by the input, and the effect of the initial states vanishes. The current design of ESNN parameters relies on the selection of spectral radius. There are many possible weight matrices with the same spectral radius, and unfortunately they do not perform at the same level of mean square error (MSE) for functional approximation.

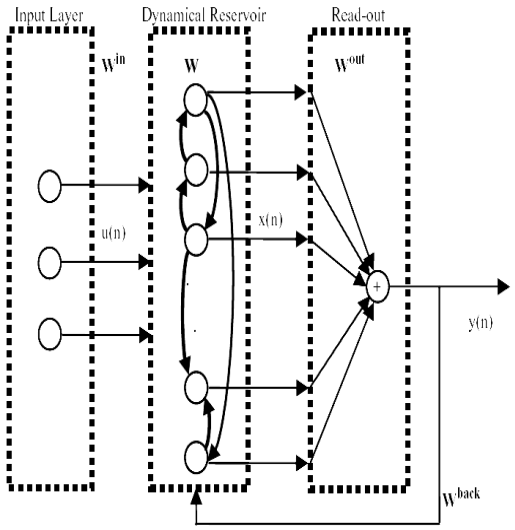


**Figure 1 Echo State Network (ESNN)**

## ALGORITHM

1.Read data
2.Separate into inputs (datain) and target outputs (dataout)
3.Initialize number of reservoirs


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4.Initialize (Input to hidden layer, output to hidden layer, hidden to hidden layer)
5.Initialize state vector

- Calculate next state= tanh (input matrix * Input vector + hidden matrix * state +output matrix * target output)
- Assign next state to present state and repeat step 5 and step 6
- Find pseudo inverse for the state matrix and multiply with targets

The recurrent network is a reservoir of highly interconnected dynamical components, states of which are called echo states. The memory less linear readout is trained to produce the output.
Consider the recurrent discrete-time neural network given in Figure 1 with M input units, N internal PEs, and L output units. The value of the input unit at time n is $u(n) = [u_1(n), u_2(n), \ldots, u_M(n)]^T$ ,

The internal units are $x(n) = [x_1(n), x_2(n), \ldots, x_N(n)]^T$ (1)
, and
Output units are $y(n) = [y_1(n), y_2(n), \ldots, y_L(n)]^T$ (2).
The connection weights are given

- in an (N x M) weight matrix $W^{back} = W_{ij}^{back}$ for connections between the input and the internal PEs,
- in an N × N matrix $W^{in} = W_{ij}^{in}$ for connections between the internal PEs
- in an L × N matrix $W^{out} = W_{ij}^{out}$ for connections from PEs to the output units and
- in an N × L matrix $W^{back} = W_{ij}^{back}$ for the connections that project back from the output to the internal PEs.

The activation of the internal PEs (echo state) is updated according to

$$x(n + 1) = f(W^{in} u(n + 1) + Wx(n) + W^{back} y(n)), \quad (3)$$

where $f = ( f_1, f_2, \ldots, f_N)$ are the internal PEs' activation functions.

Here, all $f_i$'s are hyperbolic tangent functions $\frac{e^x - e^{-x}}{e^x + e^{-x}}$. The output from the readout network is computed according to

$$y(n + 1) = f^{out}(W^{out}x(n + 1)), . \quad (4)$$

where

$f^{out} = (f_1^{out}, f_2^{out}, \ldots, f_L^{out})$ are the output unit's nonlinear functions. Generally, the readout is linear so $f^{out}$ is identity [6]. The flowcharts for training and testing ESNN are given in Figure 2 and Figure 3

## III IMAGE REGISTRATION

Characteristic points in image 1 (Source) and image 2 (Target) are defined. Characteristic points are important points through maximum alignment can be done. By this, unnecessary points choosing can be avoided and hence the ESNN can learn with less number of patterns. During training, the x, y coordinates of the characteristic points of image 1 and image 2 are input in the input layer and the horizontal, vertical shifts along with angle are given in the output layer of ESNN.

**Implementation steps:**
Training
Step 1: Identify characteristic points in image 1 and image 2.
Step 2: Calculate translation and rotation angle.
Step 3: Generate training patterns with the information obtained in step 1 and step 2.
Step 4: Train ESNN with training patterns.
Testing
Step 5: Present the same set of characteristic points and obtain values in the output layer. Find the error between obtained and actual values.


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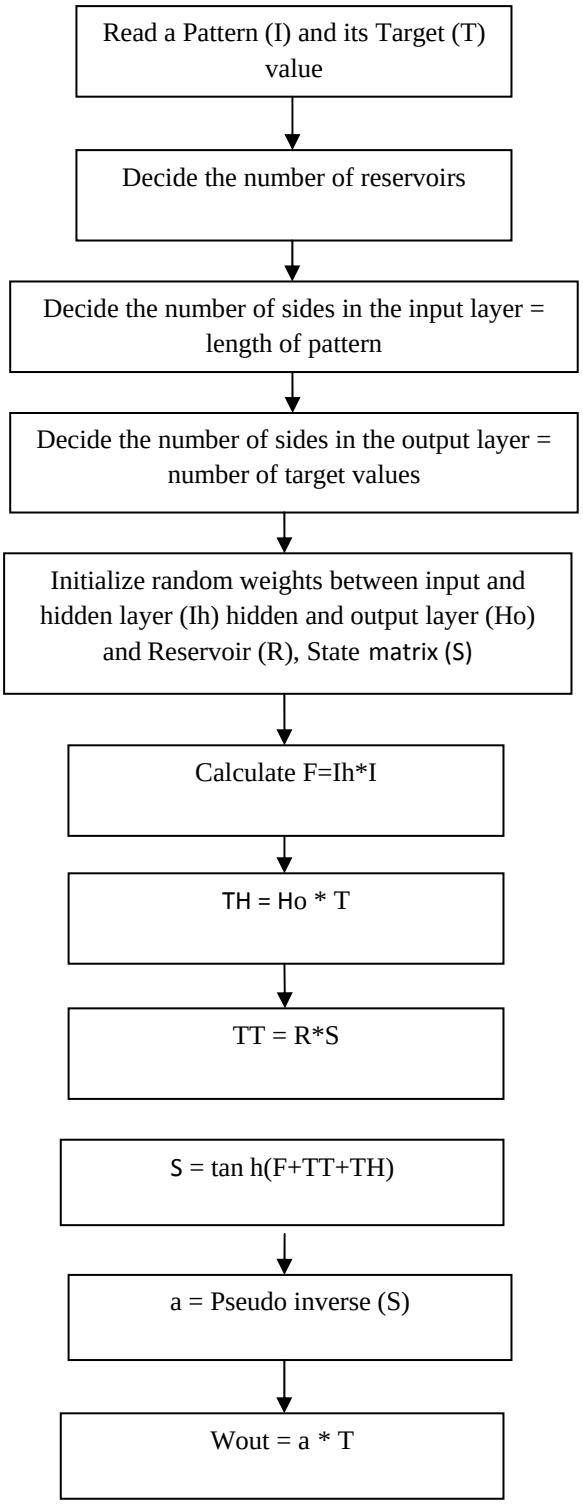


Figure 2 Flow chart for Training ESNN

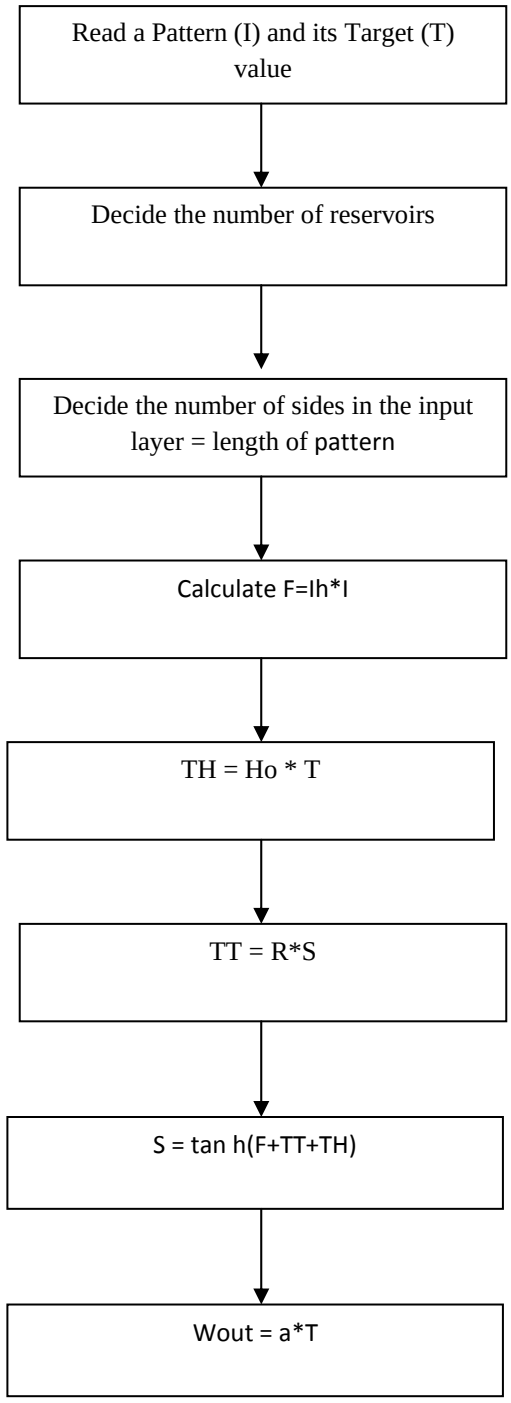


Figure 3 Flow chart for testing the ESNN

## IV. RESULTS AND DISCUSSIONS

The fMRI have been obtained with standard setup conditions. The magnetic resonance imaging of a subject was performed with a 1.5-T Siemens Magnetom Vision system using a gradient -echo


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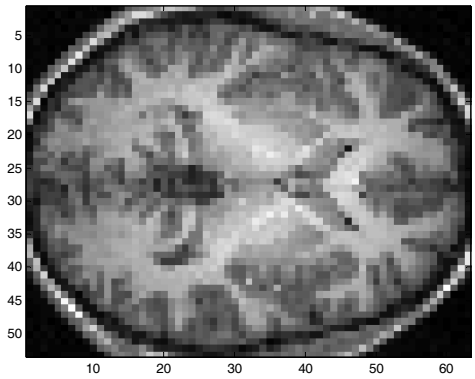


**Fig.4 Heschl's gyrus, auditory cortex(target)**

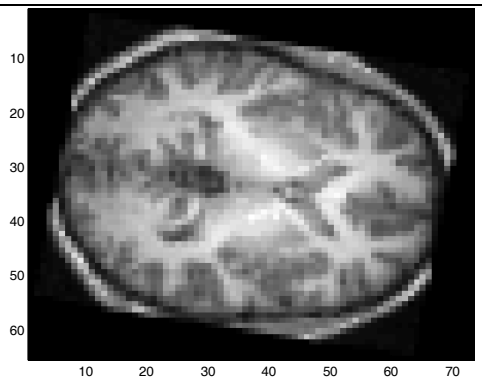


**Fig.5 Heschl's gyrus, auditory cortex ($10^o$ rotated)(source)**

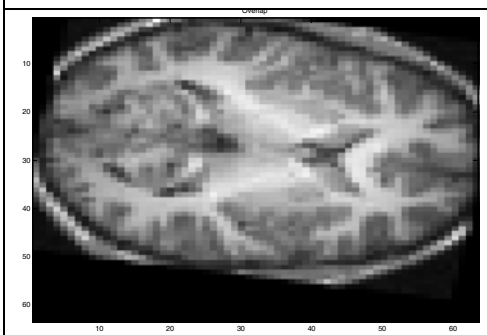


**Fig.6 First alignment**

**Fig.7 Second alignment**

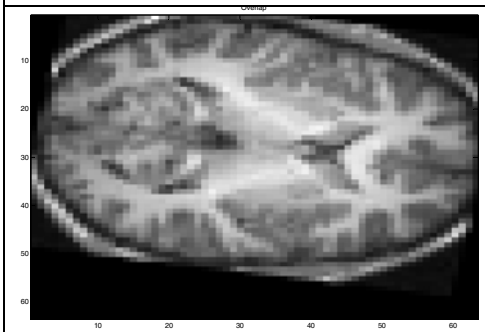


**Fig.8Third alignment**

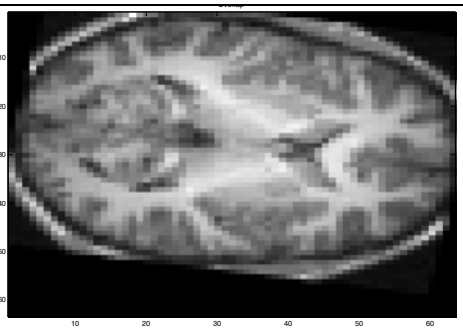
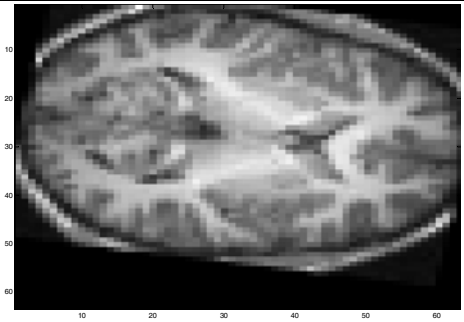


**Fig.9 Fourth alignment**



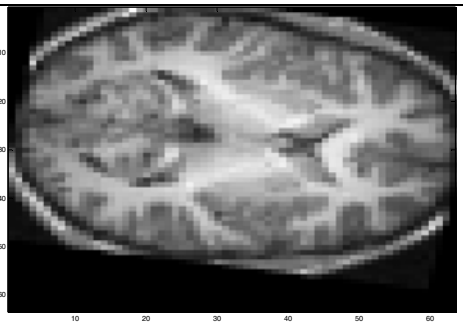




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**Fig.10 Fifth alignment**

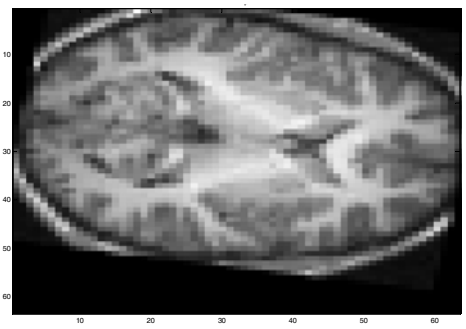

**Fig.11 Sixth alignment**

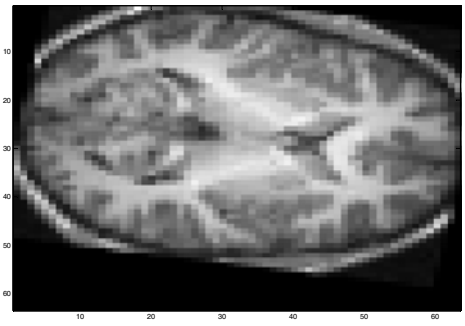

**Fig.12 Seventh alignment**

**Fig.13 Sixth alignment**

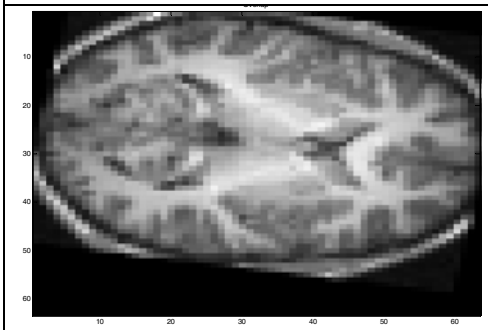

**Fig.14 Eighth alignment**

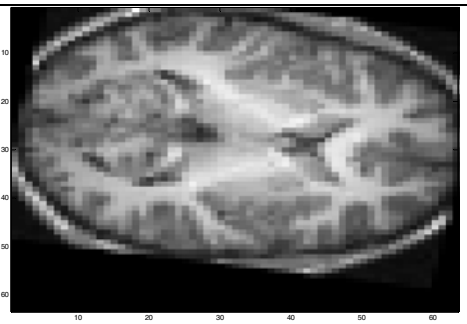

**Fig.15 Final alignment**

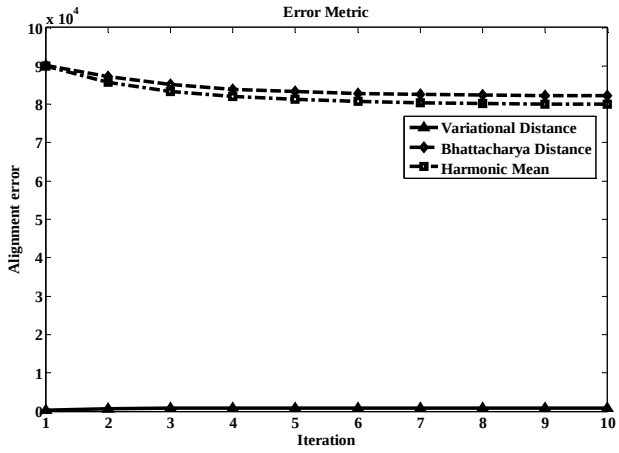


**Fig.16 Error metric**

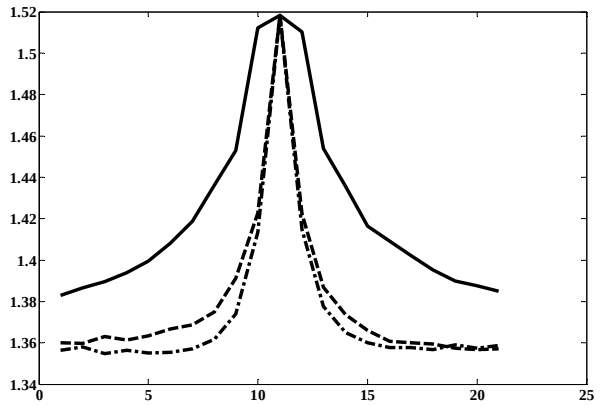

**Fig.17 MI for the alignment using ESNN**

echoplanar (EPI) sequence (TE 76 ms, TR 2.4 s, flip angle 90 , field of view 256 - 256 mm, matrix size 64 * 64, 42 slices, slice thickness 3 mm, gap 1 mm), and a standard head coil. A checkerboard visual stimulus flashing at 8 Hz rate (task condition, 24 s) was alternated with a sound (control condition, 24 s). In total, 110 samples (3-D volumes) were acquired.

Figure 4 shows the Heschl's gyrus, auditory cortex (target) image slice. This image is rotated through $10^{o}$ clockwise. This is treated as the source image (Figure 5). Figure 6 to Figure 15 shows the alignment of source with target at each iteration. Figure 16 presents the error metric of variational distance, Bhattacharya distance and Harmonic Mean and Figure 17 presents the mutual information for the alignment using ESNN.

## V. CONCLUSION

This paper describes implementation of ESNN for registration of Heschl's gyrus, auditory cortex image slice. ESNN take least time to learn the alignment of characteristic points.

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# Brain Computer Interaction Of Indian Facial Expressions Recognition Through Digital Electroencephalography

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***Abstract***— The brain computer interaction could be the interface medium of the future, instead of using peripheral input output devices .So The brain computer interaction is a path way in which through digital EEG technique the brain signals of human subject have been recorded under different poses by using Digital Electroencephalograph (EEG) 2400NP instrument. Under experimental setup The subjects have given different expressions corresponding brain signals that have been recorded through a popular technique Digital EEG. An attempt has been done to correlate these results to the facial action coding System (FACS).

***Keywords- Bci, Eeg, Expression, Facial coding System.***

All standard paper components have been specified for three reasons: (1) ease of use when formatting individual papers, (2) automatic compliance to electronic requirements that facilitate the concurrent or later production of electronic products, and (3) conformity of style throughout a conference proceedings. Margins, column widths, line spacing, and type styles are built-in; examples of the type styles are provided throughout this document and are identified in italic type, within parentheses, following the example. Some components, such as multi-leveled equations, graphics, and tables are not prescribed, although the various table text styles are provided. The formatter will need to create these components, incorporating the applicable criteria that follow.

## I. INTRODUCTION

The most important challenging application of brain computer interaction is to enables direct interaction between human and computer by directly receiving and transmitting signals to and from the brain of human subject. In the Computer system the Recognition of Facial expression of human subject is a great challenging task[1][2][3].

During expression recognition of human face there are so many complex issue arises like: neuromedical ,anatomical and psychological[4]. This is dependent on the social behavior of human.. Basically, one human being may have different expression under different -2 conditions. The human subject may have seven type of universal facial expressions like: happiness, sadness, fear, anger, surprise, disgust, and neutral so expression may consider as a vector in the seven dimensional field[5]. In anatomical FACS , the subject have been made to express expressions which will have anatomical aspects of the face. The facial expression are controlled by the brain so it is useful to correlate the expression with the brain[6]. Today's there are so many techniques available for direct contact with neural as Electroencephalography(EEG), Magneto encephalography (MEG) and FMRI[7].

## II. BCI THROUGH EEG

In brain computer interaction *electroencephalography technique* is an approximation of the cumulative electrical activity of neurons and is a measure of the brain's voltage fluctuations as detected from scalp electrodes. This technology is to augment human capabilities by enabling human subject to interact with a computer through a conscious and spontaneous modulation of their brain waves after a short training period. A brain computer interaction has been developed cerebral electric activity is recorded via the Electroencephalography: electrodes , attached on the scalp and measure the electric signal of the brain[8] . The signals are amplified and transmitted to the computer which transform them into device control command. The crucial requirement for the successful functioning of the brain computer interaction is that the electric activity in the scalp surface.

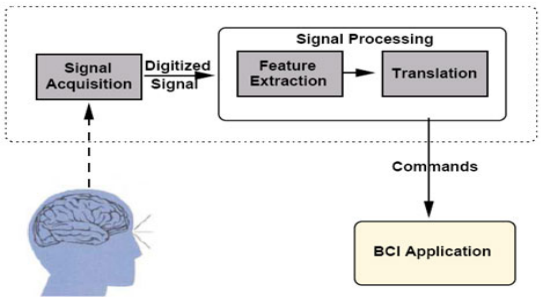


Fig1. Brain computer Interaction

Identify applicable sponsor/s here. *(sponsors)*

### EEG frequency band

There are Five rhythms as:
1) Gamma ϒ: 30-50 Hz 2) Beta β: 13-30 Hz 3) Alpha α: 8-13 Hz 4) Theta θ: 4-8 Hz 5) Delta δ: 0.5-4 Hz.

### EEG Characteristics

- It measures directly brain function.
- It has a high temporal resolution, in the range of milliseconds.
- The spatial resolution is in the range of centimeters for scalp electrodes, while implanted electrodes can measure the activity of single neurons.
- Scalp electrodes are non-invasive while implanted electrodes are invasive.
- The required equipment is portable.

### Experimental method and procedure

During eeg test the subject should be prepared to give different type of facial expressions[9]. To conduct test , the scalp must be free from oil now tie The electrode cap over head with the use of electrode cream and finally check all the electrodes are connected with subject head, now said to subject to give six universal face expression[10] and on behalf of expression see the signal fluctuation and record it with the four different regions of the brain[11].

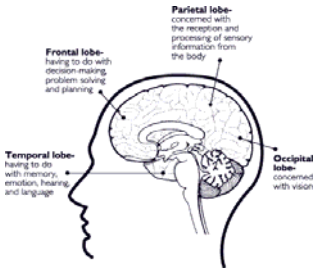


**Fig2: Electrode connected on head. Fig 3 . Four region of brain**

In our experimental setup we have to selected fifteen male persons in the age group of 6 to 30 year with non-psychiatric history have been selected for our experiment. The electrode cap was placed on the different regions of each person EEG was recorded at sites of brain region for all frontal lobe and parietal lobe are put together FP2-F4(R), FP1-F3 (L) and Occipital lobe (C4-P4(R), C3-P3 (L)/Temporal lobe are kept separate. FP1, FP2, F3, F4, F7, F8, FTC1, FTC2, C3, C4, T3, T4, TCP1, TCP2, T5, T6, P3, P4, PZ, O1, O2,A1,A2. The fig 4 contains details of connection for left and right portion of the brain in 10-20 international system[12].

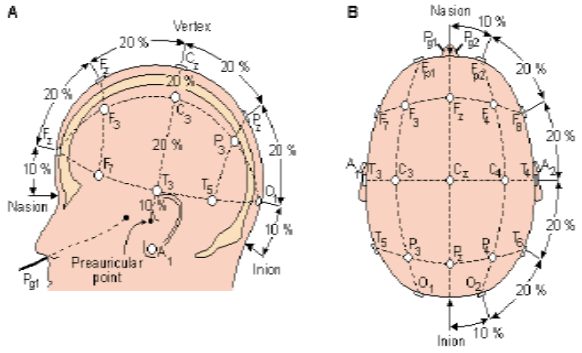


Fig 4:The international 10-20 system

The test was conducted for ten minutes and each participant was asked to give the different expressions while imaging the particular situations portraying different emotions simultaneously. The lower filter of the Neuro portable EEG was set at 1Hz, High filter at 70Hz; sensitivity at 7μV, channels 20, sweep speed 30mm/sec, Montage set 1 for all experiment[13]. The resultant facial expressions of the participants were also captured photographically with the help of a digital camera. At the same time, the signals of the different regions of the brain were mapped. The different position of connection for signal monitoring is shown in fig 4[14]. An example of mapped signal is shown in fig 5. The experiment was conducted in the sound proof environment.

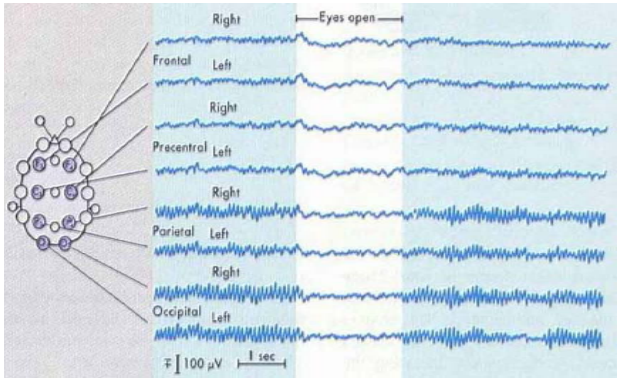


Fig5 : signal of different -different brain area.

