LaRC Local Area Networks to Support Distributed Computing

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INTRODUCTION

LaRC has initiated the development of a Local Area Network (LAN) to support a growing distributed computing environment at the Center. The purpose of the network is to provide an improved capability (over interactive and RJE terminal access) for sharing multi-vendor computer resources. Specifically, the network will provide a data highway for the transfer of files between mainframe computers, minicomputers, work stations, and personal computers.

An important influence on the overall network design has been the vital need of LaRC researchers to efficiently utilize the large CDC mainframe computers in the central scientific computing facility. Although there has been a steady migration from a centralized to a distributed computing environment at LaRC in recent years, the work load on the central resources has increased. This same experience has been noted at other large computing facilities. Therefore, major emphasis in the network design has been placed on communication with the central resources within the distributed environment. The network to be implemented will allow researchers to utilize the central resources, distributed minicomputers, work stations, and personal computers to obtain the proper level of computing power to efficiently perform their jobs.

LaRC requirements for a local area network cannot be met with a commercially available system. As with almost all local area networks of any size, a custom design is required, including both hardware and software. LaRC has elected to minimize hardware design by building a network around commercially available Ethernet products. However, network and application level software for the network gateways and various resources on the network will be developed in-house. With today's LAN technology, an in-house design of the network software appears to be the only viable approach to meet LaRC requirements. Following is a review of LaRC plans for the development of a center-wide local area network.

NETWORK CONFIGURATION

Figure 1 defines a proposed framework within which an integrated data network to support distributed computing at LaRC will be developed. The top half of Figure 1 depicts the central scientific computing resources which include multiple CDC Cyber mainframe computers and a large mass storage system with a current capacity of 16 billion words. A major resource at the central facility is a CDC Cyber 203 vector processing supercomputer. The bottom half of Figure 1 depicts the growing distributed environment at LaRC.

The total network configuration consists of three levels of network with the principal difference between the levels being transmission speed. Three different networks are used because it is not economically feasible to implement a single network with today's technology to meet LaRC's networking requirement. The design goal will be to integrate the different levels of network to form what will appear as a single networking environment to the user.

Two levels of the network are already in existence at LaRC. An interactive computing low-speed network has been in operation for six years. The interactive network is shown in more detail in Figure 2. The network supports up to 9600 baud interactive terminal traffic to various computing resources at LaRC. The heart of the network is a digital data switch from Micom Systems, Inc. located in the central scientific computing facility. The data switch operates similarily to a telephone company central office switch. Any terminal on the network can initiate a connection to any computer (or terminal) on the network. Although installed initially to support scientific computing, the network has in recent years been expanded to support administrative computing as well. Requirement for a low-speed networking is expected to continue into the foreseeable future, although the implementation might, in the future, be part of an integrated voice/data PBX.

A high-speed mainframe computer network was installed in the computer center last year. This network, Control Data Corporation's Loosely Coupled Network (LCN), provides interconnection between the CDC mainframe computers and the mass storage system in the central facility. Three parallel coax trunks, each operating at a transmission rate of 50 megabaud, are used as the transmission medium.

To optimize the value of a distributed computing environment, a means for efficiently transferring large data files between all network resources is required. The two existing networks are not suitable for this. The interactive terminal network is too slow. It is limited to data rates of 9600 baud and typically does not provide a means for guaranteeing error-free transmission. The high-speed LCN network, although fast enough, is too expensive. The cost to interface a resource to LCN is $50,000 to $100,000--obviously not practical for workstations, personal computers, and most minicomputers. A new medium-speed network is needed to fill the gap between the existing networks and provide a reasonable and cost effective means for transferring data files within LaRC's distributed computing environment. Therefore, a network is being developed to support throughput up to one megabaud at a hardware cost-per-device of less than $3000. The new network, shown at the bottom of Figure 1, will have a gateway to the high-speed LCN mainframe network. A description of the proposed medium-speed network follows.

