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ABSTRACT

Functions of the Center for Computer Sciences and Technology (CCST), a national center for computer research and development for the United States government, are described. CCST provides computer and related services to the National Bureau of Standards of which it is a part and to other government agencies on a cost-reimbursable basis. The Office of Computer Information, within the CCST, has developed an information management system, classifies computer information by concept, and provides an information service on computers and their applications. The Center has set up standards for federal information processing and provides consultation, technical assistance, and advisory services to other government agencies concerning laboratory automation, automated accounting, remote computer graphics, and specialized input/output equipment. Research and development have been initated on performance measurement of remote access computer systems, teletypewriter terminal design, a pharmacological information system, communications network planning, a data definition language, and interactive programing. (JK)

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CENTER FOR

Computer Sciences & Technology

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards

CENTER FOR COMPUTER SCIENCES AND TECHNOLOGY

The quarter century since the advent of the electronic computer saw the National Bureau of Standards as a leader in the early development of what is now the fastest growing technology in the world. The Bureau's program in this field, greatly expanded since the forties when early NBS research on computers was a partial function of the Ordnance Development Division and the National Applied Mathematics Laboratories, today is carried on by the Center for Computer Sciences and Technology (CCST) under a Congressional mandate embodied in the 1965 Brooks Bill (Public Law 89–306). This law and supporting policy guidance from the Bureau of the Budget assign to NBS the responsibility for:

(1) providing guidance in the promulgation of hardware and software standards, both for industry-wide voluntary standards and Federal standards,
(2) providing other government agencies with technical assistance and consultation in both hardware and software areas for the efficient use of computers,
(3) promoting training in various areas of computer applications,
(4) providing information services related to computer technology,
(5) providing computer services—involving the use of both equipment and programming—to NBS and to other government agencies, and
(6) engaging in exploratory research.

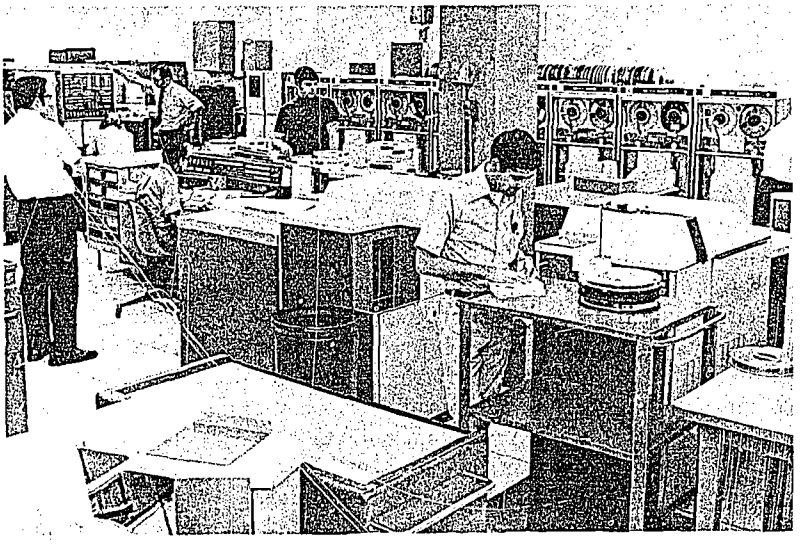
The CCST is a national center for research and development for the Government in the broad fields of computer sciences and technology. It employs a professional staff of about 150 people, consisting of mathematicians, engineers, chemists, physicists, operations research analysts, computer systems analysts, computer systems administrators, physical science administrators, and others. The work of the CCST interfaces with and is supported by the work of various other groups within the Bureau, within other agencies of the Federal Government, and within the affected organizations of the technical community outside government, such as the American National Standards Institute.

The technical work of CCST is carried out in the Office of the Center's Director, two special mission-oriented offices, and three technical divisions.

COMPUTER SERVICES

As part of its basic program, the Center operates a computer service that provides computer and related services to NBS and other government agencies on a cost-reimbursable basis. Primary emphasis is placed both on support of scientific, experimental and developmental applications and on assistance during the development and early implementation of systems that the user anticipates converting to his own computer within a specific period. Access to the main computer system, an intercoupled UNIVAC 1108/418, is provided to both on-site users and those at remote terminals connected via telephone lines.