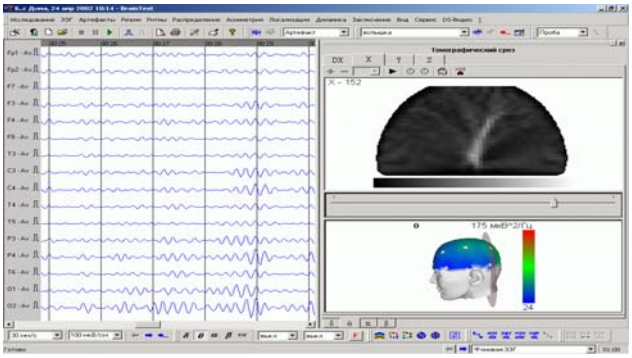

Fig 6: Eeg signal window during test


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The signals corresponding to different expressions were recorded and stored in the computer[15] .The four regions of the brain with left, right, front and back positions are identified corresponding to these positions, the average frequency and the average peak voltage are determined through commercial software available with the system The signals were recorded three times for each expression corresponding to all different seven subjects. The average values are mentioned in the Table 1.The EEG 24/NP channel unit used was from Digital Neurocompact Medicaid System[16].

The description of the apparatus used as Electrode cable, GND plug wire, Phonetic wire, EEG conducting paste, Absorbent cotton wool I.P., Sony digital camera HD 5X.

## III. Result and Conclusion

The goal of the present research work is to represent the experimental work towards bci direction. In our experimental setup, A portable Electroencephalograph system has been used for brain. It has been found that in the human subject there are twenty six muscles are responsible for the overall movement of the face. The photographic expressions for each experiment are shown in fig (7).

Happy Sad Angry Fear Disgust Surprise

Fig 7. Six Facial Expression

| **Brain Regions** | **Position 1** | | | | **Position 2** | | | | **All Four Positions Result** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | FL | | PL | | OL | | TL | | FL +PL+OL+TL | |
| | Left | | Right | | Left | | Right | | Left & Right | |
| **Expressions** | F | PV | F | PV | F | PV | F | PV | Avg. of F | Avg. of PV |
| **1.Neutral** | 24.5 | 38.6 | 22.5 | 34.0 | 21.5 | 34.5 | 20.5 | 37 | 23.0 | 35.15 |
| **2.Happy** | 24 | 44.5 | 21.9 | 42.1 | 24.5 | 36.2 | 23.1 | 32.9 | 23.37 | 42.75 |
| **3.Sad** | 22.5 | 34.3 | 26.3 | 39.6 | 20.2 | 33.0 | 22.1 | 36.8 | 25.35 | 35.92 |
| **4.Anger** | 19.6 | 35 | 26.1 | 35.6 | 23.4 | 31.1 | 20.4 | 33.4 | 22.37 | 33.77 |
| **5.Fear** | 19.7 | 36.8 | 18.9 | 34.9 | 16.6 | 27.0 | 16.9 | 36.1 | 19.11 | 35.37 |
| **6.Disgust** | 19.5 | 40.2 | 20.1 | 35.2 | 18.5 | 30.2 | 19.6 | 38.2 | 19.42 | 35.95 |
| **7.Surprise** | 13.1 | 32.4 | 17.9 | 34.7 | 13.9 | 32.8 | 13.8 | 34.7 | 14.67 | 33.65 |

Table 1. Results for different facial expression



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# PERFORMANCE EVALUATION OF CO-OPERATIVE GAME THEORY APPROACH FOR INTRUSION DETECTION IN MANET

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***Abstract*—Mobile Adhoc Network (MANET) is a collection of independent mobile nodes that can communicate to each other via radio waves. The mobile nodes that are in range of each other can directly communicate, whereas others need the aid of intermediate nodes to route their packets. These networks are fully distributed a and can work at any place without the help of any infrastructure. This property makes these networks highly exible and robust. Intrusion Detection System (IDS) is an integral part of any Mobile Ad-hoc Network (MANET). It is very important for IDS to function properly for the efficient functioning of a MANET. In this paper I evaluate the Co-Operative game theory approach for intrusion detection in MANET by comparing it with the existing other approaches. My evaluation is concentrated both on Intrusion in Application layer and network layer. Network simulator NS-2.34 is used for the simulation of the intrusions in grid network.**

## I. INTRODUCTION

A mobile ad hoc network is defined as a collection of mobile platforms or nodes where each node is free to move about arbitrarily. Each node logically consists of a router that may have multiple hosts and that also may have multiple wireless communication devices. The vision of mobile ad hoc networking is to support robust and efficient operation in mobile wireless networks by incorporating routing functionality into mobile nodes. Such networks are envisioned to have dynamic, sometimes rapidly-changing, random, multi hop topologies which are likely composed of relatively bandwidth-constrained wireless links. A MANET may be susceptible to varying degrees of intrusion that include passive eavesdropping, broadcasting of false routing information, disrupting traffic flow, etc. The nodes in the network have to cooperate in analyzing the intrusion in MANET. Thus a co operative Intrusion Detection System as shown in Figure 1.1 is needed to detect any possible intrusions that occur in the network and generate an appropriate action.

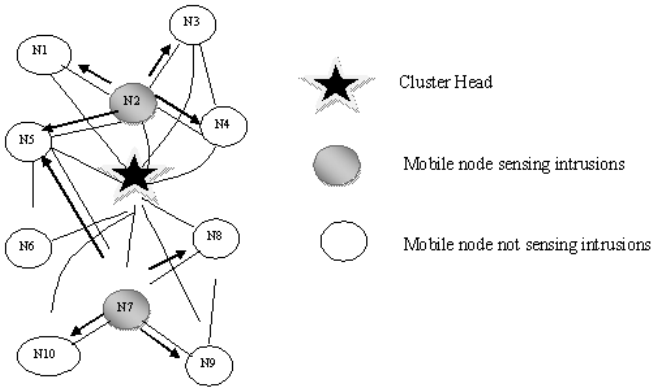


Fig 1.1 Grid Architecture Model.

In this paper, the performance of the Cooperative Game Theory that uses Shapley value algorithm to analyze the contribution of each node in detecting the intrusion is evaluated and compared with Anomaly detection approach. This ID will constantly monitor the network and report the unusual behavior of the network back to the head nodes. It will detect the unusual behavior at the application layer and at the network layer an aggregate function that computes the severity of the attack based on the values reported by the nodes is introduced. The appropriate measure is taken based on the value of the aggregation function.

Many papers have been submitted earlier on detecting and analyzing intrusions in MANET. Also some have proposed game theoretic approach for monitoring intrusions. A few of


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them are mentioned below, A Cooperative Approach for Analyzing Intrusions in Mobile Ad hoc Networks by Otrok, H. Debbabi, M. Assi, C. Bhattacharya, P.Concordia Univ., Montreal consider the problem of reducing the number of false positives generated by cooperative intrusion detection systems (IDSs) in mobile ad hoc networks (MANETs). They define a flexible scheme using security classes, where an IDS is able to operate in different modes at each security class. This scheme helps in minimizing false alarms and informing the prevention system accurately about the severity of an intrusion. Shapley value is used to formally express the cooperation among all the nodes. A Game Theoretic Formulation for Intrusion Detection in Mobile Ad Hoc Networks by Animesh Patcha and Jung-Min presents a game-theoretic model to analyze intrusion detection in mobile ad hoc networks. We use game theory to model the interactions between the nodes of an ad hoc network. We view the interac- tion between an attacker and an individual node as a two player non-cooperative game, and construct models for such a game. A Moderate to Robust Game Theoretical Model for Intrusion Detection in MANETs by Hadi Otrok, formalized a nonzero-sum noncooperative game theoretical model that takes into consideration the tradeoff between security and IDS resource consumption. The game solution will guide the leader-IDS to find the right moment for notifying the victim node to launch its IDS once the security risk is high enough.

To achieve this goal, the Bayesian game theory is used to analyze the interaction between the leader-IDS and intruder with incomplete information about the intruder. By solving such a game, we are able to find the threshold value for notifying the victim node to launch its IDS once the probability of attack exceeds that value. Simulation results show that our scheme can effectively reduce the IDS resource consumption without sacrificing security. Agah et al [4] suggested a game theoretic framework for defending nodes in a sensor network. Three schemes of defense are designed. In the first scheme the authors formulate attack-defense problem as a two-player, nonzero-sum, noncooperative game between an attacker and a sensor network. It is shown that this game achieves Nash equilibrium and thus leading to a defense strategy for the network. In the second scheme they use Markov decision process to predict the most vulnerable sensor node.

In the third scheme they use an intuitive metric (node's traffic) and protect the node with the highest value of this metric. All the above work focuses on IDS in a mobile ad hoc network at network layer, where the cooperative game theory approach goes one step further and tries to provide IDS system using cross layer approach. In my work both application layer and network layer information are considered to provide IDS. At the application layer a grid architecture proposed by Vetriselvi et al [5] is considered, where the game theoretic approach to provide security to this architecture is included.

**Existing system:**

Mobile Ad hoc Networks are wireless networks that lack infrastructure. It is vulnerable to attacks. Intrusion attacks are of particular interest and concern to the nodes, because they seek to render target systems inoperable. Many schemes are evolved to detect the attack but we can't prevent the nodes from attack properly. **Packet drooping:** This approach is presented using estimated congestion at intermediate nodes to decide if the intermediate node is not forwarding packets at the desired rate because of congestion or because of malicious behavior. It is unclear how statistical anomaly detection will succeed in the wireless domain, since it is a challenging one because of dynamic decentralization and a lack of concentration points where aggregated traffic can be analyzed. **Selfish nodes:** The cooperative enforcement mechanism based on a monitoring system, where the goal of this model is to detect selfish nodes and enforce them to cooperate. Each node keeps track of other nodes' cooperation using reputation as the cooperation metric. The System ensures that misbehaving nodes are punished by gradually stopping communication services and provides incentives for nodes, in the form of reputation, to cooperate. It is calculated by information provided by other nodes involved in each operation then also we can't stop the attack nodes, it is also less stable. **Anomaly detection**: If an anomaly is detected with weak evidence, because it uses a single layer of cluster heads. So a global detection process is initiated for further investigation about the intrusion through a secure channel. The limitations and drawbacks of this model are performance penalties and false alarm rates. **Defending node:** In a game theoretic framework, for defending nodes we use three schemes in a sensor network. In the first scheme the authors formulate attack-defense problem as a two-player, nonzero-sum, non cooperative game between an attacker and a sensor network. It is shown that this game achieves Nash equilibrium and thus leading to a defense strategy for the network. In the second scheme they use Markov decision process to predict the most vulnerable sensor node. In the third scheme they use an intuitive metric (node's traffic) and protect the node with the highest value of this metric.

## II. DESIGN AND WORKING OF THE GAME THEORY BASED IDS :

### *A. The Grid Architecture*

Heterogeneity of the mobile devices can be integrated to form an infrastructure known as grid. A grid by definition is a system that coordinates resources that are not subject to centralized control. Grid consists of three categories of nodes; Consumer node CN- Node which requests for a service, Service Provider node SPN- Node which processes the service requested by the CN, Grid Head node GHN- Node which coordinates all the nodes in its grid. This GHN is responsible for the allotment of an appropriate service provider node to a node requesting for particular service based on parameters such as cost, service time, etc. VetriSelvi et al [5] have suggested a Grid architecture that efficiently makes use of heterogeneous resources in an ad hoc network. A trace based mobility model is used to handle the movement of the nodes. Trace Based Mobility Model (TBMM) captures the regularity in movement as a movement pattern. The nodes that are going to communicate exchange this trace information that provides the position of the destination and its associated stability time. With the help of the trace information as well as the resource information appropriate service is provided to consumer nodes.


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***Grid Formation and GHN Election***

Any SPN has the privilege to contest for the grid head. A SPN starts sending 'Hello' messages to all the nodes within its hop limit. A hop limit is specified so as to keep a check on the number of nodes in a particular grid and also the density of data traffic which will result due to this broadcasting of messages. The 'Hello' message contains the stability time of its sender and hop count. On receiving a 'Hello' message, any SPN which currently does not have a head checks if the sender's stability is greater than its own stability. If it is the case it simply stops broadcasting its own 'Hello' messages and starts broadcasting the newly received message to all the nodes in its hop limit range after storing the stability of the sender as the 'GHN stability'. If not, it simply discards the message and continues to broadcast its own 'Hello' message. After finding the GHN, it sends 'Grid join' message to GHN. If a SPN node is currently functioning under a grid head and receives a 'Hello' message, it checks to see if the sender's stability is higher than its head's stability and if true, it starts broadcasting the newly received 'Hello' message after storing the stability as 'GHN stability'. Any CN on receiving a 'Hello' message simply forwards it. All the nodes store the first two highest stability times that they have received through 'Hello' messages. The node with the second highest stability is appointed as the' Secondary head' of the grid. Any node which gets elected as the GHN should periodically send 'Hello' messages to all the other nodes and if it fails to do so, it is not considered to be alive by the other nodes and a reelection takes place.

***Service Processing***

Any SPN joining a grid submits resource parameters, stability, position, type of service, service cost, etc to the GHN. A CN while requesting for a service states the type of service required and cost. The GHN maintains a Grid Maintenance Table (GMT), where in it stores the status of all the SPNs under it- their service parameters and their availability. On finding a suitable SPN for the service, it refers the SPN id to the requesting CN and assigns a job id to this service. The CN then sends a 'Service me' message to the allotted SPN which in turn completes the service and sends a 'Done' message to the CN and a 'Comp' message to the GHN indicating the completion of its assigned task. The CN sends an 'ACK' message to the GHN, acknowledging that it got the service completed by the SPN. The GHN now updates the SPN's status in the GMT. However, if an appropriate SPN is unavailable at a particular instant for a CN, it sends a service denial message prompting the CN to try later for the service request.

***Intrusions in Application Layer***

In the paper, two probable intrusions in the application layer - grid head which itself is found to be malicious and misbehaving service provider nodes are considered.

1) *Malicious GHN:* A GHN sends a service busy / service denial message when to a requesting CN if it does not find a suitable SPN. The CN keeps track of the count of the BUSY messages sent by the GHN. Once it exceeds a predefined threshold limit, the CN reports a 'Bad Head' message to the secondary head. Every time a service is being allotted to a SPN to a GHN, the SPN immediately sends 'busy' message to the secondary head. Similarly after the successful completion of service, the CN sends a 'complete' message to the secondary head. Thus the secondary head maintains the list of SPNs which are busy. When the secondary head receives the 'Bad Head' message from a CN, it checks if the SPNs are actually busy. If not, it generates a 'Ban' message and broadcasts to all the nodes. On receiving this message, all the nodes discard that node and no longer have it as their GHN and add that node's address to a list of banned nodes that they maintain after which a reelection takes place for contention to become the new grid head.

2) *Misbehaving SPN:* After being allotted a specific SPN for its service, a CN sends a 'service me' message to the SPN. A malicious SPN on receiving this message does only half the service required and reports completion of the service to both the GHN and the CN. On discovering that the service was not fully completed, the SPN generates a report to the GHN stating the essential parameters like the SPN's id, job id, etc. The GHN increments its report count for the particular SPN node and waits till the count reaches a particular predefined limit after which it checks the coalitions against the reported node. If it happens to be a winning coalition the GHN adds the SPN to the list of banned nodes and broadcasts the message on to all other nodes in the network.

***Intrusions in Network Layer***

In the network layer, two highly probable intrusions – flooding and flow disruption caused by malicious nodes are proposed. Both of these intrusions are detected by the other nodes and a coalition is formed to report the intruder.

1) *Flooding attack:* A malicious node starts sending innumerable route request/route discovery message to all the other nodes exhaustively. This affects the network bandwidth adversely and paralyses the network. This is resolved by using parameters like no. of control packets expected and received. For a certain time interval, the total no: of control packets received is counted and checked with the threshold limit. If it is exceeded then GHN is notified of the possibility of the attack. Grid Head then forms the coalition, calculates the attack value, checks whether it is a winning coalition and finds an intrusion.

2) *Flow disruption attack:* A malicious node targets a route between a particular source and destination node and starts sending junk route discovery messages to all the nodes in that particular route. Certain nodes are randomly identified as the target nodes by the attacker nodes. These attacker nodes are a few among the nodes which route data packets from and to the target nodes. When the ACK messages for the target nodes reach the attackers, they drop the packets instead of forwarding them. This causes the route between the particular source and destination to be broken thereby disrupting the flow between a pair of targeted nodes. After a stipulated waiting time, the target nodes report to its grid head. On receiving the report, the grid head carries out the similar processing of checking for coalitions and spotting a winning coalition.


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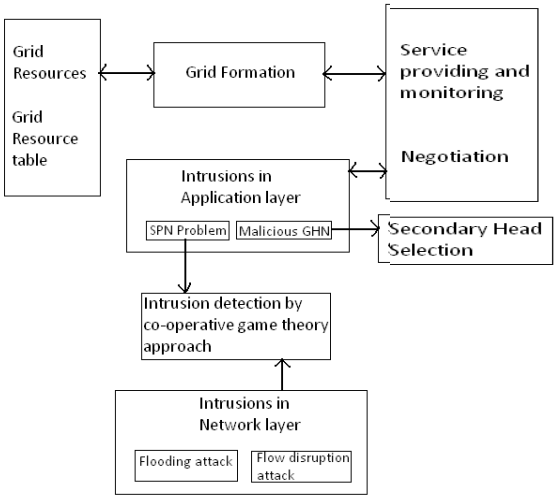


Fig 3.1 Block Diagram of Intrusion Detection System

## III. PERFORMANCE EVALUATION WITH SIMULATION.

Simulation studies are carried out to evaluate the performance of IDS in grid architecture. For simulation the network simulator NS-2.34 is used.

NS or the network simulator (also popularly called ns-2, in reference to its current generation) is a discrete event network simulator's is popularly used in the simulation of routing and multicast protocols, among others, and is heavily used in ad-hoc networking research. ns supports an array of popular network protocols, offering simulation results for wired and wireless networks alike. It can be also used as limited-functionality network simulator. It is popular in academia for its extensibility (due to its open source model) and plentiful online documentation. However, modeling is a very complex task in ns-2, given the need to learn scripting, modeling etc. NS was built in C++ and provides a simulation interface through OTcl,an object –oriented dialect of Tcl. The user describes a network topology by writing OTcl scripts, and then the main NS program simulates that topology with specified parameters.

Table 4.1 Parameters for the simulation of IDS

| | |
|---|---|
| Number of Nodes | 50 |
| Simulation Time | 500 Seconds |
| Terrain Dimension | (1000,1000) meters |
| Mobility | Random Way Point model |
| Mac-Protocol | 802.11 |
| Routing Protocols | AODV |

The performance is analyzed by increasing the number of reporters, increasing the service time, increasing the number of nodes reporters, increasing the service time, increasing the number of nodes in Grid Cluster and also the number of attackers

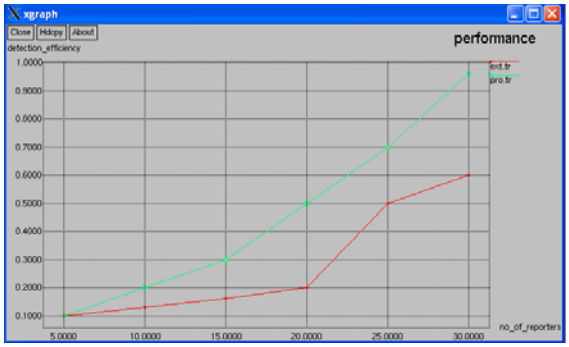


Fig 4.1 Detection Efficiency vs No.of.reporters

The above graph shows performance evaluation of our proposed scheme compare to existing system. Where the no of reporters increases the detection efficiency also increases

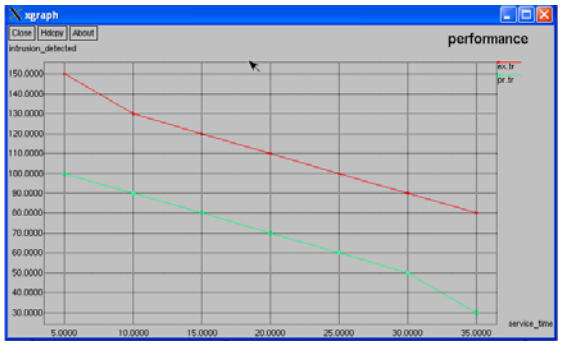


Fig 4.2 Intrusion Detected vs Service Time

The graph shows the variation in the number of intrusions detected to the increase in service time.

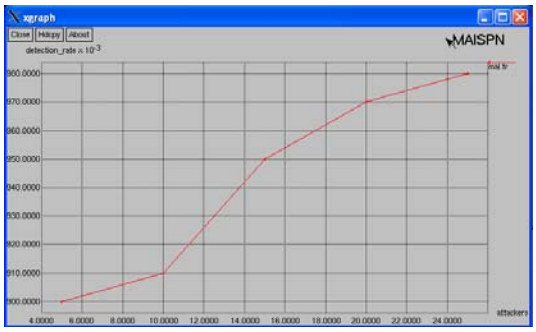


Fig 4.3 Detection Rate of ID in malicious SPN attack

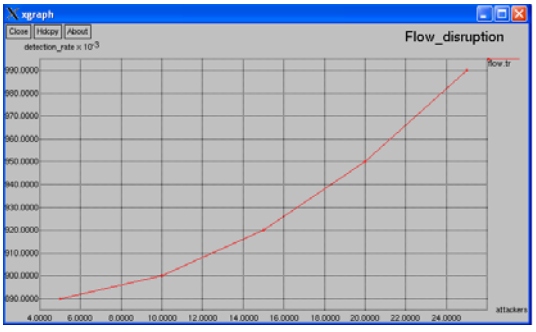


Fig 4.4 Detection Rate of ID in flow disruption attack.



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The above 4.3 graph shows our proposed scheme detect 0.98 efficiency rate in malicious SPN attack. The 4.4 graph shows our proposed scheme detect 0.91 efficiency rate in flow disruption attack.

## IV. CONCLUSION:

I have tested the performance of our system in both network layer and application layer with underlying grid architecture and in both cases the results have been positive. I have analyzed the simulation results and inferred that when there is more number of nodes participating to form coalitions, there are better chances of obtaining a good winning coalition thereby enhancing the efficiency of detecting intrusions. Also when there the number of nodes in a grid is larger, the detection time is lesser. I have also deduced that when the service time is lesser, there are more intrusions detected. Also Intrusion detection systems remain efficient in detecting all attacks with varying number of attackers. These detections are done by using the shapely value concept of game theory. The nodes of a winning coalition are enabled to get an equal share of the total gain and hence increase their reputation. Our proposed system is more efficient in detection.

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# *Hierarchical Route Optimization by Using memetic alogirithm in a Mobile Networks*

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***Abstract*-The networks Mobility (NEMO) Protocol is a way of managing the mobility of an entire network, and mobile internet protocol is the basic solution for networks Mobility. A hierarchical route optimization system for mobile network is proposed to solve management of hierarchical route optimization problems. In present paper we study hierarchical Route Optimization scheme using memetic algorithm(HROSMA) The concept of optimization- finding the extreme of a function that maps candidate 'solution' to scalar values of 'quality' – is an extremely general and useful idea. For solving this problem, we use a few salient adaptations, and We also extend HROSMA perform routing between the mobile networks.**

***Keywords-Route Optimization, Memetic algorithm personal area networks, NEMO, IP.***

## INTRODUCTION

In the trend of ubiquitous computing, many electric appliances, more electronic devices capable of integrating with wireless communications are being added. The mobile internet protocol (IP) working group within the internet engineering task force (IETF) has proposed the mobile IP protocol [1], [2] to support host mobility in IP based networks. The mobile IP aims at maintaining internet connectivity while a host is moving. The networks mobility (NEMO) protocol is a way of managing the mobility of an entire network, viewed as a single unit, which changes its points to attachments in the internet [3]. Such an internet will include one or more mobile routers (MRs) that connect it to the global internet. A mobile network can connect it to the global internet.

A mobile network can have a hierarchical structure; in this paper we propose a hierarchical Route Optimization scheme using memetic algorithm (HROSMA) for mobile network.

In addition to routing inefficiency, other criteria are important in designing a route optimization scheme for mobile networks. The concepts of network mobility were introduced to reduce the signaling overheads of a number of hosts moving as group.

The NEMO basic support protocol uses a bidirectional tunnel between the home agent (HA) and the mobile networks needs (MNNS) from sending all there location registration simultaneously when the MR changes its point of attachment. The characteristic is called mobility transparency, which is a very desirable feature for the route optimization scheme.

Mobile networks can here very complex form of hierarchy e.g. Mobile networks in a mobile network visiting mobile nodes(VMNS) in mobile networks and so on. This situation is repaired as nested mobile network.

## NEMO ARCHITECTURE

When a mobile network moves from one place to another, it changes its points of attachment to the internet, which also makes changes to its reach ability and to the Internet topology. NEMO (Network Mobility) working group has come up with NEMO support solution. NEMO support is a mechanism that maintains the continuity of session between mobile networks. Node (MNN) and their correspondent nodes (CN) upon a mobile Router's change of point attachment.
NEMO support is divided into two parts:
1. NEMO Basic Support
2. NEMO Extended Support

NEMO Basic Support is a solution for persevering session continuity by means of bidirectional tunneling between Home Agent (HA) and a mobile network. And NEMO extended Support is a solution for providing the necessary optimization between arbitrary Mobile Networks Nodes and correspondent Nodes, including routing optimization [5]. There has not been much research done with the NEMO extended Support Protocol.

A mobile Network is composed of one or more IP subnets viewed as a single unit. The Mobile Router is the gateway for the communication between the mobile network and the internet.

An Access Router (AN) is a router at the edge of an access network which provides wireless link to mobile nodes.A link is simply a physical medium via which data is transformed between multiple nodes. A Home Link is the linkattached to the interface at the Home Agent on which the Home Prefix is configured. Any Link other than Home link is foreign link.NEMO link is the link within the mobile network.

