Chapter 1 Introduction

Chuan Luo

chuanluo@buaa.edu.cn

School of Software, Beihang University

Chapter 1: outline

1.1 What is the Computer Network?

1.2 Internet History

1.3 Components of Computer Networks

1.4 Protocol layers, service models

Copyright © whq@buaa.edu.cn

1.1 What is the Computer Network?

- Collection of autonomous computers interconnected by a single technology.
- The old model of a large computer linking many terminals, serving all of the organization's computational needs is now totally obsolete.
- Distributed System is a software system built on top of a network, e.g. WWW

Copyright © whq@buaa.edu.cn

1.1 What is the Computer Network?

- Computer Network——the collection of computers:

  Connected Via communication links

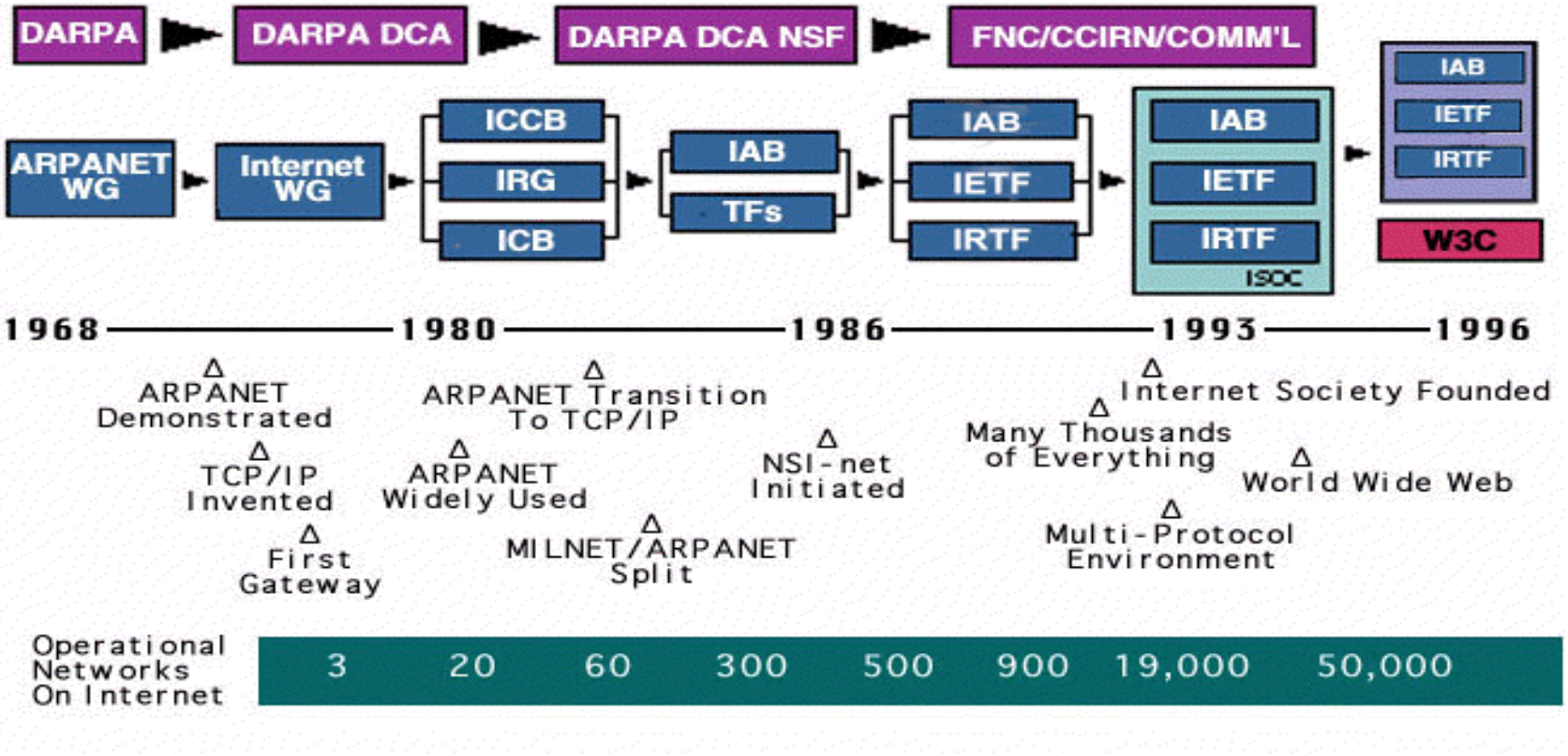
  With the target to share resources

  Resources include: computer hardware, software, information (data) and something useful to others

- In a computer network, Computer is the element of the set.

Copyright © whq@buaa.edu.cn

1.2 Internet History



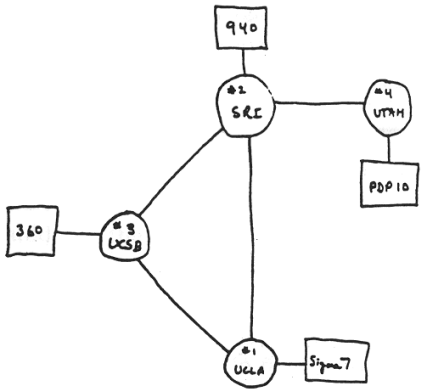
Copyright © whq@buaa.edu.cn

1.2 Internet History

1961-1972: Early packet-switching principles

- 1961: Kleinrock - queueing theory shows effectiveness of packet-switching （分组交换）
- 1964: Baran - packet-switching in military nets
- 1967: ARPAnet （美国高等研究计划署网络） conceived by Advanced Research Projects Agency
- 1969: first ARPAnet node operational

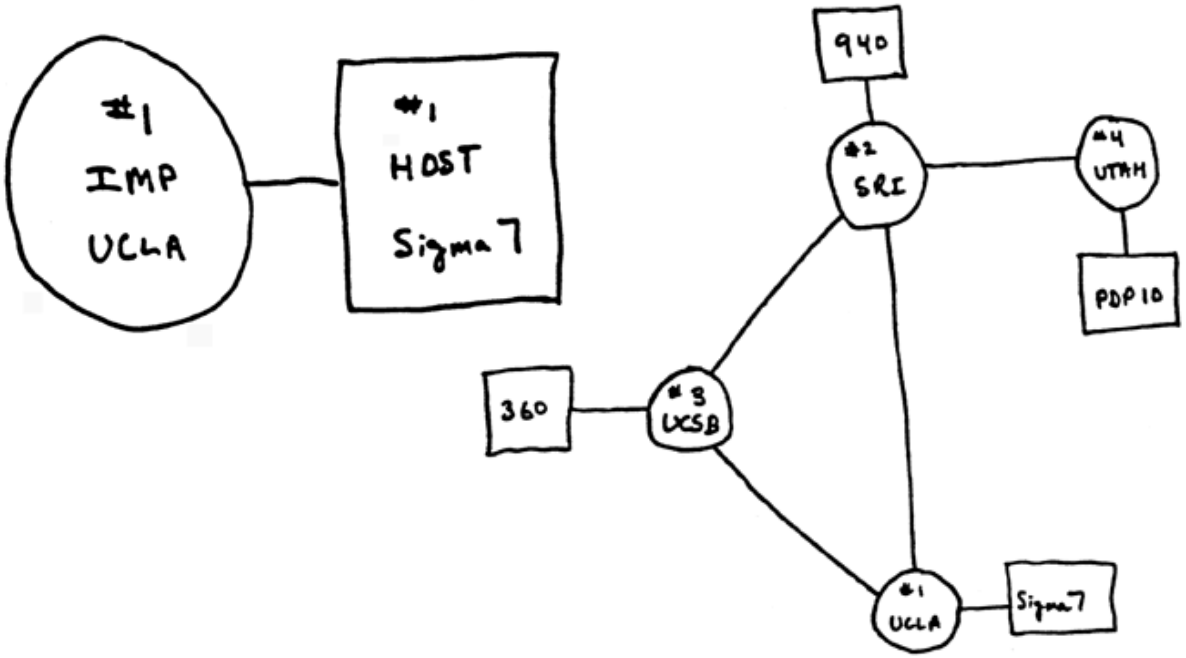
- 1972:
  - ARPAnet public demonstration
  - NCP (Network Control Protocol, 网络控制协议) first host-host protocol
  - first e-mail program
  - ARPAnet has 15 nodes



THE ARPA NETWORK

Copyright © whq@buaa.edu.cn

29OCT69	2100	LOADED OP. PROGRAM FOR BEN BARKER BBN	CSK
	22:30	Talked to SRI Host to Host	CSK
		Left Imp. program running after sending a host dead message to imp.	CSK



Copyright © whq@buaa.edu.cn

"In the Beginning, ARPA created the ARPANET.

