中国矿业大学新世纪教材建设工程资助教材

Foundamentals of Programming on the Internet

English Version · First Edition

by Zhang Shen

网络编程基础

张 申 编著

中国矿业大学出版社

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内容简介

本书是用英语编写的网络编程基础教材，主要介绍 Internet 网络的基础知识和基本概念、网络编程的基本语言——超文本标记语言 HTML、嵌入式脚本语言 JavaScript 和 VBScript、对象的基本概念、动态网页和 CSS 的基本知识、Active Server Pages (ASP)、ASP 与数据库的联接、结构化查询语言 SQL 等。书中给出了大量的例子，通过这些例子的学习和研究，有助于掌握本书介绍的基本知识和编程方法。最后有三个系统性的例子，是我们在网络化教学过程中使用的实例，这些实例可以帮助读者理解网络及网络数据库的应用。

读者可访问中国矿业大学信电学院主页 http://siee.cumt.edu.cn，进入信息工程系教学主页下载本书的全部例程，或通过电子信箱 xzzhsh@pub.xz.jsinfo.net 直接与作者联系。

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Gale Acuff 博士的推荐(代序)

I highly recommend Professor Zhang's textbook, Fundamentals of Programming on the Internet, because it is well designed, intelligent, and thoroughgoing. In my estimation, the Professor is an excellent and engaging writer who demonstrates a sincere pleasure in his work; Further, he clearly cares about the quality of his teaching, and hence, his students. I note that this text encourages students to learn from it and to enjoy it.

Gale Acuff, PhD 2002 12 2

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Gale Acuff, Ph D

2002.12.2

Preface

The Internet, which has been growing rapidly in recent years, has dramatically changed our lives. Students who are interested in publishing information on the Internet should have a basic understanding of program on the Internet. At the same time, English is a powerful tool for Chinese students studying in their major fields. Thus the purpose of this book is to combine the two —that is, to use English for learning the fundamentals of programming on the Internet.

Although, the book has been published as a textbook for students who are enrolled in Computer Science, Information Engineering, and other related majors, anyone who is interested in learning about the Internet and the World Wide Web will benefit from using it.

You will learn about basic concepts of the Internet, such as the structure and working principles, protocols, IP address and its interpretation, DNS, the World Wide Web, and applications of the Internet (chapter 1). After a brief introduction about the programming methods (chapter 2), Hypertext Markup Language (HTML) and scripting languages are discussed (chapter 3 and 4). Some Dynamic HTML and Cascading Style Sheet concepts are then briefly introduced (chapter 5). Active Server Pages (ASP) and its accessing into databases are demonstrated next (chapter 6 and 7). Many examples throughout the book will help you to learn and to practice the basic knowledge and skills of programming.

Special thanks to the Textbook Publishing Fund of China University of Mining and Technology: only with the support of TPF could this book be published to meet the demands of those readers who want to use English to learn programming on the Internet.

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A very special thanks to foreign expert Dr. Gale Acuff, who teaches at China University of Mining and Technology and who read the book carefully and revised it responsibly. Thanks to him also for his appraisal of the book to the TPF: "I highly recommend Professor Zhang's textbook, *Fundamentals of Programming on the Internet*, because it is well designed, intelligent, and thoroughgoing. In my estimation, the Professor is an excellent and engaging writer, who demonstrates a sincere pleasure in his work. Further, he clearly cares about the quality of his teaching, and hence, his students. I note that this text encourages students to learn from it and to enjoy it."

A very special thanks to Professor Wu Zeng who also enthusiasticlly recommended the book to the TPF.
Thanks to Mr. Zhang Zhenkang, who also advised me during the revision of the text.

Finally, my heartfelt thanks to all colleagues and students in the School of Information and Electrical Engineering of CUMT: without their support and encouragement, this book would not have been possible.

Zhang, Shen

2003.7.15

Table of Contents

Chapter 1
The Fundamentals of the Internet

The Internet is the largest worldwide information distribution system, a network of networks from which users of any computer on the net can, if they have permission, get information from any other computer.

The Internet that has been growing rapidly in recent years has changed our lives dramatically. The change is ongoing. In this chapter a short history of the Internet will be sketched. The structure and working principle of the Internet will be introduced. We will discuss with protocols, IP address and its interpretation DNS, World Wide Web (WWW), and applications of the Internet.

The main contents in this chapter are:

A History of the Internet
The Structure of the Internet
Protocols
The DNS System
World Wide Web and Browser
Some Applications on the Internet

1.1 A History of the Internet

We'd like to start Internet classes with a review of Internet history. Don't worry if you don't understand all the terms; the idea is to get a general picture of the Internet history.