A Mobile Router has two interfaces:-

Ingress Interface: The interface of the MR attached to a link inside the mobile network.

Egress interface: The interface of the MR attached to the home link if the MR is at home and to foreign link if it is a foreign network.


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NEMO Basic Support protocol is an extension to the Mobile Ip version 6 (MIPv6) [2]. MIPv6 is a version of Internet Protocol (IP) that supports mobile nodes.

## MOBILE ROUTERS

A Mobile Router is a router that can change its point of attachment to the network by moving from one link to another. All the Internet traffic to and from the mobile network passes through the Mobile Router. Therefore, Mobile Router has to perform certain operations to be able to support network mobility.

## HROSMA

For the hierarchical Route Optimization scheme using tree information option (HROSTIO) we use an assistant data structure and call it MNN-CN(mobile network node-corresponding node) list .It is stored at MRs and records the relationship of the MNN-C

## BASE STATION

In more environment, a cell that Is geographical region unit is geographical region unite is covered by the radio frequency of a base station. Each call is controlled by a BS which has a fixed connection to a BSC (or RNC). In mobile network infrastructure element such as base station controller (BSC), wired links and mobile switch centre (MSC) are employed to provide and maintain essential service; hence the operation interruption of a network component affects overall or partial network services.

A radiation antenna is classified as omni directional and directional with an ommnidirectional antenna, a single frequency spreads out in all directions of *360* coverage. A cell is directional antenna with each different set channel.

## SYSTEM STATE OF BASE STATION

The BS system, including antenna parts, cannot provide partial or whole service function for coverage cell when single or more fatal failures occur in the BS system. In this paper, we consider that system failures are caused by key distribution method. For example by interrupt sequence mishandling, overall system operation falls into failure state because of unanticipated handled interruption to a component of the system.

## PERSONAL AREA NETWORK

A mobile network can have a hierarchical structure e.g. a mobile network within another mobile network. This situation is referred to as nested mobile network. A personal area network (PAN) may travel a vehicle, which also contains a mobile network of larger scale fig 1 illustrate a simple larger Scale. MR-1, MR-2 are attaché their own home link. A wireless personal area network moves as a single unit with one or more mobile routers that connect it to global internet.

## MULTIOBJECTIVE OPTIMIZATION (MOO)

An unaccompanied multi objective optimization problem is a example of route optimization for mobile network. Because mobile moves as a single unit with one or more mobile routers that connect it to the global internet. We defined this problem as

"Minimize" z = f(x)
Where *f(x) = (f1(x), f2(x)…..fn(x))*
Subject to x€x
Z2 minimize PF {0}

Fig -3 an example of multiobjective optimization problem with mobile search space (MSS) x, as vector fitness function f that maps solution in x to objective vector made up of two component (mobile routers) 'costs' $z_1$ and the $z_2$ minimized.

Here if we define
a=mobile router -1
b=mobile router-2
.
.
And
1=access router -1
2=access router-2
.
.

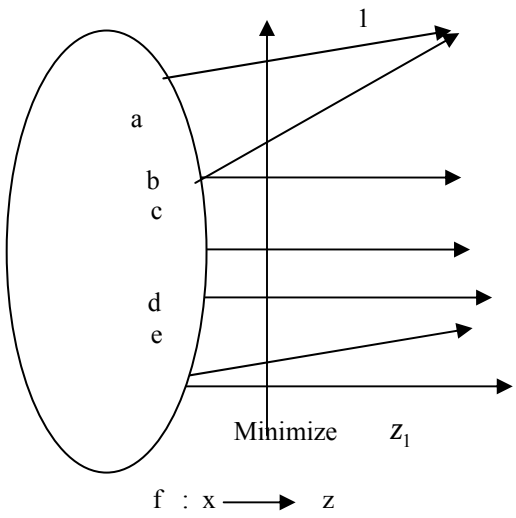


Fig-3

This fig is also defined a routing inefficiency for the traffic management and disigend a imported rout optimization schemes for traffic management of mobile networks. The concept of traffic management for the network mobility was introduce the signaling over heads of a number of hosts moving as a group as MRs.


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MEMETICALGORITHM APPROACH:-

The impressive record of Memetic Algorithms producing high quality solution in combinalarial optimization and in real -world application (e.g. see page 220[5]) is some times cited as a testament of their m herent effective – ness of robustness as black box search. However, since the advent of the no free lunch theorems [6,7,8] 109,19, 2, we know that MA, s like any other search algorithm , are only reality good to the extent to which they can be "aligned" to the specific features of a route optimization problems in mobile networks . None the less, MAs, like there fore bears evolutionary algorithms (EAs), do have unassailable advantage over other more traditional search techniques: that is their flexibility. This flexibility has important advantage, as has to solve mobile route optimization problems: one is to choose some traditional techniques. And them simplify or otherwise other the problems.

As in any other optimization scenario as route optimization problems, we should know that the out set what is a desirable outcomes; the Memetic Algorithm frame work proposed above required. The operators and procedures be selected based on their current success abs.

When a mobile network moves from one place to another it change its point attachment to the internet, which also makes changes to its reach ability and to the internet topology.

PERFORMANCEMEASURESIN MAs FOR MOO

If one is developing or using an algorithm for optimization it almost goes without saying that there should be some way to measures its performance. In MOO the situation is the same regarding the time aspect of performance assessment but the quality aspect is clearly more difficult. the extensive array of existing met heuristic , issues and methods reviewed in the section above gives a richer basis from which to design new MAs than do the existing MAs for MOO themselves. In a typical cellular network, the area of coverage is after geographically divided into hexagonal cells. The call is the basic unit of a cellular system.

In recent years, Muscat and krasnogor have provided a guiding manifesto for putting the "Memetic" back in Memetic algorithm [9, 10] advocating.

**Candidate MA framework for MOO:-**

1. MN: = initialize(MN)
2. A: = Nondom (MN)

**Algorithm Candidate MA framework for MOO**

1: MN: = Initialize (MN)
2: MN: = Nondom (MN)
3: **while** stop criterion not satisfied **do**
4: **while** stagnation _criterion not satisfied **do**
5: SAMN: =SelectFrom(PUA,sel_sc hed(succ(SEL)))
6: SAMN: =Vary (SAMN,var_sched (succ(VAR)))
7: SAMN":=LocalSearch(SAMN",I s_sched(succ(LS)))
8: MN: =Replace (PUC",rep_sched(s ucc(RED)))
9: A: =Reduce (Nandom(AUSAMN) ,red_sched(succ(RED)))
10: **end while**
11: MN: =Randomlmmigrants(P,imm_sched(succ(IMM)))
13: **return** (A)

Here we represent a Algorithm, we put forward a simple framework that could serve as a guide for making a more Memetic MA for MOO. In line1, MN (Mobile Networks) of solution is initialized. As usual this procedure may be simply random or it may employ some heuristics(s). Line 2 sets the archive A to the no dominated solution from MN. Thereafter, the main loop of the MA begins line 4 sets up an inner loop in which a stagnation criterion is checked. This should be based on some memeplex which monitors progress in diversity, proximity, and /or some other criteria. Line5-9 gives a very high level description of the update of the MN and archive. Five different 'schedulers' are employed, basically corresponding to mating selection, reproduction, lifetime learning, survival selection and update of the archive, respectively. Each scheduler chooses from a memeplex of operators, based on estimates of the current success of those operators. E.g. in line 5, Select from is the operation of mating selection, the domain of which is the union of the MN and archive, and co-domain is a Small Area Mobile Networks (SAMN), the selection is controlled by the scheduler, sel_sched, which use a success measures, succ, to choose one operators for the set SEL, of currently available operators for selection. Notice that MN and A are potentially of variable size, in this scheme. In line 11, the MN is updated using some immigration policy to rerelease it from stagnation, the archives of no dominated solution are returned in line 13.

The frame work proposed is rather broad and actually instantiating it requires us to consider how we should resolve many choices, including those considered in the following sections, at the very least. Table 1 summaries some of the MA elements / configuration choice to consider.

CONCLUSION

In this paper, we have proposed a scheme for mobile service use of BS system and memetic alogithm. The survavility of Route optimization scheme in nested mobile network modifying the process of Memetic Algorithm. Hierarchical Route Optimization scheme optimization scheme in mobile network modifying the process of memetic alogrithm. And hence the NEMO basic support protocol needs to be extended with an appropriative route optimization scheme. the optimization scheme to we easily solved by MEMETIC ALOGRITHM . We propose a scheme can achieve the hierarchical Route Optimization scheme using memetic alogrithm (HROSMA) for route optimization environment.

And hence the basic support protocol for Hierarchical Route Optimization scheme optimization scheme of Route optimization scheme for mobile network needs to be extended with an appropriative route optimization scheme. we


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propose a scheme can achieve the mobile route optimization environment. It may get a survivability scheme.

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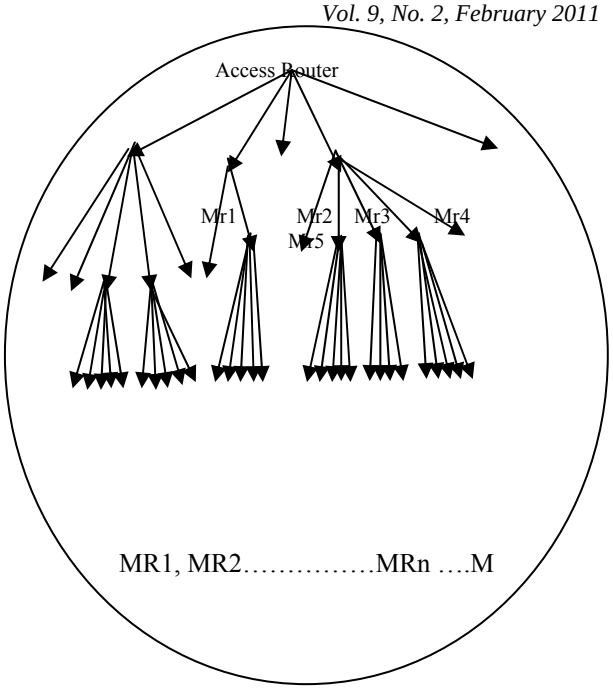


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# Performance of Call admission Control for Multi Media Mobile Network with Multi beam Access Point

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***Abstract*-A performance of call admission control scheme in different classes of calls may have different bandwidth requirement, different request call holding timings and residence times. At any time, each call of the network has the capability to provide service to at least a given number of calls for each call of calls. When the multi beam directional antennas are introduced in this system, then we shall have many challenging problems. In this system, then we have many challenging problems.**

**In this paper we propose a noble network protocol to carefully examine performance of call admission control for multimedia network, for each class of new and handoff this mobile network.**

***Keywords-Call admission control. Directional antennas, Multibeam Access point, Multimedia Network, Multiple input multiple outputs (MEMO)***

## INTRODUCTION

With the development of Multimedia from the stand point of a system Administrator, this property provides an alternative for resource planning, especially for bandwidth, allocation/ reallocation in wireless multimedia networks. The system may need to block incoming users of all of the bandwidth Has been used up to provide the highest QoS to existing users. And in mobile network local access, there is an increasing demand to improve throughput and energy efficiency for data transmission between terminals and an access point. Multibeam smart antennas bring two major benefits, spatial reuse and antenna gain, both of which are useful in improving the mobile communication efficiency. Therefore it is of great interest to consider the use of multibeam smart antenna in a mobile network, especially anthraces point. The access point is generally more powerful with less physical constraint than mobile terminals.

Recently these have been some research devoted to optimizing the mutual information of a MIMO system with interference [4]-[8]. For example, in [7-[9], signaling methods we developed to optimize the mutual information of a MIMO system where the user is one cell suffers from the co-channel interference from the users in other cells. In [10], the problem of non-reciprocal interference was recognized in case of adaptive modulation in general. A simple feedback method was developed to compensate for it is a fate single antenna transmission scenario.

The paper [11-12] showed that these two variables are dependent and derived a new degradation ratio. Also they argued that another new performance metric, the frequency of switching between different quality levels, should also be taken into accounts because users may feel more disturb by frequent switches quality levels than by poor but steady quality.

To design a cellular mobile network, comparison needs to be made between the performance measures of different protocol. Mobile which provides a multiple call analysis with an MIMO is developed for the majority of networks. in this paper we formulated and steady an adaptive performance of call admission control for Multimedia mobile network with Multiple cells , Multiple classes of calls and fairness consideration . the cellular networks here is characterized by the requested call holding time, call residence time and new call arrival process as well as capacity restriction on the number of calls due to limited bandwidth. And here we present the system model and identity the design challenges. Then we present our proposed protocol tree MEMO

## CALL ADMISSION CONTROL

The handle a Multiservice for Multimedia Network (MMMN) it is very important to employ the call admission control mechanism. First call admission control is a critical step for the provision of QoS quarantined service because it can prevent the system capacity from being overused. Second, call admission control can help the MMMN provide different classes of traffic load with different priorities by manipulating their blocking probabilities. In a MMMN System, CAC is used to accept or reject connection request based on the state information and the QoS requirement of these connection. Now we consider a Multimedia Mobile communication networks. Consists of J connected cells. There are U classes of calls (telephone, video, etc…, but for convenience we shall call all of them calls). The other assumptions and notations for this wireless mobile network are as follow


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(1) The required bandwidth of class u calls (u=1 …U) is form the minimum bandwidth requirement $b_{ju}$ to the maximum bandwidth requirement $B_{ju}$ ($0< b_{ju} \leq B_{ju}$) in cell j (j=1, 2….. J). if a call gets the maximum bandwidth for communication, it gets the worst but acceptable QoS from the network.

(2) Cell is consists of $M_j$ channels. To be fair to each class of call sin each cell, cell j reserve $K_{ju} B_{ju}$ ($K_{ju}>0$) channels, for class u calls. Notice that only the number of channels, not individual channels are reserved [13]. This implies that any time cell j will have the capability to provide the minimum QoS level service for at least $K_{ju}$ class u calls simultaneously .Please refer to the conclusion part for an explanation to a related situation.

(3) To give priority to handoff calls, a threshold value ($T_{ju} >> K_{ju}$) in cell j is predetermined and specified for class u calls. This threshold value means that a class u new call request is admitted if and only if,(a) the number of class u calls in cell j less than $T_{ju}$,(b) there is at least $b_{ju}$ available channels in cell j after possible degradation QoS for other existing calls (see II B for the degradation description),and (c) the constraint in item 2 above is not violated after admitting this class u new call. A handoff request is admitted provided there are minimum required bandwidths for this call after possible degradation QoS for other calls and that the constraint in item 2 above is not violated after admitting this class u handoff call. Clearly, $_{ju}$ should satisfy $\sum_{u=1}^{U} T_{ju}\, b_{ju} \leq M_j$.

(4) Class u new calls are generated in cell j according to a Poisson process with rate $\lambda_{ju}$, 1……U. The requested call connection time (RCCT). Which is defined as the total length of time that a call initial requests to use a channel, of a class u new call at cell j, $H_{ju}$ is exponentially distributed with mean $1/ H_{ju}$. the cell residence time, which is defined as the length of a time a call stays in the cell and which is depends on the velocity and the direction of the mobile terminal, of a class u call in cell j, $R_{ju}$ ,is exponentially distributed with mean $1/ r_{ju}$.

(5) The probability that a class u call moves from cell j to a neighboring cell k, given that it moves to a neighboring cell before the call is completed ,is $P_{ju}$ ku, where $\sum_{k=1}^{j} P_{ju}$,ku,=1.

(6) As desired above, a class u new call at cell j gains at least $b_{ju}$ channels for communication if it arrives and finds there are less than $T_{ju}$ class u calls in the cell. There is at least $b_{ju}$ channels available and the constraint in item 2 is still not violated after admitting this class u call. If any of these condition is not satisfied ,then the new call will be cleared from the network with probability $r_{ju}$,0 or will push out a class u call in the cell to a neighboring cell , say cell k, with probability $r_{ju}$,ku>0 is possible only when j and k are neighboring cells , refer to [2] for a similar protocol. It is worthy to point out that the specific values of the probability $r_{ju}$,ku for different system will depend on the signal to noise ratio at cell j and cell k for class u calls.

(7) A class u handoff call to cell bj is admitted for connection when it arrives and finds at least $b_{ju}$ channels available and the constraint in item 2 above is not violated after admitting this class u handoff call. Otherwise, the handoff call will be cleared from the network with probability $r_{ju}$, 0 or will be admitted in cell j by the system in terms of pushing out a class u call to a cell k with probability $r_{ju}$, ku.

Note that the protocol above gives priority to handoff calls as well as. Fairness for each class of calls. The key differentiation of the priority comes in form the threshold value $T_{ju}$ and the main differentiation of the fairness comes from the reservation number $K_{ju}$. The use of probability $r_{ju}$, ku can model several network features. (1) if a call is blocked at one cell, it may not be blocked by the network.
This is possible in practice, because cells often overlap to ensure complete coverage of the region and when a call is attempted, the mobile may be situated near the boundaries of two cells and it may be close to a third or fourth cell. A handoff attempt is possible to these neighboring cells when the first attempt is blocked. The protocol is called directed retry in [13]. (2) if a call arrives to a cell and finds all channels busy, it is possible to borrow a channel does not interfere with the existing calls. This is called simple borrowing strategy in [13]. Some related borrowing concepts can be found in the hybrid


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channel assignment strategy [7]. In this paper we consider the case that $r_{ju}$,ku= $r_{ju}$, $p_{ju}$,ku/( $b_{ju}$ + $r_{ju}$), thus P($R_{ju}$ < $H_{ju}$)$P_{ju}$,ku $_{ju} \equiv r_{ju}$,ku. An intuitive explanation for this assumption is that a pushed out class u call to a cell follows the same protocol as those class u calls at cell j that move out of the cell before finishing the call. We remark that the production form solution presented in this paper fails if r does not take this form.

Example: Suppose there are three classes of calls in a cell and the capacity in the cell is 15,30,45,60……the minimum and maximum numbers of channels needed by the three classes of calls are both 1,2,3,4……..and 2,4,6,8…….that is, $b_1 = b_2 = b_3$ ……=1,2,3……..and $B_1 = B_2 = B_3$ …… ….=2,4,6…….. where for simplicity we have dropped the cell index. This state space for this cell is

$$2n_1 + 2n_2 \leq 15 \quad (1)$$

$$2n_1 + 2n_2 + 2n_3 i \leq 30. \quad (2)$$

$$2n_1 + 2n_2 + 2n_3 + 2n_4 \leq 45. \quad (3)$$

$$2n_1 + 2n_2 + 2n_3 + 2n_4 + 2n_5 \leq 60. \quad (4)$$

Suppose at a call arrival epoch, or a call completion epoch, or a call handoff epoch, the new state is (1, 3, 4), which is a feasible state from equation (6). From equation (1) it is easily seen that $a_{ju}$( $n_{ju}$)=1. Based on this result and form equation (2) and (3), it is ready to drive that $u_j^*$ ($n_{ju}$) =2. Finally from equation (4), we can figure out that $m_j^*$ ($n_{ju}$) =1.

Therefore based on our channel sharing algorithm, we obtain the following channel allocation for state (2, 3, 4…):

Assign 4 channels to each of the 2 class 1 call,
Assign 4 channels to each of the 3 class 2 calls,
Assign 3 channels to each of the other 2 class 2 calls,
Assign 3 channels to each of the 4 class 3 calls.
Similarly for nth time.

## MULTIBEAM ACCESS POINT

Antenna System for CAC: two types of Multibeam smart systems. One is based on adaptive arrays and the other is based on the fixed beam directional antennas. in present study, we consider fixed multi beam antenna system.

Let antenna system consist of M sectors, each of which is oriented to provide non overlapping 360/M azimuth coverage. Each sector consists of N narrow beams with approximately 360/MN beam width per beam where the bandwidth of two edge beams of each section may be a little bit larger for better coverage. In a Multimedia Mobile Network (MMMN) system, CAC is used to accept or reject connection request based on the state information which defined as 360/MN. And we define a CAC policy in the following: let B the overall beam width resource (for subscribes k, B=DBk) and let M' be the number of traffic classes, then we can then define the system state vector as n= n ($n_1$, n2, n3,…….nm) of class I connection in the system. Assuming that the beam with requirement of classes I connection is fixed to bi, then beam width requirement vector is represented by b= (b1, b2…bm). Therefore an incoming will be accepted if sufficient beam width resources are available.

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# Multi-party Supportive Symmetric Encryption

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***Abstract*—Business data is a valuable asset for many Organizations. Organizations need security mechanisms that provide confidentiality for outsourcing their data services. Encrypting sensitive data is the normal approach in such a situation. Applications typically use Symmetric keys for encryption, or Asymmetric keys for their transmissions. In case of Asymmetric encryptions they use the public keys of the signers along with files sent. Since these identity strings are likely to be much shorter than generated public keys, the identity based key generation is an appealing option. A multi-signature scheme enables a group of signers to produce a compact, joint signature on a common document, and has many potential uses. Existing schemes with multi signers impose requirements that make them impractical, such as requiring a dedicated, distributed key generation protocol amongst potential users. These requirements limit the use of the schemes. Multi-Party or co-operative authentication on information is a trusted source of security. In this paper, we propose an encryption scheme where each authorized user's information is used to encrypt and decrypt data. This paper, presents a multi-party yet supportive, secure and identity-based scheme based on symmetric encryption, Multi-party Supportive Symmetric Encryption (MSSE). This paper takes an effort to resolve the security issues and also report on the results of the implementation**

***Keywords:*** Symmetric Encryption, Sub-key, Key Management, Key generation, Multi-party

## I. INTRODUCTION

Information channels are generally vulnerable to eavesdropping and attacks from outsiders. Strong cryptography is needed to protect these channels. Traditional access controls that provided confidentiality were designed in-house and depended on authorization policies. According to Forrester Research, enterprise storage needs grow at 52 percent per year [1] and organizations chose to outsource their data storage to third parties. One of the biggest challenges raised by data storage outsourcing was security and trust. Cryptographic approach also provided data confidentiality. Encryption is a method to securely share data over an insecure network or storage site. Users who communicated needed to establish a mutually held secret key k. In public key cryptography two parties communicated with a public and private key. The functionality allowed the parties to establish a shared symmetric key and to encrypt and decrypt messages in an ideal way using this key. The key was meant to be a long-term shared key never given to the parties, but be a part of the functionality.

## II. MULTIPLE ENCRYPTION

Multiple encryption is the process of encrypting an already encrypted message one or more times, either using the same or a different algorithm. Multiple encryption algorithms allow users to pick their own logic and the benefit of this approach is that if an algorithm turns out to be seriously broken, supporting multiple algorithms can make it easier for users to switch. Multiple algorithms add more complexity to the application.

## III. MULTI-SIGNATURE SCHEMES

Multi-signature schemes [2] allows different signers with public keys to collectively sign a message, yielding a multi-signature. Multi-signature schemes greatly save on communication costs. In most applications these public keys will have to be transmitted along with the multi-signature. The public keys of all cosigners are needed to verify the validity of such a multi-signature schemes. The inclusion of information that uniquely identifies the cosigners seems inevitable for verification For example, the signers' user names or IP addresses could suffice for this purpose; this information may even already be present in package headers:

## IV. IDENTITY BASED SIGNATURES

In an identity-based signature scheme [3], the public key of a user is simply his identity, e.g. his name, email or IP address. A trusted key distribution center provides each signer with the secret signing key corresponding to his identity. When all signers have their secret keys issued by the same key distribution center, individual public keys become obsolete, removing the need for explicit certification and all associated costs. These features make the identity-based paradigm particularly appealing for use in conjunction with multi-signatures, leading to the concept of identity-based multi-signature (IBMS) schemes. Application implementations of IBMS schemes are rather limited. While pairings have turned out extremely useful in the design of cryptographic protocols, they were only recently brought to the attention of cryptographers [4], and hence did not yet enjoy the same exposure to cryptanalytic attacks by experts as other, older problems from number theory such as discrete logarithms,


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factoring and RSA. Our scheme is essentially a multi-party co-operative Symmetric scheme with identity of the participating parties. The techniques are strengthened to provide security against concurrent.

## V. RELATED WORK

Diffie and Hellman [5] have argued that the 56-bit key used in the Federal Data Encryption Standard (DES) [6] is too small and that current technology allows an exhaustive search of the 256 keys. Double encryption has been suggested to strengthen the Federal Data Encryption Standard (DES). A recent proposal suggests that using two 56-bit keys but enciphering 3 times (encrypt with a first key, decrypt with a second key, then encrypt with the first key again) increases security over simple double encryption. At the 1978 National Computer Conference, Tuchman [7] proposed a triple encryption method which uses only two keys, K1 and K2. The plaintext is encrypted with K1, decrypted with K2, then again encrypted with K 1. Schemes that encrypt data on the client-side, enable server-side searches on encrypted data. [8] Introduced the first practical scheme for searching on encrypted data. The scheme enables clients to perform searches on encrypted text without disclosing any information about the plaintext to untrusted servers. The untrusted server cannot learn the plaintext from the encrypted search results. The basic idea is to generate a keyed hash for the keywords and store this information inside the ciphertext. The trusted server can search the keywords by recalculating and matching the hash value. [9] proposed a scheme to execute SQL queries over encrypted numeric data and is suitable for exact matches and also range queries. Its strategy is to store the encrypted numbers with some index information and to split the query into a query on the encrypted data processed by the untrusted server and a query on the returned result for post-processing results on the client. [10] presented a scheme for searches on encrypted data using a public key system that allows mail gateways to handle email based on whether certain keywords exist in the encrypted message. The application scenario is similar to [8], but the scheme uses identity-based encryption instead of symmetric ciphers. Using asymmetric keys allows multiple users to encrypt data using the public key, but only the user who has the secret key can search and decrypt the data. [11, 12] enable searches on encrypted data by constructing secure indexes. All the schemes above rely on secret keys however, which implies single user access or sharing keys among a group of users

## VI. MULTI-PARTY SUPPORTIVE SYMMETRIC ENCRYPTION (MSSE )

The basic characteristic of MSSE is sharing of information between users in the generation of the key. Each user has his own information designed as a part of the key. This section introduces the basic construction of the multi-party supportive symmetric encryption scheme built upon symmetric encryptions. The notions of security are also discussed and proofs provided in later sections. MSSE Scheme has its own unique features. The Key features being Variable key length, Key dependent rotation, Lengthy key schedule algorithm and Multiple Linear Functions with Variable of number of rounds.

