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**CCR210-REKAYASA PERANGKAT LUNAK**

Pertemuan Ke **11**

Oleh : **MALABAY**

Prodi : **Teknik Informatika/Sistem Informasi**

**DISTRIBUTED SYSTEM  
ARCHITECTURES**  
Disusun oleh : **Malabay**

Sumber dari :

1. [www.cs.ucv.ro/staff/dmancas/CD/en/Cap1.doc](http://www.cs.ucv.ro/staff/dmancas/CD/en/Cap1.doc)

2. [https://akgec.in/journals/6%20SHWETA%20ROY\\_Middleware%20Technology\\_%20\[pp%2033-38\].doc](https://akgec.in/journals/6%20SHWETA%20ROY_Middleware%20Technology_%20[pp%2033-38].doc).

## DISTRIBUTED SYSTEM ARCHITECTURES

### 1.1 INTRODUCTION

Distributed computing systems are concerned with the processing and communication of information between distributed communities of computer-based equipment. In general, the various types of equipment are referred to as **data terminal equipment**, or simply **DTE**. These include not only distributed communities of computers but also a wide range of other devices; for example, intelligent visual display terminals, computer-based workstations and associated equipment as used in an automated office, intelligent instrumentation equipment for the control of large industrial process plants, point-of-sale terminals as used in large department stores, microprocessor-based domestic electricity meters designed for remote reading, and many others. This wide range of devices means that there are many different types of distributed systems. For example, a system may be made up of a large community of visual display terminals physically distributed over a wide geographical area and communicating with a large centralized computing complex. Alternatively, a system may comprise a number of computer-based office workstations physically distributed around a single block of

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offices providing, for example, word processing functions and access to various shared resources, such as printers, copiers, file systems, etc.

Although the overall processing functions performed in the different, types of distributed system may vary considerably from one application to another, there is only a limited number of types of data network that may be used to provide the underlying data communication services. Moreover, the advent of international standards for both the structure and function of much of the communication software means that there is a degree of commonality, which is independent of the system's application. When designing the data communication facilities to be used with any form of distributed system, therefore, it is essential to have:

- a working knowledge of the different types of data communication networks available and their corresponding modes of operation and application areas; and
- an understanding of the various international standards that have now been established to aid the use of these networks.

### 1.2 COMMUNICATION NETWORK CLASSIFICATION

Before discussing the various types of distributed computing systems, it is perhaps helpful to outline the classification of the different types of communication networks and thus identify those networks to which the material in this course relates.

Communication networks can be classified into four categories according to the physical separation of the communicating devices:

- (1) Miniature (< 5 cm): Such networks are concerned with the interconnection of multiple computational elements that are implemented on the same integrated circuit.
- (2) Small (< 50 cm): Such networks are concerned with the interconnection of multiple computational units, which are located within a single rack, or piece of equipment.

- (3) Mean (< 1 km): Such networks are concerned with the interconnection of items of computing equipment (office workstations, intelligent instrumentation, etc.) which are distributed over a localized area, such as a university campus or process plant. They are referred to, therefore, as **local area networks** or **LANs**.
- (4) Large (> 10 km): Such networks are concerned with the interconnection of items of computing equipment (mainframe and minicomputers, computer-based terminals, etc.) which are distributed over a wide geographical area, be it countrywide or world-wide. These networks are referred to, therefore, as **wide area networks** or **WANs**.

Due to the short physical separations of the computational elements in the first two types of networks, all message (data) transfers are accomplished in a world-parallel mode using multiple - one line per bit - sets of physical conductors. Hence, these networks are referred to as **closely coupled systems**. In the second two types of networks, however, because of the wider physical separations between the computational elements, all message transfers are carried out in a bit-serial mode over a single pair of conductors. Such networks are referred to, therefore, as **loosely coupled systems**.

In general, closely coupled systems are concerned with the exchange of data (messages) between a homogeneous set of computational elements. The primary aim in such systems is to achieve minimum time overheads associated with each data transfer. Normally, this is accomplished by having an area of memory - **global** or **shared memory** - that is directly addressable by all the processing elements within the system. In this way, message transfers between elements are accomplished by passing the address pointers of messages between elements, rather than by physically transferring the complete messages.

In contrast, loosely coupled systems are concerned with the exchange of messages - or, more generally, information - between heterogeneous computers and other items of computer-based equipment. Moreover, because of their wider physical separations, messages are physically transferred (or transmitted) from one

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system to another. Hence, probability of transmission errors - bit corruptions - occurring during transfers is much higher. The primary aims in loosely coupled systems are:

- 1) to achieve reliable message transfers; that is, the data comprising the messages should not have any residual bit errors and should be delivered in the same order that it was presented; and
- 2) to ensure that the transferred messages have the same meaning in all systems; that is, they are interpreted in the same way.