And the ARPANET was without form and void.

And darkness was upon the deep.

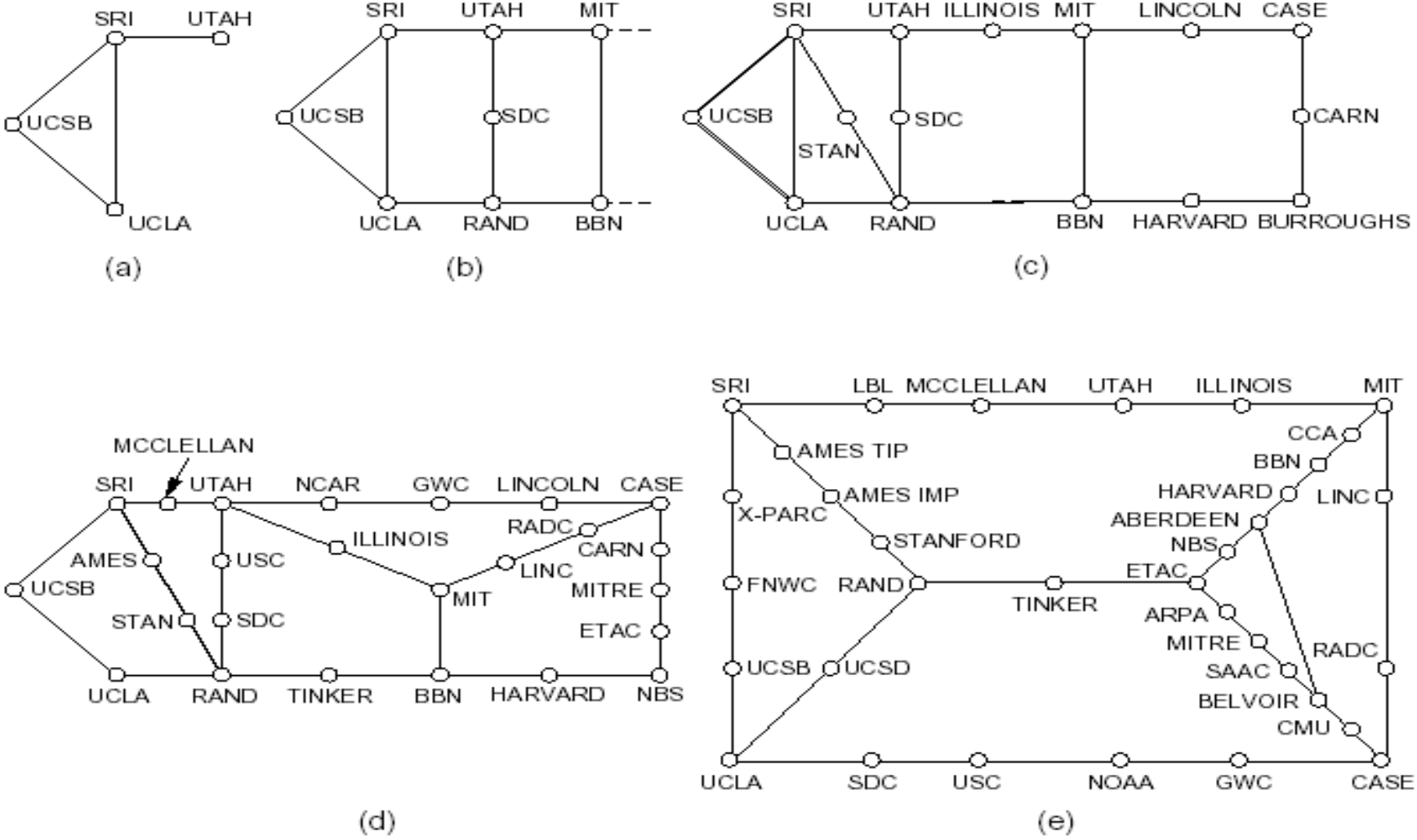
And the spirit of ARPA moved upon the face of the network and ARPA said, 'Let there be a protocol,' and there was a protocol. And ARPA saw that it was good.

And ARPA said, 'Let there be more protocols,' and it was so. And ARPA saw that it was good.

And ARPA said, 'Let there be more networks,' and it was so."

-- Danny Cohen

Initial Expansion of the ARPANET



Copyright © whq@buaa.edu.cn

1.2 Internet History

1972-1980: Internetworking, new and proprietary nets

- 1970: ALOHAnet satellite network in Hawaii
- 1974: Cerf and Kahn - architecture for interconnecting networks
- 1976: Ethernet at Xerox PARC
- ate70's: proprietary architectures: DECnet, SNA（IBM 系统网络体系结构）, XNA
- late 70's: switching fixed length packets (ATM precursor)
- 1979: ARPAnet has 200 nodes

Cerf and Kahn's internetworking principles:
minimalism, autonomy - no internal changes required to interconnect networks

best effort service model

stateless routers

decentralized control

define today's Internet architecture

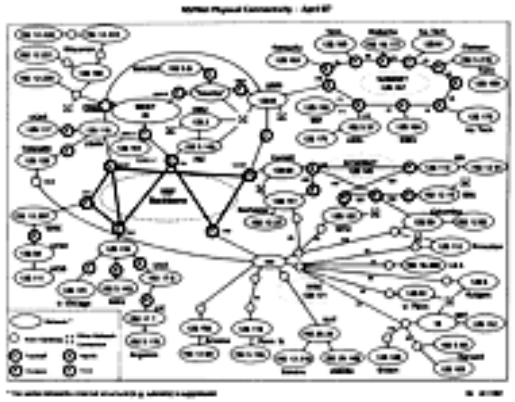
Copyright © whq@buaa.edu.cn

1.2 Internet History

1980-1990: new protocols, a proliferation of networks

- 1983: deployment of TCP/IP
- 1982: SMTP e-mail protocol defined
- 1983: DNS defined for name-to-IP-address translation
- 1985: Ftp proto
- 1988: TCP conge
- new national networks: Csnet, BITnet, NSFnet, Minitel
- 100,000 hosts connected to confederation of networks

The IBM PC 1981.



NSFNet Map, 1987

Copyright © whq@buaa.edu.cn

1.2 Internet History

1990, 2000's: commercialization, the Web, new apps

- Early 1990's: ARPAnet decommissioned
- 1991: NSF lifts restrictions on commercial use of NSFnet (decommissioned, 1995)
- early 1990s: Web
  - hypertext [Bush 1945, Nelson 1960's]
  - HTML, HTTP: Berners-Lee
  - 1994: Mosaic, later Netscape
  - late 1990's: commercialization of the Web

Late 1990's - 2000's:

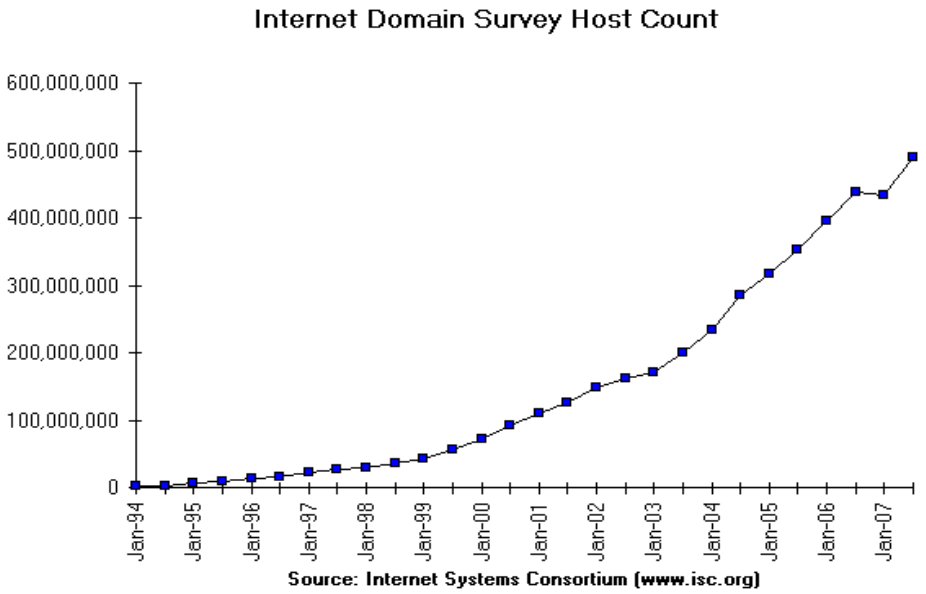
- more killer apps: instant messaging, P2P file sharing
- network security to forefront
- est. 50 million host, 100 million+ users
- backbone links running at Gbps

Copyright © whq@buaa.edu.cn

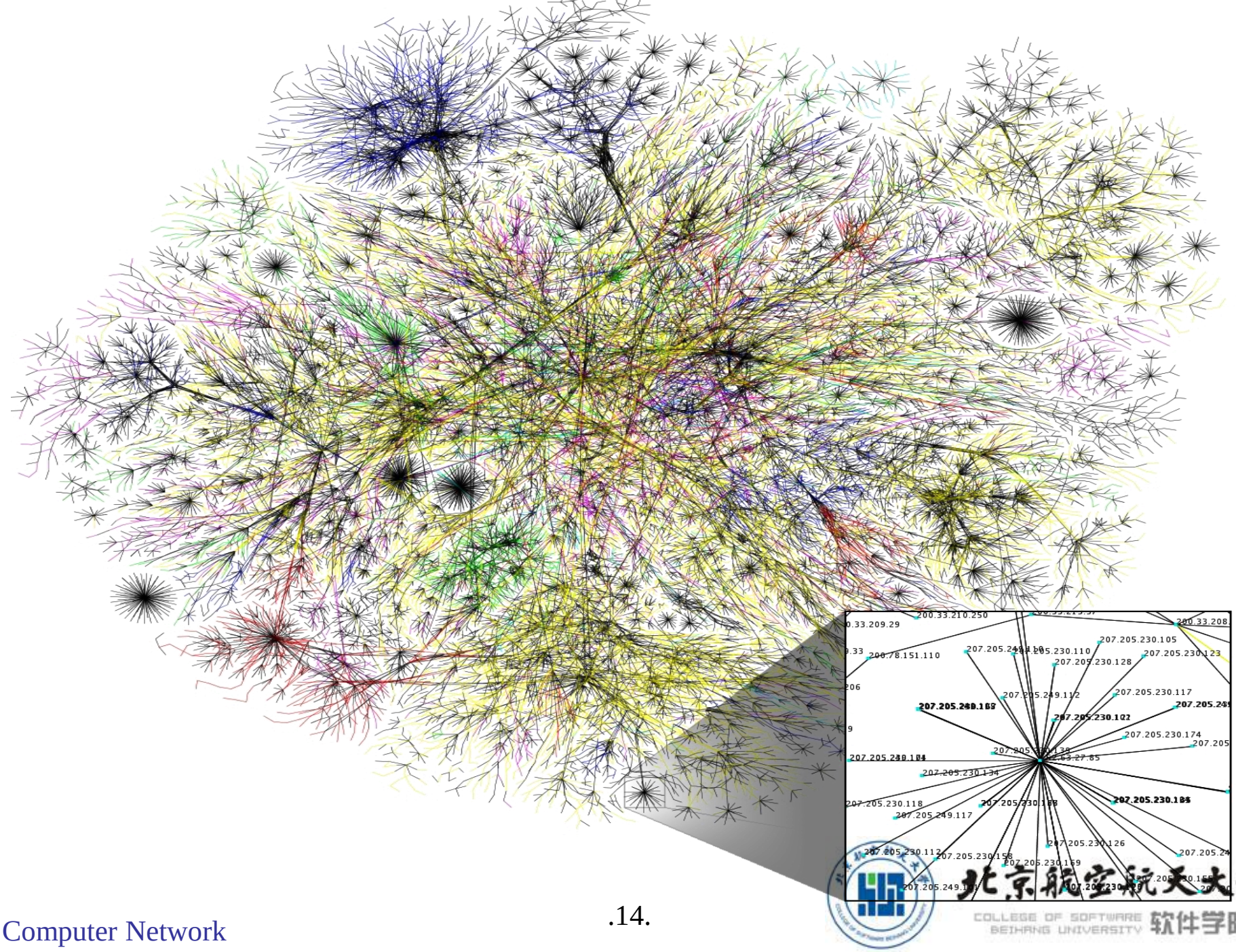
Growth of the Internet in Terms of Number of Hosts

Number of Hosts on Web:

Aug. 1981	213
Oct. 1984	1,024
Dec. 1987	28,174
Oct. 1990	313,000
Jul. 1993	1,776,000
Jul. 1996	19,540,000
Jul. 1999	56,218,000
Jul. 2004	285,139,000
Jul. 2005	353,284,000
Jul. 2006	439,286,000
Jul. 2007	489,774,000



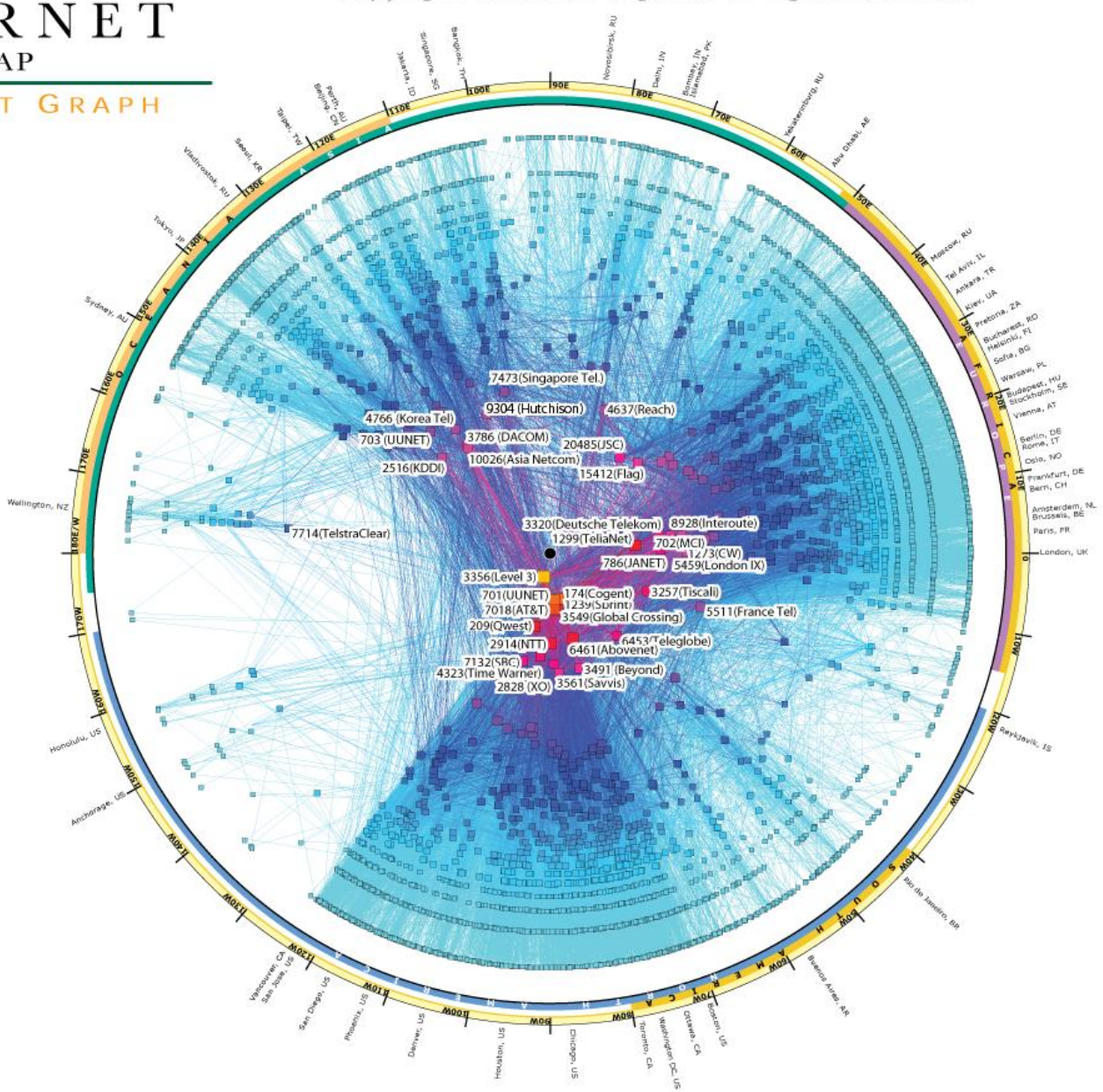
Copyright © whq@buaa.edu.cn



Computer Network
Copyright © whq@buaa.edu.cn

copyright ©2008 UC Regents. all rights reserved.

