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Data Telecommunications at the CSCF*

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Abstract

At Brookhaven National Laboratory (BNL), data telecommunication for remote job entry, interactive time sharing, networking, graphics and special purpose links have become increasingly important, rivaling the more traditional over-the-counter traffic. The BNL Central Scientific Computing Facility (CSCF) has responded to this need with a number of developments. The latest and most comprehensive of these is a "front-end" communications system built around MODCOMP II computers.

To put this project into its proper framework, some historical background is presented describing predecessor systems, the development of specifications, and the factors considered in the decision to turn to MODCOMP.

The hardware is based around dual MODCOMP II-233 processors with a specially developed link to the larger CSCF machines, two Control Data 6600 computers and one CDC 7600. The MODCOMP software is based upon an existing system developed by Chrysler Corporation, running under MAXCOM. On the Control Data side Scope 3.4/INTERCOM 4 is used as a basis. The developments and modifications, both hardware and software, necessary for these components to meet Brookhaven's specifications are described.

Certain related special purpose data link applications are described. Among them is a research project in national resource sharing networks using ARPANET, and a connection to the National Weather Service machines in Suitland, Maryland, using the bit-oriented protocol ADCCP. Future goals are briefly presented.

Preface

In the past twelve years, digital communication with computers over telephone lines has been transformed from a computer science research topic into a mandatory facility of a general purpose computing center. At Brookhaven National Laboratory, data telecommunication for remote job entry, interactive time sharing, networking, graphics, and special purpose links rivals over-the-counter traffic and, at its current rate of growth, will quickly surpass it for both program and data submission. During this period the Central Scientific Computing Facility has responded to this need with several developments. The latest and most comprehensive of these is the so called MODCOMP project described herein.

In attempting to put this project into its proper framework, it was necessary to give some historical background and to describe certain related developments. The work being reported represents the labors of many individuals, with the author acting as a chronicler of these activities. It is hoped that the bibliographic references and acknowledgements begin to assign proper credit to those other individuals whose work is cited.

The primary purpose of this report is to inform the users of the CSCF and the MODCOMP users' group (MUSE) membership of the CSCF plans for data telecommunications.

Historical Perspective

The BNL Central Scientific Computing Facility (CSCF) has, since its inception, provided general purpose computing to its community of users through traditional over-the-counter service. In the mid 1960's, Brookhaven began to experiment with remote access to computers, as did several other scientific installations. The first such system to become operational at the CSCF was the Brookhaven On-line Computer Network, or Brooknet. (1,2,3)

The Brooknet system provides a data link between the CSCF and a variety of computers using underground coaxial cables. It was originally foreseen as a means for fast, direct, data transmission between the CSCF and experimental areas for quick, on-line data analysis. Its capabilities were exploited, however, for another purpose as well, remote input-output of ordinary jobs. Once the need for purely remote batch terminals became clear, the Applied Mathematics Department designed a standard station consisting of a card reader, printer, minicomputer and associated electronics and code. Several other departments acquired this gear and a primitive remote batch service was established.

In retrospect, it can be seen that remote access experiments at similar scientific installations were to have an even greater impact on the CSCF. These include the FOCUS system developed at CERN and adapted for BNL, the Courant Institute Import/Export system which was to be incorporated into the Control Data Corp. product line, and the interactive time sharing experiments going on at several universities and commercial establishments.

FOCUS was a multiple-access file-handling system previously developed by the CERN Data Handling Division. (4) It was adapted for use for the CSCF, centered around a Control Data 3200 computer acquired for that purpose. Initially its capabilities were only in the area of low speed (10 and 30 cps) file manipulation over telephone or dedicated lines, first from eight, and then expanded to 16 terminals. Users identified to the system by name and account number could create, delete, modify, store and reference souce or binary files. They could also send files to the 6600 input queues (to which the 3200 was connected via a Brooknet link) and similarly retrieve the output. Later, under the joint auspices of an NSF grant and AEC funding, personnel at the BNL Applied Mathematics and Chemistry departments added remote batch capability on an experimental basis for a crystallographic data network called Crysnet. (5) The protocol implemented was CDC 200 UT and two 2000 baud lines were supported. FOCUS service was terminated in 1975 with the installation of a new configuration, based upon a Control Data product called Intercom.

Brookhaven took delivery of this new configuration, which represented a substantial upgrade of the CSCF, in October of 1974. The major item of equipment was a CDC 7600 processor, with the two existing 6600 computers assuming the role of "front-ends" to the large machine. As such, the 6600's were upgraded to double the previous number of peripheral processors and channels and one of the machines received more central memory. Among the other items of equipment were Control Data 7077/791 local communications controllers. The software installed was Scope 2.1 (for the 7600)/Scope 3.4 (for the 6000's). The software product for supporting remote access was called Intercom 4. (6)

The Intercom system is comprised of a terminal communications system supporting several protocols, a set of interactive commands, a text editor, and interactive capability for several high level languages, and a remote batch subsystem. Selection of different versions and options enables it to drive a choice of CDC data communications controllers, among them the 7077/791 hardware commonly known collectively as LCC's. (7,8) This hardware configuration actually consists of one or more of model 7077 Communications Stations, to which one or more model 791 Communications Subsystems Controllers may be connected. The 791 is a programmable device into which model 792 Data Set Adapters are plugged, one for each telecommunications line.