To achieve these aims, loosely coupled systems use various forms of data communication networks, in addition to internationally agreed communication protocols, and it is this type of system that is the subject of this course.

### 1.3 HISTORICAL EVOLUTION

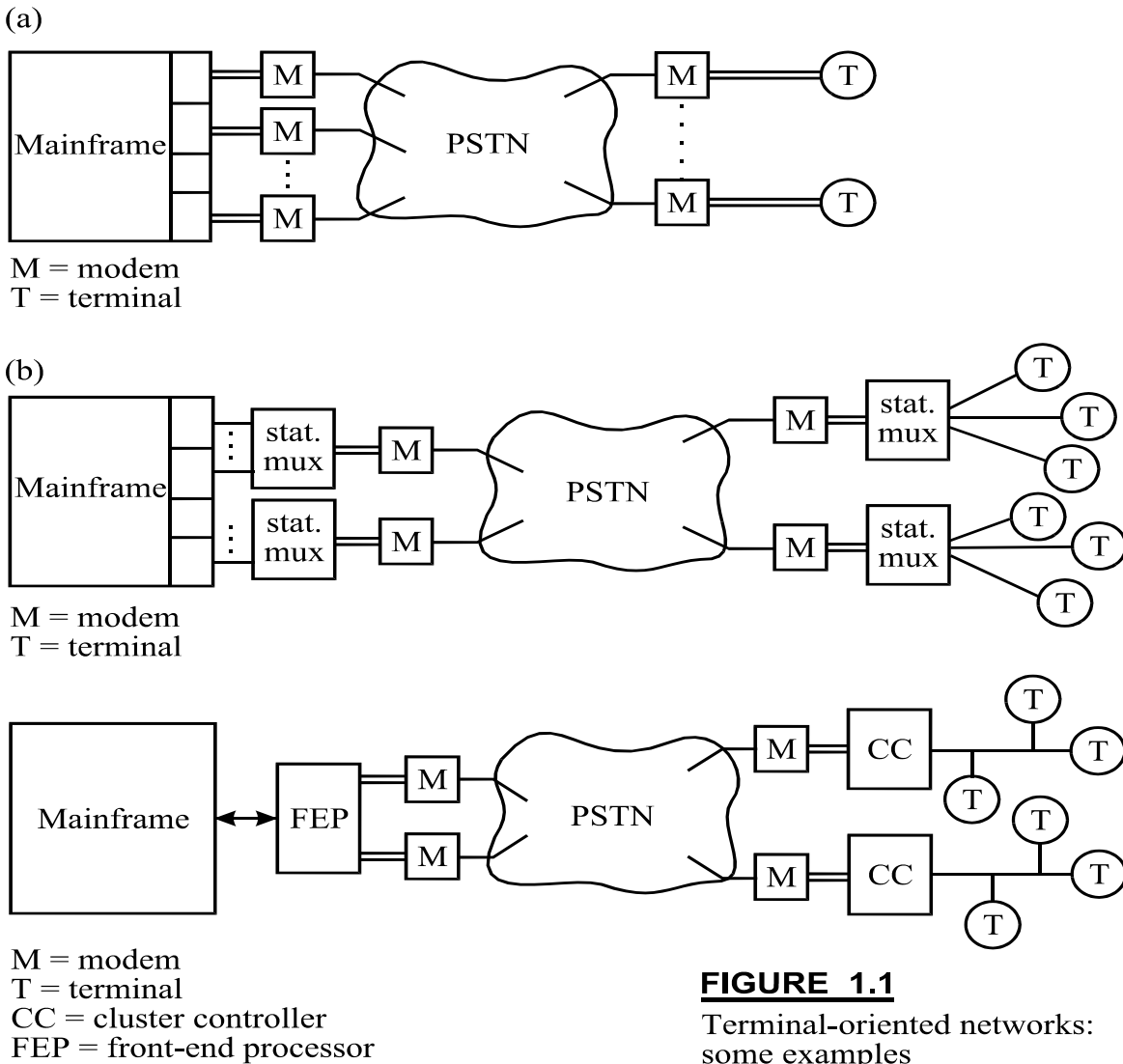
The evolution of loosely coupled distributed computing systems can perhaps best be traced by following the development of the computing resources used within any large organization. The earliest commercially available computers used were characterized by expensive hardware and relatively primitive software. Typically, an organization would purchase a single computer system, which would then be centrally located in a large, air-conditioned room. It would consist of a central processing unit (CPU) with a limited quantity of primary (RAM) memory, some secondary (tape or drum) storage, a printer, a punched-card reader and an operator console. Users normally prepared their programs and data **off-line** on a cardpunch located in a different room, and the operator would then load and run the prepared programs sequentially.