An illustrative example is the assistance to the Economic Development Administration, which began using the NBS facility from a remote terminal in the summer of 1967 and, as planned, converted to its own computer in January 1970. This assistance permitted the orderly development of a broad economic data base and information-handling techniques at a minimum cost. Terminals at U.S. Forest Service offices in Washington, D.C., Atlanta, Milwaukee, Denver, and Albuquerque were connected to the system, enabling the Forest Service to experiment with centralized road design computations and collaborative development of new design techniques. At the same time, a saving was achieved by the Forest Service by not having to acquire additional computer equipment to support the decentralized operations.



The Bureau's computer facility works three shifts a day processing data for scientists and administrators of NBS and other government agencies.

Cost/benefit analyses obtained from experimentation with various terminal equipments and various communication facilities were used in selecting equipment and facilities. This resulted in a saving of $1200 per terminal and a performance improvement of 12 to 25 percent over leased devices. Adjustments and modifications to the operating software have resulted in increased operational efficiencies and have provided the experience necessary for evolving a fully modernized multiaccess, multiprocessor computer. Conversion from contractor to in-house maintenance of the 1108 system has improved the overall stability and responsiveness of the Bureau's computer system to user requirements.

User Communications—The Computer Services Division trys to keep users up-to-date on technical matters affecting computer utilization. The system itself is used to (1) print notices of current interest at the end of each printed output; (2) produce a comprehensive user's manual and maintain an up-to-date version in on-line mass storage, and (3) maintain a list of known software bugs and tips on how to avoid them. In addition, frequent newsletters are issued containing technical information and advance notice of proposed system changes, enabling users whose programs are affected to plan accordingly. Occasional seminars presented by the systems staff serve to pass along "tricks of the trade," stimulating users to think about more efficient ways of using the system. These communications are aimed both at better service to the users and at freeing systems programmers for more effective use by reducing demands for one-to-one user counseling.

COMPUTER INFORMATION

Office of Computer Information (OCI) has been set up in the Center to serve as a specialized information center in the computer field. It functions in several ways:

Developing an Information Management System—An information management system known as CHAOTIC (Computer and Human-Assisted Organization of a Technical Information Center) provides two significant outputs: an archival magnetic tape file of information describing each item of computer information which can be used for retrospective search in a batch-processing mode or eventually in an on-line interactive mode, and a magnetic tape file from which a set of indexes is produced for immediate use as search tools. The latter include KWIC (Key Word In Context) and KWOT (Key Word Out of Title) indexes, personal and corporate author indexes, subject category listings, and a master bibliographic list.

Classifying Computer Information—Participants representing government, industry, and the academic community developed a concept-oriented classification scheme for computer program documentation,

to be used by programmers and patent searchers. The outgrowth of this work is a computer-based classification system, programmed in COBOL, known as CAIC (Computer-Assisted Indexing and Classification), based on a statistical word association approach.

Information Service—Information was provided in response to requests from government, industry, the academic community, and international organizations on the following topics: NBS reports, availability of computer programs, identification reports on official guidelines or procurement policy for ADP systems, reference material on various types of ADP equipment, American literature on cost/benefit analysis, reference materials on the computer and microfilm applications, technical aspects of data banks and data communications, standards for tape format for information interchange, ADP glossary, use of EDP in security portfolio and stock market analysis, and classification schemes for computer information. Bibliographies were prepared on: computerized numerical control, litigation and computers, optical character recognition printing, and social implications of computers.

The first three volumes of a series of studies in research and development requirements in the computer and information sciences were issued, and NBS Monograph No. 91 was reissued with additions.

STANDARDS

FIPS PUBS—Ten Federal Information Processing Standards (FIPS PUBS) have been published, the last three during fiscal 1970. The ten are: FIPS PUB 0—General Description of the Federal Information Processing Standards Register; FIPS PUB 1—Code for Information Interchange; FIPS PUB 2—Perforated Tape Code for Information Interchange; FIPS PUB 3—Recorded Magnetic Tape for Information Interchange (800 CPI, NRZI); FIPS PUB 4—Calendar Date; FIPS PUB 5—States of the United States; FIPS PUB 6—Counties of the States of the United States; FIPS PUB 7—Implementation of the Code for Information Interchange and Related Media Standards; FIPS PUB 8—Metropolitan Statistical Areas; and FIPS PUB 9—Congressional Districts of the United States.