MEDIUM-SPEED FILE TRANSFER NETWORK

The proposed configuration of the medium-speed file transfer network is shown in Figure 3. The network is designed around Ethernet technology and products. Ethernet was chosen because it has received by far the greatest amount of commercial acceptance and support. Ethernet hardware is currently available commercially to interface with more computer systems, (including DEC minicomputers and IBM personal computers), than any other LAN product. The number of supported devices is growing rapidly.

The design concept is that each building, or group of buildings, will contain an independent Ethernet network to which minicomputers, workstations, and personal computers will be attached. The individual Ethernet clusters will then be interconnected via gateways to a ring network using token-passing LAN technology. Both the Ethernet and ring networks operate at a 10 megabaud transmission rate. Two network technologies will be integrated because it is not technically feasible to implement a single Ethernet extending to all of the LaRC buildings. The total distance exceeds the one mile limitation of Ethernet. The token-passing ring does not have this distance limitation. The multiple Ethernet design allows local data traffic within an Ethernet cluster to be confined to that cluster and not impact traffic on other parts of the network. This is an important consideration since our surveys have indicated that 50-70% of total data traffic will be local.

A dedicated gateway on the ring network will provide access to the high-speed CDC LCN mainframe network. The integrated network as configured in Figure 3 will allow interconnectivity between network devices.

NETWORK CHARACTERISTICS AND CAPABILITIES

It has been necessary to set boundaries on network capability in order to develop and implement a LaRC network using reasonable resources (manpower and money). The following summarizes the capabilities of the network.

The network will support full interconnectivity: any network device will be able to communicate with any other device at both a network and application level. To provide that interconnectivity, however, it has been necessary to limit (at least initially) the kinds of equipment and the applications that will be supported. Initial implementation will accommodate only CDC Cyber mainframe computers, DED PDP/VAX minicomputers, and IBM personal computers. File transfers will be the only application initially supported.

Even though the transmission rate on the network will be 10 megabaud, the maximum throughput between any two network devices will be limited by the device throughput, which typically has been found to be less than one megabaud. All network gateways will be designed to support throughputs up to one megabaud.

The packet scheme of transmission on both the Ethernet and ring networks provides for re-transmission of data when communication errors are detected, resulting in negligible error rates on the network.

An important design criteria has been that no modifications to the computer operating systems should be required to accommodate the network software. All network software has been designed to operate external to the computer operating systems.

Finally, the network is being designed with the future in mind. The goal of the design is a network that is easily expandable and adaptable to new LAN technologies. The latter is important because rapid advancements in LAN technology result in new and improved concepts and products almost daily.

IMPLEMENTATION PLAN AND SCHEDULE

The development and implementation of the network will be in four phases. The first phase, which is now well underway, is a pilot implementation in LaRC's central scientific computing facility. The pilot effort will be completed by the end of this calendar year. The second phase will be a production implementation of the network, beginning next year, at three to six selected sites. Refinements to network design are expected to be made as a result of experience gained during the first year of production activity. The third and fourth phases of network implementation will be a continuation of production implementation at additional sites. The last phase is expected to be completed by the end of calendar year 1986.

STATUS OF NETWORK DEVELOPMENT

Installation of a ten-station Ethernet pilot network in the central computing facility has been completed. The pilot includes a CDC Cyber mainframe computer, four DEC minicomputers, and five IBM personal computers. This equipment was not purchased for the network project but is equipment that was, and continues to be used for production work. An initial, simplified version of network and file transfer software has been developed in-house for all network devices. Throughput rates of 100-450 kilobaud between network devices have been demonstrated. Typically, the limiting factor on throughput has been found to be disk I/O on the network devices. The pilot network is operational during normal working hours and is available for limited production use.

Two Ethernet clusters on the pilot have been connected to a two-node ring and primitive operation of that configuration has been demonstrated. A fully-operational three-node pilot ring with three Ethernet clusters is expected to be operational in the central computing facility by the end of this calendar year.

The work remaining during this calendar year will be to refine the network software that has been developed, adding multi-user capability and providing routing and flow control protocols that are required for the ring network.

