facilities since it is developed inside a company's building. Although there are some examples of outsource LAN's, they have to operate through the telecom facilities.

COMPUTER NETWORKS LAYER

This layer interconnects computers and applies the Telecommunications Layer for information's physical transmission. If telecommunications services are invisible for end-users, this layer is visible for them.

LAN

Local Area Networks (LAN) allow a great number and variety of user computers and devices such as printers to exchange large amounts of information at high speed over limited distances. LAN interconnects users within an area of 16 miles. LAN is a private network. Design elements for LAN fall into three main categories (Digital, 1982):

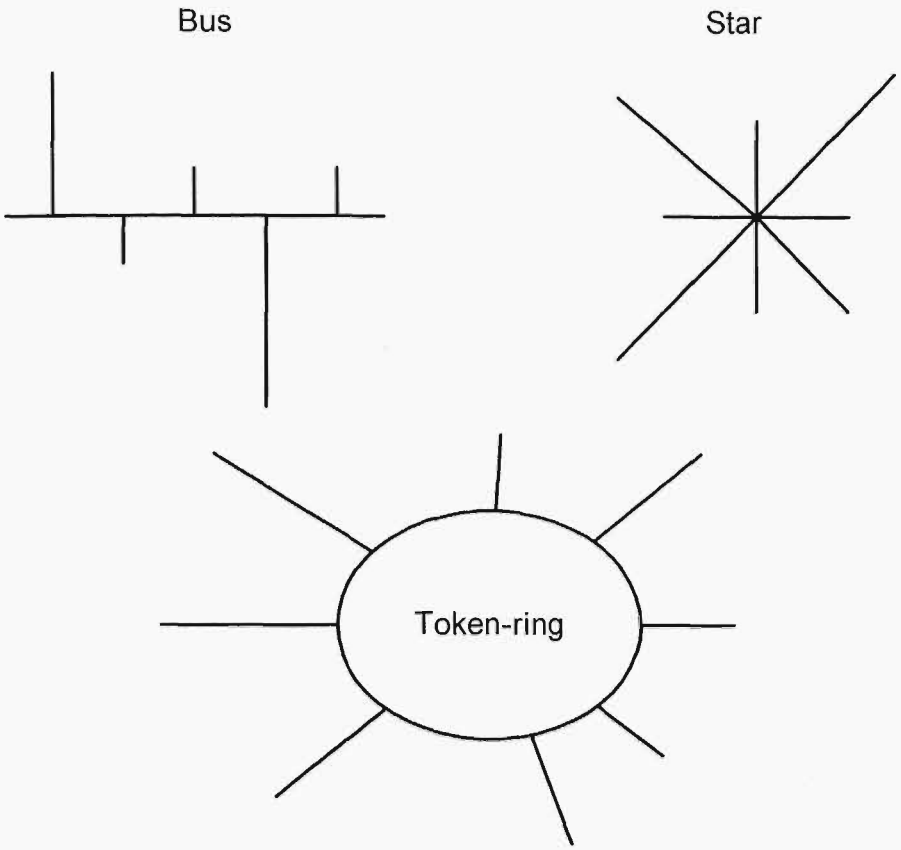
- Topology
- Access and control methods

A network topology is created by the geometric arrangements of the link and nodes that make up a network. A link (also called a line, channel or circuit) is the communications paths between two nodes. A node can be defined as an end point to any branch of a network. The hardware and software chosen for each node is determined by the functions of that node in the network.

Most LAN's are based on simple structure topologies, like the bus, star or ring. These topologies are shown in Figure 3-2.

Bus topology is organized as an open ring. Messages placed on the bus are broadcast out to all nodes. Nodes must be able to recognize their own address in order to receive transmissions. However, unlike nodes in a ring, they do not have to repeat and forward messages intended for other nodes. As a result, there is neither the delay nor the overhead associated with retransmitting messages at each intervening node, and nodes are relieved of network control responsibility at this level. The bus topology is now the most popular solution. Its commercial name is Ethernet, which has a branching-bus topology, with a

Figure 3-2: LAN Topologies



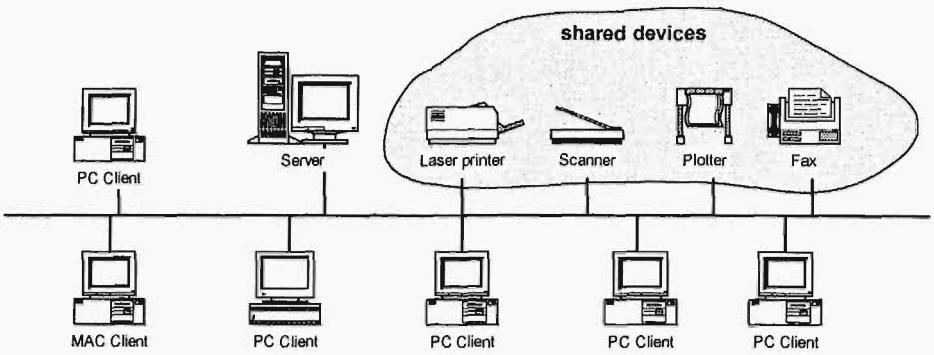
maximum distance of 1.6 miles between the two furthest nodes. Up to 1,024 nodes can be tapped onto the Ethernet coaxial cable, allowing a connection of thousands of devices.

