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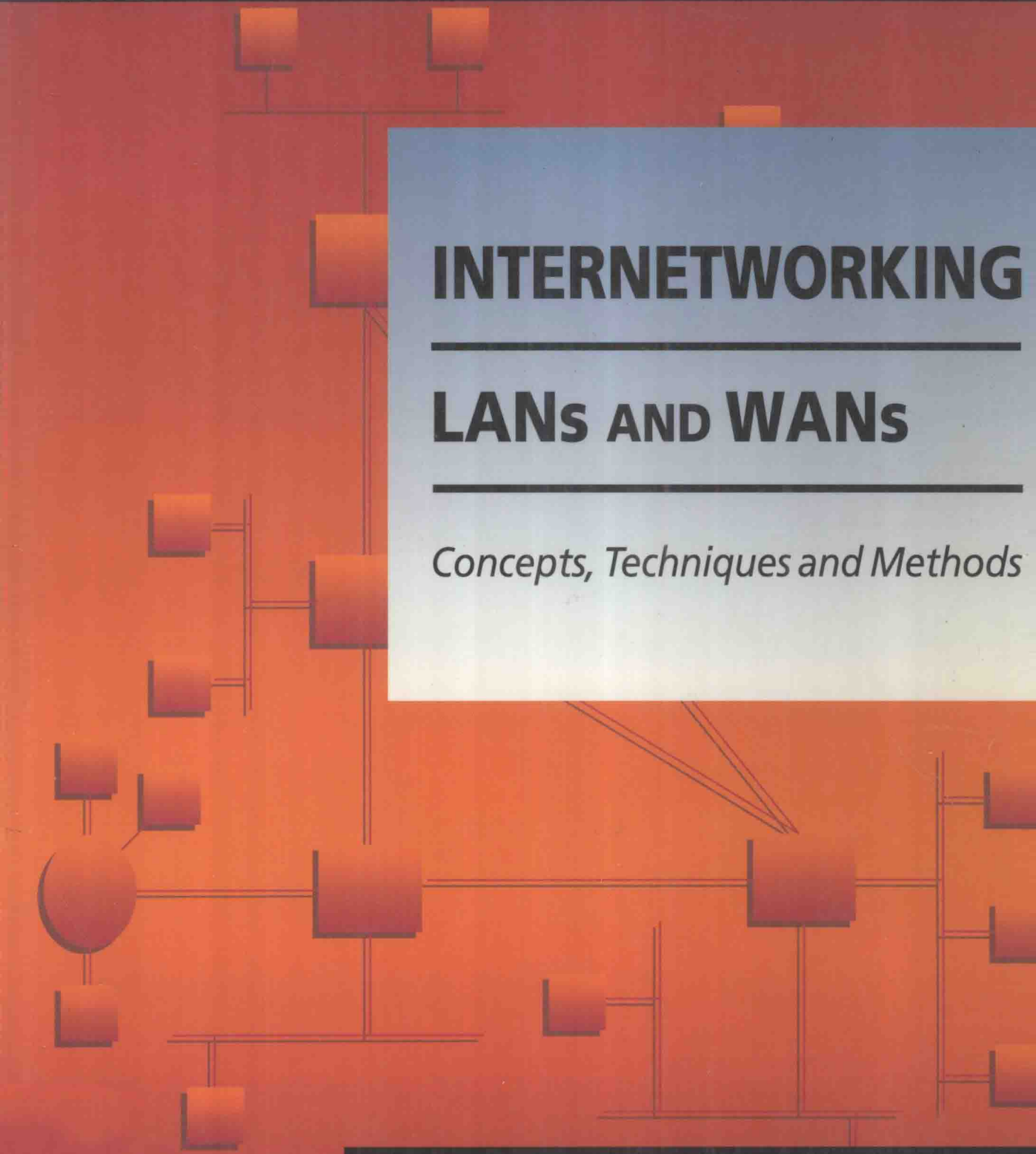

INTERNETWORKING

LANs AND WANs

Concepts, Techniques and Methods

Gilbert Held

INTERNETWORKING LANs AND WANs

CONCEPTS, TECHNIQUES AND METHODS

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PREFACE

Internetworking can be defined as the creation of networks of networks. Representing probably the most interesting and perhaps the most practical area of communications technology for small and large corporations and government agencies, internetworking provides the electronic highway necessary to link separate islands of connectivity.