While the Intercom/LCC aggregate was intended to be a fairly sophisticated system, its performance at BNL has been disappointing. The LCC hardware suffered a very short product lifetime with Control Data, hence hardware and software support for it has been poor. Reliability of this system has been poor from the outset and it has inordinately affected the stability of its environment. Ironically, during its tenure as the primary remote access system of the CSCF, remote batch and interactive processing emerged as an important aspect of the computing service to Brookhaven, thus taxing an overburdened system, increasing the visibility of the problems, and frustrating the users.

Eventually, the hardware and software maintenance personnel were able to address themselves to the arduous task of systematically identifying and solving as many of the problems as possible. In parallel with that effort, longer range questions were asked in an attempt to identify the chronic shortcomings of the system and propose some solutions. These informal studies consisted of gathering statistical evidence of the lack of reliability, measuring the traffic requirements using standard performance evaluation techniques, and surveying both the commercial sector and similar computing installations to find suitable alternatives. (9) The result of these initial deliberations was a proposal to complement the configuration through the lease of a more reliable but less capable system for the short term, and to look forward in the long run to a product capable of replacing the existing hardware with additional much needed features. (10)

The short range expedient is the COPE 65 communications controller system, which was installed at BNL in the Spring of 1977. This controller, marketed by the Harris Corporation, is a mature product of limited capability but long proven reliability as demonstrated at many other installations, including several very much like the CSCF. It supports the 200 UT remote batch protocol among others, for up to 20 synchronous lines, thus taking a considerable load off the LCC's, and improving their performance in the process. Because it doesn't use the Intercom software but rather has its own compact routines, it was able to be installed on the smaller of the two 6600's, thus bringing the total system into better balance.

Figure 1 summarizes the growth of both remote batch and interactive support for the years from 1969, when Brooknet began to be used for this purpose, through 1977 by plotting "snapshot" tallies for the intervening years. Projections are also given for the year 1979, based upon the existence of a new system described in the following section, and taking note of the user community's rapidly growing need for more and better remote access capabilities.