Star topology is frequently used for networks in which control of the network is located in the central node or switch. When this is the case, all routing of network messages traffic – from the central node to outlying nodes, between outlining nodes and from nodes to remote points – is performed by the central node. This has the effect of relieving outlining nodes of the control

function. In all star networks the central control is a single point of network failure. If it goes down, so does the entire network. The star topology is often seen in academic timesharing systems, with the central node serving as the timesharing host. It is also quite common in PBX telephone networks, adapted as LAN.

Ring topology has nodes connected in an unbroken circular manner. Transmitted messages travel from node-to-node around the ring. Each node must be able to recognize its own address in order to accept a message. In addition, each node serves as an active repeater, retransmitting messages addressed to other nodes. To transmit a message, a node has to receive a token from the network server. Then, the node with a token gains exclusive access to the channel.

Figure 3-3: LAN Components



LAN is a popular solution of the client/server computer configuration, where the following devices are interconnected: servers, clients, and share printers, OCR readers, scanners, and high-resolution monitors (Figure 3-3). It is also an infrastructure for the Intranet.

MAN

A Metropolitan Area Network (MAN) is usually a public network which interconnects LAN's, hosts, and clients of many organizations located in the same metropolitan area within a radius of 60 miles. Some of the applications of MAN's include:

- Remote online transactions processing,
- Host-to-host (channel-to-channel) connections,
- CAD to CAM interconnection,
- Teleconferencing,
- Gateway to Wide and Global Area Networks,
- Other.

MAN is implemented in a dual ring architecture which in case of a node breakdown will send a message by the second unbroken bus. MAN's are built of fiber-optic cable which allows for the speed of 100+ MB/s. Control of MAN is provided by the central node equipped in the Switched Multi-Megabit Data Service (SMMDS).

WAN and VAN

Wide Area Network (WAN) can be a private or public telecommunications network over a large geographic area such as a state or country. Mainframes, minicomputers, microcomputers, workstations, and terminals can be linked together using inter-exchange carrier circuits (AT&T, MCI, US Sprint), satellites, or microwave relay links. WAN's transport information without significant enhancement or change of character in information (Figure 3-4).

A national WAN interconnects a company's different LAN's and MAN's into one national Enterprise Information Infrastructure. Here are some examples of WAN applications:

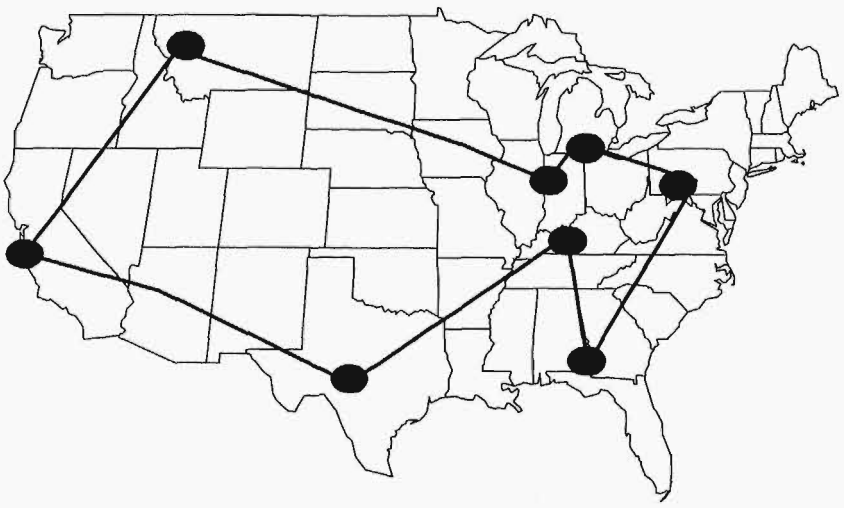
- Internal e-mail,
- Internal teleconferencing,
- Internal workgroup collaboration,
- Remote and online transactions processing,

- On-line enterprise database retrieval,
- CAD-CAM connection,
- Computer power leveling,
- EDI,
- EFT,
- Internet,
- Intranet,
- Other.

The architecture of WAN's has been evolving in two directions:

1. Circuit switching networks, mostly proprietary IBM, Compaq (Digital), HP, and Unisys networks based on leased circuits from long-distance telecommunications companies. Regardless of transmitted information volume, the circuit's provider charges the user on per time base.

Figure 3-4: Wide Area Network in a Ring Topology



2. Public switching networks (PSN) transmit information in packets and charge the user per information sent volume. These networks are more effective for users.

