《计算机网络原理》课程介绍

课程编号：40240513

讲课教师：吴建平 徐明伟 尹霞

本科生必修课

计算机科学与技术系

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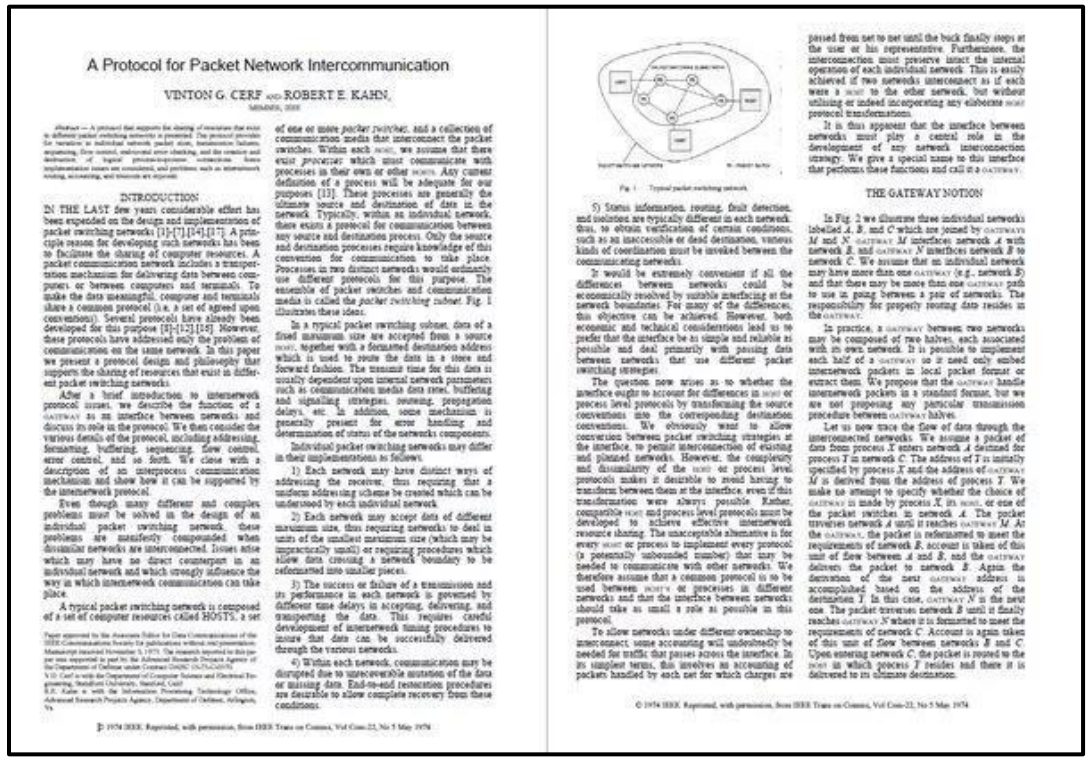


A Protocol for Packet Network Intercommunication

VINTON G. CERF AND ROBERT E. KAHN

INTRODUCTION

IN THE LAST few years considerable effort has been expended on the design and implementation of packet switching networks [1]-[7],[13-17]. A principle reason for developing such networks has been to facilitate the sharing of computer resources. A packet communication network includes a transportation mechanism for delivering data between computers or between computers and terminals. To make the data meaningful, computers and terminals share a common protocol (i.e., a set of agreed upon conventions). Several protocols have already been developed for this purpose [3]-[12],[18]. However, these protocols have addressed only the problem of communication on the same network. In this paper we present a protocol design and philosophy that supports the sharing of resources that exist in different packet switching networks.

After a brief introduction to internetwork protocol issues, we describe the function of a GATEWAY as an interface between networks and discuss its role in the protocol. We then consider the various details of the protocol, including addressing, fragmenting, buffering, sequencing, flow control, error control, and so forth. We close with a description of an interprocess communication mechanism and show how it can be supported by the internetwork protocol.

Even though many different and complex problems must be solved in the design of an individual packet switching network, these problems are manifestly compounded when dissimilar networks are interconnected. Issues arise which may have no direct counterpart in an individual network and which strongly influence the way in which internetwork communication can take place.

A typical packet switching network is composed of a set of computer resources called HOSTS, a set of one or more *packet switches*, and a collection of communication media that interconnect the packet switches. Within each HOST, we assume that there exist *processes* which must communicate with processes in their own or other HOSTS. Any current definition of a process will be adequate for our purposes [13]. These processes are generally the ultimate source and destination of data in the network. Typically, within an individual network, there exists a protocol for communication between any source and destination process. Only the source and destination processes require knowledge of this convention for communication to take place. Processes in two distinct networks would ordinarily use different protocols for this purpose. The ensemble of packet switches and communication media is called the *packet switching subnet*. Fig. 1 illustrates these ideas.