1983 - 1992 LaRC NETWORK TOPOLOGY

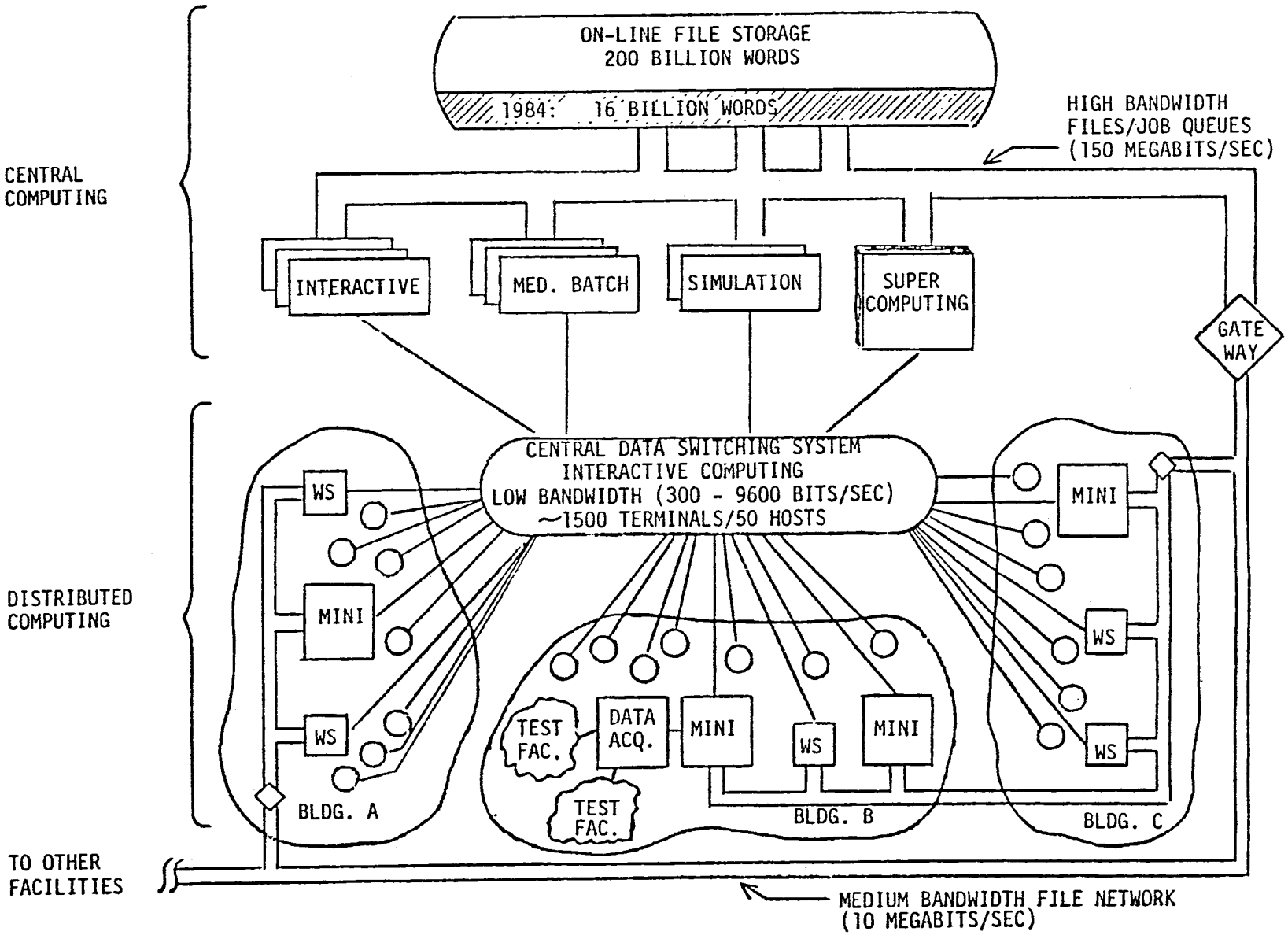

Figure 1

LaRC INTERACTIVE TERMINAL ACCESS SYSTEM