Birth of a Network—1969

The Internet began its history back to a United States Department of Defense project in 1969. The subject of the project was wartime digital communications. At that time the telephone system was about the only digital communications system. A major problem this system was that it was absolutely dependent on the communication center, the switching station that could be targeted during an attack. Would it be possible to design a communication network that could quickly reroute digital traffic around failed nodes? A possible solution had been identified in theory. That was to build a"Web"of datagram network and use dynamic routing protocols to constantly adjust the flow of traffic through the network. The Defense Advanced Research Projects Agency (DARPA) launched the DARPA Internet Program.

Infancy —1970s

In 1975, DARPA declared the project a success and handed its management over to the Defense Communications Agency. Several of today's key protocols (including IP and TCP) were stable by 1980, and adopted throughout ARPANET (Advanced Research Projects Agency) by 1983.

The Research Net—1980s

In August 1983, there were 562 registered ARPANET hosts. Many key features of the Internet were already in place, including the IP and TCP protocols. ARPANET was fundamentally unreliable in nature, as the Internet still is today. This principle of unreliable delivery means that the Internet makes only a best-effort attempt to deliver packets. The network can drop a packet without any notification to sender or receiver. Remember, the Internet was designed for military survivability. The software running on either end must be prepared to recognize data loss, re-transmitting data as often as necessary to achieve its ultimate delivery.

Driven largely by the development of the PC and LAN technology, subnetting was standardized in 1985. LAN technology made the idea of an Internetwork feasible. Subnetting opened the possibilities of interconnecting LANs with WANs.

The National Science Foundation (NSF) started the Supercomputer Centers program in 1986. the NSF decided to base their network on the Internet protocols, and the NSFNET was born. For the next decade, NSFNET would be the core of the U. S. Internet, until its privatization and ultimate retirement in 1995.

Domain Naming was stable by 1987. Until then, hostnames were mapped to IP address using static tables, but the Internet's exponential growth had made this practice infeasible.

The 1987 Internet Worm was the largest security failure in the history of the Internet. All things considered, it could happen again.

World Wide Web —1990s

The World Wide Web (WWW) has been one of the Internet's most exciting recent developments. The idea of hypertext had been around for more than a decade, but in 1989 a team at the European Center for Particle Research (CERN) in Switzerland developed a set of protocols for transferring hypertext via the Internet. In the early 1990s it was enhanced by a team at the National Center for Supercomputing Applications (NCSA) at the University of Illinois, one of the NSF's supercomputer centers. The result was the NCSA Mosaic, a graphical, Point-and-Click hypertext browser that made Internet usage easy. The resulting explosion in "Web sites" put the Internet into the public eye. Thanks for other two browsers, Netscape Navigator (NN) and Microsoft Internet Explorer (IE), we can access millions of web sites.

1.2 The Structure of the Internet

1.2.1 The Local Computers and the LAN

The smallest unit on the Internet is the individual user. In many offices and homes, each person has his or her own personal computer. In other organizations, there may be a very large computer for which each member of the organization has an individual account. In any case, it is important to imagine that each individual has a user ID (user name) within the local organization, and that all the computers within this organization are tied together with some sort of Local Area Network (LAN), as shown in Fig. 1-1. Often each department or floor in an organization has a LAN. LANs usually consist of up to 100 computers attached together through wires and special software so they can communicate easily.

Often, LANs are tied together within a large organization to make Wide Area Networks (WAN).

Fig. 1-1 shows a LAN with 5 users named A, B, C, D and E, connected together with a device called Hub, which uses Twisted-pair Cables. A Network

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Interface Card inserted in each computer is used for the data communication. The LAN makes communication between members of the same organization in a small area.

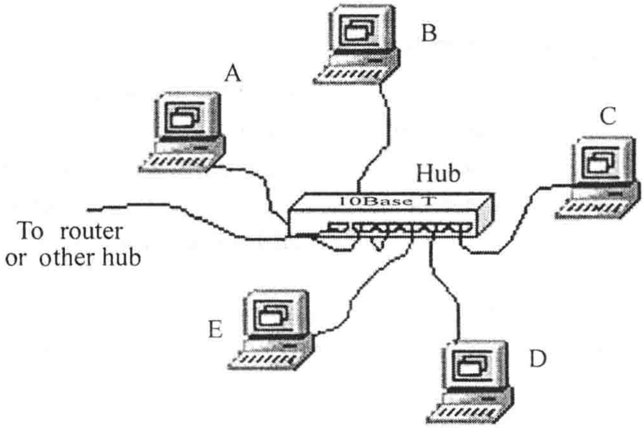

Fig. 1-1 An Example of LAN

From the hub there should be a wire, which connects to a Router or other hub when the users want to communicate with others outside of the LAN. It forms a small Internet. The Internet is the largest Internet in the world. Fig. 1-2 shows an example of a small Internet. LANs are attached to special computers called routers. A router is designed with one job in mind: directing data traffic between the LAN and the rest of the Internet. In essence, when you send a message anywhere outside your LAN, you send it to the router, which takes care of distributing the message to the rest of the Internet. Likewise, any messages or documents you receive from anywhere on the Internet have arrived at your machine through your router and your LAN.