Six proposed Federal Information Processing Standards have been forwarded to the Office of Management and Budget for adoption and approval. These include standards for:

a. Bit Sequencing of the Code for Information Interchange in Serial-by-Bit Data Transmission
b. Character Structure and Character Parity Sense in Parallel-by-Bit Data Communication in the Code for Information Interchange
c. Character Structure and Character Parity Sense for Serial-by-Bit Communication in the Code for Information Interchange

d. Hollerith Punched Card Code
e. Rectangular Holes in 12-Row Punched Cards
f. Subsets of the Standard Code for Information Interchange.

In addition, the following proposed Federal Information Processing Standards are in the process of coordination with the Federal Departments and Agencies:

a. Interface Between Data Terminal Equipment and Data Communication Equipment Employing Serial Binary Data Interchange
b. Interface Between Data Terminal Equipment and Automatic Calling Equipment for Data Communication
c. Layout of Forms for OCR Input
d. Specifications for General Purpose Paper Cards for Information Processing
e. COBOL Programming Language
f. Recorded Magnetic Tape for Information Interchange (200 CPI, NRZI)
g. Recorded Magnetic Tape for Information Interchange (1600 CPI, NRZI)

To assist the Office of Information Processing Standards in deriving requirements and plans for Federal information processing standards development, a new committee, the Federal Information Processing Standards Coordinating and Advisory Committee, was established. Seven task groups have been established, under the sponsorship of this committee, to undertake development work in the following areas:

Task Group 1—Objectives and Requirements for Standards
Task Group 2—Data Terminal and Data Systems Requirements
Task Group 3—Character Sets, Sign Conventions and Packing Techniques
Task Group 4—Subsections on Standards for Use in Requests for Proposals
Task Group 5—Federal Information Processing Vocabulary
Task Group 6—Magnetic Tape and Recorded References
Task Group 7—Magnetic Tape Labels for Information Interchange

The first of several candidate Magnetic Disk Reference Surfaces was delivered to the Office of Information Processing Standards. This is an early step in the establishment of a National Reference Disk Standard.

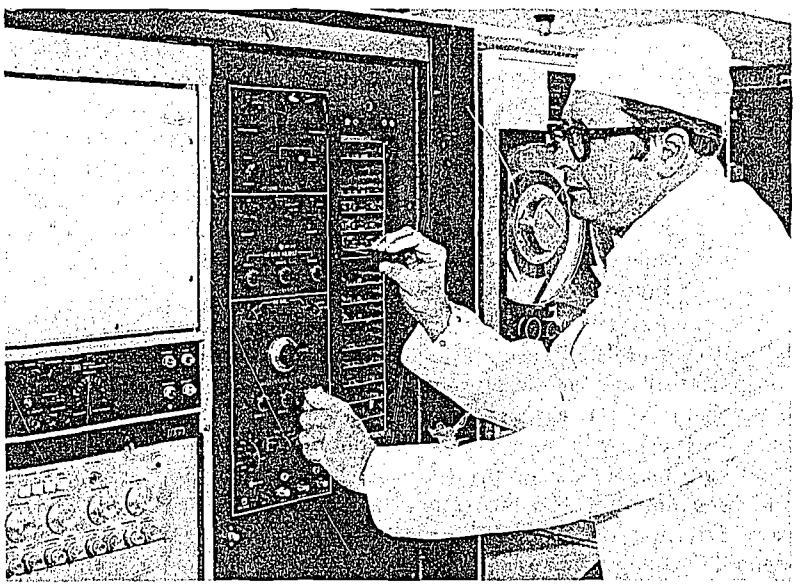
The Office of Information Processing Standards has provided expertise and professional assistance in the development of American National Standards. This has resulted in numerous National Standards being proposed by ANSI over the past year. Many technical meetings of ANSI X3 and X4 groups were hosted by the National Bureau of Standards at its facilities in Gaithersburg.