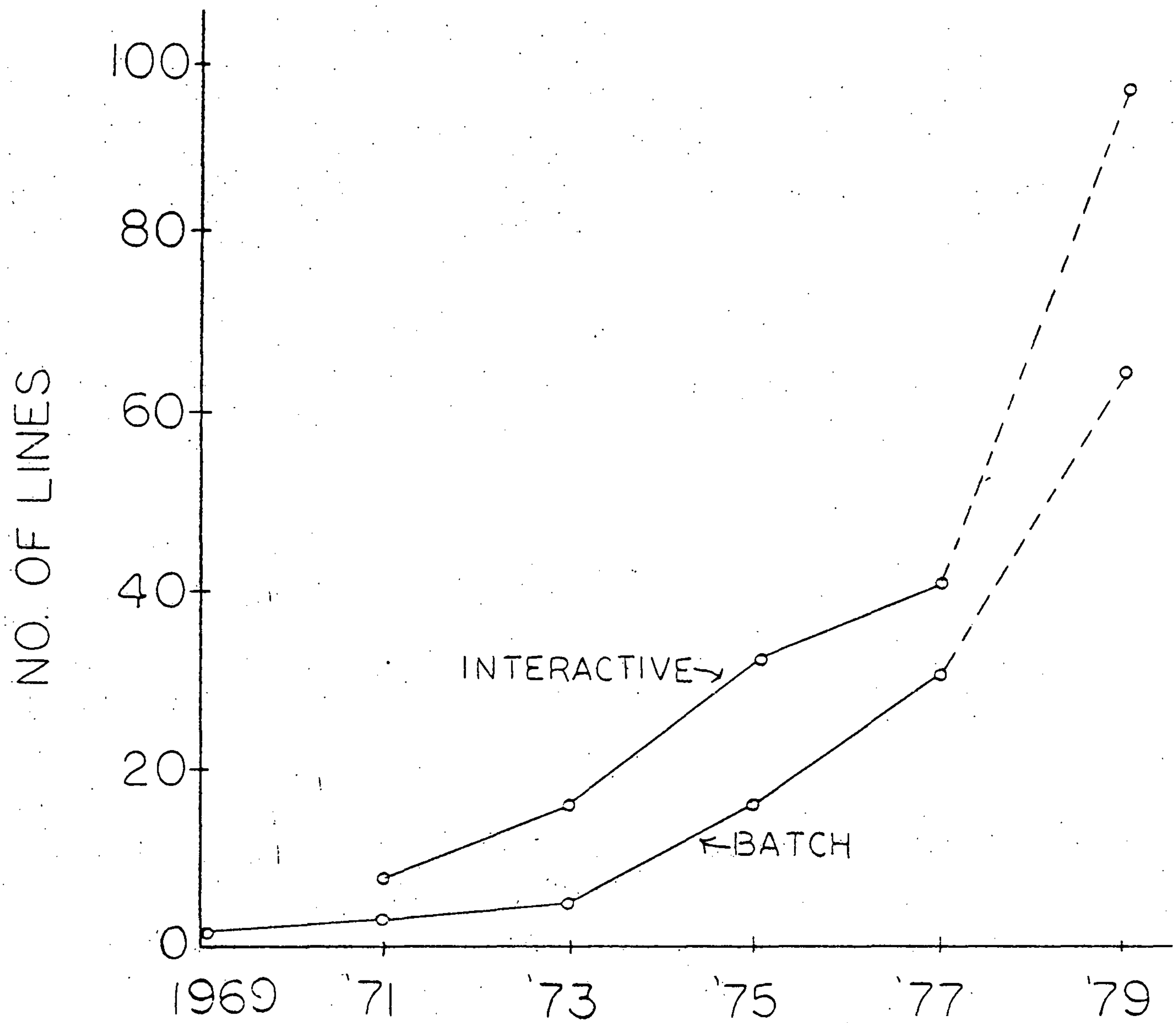

FIGURE 1:

GROWTH TRENDS FOR CSCF REMOTE ACCESS
1969 - 1979

The MODCOMP Project

In order to implement the longer term solution, a set of long range BNL data communications requirements was drafted. The latest revision of this draft, which has since become the project specification, appears in Appendix A. This specification was attached to a "price and return" proposal request emanating from the laboratory Purchasing Division. This package was sent to all known vendors of such gear. Responses were received from three vendors - Control Data Corporation, Harris Corporation, and a joint proposal from Software and Communications Concepts, Inc. and Modular Computer Corporation.

A short summary of these responses was given in a previously cited study which also reviewed in detail the current problems, the corrective work to that point, and made certain recommendations for the future. (10) One result was that the Chairman of the Appled Mathematics Department appointed a committee to evaluate the vendor responses and other alternatives. The committee met several times, both in closed session and with the vendors and reported back to the Chairman and Head of the Computer Service Division in March of 1977. This report appears as Appendix B.

Both the CDC and MODCOMP-SCC proposals were found to be marginally adequate. In the end, it was felt that a hybrid approach, using MODCOMP hardware, certain vendor supplied host software, and an in-house implementation project would be the most cost effective and responsive approach to meet the needs of the CSCF. A phased implementation would be undertaken whereby in phase 1, a COPE like system would result, thus insuring that the Harris-COPE short term expedient need not become a permanent part of the center. Phase 2 would provide the interactive capability that would allow for complete replacement of the LCC's. It was recognized that there were other installations which had developed similar systems, and part of the project would be to ascertain the availability and suitability of those developments. Hence, the hybrid approach was recommended and accepted.

Of the similar systems developed for other installations, one was found to be available to the laboratory, suitable in scope, similar in environment, and judged to be an excellent basis from which to work. This was the Chrysler Corporation Communications Facility. (11) This system uses a dual processor MODCOMP II configuration which interfaces to dual CDC Cyber 70 computers and the Intercom IV time sharing system. The Cyber-front end handlers are slight variants on the standard CDC products with improvements primarily in the areas of buffer handling. Because MODCOMP II processors are much more capable than the analogous CDC products, the Chrysler front-end machines are given a larger role, and can thus operate more independently and more reliably. A new PP driver had been written for the MODCOMP and extensive codes were written in the front end under MAXCOM, an operating system specifically designed for data communication, but there were few changes in any other software products. The synchronous 200 UT terminal handling was designed around a MODCOMP driver already in MAXCOM.

Given the availability of this working system, the goal of the first phase was expanded. It now was to include all necessary modifications to use the relevant parts of the Chrysler package concurrently with the LCC's. These modifications were in large part due to unavoidable equipment and configuration differences in both the CDC and MODCOMP hardware. Diagnostics were to be written to improve the maintainability. The result would be a phase 1 product which could do considerably more than replace COPE, having both batch and interactive capability.

The initial operational hardware configuration as ordered appears in Figure 2. It consists of a symmetric dual processor configuration connected to the dual 6600 computers of the CSCF. The processors are MODCOMP II - 233 mainframes with 64 Kilowords of storage each. They are each connected to a model 5215 dynamic peripheral switch which controls a card reader, printer and two 5.2 megabyte disks. Each processor also has a 4903 I/O coupler with separate access paths to the data communications equipment. These consist of four dual-access 1930-7 programmable communications controllers, each of which can accommodate up to 32 lines. The configuration will initially support 48 synchronous and 64 asynchronous lines. There is in this configuration expansion capability to add additional 1930's and line adapters, larger disks, and other I/O. The limiting factor for line support is likely to be MODCOMP central memory which contains individual line buffers, and which is at its hardware limit.