As computer technology and its operating software advanced, fast secondary storage - large magnetic drums and later disks - and multiprogramming operating systems were developed. This made it possible to **time share** the central processing unit between a number of active programs (or processes), thereby allowing multiple users to run their programs **interactively** and to access stored

data simultaneously via their own separate terminal. The terminals were normally electromechanical teletypewriters (TTYs) similar to those already in use in international telex networks. They were designed, therefore, to transmit and receive data over long distances and operated in a **serial mode**.

To exploit these developments, the computers used within organizations were upgraded to support, say, five or more such terminals. The computers then became known as **multi-access systems** providing **on-line** access to stored data. Initially, the terminals were all located in close proximity to the main computer complex but, because of their basic mode of operation, it soon became common practice to distribute the terminals: at first locally in different offices and later, with the aid of the ubiquitous switched telephone network and modems, nationally over wide geographical areas. An operational computer system typical at that time is shown in Figure 1.1(a).

The use of the switched telephone network as the basic data communication medium meant that communication line costs could no longer be regarded as insignificant and, indeed, soon constituted a substantial proportion of the system operating costs. To minimize these costs, therefore, devices such as statistical multiplexers and cluster controllers were introduced. Essentially, these allowed a single communication line - often permanently leased from the public telecommunications authorities - to be shared between a number of simultaneous users all located, for example, at the same remote site. In addition, the increasing level of usage of computers within organizations soon gave rise to systems containing many hundreds of terminals. The effect of this was that the central computer could no longer cope with the processing overheads associated with servicing the various communication lines in addition to its normal processing functions. This predicament gave rise to the front-end processor (FEP), which essentially offloaded the processing overheads associated with the various communication lines from the central machine.



**FIGURE 1.1**  
Terminal-oriented networks:  
some examples

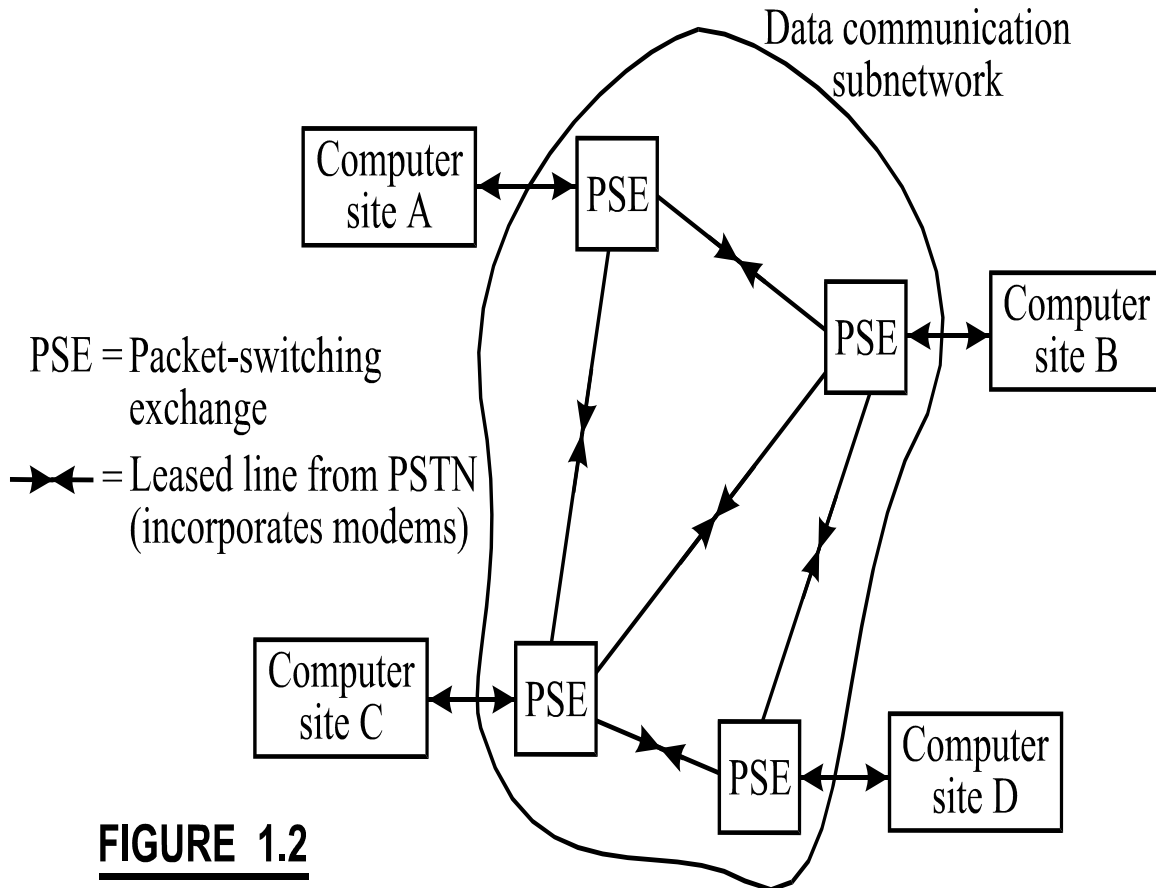
The FEP thus effectively signalled the beginning of distributed computing systems, two examples of which are shown in Figure 1.1(b).