In a typical packet switching subnet, data of a fixed maximum size are accepted from a source HOST, together with a formatted destination address which is used to route the data in a store and forward fashion. The transmit time for this data is usually dependent upon internal network parameters such as communication media data rates, buffering and signalling strategies, routeing, propagation delays, etc. In addition, some mechanism is generally present for error handling and determination of status of the networks components.

Individual packet switching networks may differ in their implementations as follows:

1) Each network may have distinct ways of addressing the receiver, thus requiring that a uniform addressing scheme be created which can be understood by each individual network.

2) Each network may accept data of different maximum size, thus requiring networks to deal in units of the smallest maximum size (which may be impractically small) or requiring procedures which allow data crossing a network boundary to be refragmented into smaller pieces.

3) The success or failure of a transmission and its performance in each network is governed by different time delays in accepting, delivering, and transporting the data. This requires careful development of internetwork timing procedures to insure that data can be successfully delivered through the various networks.

4) Within each network, communication may be disrupted due to unrecoverable mutation of the data or missing data. End-to-end restoration procedures are desirable to allow complete recovery from these conditions.

Fig. 1. Typical packet switching network.

5) Status information, routeing, fault detection, and isolation are typically different in each network. thus, to obtain verification of certain conditions, such as an inaccessible or dead destination, various kinds of coordination must be invoked between the communicating networks.

It would be extremely convenient if all the differences between networks could be economically resolved by suitable interfacing at the network boundaries. For many of the differences, this objective can be achieved. However, both economic and technical considerations lead us to prefer that the interface be as simple and reliable as possible and deal primarily with passing data between networks that use different packet switching strategies.

The question now arises as to whether the interface ought to account for differences in HOST or process level protocols by transforming the source conventions into the corresponding destination conventions. We obviously want to allow conversion between packet switching strategies at the interface, to permit interconnection of existing and planned networks. However, the complexity and dissimilarity of the HOST or process level protocols makes it desirable to avoid having to transform between them at the interface, even if this transformation were always possible. Rather, compatible HOST and process level protocols must be developed to achieve effective internetwork resource sharing. The unacceptable alternative is for every HOST or process to implement every protocol (a potentially unbounded number) that may be needed to communicate with other networks. We therefore assume that a common protocol is to be used between HOSTS or processes in different networks and that the interface between networks should take as small a role as possible in this protocol.

To allow networks under different ownership to interconnect, some accounting will undoubtedly be needed for traffic that passes across the interface. In its simplest terms, this involves an accounting of packets handled by each net for which charges are passed from net to net until the buck finally stops at the user or his representative. Furthermore, the interconnection must preserve intact the internal operation of each individual network. This is easily achieved if two networks interconnect as if each were a HOST to the other network. But without utilizing or indeed incorporating any elaborate HOST protocol transformations.

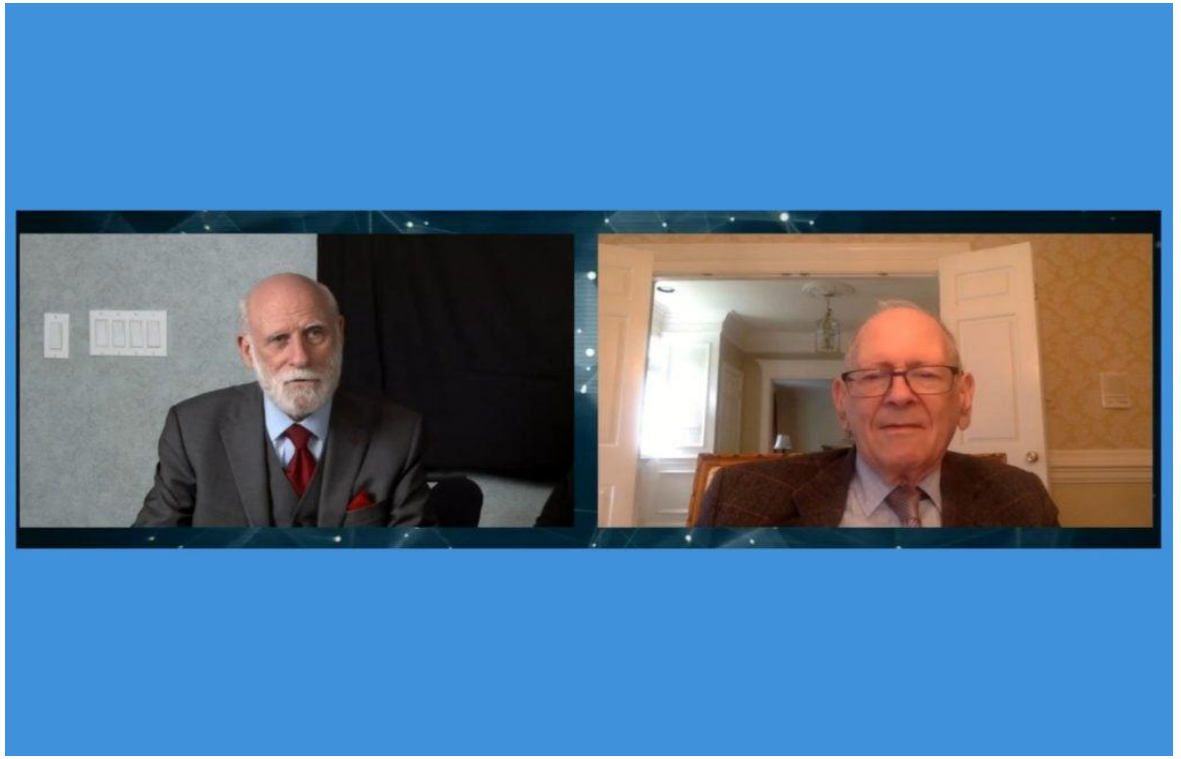
It is thus apparent that the interface between networks must play a central role in the development of any network interconnection strategy. We give a special name to this interface that performs these functions and call it a GATEWAY.