IPv4 INTERNET
TOPOLOGY MAP
AS-level INTERNET GRAPH



Copyright © wiq@ucaa.edu.cn

Internet Development in China

- An important characteristic of the Chinese internet is that online access routes are owned by the Chinese government, and private enterprises and individuals can only rent bandwidth from the state.

- The first four major national networks, namely CSTNET, ChinaNet, CERNET and CHINAGBN, are the "backbone" of the mainland Chinese Internet.

  CSTNET : (China Science and Technology Network, 中国科学技术网)

  ChinaNet : (China Telecom Corporation Limited,中国公用计算机互联网)

  CERNET: (China Education and Research Network,中国教育和科研计算机网)

  CHINAGBN : (China Golden Bridge Network,中国国家公用经济信息通信网)

Copyright © whq@buaa.edu.cn

Copyright © whq@buaa.edu.cn

The Statistical Report on the Internet Development in China(2011)

Internet Fundamental Data (By June 30, 2011)		
Internet users:485 million	Internet access rate:36.2 %	Broadband users:390 million
Mobile netizens: 31.7million	Websites:7.86 million	Group-buying users:42.2 million
Weibo users:195 million	Domain names:7.86million	Social-networking sites:230 million

Copyright © whq@buaa.edu.cn

Standard Organization

- ISO
  International Organization for Standardization （国际标准化组织，联合国甲级咨询机构）
- IEEE
  Institute of Electrical and Electronic Engineers (电气电子工程师协会)
- ITU
  International Telecommunication Union（国际电信联盟）[ITU-T(通讯标准), ITU-R(无线电标准)]
- IETF: RFC (Request for Comment)
  Internet Engineering Task Force (Internet工程任务组)

Copyright © whq@buaa.edu.cn

1.3 Components of Computer Networks

- Hardware: how you can configure a bunch of computers into a network:
  Area Networks (LAN,局域网)

  Metropolitan Area Networks (MAN, 城域网)

  Wide Area Networks (WAN, 广域网)

  Internetworks

- Software: This is what actually makes computer networks -not the hardware!
  Protocols: describe how two communicating parties exchange information.

  Services: describe what a network offers to parties that want to communicate.

  Interfaces: describe how a client can make use of network services, i.e. how the services can be accessed.

Copyright © whq@buaa.edu.cn

Classification of Network by scale

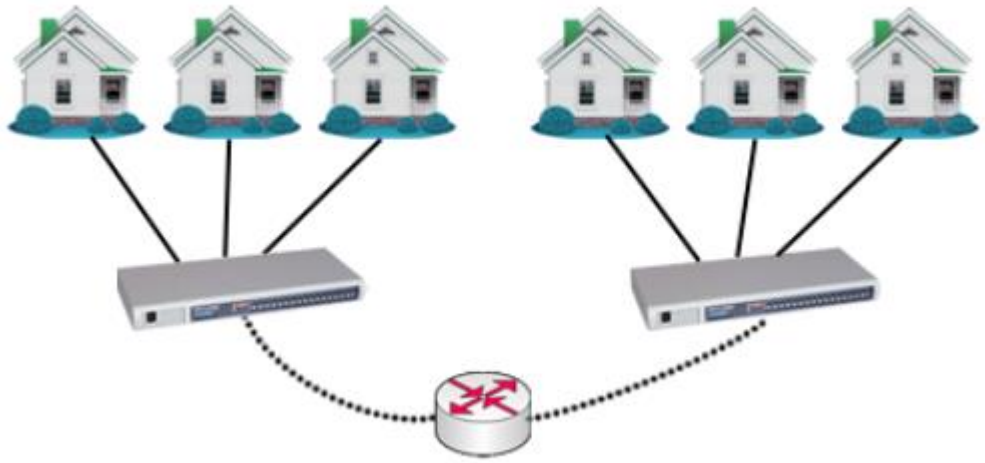
Interprocessor distance	Processors located in same	Example
1 m	Square meter	Personal area network
10 m	Room	Local area network
100 m	Building	
1 km	Campus	
10 km	City	Metropolitan area network
100 km	Country	Wide area network
1000 km	Continent	
10,000 km	Planet	The Internet

Copyright © whq@buaa.edu.cn

- WAN spans a large geographical area, often a country or continent.
- WAN is the core of Internet.

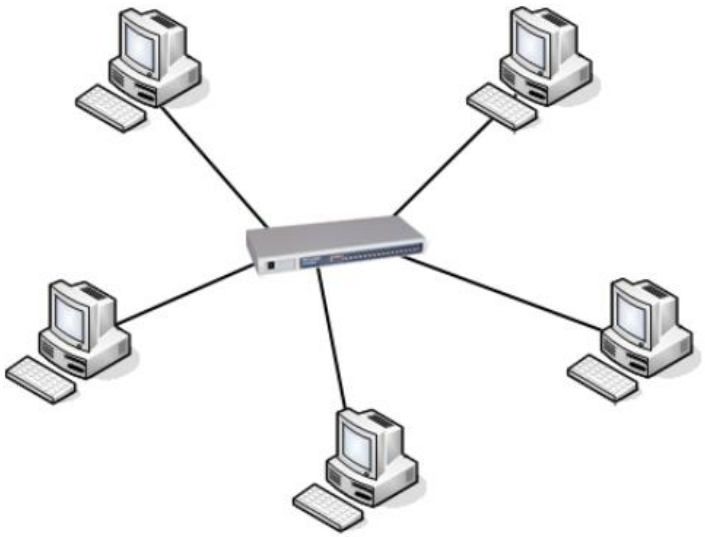
Copyright © whq@buaa.edu.cn

- MAN, covers a city or span 5 ~ 50 km.
- MAN connects Connecting multiple LANs.
- Many MAN uses the Ethernet Technology.



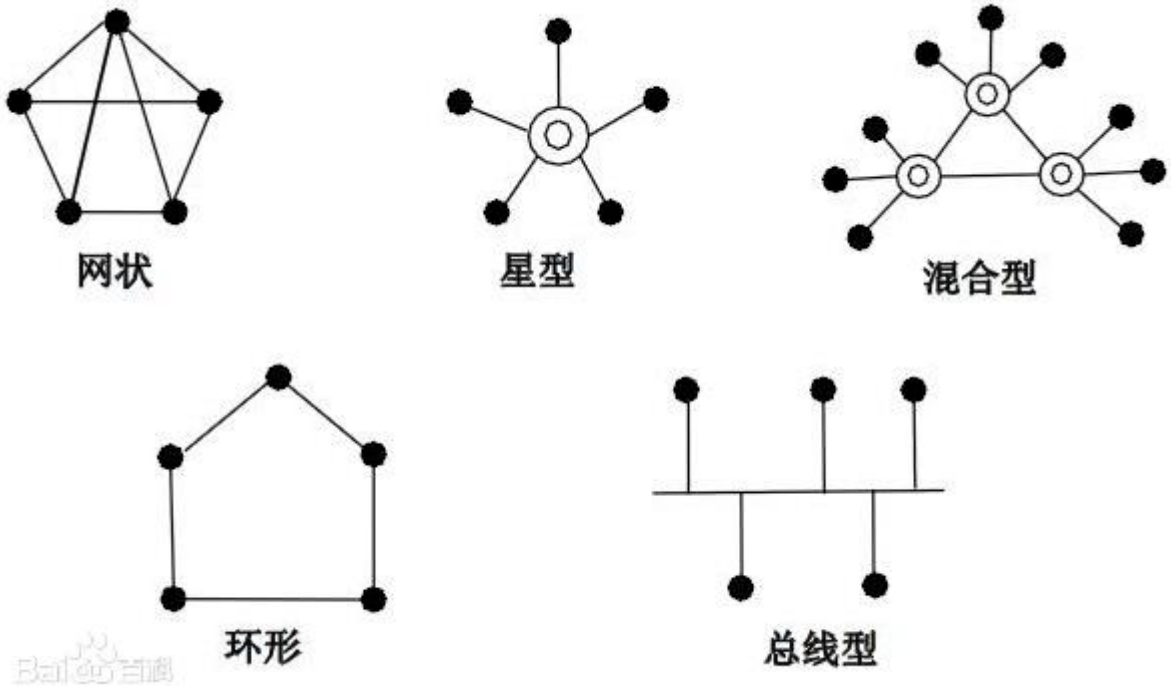
Copyright © whq@buaa.edu.cn

- LANs run at speeds of 10 Mbps to more and are up to a kilometers in size, connected by high speed communication lines.