**1.4 PRIVATE COMPUTER COMMUNICATION NETWORKS**

The structures shown in Figure 1.1 are particularly prevalent in organizations normally holding large quantities of information at a single central site, such as the major clearing banks and airlines. In such organizations, the distributed community of users access and update the information using the communication facilities outlined. However, in many organizations, it is not necessary to hold all the information centrally, and hence it soon became common place for organizations to have a number of autonomous computer systems located at different sites around

the country. Typically, these systems provided a local computing function, but there was often a requirement for them to communicate with each other, both to share resources - hardware and software - and to exchange information. To meet this type of interconnection, however, a more flexible, effectively switched communication facility was required. This development also meant that a conceptually different approach to providing the necessary data communication services had to be found as the communications link established using the switched telephone network and modems had a limited data capacity. It was at this point that it became economically more attractive to provide a separate autonomous data communication network. The requirements for such a network were in many ways similar to those provided by the normal telex network, which operates in a message store-and-forward mode. This mode, as will be expanded upon in later chapters, is ideally suited to the sporadic nature of communications between computers and other computer-related equipment.



**FIGURE 1.2**

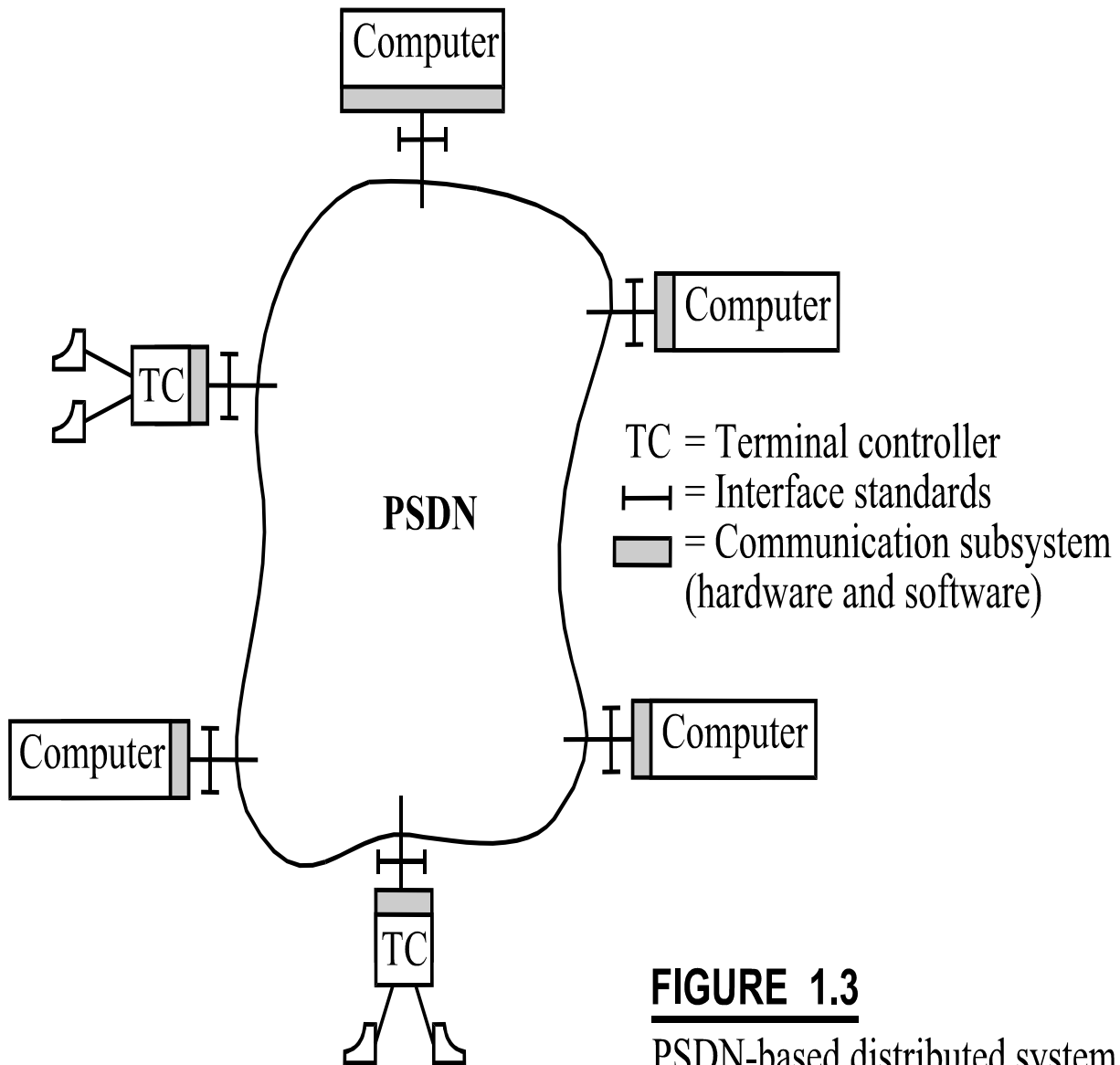
Early private computer communication network