THE GATEWAY NOTION

In Fig. 2 we illustrate three individual networks labelled *A*, *B*, and *C* which are joined by GATEWAYS *M* and *N*. GATEWAY *M* interfaces network *A* with network *B*, and GATEWAY *N* interfaces network *B* to network *C*. We assume that an individual network may have more than one GATEWAY (e.g., network *B*) and that there may be more than one GATEWAY path to use in going between a pair of networks. The responsibility for properly routing data resides in the GATEWAY.

In practice, a GATEWAY between two networks may be composed of two halves, each associated with its own network. It is possible to implement each half of a GATEWAY so it need only embed internetwork packets in local packet format or extract them. We propose that the GATEWAY handle internetwork packets in a standard format, but we are not proposing any particular transmission procedure between GATEWAY halves.

Let us now trace the flow of data through the interconnected networks. We assume a packet of data from process *X* enters network *A* destined for process *Y* in network *C*. The address of *Y* is initially specified by process *X* and the address of GATEWAY *M* is derived from the address of process *Y*. We assume an attempt to specify whether the choice of GATEWAY is made by process *X*, its HOST, or one of the packet switches in network *A*. The packet traverses network *A* until it reaches GATEWAY *M*. At the GATEWAY, the packet is reformatted to meet the requirements of network *B*, account is taken of this unit of flow between *A* and *B*, and the GATEWAY delivers the packet to network *B*. Again the destination of the next GATEWAY address is accomplished based on the address of the destination *Y*. In this case, GATEWAY *N* is the next one. The packet traverses network *B* until it finally reaches GATEWAY *N* where it is reformatted to meet the requirements of network *C*. Account is again taken of this unit of flow between networks *B* and *C*. Upon entering network *C*, the packet is routed to the HOST in which process *Y* resides and there it is delivered to its ultimate destination.



温顿•瑟夫和罗伯特•卡恩在IEEE期刊发表论文《一种分组网络通信协议》，1974

Vent Cerf and Robert E. Kahn，A Protocol for Packet Network Intercommunication，IEEE Transaction on Comm.， May 1974

- 50 Years Later, Vint Cerf and Bob Kahn Remember the Birth of TCP/IP
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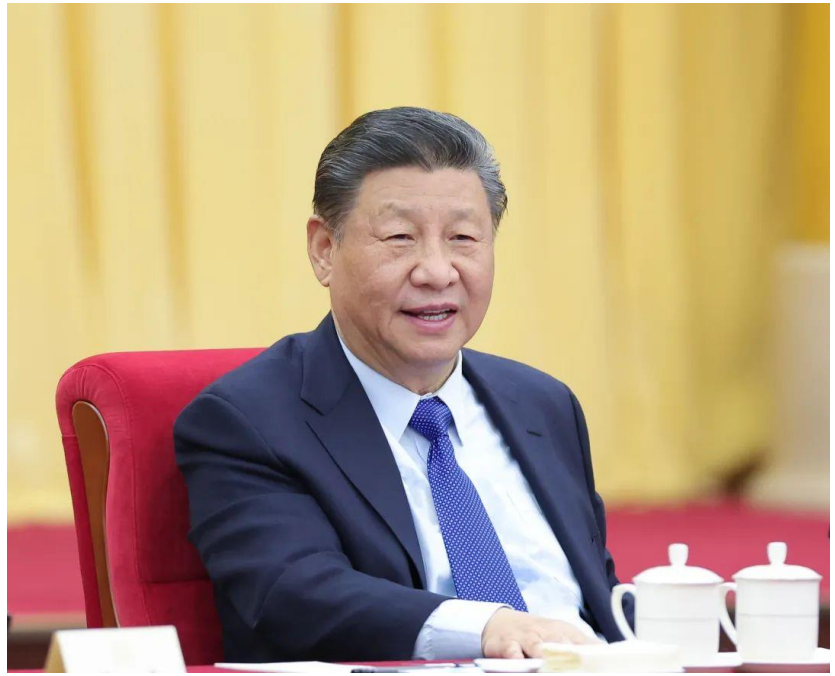

