TELECOMMUNICATIONS

Equipment Fundamentals and Network Structures

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Equipment Fundamentals and Network Structures

TO SPECIAL AGENTS OF HAPPINESS:

My Mother, Nicholetta

Carol Ware Coughlin

Almira Figueira

PREFACE

Modern technology began in the 1950's and 1960's, with the development of transistor technology. At first it was useful in improving the performance of voice communications. But then it made possible extraordinary computer capability in manageable size—and at manageable cost. First came large mainframe computers for only the largest companies; and later the microcomputer as we know it today.

The increasing use of computers, in the 1960's with their ability to manipulate and store vast quantities of information, stimulated the need for computers to communicate with one another and so telephone circuits had to be segregated and conditioned specifically for computer traffic, using the modem. Computers ushered in a new era of business communications in which data could be developed, manipulated, stored or transmitted with remarkable ease.

The recent pace of technological advancement has been breathtaking and, today, the distinction between communications and computers is no longer even necessary. Computers, at the very core of communications networks, route and control communications on major common carriers.

The decade of the 1980's is bearing the fruits of the marriage of computers and communications. For the first time networks are enabling organizations to utilize the combined processing power of computers and communications equipment.

Hence both engineering and communications managers must have a thorough knowledge of telecommunications technology to meet the challenges of assembling such networks. These professionals will shape the electronic products and systems that will allow such activities as banking, education, travel, manufacturing and medical diagnostics to be performed more efficiently. By adding communications capability to these systems, users can benefit from having fast and direct access to the enormous power of the computer.

The attempt of this book is to set in perspective the operating principles that underlie the various telecommunications equipment and network structures used to grow these systems. Having understood the basics, the communications manager can make the proper technology choice for his applications. The book also serves as a user guide to equipment that can fulfill requirements for setting up such networks.

A special thank you to Debby Garcia for her assistance in typing and preparation of this work.

Vince Coughlin

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1.1 A TELECOMMUNICATIONS OVERVIEW

The many uses of telecommunications will change work patterns, leisure time, education, health care and industry.

Communications satellites will generate their own energy from sunlight in space. New optical-fiber cables and semiconductor lasers will work with them to replace copper wire. Such satellites and fibers could transmit all the information the human race could possibly use. Whatever the limits to growth in other fields, there are no limits near in telecommunications and electronic technology.

Imagine a home ten or twenty years in the future, with television sets which can pick up international channels, and also be used in conjunction with small keyboards to provide a multitude of communication services. The home has cabling under the streets and new forms of radio provide all manner of communication facilities.

Restaurants and stores all accept bank cards, which are read by machines that automatically transfer funds between bank accounts by telecommunications. Citizens can wear radio devices for automatically calling police or ambulances if they wish. Homes have burglar and fire alarms connected to the police and fire stations.

To avoid unemployment, long weekends have become normal and are demanded by the labor unions. Paperwork is largely avoided by having computers send orders and invoices directly to other computers and by making most financial settlements, including salary payments, by automatic transmission of funds into appropriate bank accounts. What was once called the office-of-the-future has become as conventional as vending machines, and with plasma screens in briefcase lids, people take their office-of-the-future home with them.

1.1.1 Smart Telecom Banking Card Systems

Microchips are being placed in plastic cards that we carry in wallets, purses, and shirt pockets. "Smart" cards (cards containing microchips that can compute as well as hold data) could open a new frontier to designers of information systems, distributing processing power directly into the hands of the general public.

The smart card is made of a piece of plastic, incorporating an integrated-circuit chip with memory and computational capabilities. The memory is nonvolatile so it does not lose its contents when power is shut off.

The bank issues the card to an account holder, personalizing it with that individual's account number and choice of personal identification number (PIN) and inserting a secret code word associated with the bank. The bank also sets a monthly spending limit for the card. Only a bank official armed with the bank's code word can make or change an authorization, and only someone knowing the card holder's PIN can draw against it.

At the point of sale, the card is plugged into a terminal that has a separate customer keypad to protect privacy. The sales amount entered by the sales clerk through the main keyboard is displayed on the customer's keypad, and if it is acceptable, the customer enters his PIN. If this PIN agrees with the one stored inside the card and if the store's terminal has previously been activated by a legitimate store-owner's card, the transaction can proceed.

The terminal determines whether the purchase amount, plus the sum of the past month's purchases read from the customer's card, exceed the monthly authorization on the card. If there is enough credit left, the transaction is completed, and the transaction date and amount is written into the customer's card.

At the same time the date, amount, and the purchaser's account number are entered into an electronic memory inside the store's terminal. In this "store and forward" terminal attachment mode, an entire transactions file is delivered—daily or at any convenient interval—to the store's bank via a dialed telephone line or by physically transporting the memory module to the bank. The bank clears the transactions by the electronic funds transfer (EFT) from the purchaser's account to the store's account.

This transactional system performs virtually the same functions as automatic teller machines (ATMs) and self-service travelers' check dispensers, but it differs fundamentally from them by using the computational capability and memory of the smart card in place of the on-line capabilities of a host computer.

The smart card could "personalize" communications terminals, such as home terminals and telephones, acting both as the payment vehicle and the record keeper. It would be very helpful in the medical-services field, using its computational power to authenticate claims and carry personal medical histories and treatment records between interdependent, but separate, medical-information systems. It could become a social-services eligibility card, reducing the costs and errors of paper-based systems. It could replace identification documents, such as passes to secured areas, passports, and alien identification cards.