One major consideration in the configuration is to exploit its symmetry by providing switchable paths whenever possible. With dual 6600 and MODCOMP processors and dual access MODCOMP I/O and communications controllers, it was also decided to provide multiple access paths from each MODCOMP II to both 6600's. The commercial equipment needed to do this (particularly CDC 6681 couplers and MAC switch) are inordinately expensive and of outdated design. Hence, it was decided to design and fabricate a coupler for the project which was logically and operationally equivalent to that configuration to maintain as much as possible compatability with existing drivers, yet, whose internals and capabilities are far different. The device connects the MODCOMP 1941 coupler to one or two 6600 I/O channels. Most of the 6600 functions for this device are equivalent to 6681 functions. The coupler uses the MODE II connect option for communicating to the 1941. Coupler details are given elsewhere. (12)

A partial configuration suitable only for program development and some checkout was ordered first and delivered in October of 1977. It consisted of a single MODCOMP II-233 with 32 kilowords of storage, card reader and printer, one disk, one 1941 coupler and a single communications controller populated to support only a few lines. Connection to the 6600 is effected through the 1941 using an existing 6681.

In terms of implementing the first phase, installation of the Chrysler system on the Brookhaven configuration so that it could replace COPE and

MODCOMP CONFIGURATION

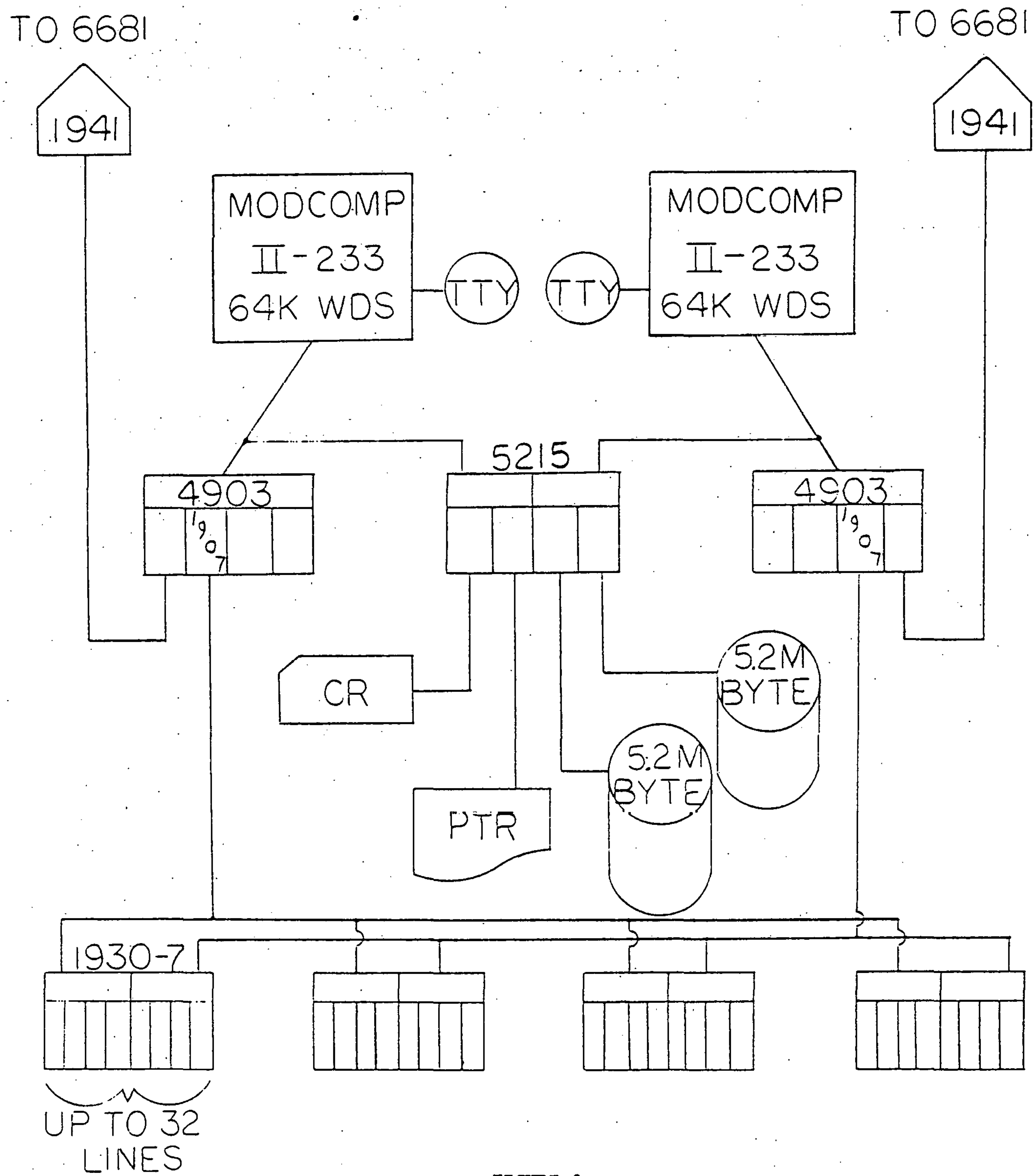

FIGURE 2

complement or perhaps even replace the LCC's, four specific tasks were to be accomplished.