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- 2024年3月6日，中共中央总书记、国家主席、中央军委主席习近平看望参加全国政协十四届二次会议的民革、科技界、环境资源界委员，并参加联组会，听取意见和建议。习近平总书记强调，**“要实现中国式现代化，互联网这一关必须要过”**。

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- 了解计算机网络的基本概念
- 掌握计算机网络各层协议的基本工作原理及其所采用的技术
- 学会计算机网络的一些基本设计方法
- 对典型计算机网络（互联网）的特点和具体实现有基本印象
- 为以后计算机网络及其应用的专题学习和研究打下基础
- 实验课：掌握计算机网络协议的基本实现技术

主要教学内容和学时分配

第一章	引言	3
第二章	计算机网络的体系结构	6
第三章	数据通信的基本原理	3
第四章	物理层	3
第五章	数据链路层	6
第六章	局域网与介质访问控制层	6
第七章	网络层	9
第八章	传送层	3
第九章	应用层	3
第十章	网络安全	3
机动		3
共计		48

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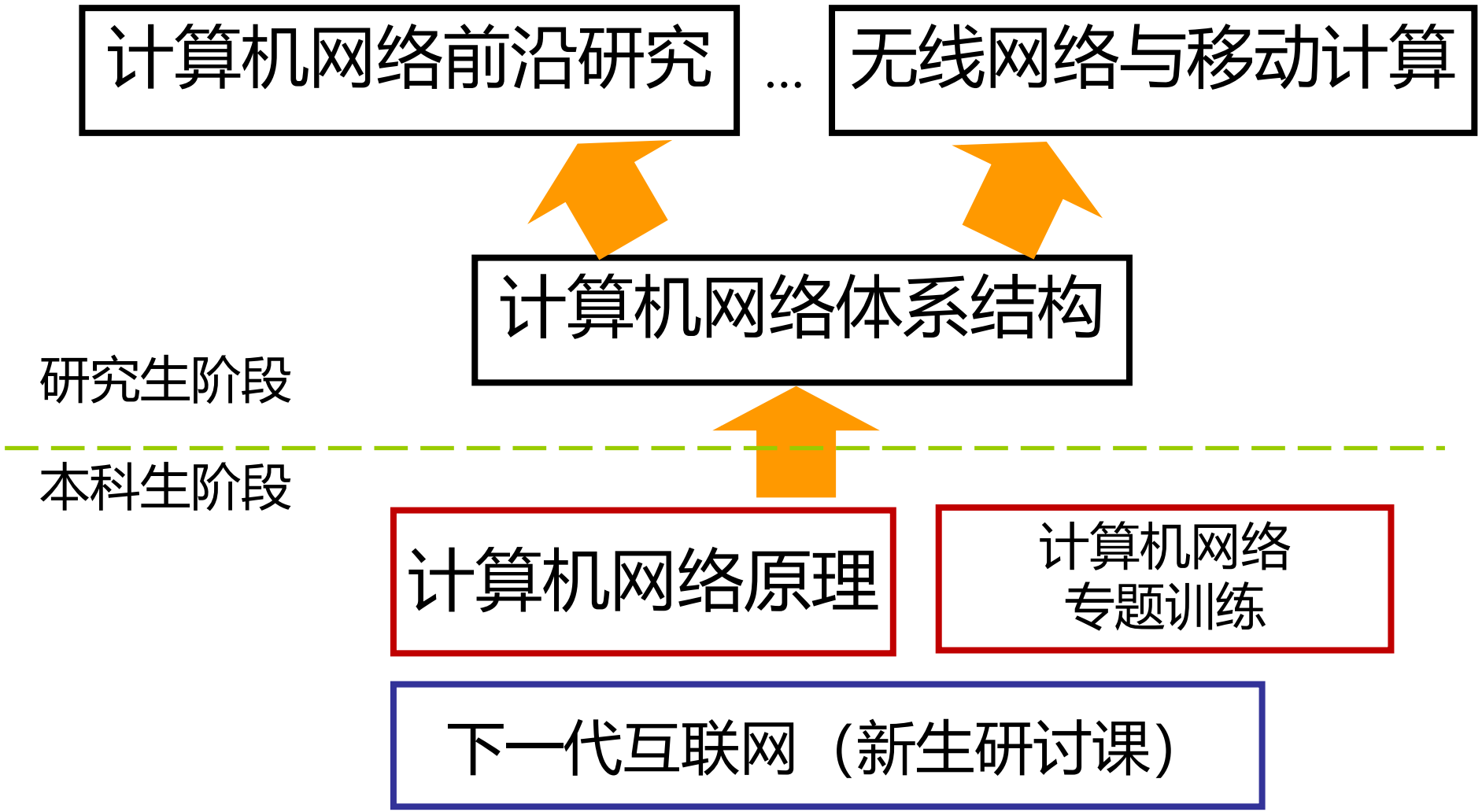
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主要参考书

