Computer Communications

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SYSTEMS AND APPLICATIONS

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Preface

The economy and convenience of extending the use of computing resources have promoted the development and expansion of communication-based computer systems. In 1970 there were fewer than 250,000 data terminals in the United States. Today there are more than 3 million, plus 200,000 facsimile machines. The expected growth rate in their numbers is over 20% per year. Present estimates are that there are 1 billion electronic messages per year generated or received by such devices. Within three years the number should almost double.

Another perspective on growth is that 70% of first-class mail is generated by computers. Almost all Fortune 500 companies are expected to have electronic mail systems in the next few years. Statistics indicate that we are inevitably heading toward an information society. This trend will be a continuing stimulation for new applications and new users. As a result, the rate of innovations in system design concepts, hardware features, and transmission services is accelerating; and as new applications become economically and operationally practical, demands increase and the cycle continues. The data terminals, or multimode terminals combining data, voice, and video capabilities, will outnumber the telephone sets used only for transmitting voice. Clearly, computer communication networks are needed.

One part of computer communication network design involves networking strategies. Volume I begins with a classification of networking alternatives (Chapter 1). Closely related are the control procedures used in the networks for managing traffic. Chapter 2 addresses control procedures at the link level. Chapter 3 deals with control procedures at higher levels; IBM's System Network Architecture and ARPANET are used as examples. Multiaccess schemes that allow a large number of terminals and computers to contend for a high-capacity channel are the topic in Chapter 4.

Another part of computer communication network design involves selection of digital transmission facilities. When common carriers provide all transmission facilities, people involved in planning computer communications systems do not need to understand the characteristics of the transmission facilities. The increasing need for wideband transmission facilities that are not provided by common carriers requires an understanding of the characteristics. Therefore, material on radio links, satellite channels, coaxial cables, and fiber optics are provided in Chapters 5, 6, and 7.

Control procedures are implemented in devices, and the devices are con-

nected by transmission facilities to form networks. The communication devices and their functions are discussed in Chapter 8.

With the proliferation of equipment and use of computer communications, one issue that cannot be ignored is the security and integrity of the data flowing through various networks. Chapter 9 presents encryption possibilities, including data encryption standards and public key systems.

Two very important and interesting parts of computer communications network design deal with the problems of analysis and optimization of large teleprocessing networks. In Chapter 10 is a presentation of stochastic analytic methods for determining network performance, with emphasis placed on those that are practical, yet robust. A unified approach to the optimization of communication networks is given in Chapter 11, contained in Volume II. The unified approach combines exact and heuristic methods.

One of the most exciting aspects of computer communication technology is the emerging use of broadband facilities in networks. There will be wide use of satellite networks ranging from point-to-point to pervasive networks, cable networks that provide capacity for hundreds of megabits per second, and packet and cellular radio networks that can be used in situations where wired networks are less convenient. A possible scenario for new networks is that satellite channels be used as part of the backbone network, radio networks be included in the regional networks for local access or in place of telephone companies' local loops, and cable networks be used for limited-distance local networks. Examples of satellite networks, cable networks, and radio networks are given in Chapters 5, 6, and 7. Packet radio networks are discussed in Chapter 12.

The multiaccess schemes used on wideband facilities will make possible increased office automation and will be essential in the office of the future. The wide adaptation of limited-distance local networks, the topic of Chapter 13, will come first. The wide acceptance of the services available through local networks will prompt and accelerate the demand for communications and services that are not available locally. Users on one local network will be able to communicate with users on a geographically remote local network or access information and network services from a remote location.

For a user to access various possible network services not available locally or to communicate with another user at a remote site, there must be networks in between. Some of these networks will be in the form of public data networks. The discussion and comparison of several public data networks, as well as several private data networks, are given in Chapter 14. The issue of interconnecting the networks is considered in Chapter 15.

Another phenomenon is that of integration, that is, the integration of packet and circuit switching into the same architecture. Because of the growing conversion to computer-controlled digital switches, more telephone plants are converting from analog to digital. As a consequence, data, digitized voice, and other digital signals can be mixed in the same network, called an integrated services digital network. The integration of packet and circuit switching is addressed in Chapter 16. The

combination of voice, data, still image, and video in the same network is addressed in Chapter 17.

