ornl

OAK
RIDGE
NATIONAL
LABORATORY

UNION
CARBIDE

ORNL/TM-7296

Fusion Energy Division Computer Systems Network

C. E. Hammons

MASTER

OPERATED BY
UNION CARBIDE CORPORATION
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

Printed in the United States of America. Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road, Springfield, Virginia 22161
NTIS price codes—Printed Copy: A02; Microfiche A01

ORNL/TM-7296
Dist. Category UC-20

Contract No. W-7405-eng-26

FUSION ENERGY DIVISION

FUSION ENERGY DIVISION COMPUTER SYSTEMS NETWORK

C. E. Hammons

Date Published - December 1980

Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
operated by
UNION CARBIDE CORPORATION
for the
DEPARTMENT OF ENERGY

ABSTRACT

The Fusion Energy Division of the Oak Ridge National Laboratory (ORNL) operated by Union Carbide Corporation Nuclear Division (UCC-ND) is primarily involved in the investigation of problems related to the use of controlled thermonuclear fusion as an energy source. The Fusion Energy Division supports investigations of experimental fusion devices and related fusion theory. This memo provides a brief overview of the computing environment in the Fusion Energy Division and the computing support provided to the experimental effort and theory research.

INTRODUCTION

The Fusion Energy Division of the Oak Ridge National Laboratory (ORNL) operated by Union Carbide Corporation Nuclear Division (UCC-ND) is primarily involved in the investigation of problems related to the use of controlled thermonuclear fusion as an energy source. The Fusion Energy Division supports investigations of experimental fusion devices and related fusion theory. The User Service Center (USC) as coupled to the data acquisition computers is a vital tool for this effort.

The USC is composed of a DECsystem10 KL10B central processing unit (CPU) and its associated peripherals, including the special equipment for interfacing the system to the National Magnetic Fusion Energy Computer Center (NMFECC) network. The current system configuration is shown in Fig. 1. The computer system is interfaced to the large-scale computers (CDC 7600 and CRAY-1) at the NMFECC at Lawrence Livermore Laboratory over a high-speed (50-kilobit/s) leased telephone line. Similar computer systems located at the Princeton Plasma Physics Laboratory, General Atomic Company, the Los Alamos Scientific Laboratory, and the Lawrence Livermore Laboratory are also interfaced over high-speed lines to the CDC 7600 and CRAY-1 computers.

The Fusion Energy Division USC has been used for several years to gather and archive data from the Oak Ridge Tokamak-Impurity Study Experiment (ORMAK/ISX) work and the ELMO Bumpy Torus (EBT) experiment. This is accomplished via a network of data acquisition computers consisting of Digital Equipment Corporation (DEC) PDP8s, PDP12s, and PDP11s, each composed of various data acquisition interfaces and devices (Fig. 2). More recently, the Neutral Beam Development Test Stand has been added to the network. The network is managed by a PDP11/45, which has a direct memory interface with the DECsystem10 memory system. The USC is also used to manipulate, interrogate, and perform calculations upon the data base generated by these experiments. Some small data reduction and analysis are performed on the USC as well as the editing and data preparation for larger calculations to be performed on the CDC 7600 and CRAY-1 computers.

The primary function of the USC may be broken down into two categories. First, the USC provides the theoretical and experimental investigators in the Fusion Energy Division access to the NMFECC and its large CDC 7600 and CRAY-1 computers. This allows the scientific staff to use the superior computing power of these systems in a cost-effective manner and provides a facility to receive, review, print, or archive the results of their computations.