- A.S Tanebaum, Computer Networks，6nd Edition, Prentice Hall, 2022（中译本，清华大学出版社）
- D.E Comer, Computer Networks and Internet, 6th Edition, 2013
- Larry L. Peterson and Bruce S. Computer Networks: a system approach，2nd Edition, 2000
- D.E Comer, Internetworking with TCP/IP

  Volume I: Principles, Protocols, and Architecture, 2000

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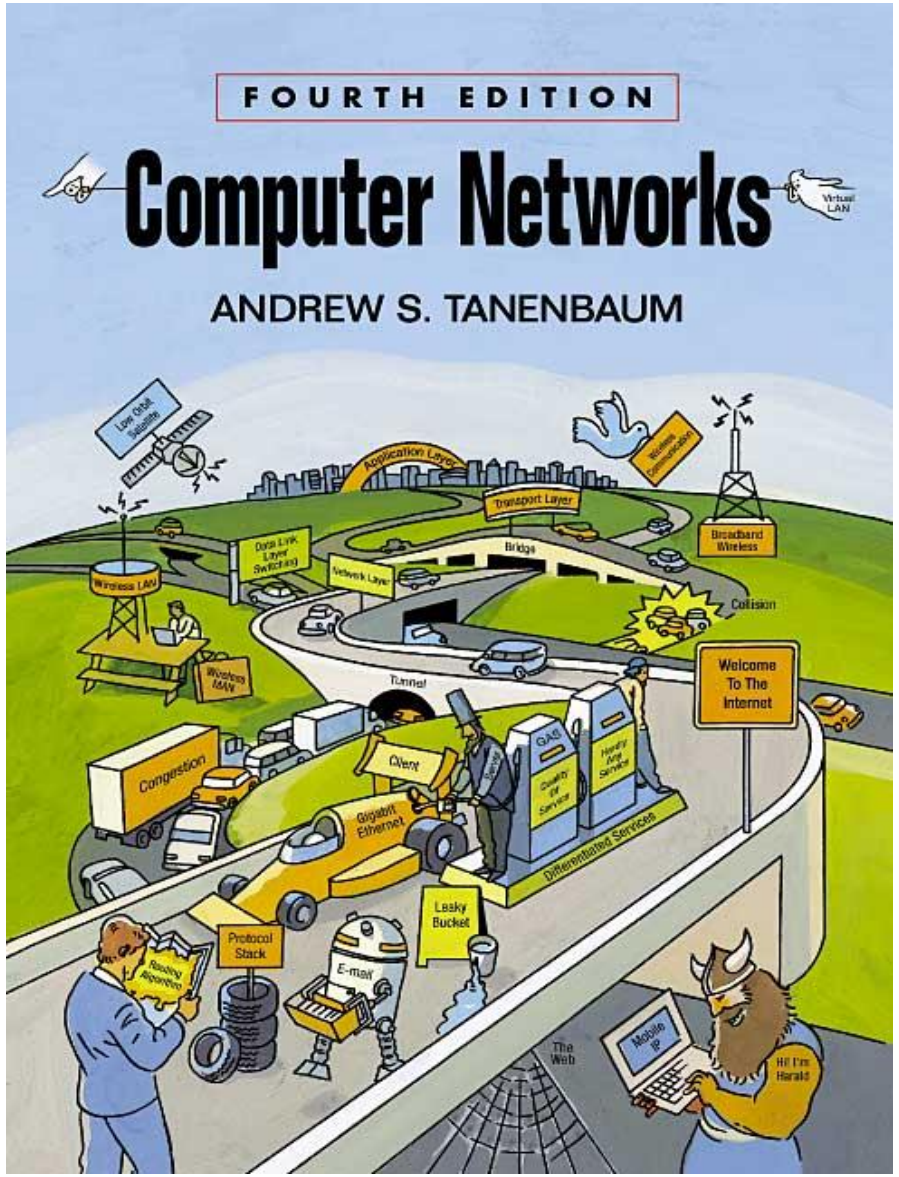
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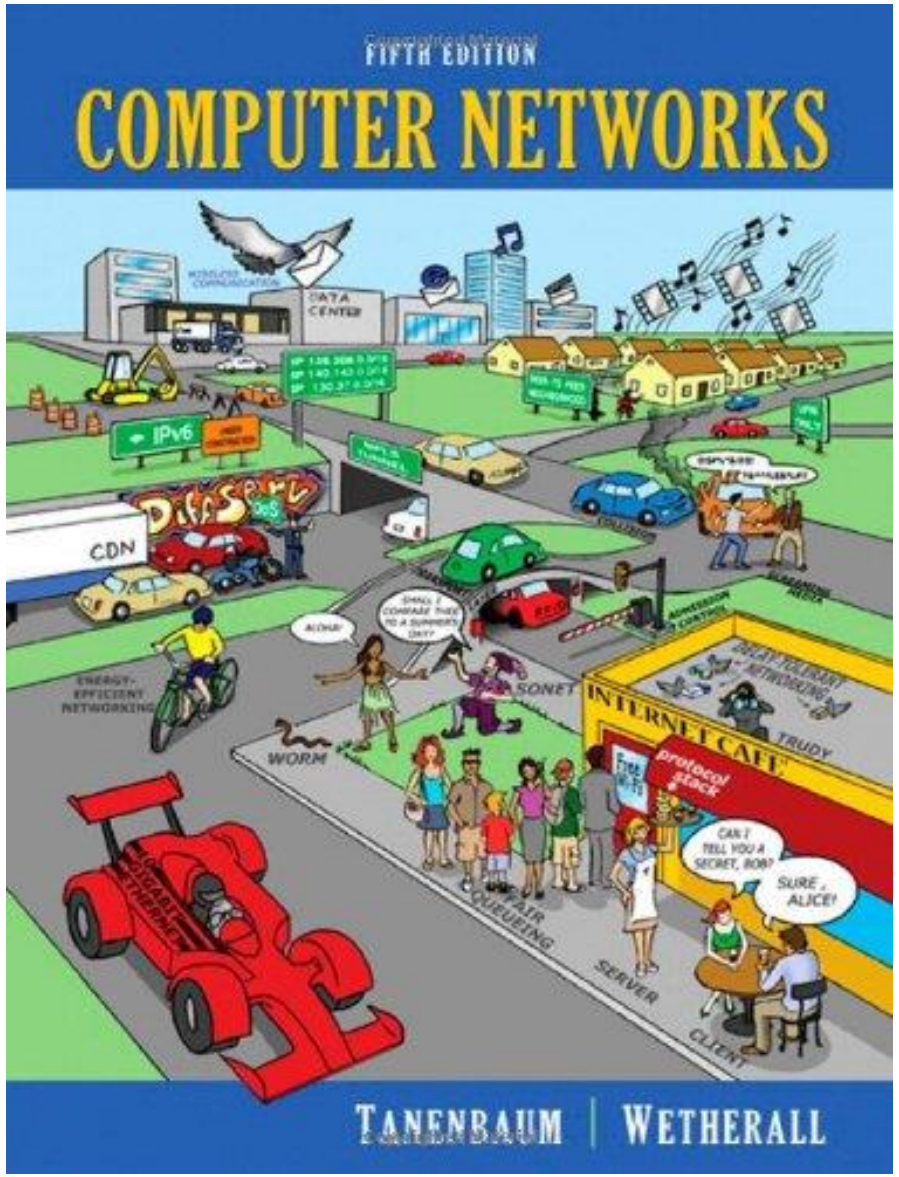
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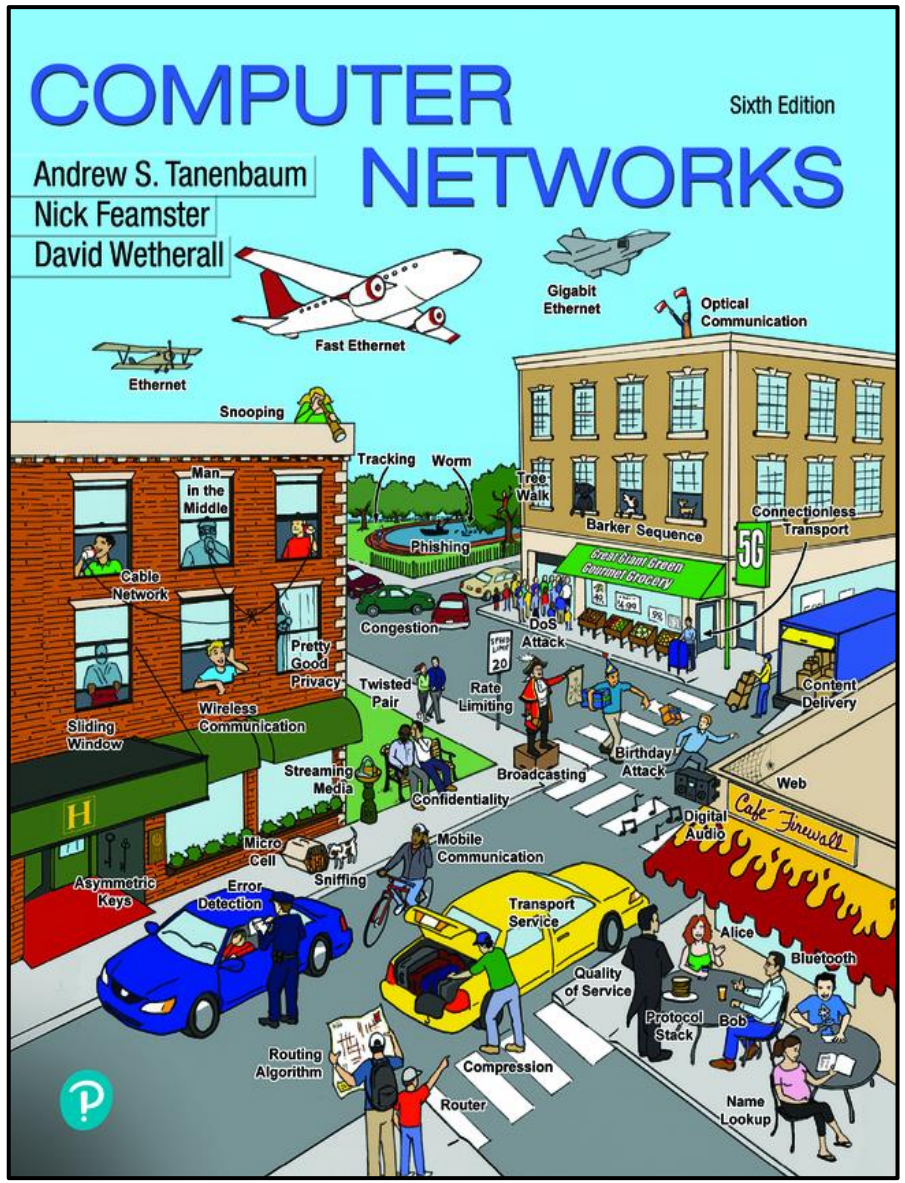
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Web
Confidentiality
Digital Audio