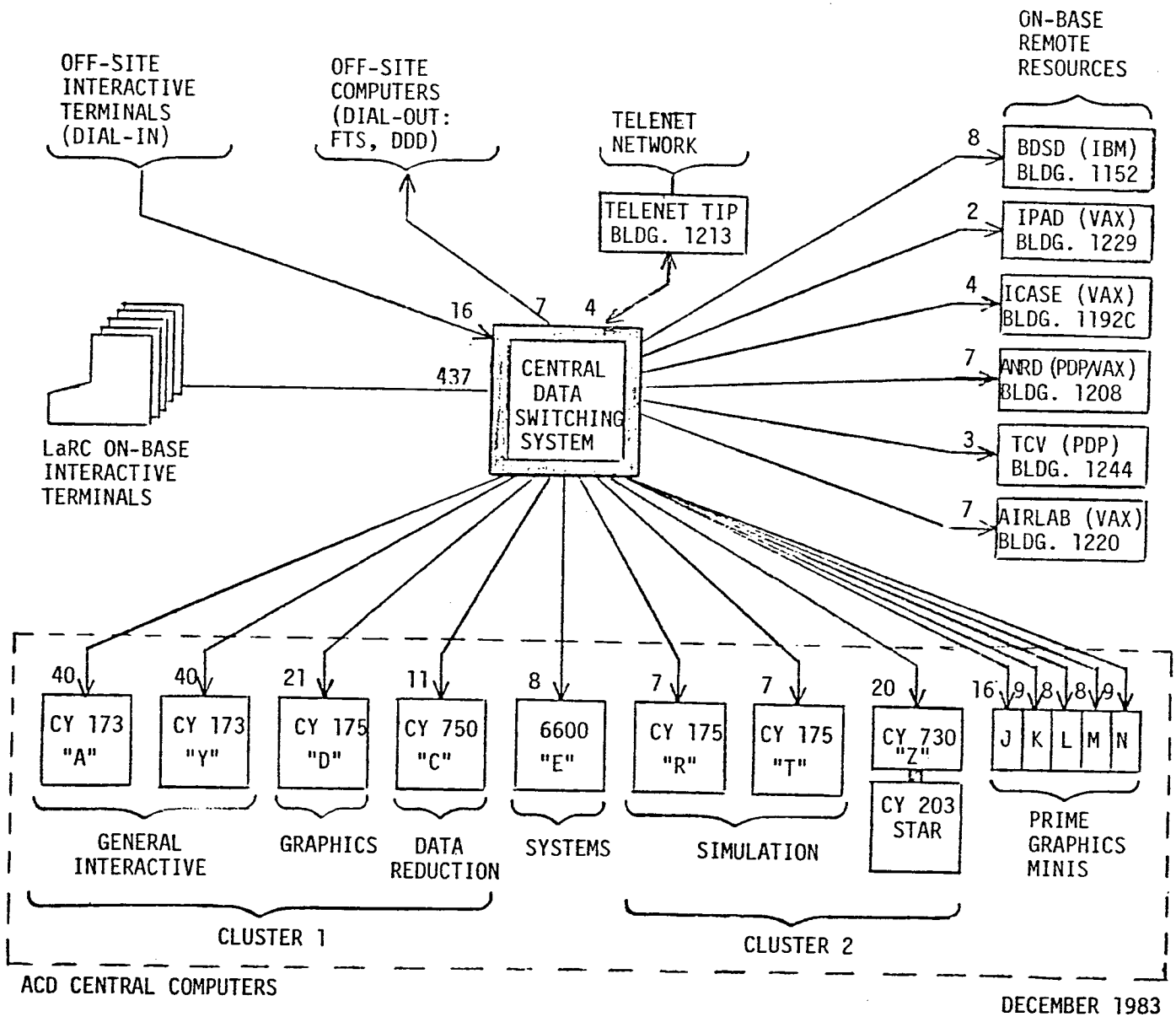

Figure 2

LaRC MEDIUM SPEED DATA NETWORK
(PROPOSED CONFIGURATION)