1) the hardware connection to at least one 6600

2) development of a suitable diagnostic capability

3) MODCOMP end modifications to handle equipment differences between the Chrysler and BNL hardware

4) Addressing of compatability and LCC coexistence problems in SCOPE 3.4/ INTERCOM IV.

The hardware connection is previously discussed. As for the diagnostics, stand-alone MODCOMP routines needed to be tested and adapted, a set of coupler link routines had to be written, and a mechanism for down-loading and triggering MODCOMP diagnostics from the 6000 was investigated. In order to create an acceptable diagnostic environment for hardware maintenance personnel, the handling of these routines was required to be as similar to existing packages and procedures as possible. This meant, among other things, that the coupler routines be run within the Control Data SMM diagnostic system. (13)

MODCOMP side modifications stem primarily from two hardware differences. The 1930 series of communication gear replaces the older 1920 series which is no longer available. The 5215 I/O switch is more versatile than its predecessor in the 4000 series. There were not expected to be any significant modifications due to the disk or 6000 link differences.

On the 6000 side, installation involves minimal modifications to INTERCOM, particularly 0ZZ and 1ZZ. More extensive are the modifications to certain areas of SCOPE. Dead start recovery, creation of DSD displays for this hardware, CMR modifications for MODCOMP tables and pointers are the most affected areas. Finally, the stand-alone routines provided by Chrysler, including the driver, autoload and dump, and a simulator package need be installed. Problems occur in DSD and CMR, both due primarily to space problems. (14)

Looking ahead to phase 2, the specification of Appendix A is the ultimate goal. In pursuit of this the following must be addressed:

1) expansion of number of lines

2) accommodation of the next version of the Control Data data telecommunications product

3) support of a richer repertory of protocols

4) special terminal handling

5) in-production diagnostics

6) fault tolerance

7) connection to both 6600's with user specification of mainframes

8) user specified ASCII/BCD.

With respect to point 2, there are indications that the next generation CDC product, tentatively termed INTERCOM V, will be based on a special product developed for Mobil Oil and included in the price and return bid proposed to BNL.

There are two prime candidates for additional protocols. It is felt that both an existing IBM protocol and a new bit-oriented protocol would be most useful. IBM Bisync, having been addressed both by CDC and MODCOMP MAXCOM, is probably the easiest to implement. The recently proposed ADCCP bit-oriented protocol is already scheduled to be used by the CSCF (see Related Developments) and will undoubtedly be most valuable in the future. (15)

Special terminal handling refers to a capability available in some time sharing systems for recognizing certain popular models of interactive terminals and taking full advantage of their special features and unique capabilities. For example, CRT and storage tube terminals can easily scroll backwards one or more lines whereas hard copy units cannot. So it should be possible to display an expression such as

$$e^{-\frac{t}{RC}}$$

rather than the usual EXP(-T/RC).

Point 6, fault tolerance, has two aspects. The first is failsoft recovery, the ability to limit the damage caused by a malfunctioning subsystem and to resume normal operation as soon after rectification as possible with minimal user impact and loss of work. The second is to be able to perform a subset of total capabilities to a limited number of users while a portion of the system is unavailable.

Point 8, user selected ASCII or BCD on 200 UT stations, may be accomplished in the course of phase 1.

Related Developments

Networking Research

Since 1973 BNL has participated along with six other AEC/ERDA/DOE laboratories in an investigation of general purpose common carrier computer networks linking the installations for experiments in computer resource sharing. The implementation uses the existing ARPANET facility. Each of the seven laboratories was free to choose or develop their own means of implementing an ARPANET connection. Each selected their own experiments, applications or collaborative arrangements to test the feasability of large scale resource sharing. Three interlaboratory groups, an Implementation Panel, an Investigator's Panel and an Objectives Panel, were organized to coordinate various aspects of the work. An ERDA wide report was issued in 1977 containing a summary of the implementation and experience at each site, along with conclusions and recommendations for further study. (16)

Implementation at BNL is based upon a PDP11/34 computer connected thru a Very Distant Host (VDH) interface to an ARPANET Interface Message Processor (IMP) node located at New York University. The implementation strategy was to confine all development work to the PDP11 and make as few changes as possible at the 6600. In an attempt to take advantage of work already accomplished, a PDP11 software system known as ELF, previously developed at University of California (Santa Barbara) Speech Compression Laboratory and Stanford Research Institute, was used as a basis. As it turned out, there was much development and debug required on the ELF system before it could meet its objectives of providing full ARPANET services to Brookhaven, including user and server TELNET and server File Transfer Protocol (FTP). INTERCOM was used for the TELNET connection from the PDP11 to the 6600, and BROOKNET was used for the FTP data path.