With the telex network, the internal message units used may be long with the effect that the response time of such networks - that is, the time delay between a message entering and subsequently leaving the network can be degraded while a number of long messages are in transit. To overcome this limitation, communication networks that carry computer data normally operate using a smaller maximum message unit known as a packet. The resulting communication network is then said to operate using packet switching or in a packet store-and-forward mode. Furthermore, since the interconnected computers are normally physically distributed over a wide geographical area, such a system is also referred to as a wide area computer communication network, or WAN. This type of distributed system is shown in diagrammatic form in Figure 1.2.

## 1.5 PUBLIC-SWITCHED DATA NETWORKS

Initially, organizations implemented their own private nation-wide data communication networks using communication lines leased from the public telecommunications authorities and their own proprietary switching equipment. Consequently, the larger computer manufacturers produced suitable communication software packages to enable their computers to communicate and exchange data using these networks. With time, however, as the impact of computer technology on the operation of organizations grew, the need arose for a computer in one organization - and hence from one manufacturer - to communicate with a (possibly different) computer in another organization; for example, to transfer funds from one bank computer to another. It was at this point that the public telecommunications authorities (or PTTs, standing for Post, Telephone and Telecommunications) in a number of countries accepted that a public-switched data network (PSDN) analogous to the normal public-switched telephone network (PSTN) was justified. Moreover, since it was intended that this network should be used to provide a communication facility for the interconnection of a possibly large number of different types of equipment from a range of manufacturers, the definition of agreed interface standards became all important.

After much discussion in various standards committees, firstly at national and later at international level, a set of internationally agreed standards were defined for interfacing and controlling the flow of information between a data terminal equipment and the various types of PSDN. An increasing number of public data networks that support these standards have now been implemented. A schematic of this type of distributed system is shown in diagrammatic form in Figure 1.3.

