Center for Advanced Computation

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

URBANA, ILLINOIS 61801

CAC Document No. 119

SEMIANNUAL TECHNICAL REPORT OF
THE CENTER FOR ADVANCED COMPUTATION

For

October 1, 1973 - March 31, 1974

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Center for Advanced Computation
University of Illinois at Urbana-Champaign
Urbana, Illinois 61801

Form Approved
Budget Bureau No. 22-R0293

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CENTER FOR ADVANCED COMPUTATION REPORT SUMMARY

This is a progress report on ARPA contract DAHC04-72-C-0001, entitled, "ILLIAC IV Applications Research at the Center for Advanced Computation, University of Illinois at Urbana-Champaign."

At the beginning of this period, formal recognition was given to division of the program entitled "ILLIAC IV Applications Research." With the concurrence of ARPA/IPT, the program has been divided into two projects with separate principal investigators.

Professor D. L. Slotnick remains as the principal investigator for research in ILLIAC IV application and related systems development. This includes the following activities:

1. Development of numerical techniques suitable for parallel processing in the areas of:

    a) Linear programming

    b) Approximation of functions

    c) The algebraic eigenvalue problem

2. ILLIAC IV multispectral image processing

3. Research in distributed computational systems of heterogeneous computers.

Detailed descriptions of the above activities are presented in Sections I-III of this report.

Professor M. S. Sher was appointed principal investigator for research and development of network access computer systems. This includes:

1. Development of the ANTS, MARK II system

2. Support of selected ARPA contractors in the installation
    of ANTS systems

3. Participation in network protocol development

4. Graphics support for programs in the CAC and Laboratory
    for Atmospheric Research

5. Operation of the UI ANTS system.

Detailed descriptions of the above activities are presented in Section IV
of this report.

I. APPLIED MATHEMATICS GROUP

A. Exponential Approximation

A document [1] was prepared describing work through October 1973, on an algorithm involving differential corrections and linear programming. Suggestions were made in that document as to possible improvements in the algorithm. Some progress has been made in carrying out those suggestions, but program debugging is still necessary before extensive trials can be carried out and conclusions reached.

B. Large Matrix Problems

The spectral synthesis method [2] developed in collaboration with members of the Chemistry Department has been tried on large problems of physical importance. The matrices for which the generalized eigenvalue problem had to be solved were of order 256. A variation of the QZ algorithm developed by Sameh and Chang [3] was used and very good results were obtained, the largest residuals being of the order of 10^{-11}. Some thought is being given to iterative methods, which should be readily adaptable to parallelism and ILLIAC IV.

The Simultaneous Iteration Method [4, 5] for finding the leading eigenvalues and corresponding eigenvectors, has been generalized to obtain the eigenvalues of a large sparse symmetric matrix in any interval [a, b], [6]. The new method is quite suitable for dealing with such sparse matrices on a parallel computer. The algorithm has been adequately tested on a serial machine and we are in the process of writing an ILLIAC IV program.

REFERENCES

1. G. Belford and J. F. Burkhalter, "A Differential Correction Algorithm
    for Exponential Curve Fitting," CAC Document No. 92, November, 1973.

2. G. Belford, R. L. Belford, and J. F. Burkhalter, "Eigenfields: A
    Practical Direct Calculation of Resonance Fields and Intensities
    for Field-swept Fixed-frequency Spectrometers," J. Magnetic
    Resonance, v. 11 (1973), pp. 251 - 265.

3. C. Chang, "An Algorithm for the Symmetric Generalized Eigenvalue Problem
    Ax = λ Bx," Master's Thesis, Department of Computer Science,
    University of Illinois, Urbana, Illinois.

4. H. Rutishauser, "Computational Aspects of F. L. Bauer's Simultaneous
    Iteration Method," Num. Math., 13 (1969), pp. 4 - 13.

