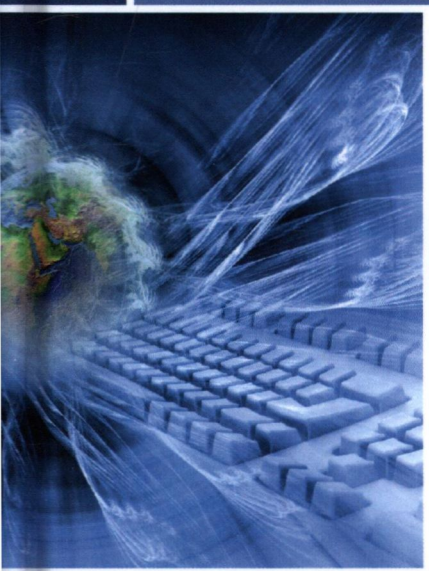
Computer Networking



Paxton Byrne

Computer Networking

This book elucidates the concepts and innovative models around prospective developments with respect to computer networking. It elucidates the various theories and techniques of this field. Computer networking refers to the science that enables computers to share data and information. It is a telecommunications network which uses a data-link system to let computers connect. These networks are used in digital audio and video, printers, World Wide Web, email, fax machines and instant messaging. The topics introduced in this text cover new techniques and the applications of computer networking. It unfolds the innovative aspects of this area, which will be crucial for the holistic understanding of the subject matter. The textbook is appropriate for those seeking detailed information in this field and will serve as a reference to a broad spectrum of readers.

Paxton Byrne received his Master of Science in Computer Networking from the University of Bedfordshire, United Kingdom. He is actively engaged in the researches focused on networking hardware, network nodes and network topology. Byrne is a visiting professor in many prestigious universities and teaches courses on computer networks. He has been the recipient of two awards for his research work in the field of wireless networking.

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Preface

This book elucidates the concepts and innovative models around prospective developments with respect to computer networking. It elucidates the various theories and techniques of this field. Computer networking refers to the science that enables computers to share data and information. It is a telecommunications network which uses a data-link system to let computers connect. These networks are used in digital audio and video, printers, World Wide Web, email, fax machines and instant messaging. The topics introduced in this text cover new techniques and the applications of computer networking. It unfolds the innovative aspects of this area, which will be crucial for the holistic understanding of the subject matter. The textbook is appropriate for those seeking detailed information in this field and will serve as a reference to a broad spectrum of readers.

To facilitate a deeper understanding of the contents of this book a short introduction of every chapter is written below:

Chapter 1- The exchange of data that occurs between computers is known as computer networks. The finest computer network is the Internet. Computer networks are used in major parts of the world and help in telecommunication facilities. This chapter provides the reader with a fascinating explanation on computer networking.

Chapter 2- Computer networks are set up with a view to permit transmission of data within a parameter and transmission protocols are created with a view of the same. Some common architectures of computer networks are personal area network, local area network, campus network and wide area network. All these topics as well as others have been included in this chapter.

Chapter 3- There are various elements involved in computer networking, such as network links and network nodes. The arrangement of these elements is termed as network topology. Some of the classifications of network topology are ring network, bus network, star network and mesh networking. This section is an overview of the subject matter incorporating all the major aspects of network topology.

Chapter 4- Packet switching is a technique by which all the data of networking communications are collected and grouped into blocks which are incidentally referred to as packets. The various packet switched networks are ARPANET, CYCLADES and IPSANET. This text provides the reader with an integrated understanding of packet switching.

Chapter 5- The Internet protocol suite or TCP/IP is the abstract model on which the Internet functions. It is mainly used in protocols, and specifies how data should be grouped, directed and then received. Some of the key principles of Internet protocol suite are also elucidated in this chapter, such as End- to- end principle and robustness principle.

Chapter 6- Network nodes are either the sending, receiving or redirecting processes as well as devices of a computer network. The nature of the data and its reception and transmission differs in each aspect of network nodes. This chapter discusses the basic processes related to nodes and the hardware related to them.