Cafe Firewall
Micro Cell
Mobile Communication
Sniffing
Asymmetric Keys
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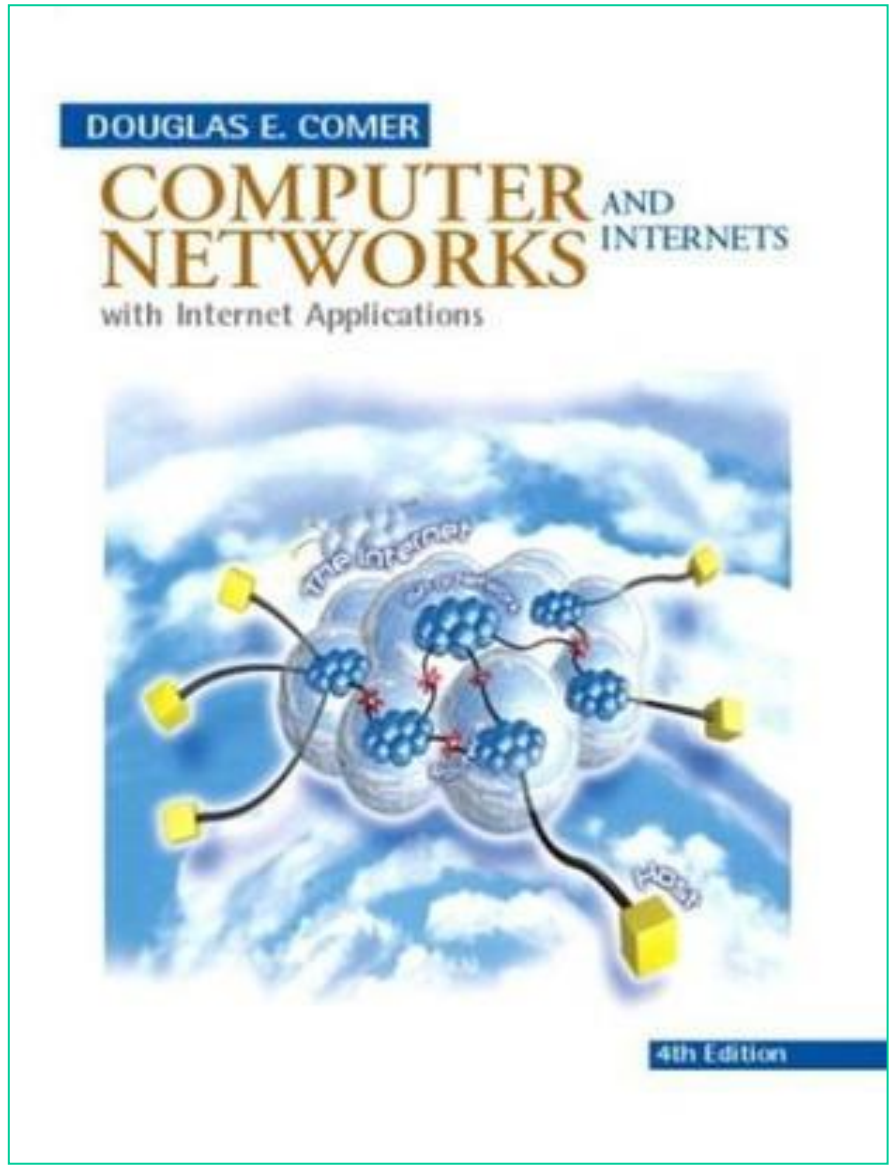
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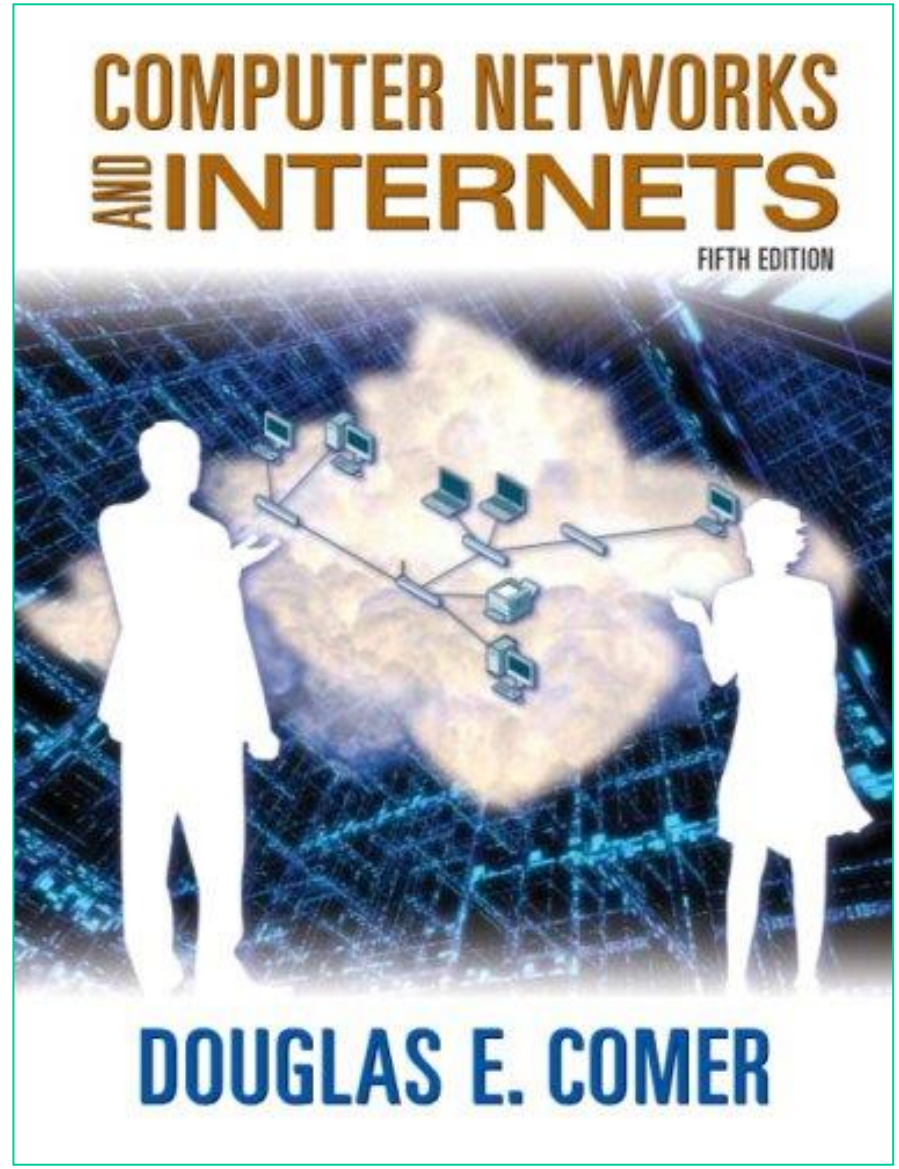
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- 实验 (40%-60%)
  - 独立开发软件路由器，合作完成组网
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- 期末考试 (50%-30%)，闭卷考试
- 课程评分情况
  - 软件路由器实验，作业：实验：考试 = 10:40:50
  - 硬件路由器实验，作业：实验：考试 = 10:60:30

实验：开发路由器

- 清华大学计算机系的学生不但会造计算机，还会造路由器！
  - “奋战三星期，造台计算机”不是神话
  - “奋战一学期，造台路由器”不在话下

- 两种实验平台可选
  - 通用开发平台：树莓派（软件路由器）
  - 专用开发平台：Thinrouter（硬件路由器）
  - 可以选择一种

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