1.2.2 Routers and the Internet Backbone

The router takes the information you give it and uses TCP/IP protocols to send the packet to other routers. Eventually, the packet will get to a high-speed communication system called the Internet Backbone — for example, the network composed of Router 1 through Router 5 in Fig. 1-2. From here, packets are transferred to other routers via the IP addresses, until the packets eventually find the correct destination. All this often happens within seconds.

For example, in Fig. 1-2 imagine user a wants to send a message to user D; the data packets will be sent at first to router RB and then Router 2. It is obvious

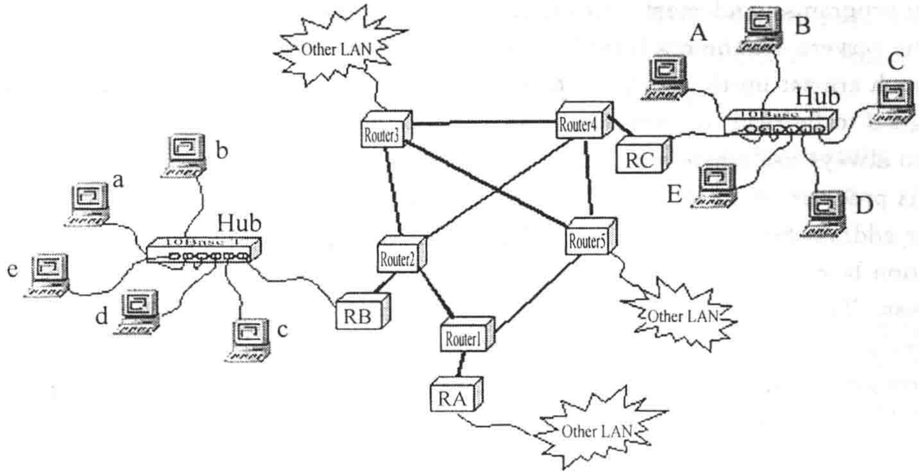

Fig. 1-2 An Example of a Small Internet

that there are many paths from Router 2 to Router 4 that the user D was connected through its LAN via router RC. It is the task of Router 2 to decide which path should be chosen to transmit the data packets according to an algorithm called a routing algorithm. Router 4 will then forward the packets to router RC, and RC will send the message to user D.

Pay attention to the words message and packet, they have different meanings here. We will explain it a bit later. How to choose the path between Router 2 and Router 4, — that is, the routing algorithm — is another topic in this chapter.

1.2.3 The Client-Server Approach

Often in the Internet computing, you will encounter the terms "client" and "server". The Internet uses what is called a client/server model of communication. In the communication process on an Internet, the computer, which asks for information is the client; the computer that provides the information is the server.

On the Internet there are many computers designed mainly for providing information to other computers or users; therefore, they are called servers. The other computers are clients on the Internet. Most of the software designed to be used via the Internet is classified as client software or server software. Client software is designed for ordinary users. Web browsers, E-mail programs, ftp programs, and most of the other Internet programs you use are clients. The servers are the big Internet computers, as mentioned above and programs which are set up to interact with clients. They generally have information designed to be read by various clients. For example, the web browser program you always use when you surf on the Internet is a web client. Let's say you use this program to go to China University of Mining and Technology (CUMT) at the address *http://www.cumt.edu.cn*. When you type the address in the location box and tell the browser to go there, it tries to find a server at that address. The CUMT has a computer (server) with all the pages of CUMT web site, as well as the appropriate programs to communicate those pages to your browser. In this communication process, of course, you are the client and CUMT is the server.

1.3 Protocols

From the discussion above, we know that one important networking concept is the protocol. Actually, protocols exist at every point where we need to do something with the network.

What is the protocol on the Internet? The following definition is from Douglas Comer: "A protocol is a formal description of message formats and the rules two or more machines must follow to exchange those messages."

Protocols usually exist in two forms. First, they exist in a textual form for people to understand. Second, they exist as programming codes for computers to understand. Both forms should ultimately specify the precise interpretation of every bit of each message exchanged across a network.