Chapter 7- Routing can be defined as the hardware and software that enable the transmission and distribution of data. It is a networking device that allows for the connection of a device to a network by navigating through various existing networks. The themes in this chapter describe the concepts, processes and technology that is used in routing.

Chapter 8- Fast local Internet protocol specifies security transparency and security and routing protocols helps in the communication of routers. The various network protocols discussed in this section are fast local Internet protocol, routing protocol, HTTPS, datagram congestion control protocol and point-to-point protocol.

Chapter 9- Network sockets are endpoints that connect computer networks whereas encapsulation is a process of designing modular communications. Other aspects of computer networking are circuit switching and routing. The following chapter unfolds its crucial aspects in a critical yet systematic manner.

Chapter 10- Computer networking has a history spanning to many decades. It began in the late 1950s and since then has made enormous progress. The history discussed in the following text is of great importance to broaden the existing knowledge on computer networking.

Finally, I would like to thank the entire team involved in the inception of this book for their valuable time and contribution. This book would not have been possible without their efforts. I would also like to thank my friends and family for their constant support.

Editor

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Introduction to Computer Networking

The exchange of data that occurs between computers is known as computer networks. The finest computer network is the Internet. Computer networks are used in major parts of the world and help in telecommunication facilities. This chapter provides the reader with a fascinating explanation on computer networking.

A computer network or data network is a telecommunications network which allows computers to exchange data. In computer networks, networked computing devices exchange data with each other using a data link. The connections between nodes are established using either cable media or wireless media. The best-known computer network is the Internet.

Network computer devices that originate, route and terminate the data are called network nodes. Nodes can include hosts such as personal computers, phones, servers as well as networking hardware. Two such devices can be said to be networked together when one device is able to exchange information with the other device, whether or not they have a direct connection to each other.

Computer networks differ in the transmission medium used to carry their signals, communications protocols to organize network traffic, the network's size, topology and organizational intent.

Computer networks support an enormous number of applications and services such as access to the World Wide Web, digital video, digital audio, shared use of application and storage servers, printers, and fax machines, and use of email and instant messaging applications as well as many others. In most cases, application-specific communications protocols are layered (i.e. carried as payload) over other more general communications protocols.

History

The chronology of significant computer-network developments includes:

- In the late 1950s, early networks of computers included the military radar system Semi-Automatic Ground Environment (SAGE).
- In 1959, Anatolii Ivanovich Kitov proposed to the Central Committee of the Communist Party of the Soviet Union a detailed plan for the re-organisation of the control of the Soviet armed forces and of the Soviet economy on the basis of a network of computing centres.

- In 1960, the commercial airline reservation system semi-automatic business research environment (SABRE) went online with two connected mainframes.
- In 1962, J.C.R. Licklider developed a working group he called the "Intergalactic Computer Network", a precursor to the ARPANET, at the Advanced Research Projects Agency (ARPA).
- In 1964, researchers at Dartmouth College developed the Dartmouth Time Sharing System for distributed users of large computer systems. The same year, at Massachusetts Institute of Technology, a research group supported by General Electric and Bell Labs used a computer to route and manage telephone connections.
- Throughout the 1960s, Leonard Kleinrock, Paul Baran, and Donald Davies independently developed network systems that used packets to transfer information between computers over a network.
- In 1965, Thomas Marill and Lawrence G. Roberts created the first wide area network (WAN). This was an immediate precursor to the ARPANET, of which Roberts became program manager.
- Also in 1965, Western Electric introduced the first widely used telephone switch that implemented true computer control.
- In 1969, the University of California at Los Angeles, the Stanford Research Institute, the University of California at Santa Barbara, and the University of Utah became connected as the beginning of the ARPANET network using 50 kbit/s circuits.
- In 1972, commercial services using X.25 were deployed, and later used as an underlying infrastructure for expanding TCP/IP networks.
- In 1973, Robert Metcalfe wrote a formal memo at Xerox PARC describing Ethernet, a networking system that was based on the Aloha network, developed in the 1960s by Norman Abramson and colleagues at the University of Hawaii. In July 1976, Robert Metcalfe and David Boggs published their paper "Ethernet: Distributed Packet Switching for Local Computer Networks" and collaborated on several patents received in 1977 and 1978. In 1979, Robert Metcalfe pursued making Ethernet an open standard.
- In 1976, John Murphy of Datapoint Corporation created ARCNET, a token-passing network first used to share storage devices.
- In 1995, the transmission speed capacity for Ethernet increased from 10 Mbit/s to 100 Mbit/s. By 1998, Ethernet supported transmission speeds of a Gigabit. Subsequently, higher speeds of up to 100 Gbit/s were added (as of 2016). The