ORNL DWG 78 366R3

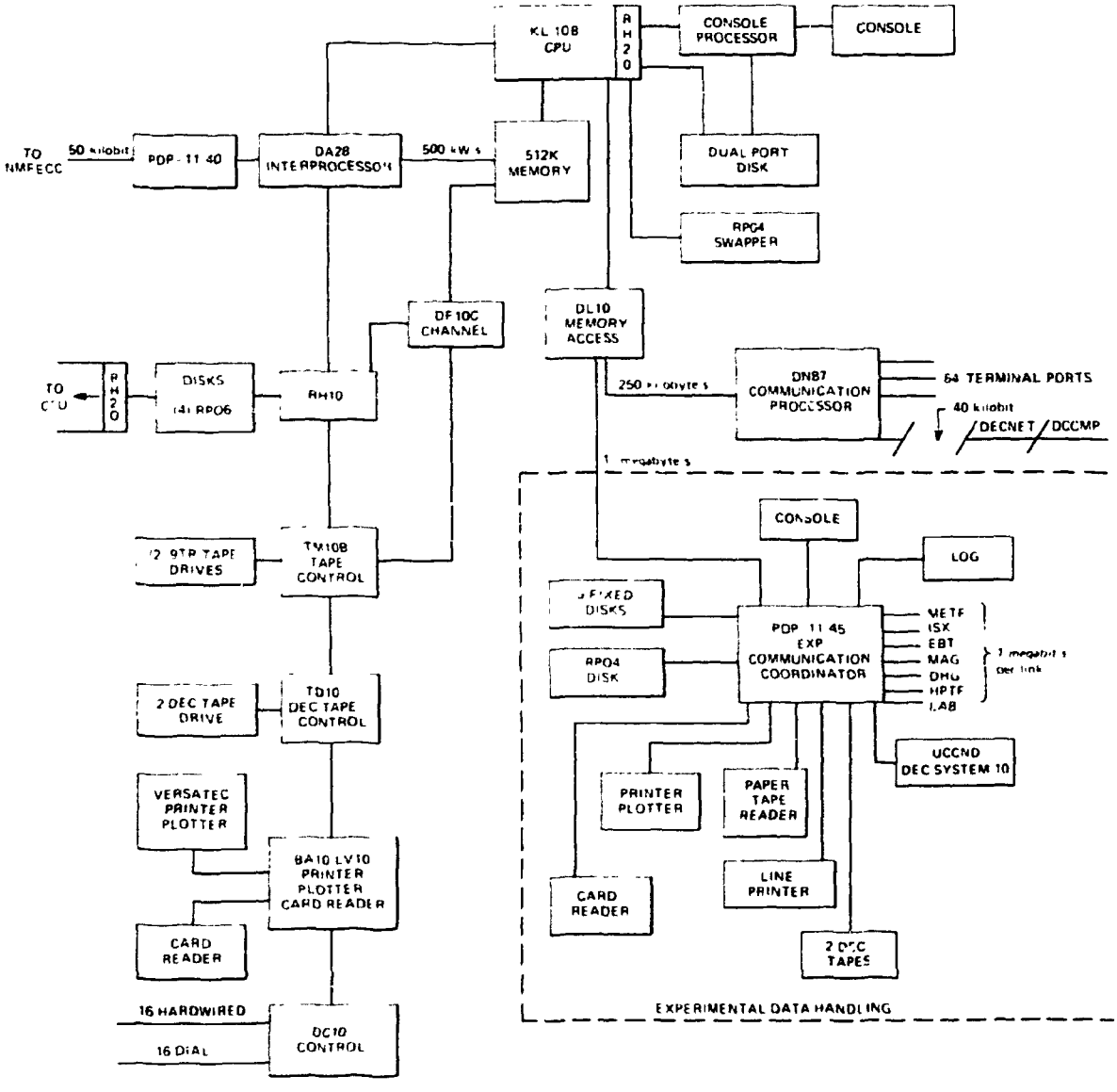

Fig. 1. ORNL Fusion Energy Division User Service Center.