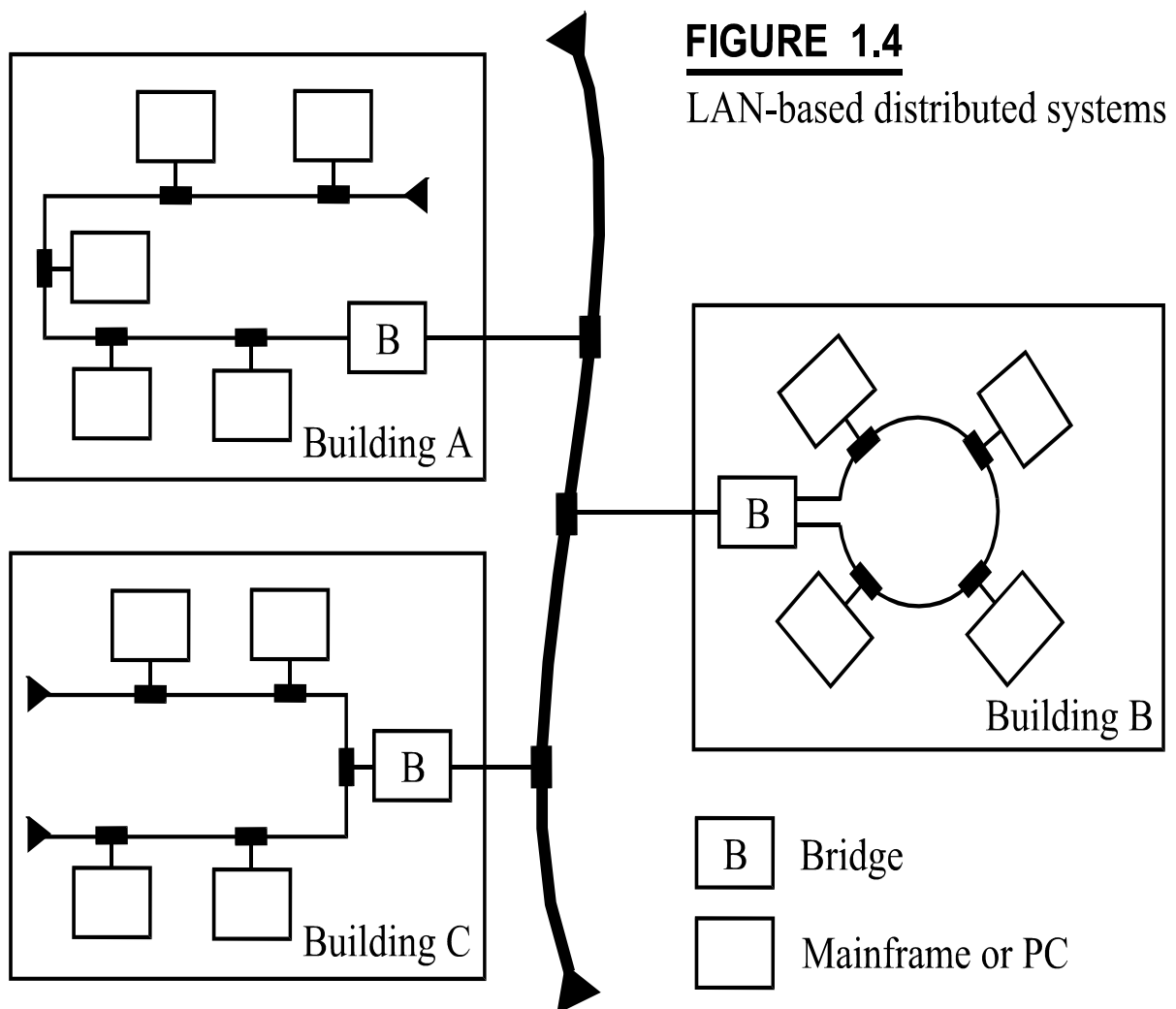


**FIGURE 1.3**  
PSDN-based distributed system

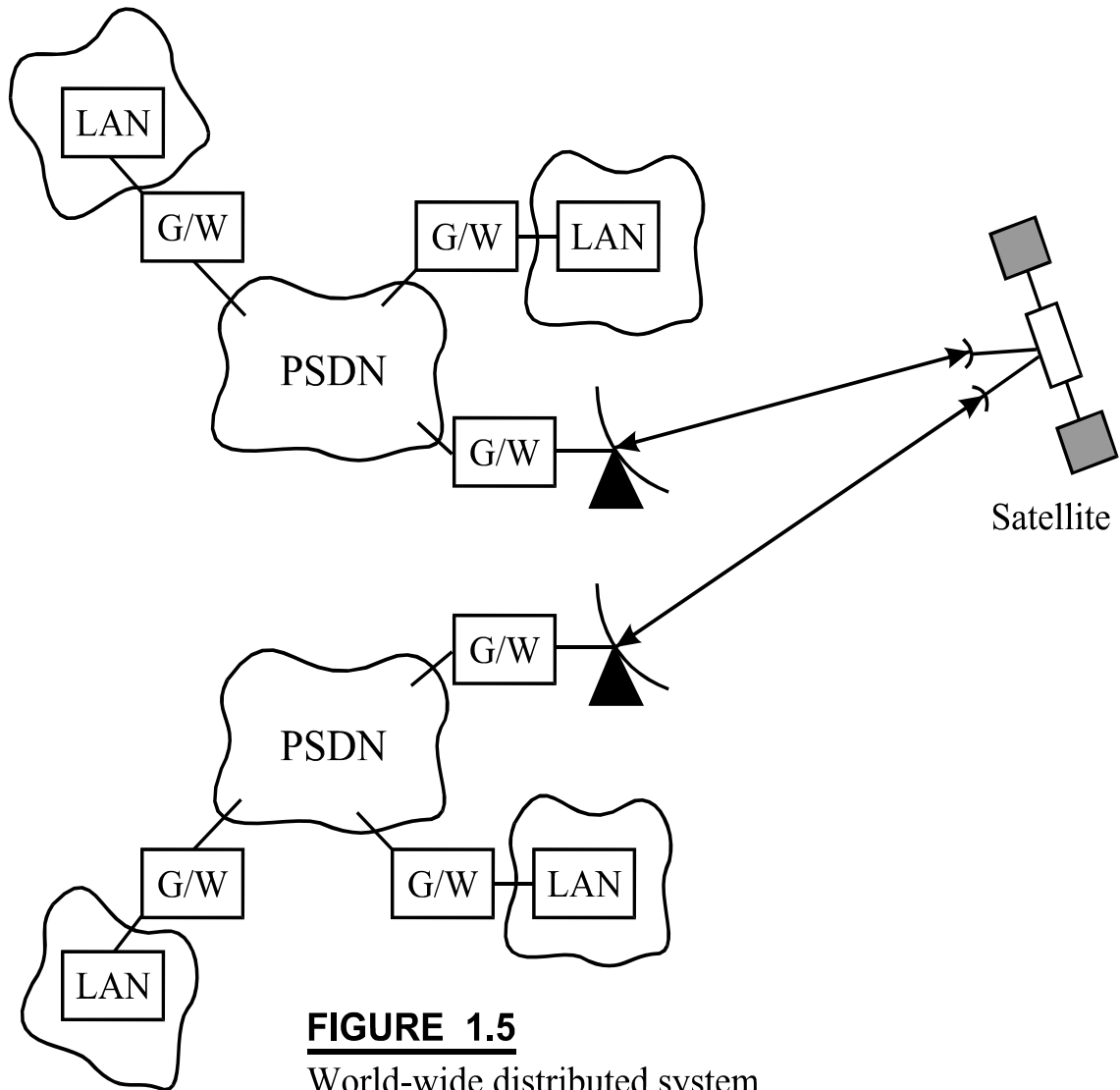
More recently, the continuing advances in integrated circuit technology have resulted in the PTTs in many countries changing the mode of operation of the conventional switched telephone network to an all digital mode of working. This means that, instead of requiring a modem to transmit data over a PSTN, it is possible to transmit data directly, and at much higher data rates than are currently used. Also, the call set-up times associated with this new generation of networks is significantly reduced. Because of their all-digital mode of working and the ability of such networks to be used for both voice and data directly, they are referred to as **integrated services digital networks or ISDNs**.

## 1.6 LOCAL AREA NETWORKS

Although the computing resources in an organization steadily increased with developing technology, the advent of the microprocessor and the associated advances in integrated circuit technology meant that, in addition to the systems just outlined, it soon became common to find a multiplicity of different computer-based devices physically located within the same building or block of offices; for example, a community of intelligent computer-based workstations performing word processing and other related functions.



Although the availability of processing power within each of these systems means that many computing tasks can be carried out locally, in many cases there is often a requirement for these systems to communicate with each other; for example, to exchange (electronic) mail or to access an expensive shared resource, such as a supercomputer for performing a specialized computing task. Since the linked computing devices in this type of network are