ability of Ethernet to scale easily (such as quickly adapting to support new fiber optic cable speeds) is a contributing factor to its continued use.

Properties

Computer networking may be considered a branch of electrical engineering, telecommunications, computer science, information technology or computer engineering, since it relies upon the theoretical and practical application of the related disciplines.

A computer network facilitates interpersonal communications allowing users to communicate efficiently and easily via various means: email, instant messaging, chat rooms, telephone, video telephone calls, and video conferencing. Providing access to information on shared storage devices is an important feature of many networks. A network allows sharing of files, data, and other types of information giving authorized users the ability to access information stored on other computers on the network. A network allows sharing of network and computing resources. Users may access and use resources provided by devices on the network, such as printing a document on a shared network printer. Distributed computing uses computing resources across a network to accomplish tasks. A computer network may be used by computer crackers to deploy computer viruses or computer worms on devices connected to the network, or to prevent these devices from accessing the network via a denial of service attack.

Network Packet

Computer communication links that do not support packets, such as traditional point-to-point telecommunication links, simply transmit data as a bit stream. However, most information in computer networks is carried in *packets*. A network packet is a formatted unit of data (a list of bits or bytes, usually a few tens of bytes to a few kilobytes long) carried by a packet-switched network.

In packet networks, the data is formatted into packets that are sent through the network to their destination. Once the packets arrive they are reassembled into their original message. With packets, the bandwidth of the transmission medium can be better shared among users than if the network were circuit switched. When one user is not sending packets, the link can be filled with packets from other users, and so the cost can be shared, with relatively little interference, provided the link isn't overused.

Packets consist of two kinds of data: control information, and user data (payload). The control information provides data the network needs to deliver the user data, for example: source and destination network addresses, error detection codes, and sequencing information. Typically, control information is found in packet headers and trailers, with payload data in between.

Often the route a packet needs to take through a network is not immediately available. In that case the packet is queued and waits until a link is free.

Network Topology

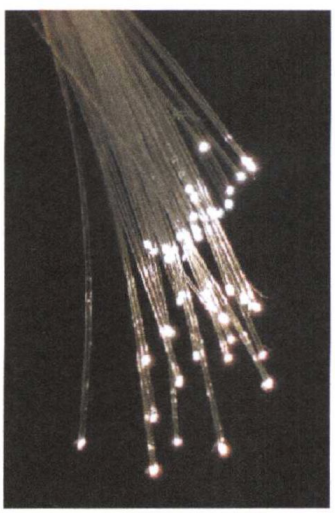
The physical layout of a network is usually less important than the topology that connects network nodes. Most diagrams that describe a physical network are therefore topological, rather than geographic. The symbols on these diagrams usually denote network links and network nodes.

Network Links

The transmission media (often referred to in the literature as the *physical media*) used to link devices to form a computer network include electrical cable (Ethernet, HomePNA, power line communication, G.hn), optical fiber (fiber-optic communication), and radio waves (wireless networking). In the OSI model, these are defined at layers 1 and 2 — the physical layer and the data link layer.

A widely adopted *family* of transmission media used in local area network (LAN) technology is collectively known as Ethernet. The media and protocol standards that enable communication between networked devices over Ethernet are defined by IEEE 802.3. Ethernet transmits data over both copper and fiber cables. Wireless LAN standards (e.g. those defined by IEEE 802.11) use radio waves, or others use infrared signals as a transmission medium. Power line communication uses a building's power cabling to transmit data.