While economy and convenience have resulted in the acceleration of demand in computer communication usage, they themselves are a direct consequence of advances in microelectronics, digitization techniques, and wideband digital transmission facilities. The availablity of low-cost, high-performance microelectronic components allows the development of new applications of data communications usage and new data communication technologies which would otherwise be economically infeasible. The advancement of digitization techniques facilities sharing of common transmission facilities for data, voice, and video traffic. Digitization techniques and the availablity of wideband digital transmission facilities together open a new horizon for applications. Applications that require inexpensive, low-error-rate, high-bandwidth facilities, such as high-speed digitial video transmission, are becoming practical. Chapter 18 presents these driving technologies that advance computer communications.

Many new network services will be developed to satisfy various application needs. A very important one is the access of distributed data bases. The issues of locating, managing, and coordinating distributed data bases are presented in Chapter 19.

Illustrated in Fig. A.1 are the interrelationships of topics covered in the book. However, each chapter is written to stand alone. Because of this, some overlap of material between certain chapters exists. Any apparent inconsistencies in terminology are attributable to the fact that definitions have not yet been agreed upon by all persons in the field of computer communications; conceptual differences may also exist between different individuals. No attempts have been made to unify definitions among the various authors. Indeed, the editor believes it is advantageous to be exposed to different definitions.

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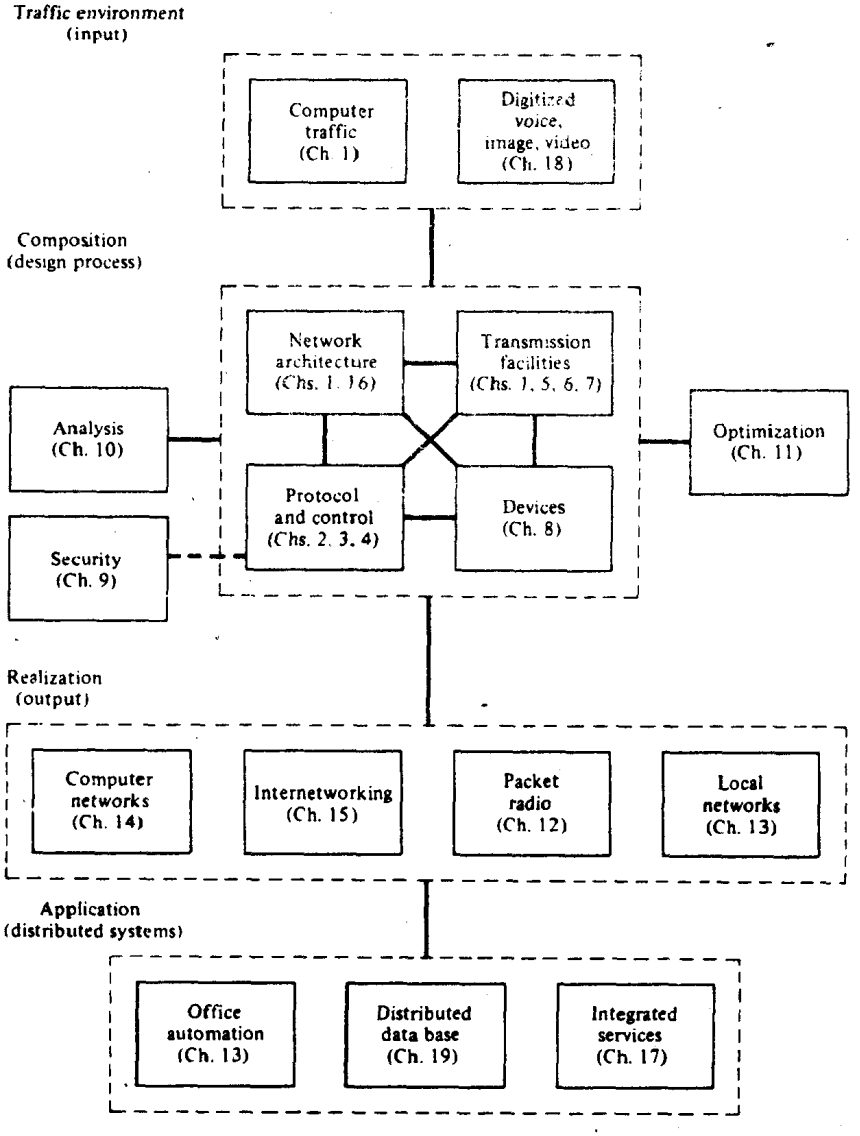

Figure A.1. Profile of computer communications.