1.2 UNDERSTANDING THE BASICS

In order to understand current trends in telecommunications and to appreciate the direction of future trends, it is necessary to understand the basics.

Let us first look at the elements of a basic telecom network. A network is an arrangement of transmission, switching, signaling and terminal equipment. The transmission system provides the electrical path for information to flow from one location to another. Switching includes identifying and connecting independent transmission links to form a continuous path from one location to another. Signaling involves supplying and interpreting the supervisory and address signals needed to perform the switching operation.

Many times organizations with many branches or regional facilities have the need to transmit and receive data frequently. They may use a data communications system consisting of a wide variety of components and many times a variety of services. The combination chosen will depend upon the merits and limitations of various networks. Perhaps one or more host processors may go through multiple front ends into one or more types of networks involving various types of terminals. A network of this type is called a "distributed network."

The electronic transmission of encoded information from one point to another requires various physical elements, devices, and systems, as well as standards and procedures. An understanding of these basic elements and concepts can help users of telcom services to take advantage of the communication systems that are now available.

1.2.1 Parallel and Serial Transmission

Short distance communications between terminals (data input/output devices) and computers may take place in a variety of ways. Some configurations, for example, involve the transmission of data characters across multiple lines. This is known as parallel transmission. If you were transmitting one bit of a seven-bit ASCII code character per line, you would need seven lines. This method of transmission is called parallel-by-bit serial-by-character (see Fig. 1–1). This method is often used over short distances. However, over long distances (involving miles) serial transmission is preferred because it involves only one data line.

In order to send data over a single line, the bits must be transmitted in series. This is called (appropriately) serial transmission. It is the most widely used method of transmitting data. In seven-bit ASCII, a "C" would appear as illustrated in Fig. 1–2.

1.2.2 Channels and Facilities

A communications link or channel is a path for electrical transmission between two or more stations or terminals. It may be a single wire, a group of wires, a coaxial cable, or a special part of the radio frequency spectrum. The purpose of a channel is to carry informa-

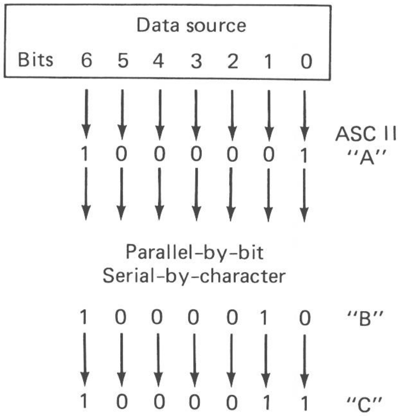

Fig. 1-1. Parallel-by-bit and serial-by-character transmission.

tion from one location to another. All channels have limitations on their information handling abilities, depending upon their electrical and physical characteristics.

There are three basic types of channels: simplex, half-duplex and full-duplex. As an example of each, consider transmission between points A and B in Fig. 1-3. Transmission from A to B only (and not from B to A) requires a simplex channel. Simplex channels are used in loop mode configurations such as supermarket checkout terminals. Transmission from A to B and then from B to A, but not simultaneously, requires a half-duplex channel. If a two-wire circuit is used, the line must be turned around to reverse the direction of transmission. A four-wire circuit eliminates line turnaround. Transmission from A to B and from B to A simultaneously describes a full-duplex channel. Although four wires are most often used, a two-wire circuit can support full-duplex communications if the frequency spectrum is subdivided into receive and transmit channels.

Fig. 1-2. Serial transmission is most often used.

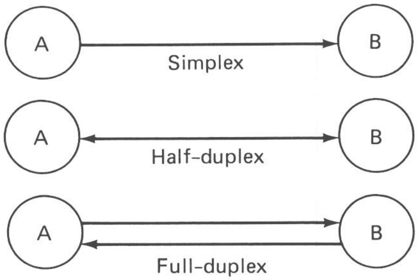

Fig. 1-3. Types of communications channels.

In addition to the direction of transmission, a channel is characterized by its bandwidth. In general, the greater the bandwidth of the assigned channel, the higher the possible transmission speed. This speed it usually measured in terms of the number of line signal elements per second, the baud rate. If a signal element represents one of two binary states, the baud rate is equal to the bit rate. When more than two states are represented, as in multilevel modulation, the bit rate exceeds the baud rate.

1.2.3 Digital Versus Analog Transmission

Digital transmission can be applied to digital data or analog voice signals. In either case, information is sent over the communications channel as a stream of pulses. If analog to digital conversion is required, the signal voltage values are sampled and represented in binary format (see Fig. 1-4). Pulses transmitted over a communication line are distorted by line capacitance, inductance, and leakage. The longer the line or the faster the pulse rate, the more difficult it is to interpret the received signal. This signal degradation is the reason for the closely spaced regenerative repeaters used in digital data transmission facilities. When noise and distortion threaten to destroy the integrity of the pulse stream, the pulses are detected and regenerated. If the regeneration process is repeated properly, the received signal will be an exact replica of the transmitted signal. It is possible to transmit pulses over short distances using privately owned cable or wire pairs. This is baseband transmission and usually requires line