NBS staff members have contributed to the development of International Recommendations in the area of information processing through ISO Technical Committee 97 and its subcommittees.

Arrangements have been made through the NBS Clearinghouse for Scientific and Technical Publications to have FIPS PUBS made available in microfiche form. In addition, arrangements have been made to provide the long list of data element standards having lists of items recorded in machine-sensible form on magnetic tape and punched cards.

Information pertinent to the Federal information processing standards program appears in a regular monthly column, entitled FIPS Notes, in the NBS Technical News Bulletin.

NBS Standard Reference Magnetic Tape—The CCST is now supplying the Office of Standard Reference Materials with SRM 3200—unrecorded secondary standard magnetic tape, which is now in use by the computer tape and equipment industries nationally and internationally. For the first time these Government-sponsored reference tapes are available to industry for use in evaluating the performance of magnetic computer tapes and maintaining control over their production. This standard tape resulted from research on tape characteristics, in the course of which the performance measurements laboratories had to develop new instrumentation, a tape evaluation system that measures the amplitude of signal pulses read from the tape. This instrumentation is now used in calibrating the standard



Adjusting circuitry that measures the amplitude of pulses recorded on reference magnetic tape in order to calibrate the tape.

tapes and in maintaining the primary and secondary reference tapes held in repository. The prototype instrumentation has been redesigned and a new model fabricated for the General Services Administration's Magnetic Surfaces Laboratory, which is now located at the Bureau's Gaithersburg laboratory complex. Here it is used in performing qualification and acceptance tests in procuring magnetic tape for use with computers in the Federal Government.

TECHNICAL ASSISTANCE AND ADVISORY SERVICES

As a part of its central mission, the Center provides consultation, technical assistance, and advisory services to other government agencies. The services range from brief consultations to such long-range projects as providing technical assistance in the design and development of computer systems, and other-agency sponsored exploratory research.

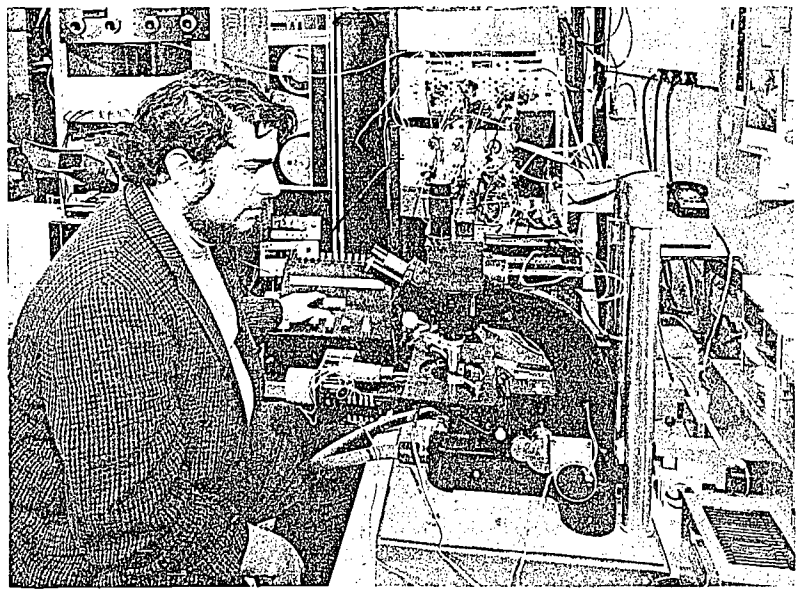
Consulting services have continued to the Lister Hill Center for Biomedical Communications of the National Library of Medicine on problems of optical character recognition, networking, compatibility, and health records. Consultation has been provided to the Patent Office with respect to handling patents for computer programs and in undertaking an experimental computer-assisted patent classification system. The Department of State was advised on the potential use of a large on-line information retrieval system. Assistance was rendered to the U.S. Office of Education in the evaluation of computer-related education research programs. The Department of Housing and Urban Development was assisted in evaluating contract proposals for urban information systems. Consultation was given the Post Office Department on a time-sharing system used to redirect mail to servicemen in Viet Nam whose duty stations have been changed. Other consulting services have been provided to the Department of Commerce, the Agency for International Development, the Department of State, the Department of Justice, and the National Commission for Product Safety.