5. H. Rutishauser, "Simultaneous Iteration Method for Symmetric Matrices,"
    Num. Math., 16 (1970), pp. 205 - 223.

6. A. Sameh, J. Lermit, and K. Noh, "On the Intermediate Eigenvalues of
    Symmetric Sparse Matrices," CAC Document No. 91, Center for Advanced
    Computation, University of Illinois, Urbana, Illinois 61801.

II. PICTORIAL PATTERN INFORMATION PROCESSING

A. Introduction

With continued support from ARPA, NASA and USGS, development of
ARPA Network and ILLIAC IV multispectral image processing facilities
continues. At the request of Information Sciences Institute (ISI), the
interactive TENEX multispectral image editing system has now been moved
from ISI to Bolt, Beranek & Newman (BBN) where it will be generally
accessible to ARPA Network users at BBN commercial rates. The Statistical
Reporting Service (SRS) of USDA plans to use this system for editing and
small-scale analysis of ERTS data corresponding to ground truth areas over
two states. The ARPA-supported image modeling group of Purdue will also
be using this software to achieve immediate ARPA Net image processing
capabilities.

B. ILLIAC IV Pattern Information Processing

Both multivariate cluster analysis and statistical classification
ASK algorithms are now operational on ILLIAC IV for large-scale analysis of
ERTS multispectral imagery. Direct comparisons between the ILLIAC IV and
the IBM 360/67 of LARS/Purdue indicate processing speed ratios between two
and three orders of magnitude for these two algorithms. The availability
of instruction overlap on ILLIAC IV and more comprehensive data management
systems will greatly improve existing ILLIAC IV processing rates and throughput
capabilities. NASA support has been secured for development of ERTS data
management and editing on the IBM 360/67 at Ames Research Center.

C. Image Processing Graphics Support

        Software has been developed for plotting in color interpreted

pictorial information using the Zeta plotter. ERTS data interpretations

can now be plotted as colored resource maps equivalent with respect to scale

and geography to USGS 7½' quadrangles. CAC Imlac image processing software

will be shared with NASA/Ames and Purdue. Extensive use of the DICOMED film

scanning output device at NASA/Ames is being planned.

D. Pattern Information Processing Algorithms

        Research continues toward the development of pattern information

correlation algorithms. Current work involves the development of efficient

procedures for determining maximum-entropy minimum-energy information

distributions within networks. The MEME pattern correlation coefficient is

being researched as a mathematical basis for stereopsis. A report in this

area is forthcoming.

III. DISTRIBUTED SYSTEMS

A. Introduction

The Distributed System Group conducts research in distributed computational systems of heterogeneous computers. The principal effort in the six month period has been directed to outline the scope of the problem and to determine the range of costs and benefits accrued by a single software environment that spans several computers. Preliminary results indicate that a large class of systems can be implemented as distributed systems on dissimilar computers and have higher performance, higher reliability and lower cost than would be achievable on a single computational facility.

B. PL/1 Compatibility

The PL/1 compatibility study was completed in December of 1973, with the exception of the study of I/O compatibility. It appears reasonable to use PL/1 as a compatible language for distributed systems. PL/1 multi-tasking and compile time facilities are currently planned to be dropped from the final PL/1 ANSI standard. Therefore, the incompatibility of those facilities, as they currently exist on different vendor equipment, becomes a moot question. At the beginning of the project, PL/1 was considered as a good general choice due to its availability on Multics, IBM, and Burroughs equipment. Since then, PL/1 compilers have become available on, or will shortly become available for Honeywell GCOS, UNIVAC, Control Data, and Data General Equipment.

C. Multi-machine Education

An education effort was undertaken to improve the fluency of distributed system group programmers in the use of Multics, the B6700, TSO on OS/360, and TSS on the 360/67. That program has been completed. The programmers are fluent in the generation of software on each of those systems at the level of interaction with the network control program (when such interactions are permitted).