Copyright © whq@buaa.edu.cn

Classification of Network by Topological structure（拓扑结构）



Copyright © whq@buaa.edu.cn

Classification of Network by Transmission switching method

- circuit switching（电路交换）：

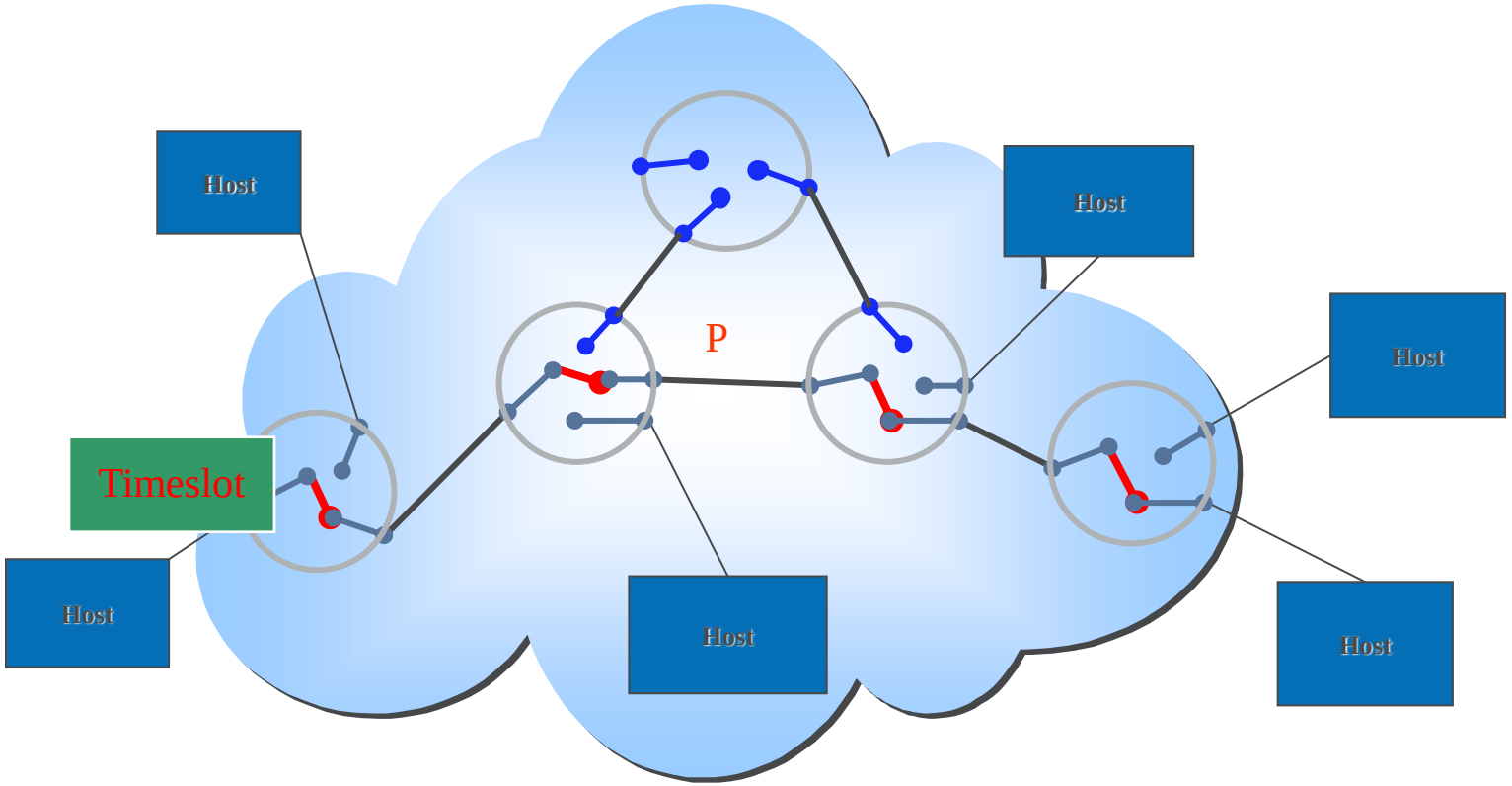
  dedicated circuit per call: telephone net

- packet-switching（分组交换）：

  data sent through net in discrete “chunks”

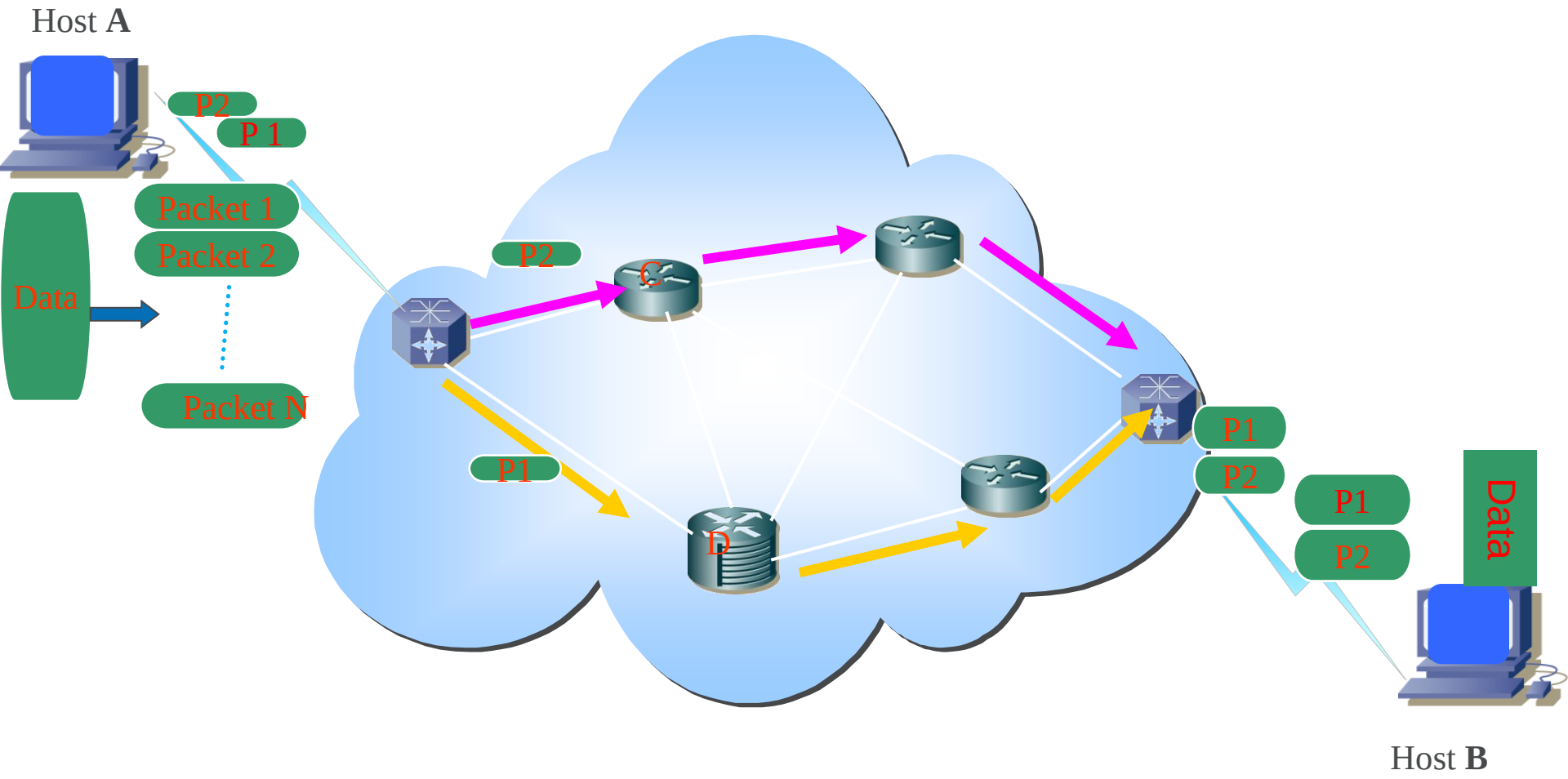
Copyright © whq@buaa.edu.cn

Circuit Switching



Copyright © whq@buaa.edu.cn

Packet Switching



Copyright © whq@buaa.edu.cn

1.4 Protocol layers, service models

- What’s a protocol （协议）?