The public packet switching networks are called Value Added Networks (VAN) since they provide additional services for the users, such as problem shooting, private network management, storage renting, and software renting, as well as training and turn-key installation of networks. Among the largest VAN's one can recognize:

- Telenet, the world's largest network, owned by U.S. Sprint with nodes in all major American and world cities
- Tymnet, owned by Boeing (after the merger with McDonnell Douglas), provides local access for users of America on Line, Prodigy and other similar services
- Accunet, owned by AT&T, covers all major American cities
- National networks in a majority of developed and developing countries

GAN and VAN

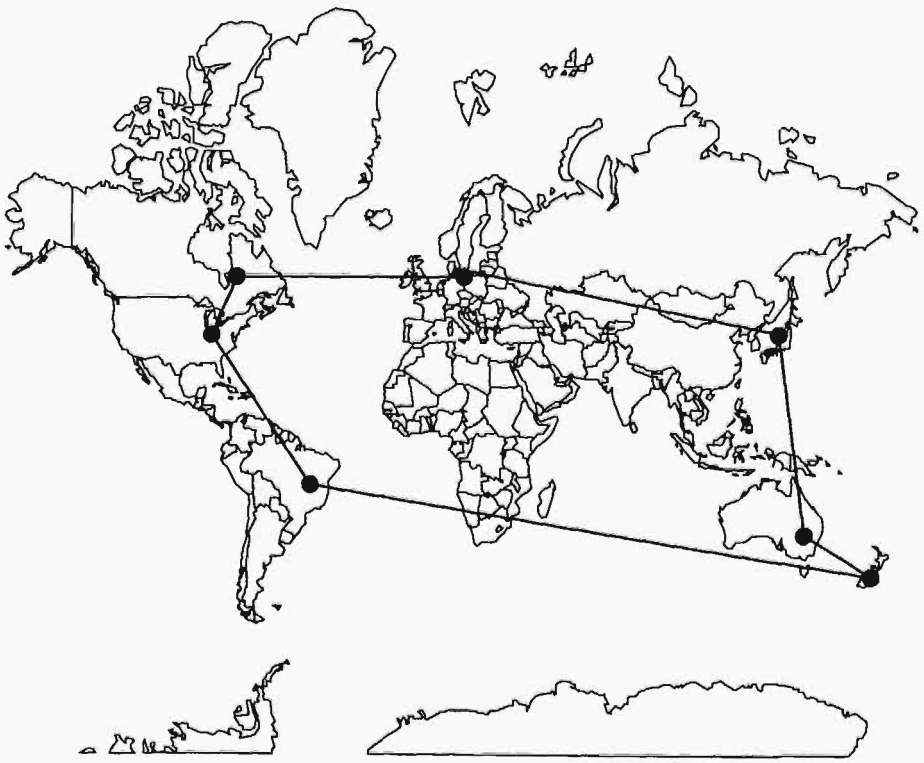
To support the development of a global economy and its global corporations, called consortia, Global Area networks (GAN) are implemented at the international level. GAN's interconnect LAN's, MAN's, and WAN's from different countries. Among the most popular applications transmitted through GAN's are the following ones:

- Global purchasing,
- Global inventory control,
- Global distribution,
- Global trading of commodities and stocks,
- Global fund transfer,

- EDI,
- E-commerce,
- Teleconferencing,
- Global service or production scheduling,
- Global human resources management,
- Other.

GAN's can be private or public. The latter is a typical VAN, which can support all users' needs, from the network installation to trouble shooting and

Figure 3-5: Global Area Network in a Ring Topology



private network management. The architecture of a GAN is illustrated in Figure 3-5.

INTERNET LAYER

Internet

The Internet is a public, global network of web-driven computers (servers) that provide free access to the majority of info-communication services for individual and organizational users. The Internet is an international computer network of networks that connect government, academic, and business institutions as well as individual users. In the 1960's the Department of Defense developed the Internet. Its first Wide Area Network was called the ARPANET after the name of the Advance Research Project Agency. Then in 1983 ARPA opened the ARPANET for public applications, and since then this network has been called the Internet. It is an open system since the technical specification needed to build Transmission Control Protocol and Internet Protocol (TCP/IP) is open for everyone who wants to develop network tools and applications. By the year 2000, the Internet was used by several million servers and over 100 million individuals. The Internet as a whole reaches around the globe, connects computers from personal computers to supercomputers, and is not administered by a single authority.

The Internet architecture is shown in Figure 3-6, which is composed of the following components:

- Backbone Network Services at the speed of 3 TB (Tera Bits per second = 1000 GB per second) between the Internet main nodes composed by the computer super centers;

- Internet Registrars are responsible for registering Internet domain names, such as *www.cnn.com*, to people and organizations. They are overseen by boards made up of representatives from private and public institutions;

- Internet Registry tracks the connections between Internet addresses such as 125.34.24.21 and domain such as *www.zdnet.com*;

- Internet Society steers the direction of the Internet and its development in the scope of its technological and architectural issues, e.g., how TCP/IP and other Internet protocols should work.