D. Network Protocols

The study of process-to-process protocols that live on top of standard ARPA network host-to-host protocols was begun this period. This study was conceptualized as an investigation of process control and data transfer protocols. It has evolved into an identification of the need for network-wide utilities and the provision of protocols to support those utilities.

The concept of a data management protocol to study a resilient process-to-process protocol has been chosen. The data management protocol under study would be data management system independent. It would recognize the difference between the transmission of update requests vs. the transmission of read requests. The protocol may be multi-level and take into account that parts of it might be executed in a communications front-end, like ANTS, a large host, or even an intelligent local terminal with an imbedded micro-processor.

E. Network Economics

A study of the performance and economic implications of distributed systems was begun and some preliminary results generated.

These results indicate that, for certain tasks up to two orders of magnitude, cost and performance improvement can be achieved by the correct choice of machine on the ARPA Network. Furthermore, some machines which are the very best at some task (e.g., the 360/91 at number crunching) are the worst at other tasks (e.g., the 360/91 at data management). Distributed computing seems to be feasible for surprisingly small tasks.

A program of benchmarking various machines on the network has begun. The purpose of the program is to quantify the effectiveness of each of the hosts in a full cost recovery heterogeneous environment. A detailed set of numerical benchmarks has already been run and some preliminary data management benchmarks have been generated to produce the conclusions in the first paragraph of this section. More detailed benchmarks in the areas of number crunching, bits and character flogging, file flogging, and console management are nearly complete.

F. Network Consultation and Assistance

Due to its unique experience with distributing computing and expertise on a multiplicity of ARPA network computational facilities, the Center for Advanced Computation has been frequently called upon to provide general consultation and assistance to other ARPA contractors and Department of Defense agencies who wish to use the ARPA Network in a more production oriented mode. In particular, the Center has provided extensive assistance to the ARPA Biocybernetics project to ease their use of the Multics based Consistent System and to link Consistent System capabilities with the BIOMED statistical package available at the

CCN 360/91. The Center has also consulted with the Joint Technical
Support Activity on a set of WWMCCS related problems. Of particular
interest have been the provision of distributed data management facilities
in a hostile environment.

ADMINISTRATION AND FISCAL STATUS

A. Administration

During this report period, Professor Hugh Folk became director of the Center for Advanced Computation.

B. Fiscal Status

Actual expenditures through 31 March 1974: $2,995,409

Expenditures for the six month period covered in this report (1 October 1973 - 31 March 1974):

October	$ 2,615.00
November	25,340.00
December	67,535.00
January	136,668.00
February	67,229.00
March	58,891.00
	358,278.00

Obligations remaining: $249,600.

IV. NETWORK ACCESS SYSTEMS

A. Introduction

The Network Terminal Systems (NTS) Project in the Center for Advanced Computation has the following objectives: (1) Design and Development of the ANTS, MARK II system, (2) Support of selected ARPA contractors in the installation of ANTS systems, (3) Participation in network protocol development, (4) Graphics support for programs in the CAC and Laboratory for Atmospheric Research, and (5) Operation of the University of Illinois ANTS system.

B. ANTS, MARK II

During the last six month period, it was recognized that the ANTS, MARK II system as designed by Gary Grossman, would require a larger development effort than had originally been projected. As the design matured over the summer of 1973, it was becoming clear that the development of a general purpose data communications system for front-ending to the ARPANET was an objective requiring more effort than the initially projected two man years. Rather than reduce the design objectives, the decision was made to add staff to both the ANTS, MARK II coding effort and the continued development of the PEESPOL compiler. To this end, one staff member was added in October to our previous one-man PEESPOL development effort and, by February, five staff members and a graduate assistant had been added to our initial three-man effort in ANTS, MARK II development. An additional full-time staff member was added in November for documentation and user support.