network protocol

- **all** communication activity in Internet governed by protocols

protocols define

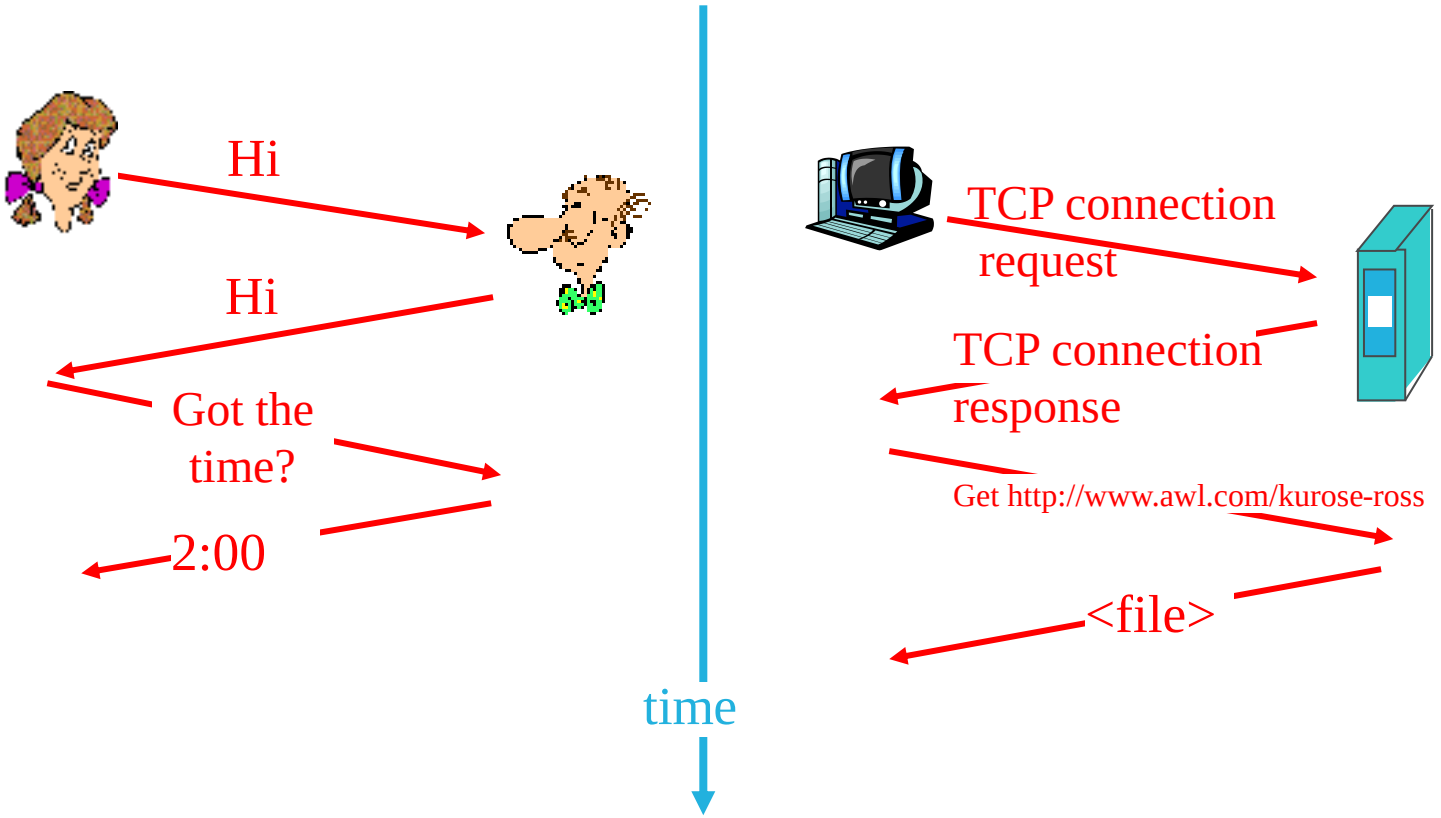
- *format, order of messages sent and received among network entities, and*
- *actions taken on the transmission/receipt of a message*

Protocol Elements

- Syntax （语法）
- Semantics（语义）
- Timing（时序关系）
- Actions（动作）

Copyright © whq@buaa.edu.cn

a human protocol and a computer network protocol:



Q: Other human protocols?

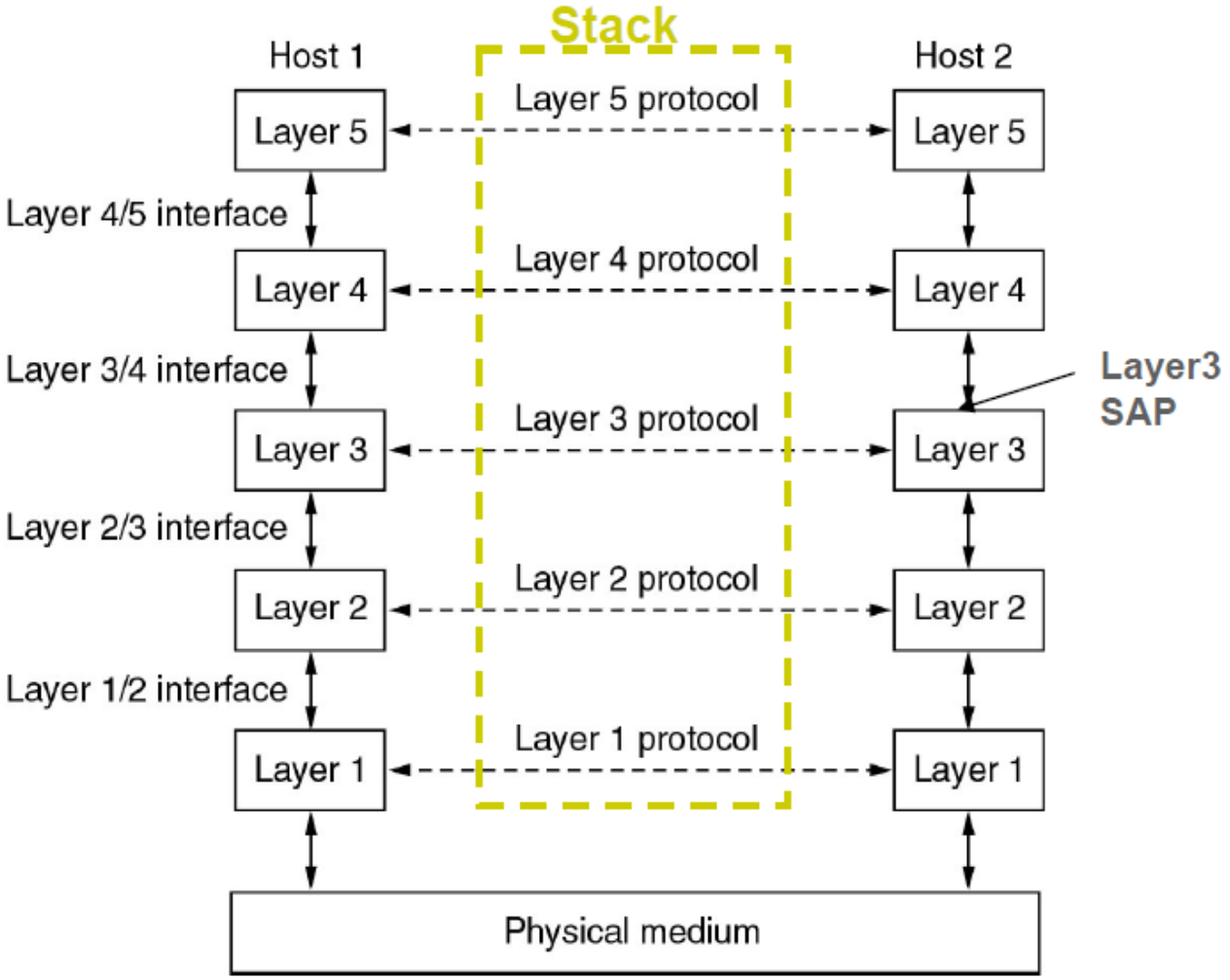
Copyright © whq@buaa.edu.cn

Why Layering

- most network software are organized as a stack of layers or levels, each one built upon the one below it.
  - reduce design complexity
    - divide the communication problem into subpieces and to design a separate protocol for each subpiece, making each protocol easier to design, analyze and implement.
  - Independence
    - Each layer could be designed independently, as long as keep in mind the services the lower layer provides for it and the services it should provides for the upper layer.
  - Flexibility
    - Allow subsets of protocols be used as needed and allow any one of the protocols be replaced or updated.