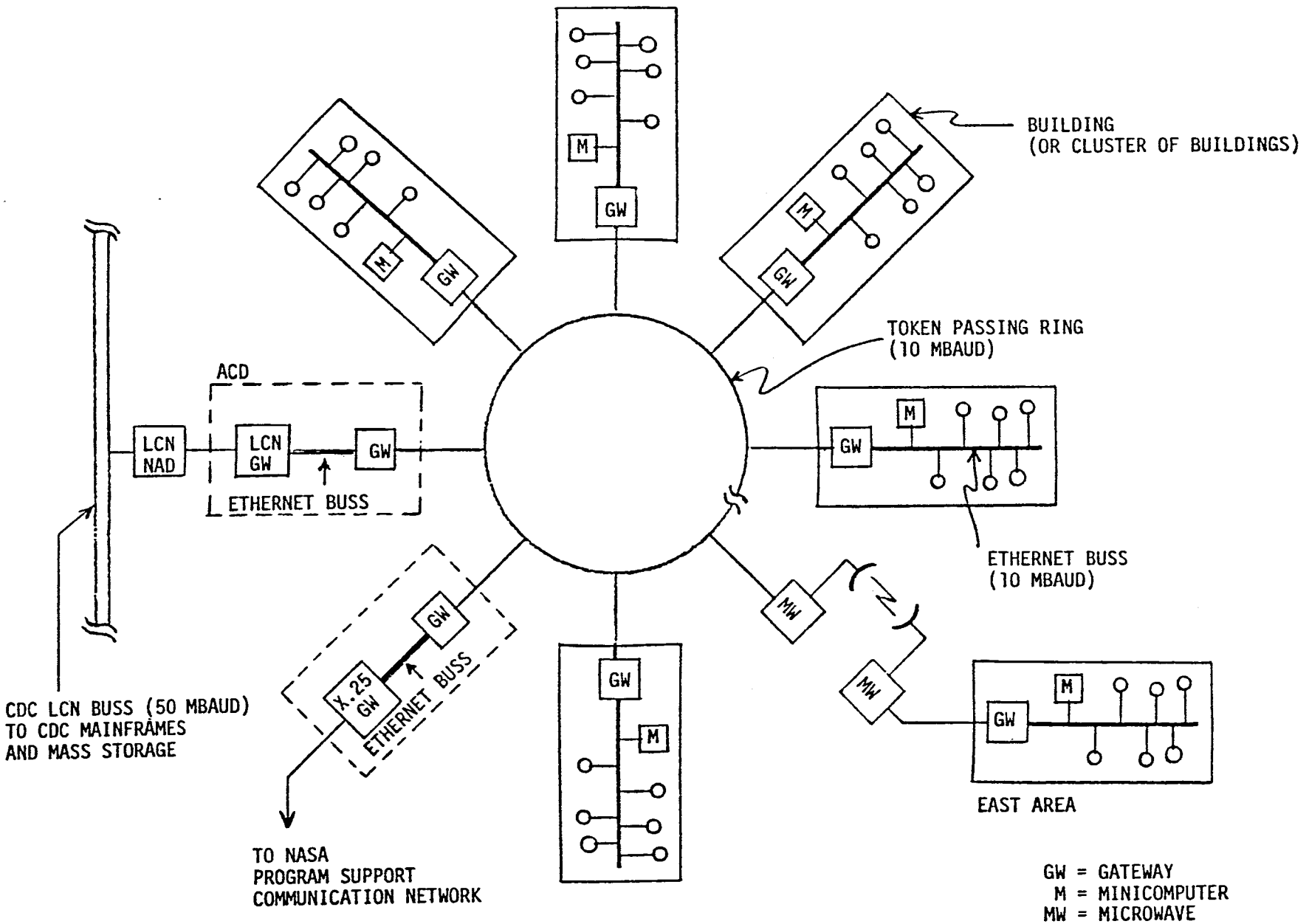

Figure 3