During the first half of the six month period, coding of level 0 and 1, and check out of all level 0 and a few level 2 functions were completed. In the second half of this period, coding of level 2 was also completed, including the terminal handler and NCP, as well as TELNET. These, along with level 0 modules were in a check-out phase at the end of this period. The user TELNET version of ANTS, MARK II is expected to be making connections to the network by mid-April with server TELNET providing login capability from the network by early May. Concurrent with this development, we are coding software drivers to provide support for various PDP-11 peripherals such as the DH11, DL11, DJ11, RF11 disk, RK05 disk, and LV11 (Versatec). We are also designing user and server FTP and NETRJE software for ANTS, MARK II.

Due to an expressed concern by the ANTS Steering Committee, we are currently carefully examining the problem of language compatibility with the goal of providing a means of using code written in PAL and/or BCPL with ANTS by Fall of 1974. Among the approaches being examined are:

a) A PAL-to-PEESPOL source translator utility which would enable users to transfer their code to PEESPOL:

b) Eventually, an ARPANET standard PDP-11 object file format to allow binding of object modules produced by different compilers;

c) Temporarily, a utility which transforms PAL or BCPL object modules into PEESPOL object modules for binding by the PEESPOL compiler;

d) Automatic generation of global source declarations
for use in compiling modules in PAL or BCPL for use
with ANTS; leaving empty "slots" in ANTS for linking
in such modules;

e) A binder, running on the PDP-11, suitable for linking
object modules produced by the above means into ANTS.

A debugging system was developed which consists of two facilities:
a run-time interactive debugger similar in function to DEC DDT, and a disk-
image patcher which runs independently of ANTS. This system has facili-
tated the debugging process and greatly reduced the number of required
recompilations.

C. ANTS Steering Committee

The ARPA-IPT office established an ANTS Steering Committee to help guide the ANTS, MARK II development and assess its suitability as a network access mechanism. In January of 1974, the ANTS Steering Committee met with the members of the NTS staff for three days of technical discussions and planning sessions. The members of the Steering Committee are Ken Pogran, Jerry Burchfiel, Tom Boynton, and Dave Crocker.

A part of the technical discussion was centered around the ANTS, MARK II system design and use of the PEESPOL compiler for implementing site-specific applications on the PDP-11. The consensus of the Steering Committee was that "ANTS is an excellent general purpose network access device, and that it offers a good base upon which to build specialized network access facilities." It was also generally agreed that "the development of PEESPOL had contributed greatly to the cleanliness and extensibility of the ANTS system."

Another topic of the technical discussion was directed at establishing a set of general specifications for ANTS. The specifications call for individual ANTS systems to be tailored according to the hardware on the system and the software modules desired. Obviously, for any given system, the software which can be included depends on the hardware available. The specifications outline the user-level features available in ANTS, MARK II, including TIP-emulation, command abbreviation/completion, rich terminal support and other generally friendly features.

The determination of priorities by the ANTS Steering
Committee was very closely tied to the technical discussion. The
outcome of those sessions was a plan for the production of the initial
working version of ANTS, MARK II and an ordering of priorities for
subsequent required features. These plans called for the installation
of the first version to be installed at UCLA-NMC in April supporting
basic TELNET. In terms of user-level features, this first installation
will support:

> command abbreviations;
> character and line modes;
> line mode input editing;
> line feeds inserted after carriage control functions;
> variable timing delay for terminal carriage control functions;
> diversion of terminal output to the printer; and
> multiple connections per terminal.

Activities which we are trying to complete in the current
fiscal year include:

> user and server FTP;
> NETRJE;
> device drivers for the DH11, RK11, DL11, and DC11;
> documentation; and
> extensions to PEESPOL to support separate module compilation
>   and linkage.

Other activities, to be jointly supported by ARPA, Lincoln
Labs, and NASA Ames include: device drivers for the MT11, DT11, PC11,
and possibly a LP11. These are expected to be completed during the
summer.

The ANTS Steering Committee strongly recommended to ARPA
that continued support be given to such activities as fancy terminal
support, command completion, and extended TELNET; documentation and

user support, changes and future developments to network protocols, ANTS reliability enhancements, maintenance and slight improvements to the PEESPOL compiler, system measurements, and various cooperative efforts with other network activities.