Copyright © whq@buaa.edu.cn

Layering Model



- Layers, protocols, services, interfaces and stack.

Copyright © whq@buaa.edu.cn

OSI & TCP/IP Reference Model

- ISO/OSI (OSI/RM)

  Open System Interconnection Reference Model (开放式系统互联)

  seven layers, the legal standard (合法标准)

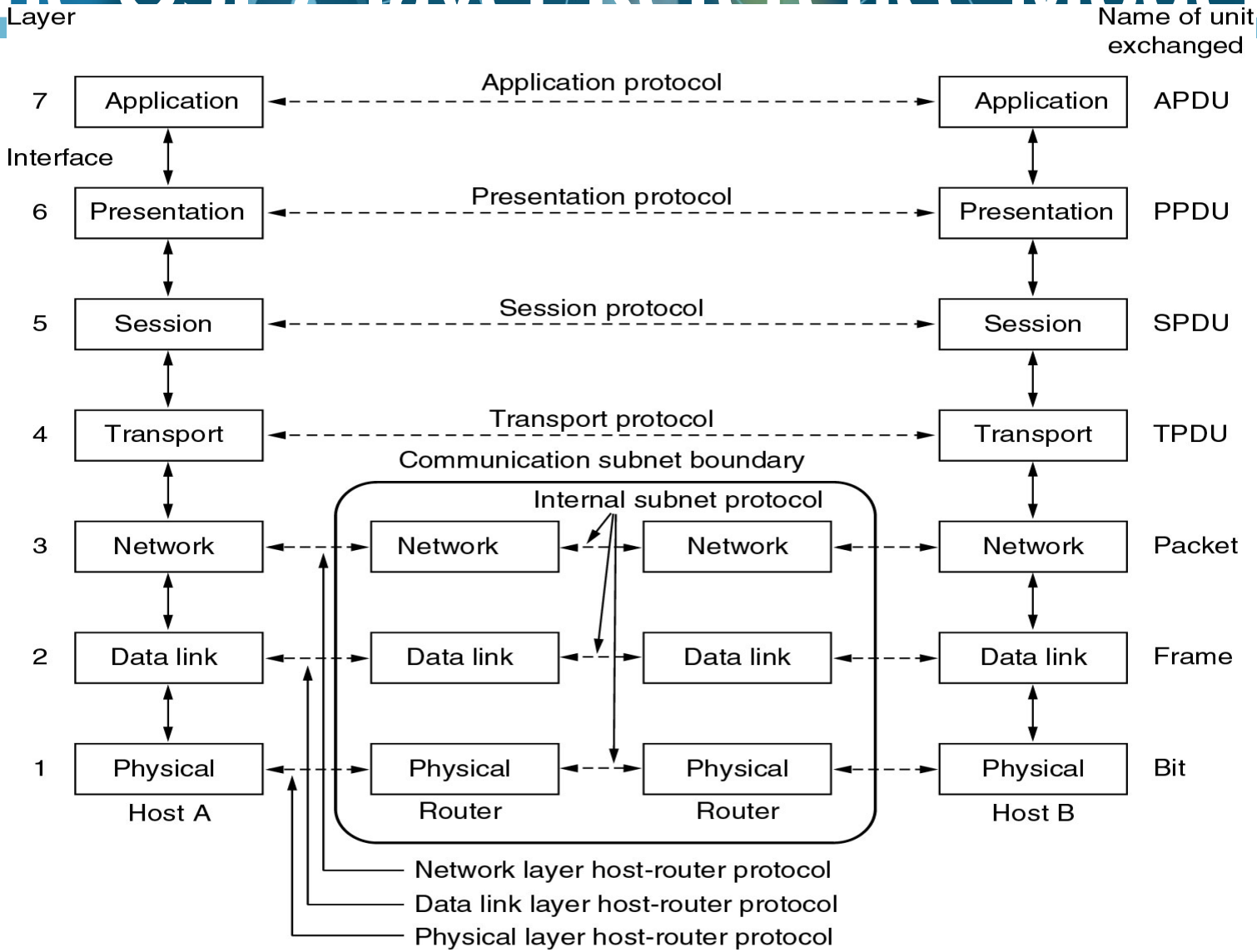
- TCP/IP (TCP/IP Suite)

  Transmission Control Protocol and Internet Protocol Suite

  four layers, the de facto standard (事实上的标准)

