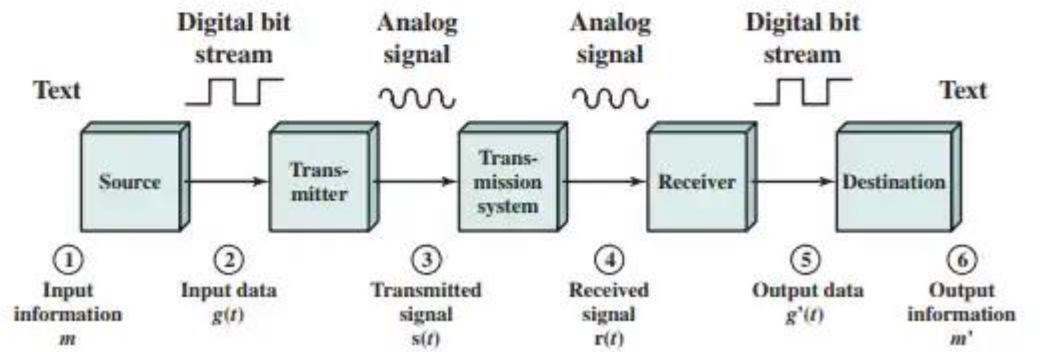
Data Communications – Networks

The user of the PC wishes to send a message m to another user. The user activates the electronic mail package on the PC and enters the message via the keyboard (input device). The character string is briefly buffered in main memory. We can view it as a sequence of bits (g) in memory. The personal computer is connected to some transmission medium, such as a local area network, a digital subscriber line, or a wireless connection, by an I/O device (transmitter), such as a local network transceiver or a DSL modem. The input data are transferred to the transmitter as a sequence of voltage shifts [g(t)] representing bits on some communications bus or cable. The transmitter is connected directly to the medium and converts the incoming stream [g(t)] into a signal [s(t)] suitable for transmission.



The transmitted signal s(t) presented to the medium is subject to a number of impairments. Thus, the received signal r(t) may differ from s(t). The receiver will attempt to estimate the original s(t), based on r(t) and its knowledge of the medium, producing a sequence of bits g′(t). These bits are sent to the output personal computer, where they are briefly buffered in memory as a block of bits (g′). In many cases, the destination system will attempt to determine if an error has occurred and, if so, cooperate with the source system to eventually obtain a complete, error-free block of data. These data are then presented to the user via an output device, such as a printer or screen. The message (m′) as viewed by the user will usually be an exact copy of the original message (m). Now consider a telephone conversation. In this case the input to the telephone is a message (m) in the form of sound waves. The sound waves are converted by the telephone into electrical signals of the same frequency. These signals are transmitted without modification over the telephone line. Hence the input signal g(t) and the transmitted signal s(t) are identical. The signal s(t) will suffer some distortion over the medium, so that r(t) will not be identical to s(t). Nevertheless, the signal r(t) is converted back into a sound wave with no attempt at correction or improvement of signal quality. Thus, m′ is not an exact replica of m. However, the received sound message is generally comprehensible to the listener.

Networks

One type of network that has become commonplace is the local area network. Indeed, LANs are to be found in virtually all medium- and large-size office buildings. LANs, especially Wi-Fi LANs, are also increasingly used for small office and home networks. As the number and power of computing devices have grown, so have the number and capacity of LANs found in business networks. The development of internationally recognized standards for LANs has contributed to their proliferation in enterprises. Although Ethernet has emerged as the dominant LAN architecture, business managers still have choices to make about transmission rates (ranging from 100 Mbps to 100 Gbps) and the degree to which both wired and wireless LANs will be combined within an enterprise network. Interconnecting and managing adiverse collection of local area networks and computing devices within today's business networks presents ongoing challenges for networking professionals.

A business need for a robust network to support voice, data, image, and video traffic is not confined to a single office building or LAN; today, it is an enterprise wide communication requirement. Advances in LAN switches and other data communication technologies have led to greatly increased local area network transmission capacities and the concept of integration. Integration means that the communication equipment and networks can deal simultaneously with voice, data, image, and even video. Thus, a memo or report can be accompanied by voice commentary, presentation graphics, and perhaps even a short video introduction, demonstration, or summary. Image and video services that perform adequately within LANs often impose large demands on wide area network transmission and can be costly. Moreover, as LANs become ubiquitous and as their transmission rates increase, the need for enterprise networks to support interconnections among geographically dispersed areas has increased. This, in turn, has forced businesses increase wide area network transmission and switching capacity. Fortunately, the enormous and ever-increasing capacity of fiber optic and wireless transmission services provides ample resources to meet these business data communication needs. However, the development of switching systems that are capable of responding to the increasing capacities of transmission links and business communication traffic requirements is an ongoing challenge not yet conquered.

