

计算机网络

Instructor: Xiao Mingzhong(肖明忠)
Room:EB-511
Email: xmz@bnu.edu.cn

TA:
? ? ?

Course resource:
QQ群: 241817373

About the course (1/5)

□ The purpose of the class

- Let students learn and get familiar with the basic concepts and aspects of computer networks;
- thoroughly understand network architectures, **primary ideas** of network engineering, as well as applications;
- build up ground work for further study and R&D in computer networks field.



About the course (2/5)

□ The contents of the class

- Will systematically teach computer networks principles, ISO/OSI reference model (the seven layers), especially the hybrid module of **five layers**, and TCP/IP module:
- Physical → Data link → Network → Transport → Session* → Presentation* → Application
- Network management * and network security*

About the course (3/5)

□ References

- Computer networks and Internets, Douglas Comer.
- Computer Networking: A Top-Down Approach Featuring the Internet. James F. Kurose & Keith W. Ross. Pearson Education.
- Computer Networks: A Systems Approach. Larry L. Peterson and Bruce S. Davie, Morgan Kaufman.
- 计算机网络, 谢希仁. 电子工业出版社.
- 计算机网络, 特南鲍姆, 清华出版社.
- 计算机网络高级软件编程技术, 吴功宜等, 清华出版社.
- Unix网络编程, W.理查德·史蒂文斯,人民邮电出版社.
-



About the course(4/5)

□ Time & location

- 1-16周, 周一34节(10:00-11:40), 九,102
 - 51放假
- 1-8周, 周三12节(8:00-9:40), 九,102
 - 清明放假

□ Assignments

- 实验 (不少于8个wireshark实验 或 能用的网络应用开发)
- 教材习题 (每章所有, 未讲除外, 鼓励协商, 独立纸版提交)

□ Grading policy

- 60% for assignments.
- 40% for final (来源于ppt及教材习题).



About the course(5/5)

□ Others

- 预习及课后复习与课堂教学关系?
- 教材或教学计划适宜?
- 课程难?
- 考勤与成绩的关系?
- 语言?
-

投入!



Computer Networks

Chapter 1:Introduction

(Version February 13, 2023)

Xiao Mingzhong

CIST, Beijing Normal University

Outline

- 计算机网络的应用简介
- 计算机网络的定义及分类
- How to design a network?*
- Example networks
- 网络标准化



计算机网络的应用

- 硬件资源共享**
打印机, 远程桌面, 远程终端, 网络存储...
- 远程信息访问**
Web, Ftp, 搜索引擎, ...
- 人与人间的通信**
Email, QQ, 微信, ...
- 交互式娱乐应用**
电子游戏, 在线点播, 网络电视, IP电话, ...
- 电子商务**
Taobao, dangdang, JD, ...
- 应用模型***
Designer: [C/S vs P2P](#), User: [Mobile vs Fixed](#), [Business vs Home](#)
- 社会问题**
Political, Privacy, Freedom of speech, Spam, Virus, Copyright, Security, ... 



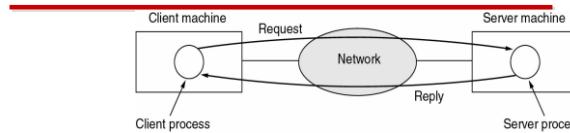
移动应用 vs 固定应用 (用户角度看)

Wireless	Mobile	Applications
No	No	Desktop computers in offices
No	Yes	A notebook computer used in a hotel room
Yes	No	Networks in older, unwired buildings
Yes	Yes	Portable office; PDA for store inventory

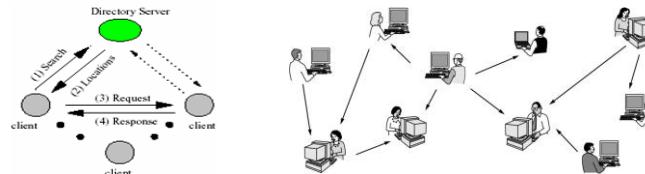
- 移动和无线的区别. (e.g. ad-hoc net.)