Laboratory Automation—The CCST continued assistance to NBS laboratories in the design and development of laboratory automation equipment and in the design and programming of systems to accompany them. New instrumentation creates demands for real-time control of experiments, precision in computation, and the processing of masses of data. One such project is concerned with the system design and programming of a laboratory facility for the Analytical Chemistry Division of NBS. The computer is programmed to acquire signals on-line and in real time from several instruments simultaneously and to be responsive to the scientist's requests for service. Applications will include processing environmental sensor data, test-

ing combustion efficiency of auto engines, controlling urban transportation flow, and computing data from electrocardiograms.

NBS data automation scientists have assisted other scientists in setting up data acquisition systems, some using small, dedicated electronic computers. In one such installation at the Bureau, a Hall-effect experiment was connected, via special-purpose hardware, to a time-shared computer. The voltage sequence magnetic flux, and specimen temperature were under control of the remote computer. The interaction between the experiment control and the computer was stylized so that they could communicate as if a human operator were seated at the console.

In another application of data automation, a biological microscope at the National Institutes of Health was fitted with a mechanical stage which could be moved in three dimensions under control of an associated computer. The computer selects the illumination wavelength and intensity, controls the scan, measures light transmission at each point scanned, and writes the data on magnetic tape or sends it via telephone line to a large computer for processing. This system is being used for pattern recognition in identifying blood cells, for autoradiograph scanning, to produce three-dimensional representations of tissue scanned, for microspectrophotometric analyses, and as a design tool in creating new scanning systems.



A computer controls the scan and records data from this microscope.

Automated Accounting System—An automated accounting system has been developed during the past two years for the Agricultural Research Service. The complex multiphase system was originally designed for three terminals in distant cities. Subsequent reorganization modified the original concept and the system is now being completed for a computer in the Agriculture Library, where it will have a centralized input.

The U.S. Army TACFIRE Program—NBS consultants assisted the Army TACFIRE program by participating in monitoring contracts for both hardware and software required in this multiple, real-time computer system.

Remote Computer Graphics—A study of system design and support of remote computer graphics has been completed for the National Aeronautics and Space Administration. This activity included the development of a graphical text editor, which was used at the NBS research facilities to study the performance, in general, of graphical displays connected to time-shared systems by communication lines of limited bandwidth.

Microfilm Reader-Copier—A microfilm reader-copier called the Select-a-Frame has been developed for the National Library of Medicine to provide a rapid means of making automatically original-size prints of frames selected from rolls of microfilm.

RESEARCH AND DEVELOPMENT

Performance Measurement—A study was initiated to measure the performance of remote access computer systems. The computer programs being written will allow the in-house time-sharing research system to be used as a tool in measuring the performance of other time-sharing systems. The output of this work is expected to be useful to those individuals and groups having to select one of several time-sharing systems for remote terminal work.

Teletypewriter Terminal Design—A multiheaded teletypewriter terminal has been designed and constructed for use with in-house CCST programs. This terminal consists of three teletypewriter devices that are mediated by an electronic system to communicate over a single line with the remote computer system. The new terminal will permit simultaneous operation and printout of clean hard copy for later reference. It will also facilitate multiple terminal experiments using only the single line to the computer.

Pharmacological Information System—A computerized pharmacological information system designed with support from the National Institutes of Health is geared to the highly complex needs of drug researchers. Its purpose is to enable a small pharmacological research group having no knowledge of computers to set up its own data file. The system would place emphasis on the portion of the file having

interest to the group and would offer facilities for the drug researchers to query the file and receive answers. A sample file compiled of psychotropic drugs and related compounds includes information on names of compounds, chemical structures, physiological action in humans, and lethal doses of drugs in experimental animals. One major benefit of the system is the potential for rapid screening of large masses of data.

Communications Network Planning—The Defense Communications System controls large, complex switched networks that use the facilities of commercial communications carriers. The Defense Communications Agency (DCA) staff requires methodologies for effective and economical network planning, design, and management in order to reduce the network's susceptibility to large-scale attack, to improve reliability, and to optimize other facets within the constraints of availability, cost, and such factors. The CCST assisted the DCA in developing new methodologies and efficient computer programs, implementing them for application to the planning, design, and management of the Defense Communications System.

Two-Dimensional Graphic Structures—Recent years have seen an increased interest in computer graphics—both the entry of graphical data into a computer and in the computer generation of graphic displays for human viewing. Although there has been progress in hardware for graphic processing, the field remains in its infancy. One reason is the difficulty of processing or describing a graph in terms other than an assemblage of points and lines. Research is being conducted into the linguistics of two-dimensional graphic structures—the nature of relationships among elements, ways of determining well-formedness, and ways of translating between two- and one-dimensional representations. The areas of immediate interest are Chinese characters and molecular diagrams.

Data Definition Language—Work was begun on developing a data definition language (DDL) that will permit any data file to be described and the description interpreted by a programming language compiler. Such a DDL would promote the interchange of data and programs from one computer system or from one installation to another. The eventual goal is to incorporate the DDL into a system that can translate data files, structurally revising them to effect their movement from computer system to computer system.

Interactive Programming—An experiment is being conducted in the design of a computer program for interactive use by a program designer for producing other computer programs. The program with which the designer works is called a "generator program." Generators have their principal use in such applications as computer-assisted instruction, or in writing interrogation programs that might, for example, be used to elicit a medical history from a patient. Special-

ists in computer-related areas can relieve others of the need to specialize by making it less difficult and costly to write interactive computer programs and by improving the conversational fluency of such programs. Thus, a program generator might produce only true/false or multiple-choice computer-assisted instruction programs, with a systems programmer creating a generator which would then be used by a teacher or course author to produce the actual courses.

TRAINING

The Center attempts to maintain awareness in the profession of recent technical developments in electronic data processing. To this end, a course was sponsored in conjunction with the Personnel Division; it was called "Advanced Concept and Principle of Third Generation Computer Services."

Training has also been supplied at the Center to foreign nationals, under sponsorship of the Agency for International Development.

CONFERENCES AND SYMPOSIA

The Center conducts a colloquium series with the primary objective of fostering discussion on various aspects of computer applications, such as problems, policies, long-range plans, and new product developments. Half of the speakers come from industry and half from Government. The audience is restricted to seventy-five people in order to obtain highly responsive audiences.

On April 27 and 28, 1970, NBS hosted the ACM First Workshop on Terminals and Communications, sponsored by the Association for Computing Machinery.

The Workshop was attended by about 150 representatives, drawn largely from the terminal, computer, and communications industries and from Government. Presentations covered principles of basic data movement, standardization work in progress worldwide, the economic value of standardization, communication systems performance, control procedures, live discipline and protocol, networks, keyboards, cathode ray tube display terminals, interactive interfaces, and programming for communications processors.

Representatives from the Center participated with major ADP policy-making officials in Government and industry management at a conference held in Charlottesville, Virginia, September 15-17, to examine the impact of developments on the Government's policies and practices for selecting, procuring, and managing computer systems.

In December 1969 the Center cosponsored a conference for 450 registrants on image storage and transmission systems for libraries; the other sponsors were the Federal Library Committee's Task Force

on Automation, the Lister Hill National Center for Biomedical Communications, and the Panel on Information Science and Technology of the Committee on Science and Technology. Members of the Center also participated in Federal Library Committee task forces, including those for: (1) compilation of descriptions of mechanized information systems in Government agencies, (2) revision of the COSATI-sponsored standard for microfiche, (3) study of the status of automation activities in the Federal library community, and (4) preparation of a definitive report on the impact of information sciences technology on the economy and on policy implications.

Several members of the CCST are chairmen of active professional committees, such as the Special Interest Group on Computer Systems Installation Management of the ACM; they have chaired meetings and panel discussions at national conferences in addition to presenting papers at conferences. Several members of the Center's staff serve on important policy-making committees in the profession, both nationally and internationally, in connection with standards activities and with other functions in the data processing field.

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