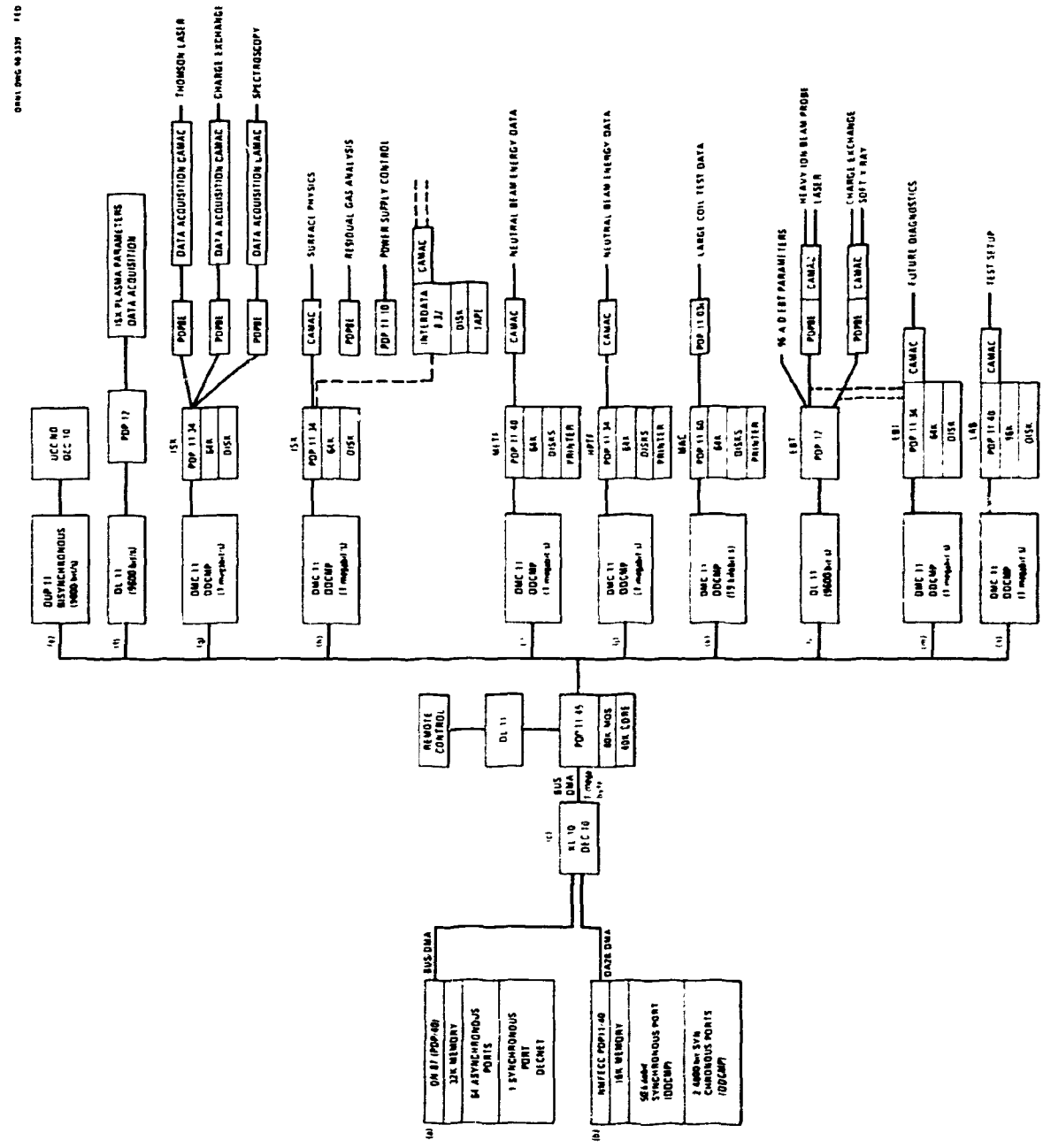

Fig. 2. User Service Center data acquisition systems network.

Second, the USC is networked to the fusion-related experiments via the smaller-scale data acquisition systems located at each experimental device control area. This network provides a means of rapidly storing, retrieving, and analyzing the results of an experiment in nearly real-time fashion. This allows better choice of experimental parameters and has proven to be very valuable in saving expensive experimental time. As a consequence of local preliminary analysis, certain quantities of reduced data can be used on the large computers at the NMFECC to further refine and apply the results for sharing with the fusion community. There is an ongoing effort to make the experimental data bases more usable by offsite fusion-related experimental groups funded by the Department of Energy (DOE).