Similar to a brick mason, we need a good foundation prior to mastering internetworking concepts and techniques. This foundation is presented in the first five chapters of this book. Those chapters provide a detailed examination of the operation and utilization of different types of networks, performance issues and the constraints and limitations imposed upon many networks due to technology. In addition, due to the importance of *de facto* and *de jure* standards we must also become aware of applicable networking standards which are presented in the first part of this book.

Once a foundation of information is presented in the first five chapters of this book we are ready to focus our attention upon the major focus of this book—internetworking. In the remainder of this book we will examine a variety of internetworking topics, ranging in scope from basic concepts to the operation and utilization of different types of communications equipment and communications carrier line facilities. In doing so we will examine several key performance issues that will assist you in determining the minimum level of performance required to avoid internetwork degradation. In addition, we will create several mathematical models you can adapt to your specific communications environment to project different types of performance prior to actually ordering hardware or communications facilities. By using these models you may be able to avoid selecting the wrong equipment or communications carrier facilities based upon intuition or a salesperson's educated guess.

As a long time communicator, as both a networking manager and an author, I welcome your comments. If you would like to see future editions of this book expand upon a specific area or cover a presently omitted area, or if you have any other comments, please feel free to write me. You can write to me through my publisher at the address listed in this book or you can send a message directly to GHELD on MCI Mail.

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Although sometimes overlooked, a book is a team effort in which the author's manuscript is just one portion of a considerable amount of work required by many individuals. From the issuance of a contract based upon a market analysis to the typing of the manuscript and through the movement of the manuscript into the production process many persons contribute their skills. I would be remiss if I did not take the opportunity to acknowledge the efforts of several individuals whose work was essential in enabling you to read this book. However, prior to doing so I would like to thank my family for their patience and understanding as I developed the manuscript for this book.

I would like to thank Ann-Marie Halligan and Laura Denny for efforts in arranging for the review of my proposal, and for providing guidance and arranging for the contract that enabled this writing project to go forward. Once again, Mrs Carol Ferrell and Mrs Linda Hayes deserve a considerable 'thank you' for converting my handwritten notes and diagrams into a professional manuscript. Last but not least, I would like to thank Mr Stuart Gale and the members of his production team for their effort in converting the manuscript into the book you are reading.

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1

NETWORK CONCEPTS

In this introductory chapter, we will focus our attention upon the key concepts behind the construction of wide area networks (WANs) and local area networks (LANs). In doing so we will first examine each type of network to obtain an understanding of its primary design goal. Next, we will compare and contrast their operation and utilization as well as examine the primary *de facto* and *de jure* standards that govern the operation of different types of networks. As this is an introductory chapter, we will cover LAN and WAN networking concepts without concern for specific details which are presented in later chapters in this book.

1.1 WIDE AREA NETWORKS

The evolution of wide area networks can be considered to have had its origination in the mid- to late 1950s, commensurate with the development of the first generation of computers. Based upon the use of vacuum tube technology, the first generation of computers were physically relatively large, power-hungry devices whose placement resulted in a focal point for data processing and the coining of the term 'data center'.

Computer-communications evolution

Originally, access to the computational capability of first generation computers was through the use of punched cards. After an employee of the organization used a keypunch to create a deck of cards, that card deck was submitted to a window in the data center, typically labeled input/output (I/O) control. An employee behind the window would accept the card deck and

complete a form which contained instructions for running the submitted job. The card deck and instructions would then be sent to a person in production control who would schedule the job and turn it over to operations for execution at a predefined time. Once the job was completed, the card deck and any resulting output would be sent back to I/O control, enabling the job originator to return to the window in the data center to retrieve his or her card deck and the resulting output. With a little bit of luck, programmers might see the results of their efforts on the same day that they submitted their job.

Since the computer represented a considerable financial investment for most organizations, it was understandable that they would be receptive to methods that would enable an extension of access to its computational capability. By the mid-1960s, several computer manufacturers had added remote access capabilities to one or more of their computers.