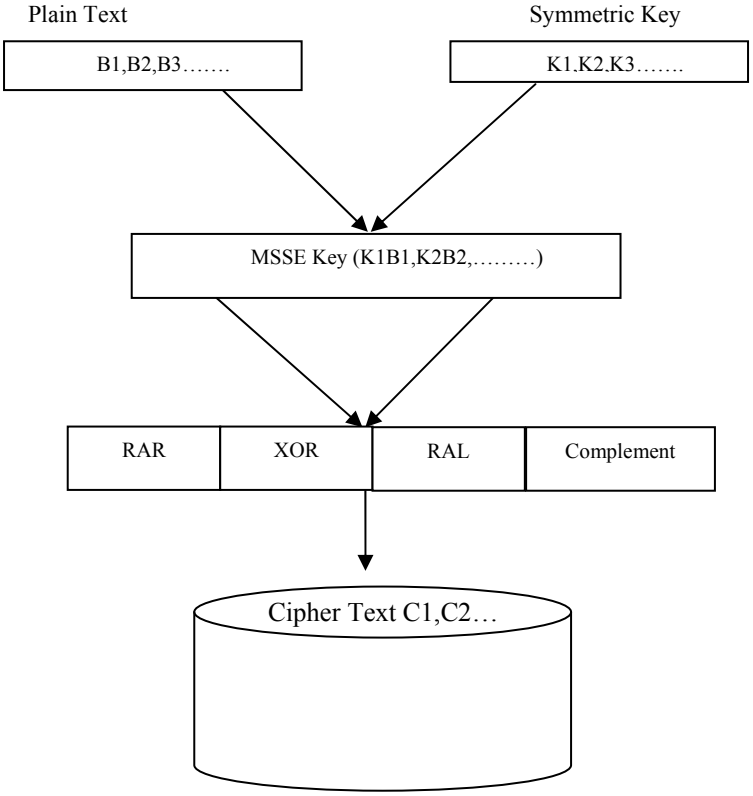


Fig. 2. MSSE Architecture

## VII. KEY GENERATION

The key will be generated with both the sender, receiver and servers name included. Since the key comprises of various components and is a combination of server and client related information, it makes it hard for the attacker to guess the key. The step by step procedure is as follows:

### *A. A KEY GENERATION ALGORITHM*

Sender and Receiver agree on two numbers "**p**" and "**g**" , where p is a large prime number and g the base generator. Sender then chooses his secret odd number called "**a**". Similarly the Receiver's secret odd number is "**b".** Sender and Receiver exchange their numbers. The senders email id is known to the receiver and the receiver knows the senders email id. Sender knows **p, g, a, b, receivers emailID** and the Receiver knows **p, g, b, a, senders emailID.**

### B *FUNCTION MAIN KEY*

**INPUT**: p,g,a,b and Senders Email Id, Receivers Email ID
**OUTPUT**: 512 bit Secret Key
The First part of the key $\mathbf{k_1}$ is the senders email id converted into its ASCII value in 192 bits or 49 bytes. The sender Computes the Key for Encryption as $\mathbf{k_2} = \mathbf{g}^{\mathbf{b}} \bmod \mathbf{p}$. The Third part of the key $\mathbf{k_3}$ is the receivers email id converted into its ASCII value in 192 bits or 49 bytes. The final and


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fourth part of the encryption key is computed as $\mathbf{k_4} = \mathbf{g}^{\mathbf{a}} \bmod \mathbf{p}$. The Secret key is generated as **Key K = $k_1||k_2||k_3||k_4$.** as demonstrated in Fig. 1.

| Email Id of the Sender in 192 bits (49 Bytes) | 64 bit key of Receiver | Email Id of the Receiver in 192 bits (49 Bytes) | 64 bit key of Sender |
|---|---|---|---|

Fig. 1. The 512 bit Encryption key

For example,

p=11 and g = 10 and a=5 and b=8 Then
$K_2 = 10^5 \bmod 11$ would be 10 and $K_4 = 10^8 \bmod 11$ would be 10

If the email id of the sender vnkumar62@yahoo.com , this would be translated into the following sequence 118 110 107 117 97 114 54 50 64 121 97 104 111 111 46 99 111 109

If the email id of the receiver is ssdarvind@yahoo.com , this would be translated into the following sequence 115 115 100 97 114 118 105 115 100 64 121 97 104 111 111 46 99 111 109
The **Key K = $k_1||k_2||k_3||k_4$**

00001010 01110110 01111000 01110101 01110101 01100001 01110110 00110110 00110010 01000000 01111001 01100001 01101000 01101111 01101111 00101010 01100011 01101111 01101101 011110111 011110111 01100100 00110110 01110110 01110110 01101001 01111000 01100100 01101000 01101111 01101111 00101010 01100011 01101111 01101101 00001010.

Here a 432 bit key is generated. It will be split into 216 Two bit keys. It will have a minimum of 40 rounds of sub-keys for one round of the Secret key. Approximately 256 x 216 i.e 50k bytes of Plain text will be converted to Cipher text with one round of the key.

**C** *KEY SCHEDULING (DIVIDE-KEY FUNCTION)*
This function is called Divide-key function because it creates Two bit keys from the secret key. The function knows the length of the secret key in advance and then correspondingly splits the secret key into equal 2 bit sub-keys as explained in equation (1) :

$$K_{(1,2,3,4....l)} = K_{(1to\text{-}2,\ 3to48,\ \ldots\ldots l\text{-}2\ to\ l)}, \quad \ldots\ldots\ldots (1)$$

where 1,2,4….l are the no of sub keys and l is the variable length of the key based on the senders and receivers email id's and agreed numbers p,g, a,b.

*D MSSE ENCRYPTION ALGORITHM*
Step 1: Generate 512 bit Secret key using Main_Key function
Step 2: split the Secret key into 2 bit Sub-keys with Divide-key Function
Step 3 : counters ky=0,j=0,kcnt=keylength in bits /2
For i=0 to msglength do step 512
j= j+1
C[i] = M[i] SHL //SHL Once
C[i] = M[i] SHL // SHL Second Time
C[i] = M[i] XOR $k_j$ // XOR of two bit sub key padded with zeros to get 8 bits is done
If j > kcnt then
J=0
End if
Next i
Step 4 Display C
INPUT: M=(m1….$m_{512}$) plain text and K =(k1….$k_{256}$) 256 bit Secret key split as 2 bit key
OUTPUT: C=512 byte cipher text

*E MSSE DECRYPTION ALGORITHM*
Step 1: Generate 512 bit Secret key using Main_Key function
Step 2: split the Secret key into 2 bit Sub-keys with Divide-key Function
Step 3 : counters ky=0,j=0,kcnt=keylength in bits /2
For i=0 to msglength do step 512
j= j+1
C[i] = M[i] XOR $k_j$ // XOR of two bit sub key padded with zeros to get 8 bits is done
C[i] = M[i] SHR //SHR Once
C[i] = M[i] SHR // SHR Second Time
If j > kcnt then
J=0
End if
Next i
Step 4 Display M
INPUT: C=(c1….$c_{512}$) cipher text and K =(k1….$k_{256}$) 256 bit Secret key split as 2 bit key
OUTPUT: M=512 byte plain text.


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## VIII SECURITY ANALYSIS

An attacker (or a software agent) that gains privileged access to the data storage or a untrustworthy employee, can intercept the communications between clients and the server. The attacker is restricted to passive attacks, i.e. attacks are based upon observed data. In most cases the attacker is isolated from the users and initialized by the client. The goal of the attacker is to gather direct or indirect information about the stored data. The following points ensure the unpredictability of the results for the attacker

- The algorithm involves Rotating the bits, XORs, Complements and Rotating Lefts, ensuring no test blocks of cipher text are the same..
- Due to keys change for each block, it is very hard to perform the cryptanalysis on the keys.
- Due to 512-bit key and 2-bit Sub-Key, the cipher becomes more secure. Because, a total $2^{256} + 2^n$ number of permutations are possible where 256 >= n>=2. So, brute force attack is much time taking, nearly 1.079x1028 year for a personal computer which permutes thousands of 128-bit numbers in 1 second for n=7. If we increase the value of n then the number of years required for brute force attack will increase. The lesser the size of n, the number of key generation is more. Hence, in both the cases, we are optimizing security.
- Since the Sub-key changes for every block, secure key exchange becomes unnecessary, reducing the network traffic.
- If an attacker is so lucky and he does the best guess, the probability for guessing the key will be $(1/2^{128})$ or 2.938*10-39, for Number of bits it will be $(1/ 2^7)$ or $7.812x10^{-3}$ when n=7 and the joint probability for both will be $(1/2^{128})*(1/ 2^7)$ or $2.295*10^{-}41$, achieving message confidentiality.

## IX CONCLUSION AND FUTURE SCOPE

In this paper, we presented a new data encryption scheme that does not require a trusted data server. Unlike previous searchable data encryption schemes that require a shared key for multi-user access, each user in our system has a unique set of keys. The data encrypted by one user can be correctly decrypted by all the authorized users in the system. Moreover the keys can be easily revoked without any overhead, i.e. without having to re-encrypt the stored data.

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# High Efficiency QoS Guarantee, Channel Aware scheduling scheme For Polling Services in WiMAX

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***Abstract*—This Paper offers an efficient channel aware scheduling scheme for IEEE 802.16e WiMAX Mobile, real-time and non-real-time polling service. Compared to a similar scheduling approach, our considered scheduler can guarantee and achieve lower delay with a good average throughput. In order to achieve this object, we introduce a scheduling scheme with four different segments in a decision making process. The first part, a time dependent function that considers the time when packets wait in queues and in a jitter area to prevent packet deadline. Buffer utility function, as the second part, considers buffer size in scheduling to prevent overflow, specifically in nrtPS class with large size packets. The third part, retrieved from proportional fairness algorithms, which in normal conditions gives a fair share to users. Channel SNR and service class weight are also involved in this part. The final section of scheduling relationship, channel condition, is defined more accurately by RSSI and CINR parameters. The simulation results in OPNET show that our proposed scheme has a very good delay and packet loss ratio accompanied by a high throughput. In another scenario, with different number of users and limit resources, we show relationship between admission control and scheduling.**

***Keywords-component; IEEE 802.16e; WiMAX; Scheduling; QoS; Resource Allocation; OPNET***

## I. INTRODUCTION

In recent years, bandwidth hungry applications, such as video and music streaming, large file downloads, etc have been significantly used. Wireless and vehicular accession to such contents lead companies and standard organizations like, 3GPP and IEEE, to develop BWA technology. IEEE 802.16 standard families with long distance and QoS mechanism support are among the important and active technologies for these Issues also, counted as a strong 4G candidate under the development of 802.16m standard version. In our survey, IEEE 802.16e mobile-WiMAX standard [1] has been studied for its special features like power management and handover capability rather than for its fixed version. Two PHY and MAC layers are defined by standard, which in Medium Access Control layer are responsible for QoS mechanism such as call admission control and scheduling. For resource allocation, channel aware scheduling [2] are cross layer processes which use some physical layer parameters like SNR, CINR and RSSI for decision making procedure. Unlike channel unaware scheduling which assumes error free transmission media, in wireless system, for its extreme time varying nature, we need to consider channel condition to prevent waste of resource.

Mobile-WiMAX uses TDD mode that makes channel estimation easier, also operates in 2-11GHz Frequency Range. Both access technologies, OFDM and OFDMA can be used in WiMAX. Our used technology is OFDMA that increases Bandwidth utilization but makes scheduling problem more difficult. Scheduler in OFDM decides for OFDM symbol and all subcarriers are allocated to one user, nevertheless each subcarrier can select different Modulation and coding scheme which makes it difficult to estimate average rate in a forward frame. Decision making for OFDMA is much more difficult than for a time scheduler, because it must select subchannel in a frequency domain.

The smallest allocation unit by Scheduler is called slot. In OFDMA, slot is a combination of some subcarriers and some OFDM symbols. Depending on permutation process, slot may have different definitions. For instance, for uplink in PUSC, each slot consists of 3 OFDM symbols and 16 subcarriers. The other issues are burst in a downlink that must be rectangular Fig. 1. which makes it difficult for a downlink scheduler to select the slot in such a manner that best fits to the user allotment [3], [4], [5]. Packing and Fragmentation are other options that can be used by WiMAX equipment to fit MAC SDU in Mac PDU.

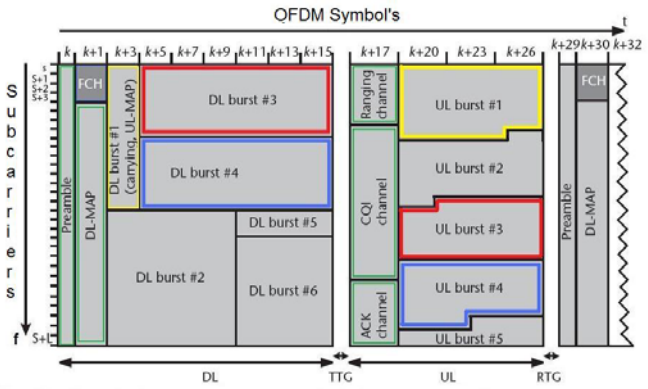


Fig. 1. OFDMA Frame in 802.16e


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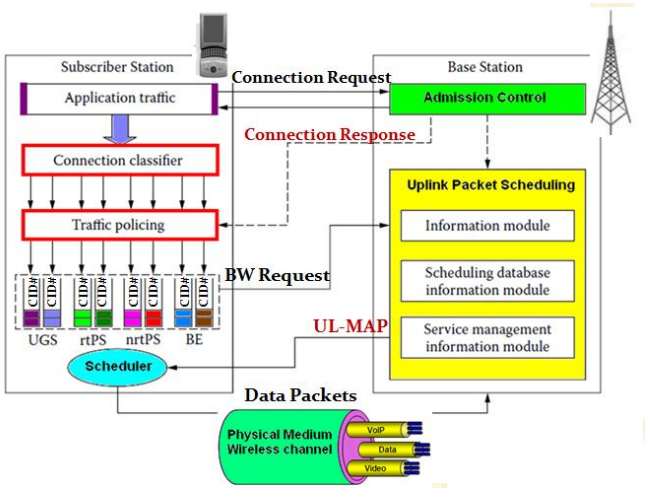


Fig. 2. Admission control and scheduling for user

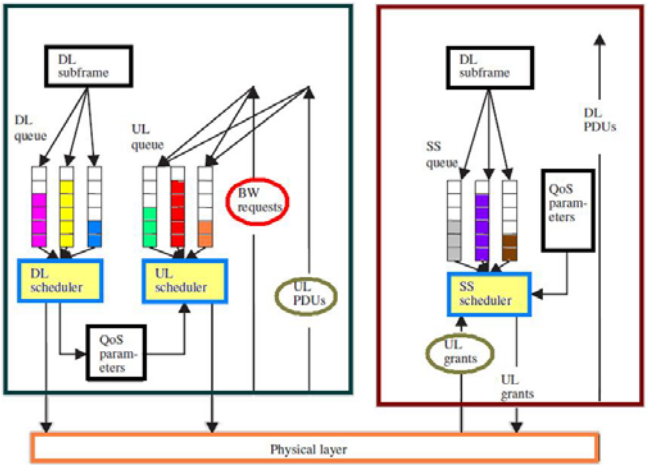


Fig. 3. Centralized scheduling in WiMAX

Both of the two procedures utilize transmission frame but increase overhead and must be considered in scheduling. The most important parts in QoS are scheduling and call admission control Fig. 2. which open spaces in standard and have been done by MAC layer. Medium access control layer consists of 3 sublayers; a) convergence sublayer, b) common part sublayer and c) security sublayer. In convergence sublayer, packet classification and getting proper CID and SFID have been done. According to the requirements and the specific parameters, packets are classified into 5 QoS service classes. 1) UGS: this class gets fix bandwidth without any overhead and can guarantee QoS, but wastes resource when traffic changes. 2) ertPS: this service is suitable for VoIP traffic with silent suppression and needs a polling mechanism to inform end of the silence, similar to UGS, QoS parameters are maximum latency tolerance, maximum sustained rate and tolerated jitter. 3, 4) rtPS, nrtPS: These two service classes are for real-time and non-real-time variable rate traffic. For varying nature of packet size like video streaming in rtPS and FTP download in nrtPS. Polling mechanism is needed to specify what amount of resource must be granted to the users. For nrtPS, there exists no delay guarantee but minimum throughput is guaranteed. 5) BE: most of the traffic is classified to this QoS class of services. After all other classes being allocated, there will be no QoS guarantee and queue to use the remaining resources when other class was allocated.

In point to point configuration, WiMAX uses a centralized scheduling Fig. 3. It means, Base station makes decision for uplink and downlink traffic. Even the grant for a user is based on GPSS (grant per subscriber station), we'll need another scheduler in mobile station. Another grant method, GPC (grant per connection) was outdated in IEEE 802.16e. Before a packet be classified and a scheduler make a decision, the call admission control unit accepts or rejects the new connection, according to the estimation of a system capacity. Clearly, inappropriate capacity estimation by CAC unit degrades scheduling performance, especially when it accepts more than system real capability.

## II. Polling And Related Works

### A. Polling Service

Bandwidth request in WiMAX is categorized as either implicit or explicit method. In WiMAX mobile, there exists as a whole, 11 different ways for bandwidth request. Unsolicited request, bandwidth stealing, poll-me bit, piggybacking, codeword over CQICH, CDMA code-based and contention region based are as implicit method. Polling based methods like unicast polling, multicast polling, broadcast polling and group polling are categorized as explicit method. Guarantee QoS, required information about the user queues such as buffer size and head of line packet states. There is a need for delay and throughput guarantee in an uplink for a service class. Its suitable and possible bandwidth request way is polling based method. In this way, station polls users for requesting slot in a periodic interval to transmit their packets.

In polling mechanism, at first, user bandwidth must be admitted by admission control unit. According to QoS parameters defined for queues base station, poll users in a periodic interval to request for a bandwidth. These polling intervals may be addressed to individual SSs (unicast polling) or to groups of SSs (broadcast or multicast polling). Polling-based service scheduler uplink traffic makes decision for queues and then grants bandwidth, in accord to the available resources and the number of users. Users by decoding UL-MAP in uplink can be informed about their grants.

Choosing suitable approach and polling mechanism delay are the two problems for this method [6]. Unicast polling prevents the request collisions and can guarantee the delay, but by an increase in the number of stations, tremendous bandwidth for polling are required which decrease bandwidth for the grant.


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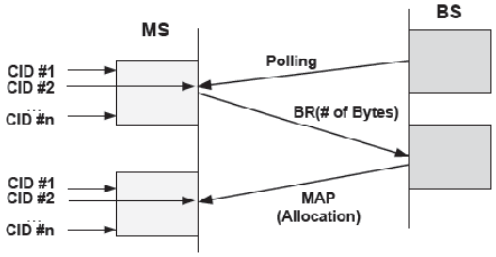


Fig. 4. Polling based bandwidth request mechanism

Multicast or broadcast polling mechanism, according to contention-based area, is a better approach for a large number of users, but decreases throughput of the system.

According to Fig. 4. polling mechanism in WiMAX is a 3 way handshaking process which increases delays in the queues. A user waiting for poll intervals also must wait for the response of scheduler for grants. In the best situation, after 2 frames, request for queues, can access to the channel.

*B. Common Channel Aware QoS Scheduling Algorithms*

Fairness, delay, throughput, Energy Consumption, Power Control, Complexity and Scalability are the important parameters in scheduler design, a metric evaluation and comparison. Scheduling in WiMAX can be classified in two main parts, channel aware and channel unaware methods. In which these method can be used for intra-class and inter-class scheduling. Most of the channel unaware scheduling comes from router and CPU fundamentals that extended for WiMAX [7], [8], [9], [10]. This series of algorithms assume an error free idle channel for each user, and share resources according to their capacity and QoS parameters. In wireless transmission channel, for each user, conditions differ and degrade in frequency and time domain. So channel state must be considered in resource allocation decision making process. WiMAX uses CQI Channel to inform base station about channel conditions. CQICH information primarily is used by adaptive modulation and coding module to select the best scheme in transmission. Channel aware scheme also can use these channel parameters in RSSI and CINR decision makings. For the algorithms that use channel state, four main categories can be named as: Proportional Fairness based, QoS guarantee based, power constraint and System throughput maximization.

The goal, in PF-based scheme [11], is to achieve the long-term fairness between the queues, especially in BE service class which offers no guarantee for quality of service. In PF-based scheme each user who can maximize Eq.1 gets an opportunity for transmission.

$$C_i(t) = \frac{r_i(t)}{R_i(t)} \qquad (1)$$

Where, $r_i(t)$ is an achievable data rate of user i and $R_i(t)$ is an average data rate in a given time window $T_i(t)$. $R_i(t)$ is computed by an exponential averaging in past $T_i$ windows expressed in Eq.2 :

$$R_i(t) = \begin{cases} \left(1 - \frac{1}{T_i}\right) R_i(t-1) + \frac{r_i(t)}{T_i} & q_i(t) \neq 0 \\ R_i(t-1) & q_i(t) = 0 \end{cases} \qquad (2)$$

$T_i(t)$ has impact on throughput, but its accurate selection is difficult. Proportional Fairness algorithms do not guarantee delay or throughput, also short time fairness are not satisfied. It cannot be a proper method for a delay sensitive traffic and for an application minimum throughput requirement, and it needs to be modified differently.

QoS guarantee algorithms provide delay and throughput requirements for each service class that needs QoS. M-LWDF families [12] are the most important algorithms in this category that try to modify LWDF, in which throughput, are optimal. As one of these approaches in [13] queue i that maximizes Eq.3 in subchannel k, can get permission to transfer its packet.

$$Channel\_gain(i,k) \times HOL\_packet\_delay(i) \times \frac{a(i)}{d(i)} \qquad (3)$$

In this equation $a(i)$ is throughput in coming frames and $d(i)$ is average throughput in past specific time window. Channel gain is the normalized ratio of the square of noise at the receiver and the variance of Additive White Gaussian Noise. HOL_delay is a waiting time in buffer for packet in head of the queues. This algorithm using some buffer state information in decision making, are useful for QoS guarantee.

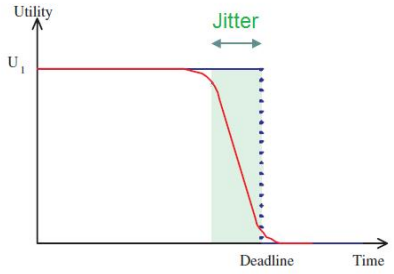


Fig. 5. Time Utility Function

Another QoS-based approach is UEPS scheme [14] that uses time utility function to make an urgency when, packets in queues, enter jitter area or next to deadline. $U_i(t)$ is time utility function for delay. According to Fig. 5. when packets enter to a jitter area, first derivative of $U_i(t)$ increases and Eq.4 gets more weight and consequently, high probability to access the resources.


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$$|U_i'(t)| \times \frac{R_i(t)}{R_i'(t)} \quad (4)$$

Where, $R_i(t)$ is similar to $r_i(t)$ and $a(i)$, is a channel capacity for queue i. $R_i'(t)$ is equally calculated by Eq.2 and $U_i'(t)$, time utility function, is the absolute value of the first derivative of $U_i(t)$. UEPS do not consider buffer size that may overflow when the packet size is big.

In throughput maximization algorithms [14], user with better channel state, in a heuristic approach, gets more resources without QoS guarantee and fairness. Two important factors in channel quality are RSSI and CINR, where CINR has more weight. One of these approaches is MAX CINR, in which user with the highest CINR in its channel, gets more permission to transfer in channel. MAX CINR cannot guarantee QoS and degrade fairness. To choose user with the best channel condition, maximize throughput.

Another channel aware algorithms category is power constraint based approach which considers sleep and Idle mode and also battery limited [15]. Using power management method increases delay, because mobile station goes to sleep for a specific interval till base station wants to be aware or unaware periodically. Packets in buffer remain until mobile station is aware.

## III. Soft Tracking Variation of the Parameters of QoS

Scheduling decision consists of 4 main parts the goal of defining each algorithm is to meet QoS by tracking important parameters more accurately. For polling services rtPS and nrtPS we do not need two schedulers for intra-class and for inter-class scheduling. For simplicity the weight of two polling classes is inserted into main equation. In spite of the simplification of scheduling to remove 2 steps scheduling into 1 step, if parameters are not assigned properly, algorithms create cross point that degrade performance of scheduling.

### A. Average Rate Updating

At First part of proposed scheduling scheme, we use Proportional fairness relationship which provides long-term fairness among users. In normal conditions when no packet is near to deadline or buffer is not shortly to overflow, it is better to keep fairness among users in achieving resources. We make some changes in PF formula, $\frac{R_i(t)}{U_i(t)}$ to adapt them to rtPS and nrtPS service classes. According to user channel and his SNR in calculated sub-channel, $R_i(t)$ is achievable data rate in coming frame. After that adaptive and modulation coding decides what types of MCs are suitable for user subcarriers, scheduler add all of them to find out user data rate in coming frame. $U_i(t)$ is calculated by Eq.5.

Table I
$S_i$ selection for different polling service

| Class of service | $S_i$ |
|---|---|
| rtPS | Number of frame needed to transfer packets × A |
| nrtPS | Number of frame needed to transfer packets × B |

$$U_i(t) = \begin{cases} \left(1 - \frac{1}{S_i}\right) U_i(t-1) + \frac{R_i(t)}{S_i} & q_i(t) \neq 0 \\ U_i(t-1) & q_i(t) = 0 \end{cases} \quad (5)$$

$S_i$ is time window that measures average user data rate. In proposed scheme $S_i$, relationships have been exerted according to the number of required frames to transfer user packets, and also weight of classes is inserted in this part. $S_i$ selection is done according to Table I.

Where A and B are rtPS and nrtPS weight in resource allocation. Prior to this, weight of class is used to make a decision in inter-class scheduling. When number of frames, needed to transfer user packet, increases, users have fewer chance to get resources. This is what we need for rtPS with a small packet but it must be transferred as soon as possible.

### B. Deadline

rtPS is a real-time service class where, more often, traffics sensitive to delay are classified in this category. Packet size for rtPS is not big and if it does not transmit in a specific time interval, deadline, system throws the packet away. Deadline is counted relative to the waiting time in the buffer, and if it rises from determined threshold, related to its application, it'll be thrown away by system. We implement an emergency when packets are close to deadline to prevent loss of packet. $T_i(t)$ is time utility function in Fig. 6. which has 2 different graphs, T1 and T2. In our proposed scheme we use the first derivatives of $T_i(t)$.

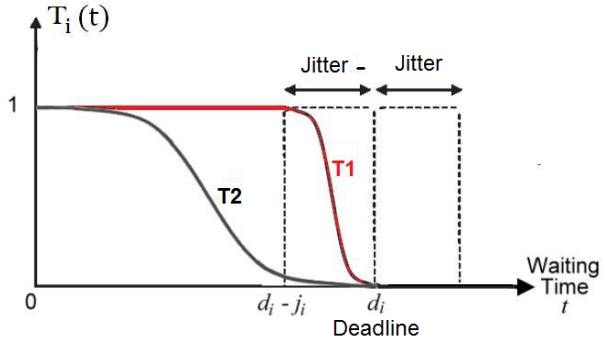


Fig. 6. Time Utility Function in Proposed scheme

In normal condition when packet is not near its deadline, first derivative of $T_i(t)$ is very small and there is no need for urgent transmission. When packet stays for a long time in buffer and closer to its deadline, emergency occurs. For two polling services, we select time utility function by Table II.


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Table II
$T_i$ for different polling service

| Class of service | $T_i$ |
|---|---|
| rtPS | T2 |
| nrtPS | T1 |

Table III
$B_i$ for different polling service

| Class of service | $B_i$ |
|---|---|
| rtPS | B1 |
| nrtPS | B2 |

Packet waiting time previous to enter to jitter area, first derivative of rtPS increases, and is shown in T2. Jitter does not define QoS parameters for nrtPS service class but in this part of scheme, according to application, we defined threshold and jitter area for non real-time traffic, when get permission to transmit while waiting too much time in queues. According to T1, in nrtPS, when packet enters the predefined jitter area, the incline of T1 increases more rapidly and causes more weights in scheduling decision. In this way we can guarantee delay for real-time traffic. Important point is that deadline in nrtPS is very large about 3 seconds, for example, but in rtPS is about milliseconds.

### C. Buffer overflow

Buffer size and number of packets in a buffer are the important parameters which must be considered in making decision for bandwidth allocation, especially when the size of packet is big. When packets do not get permission to transmit and with a finite buffer size, overflow can occur. Delay for a thrown away packet, because of overflow, considered as deadline time and this time is added to average delay and increases it. Most of the time, buffer overflow degrades system performance and causes very bad damage.

In this scheme we introduce a buffer utility function alike a time utility function to manage buffers and involve their states in scheduling decision. $B_i(t)$, with two graphs B1 and B2, is a function which depends to buffer size and is illustrated in Fig. 7.

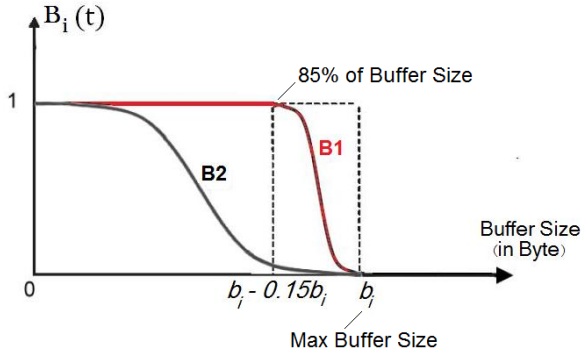


Fig. 7. Buffer State Utility Function

In nrtPS service class, size of the packet is big and it is not so much sensitive to delay, but in rtPS, size of the packet is not big and the possibility of overflow in finite buffer is low. According to Table III, we select $B_i(t)$and use the absolute value of the first derivative of $B_i(t)$ in our proposed scheme to consider different polling classes and their impacts.

Overflow for nrtPS with large packet size is more possible than for rtPS. For this reason, we choose B2 for nrtPS in which the impact of incline and consequently weight of buffer is softer and increases before being close to overflow. According to our experiments for rtPS, we don't need to consider buffer size because of packet size, until 85 percent of overall buffer size is filled. When size of the buffer reaches to 85 percent relative to overall size, something like emergency has occurred and slope of B1 increases which causes to more weight in scheduling decision.

### D. CINR and RSSI

In average rate updating formula and $R_i(t)$, to consider channel state we only use SNR, which is in WiMAX, power of noise are calculated by Eq. 6.

$$-174 + 10 \times \log\left(BW \times n \times \frac{Used\ FFT}{All\ FFT}\right) + Noise\ Figure(Amplifier) \quad (6)$$

-174 is normal thermal noise in dBm/Hz for base station environment, BW is overall system bandwidth and n is the number of OFDM symbols. In SNR we cannot accurately determine channel state. CINR and RSSI are two important parameters in channel quality which are considered to make a better channel estimation for scheduling decision. CINR is already and usually used in throughput maximizing scheduling algorithms, and RSSI almost used in power constraint scheme to consider power in each subcarrier.

We introduced $M(RSSI, CINR)$defined by Eq.7 for a better consideration of channel state in making a decision.

$$M(RSSI, CINR) = |\log(RSSI(mW))|^{-1} \times CINR^2(mW) \quad (7)$$

CINR are more important parameter than RSSI. For example, a condition those two Base Stations are close to each other, in this situation when user is near the base station, RSSI is high but CINR is low which means Signal strength is high but channel condition, is not really good because of interference. High CINR shows better channel with low packet loss probability. According to the ranges of CINR and RSSI we offer Eq.7 where CINR has more weight in equation.

### E. Final relationship

Final relationship in our proposed scheme for scheduling decision making is represented by Eq.8 for real-time and non-real-time class of service.

$$|T_i'(t)| \times |B_i'(t)| \times \frac{R_i(t)}{U_i(t)} \times M(RSSI, CINR) \quad (8)$$

And according to the previous section, $|T_i'(t)|$ is the absolute value of the first derivative of time utility function,


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**At each scheduling instance {**
**for** $j=1$ *to* $N$ **{ update** $\left|\frac{dT_j(t)}{dx}\right|$ , $\left|\frac{dB_j}{dx}\right|$ , ***RSSI(j)*** , ***CINR(j)*** , **and** $\frac{R_j(t)}{U_j(t)}$
**if** $(Q_j(t) \neq 0)$ $\{U_j(t) = \frac{1}{S_j} * R_j(t) + (1 - \frac{1}{S_j}) * U_j(t-1)\}$
**if** $(Q_j(t) = 0)$ $\{U_j(t) = U_j(t-1)\}$
**}**
$QoS\_schedule = 0$
**for** $j=1$ *to* $N$ **{ if** $(Q_j(t)) > 0)$ $\{ QoS\_schedule = 1 \}$ **}**
**if** $(QoS\_schedule > 0)$ **{** $IS = arg\ max\ j$
$(\left|\frac{dT_j(t)}{dx}\right| * \left|\frac{dB_j(t)}{dx}\right| * M(RSSI(j),CINR(j)) * (\frac{R_j(t)}{U_j(t)}))$ **}**

**<Variables>**
$T_j(t)$**: Time utility Function for MS** *j*'s
$B_j$**: Buffer Utility Function for MS** *j*'s
*RSSI(j)*: **Received signal strength Indicator of MS** *j*'s **(mw)**
*CINR(j)*: **Carrier to Interference and Noise Ratio of MS** *j*'s **(mw)**
$N$ **: Number of MS's having QoS class connection**
$R_j(t)$**: Data Rate for MS** *j*'s **in coming farme according to bits/sec**
$IS$ **: Index of the selected MS**
$U_j(t)$ **: Average Data Rate in** $S_i$ **Farme before**
$Q_j(t)$**: Buffer state for MS** *j*'s **according to number of packets**

Fig. 8. Algorithms for proposed scheme

$|B_i'(t)|$ is absolute value of the buffer size in dependant function, $R_i(t)$ is user's data rate in coming frame, $U_i(t)$ is user's average data rate in $S_i$ time window of past, and finally $M(RSSI, CINR)$ is channel state function for better measuring channel condition. This scheme with its used parameters is showed in Fig. 8.

## IV. Performance Evaluation

### A. Simulation Environment and Parameters

For performance evaluation we developed wimax layers in OPNET simulator [16]. Scheduling for polling based service and BE service worked in wimax_bs_control process model. At first we compared our proposed scheme with UEPS, PF, OFDM frame-based PF [17], M-LWDF and MAX CINR in a simple scenario and then, at second case, we studied admission control impact on our scheduling scheme. For our simulation, we used TDD mode with 20MHz OFDMA access technology and PUSC permutation in uplink and downlink. Frame duration are 5 msec with 48 OFDM symbols in each farme, 12 for uplink and 36 OFDM symbols for downlink. TTG is 106 µsec and RTG is 60 µsec and numbers of data subcarriers in uplink are 1440 and in downlink are 1120 of 2048 subcarriers. Transmitted power for Base station and user station is equal to 0.5 watt. We can evaluate scheduling scheme when there are few resources, and users compete for achieveing bandwidth. There are two possible ways for resource limitation, one way is to increase number of users, then output analysis would be much more difficult, and the other one is limitation by Admission control unit. In our simulation the latter is used, by Admission control we create competition for bandwidth .

### B. Schedulers for Multiple Traffic Classes

At first we design a simple scenario to compare our scheme with some main QoS guarantee and Fairness channel aware algorithms.

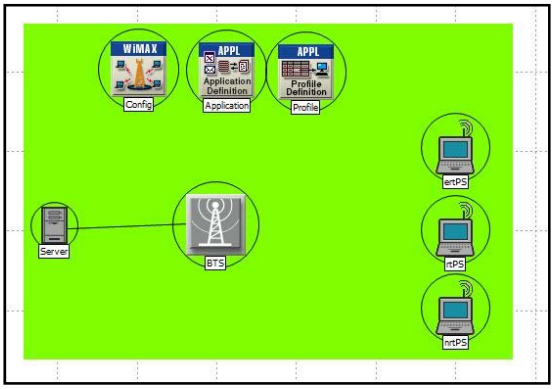


Fig. 9. First simulation scheme in OPNET

In Fig. 9. we define 3 user station and one base station that is directly connected to the server. Stations have 3 different classes of service, ertPS, rtPS and nrtPS where resources are limited by admission control. For ertPS node we define voice application whose frame size is 57 bytes and with 0.25 seconds inter-arrival time. In second node, we implement rtPS with video application in which frame size have chi-square distribution with a 32kbytes mean and 12frame/sec. At FTP, the third node, download traffic application is classified into nrtPS service class. For third node, we define traffic by a variable rate in which packet size has a exponential distribution with 86kbytes mean and Poisson inter-arrival time with 500 milliseconds mean. All traffics transfer in TCP/IP and the header of these protocols must be measured in calculations. Channel model for pathloass is based on Erceg model and for multipath modeling we use ITU pedestrian model. Terrain is mostly flat with light tree densities. At first we evaluate WiMAX average delay for and in our proposed scheme we consider 2 parameters first with variable $S_i$ according to the above mentioned equation and second with a fixed $S_i$ equal to 1000. Fig. 10. shows that average delay for our scheme is lower than the other schemes even with a fixed time window. By holding time window $S_i$ fixed or variable average delay does not change, but with a variable time window, at the beginning, causes lower delay. Fig. 11. illustrated average throughput of system which consider with and without $M(RSSI, CINR)$ . Better measured channel condition causes more average throughput, because error in bit rate decreases in transmission occurrence.


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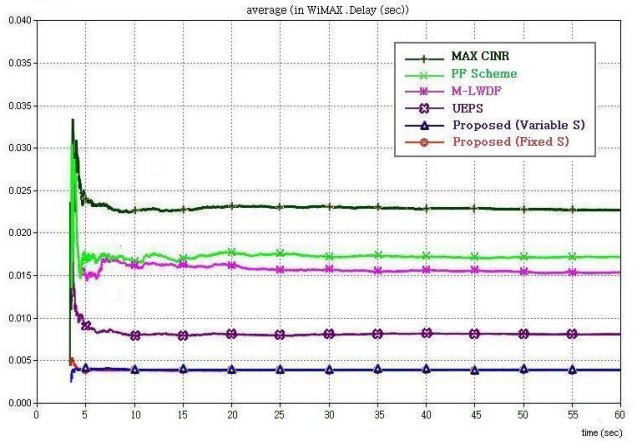


Fig. 10. Average delay in WiMAX system

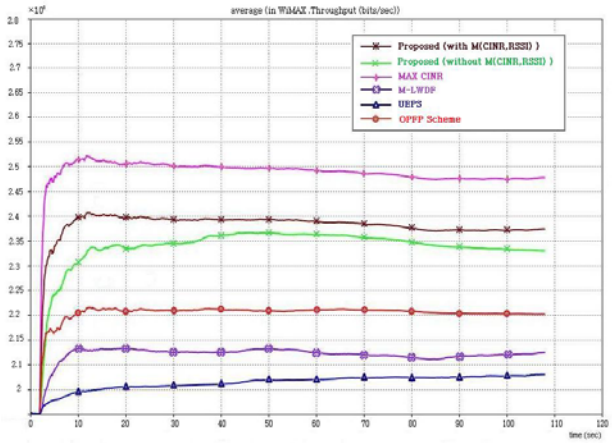


Fig. 11. Average throughput in Mbps

Obviously MAX-CINR have better throughput than proposed scheduling, because user with a better channel condition can get a high priority without any QoS guarantee. Variable time window in average data rate calculation causes better throughput even if we do not consider $M(RSSI, CINR)$. For nrtPS, buffer management has an important role to prevent overflow and increase throughput especially when resources for scheduling are limited and only high priorities can get permission.

Packet loss ratio in our scheme is approximately equal to MAX-CINR as considered in Fig. 12. In Fig. 11 throughput is lower than MAX-CINR which shows more error bit rate. For using different coding scheme as CRC and convolution coding adaptively with channel condition some missed bits recovered and consequently packet loss ratio has no expansion. MAX-CINR for selecting users with appropriate channel states, error correction schemes are not required any more, but in our scheduling, error correction schemes are helpful and hinders loss of packets as in MAX-CINR.

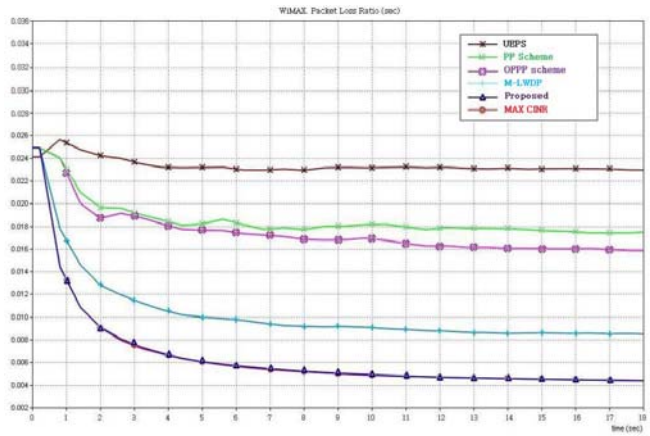


Fig. 12. Packet loss ratio in WiMAX

### A. *Impact of Admission Control in scheduling*

In this scenario we investigate Admission control unit impact on our scheduling scheme. Channel condition, OFDM symbol duration, number of subcarriers, frequency, bandwidth and permutation are the same as in before section. QAM64 modulation with ¾ coding rate is used for all users whose distance from base station is the same according to Fig. 13.

Three types of services have been defined for users, ertPS, rtPS and nrtPS. All users have constant data rates for ertPS defining 16kbps with 100 bytes packet size. Data rate for rtPS are 56kbps with 400 bytes packet size and in nrtPS data rate is 120kbps with 800 bytes packet size. Users randomly get one of the services in a network. After limitation made on resources by admission control, maximum users that can be supported with this configuration are 72 users. We force admission control to cross the line and accept 80. We have investigated throughput of the system in different points with distinctive number of users, as shown in Fig. 14.

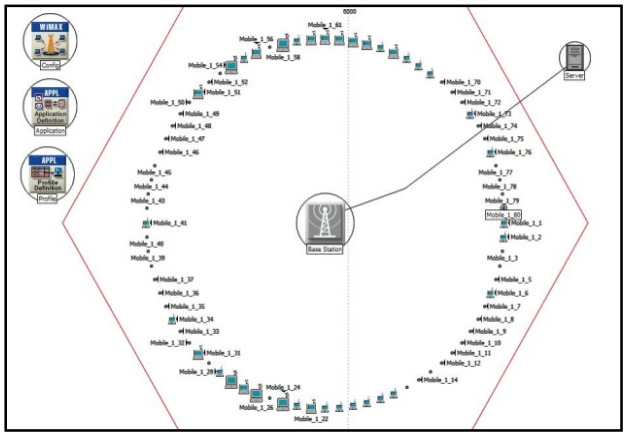


Fig. 13. Admission control Analysis scheme in OPNET


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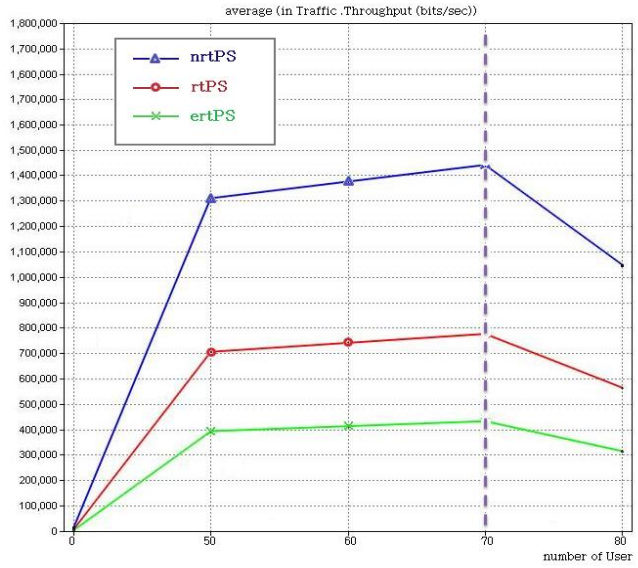


Fig. 14. Average throughput for different class of service

After increasing 70 users to 80 users, throughput badly degrades because admission control accepted more than system's supported capacity and scheduler cannot properly allocate. It shows a high relationship between scheduler and admission control unit. Simulation results are for 15 minutes.

## V. Conclusions and Future Study Issues

PF and OFPF are suitable for BE service class but cannot guarantee QoS. They have high delay and low throughput rather than QoS guarantee algorithms. Since M-LWDF and UEPS do not consider buffer state and channel condition exactly they have lower performance to proposed scheme. Original UEPS uses one graph to represent emergency but in our scheme to remove inter-class scheduling in delay and buffer state functions we use 2 figures. We have also much better considered channel condition by CINR and RSSI, in making a decision. Simulation results show better delay and high throughput for proposed scheme with the near to same packet loss ratio equal to MAX-CINR which is the highest in throughput. Admission control evaluated as important unit in good performance of scheduling and almost estimate channel capacity more precisely.

Power management mechanism which examines Idle and sleep state in increasing delay is not considered in our work. In real world power saving and battery consideration is necessary. Fairness index is another aspect that can be studied in this kind of works to properly compare with PF-Based scheme. Other great approaches are smart antenna and MIMO-OFDM which are highly used in 4G wireless system and make scheduling harder in resource allocation. A lot of matters could be regarded in resource allocation to make it better but they may also create more complexity.

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# A Quantization based blind and Robust Image Watermarking Algorithm

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*Abstract*—**Security and privacy issues of the transmitted data have become an important concern in multimedia technology. Watermarking which belong to the field of information hiding has seen a lot of research interest recently. Watermarking is used for a variety of reasons including security, content protection, copyright management, trust management, content authentication, tamper detection and privacy. Recently many watermarking techniques have been proposed to support these applications but one major issue with most of the watermarking techniques is that these techniques fail in the presence of severe attacks. This has been a major threat to content providers because if the digital content is dramatically changed then it would be difficult to prove the existence of a watermark in it and consequently its ownership. To tackle this security threat towards ownership issues in this paper, we propose a computationally efficient and secure two quantization based watermarking algorithms which offer incredible performance in presence of malicious attacks which try to remove ownership information. The performance of the proposed techniques is compared with that of other watermarking techniques and it gives a very good perceptual quality especially at lower bit rates. We present experimental results which show that the proposed techniques outperform many techniques for multimedia over wireless applications. The proposed schemes are backed up with excellent results.**

***Keywords-component; Watermark Detection; Watermarking; DCT; DWT; Quantization***

## I. INTRODUCTION

Watermarking is a method of hiding proprietary information in digital media like photographs, digital music, or digital video. The ease with which digital content can be exchanged over the Internet has created copyright infringement issues. Copyrighted material can be easily exchanged over peer-to-peer networks, and this has caused major concerns for those content providers who produce these digital contents. In order to protect the interest of the content providers these digital contents can be watermarked.

The process of *embedding* a *watermark* in a *multimedia object* is termed as watermarking. A Watermark can be considered as a kind of a signature, which reveals the owner of the multimedia object. Content providers want to embed watermarks in their multimedia objects (digital content) for several reasons like copyright protection, content authentication, tamper detection etc. A watermarking algorithm embeds a *visible* or *invisible watermark* in a given multi-media object. The embedding process is guided by use of a *secret key*, which decides the locations within the multimedia object (image) where the watermark would be embedded. Once the watermark is embedded it can experience several *attacks* because the multimedia object can be digitally processed. The attacks can be unintentional (in the case of images, low pass filtering or gamma correction or compression) or intentional (like cropping). Hence, the watermark has to be very robust against all these possible attacks. When the owner wants to check the watermarks in the possibly attacked and distorted multimedia object, s/he relies on the secret key that was used to embed the watermark. Using the secret key, the embedded watermark sequence can be extracted. This extracted watermark may or may not resemble the original watermark, because the object might have been attacked.

Hence, to validate the existence of a watermark, either the original object is used to compare and ascertain the watermark signal (*non-blind watermarking*), or a correlation measure is used to detect the strength of the watermark signal from the extracted watermark (*blind watermarking*). In correlation based detection, the original watermark sequence is compared with the extracted watermark sequence, and a statistical correlation test is used to determine the existence of the watermark.

### A. *Requirements of Digital Watermarking*

There are three main requirements of digital watermarking. They are *transparency*, *robustness* and *capacity*.

Transparency or Fidelity, The digital watermark should not affect the quality of the original image after it is watermarked. Cox et al. (2002) defines transparency or fidelity as 'perceptual similarity between the original and the watermarked versions of the cover work' [1]. Watermarking should not introduce visible distortions because if such distortions are introduced it reduces the commercial value of the image.


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Robustness, Cox et al. (2002) defines robustness as the 'ability to detect the watermark after common signal processing operations' [1]. Watermarks could be removed intentionally or unintentionally by simple image processing operations like contrast or brightness enhancement, gamma correction etc. Hence watermarks should be robust against a variety of such attacks into four basic categories, attacks that try to remove watermarks totally, attacks that try to remove the synchronization between the embedder and the detector, cryptographic attacks and protocol attacks.

Capacity or Data Payload, Cox et al. (2002) define capacity or data payload as 'the number of bits a watermark encodes within a unit of time or work' [1]. This property describes how much data should be embedded as a watermark to successfully detect during extraction. Watermark should be able to carry enough information to represent the uniqueness of the image. Different applications have different payload requirements [1].

Security, according to Kerckhoff's principle the security of a cryptosystem depends on the secrecy of the key and not on the cryptographic algorithm. Same rule applies to water-marking algorithms, i.e. the watermarking algorithms must be public but watermark embedding should base on a secret key [2].

To prevent image manipulations and fraudulent use of modified images, the watermark should survive modifications introduced by random noise or compression, but should not be detectable from non-authentic regions of the image. The original image cannot be used by the watermark detect or to verify the authenticity of the image. In this paper, we investigate the application of a recently developed quantization based watermarking scheme to image authentication. The two proposed watermarking techniques allow reliable blind watermark detection from a small number of pixels, and thus enable the detection of local modifications to the image content.

## II. HISTOGRAM EQUAL AREA DIVISION QUANTIZATION TECHNIQUE

The technique calculates the quantization levels using a method that is dependent on the image content (hence the word "adaptive") and then round off the pixels values to the nearest quantization level. In this way, the number of transmitted values is reduced. The quantization scheme provides a wide range of compression ratios (CRs) with a very slight degradation of the signal-to-noise ratio (SNR).

HEAD is a quantization technique in which the transmitted values are reduced by mapping the values of image pixels to a finite number of quantization levels.

*The HEAD quantization procedure can be listed as follows:*

1. The area under the histogram of the image pixels is divided into a number of vertical slices with equal areas. Thus each slice has a width that is inversely proportional to its height. The number of these slices is equal to the number of quantization levels.
2. On the horizontal axis of the sliced histogram, each slice has start and end points. The midpoint value (on the width) of each slice is considered as a quantization level.
3. In this way, we get a non-uniform quantization in which the density of the quantization levels increases in proportion to the probability of occurrence of the pixel value.
4. All the pixel values that lie within the width of a slice are mapped to the quantization level that is represented by the midpoint of this slice.

The resultant compression ratio and signal-to-noise ratio vary depending on the chosen number of quantization levels.