Wired Technologies



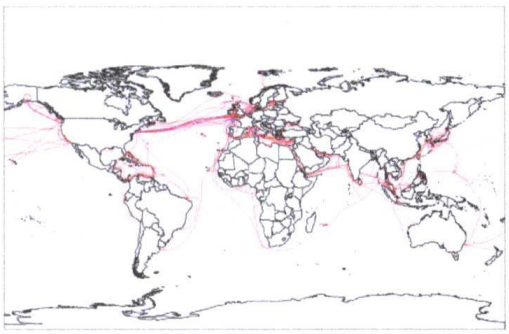
Fiber optic cables are used to transmit light from one computer/network node to another

The orders of the following wired technologies are, roughly, from slowest to fastest transmission speed.

- *Coaxial cable* is widely used for cable television systems, office buildings, and other work-sites for local area networks. The cables consist of copper or alumi-

num wire surrounded by an insulating layer (typically a flexible material with a high dielectric constant), which itself is surrounded by a conductive layer. The insulation helps minimize interference and distortion. Transmission speed ranges from 200 million bits per second to more than 500 million bits per second.

- ITU-T G.hn technology uses existing home wiring (coaxial cable, phone lines and power lines) to create a high-speed (up to 1 Gigabit/s) local area network
- *Twisted pair wire* is the most widely used medium for all telecommunication. Twisted-pair cabling consist of copper wires that are twisted into pairs. Ordinary telephone wires consist of two insulated copper wires twisted into pairs. Computer network cabling (wired Ethernet as defined by IEEE 802.3) consists of 4 pairs of copper cabling that can be utilized for both voice and data transmission. The use of two wires twisted together helps to reduce crosstalk and electromagnetic induction. The transmission speed ranges from 2 million bits per second to 10 billion bits per second. Twisted pair cabling comes in two forms: unshielded twisted pair (UTP) and shielded twisted-pair (STP). Each form comes in several category ratings, designed for use in various scenarios.



2007 map showing submarine optical fiber telecommunication cables around the world.

- An *optical fiber* is a glass fiber. It carries pulses of light that represent data. Some advantages of optical fibers over metal wires are very low transmission loss and immunity from electrical interference. Optical fibers can simultaneously carry multiple wavelengths of light, which greatly increases the rate that data can be sent, and helps enable data rates of up to trillions of bits per second. Optic fibers can be used for long runs of cable carrying very high data rates, and are used for undersea cables to interconnect continents.

Price is a main factor distinguishing wired- and wireless-technology options in a business. Wireless options command a price premium that can make purchasing wired computers, printers and other devices a financial benefit. Before making the decision to purchase hard-wired technology products, a review of the restrictions and limitations of the selections is necessary. Business and employee needs may override any cost considerations.

Wireless Technologies

Computers are very often connected to networks using wireless links

- *Terrestrial microwave* – Terrestrial microwave communication uses Earth-based transmitters and receivers resembling satellite dishes. Terrestrial microwaves are in the low-gigahertz range, which limits all communications to line-of-sight. Relay stations are spaced approximately 48 km (30 mi) apart.
- *Communications satellites* – Satellites communicate via microwave radio waves, which are not deflected by the Earth›s atmosphere. The satellites are stationed in space, typically in geosynchronous orbit 35,400 km (22,000 mi) above the equator. These Earth-orbiting systems are capable of receiving and relaying voice, data, and TV signals.
- *Cellular and PCS systems* use several radio communications technologies. The systems divide the region covered into multiple geographic areas. Each area has a low-power transmitter or radio relay antenna device to relay calls from one area to the next area.
- *Radio and spread spectrum technologies* – Wireless local area networks use a high-frequency radio technology similar to digital cellular and a low-frequency radio technology. Wireless LANs use spread spectrum technology to enable communication between multiple devices in a limited area. IEEE 802.11 defines a common flavor of open-standards wireless radio-wave technology known as Wifi.
- *Free-space optical communication* uses visible or invisible light for communications. In most cases, line-of-sight propagation is used, which limits the physical positioning of communicating devices.

Exotic Technologies

There have been various attempts at transporting data over exotic media: