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Abstract

For MFTF-B, the plasma diagnostics system is expected to grow from a collection of 12 types of diagnostic instruments, initially producing about 1 Megabyte of data per shot, to an expanded set of 22 diagnostics producing about 8 Megabytes of data per shot. To control these diagnostics and acquire and process the data, a system design has been developed which uses an architecture similar to the supervisory/local-control computer system which is used to control other MFTF-B subsystems.

This paper presents an overview of the hardware and software that will control and acquire data from the plasma diagnostics system. Data flow paths from the instruments, through processing, and into final archived storage will be described. A discussion of anticipated data rates, including anticipated software overhead at various points of the system, is included, along with the identification of possible bottlenecks. A methodology for processing of the data is described, along with the approach to handle the planned growth in the diagnostic system. Motivations are presented for various design choices which have been made.

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Introduction

Control of plasma diagnostics equipment and the subsequent acquisition and processing of the data therefrom on the Mirror Fusion Test Facility (MFTF-B) is a function of the two computer systems are part of the control system for MFTF-B. These systems are designated the Supervisory Control and Diagnostics System (SCDS) and the Local Control and Instrumentation System (LCIS). They have been extensively described in previous Fusion Engineering Conferences (1-21). Further, a preliminary discussion of plasma physics data acquisition was presented in reference 22.

We will discuss in this paper the various hardware and software components of the two main systems which compose the plasma diagnostics control, data acquisition and processing system. These components are:

1. The local control computers
2. The bulk data network
3. The PLEX system
4. The LCIS/SCDS data link
5. The SCDS hardware dedicated to plasma diagnostics
6. The plasma diagnostics workstation
7. The database system
8. The data processing system.

And finally we will present an analysis of the various data rates and how they fit together.

The Local Computer Network

For each diagnostic there will be one or more LSI-11/23s called a Local Control Computer (LCC) connected on one side via a fiber optic link to one or more CAMAC crates. See Figure 1. Each crate, in turn, will be connected to the diagnostic hardware. The other side of the LCC is connected to SCDS via an RS-232c 9600 baud line. This is similar to the current LCIS configuration for the balance of MFTF-B (9, 13, 16).

The main difference in the LCC network for diagnostics, compared to the network for the balance of the system, is caused by the volume of data which must be handled. Currently this is predicted to be in the neighborhood of eight megabytes per shot. A bulk data network composed of a commercial baseband (ten megabits per second) Local Area Network (LAN) is superimposed on the conventional network to speed the data transfer (23). A master LCC is used to manage the traffic and it has direct memory access to the Diagnostic Data Processor (DDP) of SCDS. The reason the master LCC stands between the LAN and the

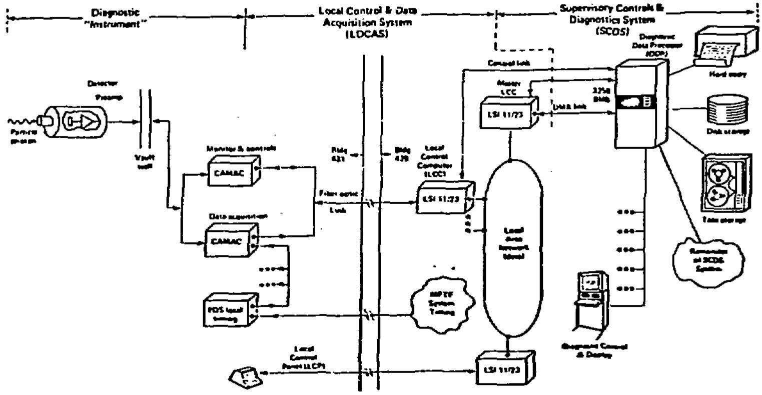

Figure 1.

DDP is that commercial hardware and lower level software for the LAN was available for the LSI-11 but would have to be especially constructed for the Perkin-Elmer DDP. This made the imposition of the buffering LSI-11 very inexpensive.

Synchronization of the various diagnostics with the rest of the shot is done through the master timing system which is used everywhere in the system (13).

PLEX is the software system for the LCCs used elsewhere in MFTF-B. It is currently planned to use the standard PLEX software for all the operations in the diagnostics LCIS also (5). There will have to be some customizing, no doubt, but the term "standard PLEX" describes only a core of software which is unchanged in all systems. Each system requires modified extremities, primarily because of memory size limitations.

In a typical sequence, control information for set-up, calibration, etc., will flow from the DDP down the RS-232c lines to the LCCs. Monitor information on system status will flow back up these lines. Further, control information specifying what data is to be collected and the order of collection will flow down the RS-232c line from the DDP to the master LCC. The master clock system will then trigger and synchronize all operations during a shot including transient data collection and storage in the CAMAC crates. Following the shot, each LCC will collect the data from the CAMAC crates and simultaneously, the master LCC will initiate transfers of this data from the LCC memory through the master LCC memory to the DDP memory.

Finally it must be mentioned that the system described above is duplicated so that there are actually two identical systems, one serving one half of the diagnostics and the other serving the other half. Balance here is achieved when the quantity of data from one half equals the quantity of data from the other half. There are two DDPs, too, so that the actual data rate is twice that of the one system. Further, by using two master LCCs in each LAN we avoid a single point failure bringing down a major piece of the system and simultaneously improve the data transfer rate. The standard LCC switchover mechanism employed elsewhere on SCDS takes care of a DDP failure. See Figure 2.

The Supervisory Computer System

The supervisory system, SCDS, is shown in Figure 3. Two machines, DDP-I and DDP-II, support the plasma diagnostics system. Each machine has eight megabytes of memory, half of which is dedicated to buffering the data collected from the diagnostics. Thus it is anticipated that shortly after completion of a shot all data from that shot will be contained in the memory of SCDS.

Each DDP has 600 megabytes of disk storage which is enough to store the data from approximately one day of experimental operation. Further, each machine has a 6250 bpi tape transport for long term storage of experimental data and calculations.

The User Interface

The user interface for controlling and monitoring of MFTF-B exclusive of plasma diagnostics is a color graphics oriented menu driven system (6). Processing and display of machine diagnostic data (e.g. waveforms from the sustaining neutral beam system) has few options. What you see is what you get. For controlling and monitoring plasma diagnostics apparatus, a graphics oriented menu driven system is adequate since the functions are not too different from those of the balance of the MFTF-B system. However, the processing and display of the plasma physics data from a shot requires a flexibility which makes an exclusively menu driven system impractical.

A microprocessor based workstation with color graphics, mouse, keyboard, etc. is used as the interface to the diagnostics equipment (22). The touch sensitive panels used on the balance of the system are replaced by the use of a mouse or other pointing mechanism. However, the addition of a keyboard adds considerable flexibility to the system since the user will have the ability to type in long strings of symbols which is a capability unavailable on the SCDS consoles.

The workstation, shown in Figure 4, thus is a compromise between the standard SCDS consoles and the more-or-less standard computer terminal. It will offer a sophisticated menu capability where that is appropriate and a more cumbersome keyboard protocol where that is required for maximum flexibility.

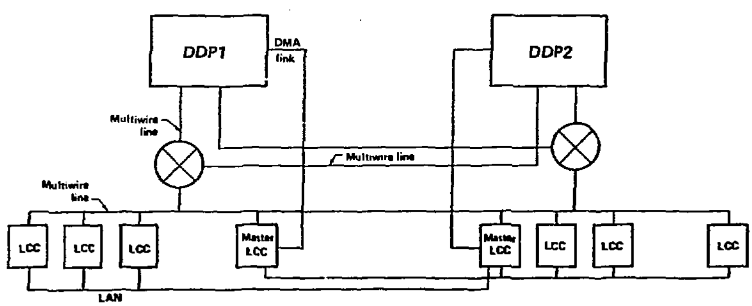

Figure 2.

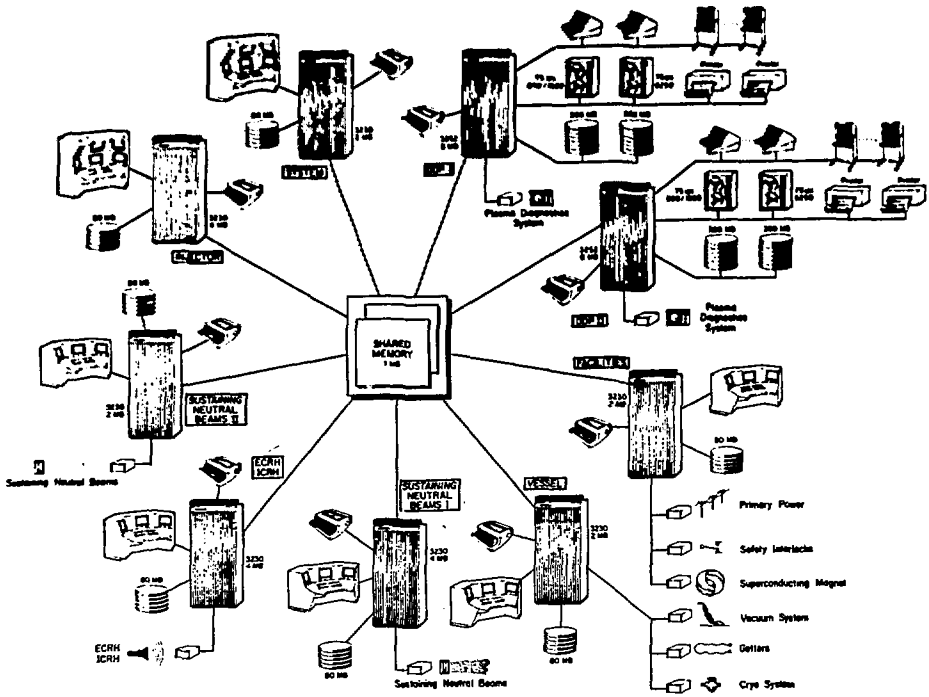

Figure 3.