This technique is irreversible, i.e. the quantized values can't be converted back to their original values leading to information loss.

## III. DCT PROPOSED WATERMARKING TECHNIQUE

The first proposed watermarking scheme is a blind quantization based scheme [4]. A block diagram detailing its steps is shown in Fig. 1. The input $N*M$ image; an image assumed to be a matrix has length of $N$ rows and width of $M$ columns, is first converted into single vector by concatenating successive rows beside each other to form a long row that contains all the image pixels using matrix to vector converter. This vector is exposed to DCT [5]-[7] to transform the image from spatial domain into frequency domain in which energy of the image information is concentrated in a few number of coefficients. The output of the DCT process is a vector that has the same length of the image) number of pixels in the image), but with many values approximated to zeros. After applying the DCT the output coefficients are arranged in a descending order according to the pixels probabilities. The output vector of the DCT is now ready to be processed by the histogram equal area quantization technique to choose the appropriate values used in the watermark embedding process, quantization levels. The watermarked coefficients vector is reshaped and returned back to the spatial domain using IDCT.

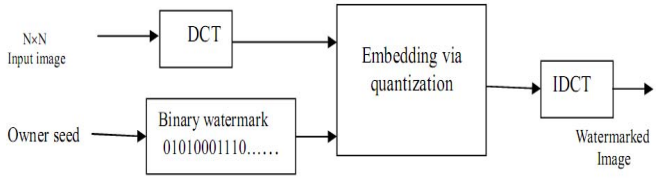


Figure 1. The first proposed image watermarking scheme.

### A. *Watermark Embedding*

The steps of watermark embedding can be summarized as follows:


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1. The host image is transformed into the DCT domain; the transformed coefficients are watermarked using HEAD quantization using 4 quantization levels $t_0$, $t_1$, $t_2$, and $t_3$.
2. A binary watermark of the same size as the image of interest is created using a secret key, which is a seed of a random number generator.
3. Each $w_{ij}^s$ of the selected DCT Coefficients is quantized. The quantization process can be summarized as follows:

If $x_{ij} = 1$ and $w_{ij}^s > 0$, then $w_{ij}^{'s} = t2$,

If $x_{ij} = 0$ and $w_{ij}^s > 0$, then $w_{ij}^{'s} = t1$,

If $x_{ij} = 1$ and $w_{ij}^s < 0$, then $w_{ij}^{'s} = -t_3$,

If $x_{ij} = 0$ and $w_{ij}^s < 0$, then $w_{ij}^{'s} = -t_0$. (1)

Where $x_{ij}$ the watermark is bit corresponding to $w_{ij}^s$, and $w_{ij}^{'s}$ is the watermarked coefficient. After all the selected coefficients are quantized, the inverse discrete cosine transform (IDCT) is applied and the watermarked image is obtained.

*B. Watermark Detection*

1. The possibly corrupted watermarked image is transformed into the DCT domain as in the embedding process.
2. The extraction is performed on the coefficients.
3. All the coefficients of magnitude equal to $t_1$, $t_2$, $-t_3$ and $-t_0$ are selected; these are denoted $w_{ij}^{'s}$ .The watermark bits are extracted from each of the selected DCT coefficients with Eq.2. Fig. 2 illustrates the watermark detection process.

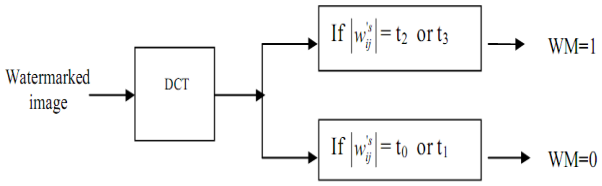


Figure 2. Watermark detection in the proposed scheme.

If $|w_{ij}^{'s}| = t_2$ or $t_3$, then the recovered watermark bit is a 1.

If $|w_{ij}^{'s}| = t_0$ or $t_1$, then the recovered watermark bit is a 0

(2)

4. The recovered watermark is then correlated with the original watermark in the watermark file, obtained via the secret key. This allows a confidence measure to be ascertained for the presence or absence of a watermark in an image.

## IV. DWT WATERMARKING TECHNIQUE

Dugad et al. presented a blind additive watermarking scheme operating in the wavelet domain [8]. Three-level wavelet decomposition with Daubechies 8-tap filters was used. No watermark was inserted into the low-pass sub-band. Unlike some non-blind watermarking schemes [9][10], this scheme allows a watermark to be detected without access to the original image. It performs an implicit visual masking as only wavelet coefficients with large magnitude are selected for watermark insertion. These coefficients correspond to regions of texture and edges in an image. This scheme makes it difficult for a human viewer to perceive any degradation in the watermarked image. Also, because wavelet coefficients of large magnitude are perceptually significant, it is difficult to remove the watermark without severely distorting the watermarked image. The most novel aspect of this scheme was the introduction of a watermark consisting of pseudorandom real numbers. Since watermark detection typically consists of a process of correlation estimation, in which the watermark coefficients are placed in the image, changes in the location of the watermarked coefficients are unacceptable. The watermarking scheme proposed by Dugad et al. is based on adding the watermark in selected coefficients with significant energy in the transform domain in order to ensure the non-erasability of the watermark. This scheme has overcome the problem of "order sensitivity".

Unfortunately, this scheme has also some disadvantages. It embeds the watermark in an additive fashion. It is known that blind detectors for additive watermarking schemes must correlate the possibly watermarked image coefficients with the known watermark in order to determine if the image has or has not been marked. Thus, the image itself must be treated as noise, which makes the detection of the watermark exceedingly difficult [8]. In order to overcome this problem, it is necessary to correlate a very large number of coefficients, which in turn requires the watermark to be embedded into several image coefficients at the insertion stage. As a result, the degradation in the watermarked image increases. Another drawback is that the detector can only tell if the watermark is present or not. It cannot recover the actual watermark.

The scheme in [11] is another example of wavelet-based watermarking schemes. A noise-like Gaussian sequence is used as a watermark. To embed the watermark robustly and imperceptibly, watermark components are added to the significant coefficients of each selected sub-band by considering the human visual system (HVS) characteristics. Some small modifications are performed to improve the HVS model. The host image is needed in the watermark extraction procedure.

## V. PROPOSED DWT WATERMARKING TECHNIQUE

Discrete wavelet transform is a technique using which a 2D image can be transferred from spatial domain to frequency domain. The input $N*M$ image; an image assumed to be a matrix has length of $N$ rows and width of $M$ columns, is exposed to wavelet transform. After one level DWT an image $I$ is decomposed into four subbands LL, HL, LH, and HH. LL is called the approximate band and it contains most of the


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energy. In the algorithm we decompose the image into four levels and embed the watermark in HL, LH sub-bands. Here we assume the size of the watermark logo is in multiple of the sub-band size. In the second proposed a quantization based watermarking algorithm, we incorporate implicit visual masking by embedding the watermark in the LH, HL sub-bands. The output vector of the wavelet is now ready to be processed by the histogram equal area quantization technique to choose the appropriate values used in the watermark embedding process, quantization levels. The watermarked coefficients vector is reshaped and returned back to the spatial domain using IDWT.

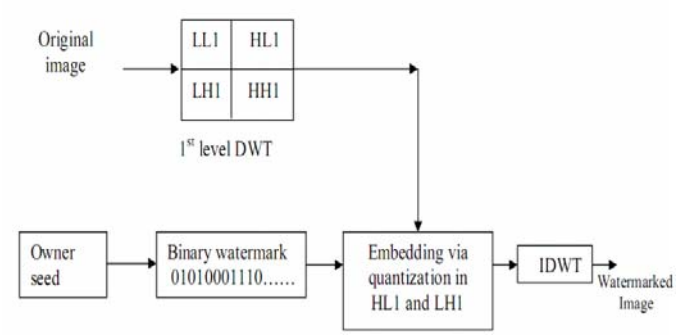


Figure 3. The proposed image watermarking scheme.

### A. Watermark Embedding

The steps of watermark embedding can be summarized as follows:

1. The host image is transformed into the wavelet domain; one level Daubechies wavelet with filters of length 4 is used. The coefficients (excluding the $LL_1$ and HH1) coefficients are watermarked using HEAD quantization using 4 quantization levels $t_0$, $t_1$, $t_2$, and $t_3$.
2. A binary watermark of the same size as the subbands of interest is created using a secret key, which is a seed of a random number generator.
3. Each $w_{ij}^s$ of the selected wavelet coefficients is quantized. The quantization process can be summarized as follows:

   If $x_{ij} = 1$ and $w_{ij}^s > 0$, then $w_{ij}^{'s} = t2$,

   If $x_{ij} = 0$ and $w_{ij}^s > 0$, then $w_{ij}^{'s} = t1$,

   If $x_{ij} = 1$ and $w_{ij}^s < 0$, then $w_{ij}^{'s} = -t_3$,

   If $x_{ij} = 0$ and $w_{ij}^s < 0$, then $w_{ij}^{'s} = -t_0$. (3)

   Where $x_{ij}$ the watermark is bit corresponding to $w_{ij}^s$, and $w_{ij}^{'s}$ is the watermarked wavelet coefficient. Figure (3) shows the watermark embedding in a positive wavelet coefficient.

4. After all the selected coefficients are quantized, the inverse discrete wavelet transform (IDWT) is applied and the watermarked image is obtained.

### B. Watermark Detection

1. The possibly corrupted watermarked image is transformed into the wavelet domain using the same wavelet transform as in the embedding process.
2. The extraction is performed on the coefficients in the first level wavelet transform (excluding the $LL_1$ subband).
3. All the coefficients of magnitude equal to $t_1$, $t_2$, - $t_3$ and - $t_0$ are selected; these are denoted $w_{ij}^{'s}$ .The watermark bits are extracted from each of the selected DCT coefficients with Eq.4. Fig. 4 illustrates the watermark detection process.

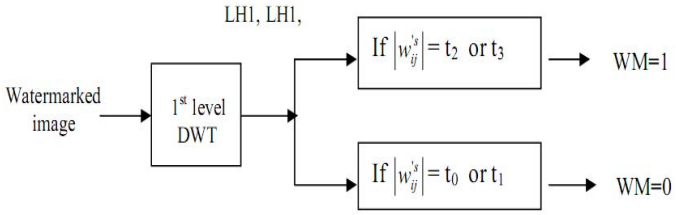


Figure 4. Watermark detection in the proposed scheme.

If $|w_{ij}^{'s}| = t_2$ or $t_3$, then the recovered watermark bit is a 1.

If $|w_{ij}^{'s}| = t_0$ or $t_1$, then the recovered watermark bit is a 0 (4)

4. The recovered watermark is then correlated with the original watermark in the watermark file, obtained via the secret key. This allows a confidence measure to be ascertained for the presence or absence of a watermark in an image.
5. The recovered watermark is then correlated with the original watermark in the watermark file, obtained via the secret key, only in the locations of the selected coefficients. This allows a confidence measure to be ascertained for the presence or absence of a watermark in an image.

## VI. PERCEPTUAL QUALITY METRICS

Two metrics for ascertaining the quality of a watermarked image are highlighted in this section. These metrics are the Mean Square Error (MSE), and the Peak Signal to Noise Ratio (PSNR). The MSE measures the average pixel-by-pixel difference between the original image (I) and the watermarked image ( $\hat{I}$ ) [12].

$$MSE = \frac{1}{MN}\sum_{m,n}(I_{m,n} - \hat{I}_{m,n})^2 \quad (5)$$

$$PSNR\ (dB) = 10 \log_{10} \frac{I_{peak}^2}{MSE} \quad (6)$$



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Where $I_{peak}$ is the peak intensity level in the original image (most commonly 255 for an 8-bit grayscale image), M and N are the dimensions of the image.
The original and recovered messages or watermarks can be compared by computing the Normalized Correlation (NC) [12]:

$$NC = \frac{m^{*}.m}{\|m^{*}\|.\|m\|} \quad (7)$$

Where m is the original message and $m^{*}$ is the recovered message. For unipolar vectors, $m \in \{0, 1\}$, and for bipolar vectors, $m \in \{-1, 1\}$.

## VII. Simulation Results

For all the tests in this paper, MATLAB is used. All tests are performed upon the 8-bit grayscale 256 × 256 cameraman image. To simulate the watermarking schemes on the cameraman image, the four quantization levels are T0=113; T1=124; T2=156; T3=159.

Results of the two schemes for the cameraman image are shown in Fig. 5 and Fig. 6, respectively. The comparison of fidelity is shown in Table I. The numerical evaluation metrics for all schemes in the absence and presence of attacks are tabulated in Tables II. From Table II, we notice that the proposed watermarking scheme achieves the lowest distortion in the watermarked image in the absence of attacks we find that the proposed using wavelet give the image with fidelity better than the tech using DCT. From Table II it gives the comparison between our technique using DCT and wavelets, we notice also that a percentage of around 50% of the input watermark bits can be extracted in the proposed scheme with most of the attacks.

In the case of DCT we find that we can detect watermark at the presence of blurring, Gaussian or compression attack, in the case of wavelet we can detect the watermark at the presence of Gaussian, resizing, blurring or compression attack. We compare our results to daugads [8], LSB technique [9] and the technique in [4].

In the case of LSB technique, we find it is difficult to detect the watermark at the case of attacks applied to the watermarked image.

The technique in [4] gives better result than the existed technique and the proposed one in the case of compression.

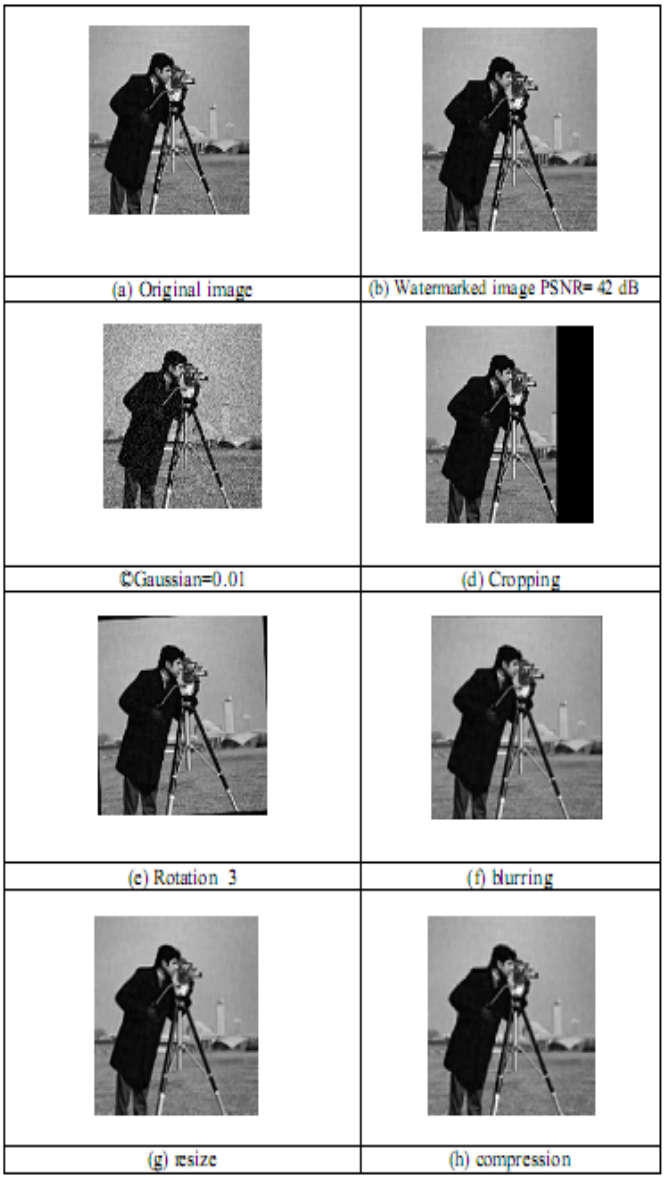


Figure 5. Watermarked image using proposed technique with DCT with and without attacks.


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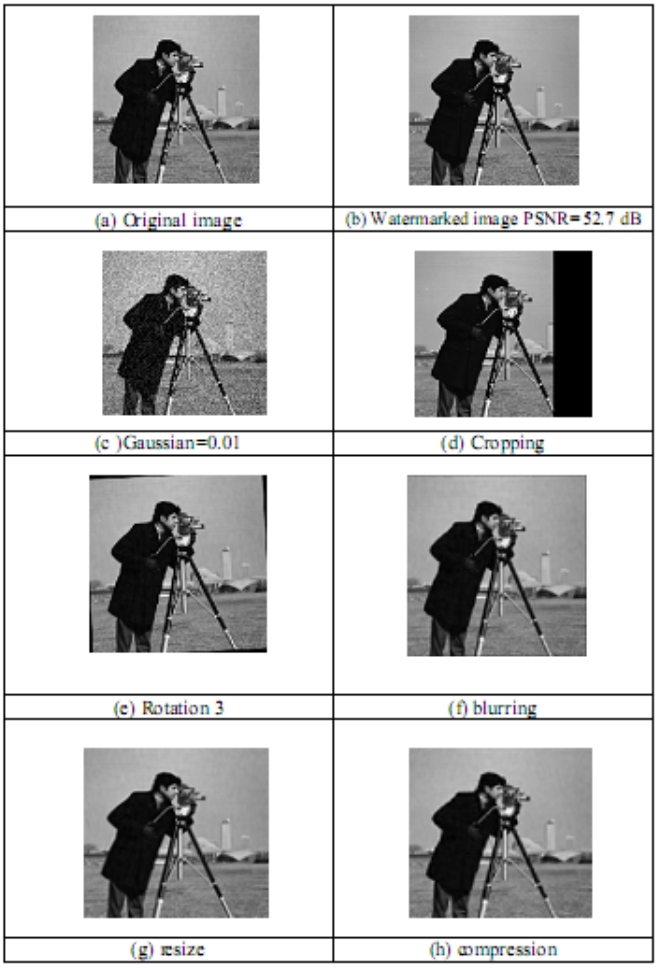


Figure 6. Watermarked image using the proposed DWT technique with and without attacks.

TABLE I. EVALUATION METRICS VALUES FOR ALL SCHEMES FOR THE CAMERAMAN IMAGE.

| Scheme | PSNR | NC |
|---|---|---|
| **DCT proposed technique** | 42 | 1 |
| **DWT Proposed technique** | 52.7 | 1 |
| **LSB scheme blind** | 51.64 | 1 |
| **daugad Scheme blind** | 38.42 | 0.39 |
| **Quantization Tech in [4]** | 47.29 | 1 |

TABLE II. COMPARISON OF NC OF THE EXTRACTED WATERMARKS FOR OUR SCHEME FOR THE CAMERAMAN IMAGE AND THE OTHER EXISTING TECHNIQUES.

| Type of attack | DCT proposed technique | DWT Proposed technique | Daugad technique | LSB technique | Quantization Tech in [4] |
|---|---|---|---|---|---|
| No attacks | 1 | 1 | 0.39 | 1 | 1 |
| Gau 0.01 | 0.24 | 0.24 | 0.009 | 4.5e-004 | 0.07 |
| Gau 0.006 | 0.4 | 0.42 | 0.19 | 0.0013 | 0.26 |
| Gau 0.0006 | 0.8 | 0.7 | 0.28 | 0.0038 | 0.39 |
| cropping | 0.2 | 1 | 0.19 | -0.0059 | 0.65 |
| rotation | 0.04 | 0.2 | 0.087 | -0.003 | 0.15 |
| blurring | 0.42 | 0.54 | 0.12 | 0.0006 | 0.33 |
| Resizing 0.4 | 0.22 | 0.667 | 0.17 | 0.36 | 0.39 |
| compression | 0.5 | 0.7 | 0.27 | -0.0016 | 0.79 |

## VIII. CONCLUSION

This paper presented a blind DCT –DWT based image watermarking schemes. These schemes depend on the quantization of coefficients within certain amplitude ranges in a binary manner to embed meaningful information in the image. Experimental results have shown the superiority of the proposed schemes from the host image quality point of view and the blindness point of view.

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# Robust Techniques of Web Watermarking

## Using Verbs, Articles and Prepositions

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***Abstract*—Internet is an attractive, rapid and economical way of electronic information distribution. With advent and tremendous growth of Internet, information is going paperless and is transforming into electronic information over the paper distribution.**

**But it also makes protection of its intellectual property very difficult. Once the information is available on the Internet, it's open to any threats like illegal copying, distribution, tampering and authentication. Intellectual rights for the information available on web are a serious issue.**

**In this paper natural language digital watermarks are proposed for the web based electronic data. And a problem of investigating the authorship of web based text/data is investigated with a improved security. Several robust techniques of web page imperceptible digital watermarking using Verbs, Articles and Prepositions are studied for the protection of content available on www. On this basis, web watermarking algorithm is designed and implemented. A key consisting of natural watermarks along with a unique author id (issued by the CA) is integrated to any content to be published on the web. The key to be integrated is further encrypted suing AES (Advanced Encryption Standard) to add another layer of security. And it is also tested with different web sites to see its functionality and robustness.**

***Keywords- Digital Watermarking, Verbs, Articles, Prepositions, encryption, HTML, AES, CA.***

### I. INTRODUCTION

Internet is an attractive, rapid and economical way of electronic information distribution. With advent and tremendous growth of Internet, information is going paperless and is transforming into electronic information over the paper distribution.

But it also makes protection of its intellectual property very difficult. Once the information is available on the Internet, it's open to any threats like illegal copying, distribution, tampering and authentication. Intellectual rights for the information available on web are a serious issue.

Different techniques are used for securing information like steganography, cryptography and watermarking but adopting different ways. Steganography hides the existence of information and makes it imperceptible for a viewer. A cover medium is used as a carrier in which secret data is embedded that the intended recipient is the only one to know the existence of secret message [1].

Cryptography encrypts the information using a key and the party having a key can only decrypt and reveal the message. So, people are aware of an existence of some hidden communication. It makes data unreadable by writing into secret code and it ensures authentication, confidentiality and integrity [2].

Where, watermarking is a process of embedding secret information into a digital signal to identify the owner of that media [3].

In this paper, several robust techniques of web page digital watermarking using common Verbs, Articles and Prepositions are studied for the protection of content available on www. On this basis, web watermarking algorithm is designed and implemented. And it is also tested with different web sites to see its functionality, robustness and the capacity.

Internet contains different types of data i.e. image, video, audio and text. Based on this organization digital watermarking may be classified as image watermarking, video watermarking, audio watermarking, and text watermarking. But the basic principles are motives are same to secure the information against different threats. Unauthorized copying, propagation and tampering are very common attacks and are difficult to overcome. A lot of research has been done on different types of data but web based text has not been highlighted in this effect.

In view of the fact that digital contents are easy to copy or process, they are likely to be wrongly used. A digital watermarking method is one of the efficient countermeasures against such wrongness and can be categorized into perceptible and imperceptible techniques. Many perceptible techniques have been studied for the text but few imperceptible techniques are available for the electronic text.

Digital watermarking is proved to be a mode of identification for the creator, owner or distributor of data. Its aim is to make the data beyond dispute. In case of illicit use, the watermark facilitates the claim of ownership and successful examination. It makes large scale distribution simple and economical.

Hyper Text Markup Language (HTML) is used by web browsers to understand, interpret and structure text, image and other types of data. All web browsers have the default characteristics of every item of HTML. Web developers can use different languages and tools to create web pages but these are further interpreted into HTML by all the web browsers.


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Hence, HTML is a basic building block of web pages but the general source code of these pages is easily available on a single right-click of view source. Any data in general and text in particular is open to many threats and attacks. It is observed that intentionally or unintentionally illegal copying of data from the internet has become a universal practice and has a great effect on the privacy of information and copyright is no more an optimal solution. Digital Watermarking methods are considered a strong mechanism to identify the original owner and to prove the intellectual property. Imperceptible digital web page watermarking techniques can provide solutions for the intellectual property of content available on these pages.

In Digital watermarking a hidden marker is embedded to the data which is generally un-observable and can be only drained by special detector. The goal is not to change the original characteristics but to use the human's insensitive perceptual organs.

With the ever increasing growth of internet users all over the world, it is very important to secure the web pages and its content. Unlike other forms of carriers, there is a wide bandwidth present in web pages for information hiding or embedding watermarks and many robust techniques can be developed for web page watermarking. Web page watermarking is to achieve the integrity of web pages which is a very popular and rich source of information.

## II. REALTED WORK

J. Wu and D.R in [4] have proposed APS Authorship Proof Scheme based on natural language watermarks. A predefined security level has been defined and as long as it is less than the probability measure and is considered secure. They have proposed a solution for catering long text and are robust. They have used meaning and literal representations to embed watermarks and have also used edit distance against fault tolerance.

Qijun Zhao, Hondtao Lu [5] have proposed scheme for the tamper proof web pages in which watermarks are generated on the basis of the Principal Component Analysis (PCA) technique. Upper and lower cases are considered for embedding watermarks in to HTML tags.

Fei, Wang, Zhand and Li in [6] have presented a watermarking scheme to embed different fingerprints in XML data which can be used to trace illegal distribution. Their scheme attempts to reduce the modification attack and maintains the robustness level.

Shi, Kim and S. in [7] have studied approaches for secure embedding and detection of a watermark in an un-trusted environment. They have considered Zero-Knowledge Watermark Detection (ZKWMD) protocols for authorship proof and a Chameleon-like stream cipher that achieves simultaneous decryption and fingerprinting of data tracing illegal distribution of broadcast messages.

Some further techniques have also been proposed in [8] and [9] based on HTML web files. Mohammed and Sun in [8] have proposed some digital watermarking techniques for HTML pages where they have focused on exploiting white space, line breaks, attributes ordering, string delimiter and color values. All above mentioned techniques were just proposed and not implemented however, some of these have been tested to show sample results. Ala'a and Mazin in [9] have also used HTML files to achieve secret communication. They have exploited white space to hide a secret data in an HTML file and have further encrypted by using colored data by using Data Encryption Standard Algorithm.