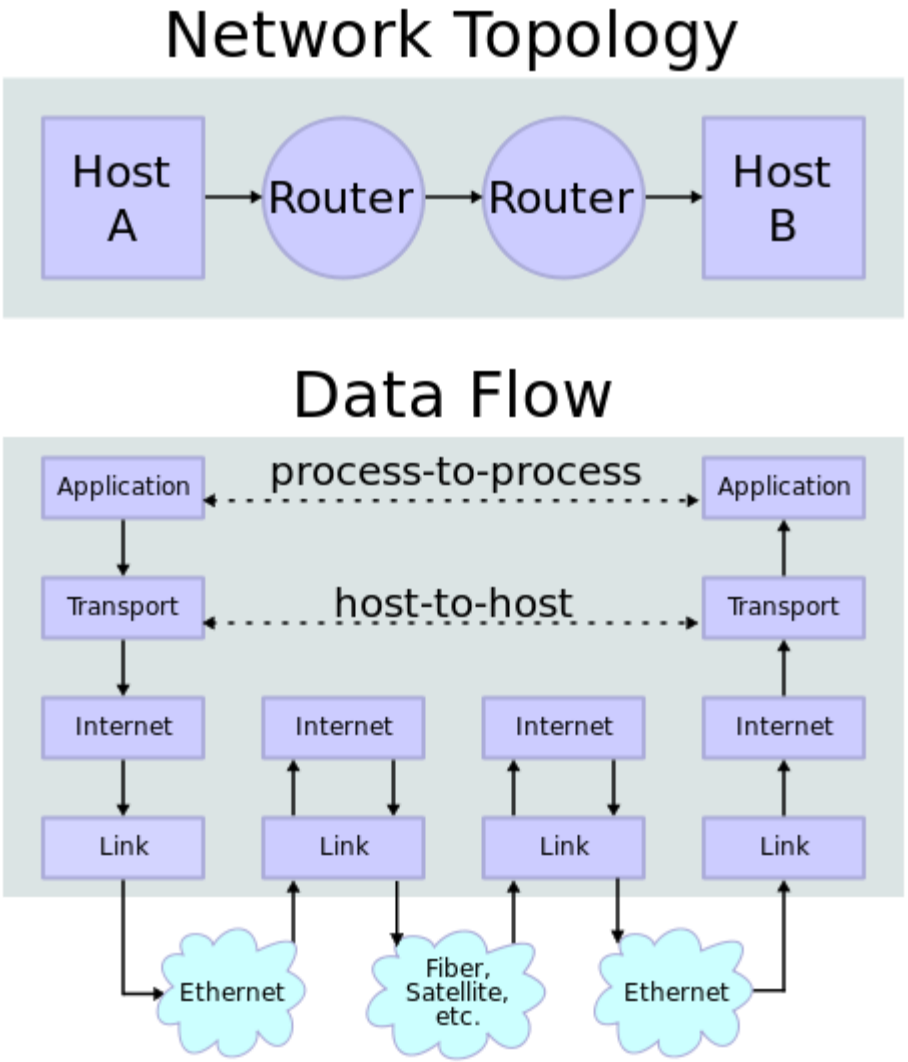
Copyright © whq@buaa.edu.cn

The OSI 7-layer Reference Model



Copyright © whq@buaa.edu.cn

TCP/IP reference model



Copyright © whq@buaa.edu.cn

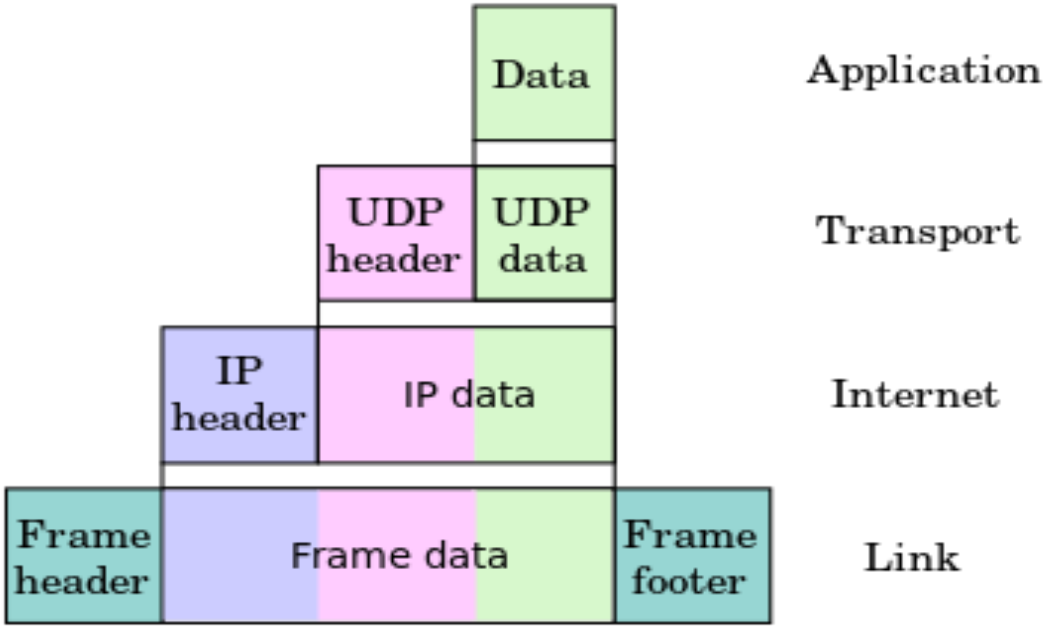
Comparing OSI and TCP/IP Models

- Much in common:
  - a stack of independent protocols
  - functionality of the layers is roughly similar
- Many differences:
  - a stack of independent protocols
  - Services, interfaces and protocols are central concepts of the OSI model, TCP/IP model doesn't distinguish these concepts and is not a general model.
  - OSI model was devised before the corresponding protocols, with TCP/IP the reverse was true.
  - OSI model/protocols took too much time and are too complex, while TCP/IP is simple and not so comprehensive.
  - Number of layers
- OSI model has proven to be exceptionally useful for discussing computer networks, OSI protocols have not become popular.
- TCP/IP Model is practically nonexistent, but protocols are widely used, deeply entrenched, and thus hard to replace.

Copyright © whq@buaa.edu.cn

Data Encapsulation（数据封装）

- Encapsulation is a method of designing modular communication protocols in which logically separate functions in the network are abstracted from their underlying structures by inclusion or information hiding within higher level objects.



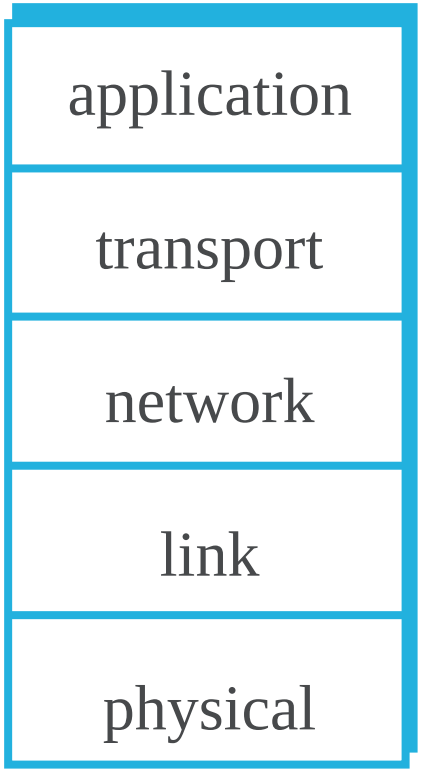
Copyright © whq@buaa.edu.cn

Protocol Data Unit (PDU)

Data unit	Layer	Function
Data	Application	Network process to application
	Presentation	Encryption, decryption and data converting
	Session	Managing sessions between applications
Segments	Transport	End-to-end connection and reliability
Packets (datagrams)	Network	Path determination and logical addressing
Frame	Data link	Physical addressing
Bit	Physical	Signal and binary transmission

Copyright © whq@buaa.edu.cn

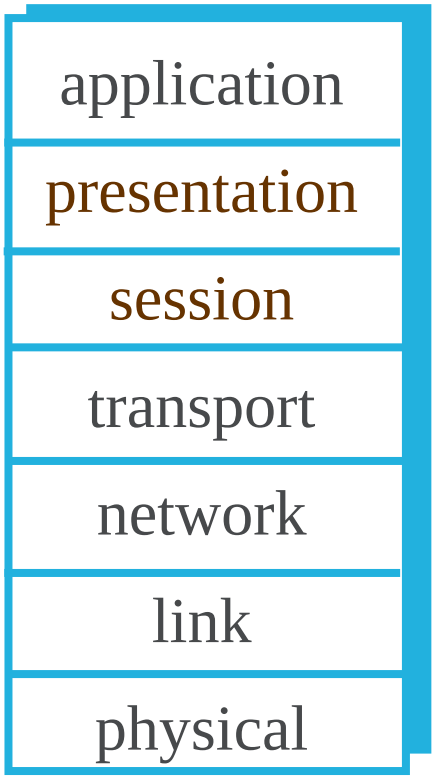
- application: supporting network applications
  FTP, SMTP, HTTP
- transport: process-process data transfer
  TCP, UDP
- network: routing of datagrams from source to destination
  IP, routing protocols
- link: data transfer between neighboring network elements
  PPP, Ethernet
- physical: bits “on the wire”



Copyright © whq@buaa.edu.cn

- *presentation*: allow applications to interpret meaning of data, e.g., encryption, compression, machine-specific conventions
- *session:* synchronization, checkpointing, recovery of data exchange
- Internet stack "missing" these layers! these services, *if needed,* must be implemented in application

  needed?



Copyright © whq@buaa.edu.cn

OSI Physical Layer

- 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

Copyright © whq@buaa.edu.cn

OSI Data Link Layer

- Essence:

  transform a raw transmission facility into a line that appears free of undetected transmission errors to the network layer=>send bits in frames that add redundancy to detect something went wrong

- Provide the mechanisms so that fast senders don’t overwhelm slow receivers (flow control)
- Broadcast networks have an additional issue in the data link layer: how to control access to the shared channel.

Copyright © whq@buaa.edu.cn

OSI Network Layer

- Essence: Describes how routing (and congestion) is to be done and allow heterogeneous networks（异质网络） to be interconnected.

  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?

  Can we detect and avoid “hot spots?”

Copyright © whq@buaa.edu.cn

OSI Transport Layer

- Essence: specify how to handle details of reliable transfer, this layer provides the actual network interface to applications

  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

  Also support for datagrams: unreliable message passing on a per-message basis

Copyright © whq@buaa.edu.cn

OSI Session & Presentation Layer

- **Session:**
  tells how applications can set up “long-lasting” communications, for example, allowing a connection to be re-established when suddenly broken (think of downloading large files).

- **Presentation:**
  Describes everything that is needed to exchange data in a platform-independent way. Example: think of byte ordering in different computers, or passing “binary” data through e-mail.

Copyright © whq@buaa.edu.cn

OSI Application Layer

- Essence: contains a variety of protocols that are commonly needed by users.

  Traditional: Name services (DNS), security, e-mail, (SMTP), News (NNTP), Web (HTTP)

  Modern: All types of middleware protocols to support distributed systems:

  - RMI（远程方法调用）
  - CORBA (IIOP,公共对象请求代理体系结构)
  - DCOM（分布式组件对象模型）

Copyright © whq@buaa.edu.cn