Among the applications addressed by BNL in the course of investigating network capabilities were ERDA-wide teleconferencing and electronic mail, data base exchange, accessing special software (such as MACSYMA at MIT) use of special graphics facilities, software distribution, and even later stages of the ELF system development itself! The evaluation of most of these experiments was quite positive. The multilaboratory report concluded that computer networks can be used to good effect to provide for better utilization of resources and improvement in the quality of research. It went on to recommend areas for further study, including development of a standard command language, greater use of exportable software and distributed data bases, and research into human/machine interfaces using minicomputer front-ends and microprocessor-based intelligent terminals.

For the longer term, it has been urged that techniques be developed to incorporate wider band transmission systems. ARPANET has been least practical for applications involving transfer of large amounts of data. These problems can be overcome only with higher bandwidth channels.

A versatile, highly capable telecommunications system at the CSCF would greatly facilitate implementation of new network interfaces for the work to come. By the same token, network experiences help to expose users to the state-of-the-art in time sharing capability. For this reason the MODCOMP project was undertaken with networking needs in mind. One of the attractions of MAXCOM is the relative ease with which new protocols can be introduced. The requirement for special terminal handling was inspired largely by experience with other time sharing systems. And future reliance on networking will surely impose an additional load on telecommunications traffic, both in the number and the speed of the lines. Hence, MODCOMP is both a product of and a factor in the networking research activity.

Meteorology Link

A data link is being effected between the Brookhaven CSCF and the National Weather Service (NWS) Computer Center in Suitland, Maryland using a PDP11/70 computer located at the CSCF. In addition to receiving, sending and processing NWS data, the machine will examine, display and preprocess both meteorological and oceanographic data and, in subsequent phases, be used for computer graphics research and real time data analysis. (17)

The PDP11/70 will be connected to both the CSCF and NWS via telecommunications lines. Protocols used at the NWS end is a subset of ADCCP and 200 UT will be used to connect to the CSCF. RSX11M in the operating system to be used in the PDP11. Software is based upon exisiting DEC products as much as possible but considerable development has been required to produce a unified system and design an ADCCP driver.

There are various specific capabilities a user may invoke in the initial phase of this system. These are referred to in the system as tasks. The input task contains the ADCCP handlers matched to the subset defined by NWS. The 200 UT task will allow transfer to the 6600 and interaction with the CSCF machines based upon the DEC MUX 200 package. A transaction log query will allow a user at an RSX terminal to examine a transaction file, giving the status of all bulletins and files known to the system. The IRIS library task will allow the user to select execution of certain oceanography programs on the PDP11. In addition, there are likely to be file translation tasks determined by the application.

The relationship of this effort to the MODCOMP project is obvious. It provides for an initial implementation experience with a bit oriented protocol, ADCCP. In turn, the completion of phase II of the MODCOMP project raises the possibility of an ADCCP/ADCCP symmetric link for the PDP11 in the future. And much of the capability perceived by the RSX terminal user is derived not from the PDP11 but from INTERCOM through the 6000 front end.

Graphics, Intelligent Terminals, and Personalized Computing

Many in the computing industry forecast a considerable increase in the use of more capable terminals in the future. There is no reason to expect that CSCF users will not wish to follow that trend; indeed there is already a far greater demand for graphics capabilities (including fast communications lines) than the CSCF can now accommodate. Increased proliferation of graphics terminals augmented with microprocessors and cassettes can be expected to modify the nature of telecommunications needs. (18)

These so called intelligent terminals, of which graphics tubes are but one aspect, will have some stand-alone processing capability of their own. Many have BASIC interpreters, text editors, and the like, with some sort of tape or disk storage for file segments. Much of the editing work now being done at the CSCF using INTERCOM can be handled by these terminals off-line provided the terminal can connect to the CSCF to complete the processing. This is likely to require high-speed ASR-type MODE III transmissions at speeds of up to 9600 baud, a service the CSCF cannot contemplate prior to MODCOMP. The CSCF must remain aware of the technological advances such as the advent of such terminals inasmuch as they can profoundly shift the emphasis of telecommunication services within a very short time.

Acknowledgements

BROOKNET was an effort that involved a great number of people. The Principle Investigators of the BROOKNET research were G. Campbell, J. E. Denes, K. Fannin, and A. M. Peskin. Also making sizeable contributions were J. Friedman, K. Fuchel, R. Horwitz, A. Kandiew, S. L. Padwa and M. Strongson on the software project, and M. Leopold, I. Lewis, N. Schumburg, and R. Trondle for the hardware aspects.

Work on FOCUS at Brookhaven involved G. Campbell, H. Berry, C. Benkovitz, H. B. Chiang, S. Sevian and H. J. Bernstein (on Crysnet aspects). The hardware was designed by R. Trondle, who has since also been the primary CSCF contact on telephone company liaison and common carrier issues.

Most INTERCOM investigations at BNL were conducted by F. Castellano and S. Sevian. Certain LCC hardware improvements were developed by L. Burgar.

The task force assembled to evaluate and recommend alternatives for the long term consisted of G. Campbell, L. Lawrence, A. M. Peskin, and C. Pittenger. The subsequent MODCOMP implementation team assembled consists of L. Burgar, F. Castellano, K. Fuchel, S. Sevian, and G. Snape.