Wu, Jiwu, Huang, and Shi in [10] have proposed a self-synchronization algorithm for audio watermarking to facilitate assured audio data transmission. The synchronization codes are embedded into audio with the informative data, thus the embedded data have the self-synchronization ability. They have embedded the codes and hidden informative data into the low frequency coefficients in DWT (discrete wavelet transform) domain.

Hasan in [11] have explored the morpho-syntactic tools for text watermarking and develops a syntax-based natural language watermarking scheme for Turkish language. The unmarked text is first transformed into a syntactic tree diagram in which the syntactic hierarchies and the functional dependencies are coded. The watermarking software then operates on the sentences in syntax tree format and executes binary changes under control of Word-net to avoid semantic drops.

Chang and Clark in [12] have described a method for checking the acceptability of paraphrases in context. They have used Google n-gram data and a CCG parser to certify the paraphrasing grammaticality and fluency. In which they have collected the human findings for the evaluation and have integrated text paraphrasing into a Linguistic Steganography system, by using paraphrases to hide information in a cover text.

Zhu and Sang in [13] watermarking programs based on the discrete cosine transform (DCT) domain DC component (DC) has been adopted. Through adjusting the block DCT coefficient of the image the watermarks are hidden. And blocking the selected image according to 8×8 pixel, then dividing the selected image into four non-overlapped sub image blocks according to 4×4 pixel, and thus the watermarks are embedded through adjusting their DCT coefficient.

Kim, Moon and Oh in [14] have proposed an idea of using word classification and inter word space statistics. They have segmented the words to add information in to text content by modifying the statistics of inter word space.

Meral, Unkar, Sankor, OZ and Gunor in [15] have explored the morphosyntatic tools for text watermarking and have come up with a syntax based natural language watermarks. They have developed the system for Turkish language, in which syntax free format sentences are executed into binary changes


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under wordnet to avoid semantic drops. The algorithm transforms the raw sentences into their Treebank representation and syntactic tree by randomizing their occurrences.

## III. SYSTEM MODELS

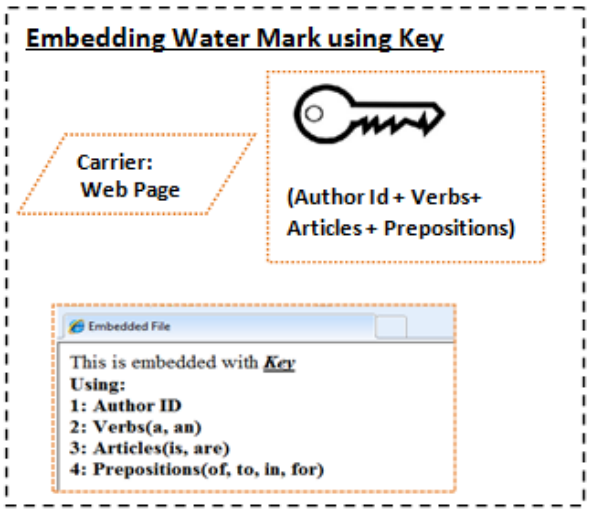


**Figure 1: Embedding Phase**

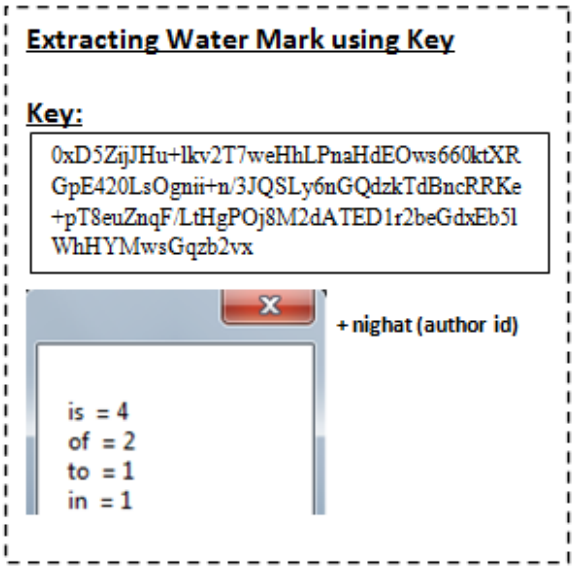


**Figure 2: Extraction Phase**

## IV. PROPOSED METHODOLOGY

When an author/writer contributes his/her text to the web, then one needs to protect his/her intellectual rights. In this paper, the copyright conventions to be integrated are studied in light on English grammatical rules (Verbs, Articles and Prepositions) which are the structural part of any text. The articles, verbs and prepositions (natural language watermarks) used in this research come under most common and first 100 words in English in frequency order. And that make up about half of all the written material. Below there is a composite table as well as separate tables with respect to their frequencies.

To publish and keep the copyrights a key is given to an author so that whenever an author publishes something on web, he/she needs to integrate this key along with the content to be published. Key is the main part mart and it constitutes of many things. To make a key first need to have a unique author id from the CA (Certified Authority) and then natural watermarks are added to this author id to make a key.

$$\text{Key} = \left( \sum_{\text{length}=1}^{n} (A + V + P) + \sum_{\text{lenght}=1}^{n-1} \text{AID} \right) \quad (1)$$

Where

A=Articles

V=Verbs

P=Prepositions

AID = Author ID

Length= size of author id and watermarks

Natural Language Watermarks (NLW) are extracted from the content. Depending on the numbers of these NLW and key will be constructed. Each time a different key can be generated for the publishing but with the same author id as its uniquely generated. So far the size of key and author id is not restricted to any specific length but can be taken into consideration.

CA can be a registered company issuing ID's or can also be regulated by the website owners.

So, in brief a unique author id is concatenated with three sets of natural watermarks (verbs, articles and prepositions) to generate a secret key which is further encrypted using a cryptographic algorithm AES (Advanced Encryption Standard) before adding it to a webpage.

The sets of natural watermarks used are:

*A. List of most frequently used verbs in English:*

| ***List of Verbs*** | **Letter/s and values** | |
|---|---|---|
| | Letter/s | Frequency |
| | is | 15% |
| | are | 34% |

**TABLE 1: Verbs and Frequencies**

*B. List of most frequently used indefinite articles in English:*

| ***List of articles*** | **Letter/s and values** | |
|---|---|---|
| | Letter/s | Frequency |
| | a | 15% |
| | an | 23% |

**TABLE 2: Articles and Frequencies**



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*C. List of most frequently prepositions in English:*

| ***List of Prepositions*** | **Letter/s and values** | |
|---|---|---|
| | Letter/s | Frequency |
| | of | 9% |
| | to | 23% |
| | in | 15% |
| | for | 16% |

**TABLE 3: Prepositions and Frequencies**

## V. IMPLEMENTATION DETAILS

The proposed system has been implemented in C# language using Visual Studio.net framework. The program works as a parser where it reads and checks the textual content form the <body> tag of an HTML page. It checks how many natural watermarks (verbs, articles and prepositions) are there. It then concatenates these natural language watermarks with the Author ID and then combine it generates a secret key. Author ID should be a unique ID for every author and usually needs to be assigned by the CA (Certified Authors). My program has also the ability to generate an author id as an individual CA of any website as well can take a pre-assigned id.

The program also has an ability to generate key for published websites, static pages and can create also one at the run time. Key which is to be integrated in an HTML page is further encrypted using a standard AES (Advanced Encryption Standard) to add another layer of security.

## VI. RESULTS AND ANALYSIS

I have tested many websites and here I am showing the results of few websites like Wikipedia, EnglishThroughStories and BBC news.

Test 1: In Wikipedia I have searched an article (information security) as mentioned on the link below and found 768 natural watermarks, which shows that there is a big bandwidth available. I have an author id (nighat), which I kept same for different tests on different websites.

Web link of Wikipedia, which I have used for the embedding cycle

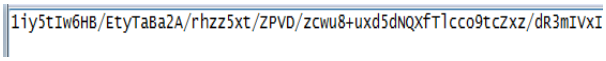
http://en.wikipedia.org/wiki/Information_security

Table 4 shows the detail of each watermark used to generate a secret key.

| ***Author id:*** | **Watermarks** | |
|---|---|---|
| | Letter/s | Frequency |
| ***nighat*** | is | 128 |
| | are | 70 |
| | of | 265 |
| | to | 217 |
| | in | 88 |
| | for | 73 |

**TABLE 4: Watermarks of Wikipedia**

Generated encrypted secret key to be embedded in HTML page:




Test 2: In EnglishThroughStories I have searched a script as mentioned on the link below and found 498 natural watermarks. I have an author id (nighat), which I kept same for different tests on different websites.

Web link of EnglishThroughStories, which I have used for the embedding cycle

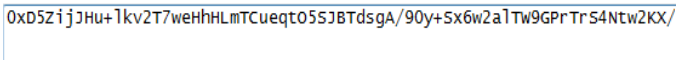
http://www.englishthroughstories.com/scripts/scripts.html

Table 5 shows the detail of each watermark used to generate a secret key.

| ***Author id:*** | **Watermarks** | |
|---|---|---|
| | Letter/s | Frequency |
| ***nighat*** | is | 24 |
| | are | 14 |
| | of | 93 |
| | to | 224 |
| | in | 90 |
| | for | 53 |

**TABLE 5: Watermarks of EnglishThroughStories**

Generated encrypted secret key to be embedded in HTML page:




Test 3: In BBC news I have searched a news article as mentioned on the link below and found 224 natural watermarks. I have an author id (nighat), which I kept same for different tests on different websites.

Web link of BBC news, which I have used for the embedding cycle

http://www.bbc.co.uk/news/world-middle-east-12362826

Table 6 shows the detail of each watermark used to generate a secret key.

| ***Author id:*** | **Watermarks** | |
|---|---|---|
| | Letter/s | Frequency |
| ***nighat*** | is | 17 |
| | are | 10 |
| | of | 68 |
| | to | 57 |
| | in | 48 |
| | for | 24 |

**TABLE 6: Watermarks of BBC news**



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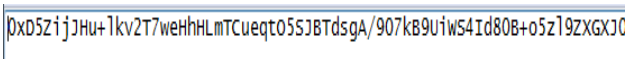
Generated encrypted secret key to be embedded in HTML page:




A graphical view and comparisons of each set of watermarks with respect to the frequency of every watermark used in English text is shown in Figure 3.

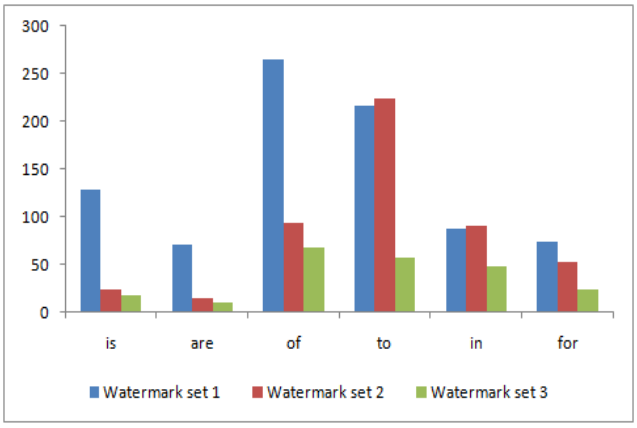



**Figure 3: Frequency Comparison of Watermarks**

## VII. CONCLUSION

Different natural language watermarks have been used in this research. Semantic based watermarks have been proposed using verbs (is, are), articles (a, an) and prepositions (of, in, to, for). The system has been implemented using C# language and different common websites are used for the testing purposes to see the effect of results. Natural watermarks are combined with an author id to generate a secret key to protect copyrights for a web page. The secret key is further encrypted using one of the popular and strong encryption standard AES (Advanced Encryption Standard). And this secured encrypted key is embedded with the web page for the protection of authorship rights.

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# Performance Evaluation of Improved Routing Algorithm for Irregular Network-on-Chip

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***Abstract*—In this paper, a new wormhole-switched routing algorithm for irregular 2-dimensional (2-D) mesh interconnection Network-on-Chip is proposed, where not only no virtual channel is used for routing but also no virtual channel is used to pass oversized nodes (ONs). We also improve message passing parameters of ONs as well as comparing simulation results of our algorithm and several state of art algorithms. Simulation results show that our proposed algorithm, i-xy (improved/irregular-xy), has a higher saturation point in comparison with extended-xy and OAPR algorithms. Furthermore, it has less blocked messages and higher routed/switched messages in the network. Moreover, the network uses i-xy has higher utilization compared to other networks which uses e-xy and OAPR from 35 percent to 100 percent, for the irregular 2-D mesh NoC.**

***Keywords-Network-on-Chip, performance, wormhole switching, irregular 2-D mesh, routing, utilization***

## I. INTRODUCTION

As technology scales, Systems-on-Chips (SoCs) are becoming increasingly complex and heterogeneous. One of the most important key issues that characterize such SoCs is the seamless mixing of numerous Intellectual Property (IP) cores performing different functions and operating at different clock frequencies. In just the last few years, Network-on-Chip (NoC) has emerged as a leading paradigm for the synthesis of multi-core SoCs [1]. The routing algorithm used in the interconnection communication NoC is the most crucial aspect that distinguishes various proposed NoC architectures [2], [3]. However, the use of VCs introduces some overhead in terms of both additional resources and mechanisms for their management [4].

Each IP core has two segments to operate in communication and computation modes separately [5]. On-chip packet switched interconnection architectures, called as NoCs, have been proposed as a solution for the communication challenges in these networks [6]. NoCs relate closely to interconnection networks for high-performance parallel computers with multiple processors, in which each processor is an individual chip.

A NoC is a group of routers and switches that are connected to each other on a point to point short link to provide a communication backbone of the IP cores of a SoC. The most common template that proposed for the communication of NoC is a 2-D mesh network topology where each resource is connected with a router [7]. In these networks, source nodes (an IP-Core), generate packets that include headers as well as data, then routers transfer them through connected links to destination nodes [8].

The wormhole (WH) switching technique proposed by Dally and Seitz [9] has been widely used in the interconnections such as [10], [11], [12], [15] and [16]. In the WH technique, a packet is divided into a series of fixed-size parts of data, called flits. Wormhole routing requires the least buffering (flits instead of packets) and allows low-latency communication. To avoid deadlocks among messages, multiple virtual channels (VC) are simulated on each physical link [12]. Each unidirectional virtual channel is realized by an independently managed pair of message buffers [13].

This paper presents a new routing algorithm for irregular mesh networks by base that enhances a previously proposed technique. The primary distinction between the previous method and the method presented in this paper is passing messages from ONs in the network. Simulation results show that utilization of network by e-xy and OAPR algorithm is worse than the improved one, i-xy. We have been simulated every three algorithms for 5% and 10% of oversized nodes with uniform and hotspot traffic. Results for all situations show that our algorithm has higher utilization and can work in higher message injection rates, with higher saturation point.

The rest of the paper is organized as follows. In section II some deterministic-based routing algorithms are discussed. Then the new i-xy irregular routing algorithm is explained followed by Section III in which our experimental results are discussed. Finally, Section IV summarizes and concludes the work.

## II. IRREGULAR ROUTING

Routing is the act of passing on data from one node to another in a given scheme [11]. Currently, most of the proposed algorithms for routing in NoCs are based upon deterministic routing algorithms which in the case of oversized nodes, cannot route packets. Since adaptive algorithms are very complex for Network-on-Chips, a flexible deterministic algorithm is a suitable one [14]. Deterministic routing


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algorithms establish the path as a function of the destination address, always applying the same path between every pair of nodes. This routing algorithm is known as dimension-order routing (x-y routing). This routing algorithm routes packets by crossing dimensions in strictly increasing (or decreasing) order, reducing to zero the offset in one dimension before routing in the next one [13]. To avoid deadlocks among messages, multiple virtual channels (VC) are simulated on each physical channel [12]. But in this paper, we use no VCs in proposed algorithm and introduced a deadlock and live lock-free irregular routing algorithm.

Many algorithms have been suggested to operate in faulty conditions without deadlock and livelock. We can modify these algorithms to use in irregular interconnection networks. Some of these algorithms like [10], [11], [12], [15] and [16] are based on deterministic algorithms. In [15], Wu proposed a deterministic algorithm. This proposed algorithm uses odd-even turn model to pass the block faults. Also, the algorithm proposed by Lin et al. [16] uses above mentioned method. Since our proposed algorithm is similar to these algorithms (uses no virtual channel), in the next section, we are going to describe how these deterministic algorithms work and how we have improved them. The main idea describes in the rest of this section.

### *A. Extended-XY Routing Algorithm*

The algorithm presented by Wu [15], extended-xy, uses no VCs by implementing odd-even turn model which is discussed in [17]. Such an algorithm is able to pass faulty ring and orthogonal faulty blocks. This algorithm consists two phases; in phase 1, the offset along the x dimension is reduced to zero and, in phase 2, the offset along the y dimension is reduced to zero [15].

This algorithm has two modes, normal and abnormal mode. The extended-xy routing follows the regular x-y routing (and the packet is in a "normal" mode) until the packet reaches a boundary node of a faulty block. At that point, the packet is routed around the block (and the packet is in an "abnormal" mode) clockwise or counterclockwise based on certain rules: Unlike routing in a fault-free routing, the fault-tolerant routing protocol has to prepare for "unforeseen" situations: a faulty block encountered during the routing process. This is done by three means: 1) the packet should reside in an even column when reaching a north or south boundary node of the routing block in phase 1. 2) In phase 1, the packet should be routed around the west side since, once the packet is east-bound, it cannot be changed to west-bound later. 3) The two boundary lines, one even and one odd, offer just enough flexibility for the packet to make turns for all situations.

In phase 2, to route around the routing block, odd columns (even columns) are used to perform routing along the y dimension when the packet is east-bound (west-bound). The packet is routed around the routing block either clockwise or counterclockwise in phase 2. Note that during the normal mode of routing the packet along the x or y dimension, no 180 degrees turn is allowed. For example, the positive x direction cannot be changed to the negative x direction [15]. Additional information and introduced algorithm about extended-xy algorithm can be found in [15].

### *B. OAPR Routing Algorithm*

The algorithm presented by S.Y. Lin et al. [16], OAPR, described as follows:

1) Avoid routing paths along boundaries of ONs. In the environment of faulty meshes, we can only know the information of faulty blocks in real-time. However, the locations of ONs are known in advance. Therefore, the OAPR can avoid routing paths along boundaries of ONs and reduce the traffic loads around ONs.

2) Support f-rings and f-chains for placements of ONs. The OAPR solves the drawbacks of the e-xy and uses the odd-even turn model to avoid deadlock systematically. However, the e-xy cannot support ONs placed at boundaries of irregular meshes. In order to solve this problem, the OAPR applies the concepts of f-rings and f-chains [12]. With this feature, the OAPR can work correctly if ONs are placed at the boundaries of irregular meshes. Additional information and introduced algorithm about extended-xy algorithm can be found in [16].

### *C. Improved-XY Routing Algorithm*

This algorithm is based on if-cube2 [10], [11], and similar to extended-xy [15], OAPR algorithm [16] and odd-even turn model [17] uses no virtual channel. Like extended-xy algorithm, able to pass ring blocks of oversized nodes and also chain blocks that not considered in extended-xy routing. Moreover, when a network uses OAPR algorithm, all ONs vertically overlapping must be aligned on the east edge, but in improved-xy this constraint has been removed. Like [11] each message is injected into the network as a row message and its direction is set to null until it reaches to the column of the destination node. Then it would be changed as a column message to reach the destination. A column message could not change its path as a row message, unless it encounters with oversized region. In such a situation, a column message could change its direction into clockwise or counter-clockwise. First, each message should be checked if it has reached to destination node. Else, if this message is a row message and has just reached to the column of destination node, it would be changed as a column message.

For regular meshes, the e-cube provides deadlock-free shortest path routing. At each node during the routing of a message, the e-cube specifies the next hop to be taken by the message. The message is said to be blocked by an oversized node, if its e-cube hop is on an oversized region. The proposed modification uses no virtual channels and tolerates multiple oversized blocks.

To route messages around rings or chains, messages are classified into four types: East-to-West (EW), West-to-East (WE), North-to-South (NS), or South-to-North (NS). EW and WE messages are known as row messages and NS and SN as column messages. A message is labeled as either an EW or WE message when it is generated, depending on its destination. Once a message completes its row hops, it becomes a NS or a SN message to travel along the column. Thus, row messages


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can become column messages; however, NS and SN messages cannot change their types.

Next, if a message encountered with an oversized region, the Set-Direction(M) procedure would be called to set the direction of the message. The role of this procedure is to pass oversized region by setting the direction of message to clockwise or counter-clockwise. Again, the direction of the message will be set to null when it passed oversized region. While the direction of a message is null, e-cube algorithm used to route messages and it can be use odd/even row/columns. Fig. 1 show the using of odd and even row and columns when a message is passing an oversized node.

Using this modification of passing oversized regions, simulations are performed to evaluate the performance of the enhanced algorithms in comparison with the algorithms proposed in prior work. Simulation results indicate an improvement in the utilization and switched/routed messages for different cases of ONs, and different traffics. Furthermore, the enhanced approach can handle higher message injection rates (i.e., it has a higher saturation rate). In the following of this section, the proposed algorithm, Improved-XY(i-xy), and Set-Direction(M) procedures, have been given.

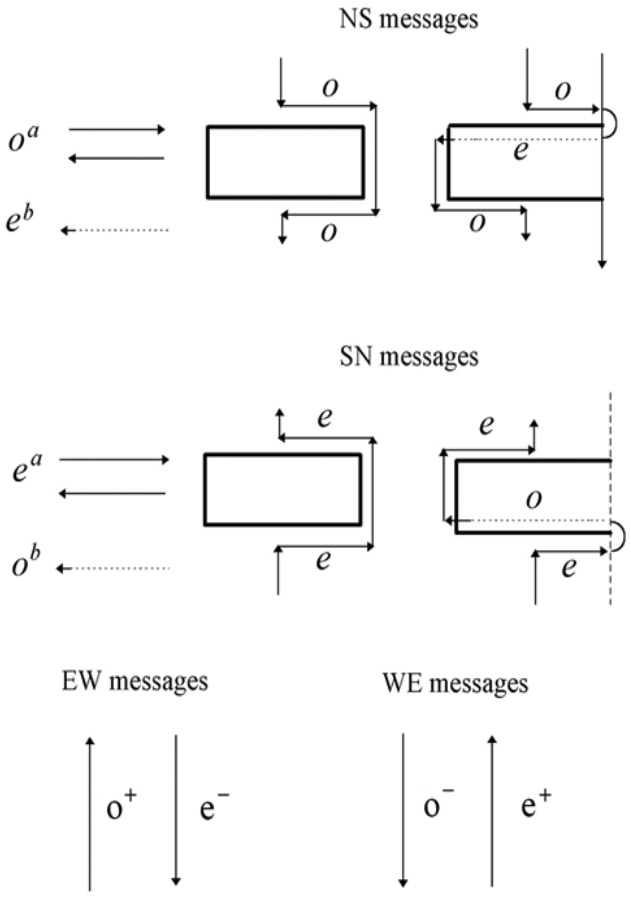


Figure 1. Usage of odd and even row or columns.

**Algorithm Improved-XY(i-xy)**

/* the current host of message M is *(s1 , s0)* and its destination is *(d1 , d0)*. */

0. If *s1 = d1* and *s0 = d0*, consume M and return.
1. If M is a row message and *s0 = d0* then change its type to NS, if *s1 > d1*, or SN, if *s1 < d1*.
2. If the next e-cube hop is not blocked by an oversized node, then set the status of M to normal and set the direction of M to null.
3. Otherwise, set the status of M by Set-Direction(M).
4. If the direction of M is null, then use its x-y hop,
5. Otherwise, route M on the oversized node according to the specified direction.

**Procedure Set-Direction(M)**

0. If M is a column message and its direction is null, then set *(l1, l0) = (s1, s0)*.
1. If the direction of M ≠ null and the current node is an end node then reverse the direction of M and return.
2. If M is a column message and *s0 ≠ l0*, then return.
3. If M is a column message and *s1 ≠ l1*, *s0 = l0*, then set its direction to null.
4. If the next e-cube hop of M is not faulty, set its direction to null and return.
5. If direction of M is not null, then return.
6. If M is a WE message, set its direction to
   6.1 clockwise if *s1 < d1*, or
   6.2 counter-clockwise if *s1 > d1*, or
   6.3 either direction if *s1 = d1*.
7. If M is an EW message, set its direction to
   7.1 clockwise if *s1 > d1*, or
   7.2 counter-clockwise if *s1 < d1*, or
   7.3 either direction if *s1 = d1*.
8. If M is an NS message, set its direction to clockwise, if the current node is not located on the EAST boundary of 2D meshes, or counter-clockwise, otherwise, and set *(l1 , l0) = (s1 , s0)*.
9. If M is an SN message, set its direction to counter-clockwise, if the current node is not located on the EAST boundary of 2D meshes, or clockwise, otherwise, and set *(l1 , l0) = (s1 , s0)*.