CS vs P2P (应用设计模型)



- 客户服务器模型的请求和应答



- P2P模型(节点既服务别的节点,也向别的节点索求服务)



商务应用 vs 家庭应用 (用户角度看)

Tag	Full name	Example
B2C	Business-to-consumer	Ordering books on-line
B2B	Business-to-business	Car manufacturer ordering tires from supplier
G2C	Government-to-consumer	Government distributing tax forms electronically
C2C	Consumer-to-consumer	Auctioning second-hand products on-line
P2P	Peer-to-peer	File sharing (free?)

- 电子商务的一些形式

- 家庭应用: 炖具协同工作系统, ...



What is the Computer Network?

- 过去:计算机系统高度集中化,通常位于一个很大的房间中(计算中心)
 - Hardware: VAX,TJ,... OS: VMS, Unix,...
 - Hardware: Terminal → PC OS: DOS, ...
 - 每台机器独立自治,没有做到联机交换信息
- 现在:大量独立且互连的计算机共同完成计算任务,这些系统称为computer networks.
 - 若两台计算机能够交换信息,则称是互连的,含硬连接和软连接;
 - Computer network是指使用同一种技术连接一组自主计算机构成的信息交换系统.不同的网络具有不同的大小、形状和形式。
 - 如何设计这些网络,并使它们互连互通是计算机网络领域的主要工作内容。



按传输技术分类

- 广播式网络(Broadcast networks)
 - 网络上的所有机器共享一条“单一的通信信道”
 - 任何机器发出的消息,都能被其他机器接收到(以太网中,此消息术语为帧)
 - 在消息中至少有接收方标识符(address field, 通信节点需要命名!)
 - [例子LAN](#)
- 点对点网络(Point-to-point networks)
 - 两台机器间有多条路可达
 - 消息从源机器到达目的机器,要经过若干中间机器(如: routers)中转
 - 寻找一条“合适”的路是要事(称为Routing问题)
 - [例子WAN](#)
- 不管什么类型网络,其传输操作(服务)可有
 - 单播Unicasting(1->1); 广播Broadcasting(1->n);
 - 组播Multicasting(1->m); 泛播Anycasting(1->anyone)



按网络大小(规模)分类

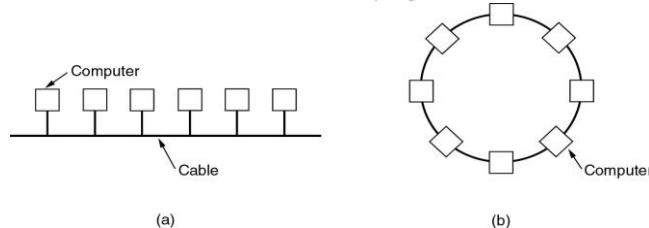
Interprocessor distance	Processors located in same	Example
1 m	Square meter	Personal area network
10 m	Room	
100 m	Building	
1 km	Campus	Local area network
10 km	City	
100 km	Country	
1000 km	Continent	Metropolitan area network
10,000 km	Planet	

□ 网络类型按大小分类



局域网 LAN

LANs 通常是采用广播技术, 网络拓扑结构topologies常见有:

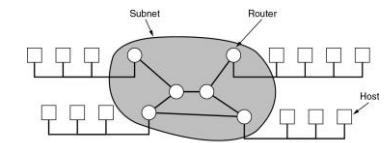


两种广播式局域网:

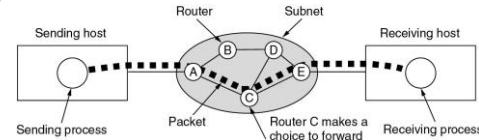
- (a) 总线型Bus→所有机器都连接到一根电线上。
 - (b) 环网Ring→一个令牌(token,短消息)沿环传播。
- 有疑惑? MAC问题。



广域网 WAN



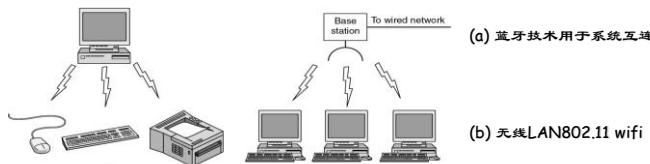
□ 一个广域网的例子



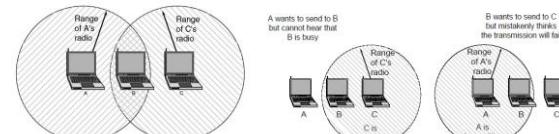
□ 消息从发送者到接收者的路径(子网技术：包交换和虚电路)



无线网络 Wireless networks



(b) 无线LAN802.11 wifi



□ 一个节点的信号发射范围不能覆盖全局(如:ad-hoc网络)



家庭网络

□ 家中设备互联互通:

- Computers
- Entertainment (audio equipment, game centers)
- Telecommunications (mobile phones, fax devices, intercom)
- Appliances (refrigerator, microwave, central heating, lights)
- Telemetry (alarms, cameras, thermostat)

□ 家庭网络技术

- decentralized versus centralized
- the specific requirements:

100% robust; very easy to use; self-managing; high bandwidth; security; low price.



互联网络

□ **internet(互联网):** 不同类型的网络通过 gateway 互连互通。

- Internet(因特网) is one specific internet.
- Internet is an overlay network(覆盖网络).

□ **Examples:**

- Connecting a collection of different kinds of LANs within a department (combine wired/wireless).
- Connecting LANs to each other through a WAN (think of enterprise networks for multinationals).
The WAN acts as a subnet.
- Connecting WANs to each other (the Internet).



小结

□ 计算机网络

- 就是独立自治的计算机系统，使用同一种技术互连起来，可能提供单播、组播、广播和泛播传输操作的基础设施；
- 分类
 - 按传输技术：广播式网络和点到点网络（包交换和电路交换）；
 - 按网络规模：局域网，城域网，广域网，Internet，无线网络，家庭网络，个人区域网络，...
 - 不同的网络具有不同的技术特点，适宜不同的环境。
- 应用
 - 涉及人类社会生活的方方面面；
 - Client/Server, P2P是两种网络应用开发模型。



How to design a network?

□ Laying design principle

- What is the protocol?
- Protocol Hierarchies
- Some common design issues for the layers

□ Six different types of service

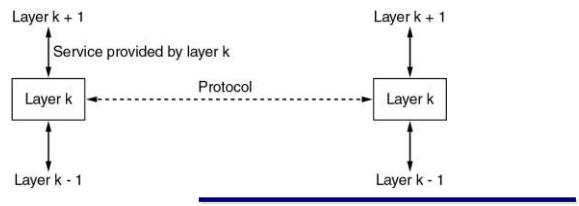
- Implementing a simple connection-oriented service

□ Reference Models



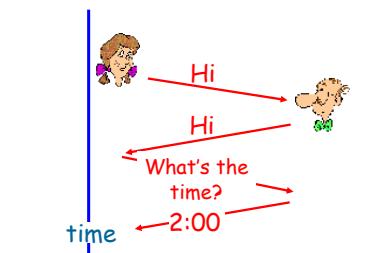
分层设计：

- 每一层建立在其下一层之上，使用下层服务完成自己“事”
- 不同的网络分几层，叫什么名字，各做些什么事等等不同
- 底层对高层是如何提供服务的细节被“封闭”起来，高层通过服务接口享用服务。
- 一台机器上的第k层通信体与另一台机器上的第k层通信体采用同样的协议进行消息通信（交换）。

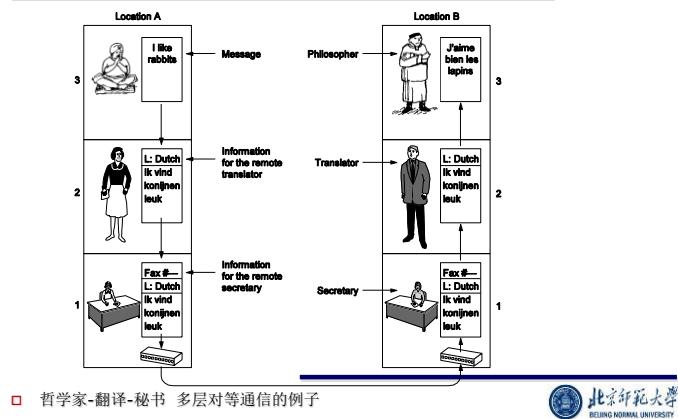


什么是协议？

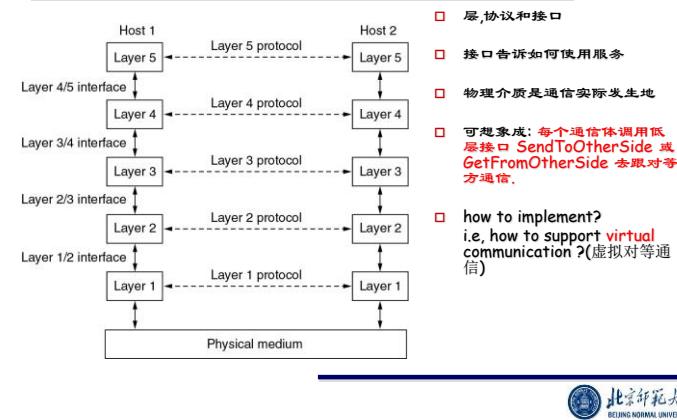
- 协议就是通信体间的消息交换规则和约定。
- 协议描述两个通信体是如何交换消息的，包括消息的格式，传输顺序，以及对收到消息采取的动作。



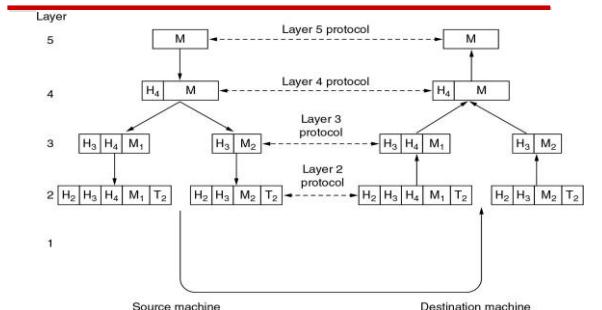
多层对等通信的例子



网络协议层次



通过加“头”支持虚拟对等通信



每一层通常都要考虑的问题

- 编址Addressing
每一层的通信体都需要“标识”(命名)
- 差错控制Error Control (why?)
物理传输介质会传错。
- 流量控制Flow Control
如何做到通信体间收发速度的协调, 不至于淹没慢速的接收方。
- 多路复用Multiplexing (connection)
底层两通信体同时为上层多对通信体服务(向上多路复用), 或上层两通信体同时使用底层多对通信体来服务自己(向下多路复用)。
- 路由Routing寻址
消息如何到达对方?
When there are multiple paths between source and destination, a route must be chosen.

六种不同的服务类型

	Service	Example
Connection-oriented	Reliable message stream	Sequence of pages
	Reliable byte stream	Remote login
Connection-less	Unreliable connection	Digitized voice
	Unreliable datagram	Electronic junk mail
Acknowledged datagram	Acknowledged datagram	Registered mail
	Request-reply	Database query

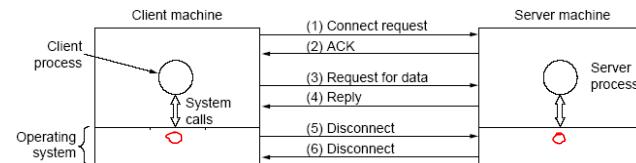
- 1)向上层提供的服务可为: 面向连接服务 (C-U-R) 和 无连接服务(每条报文消息独立路由).
 2)可靠服务就是带确认的服务.
 3)一个服务由一系列的服务原语primitives给出.



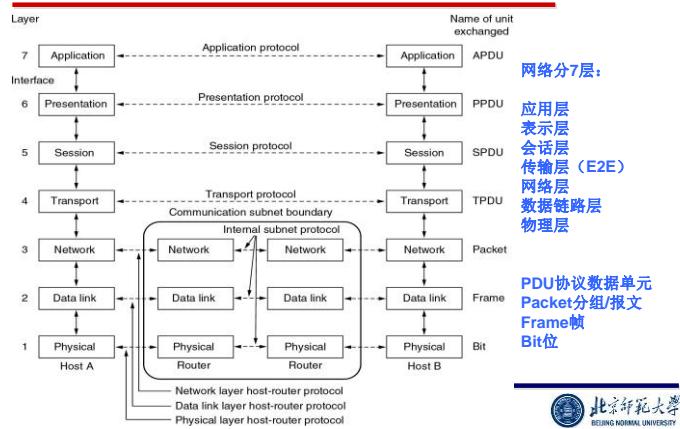
例子：一个面向连接服务的可能设计

Primitive	Meaning
LISTEN	Block waiting for an incoming connection
CONNECT	Establish a connection with a waiting peer
ACCEPT	Accept an incoming connection from a peer
RECEIVE	Block waiting for an incoming message
SEND	Send a message to the peer
DISCONNECT	Terminate a connection

Ex. 面向连接服务上 一个C/S交互 引发的直接下层消息交互过程



ISO/OSI reference model (参考模型)



OSI 物理层

物理传输介质（有线或无线）连接的两点间

如何采用某种能量形式（如：电压的高低，光的有无等）表达数据位，涉及机械（如接口等）和电气等方面的问题。简单讲就是数据位的传输问题，如何向对方表达1还是传0，一个信号也可表达若干数据位。

Essence: Describes the transmission of raw bits in terms of mechanical and electrical issues:

Example: Connect two computers by means of a wire:

- Setting -3V on the wire corresponds to a binary 1; +4V is a binary 0
- The wire is not to be longer than 15 meters
- You may change the voltage at most 20,000 times per second (**Question:** what's the transfer rate?)



OSI 数据链路层

试图解决物理连接的两点间：差错控制和流量控制问题。
在广播式网络中，还有MAC问题。

差错控制就是解决物理层传输位的时候可能造成的错误，方法：若干位+冗余位作为一个传输单元（帧），接收方根据收到的帧判断是否存在传输错误。若无错交给上层，否则要求对方重发或无视等等。

Bits	8	8	8	≥ 0	16	8
Examples:	01111110	Address	Control	Data	Checksum	01111110

- Add a **parity bit** to every 7 transmitted bits: 1 says there were odd number of 1's; 0 says there were an even number of 1's
- Add a **checksum** (cyclic redundancy check) that should match the bits before it



OSI 网络层

三个问题：路由问题，拥塞控制问题 和 互联互通问题，
就是包在通信子网中如何到达目的通信体的一些问题。

- How do we find out which computers/routers are in the network?
- How do we calculate the **best route** from A to B?
- What happens when a computer/router goes down?
- Should **multicasting/broadcasting** be supported?
- What happens if a router becomes overloaded and starts dropping packets (**congestion**)?
- Can we detect and avoid “hot spots”?