The Meteorology link is being implemented by R. Cederwall, B. A. Martin, and S. L. Padwa. The ARPANET link implementation was performed by Principle Investigator G. Campbell, S. Heller and L. Yeh.

Appendix A
Goals of the MODCOMP Project
(A Revised Version of the 1976 CSCF Data Communications Specifications)

A. Peskin

I. System Definition

The MODCOMP communications processor system is to have the following properties:

A. It can serve to replace or coexist with the Control 7077/791 communications controllers currently installed.

B. Acts as a line-driver for Control Data Intercom Communications, both remote batch and interactive.

C. Acts as a "front-end" communications link with either CDC 6600 host central processing unit. Physical connection of each communications processor with either or both host computers will be possible. Logical connection will be effected by a command by the individual remote specifying its data path.

D. Will interface to the CDC 6000 series computers using Scope and Intercom V/REBS or alternatively Intercom IV, a decision on which will be made in due course. Operational procedures for exisiting terminals will not require change and no existing capabilities of Intercom will be lost.

E. Either of the two MODCOMP II processors serving the System can operate alone to drive all the synchronous ports and some of the asynchronous lines, perhaps with a degraded response time.

II. Capabilities

A. Line management capabilities

1. The initial configuration must be immediately capable of supporting up to 48 2000, 4800 or 9800 baud synchronous lines simultaneously. It must also be able to support up to 64 simultaneous 110-9600 baud interactive asynchronous transmissions.

2. System must be expandable to support a 64 synchronous - 96 asynchronous capability by adding only 1930 series equipment.

3. Must interface to connectors, logic and electrical circuits as specified by EIA RS-232 C and CCITT REC V24. Must support full and half duplex connections.

4. Must be capable of sustaining a batch throughout equivalent to 30,000 full 132-column random character print lines per minute aggregate. Delay introduced by the communications processor on interactive commands (from carriage return to response)

should not exceed 5 seconds when fully loaded.

5. Must be able to accommodate a large variety of popular data sets including the Bell 103, 201, 203, 208, and 209's or their equivalents.

6. Among the supported modem strapping options and features should be:

   a. Automatic answer
   b. Dial-up or dedicated lines, half or full duplex
   c. Carrier controlled by "Request to be sent"
   d. Accommodate variable delays between request-to-send and clear-to-send

7. Among the terminals supported should include:

   CDC 200 UT
   CDC 731, 732, 734
   COPE 1200, 1600, 30, 40
   Teletype 33, 35, 38 (ASR and KSR)
   Tektronix 4010, 4012, 4014, 4051, 4006
   Hazeltine 2000
   TI 725, 735, 745
   IBM 2780, 3780
   IBM 2740, 2741
   IBM 3270, 3770

8. Automatic baud rate detection may be supported.

B. Protocols

1. The following terminal protocols should be supported concurrently and intermixed by the communications processor:

   a. CDC MODE 4 (200 UT)
   b. CDC MODE 3 (Teletype)
   c. IBM 2780 - 3780 BISYNC
   d. The emerging industry standard bit or oriented protocol (ADCCP/CDCCP/SDLC/HDLC)

2. Party line or multidropping of dedicated link remote batch terminals will be supported.

3. Transmission of binary information as well as ASCII and BCD, including 256 character codes, will be allowed.

4. Terminals will be allowed to have multiple input and output devices with software to support magnetic tape, plotters, paper tape, cassettes, and other peripherals.

5. Special features may be defined for handling popular terminals with special features such as backspacing and backlining, vector drawings, ASR cassettes, etc.

III. Performance

A. Maintainability

The system must be implemented using acceptable industry standards and techniques for generating highly maintainable hardware and software to maximize mean time between interruption (MTBI) and minimize mean time to recover (MTTR). A loopback test mode should be provided as well as a complete set of diagnostic routines which can be run by a computer operator on-line. Most diagnostic procedures initiated by the operator should not require dead start, IPL, or similar interruption of the host mainframes.

B. Reliability

It is essential that the communications gear meet the following requirements:

1. System up time $\frac{\text{T up}}{\text{T up + T down + T recovery}}$

   must exceed 95%. MTBI must be greater than 100 hours.

2. The system will not crash because its bandwidth or buffer storage requirements have been exceeded. Rather, it will simply degrade to an appropriate level.

3. The system should not crash due to a single line or terminal malfunctioning.

4. The system should be able to hold message communication and provide rudimentary command processing even if all host computers are unavailable.

5. Loss of either host CPU should still allow a reconfiguration so that all communication lines can operate, perhaps in a degraded mode.

6. Malfunctioning communication lines can be disconnected, repaired, and returned to service without requiring a dead start or IPL on either the hosts or the communications processor and without adversely affecting the other users.

C. Error Handling

1. A history of communication line errors such as parity errors, retransmission requests, and time outs will be automatically generated, logged, and kept for the perusal of operations or maintenance personnel.