The USC power is supplied via a 50-kW motor-generator set and an equivalently rated ac power line conditioning and filtering system. This is necessary because of the nature of the fusion-related experimental devices, which produce high impulses and deep ac power sags on the primary power feed. The air conditioning is dedicated exclusively to the USC in order to maintain a suitable operating environment for the computing equipment.

The USC vital segments are monitored and analyzed daily, weekly, and monthly in order to disclose the trends in system utilization. This allows the USC staff to continue to remove and, frequently, prevent USC bottlenecks. The data collected and compared with budget forecasts in WPA/FTPs are important in anticipating future needs of the Division research efforts.

The USC at ORNL is vital to the experimental and theoretical research being conducted in the Fusion Energy Division and should continue to couple the experimentalists and theorists to the supercomputers in the NMFECC.

COMPUTING ENVIRONMENT

The USC's workload is composed of interactive computing and data communications. The USC is used to edit and briefly test large scientific codes intended for execution on the supercomputers at the NMFECC. It also serves as the archive for the large experimental data bases created by the fusion-related devices. These data bases are analyzed on the USC by small- to medium-scale scientific codes. Finally, the USC is the gateway to the NMFECC for the scientific staff that supports the Division's work. It allows access via a wide variety of terminals and rapidly provides hard copy plots and prints of computational results.

The operating system employed on the USC is DEC's TOPS10 timesharing system. The USC has made available to the user staff a wide variety of utility programs and compilers, such as FORTRAN, COBOL, BASIC, APL, TECO, TEDI, SOS, MACRO, MACRO11, BATCH, and FILCOM. PASCAL for minicomputers is being evaluated.

The USC is operational 24 hours a day, but is unattended on the nonprime shift. Maintenance for the USC is provided by contract with DEC, the OEM, as determined by competitive bidding. Nearly all of the small-processor-based systems are maintained by an in-house staff.

Use of the USC is restricted to Fusion Energy Division staff and support personnel from the UCC-ND Computer Sciences and Engineering Divisions. There are a few users outside these divisions who offer specialized support.

The USC has data communications, as depicted in Fig. 2, with several computer systems. It is connected to the supercomputers at Lawrence Livermore Laboratories in California via a 50-kilobit synchronous leased circuit. The circuit is driven by PDP11s on each end. The USC is interfaced to the Division's data acquisition systems and the Computer Sciences Division's large computing systems by the PDP11/45 processor, which in turn is attached by a UNIBUS connection to the KL10.

The USC provides no offsite workload sharing since it is fully utilized by the Division theory and experimental staff. The data bases collected from fusion-related experiments are not yet routinely shared offsite because they are very particular to the Division's research staff and are not subject to effective use by other organizations. An effort is under way, however, to improve the usefulness of the data to other users.

DATA ACQUISITION

The minicomputer systems at the ORNL User Service Center consist of a networked system of data acquisition systems associated with various fusion-related experiments and their associated communications coordinating processors. These systems range in size from microprocessors to the large KL10 USC system. These systems are depicted in Fig. 2. The DMC11/DDCMP links are one-megabit, full-duplex, coaxial data links operating on local circuits. The operating systems for the DEC PDP8s and PDP11s are OS8 and RSX11M, respectively.

Figure 2(a): The DN87 (PDP11/40) network processor provides terminal access to the USC, with character speeds ranging from 10 to 1920 characters per second. There is a synchronous data port installed for networking to another system or DN87. The processor is attached to the USC via its UNIBUS and one of the eight memory ports.

Figure 2(b): The NMFECC PDP11/40 provides access to the large-scale computers in Livermore (for scientists and programmers). The communications circuit is currently operating at 50 kilobits per second. The protocol employed is the DEC Digital Data Communications Message Protocol, DDCMP. It is attached to the User Service Center via a DA28 interprocessor buffer and one of the eight memory ports.