Contents

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Optimization of Data/Computer Networks

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11.1 INTRODUCTION

Geographically distributed data terminal equipment (DTE), such as terminals, data processing facilities, or computer resources, communicate with each other through data/computer communications networks. Figure 11.1 illustrates one such network. The data/computer communication network architectures used in the distributed environment are those illustrated in Figs. 11.2 to 11.4.

Figure 11.2 depicts the tree-shaped, hierarchical architecture, in which the local access network, defined as the circuits interconnecting the terminals and/or terminal control units, are connected to the concentrating devices, most likely multiplexers, statistical multiplexers, or concentrators. (See Chap. 8 and [CHOU 76] for a description of these devices.) The concentrating devices are in turn connected to the host computer. (The concentrating functions may be performed as part of a remote processor's responsibility.) The circuits shown interconnecting the concentrating devices and the host computers are called the *backbone network*. Both the local access and the backbone networks may be point-to-point or tree-shaped connections. Occasionally, ring-shaped connections of terminals may also occur. Often, the local access networks terminate directly at the host computer instead of through the concentrating devices.

The mesh-shaped switching architecture is illustrated in Fig. 11.3. In this architecture the local access network is comprised of both the terminal devices and the host computers connected in either a point-to-point or multipoint configuration. The local access networks are connected to the switches. The backbone network for this architecture is defined as the interconnecting circuits between the switches. The backbone network of this nature is usually mesh shaped (but not necessarily), and may employ circuit, message, packet, or integrated switching.

Figure 11.4 presents the architecture associated with a ring-shaped, ring-

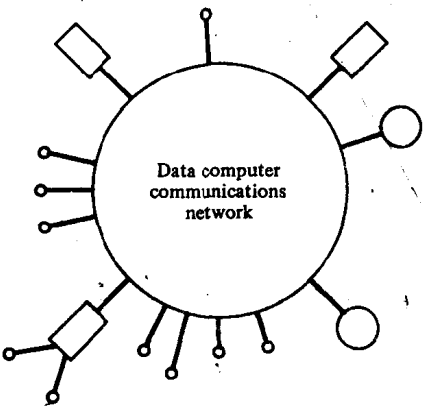

Figure 11.1. Communications network for a distributed data processing system. Rectangle, host computer; large circle, remote processor; small circle, terminal or terminal control unit.

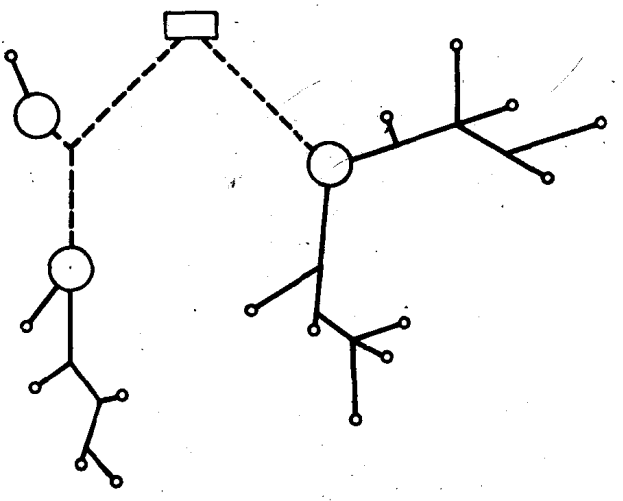

Figure 11.2. Tree-shaped, hierarchically controlled data communication network architecture. Rectangle, host computer; large circle, remote processor or concentrator; small circle, terminal or terminal control unit. Dashed line, backbone; solid line, local access.