2. The front-end processor must include a keyboard and a teleprinter to be used for operator communication. The processor must be capable of transmitting a message-of-the-day to all terminals at connection time. Similarly, operators may broadcast a message to all connected terminals. Error malfunction information will be printed out to the operator from this teleprinter.

3. The processor should be able to recognize a host system failure (for example, through a time-out mechanism) and must so notify remote users.

4. A severely malfunctioning line will be automatically turned off by the system with an appropriate operator message.

IV. Documentation to be generated

A full set of manuals including installation, operation, hardware and software documents will be generated as though by a commercial vendor. These will accompany hardware prints and software and diagnostic listings.

mk

Appendix B
Telecommunications Working Group Report
to R. B. Marr, J. E. Denes, March 8, 1977

The working group appointed to evaluate the various approaches and proposals for a long-range solution to the CSCF data communications problems has concluded its deliberations. In the course of its work it evaluated the "price and return" proposals of Control Data and Modcomp as well as exploring in-house and hybrid alternatives. Design philosophy, implementation and maintainability questions were investigated. Recommendations for action are made herein.

CDC vs MODCOMP

A great deal of the group's time was spent in comparative analysis of the technical attributes of the CDC and MODCOMP proposals. The following are the major items of advantage attributed to the CDC proposal.

1. Even though a QSS is involved, software support should prove better than that of an independent vendor.

2. Facilities for in-production diagnosis and repair of individual lines is proposed.

3. HASP protocol is readily supported. New protocols are probably more easily written.

4. Dcomentation, while never one of CDC's strong points (especially on QSS's), promises to be better this time around.

5. This is the only vendor that supports interactive use of synchronous terminals.

6. Host implementation is considered better than MODCOMP's control point approach.

The main advantages attributed to MODCOMP are as follows:

1. Hardware and software architecture are both excellent for communications.

2. Maintainability of the hardware is generally superior to that of CDC, and cost of that maintenance should be lower.

3. Character throughput is much greater than that of CDC.

4. Expansion seems more easily facilitated.

There are two non-technical factors which are nonetheless of great importance. The first is that the cost of the CDC configuration is considerably greater than that of MODCOMP. On the other hand, the MODCOMP team has chosen to bid their system through their turnkey software firm, Software and Communications Concepts, an outfit which may not be of critical size to responsibly shoulder a contractual commitment complete with credits, damages, etc.

Alternatives

As for in-house projects, the committee has considered the microprocessor proposal advanced last year, the Berkeley approach, moving to KRONOS/NOS, and possibilities involving the use of commercial hardware and special software.

Recommendations

Both the CDC and MODCOMP proposals were found to be marginally adequate. I think the sentiment of the committee may slightly favor MODCOMP on technical grounds and price. However, neither proposal generated a great deal of excitement because of the disadvantages associated with each. (Of course, it is recognized that for any system to be totally satisfactory in the current CSCF environment, other general system improvements would be required, such as adequate CM and disk and possibly surgery on Scope 3.4, and this fact tends to dampen enthusiasm for any isolated proposal.)

While it was difficult to arrive at a unanimous conclusion, a majority of the group felt that a hybrid approach, using MODCOMP hardware, perhaps some COPE and CDC host software, the MAXCOM mini operating system and an in-house implementation project, would be a cost effective and responsive approach to the needs of the CSCF. The strategy recommended is a phased approach similar to that followed by MODCOMP and LBL. In phase 1, MODCOMP would be developed as a front-end to a COPE-like system, thus insuring that we could cancel the Harris lease within two years. At the same time, our system designers and implementers would gain valuable experience in preparation for phase 2, which would provide the interactive portion and complete replacement of the LCC's. Details of this phase are still obscure and their resolution would be a part of the project. For host software, one might choose INTERCOM, the REBS QSS, or systems from Martin-Marrieta, Chrysler, Raytheon, etc., all of whom have gone this way, as a basis. There may or may not be microporcessors driving the lines. But the system would center around a MODCOMP IV, MAXCOM configuration. Note that this strategy circumvents the major disadvantages of the MODCOMP approach (the small software house taking the responsibility) and the originally proposed microprocessor project (stagefright on the part of the systems programmers).

Implementation of this effort has not been costed out but my personal estimate is that it would require approximately $200K capital equally spread over two fiscal years, 2-3 man years/year effort in programming from summer of 77 to end of 1979. One man year/year of such effort should be from the Lawrence group. The rest would be provided from the Heller group. Some hardware involvement will be needed as well, for example, for a 6000 to MODCOMP interface.

Some of the reservations about the advisability of this approach are expressed in the attachment from G. Campbell, along with suggested alternatives. His thesis is that the best proposal can only be determined in the context of other plans and expectations, but the others on the committee may have felt that it was a "chicken and egg" situation; the decision would have bearing on future plans and expectations as well.

The committee also takes cognizance of the recommendation of the Remsberg committee to release the NNDC KA10 computer to AMD when it is replaced. This machine, suitably interfaced to the 7600, would provide an important supplement to the front-end communications capabilities of the CSCF. If it is not made available, perhaps AMD could consider acquisition of a machine in the DEC 20 class in the future.

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