D. ANTS, MARK I

During the months of December, January, and February, an effort was launched to make a number of improvements and enhancements to the current MARK I prototype ANTS system. This system was then installed at a number of sites on the network as an interim measure to provide network access before the initial delivery of MARK II.

A separate information bulletin has been sent to all sites receiving MARK I installation detailing the differences between the latest version and previous versions. In addition, a user guide has been written detailing the current commands and available capabilities of MARK I ANTS. It was distributed the week of March 4, 1974.

The following sites on the network are running the MARK I system:

Center for Advanced Computation - University of Illinois
Network Terminal Systems Group - University of Illinois

Army Materiel Command - Ft. Belvoir, Virginia
Ballistic Research Laboratory - Aberdeen Proving Grounds,
    Maryland
Network Measurement Center - University of California,
    Los Angeles
Lawrence Livermore Laboratory - RISOS Project

E. PLATO/ANTS

The experimental linkup between a modified PLATO IV plasma
terminal at UCSB and the PLATO system at Illinois appears to be
successful. The terminal at Santa Barbara is attached to the IBM 360/75
(it is standard ASCII compatible) and from there can access the network.
At the Illinois end, the PLATO system is connected to ANTS through a
direct phone line. As an interim measure, the software of MARK I was
experimentally modified to listen on preassigned sockets for the PLATO
connection. The user at UCSB must set up two simplex connections to
these numerically adjacent sockets.

In mid-March, the PLATO software was installed in the production
MARK I system at Illinois on an experimental basis. It will remain there
so long as it does not appear to unduly degrade system performance. The
multi-user PLATO module may be written for MARK II. In MARK II, the module
would be overlayable and the connection would be initiated through a normal
ICP connection.

F. PEESPOL

Work on PEESPOL over the past six months has been a mixture
of debugging of new features implemented in the previous six months, and
adding new features to the compiler. Among the new features are:

    Miscellaneous macro generator improvements and enhancements;
    Up-level addressing;
    Allocation of separate code and data;
    Greatly enhanced loop control facilities;
    New patch merging facilities;
    Miscellaneous listing readability improvements; and
    Separate compilation and binding facilities

G. Hardware

During this reporting period, several IMP Interfaces were delivered. These went to Ames, UCLA, and NBS. Along with the Ames interface, our first "Distant Host Adapter" was delivered.

A new, improved "IMP Indicator Panel" was delivered during this period. The panel consists of 143 light emitting diodes that display the state of the major registers and control elements in the IMP Interface. Currently, Ames is the only site with this new panel.

Improvements were made to the IMP Interface to improve its operation with both the PDP-11 and the IMP. These improvements are manifest in the form of Engineering Change Orders Nos. 4, 5, 6 and 7, which have been incorporated into most interfaces.

A report is in preparation for ARPA's Interface Standardization Committee. This report, to be completed in early April, describes the history of the Illinois interface, its users, desirable engineering changes which could be issued, and a detailed response to the Committee's questionnaire of 29 March.

H. Documentation

A concentrated effort in documentation was begun in December. A preliminary plan for desirable documentation has been outlined. Several new documents are being written at the present time, and revisions to existing documents are either under way or contemplated. Existing and planned documentation are summarized below.

As one might expect, the major problem with providing documentation is the pressing need for programmers to move on to their next

task. This will be alleviated by assigning personnel to the documenta-
tion section at appropriate milestones in their work, until the required
documentation is completed.

Summary of Available Documentation

Bouknight, J. W., Gary Grossman, and Dave Grothe, "A New Approach to
        Network Access," NTS Document No. 1. Paper presented at the
        Data Communication Interface '73 Symposium, St. Petersburg,
        Florida, November 1973. Urbana, Ill.: Center for Advanced
        Computation, University of Illinois at Urbana-Champaign, 1973.
        7 pages.