OSI 传输层

向上层提供**端到端**的传输服务，
通常是面向连接和无连接服务都提供，具有不同的传输可靠性。
要考虑的问题主要有：E2E的传输差错控制和流量控制。
对比链路层，这里是子网传输，非物理层传输，延迟抖动等波动大是差异。

两台机器具备了E2E的消息传输能力，就可以彼此交互了（实现应用！）

- Often provides network interface through **sockets** (UNIX, Windows)
- Allows to set up a connection to another application, and subsequently deliver data **reliably**, and **in the order** that it was sent
- Often also support for **secure connections**
- Also support for **datagrams**: unreliable message passing on a per-message basis



OSI 会话、表示层和应用层

会话层：解决一个应用会话/通信过程如何持续的问题。
比如：大文件的断点续传，连接突然断掉又能自动重新建立。

表示层：怎么以平台无关的方式 表示要交换数据 的问题。
比如：不同计算机的字节序号问题，用email来传输二进制数据等。

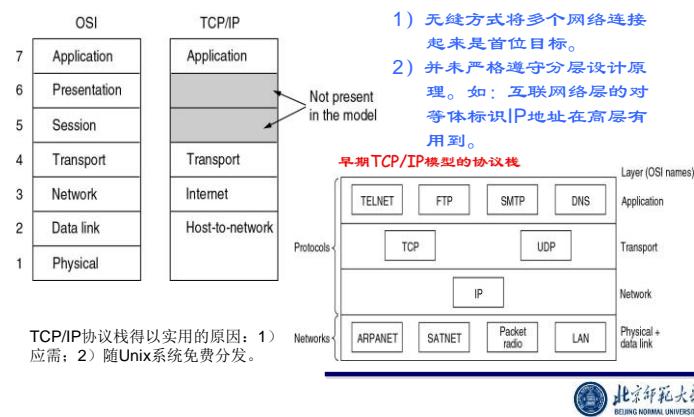
应用层：contains the rest.
传统应用：Name services(如:DNS),Email(如:SMTP),Web(如:http)...
现代：all types of middleware protocols to support distributed systems.

- New transfer protocols for object systems like Java (RMI), CORBA (IIOP), DCOM (proprietary)
- Special protocols to handle replication, fault tolerance, caching, data persistence, etc.

高级应用协议：
High-level protocols: Special application-level protocols for e-commerce, banking, EDI, etc.



TCP/IP 模型



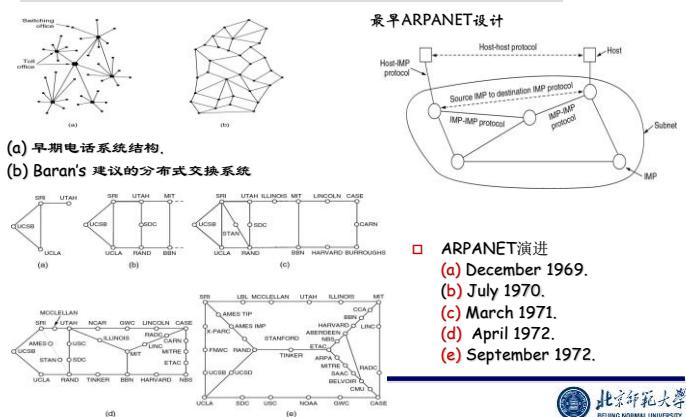
Example Networks

- Internet*
- Connection-Oriented Networks:
X.25, Frame Relay, and ATM
- Ethernet*
- Wireless LANs: 802.11*
- 3G, 4G, RFID and Sensor networks