The opportunities for a business to use its enterprise network as an aggressive competitive tool and as a means of enhancing productivity and slashing costs are great. When business managers understand these technologies, they can deal effectively with data communication equipment vendors and service providers to enhance the company's competitive position.

Wide Area Networks

Wide area networks generally cover a large geographical area. They often require the crossing of public right-of-ways, and typically rely at least in part on circuits provided by one or more common carriers—companies that offer communication services to the general public. Typically, a WAN consists of a number of interconnected switching nodes. A trans-mission from any one device is routed through these internal nodes to the specified destination device. These nodes (including the boundary nodes) are not concerned with the content of the data; rather, their purpose is to provide a switching facility that will move the data from node to node until they reach their destination. Traditionally, WANs have been implemented using one of two technologies: circuit switching and packet switching. Subsequently, frame relay and ATM networks assumed major roles. While ATM and, to some extent frame relay, are still widely used, their use is gradually being supplanted by services based on gigabit Ethernet and Internet Protocol technologies. Circuit Switching In a circuit-switching network, a dedicated communications path is established between two stations through the nodes of the network. That path is a connected sequence of physical links between nodes. On each link, a logical channel is dedicated to the connection. Data generated by the source station are transmitted along the dedicated path as rapidly as possible. At each node, incoming data are routed or switched to the appropriate outgoing channel without delay. The most common example of circuit switching is the telephone network.

Packet Switching

In a packet-switching network, it is not necessary to dedicate transmission capacity along a path through the network. Rather, data are sent out in a sequence of small chunks, called packets. Each packet is passed through the network from node to node along some path leading from source to destination. At each node, the entire packet is received, stored briefly, and then transmitted to the next node. Packet-switching networks are commonly used for terminal-to-computer and computer-to-computer communications.

Frame Relay

Packet switching was developed at a time when digital long-distance transmission facilities exhibited a relatively high error rate compared to today's facilities. As a result, there is a considerable amount of overhead built into packet switching schemes to compensate for errors. The overhead includes additional bits added to each packet to introduce redundancy and additional processing at the end stations and the intermediate switching nodes to detect and recover from errors.

With modern high-speed telecommunications systems, this overhead is unnecessary and counterproductive. It is unnecessary because the rate of errors has been dramatically lowered and any remaining errors can easily be caught in the end systems by logic that operates above the level of the packet-switching logic. It is counterproductive because the overhead involved soaks up a significant fraction of the high capacity provided by the network.

Frame relay was developed to take advantage of these high data rates and low error rates. Whereas the original packet-switching networks were designed with a data rate to the end user of about 64 kbps, frame relay networks are designed to operate efficiently at user data rates of up to 2 Mbps. The key to achieving these high data rates is to strip out most of the overhead involved with error control.

ATM

Asynchronous transfer mode, sometimes referred to as cell relay, is a culmination of developments in circuit switching and packet switching. ATM can be viewed as an evolution from frame relay. The most obvious difference between frame relay and ATM is that frame relay uses variable-length packets, called frames, and ATM uses fixed-length packets, called cells. As with frame relay, ATM provides little overhead for error control, depending on the inherent reliability of the transmission system and on higher layers of logic in the end systems to catch and correct errors. By using a fixed packet length, the processing overhead is reduced even further for ATM compared to frame relay. The result is that ATM is designed to work in the range of 10s and 100s of Mbps, and in the Gbps range.

Local Area Networks

As with WANs, a LAN is a communications network that interconnects a variety of devices and provides a means for information exchange among those devices. There are several key distinctions between LANs and WANs:

1. The scope of the LAN is small, typically a single building or a cluster of buildings. This difference in geographic scope leads to different technical solutions, as we shall see.

2. It is usually the case that the LAN is owned by the same organization that owns the attached devices. For WANs, this is less often the case, or at least a significant fraction of the network assets is not owned. This has two implications. First, care must be taken in the choice of LAN, because there may be a substantial capital investment (compared to dial-up or leased charges for WANs) for both purchase and maintenance. Second, the network management responsibility for a LAN falls solely on the user.

3. The internal data rates of LANs are typically much greater than those of WANs. LANs come in a number of different configurations.

The most common are switched LANs and wireless LANs. The most common switched LAN is a switched Ethernet LAN, which may consist of a single switch with a number of attached devices, or a number of interconnected switches. The most common type of wireless LANs are Wi-Fi LANs.