        This document is an overview of the ANTS MARK II system. It is
        slightly out of date, but the best public summary.

Bouknight, Jack, "IMP Interface Manual," NTS Document No. 2. Urbana,
        Ill.: Center for Advanced Computation, University of Illinois
        at Urbana-Champaign, 1973. 150 pages.

        A technical description and installation manual for the PDP-11
        to interface designed by the University of Illinois.

Bouknight, Jack, "ANTS Mark I Support System." Urbana, Ill.: Center for
        Advanced Computation, University of Illinois at Urbana-Champaign,
        1974. 65 pages.

        This is a new document which is presently in first-draft form.
        It describes the programs and procedures used to maintain
        ANTS Mark I through network connection to the UCSD B6700.

Grothe, David, "PEESPOL: A Metaprogramming Language for Operating Systems."
        Urbana, Ill.: Center for Advanced Computation, University of
        Illinois at Urbana-Champaign, 1974. 17 pages.

        A technical paper describing the metalanguage facilities of
        PEESPOL.

Grothe, David, "PEESPOL Reference Manual," NTS Document No. 5. Urbana,
        Ill.: Center for Advanced Computation, University of Illinois
        at Urbana-Champaign, 1973. 164 pages.

        This is the definitive statement of the PEESPOL language. The
        entire language syntax is specified in BNF, with prose descrip-
        tions of semantics. It is not intended as an introduction to
        the language. This document will be revised shortly to expand
        the number of illustrative figures, particularly in the
        appendices. Efforts will be undertaken to provide an alpha-
        betized index of the BNF for easy reference purposes.

Kelley, Karl, "ANTS Mark II System Description." Urbana, Ill.: Center
        for Advanced Computation, University of Illinois at Urbana-
        Champaign, 1974. 60 pages.

        This new document is presently in first draft form. The
        early chapters give an overview of the ANTS Mark II system.
        Later chapters will provide increasingly detailed descriptions
        of major elements of the ANTS code.

Kelley, Karl, "Plan for Documentation of ANTS." Urbana, Ill.: Center
        for Advanced Computation, University of Illinois at Urbana-
        Champaign, 1974. 15 pages.

        This is a new and temporary document used for planning purposes
        only.

Network Terminal System Group, "ANTS Mark I User Guide," NTS Document
        No. 6. Urbana, Ill.: Center for Advanced Computation, Univer-
        sity of Illinois at Urbana-Champaign, 1974. 55 pages.

        This is a new document, created from the outdated "Getting
        Started on the ARPANET   It will be distributed shortly to
        all Mark I users. A limited set of examples will be expanded
        in future revisions.

Network Terminal System Group, "Network User's Handbook," NTS Document
        No. 3. Urbana, Ill.: Center for Advanced Computation,
        University of Illinois at Urbana-Champaign, 1973. 150 pages.

        A handbook designed primarily for use at Illinois, this document
        describes the user interface to ANTS, and introduces various
        user sites on the network. The document is intended primarily
        for ANTS users at the University of Illinois. It is in need of
        revision for reasons of outdated personnel information and
        changes to ANTS MARK I.

Sher, M. S., "A Case Study in Networking," NTS Document No. 4. Urbana,
        Ill.: Center for Advanced Computation, University of Illinois
        at Urbana-Champaign, 1973. 18 pages.

        An article first published in the Fall 1973 issue of the EDUCOM
        Bulletin and later revised for publication in the March 1974
        issue of Datamation. It describes the experience at Illinois
        of moving from a local B6700 operation to almost total dependency
        on ARPANET service sites.

Sher, M. S., "Retail Outlets for Network Computer Services," NTS Document
        No. 7. Urbana, Ill.: Center for Advanced Computation, Univer-
        sity of Illinois at Urbana-Champaign, 1974. 14 pages.

        An invited paper presented at the AAAS symposium, "Organizing
        Computer Networks for Science," San Francisco, February 26, 1974.