Remote batch transmission

One method of providing remote access was obtained by the installation of a batch terminal at a remote location. That terminal was connected via a telephone company supplied analog leased line and a pair of modems to the computer in the corporate data center.

The first type of batch terminal developed to communicate with a data center computer contained a card reader, printer, serial communications adapter, and hard-wired logic in one housing. The serial communications adapter converted the parallel bits of each internal byte read from the card reader into a serial data stream for transmission. Similarly, the adapter performed a reverse conversion process by converting a sequence of received serial bits into an appropriate number of parallel bits to represent a character internally within the batch terminal. Since the batch terminal was located remotely from the data center, it was often referred to as a remote batch terminal, while the process of transmitting data was referred to as remote batch transmission. In addition, the use of a remote terminal as a mechanism to group a number of card decks representing individual jobs to be executed at the remote data center resulted in the term 'remote job entry terminal' being used as a synonym to reference this device.

Figure 1.1 illustrates in schematic form the relationship between a batch terminal, transmission line, modems, and the

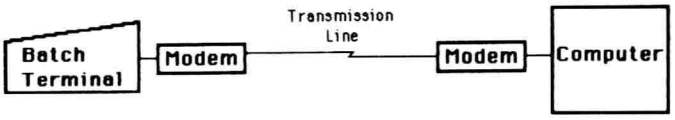

Figure 1.1 Remote batch transmission. The transmission of data from a remote batch terminal represents one of the first examples of wide area data communications networks.

data center computer. Since the transmission line connected a remote batch terminal in one geographic area to a computer located in a different geographic area, Figure 1.1 represents one of the earliest types of wide area data communications networks (WAN).

Paralleling the introduction of remote batch terminals was the development of a series of terminal devices, control units, and specialized communications equipment which resulted in the rapid expansion of interactive computer applications. One of the most prominent collections of products was introduced by the IBM Corporation under the trade name 3270 Information Display System.

IBM 3270 Information Display System

The IBM 3270 Information Display System was a term used to originally describe a collection of products ranging from interactive terminals, referred to as display stations that communicate with a computer, through several types of control units and communications controllers. Later, through the introduction of additional communications products from IBM and numerous third party vendors and the replacement of previously introduced products, the IBM 3270 Information Display System became more of a networking architecture and strategy rather than a simple collection of products.

First introduced in 1971, the IBM 3270 Information Display System was designed to extend the processing power of the data center computer to remote locations. Since the data center computer typically represented the organization's main or primary computer, the term 'mainframe' was coined to reference a computer with a large processing capability. As the mainframe was primarily designed for data processing, its utilization for supporting communications degraded its performance.

Communications controller

To offload communications functions from the mainframe, IBM and other computer manufacturers developed hardware whose primary function was to sample communications lines for incoming bits, group bits into bytes, and pass a group of bytes to the mainframe for processing as well as performing a reverse function for data destined from the mainframe to remote devices. When first introduced, such hardware was designed using fixed logic circuitry and the resulting device was referred to as a communications controller. Later, minicomputers were developed to execute communications programs; the ability to change the functionality of communications support by the modification of software was a considerable enhancement to the capabilities of this series of products. Because both hard-wired communications controllers and programmed minicomputers performing communications offloaded communications processing from the mainframe, the term 'front-end processor' evolved to reference this category of communications equipment. Although most vendors reference a minicomputer used to offload communications processing from the mainframe as a front-end processor, IBM has retained the term 'communications controller', even though their fixed logic hardware products were replaced over 20 years ago by programmable minicomputers.

Control units

To reduce the number of controller ports required to support terminals as well as the cabling between controller ports and terminals, IBM developed 'poll and select' software to support its 3270 Information Display System. Doing so enabled the communications controller to transmit messages from one port that could be destined to one or more terminals in a predefined group of devices. To share the communications controller port IBM developed a product called a control unit which acts as an interface between the communications controller and a group of terminals.

In general terms, the communications controller transmits a message to the control unit. The control unit examines the terminal address and retransmits the message to the appropriate terminal connected to the control unit. Thus, control units can be considered as devices which economize on the number of lines required to link display stations to mainframe computers. Both local and remote control units are available, with the key