Usually multiple protocols will be in use simultaneously. Computers usually do several tasks , and often for several people at one time. Therefore, most protocols support multi-task.

Here, of course, we can only talk about some of the most important protocols in textual form. Readers, if interested, can easily find them on the Internet.

1.3.1 TCP/IP Protocol

IP Protocol

The Internet Protocol (IP) provides all of the Internet's data transport services. IP is the Internet's most basic protocol. A TCP/IP network can be defined as a communication medium that can transport IP packets. Almost all other TCP/IP functions are constructed by layering atop IP.

IP is a datagram-oriented protocol, treating each packet independently. This means that each packet must contain complete addressing information.

IP provides several services:

Addressing: IP headers contain 32-bit addresses which identify the sending and receiving hosts. These addresses are used by intermediate routers to select a path through the network for the packet.

Fragmentation: IP packets may be split, or fragmented, into smaller packets. This permits a large packet to travel across a network which can handle only smaller packets. IP fragments and reassembles packets transparently.

Packet timeouts: Each IP packet contains a Time To Live (TTL) field, which is decremented every time a router handles the packet. If TTL reaches zero, the packet is discarded, preventing packets from running in circles forever and flooding a network.

Type of Service: IP supports traffic prioritization by allowing packets to be labeled with an abstract type of service.

Options: IP provides several optional features, allowing a packet's sender to set requirements on the path it takes through the network (source routing), trace the route a packet takes (record route), and label packets with security features.

IP Packet Structure

All IP packets are structured the same way—an IP header followed by a variable-length data field. Fig. 1-3 shows an IP header, and a summary of the contents of the Internet header follows:

Version: 4 bits

The Version field indicates the format of the Internet header. This document describes version 4.

IHL: 4 bits

Internet Header Length is the length of the Internet header in 32-bit words, and thus points to the beginning of the data. Note that the minimum value for a correct header is 5.

0	3,4	8	16	19 — 31
Version	IHL	Type of Service	Total Length	
Identification			Flags	Fragment Offset
Time to Live		Protocol	Header Checksum	
Source IP Address				
Destination IP Address				
Options				Padding

Fig. 1-3 The Structure of IP Header

Type of Service: 8 bits

The type of service is used to specify the treatment of the datagram during its transmission through the Internet system.

Total Length: 16 bits

Total Length is the length of the datagram, measured in bytes, including Internet header and data. This field allows the length of a datagram to be up to 65,535 bytes. Such long datagrams are impractical for most hosts and networks. All hosts must be prepared to accept datagrams of up to 576 bytes (whether they arrive whole or in fragments).

Identification: 16 bits

An identifying value assigned by the sender to aid in assembling the fragments of a datagram.

Flags: 3 bits

Various Control Flags.

Bit 0: reserved, must be zero

Bit 1: (DF) 0 = May Fragment, 1 = Don't Fragment.

Bit 2: (MF) 0 = Last Fragment, 1 = More Fragments.

Fragment Offset: 13 bits

This field indicates where in the datagram this fragment belongs. The fragment offset is measured in units of 8 bytes (64 bits). The first fragment has offset zero.

Time to Live: 8 bits

This field indicates the maximum time the datagram is allowed to remain in the Internet system. If this field contains the value zero, then the datagram must be destroyed. This field is modified in Internet header processing. The time is measured in units of seconds, but since every module that processes a datagram must decrease the TTL by at least one, even if it processes the datagram in less than a second, the TTL must be thought of only as an upper bound on the time a datagram may exist. The intention is to cause undeliverable datagrams to be discarded, and to bound the maximum datagram lifetime.

Protocol: 8 bits

This field indicates the next level protocol used in the data portion of the Internet datagram.

Header Checksum: 16 bits

A checksum on the header only. Since some header fields change (e. g., time to live), this checksum is recomputed and verified at each point that the Internet header is processed.

Source Address: 32 bits

The source address.

IP addresses are 32 bit addresses used by the IP protocol to specify source and destination hosts. IP addresses are conventionally separated into four bytes and written in dotted quad notation: four integer numbers ranging from 0 to 255, separated by periods. Every network interface is assigned a unique IP address.

Destination Address: 32 bits

The destination address.

Options: variable

The options may appear or not in datagrams. They must be implemented by all IP modules. What is optional is their transmission in any particular datagram, not their implementation.

In some environments the security option may be required in all datagrams.

The option field is variable in length. There may be zero or more options. There are two cases for the format of an option:

Case 1: A single octet of option-type.

Case 2: An option-type octet, an option-length octet, and the actual option-data octets.

Padding: variable

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