physically located close to one another within the same organization, the communication facility provided is referred to as a private local area data network, or simply LAN. It is perhaps not surprising that there are a number of different types of LAN, both in terms of their topology and their mode of operation, since each has been designed for use in a different application domain. Thus, there are LANs that have been designed for use in technical and office environments, LANs for use in manufacturing industry, and so on. An example of typical LAN-based distributed systems is shown in Figure 1.4.



**FIGURE 1.5**  
World-wide distributed system

Although the architecture shown in Figure 1.4 is typical of those used within a single organization, an increasing number of large organizations are establishing countrywide and indeed world-wide communication networks. In this way, a system such as an advanced workstation connected to a LAN in one part of a country can communicate in a transparent way - that is, without any regard to its physical location - with a system connected to an LAN in a different part of the country or indeed a different country.

Typically, the intermediate link between the two LANs may be through one or more public data networks with, possibly, a satellite link between them. This is shown in diagrammatic form in Figure 1.5.

The devices that form the link between the various networks are known as internetwork bridges (to link together two LANs) and internetwork gateways (to link together a LAN and a PSDN), respectively.

#### IV. MIDDLEWARE APPLICATIONS

Middleware services provide a more functional set of application programming interfaces to allow an application to:

- Locate transparently across the network, thus

providing interaction with another service or application.

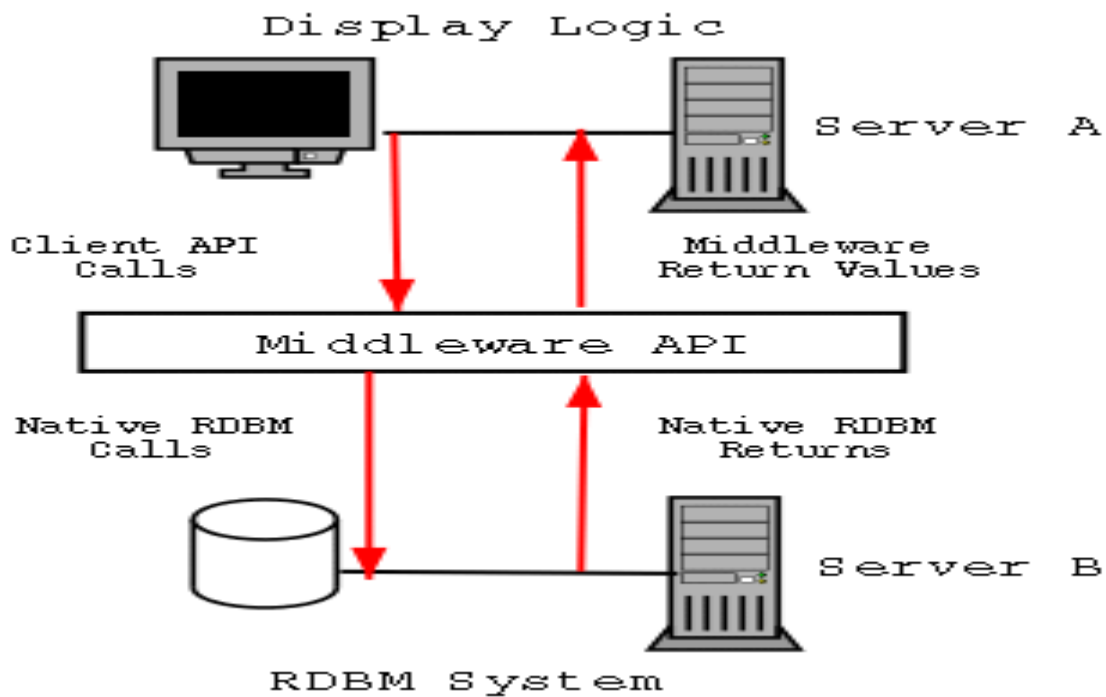


Figure 3 **Middleware in Client-server architecture**

- Be independent from network services
- Be reliable and available always when compared to the operating system and network services.

## V. TYPES OF MIDDLEWARE

*Hurwitz's classification system organizes the many types of middleware that are currently available.. These classifications based on scalability and recoverability are mentioned below.*

*Remote procedure call (RPC) is an Inter-process communication technology that allows a computer program to cause a subroutine or procedure to execute in another address space without the programmer explicitly coding the details for this remote interaction.*

Thus, the programmer would write essentially the same code whether the subroutine is local to the executing program, or remote. When the software in question is written using object-oriented principles, RPC may be referred to as remote invocation or remote method invocation. Client makes calls to procedures running on remote systems, which can be asynchronous or synchronous.



## EVOLUTION OF MIDDLEWARE TECHNOLOGY

Message Oriented Middleware—Message-oriented middleware (MOM) is a client/server infrastructure that increases the interoperability, portability, and flexibility of an application by allowing the application to be distributed over multiple heterogeneous platforms. It reduces complexity of developing applications that span multiple operating systems and network protocols by insulating the application developer from details of various operating system and network interfaces.

APIs that extend across diverse platforms and networks are typically provided by the MOM. MOM is software that resides in both portions of client/server architecture and typically supports asynchronous calls between the client and server applications. Message queues provide temporary storage when the destination program is busy or not connected.

MOM reduces the involvement of application developers with the complexity of the master-slave nature of the client/server mechanism.

MOM comprises a category of inter-application communication software that generally relies on asynchronous message-passing, as opposed to a request-response metaphor.

Most message-oriented middleware depend on a message queue system, but there are some implementations that rely on broadcast or multicast messaging systems.

Messages sent to the client are collected and stored until they are acted upon, while the client continues with other processing.

Object Request Broker — In distributed computing, an object request broker (ORB) is a piece of middleware software that allows programmers to make program calls from one computer to another via a network. ORBs promote interoperability of distributed object systems because they enable users to build

systems by piecing together objects from different vendors that communicate with each other via the ORB.

ORB's handle the transformation of in-process data structures to and from the byte sequence, which is transmitted over the network. This is called marshalling or serialization.

Some ORB's, such as CORBA-compliant systems, use an Interface Description Language (IDL) to describe the data which is to be transmitted on remote calls.

In addition to marshalling data, ORB's often expose many more features, such as distributed transactions, directory services or real-time scheduling.