Figure 2(c): The KL10 processor/DECsystem10 is diagrammed in Fig. 1.

Figure 2(d): The PDP11/45 is the local wide-band data communications coordinator for the data acquisition systems that serve the fusion-related experiments in the Division. It provides temporary spooling on a large 100-megabyte disk and file routing so that experimental data are stored in the appropriate area on the USC. The PDP11/45 also offloads the USC somewhat by providing auxiliary printing and plotting with a slow impact printer and a good-quality Versatec printer-plotter. The processor shares the same memory port as the DN87/PDP11/40 processor and sends and receives data in duplex at burst rates of one megabyte per second.

Figure 2(e): The PDP11/45 has a binary synchronous link to the DEC10 in the Computer Sciences Division's central facilities. This 9600-bit-per-second link is used by Computer Science Division support staff to move data files between the USC and the UCC-ND central facilities. The central facilities are described in the long-range site plan submitted by UCC-ND.

Figure 2(f): The PDP12 processor has been serving the ISX group of the Division for a number of years. It is currently used to monitor many parameters of the experiment. It has a built-in cathode-ray tube (CRT) display, which allows immediate review of raw data, and transmits pertinent parameters to the USC for archiving via a medium-speed asynchronous link.

Figure 2(g): The PDP11/34 serves as the acquisition and data flow coordinator for three PDP8 minicomputers, which take diagnostic data from CAMAC (IEEE-STD-583) interfaces attached to the Thomson scattering laser system, charge exchange measurements, and spectroscopy analysis diagnostics. These diagnostics are used to study the ISX tokamak confinement operations.

Figure 2(h): Another PDP11/34 is currently dedicated to taking surface physics data and sending them to the USC for storage and analysis. Some preliminary review of the experimental data is provided. The PDP8 serving the residual gas analyzer diagnostic is not attached via communications circuits, and any data to be stored are manually transmitted via DECtape from another processor that has a high-speed link to the PDP11/45. Similarly, the PDP11/10 monitors and controls the ISX power supply; its data is at another point. The Interdata 8/32 processor will be used to operate and acquire data from future diagnostics.

Figure 2(i): The PDP11/40 is used to coordinate data collected by the CAMAC interfaces, which are attached to various sensors being used to study the operation of the medium-energy neutral beam generators in the Medium Energy Test Facility (METF). The data are partially analyzed and displayed or plotted and are sent to the USC for archiving on disk and tape.

Figure 2(j): The PDP11/34 is used to coordinate data for the high-power neutral beams in the High-Power Test Facility (HPTF) using essentially the same programming as that of the METF system [Fig. 2(i)].

Figure 2(k): The PDP11/60 services the PDP11/03s that are used to monitor test points during the large superconducting coil tests. The data are collected by the small PDP11/03s and are passed to the PDP11/60 for routing and storage. Some preliminary analysis of the data is performed by the PDP11/60.

Figure 2(l): The PDP12 currently serves as the coordinating computer for the ELMO Bumpy Torus (EBT) experiment. Its role as a coordinating computer will be assigned to a PDP11/34 [see Fig. 2(n)]. The PDP12 has 96 analog-to-digital converters for monitoring EBT parameters and has two PDP8s attached. The PDP8s are used to acquire

data from the following diagnostics: charge exchange, soft x-ray, heavy-ion beam probe, and laser. The CAMAC interfaces are used in direct data acquisition.

Figure 2(m): The PDP11/34 was recently acquired to upgrade the data acquisition effort at the EBT experiment. It will assume the role of communications coordinator in the near future. It has a CAMAC driver that will allow it to readily support new diagnostic requirements.

Figure 2(n): The PDP11/40 is used to set up and test various types of data acquisition interfaces. It has two different types of CAMAC drives so that any CAMAC-based data acquisition configuration can be checked prior to installation on the target experiment. It also serves as an emergency spare component source for processors that serve major division experiments.