ADMINISTRATION AND FISCAL STATUS

A. Fiscal Status

        Actual expenditures through 31 March 1974: $ 316,826

        Expenditures for the six month period covered in this report

(1 October 1973 - 31 March 1974):

October	$	44,692
November		45,706
December		52,914
January		45,845
February		54,386
March		71,508
	$	315,051
Obligations remaining:	$	163,038

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        ment," CAC Document No. 115. Urbana, Illinois: Center for
        Advanced Computation, University of Illinois at Urbana-
        Champaign, April 1974.

Belford, Geneva, "Some Experiments in LaPlace Transform Inversion,"
        CAC Technical Memo No. 22. Urbana, Illinois: Center for
        Advanced Computation, University of Illinois at Urbana-
        Champaign, April 1974.

Belford, Geneva G., and John F. Burkhalter, "A Differential Correction
        Algorithm for Exponential Curve Fitting," CAC Document No. 92.
        Urbana, Illinois: Center for Advanced Computation, University
        of Illinois at Urbana-Champaign, November 1973.

Belford, Geneva, R. Jonathan Lermit, George Purdy, and Ahmed H. Sameh,
        "Computational Mathematics Abstracts," CAC Document No. 90.
        Urbana, Illinois: Center for Advanced Computation, University
        of Illinois at Urbana-Champaign, November 1973.

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        April 1, 1973 - September 30, 1973," CAC Document No. 93.
        Urbana, Illinois: Center for Advanced Computation, University
        of Illinois at Urbana-Champaign, October 1973.

Chang, Chang-Chung, "An Algorithm for the Symmetric Generalized Eigen-
        value Problem for $Ax = \lambda Bx$," CAC Document No. 110. Urbana,
        Illinois: Center for Advanced Computation, University of
        Illinois at Urbana-Champaign, February 1974.

Huang, Hui-Ming, "A Parallel Algorithm for Symmetric Tridiagonal Eigen-
        value Problems," CAC Document No. 109. Urbana, Illinois:
        Center for Advanced Computation, University of Illinois at
        Urbana-Champaign, February 1974.

Lermit, R. Jonathan, "Numerical Methods for the Identification of
        Differential Equations," CAC Document No. 86. Urbana,
        Illinois: Center for Advanced Computation, University of
        Illinois at Urbana-Champaign, October 1973.

McDaniel, Lawrence M., "Mathematical Software and Computer Networks,"
        CAC Document No. 94. Urbana, Illinois: Center for Advanced
        Computation, University of Illinois at Urbana-Champaign,
        October 1973.

Ray, Robert M., and John Thomas, "ILLIAC IV Execution Times for Two
        ERTS-1 Data Interpretation Algorithms," CAC Technical Memo
        No. 13. Urbana, Illinois: Center for Advanced Computation,
        University of Illinois at Urbana-Champaign, September 1973.

Ray, Robert M., "ILLIAC IV Multispectral Image Processing Research,"
        CAC Document No. 112. Urbana, Illinois: Center for Advanced
        Computation, University of Illinois at Urbana-Champaign,
        March 1974.

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        mediate Eigenvalues of Symmetric Sparse Matrices," CAC
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        Computation, University of Illinois at Urbana-Champaign,
        October 1973.

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        CAC Technical Memo No. 17. Urbana, Illinois: Center for
        Advanced Computation, University of Illinois at Urbana-
        Champaign, March 1974.

Thomas, John, "An ILLIAC IV Algorithm for Statistical Classification
        of ERTS-1 Imagery," CAC Technical Memo No. 18. Urbana,
        Illinois: Center for Advanced Computation, University of
        Illinois at Urbana-Champaign, March 1974.

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A. H. Sameh, advisor. May 1974.

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advisor. January 1974.