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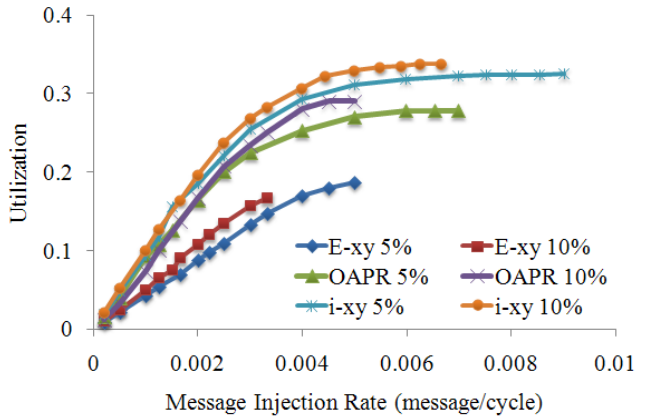
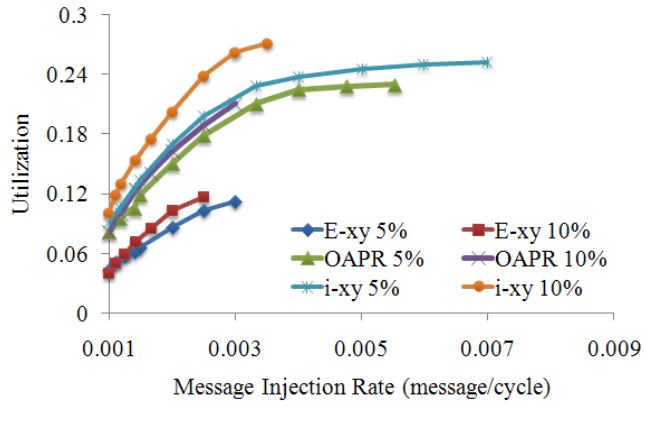
### D. Deadlock- and Live lock-Freeness

A WE message can travel from north to south or south to north, if its next e-cube hop is an oversized node. A north-to-south (south-to-north) WE message can take south-to-north (north-to-south) hops only if it encounters an end node and takes an u-turn at the end node. No deadlock occurs among EW messages can be assured by similar statements. NS messages can travel from north to south but not from south to north; there can't be a deadlock between NS messages waiting in different rows. NS messages are designed to get around the oversized components in a counterclockwise direction. An NS message can take an u-turn at an end node on the west boundary of 2-D meshes and change its direction to be clockwise, but can't take an u-turn at the east boundary of 2-D meshes, since no entire row of out-of-order components is allowed. Thus, no deadlock can occur between NS messages waiting on the same row. No deadlock can occur among SN messages that are assured by similar statements. Since the number of oversized nodes and broken links is finite and message never visits an oversized node more than once, our routing scheme is also live lock-free.




a)




b)

Figure 2. Utilization of i-xy, e-xy, and OAPR routing algorithms for 5% and 10% ONs by 32 flits packets a) Uniform traffic b) Hotspot traffic.

## III. Results and Discussions

In this section, we describe how we perform the simulation and obtain results from simulator. Moreover, we show the improvements of the primitive algorithms by our modification. In order to model the interconnection network, an object-oriented simulator was developed base on [10], [11].

Some parameters we have considered are an average number of switched messages (ANSM) and average number of routed messages (ANRM) in each period of time. The other examined parameter in this paper is the utilization of the network which is using our routing algorithm, i-xy. Utilization illustrates the number of flits in each cycle, which passed from one node to another, in any link over bandwidth. Bandwidth is defined as the maximum number of flits could be transferred across the normal links in a cycle of the network. We have examined utilization over message injection rate (MIR) and average message delay (AMD) over utilization for all sets of cases. The last parameter we have considered is the average number of blocked messages (ANBM) in the network. Simulation methodology describes in the rest of this section.

### A. Simulation Methodology

A flit-level simulator has been designed. We record average message latencies, utilization and some other parameters measured in the network with the time unit equal to the transmission time of a single flit, i.e. one clock cycle. Our study is performed for different rates: 5%, and 10% of oversized nodes. Our generation interval has exponential distribution which leads to Poisson distribution of number of generated messages per a specified interval. In our simulation studies, we assume message length to be equal to 32 flits and we use an 8 x 8 2-dimensional irregular mesh network, and it takes one cycle to transfer a flit on a physical channel. Two different traffic patterns are simulated:

- Uniform traffic: The source node sends messages to any other node with equal probability.
- Hotspot traffic: Messages are destined to a specific node with a certain probability and are otherwise uniformly distributed.

The number of messages generated for each simulation result, depends on the traffic distribution, and is between 1,000,000 to 3,000,000 messages. The simulator has three phases: start-up, steady-state, and termination. The start-up phase is used to ensure the network is in steady-state before measuring message latency. So, we do not gather the statistics for the first 10% of generated messages. All measures are obtained from the remaining of messages generated in steady-state phase. Messages generated during the termination phase are also not included in the results. The termination phase continues until all the messages generated during second phase have been delivered [10], [11]. In the rest of this section we study the effect of using predefined odd/even row and columns on the performance of i-xy. We perform this analysis under a different traffic distribution pattern. It is noted that only parts of simulation results are presented in this paper.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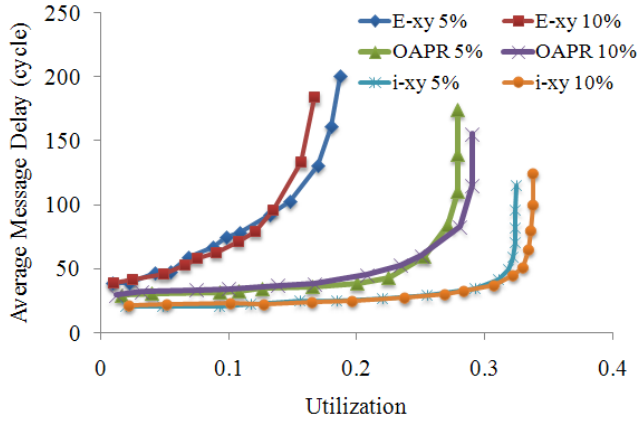
Figures 2, 3, 4, 5, and 6 show the simulation results for two different oversized node cases, 5 percent and 10 percent, with uniform and hotspot (p=10%) traffic.

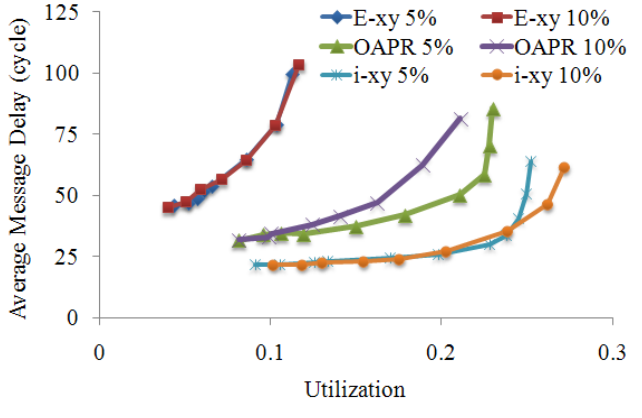
### B. *Comparison of i-xy, e-xy, and OAPR Routing Algorithms*

Uniform traffic is the most used traffic model in the performance analysis of interconnection networks [10], [11]. Fig. 2a, 3a, 4a, 5a, and 6a displays the effect of the improvement on the performance of i-xy, e-xy, and OAPR routing algorithms in 2-D irregular mesh interconnection network for this traffic pattern.

In order to generate hotspot traffic we used a model proposed in [10]. According to this model each node first generates a random number. If it is less than a predefined threshold, the message is sent to the hotspot node. Otherwise, it is sent to other nodes of the network with a uniform distribution.




a)

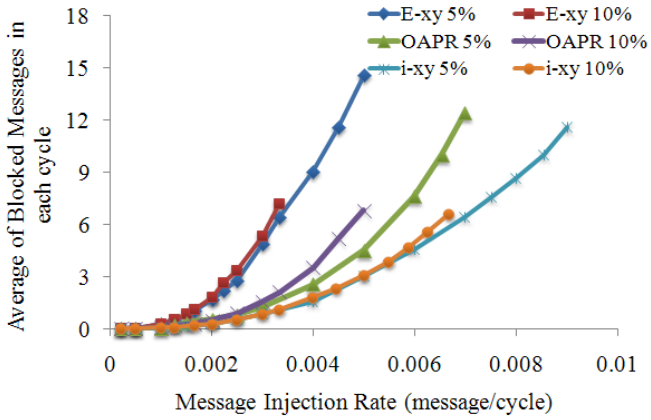



b)

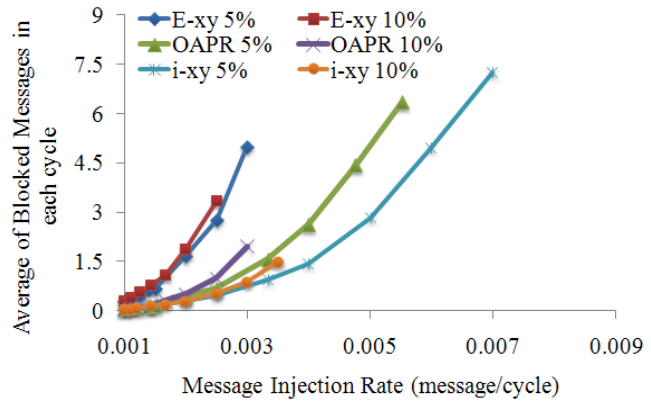
Figure 3. Performance of i-xy, e-xy, and OAPR routing algorithms for 5% and 10% ONs by 32 flits packets a) Uniform traffic b) Hotspot traffic.

As the mesh interconnection network is not a symmetric network, we have considered two types of simulation for hotspot traffic in this network. In one group of simulations, a corner node is selected as the hotspot node and in the other group; a node in the middle of the network is chosen as the hotspot node, and finally averaged. Hotspot rate is also considered in our study, namely 10%. Fig. 2b, 3b, 4b, 5b, and 6b illustrates the effect of the performance of every three above mentioned routing algorithms for hotspot traffic distribution pattern.

We defined utilization as the major performance metric. For an interconnect network, the system designer will specify a utilization requirement. Fig. 2a and 2b shows the utilization over the message injection rate for two cases of oversized nodes with two different traffic patterns, uniform and hotspot traffic, on 8 x 8 irregular 2-dimensional mesh Network-on-Chip. As we can see, the network which uses extended-xy and OAPR algorithm is saturated with low MIR while the improved-xy algorithm has a higher saturation point. As an example in 10% case of extended-xy, the utilization for 0.0033 MIR is lower 16.67% and for OAPR is 25%, yet the other algorithm, improved-xy, works normally even for 0.0067 MIR with 33.8% utilization at 100% traffic load (fig. 2a). In fact our irregular routing algorithm has higher utilization. Additionally, improvement can be found in other traffic pattern.




a)




b)

Figure 4. ANBM of i-xy, e-xy, and OAPR routing algorithms for 5% and 10% ONs by 32 flits packets a) Uniform traffic b) Hotspot traffic.

The most important comparison we have done between these three algorithms is the rate of average message delay over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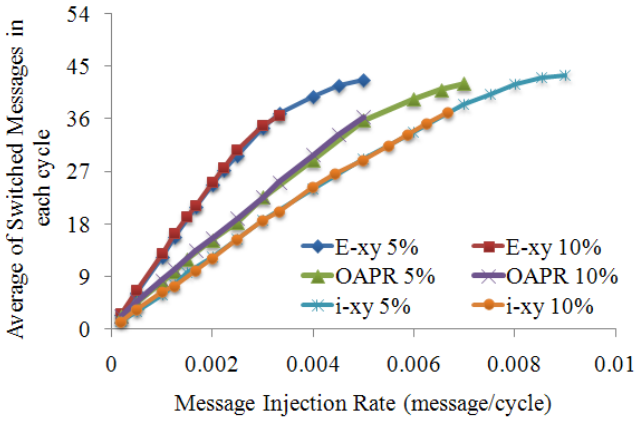
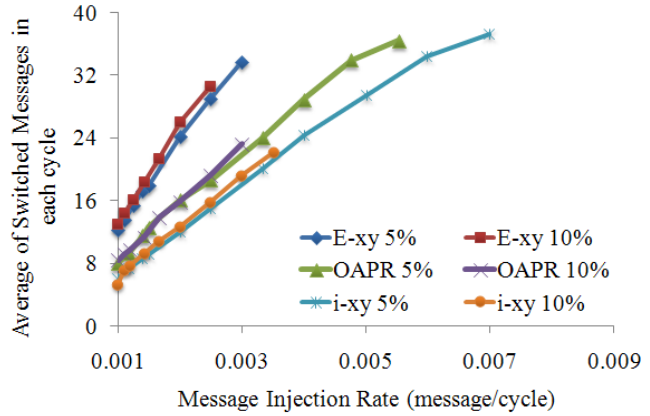
utilization. Comparative performance across different cases in fig. 3a and fig. 3b is specific to the several oversized node sets used. For each case, we have simulated previous sets up to 100% traffic load.




a)




b)

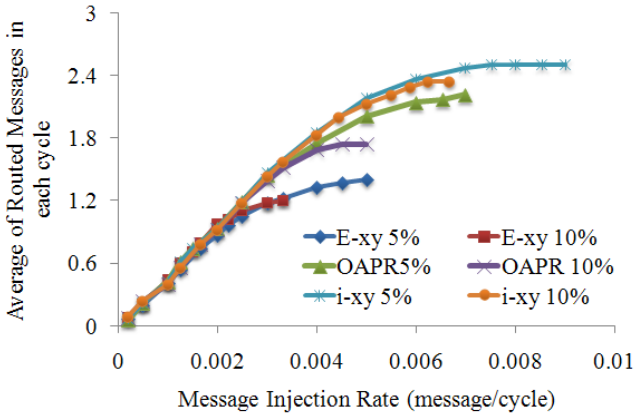
Figure 5. ANSM of i-xy, e-xy, and OAPR routing algorithms for 5% and 10% ONs by 32 flits packets a) Uniform traffic b) Hotspot traffic.

As an example, we consider the amount of average message delay for both algorithms with 16% utilization in 5% mode in uniform traffic (fig. 3a). At this point, the network which uses e-xy has more than 183 AMD at 100% traffic load and the network uses OAPR has more than 38 AMD, while the other network using i-xy, has less than 24 AMD, and it has not been saturated. Comparing the utilization of these algorithms for 100% traffic load, it is obvious the network using i-xy has 32.5% utilization, whereas the OAPR has 27.86% and the other one has just 16.67% utilization. We have improved utilization of network more than 16% by our proposed algorithm at 100% traffic load compared to OAPR for this case, and about twice for extended-xy. Other case is also considerable.

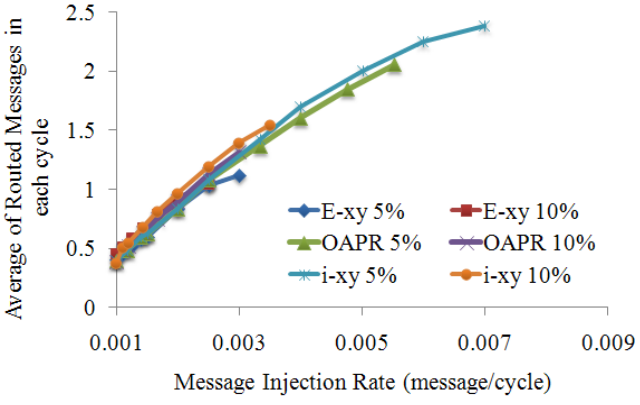
The next parameter we have examined is the average number of blocked messages (ANBM) in each cycle which illustrates average number of blocked messages in the network because no buffer is available to pass to the next node. If nodes of a communication system have more free buffers, messages may deliver simply across the interconnection network.

As it is shown in fig. 4a and 4b a fraction of delays which messages are encountered by, is the delay of waiting for an empty buffer for the next hop. For instance, comparing three algorithms in fig. 4b for 10% mode by hotspot traffic in 0.0025 MIR, it is clear that when a network uses e-xy, over 3.35 messages blocked in every cycle and this number for OAPR at this point is more than 0.99 messages, but by using i-xy algorithm, less that 0.55 messages blocked in every cycle. This condition is repeated for the other case shown in fig. 4a for uniform traffic which is substantial.

Fig. 5 shows the average number of switched messages (ANSM) in each cycle over the message injection rate (MIR) for all cases. It is clear; the network uses i-xy algorithm has minor improvement at 100% traffic load compared to the other two above mentioned algorithms. As an example in fig. 5a in 10% mode of extended-xy and OAPR, the ANSM at saturation point is about 36.5, yet ANSM for the other algorithm, improved-xy is more than 37. In fact our irregular routing algorithm has similar behavior for this parameter. But, this parameter for hotspot traffic distribution has better condition.




a)




b)

Figure 6. ANRM of i-xy, e-xy, and OAPR routing algorithms for 5% and 10% ONs by 32 flits packets a) Uniform traffic b) Hotspot traffic.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The last parameter we consider is the average number of routed messages (ANRM) in each cycle. As it is shown in fig. 6a and fig. 6b, the ANRM for improved-xy has higher in comparison to extended-xy and OAPR algorithms. For instance, in fig. 6b in hotspot traffic by 5% mode of extended-xy, the ANRM for 0.003 MIR is 1.12 messages and the network saturated at 0.0055. The network uses OAPR algorithm (at saturation point) has 2.05 ANRM, but this number for improved-xy algorithm is more than 2.37 in 0.007 MIR at saturation point. Also, enhancement can be found by using uniform traffic in fig. 6a.

## IV. CONCLUSION

Designing a deadlock-free routing algorithm that can tolerate unlimited number of oversized nodes is not an easy job. Oversized blocks are expanded, by disabling good nodes, to be rectangular shapes in existing literature to facilitate the designing of deadlock-free routing algorithms for 2-D irregular mesh networks. The simulation results show the improvement of network utilization (from 35% to 100%), which are needed to work with rectangular oversized nodes, can be recovered if the number of original oversized nodes is less than 10% of the total network.

We have been simulated every three algorithms for the same message injection rates, oversized node situations, message lengths, network size, and the percentage of oversized nodes and in many cases our studies have better results in comparison with the other two algorithms.

We also showed that in various traffics and different number of oversized nodes, these oversized blocks can be handled. The deterministic algorithm is enhanced from the non-adaptive counterpart by utilizing the way of passing oversized nodes by the proposed algorithm when a message is blocked. The method we used for enhancing the extended-xy and OAPR algorithms is simple, easy and its principle is similar to the previous algorithm, if-cube2. Moreover, ANBM and ANRM are improved by our proposed algorithm. In conclusion improved-xy has better performance compared to extended-xy and OAPR and is feasible for Network-on-Chip.

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***Track A: Security***

Access control, Anonymity, Audit and audit reduction & Authentication and authorization, Applied cryptography, Cryptanalysis, Digital Signatures, Biometric security, Boundary control devices, Certification and accreditation, Cross-layer design for security, Security & Network Management, Data and system integrity, Database security, Defensive information warfare, Denial of service protection, Intrusion Detection, Anti-malware, Distributed systems security, Electronic commerce, E-mail security, Spam, Phishing, E-mail fraud, Virus, worms, Trojan Protection, Grid security, Information hiding and watermarking & Information survivability, Insider threat protection, Integrity
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Location Anonymity schemes, Intrusion detection and prevention techniques, Cryptography, encryption algorithms and Key management schemes, Secure routing schemes, Secure neighbor discovery and localization, Trust establishment and maintenance, Confidentiality and data integrity, Security architectures, deployments and solutions, Emerging threats to cloud-based services, Security model for new services, Cloud-aware web service security, Information hiding in Cloud Computing, Securing distributed data storage in cloud, Security, privacy and trust in mobile computing systems and applications, **Middleware security & Security features:** middleware software is an asset on
its own and has to be protected, interaction between security-specific and other middleware features, e.g., context-awareness, **Middleware-level security monitoring and measurement:** metrics and mechanisms for quantification and evaluation of security enforced by the middleware, **Security co-design:** trade-off and co-design between application-based and middleware-based security, **Policy-based management:** innovative support for policy-based definition and enforcement of security concerns, **Identification and authentication mechanisms:** Means to capture application specific constraints in defining and enforcing access control rules, **Middleware-oriented security patterns:** identification of patterns for sound, reusable security, **Security in aspect-based middleware:** mechanisms for isolating and enforcing security aspects, **Security in agent-based platforms:** protection for mobile code and platforms, Smart Devices: Biometrics, National ID cards, Embedded Systems Security and TPMs, RFID Systems Security, Smart Card Security, Pervasive Systems: Digital Rights Management (DRM) in pervasive environments, Intrusion Detection and Information Filtering, Localization Systems Security (Tracking of People and Goods), Mobile Commerce Security, Privacy Enhancing Technologies, Security Protocols (for Identification and Authentication, Confidentiality and Privacy, and Integrity), Ubiquitous Networks: Ad Hoc Networks Security, Delay-Tolerant Network Security, Domestic Network Security, Peer-to-Peer Networks Security, Security Issues in Mobile and Ubiquitous Networks, Security of GSM/GPRS/UMTS Systems, Sensor Networks Security, Vehicular Network Security, Wireless Communication Security: Bluetooth, NFC, WiFi, WiMAX, WiMedia, others

This Track will emphasize the design, implementation, management and applications of computer communications, networks and services. Topics of mostly theoretical nature are also welcome, provided there is clear practical potential in applying the results of such work.

***Track B: Computer Science***

Broadband wireless technologies: LTE, WiMAX, WiRAN, HSDPA, HSUPA, Resource allocation and interference management, Quality of service and scheduling methods, Capacity planning and dimensioning, Cross-layer design and Physical layer based issue, Interworking architecture and interoperability, Relay assisted and cooperative communications, Location and provisioning and mobility management, Call admission and flow/congestion control, Performance optimization, Channel capacity modeling and analysis, Middleware Issues: Event-based, publish/subscribe, and message-oriented middleware, Reconfigurable, adaptable, and reflective middleware approaches, Middleware solutions for reliability, fault tolerance, and quality-of-service, Scalability of middleware, Context-aware middleware, Autonomic and self-managing middleware, Evaluation techniques for middleware solutions, Formal methods and tools for designing, verifying, and evaluating, middleware, Software engineering techniques for middleware, Service oriented middleware, Agent-based middleware, Security middleware, Network Applications: Network-based automation, Cloud applications, Ubiquitous and pervasive applications, Collaborative applications, RFID and sensor network applications, Mobile applications, Smart home applications, Infrastructure monitoring and control applications, Remote health monitoring, GPS and location-based applications, Networked vehicles applications, Alert applications, Embeded Computer System, Advanced Control Systems, and Intelligent Control : Advanced control and measurement, computer and microprocessor-based control, signal processing, estimation and identification techniques, application specific IC's, nonlinear and adaptive control, optimal and robot control, intelligent control, evolutionary computing, and intelligent systems, instrumentation subject to critical conditions, automotive, marine and aero-space control and all other control applications, Intelligent Control System, Wiring/Wireless Sensor, Signal Control System. Sensors, Actuators and Systems Integration : Intelligent sensors and actuators, multisensor fusion, sensor array and multi-channel processing, micro/nano technology, microsensors and microactuators, instrumentation electronics, MEMS and system integration, wireless sensor, Network Sensor, Hybrid

Sensor, Distributed Sensor Networks. Signal and Image Processing : Digital signal processing theory, methods, DSP implementation, speech processing, image and multidimensional signal processing, Image analysis and processing, Image and Multimedia applications, Real-time multimedia signal processing, Computer vision, Emerging signal processing areas, Remote Sensing, Signal processing in education. Industrial Informatics: Industrial applications of neural networks, fuzzy algorithms, Neuro-Fuzzy application, bioInformatics, real-time computer control, real-time information systems, human-machine interfaces, CAD/CAM/CAT/CIM, virtual reality, industrial communications, flexible manufacturing systems, industrial automated process, Data Storage Management, Harddisk control, Supply Chain Management, Logistics applications, Power plant automation, Drives automation. Information Technology, Management of Information System : Management information systems, Information Management, Nursing information management, Information System, Information Technology and their application, Data retrieval, Data Base Management, Decision analysis methods, Information processing, Operations research, E-Business, E-Commerce, E-Government, Computer Business, Security and risk management, Medical imaging, Biotechnology, Bio-Medicine, Computer-based information systems in health care, Changing Access to Patient Information, Healthcare Management Information Technology. Communication/Computer Network, Transportation Application : On-board diagnostics, Active safety systems, Communication systems, Wireless technology, Communication application, Navigation and Guidance, Vision-based applications, Speech interface, Sensor fusion, Networking theory and technologies, Transportation information, Autonomous vehicle, Vehicle application of affective computing, Advance Computing technology and their application : Broadband and intelligent networks, Data Mining, Data fusion, Computational intelligence, Information and data security, Information indexing and retrieval, Information processing, Information systems and applications, Internet applications and performances, Knowledge based systems, Knowledge management, Software Engineering, Decision making, Mobile networks and services, Network management and services, Neural Network, Fuzzy logics, Neuro-Fuzzy, Expert approaches, Innovation Technology and Management : Innovation and product development, Emerging advances in business and its applications, Creativity in Internet management and retailing, B2B and B2C management, Electronic transceiver device for Retail Marketing Industries, Facilities planning and management, Innovative pervasive computing applications, Programming paradigms for pervasive systems, Software evolution and maintenance in pervasive systems, Middleware services and agent technologies, Adaptive, autonomic and context-aware computing, Mobile/Wireless computing systems and services in pervasive computing, Energy-efficient and green pervasive computing, Communication architectures for pervasive computing, Ad hoc networks for pervasive communications, Pervasive opportunistic communications and applications, Enabling technologies for pervasive systems (e.g., wireless BAN, PAN), Positioning and tracking technologies, Sensors and RFID in pervasive systems, Multimodal sensing and context for pervasive applications, Pervasive sensing, perception and semantic interpretation, Smart devices and intelligent environments, Trust, security and privacy issues in pervasive systems, User interfaces and interaction models, Virtual immersive communications, Wearable computers, Standards and interfaces for pervasive computing environments, Social and economic models for pervasive systems, Active and Programmable Networks, Ad Hoc & Sensor Network, Congestion and/or Flow Control, Content Distribution, Grid Networking, High-speed Network Architectures, Internet Services and Applications, Optical Networks, Mobile and Wireless Networks, Network Modeling and Simulation, Multicast, Multimedia Communications, Network Control and Management, Network Protocols, Network Performance, Network Measurement, Peer to Peer and Overlay Networks, Quality of Service and Quality of Experience, Ubiquitous Networks, Crosscutting Themes – Internet Technologies, Infrastructure, Services and Applications; Open Source Tools, Open Models and Architectures; Security, Privacy and Trust; Navigation Systems, Location Based Services; Social Networks and Online Communities; ICT Convergence, Digital Economy and Digital Divide, Neural Networks, Pattern Recognition, Computer Vision, Advanced Computing Architectures and New Programming Models, Visualization and Virtual Reality as Applied to Computational Science, Computer Architecture and Embedded Systems, Technology in Education, Theoretical Computer Science, Computing Ethics, Computing Practices & Applications

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