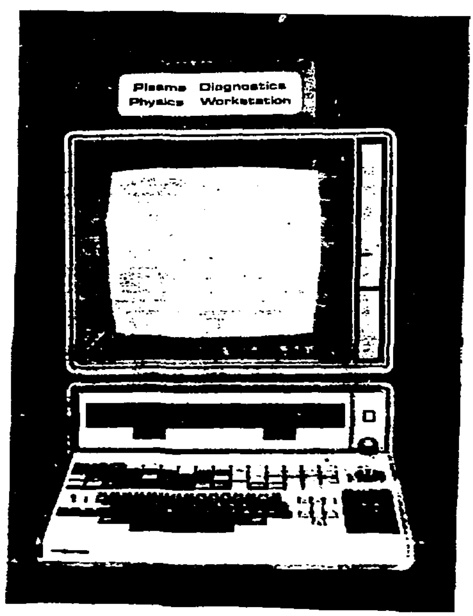

Figure 4.

Software

Much of the software for this system is in the conceptual design phase and hence does not have a great deal of form yet. This section therefore, presents preliminary thinking.

The database and the system to control it have been discussed previously (3, 4, 19, 20). It is relational, meaning that it is a collection of two dimensional arrays, each array having a name, and each row of an array is a Pascal record type. To access data in the database the user need only know the array name and size, and the record structure.

A special type of array, called a ring, is defined for the database. The ring allows a user to add new data (a row) without taking cognizance of where the data goes, i.e., there is a "next" row into which the data goes. This type of structure is used for storage of physics data from an experiment. However, because the size is finite, new data will eventually write over old data.

Long term storage is accomplished using magnetic tape as a medium. An archive system is being added to the database system so that as a ring approaches the time that new data will destroy old data, the old data will be transferred to tape and an appropriate directory entry made so that the old data can be found at a later time.

Processing and output of the diagnostics data will proceed using two protocols. The conventional protocol will simply require the user to invoke a data processing task using the monitor supplied by the computer vendor. The task will then get its data from the database or other standard input device and send the results to some output device.

The more interesting protocol will allow the user to specify an input data set, a sequence of processes and finally an output process. Such a system, called a data stream system, would allow, for example, a user to specify a scaling and a filter on one data vector, a different scaling and filter on another vector and finally plotting of one resultant vector against the other eliminating the time parameter. This system is similar to the pipe system of UNIX.

Performance Estimate

At the end of a shot data will start to move from a diagnostic into a DDP memory. Initially, a block will move from the diagnostic via the LAN to the memory of the master LCC. Once the first block is transferred, a DMA transfer is initiated into the DDP memory. Simultaneously with the transfer to the DDP, another transfer is initiated from a diagnostic to the master LCC.

The transfer rate of the LAN is 150 kbytes/sec. The Q-bus of the master LCC is used for DMA transfers from the LAN into LCC memory and from LCC memory into DDP memory. Since the observed Q-bus rate is 800 kbytes/sec. it is assumed that it can handle the 150 kbytes/sec. from the LAN with adequate bandwidth to move the data from the LCC memory into the DDP memory. The channel into the DDP is rated at 20,000 kbytes/sec. and so poses no problem. Thus the LAN rate is the controlling rate and assuming a 20% overhead transfer of four megabytes will require about 34 seconds. This time will be substantially reduced using two master LCCs in each LAN.

Once in the DDP memory the data must be transferred into the database. Measurement indicates that it takes ten milliseconds to transfer one page into memory and for a multiple page transfer it takes five milliseconds plus five milliseconds per page. Thus, assuming a one kbyte page size, it will take no less than twenty-five milliseconds and no more than forty milliseconds to transfer the four megabytes of data into the database. Thus the transfer into the database can go on in the shadow of the LAN transfers

Transfer from DDP memory to disk is a database system function and requires about twenty-six milliseconds per page on average. Thus it will require a total of about 104 seconds to transfer the data to disk, but very little of this time involves the processor.

The transfer from disk back out to magnetic tape for long term storage is not limited by the transfer rate of the tape but is restricted by system considerations. To avoid too many disk seek operations requires good sized buffers. But the size of the buffers is limited by the amount of processing going on. So it is best to send the data to tape during the maintenance shift. If this can be done then the transfer to tape can be made transparent to normal operations. However, if the database ring for shot data becomes full during a good experimental day, transfer to tape will have to be initiated early which may begin to stretch the intershot period somewhat.

Conclusion

What has been presented above is an overview of the physics data acquisition and processing system for MFTF-B. This system is a subsystem of the SCDS and LCIS which controls and monitors all parts of MFTF-B. The system described above is in various stages of design and implementation with start-up scheduled for 1985.

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