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER CAC Document No. 119	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Semiannual Technical Report of the Center for Advanced Computation October 1, 1973 - March 31, 1974		5. TYPE OF REPORT & PERIOD COVERED Research Report
		6. PERFORMING ORG. REPORT NUMBER CAC-119
7. AUTHOR(s) Center for Advanced Computation		8. CONTRACT OR GRANT NUMBER(s) DAHC04-72-C-0001
9. PERFORMING ORGANIZATION NAME AND ADDRESS Center for Advanced Computation University of Illinois at Urbana-Champaign Urbana, Illinois 61801		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS ARPA Order No. 1899
11. CONTROLLING OFFICE NAME AND ADDRESS Advanced Research Projects Agency 1400 Wilson Boulevard Arlington, Virginia		12. REPORT DATE May 1, 1974
		13. NUMBER OF PAGES 25
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) U. S. Army Research Office Duke Station Durham, North Carolina		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Copies may be requested from the address given in (9) above.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

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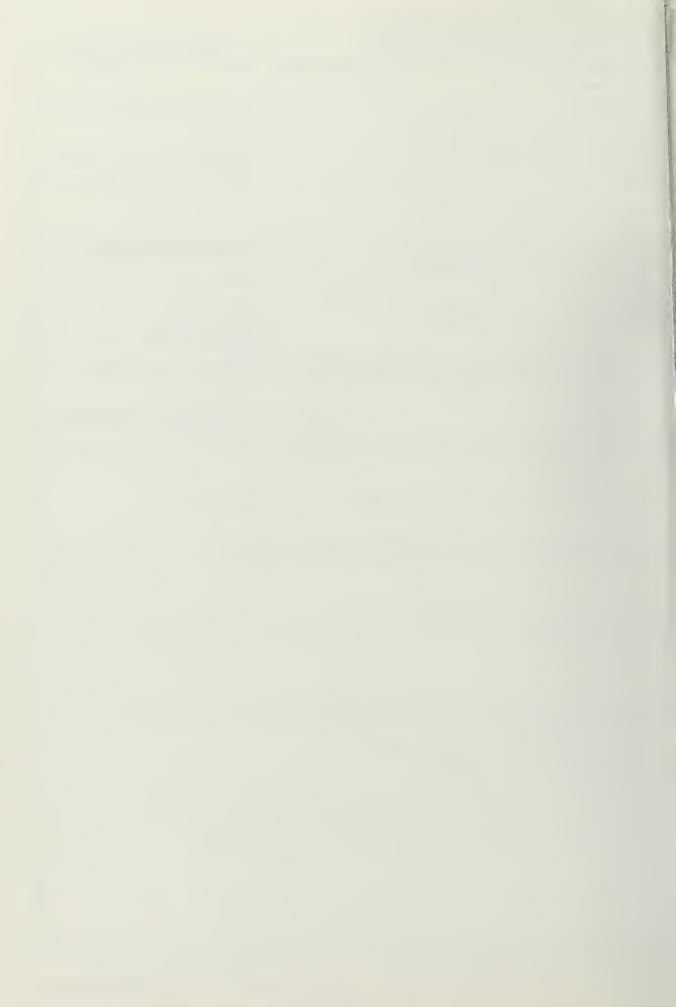
18. SUPPLEMENTARY NOTES

None

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Applied mathematics
Pictorial pattern information processing
Distributed computer systems
Network terminal systems

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

See the Report Summary on page 1 within the report itself.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Abstracts

This is a progress report on ARPA contract DAHC04-72-C-0001, entitled, "ILLIAC IV Applications Research at the Center for Advanced Computation, University of Illinois at Urbana-Champaign." During this period there was research in the following areas: (1) Applied mathematics, (2) Pictorial pattern information processing, (3) Distributed computer systems, and (4) Network terminal systems.

Key Words and Document Analysis.   17a. Descriptors

Applied mathematics
Pictorial pattern information processing
Distributed computer systems
Network terminal systems

7b. Identifiers/Open-Ended Terms

7c. COSATI Field/Group