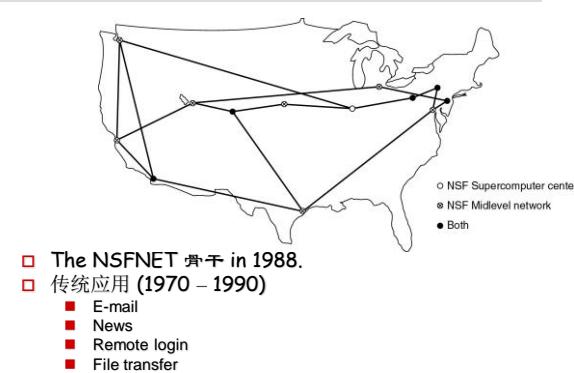
不同网络具有不同的目标、规模和技术。



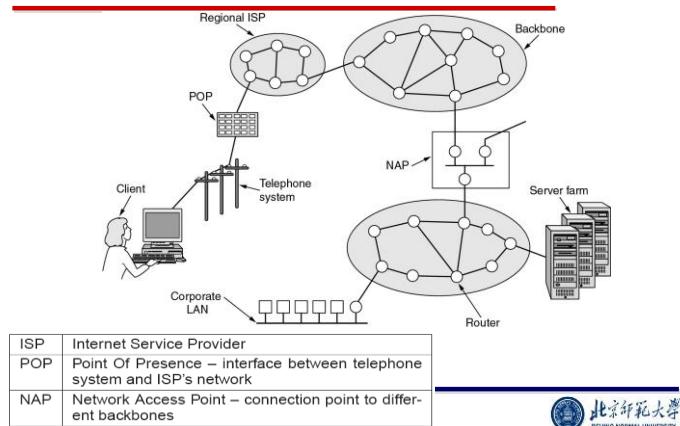
ARPANET (Internet 1)



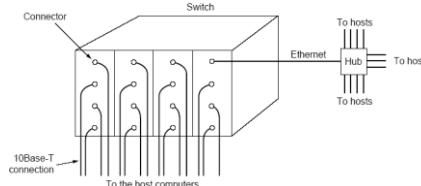
NSFNET (Internet 2)



Internet 3



Ethernet



最常用组网方式



网络标准化 (ITU & ISO)

- 国际电信联盟
 - ITU-T's task is to make technical **recommendations** about telephone, telegraph, and data communication interfaces. Such as V.24, V.90.
- 国际标准化组织
 - ANSI standards are frequently adopted by ISO as international standards.
 - IEEE standardization group → IEEE's 802 committee has standardized many kinds of **LANs** → 802 working groups(17)
- IAB (因特网结构委员会)
 - IRTF (Internet Research Task Force)
 - IETF (Internet Engineering Task Force)
 - Steering Committee
 - Work Groups
 - Proposed Standard (RFC, Request for Comments) → Draft Standard → Standard

Number	Topic
802.1	Overview and architecture of LANs
802.2 ↓	Logical link control
802.3 *	Ethernet
802.4 ↓	Token bus (was briefly used in manufacturing plants)
802.5	Token ring (IBM's entry into the LAN world)
802.6 ↓	Dual queue dual bus (early metropolitan area network)
802.7 ↓	Technical advisory group on broadband technologies
802.8 ↑	Technical advisory group on fiber optic technologies
802.9 ↓	Isochronous LANs (for real-time applications)
802.10 ↓	Virtual LANs and security
802.11 *	Wireless LANs
802.12 ↓	Demand priority (Hewlett-Packard's AnyLAN)
802.13	Unlucky number. Nobody wanted it
802.14 ↓	Cable modems (defunct: an industry consortium got there first)
802.15 *	Personal area networks (Bluetooth)
802.16 *	Broadband wireless
802.17	Resilient packet ring



Summary

- 计算机网络可分为**LANs, MANs, WANs**和**internet**等。每种网络都有其特点、技术、速度及适宜场景等。
- 大多数网络支持协议分层设计，**k-1**层向**k**层提供服务并对上层屏蔽细节。
- 服务分为面向连接和无连接服务两种。
- 虚拟对等通信通过加“头”实现。
- ISO/OSI是理论设计模型，而事实上的标准是TCP/IP。
- 周知的网络有：Internet, ATM, Ethernet, and the IEEE 802.11 无线LAN (wifi)
- 主要的标准化组织：ITU-T, ISO, IETF, IEEE



名人名言

□ Leonard Kleinrock(伦纳德·克兰罗克)

- 创建Internet第1个节点
- 创造的分组交换原理成为因特网的支撑技术
-

□ 对进入网络领域的学生的忠告

- “因特网以及与它相关的东西是一个巨大的战场，充满了令人惊奇的挑战，为众多创新提供了广阔空间。
不要受今天技术的束缚，开动大脑，想象能够做些什么，并去实现它。”

