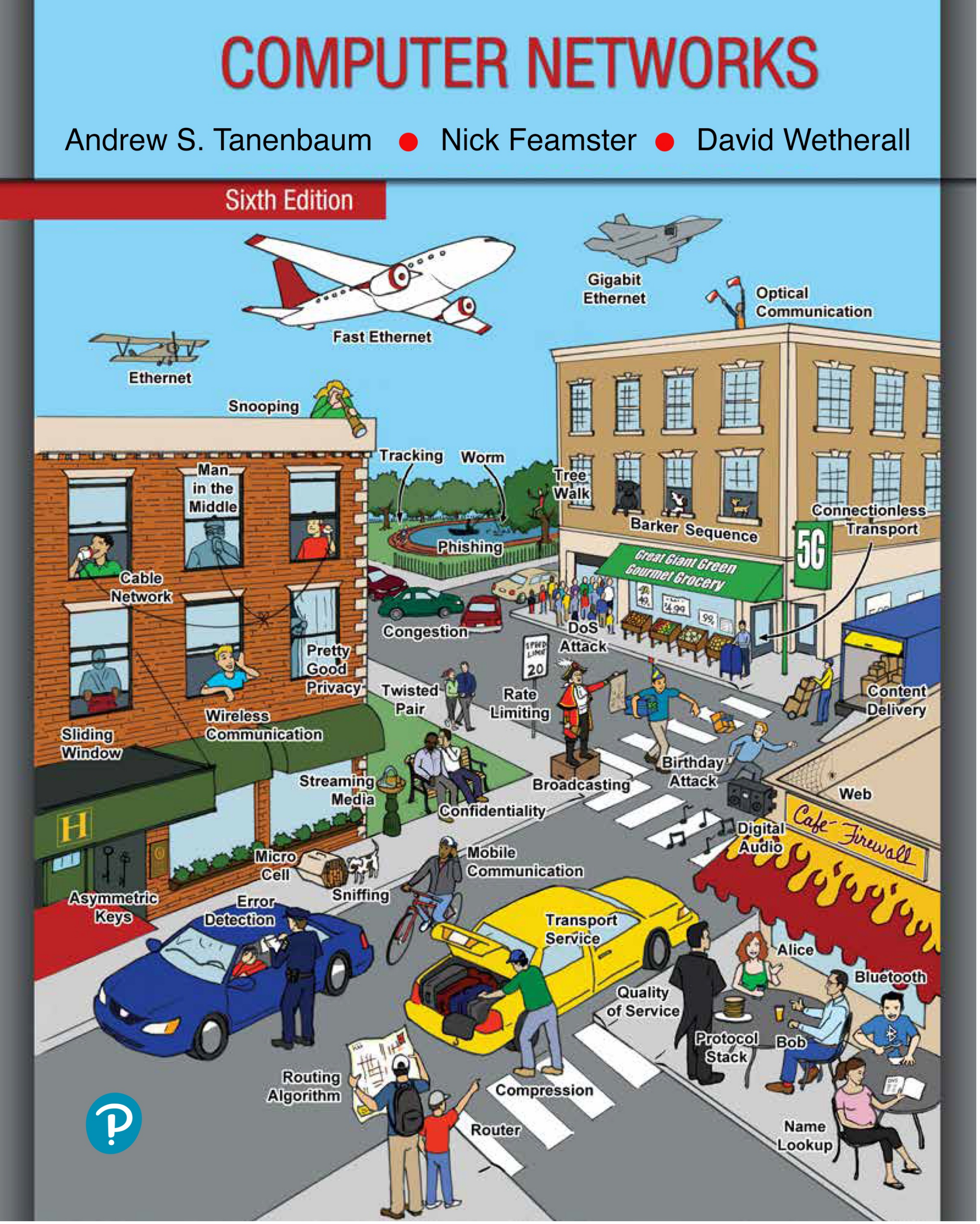


Chapter 1

Introduction

1.1 √

Uses of Computer Networks

- Computer network

  相互连接
  - Large number of separate but interconnected computers do a job
  - Collection of interconnected, autonomous computing devices

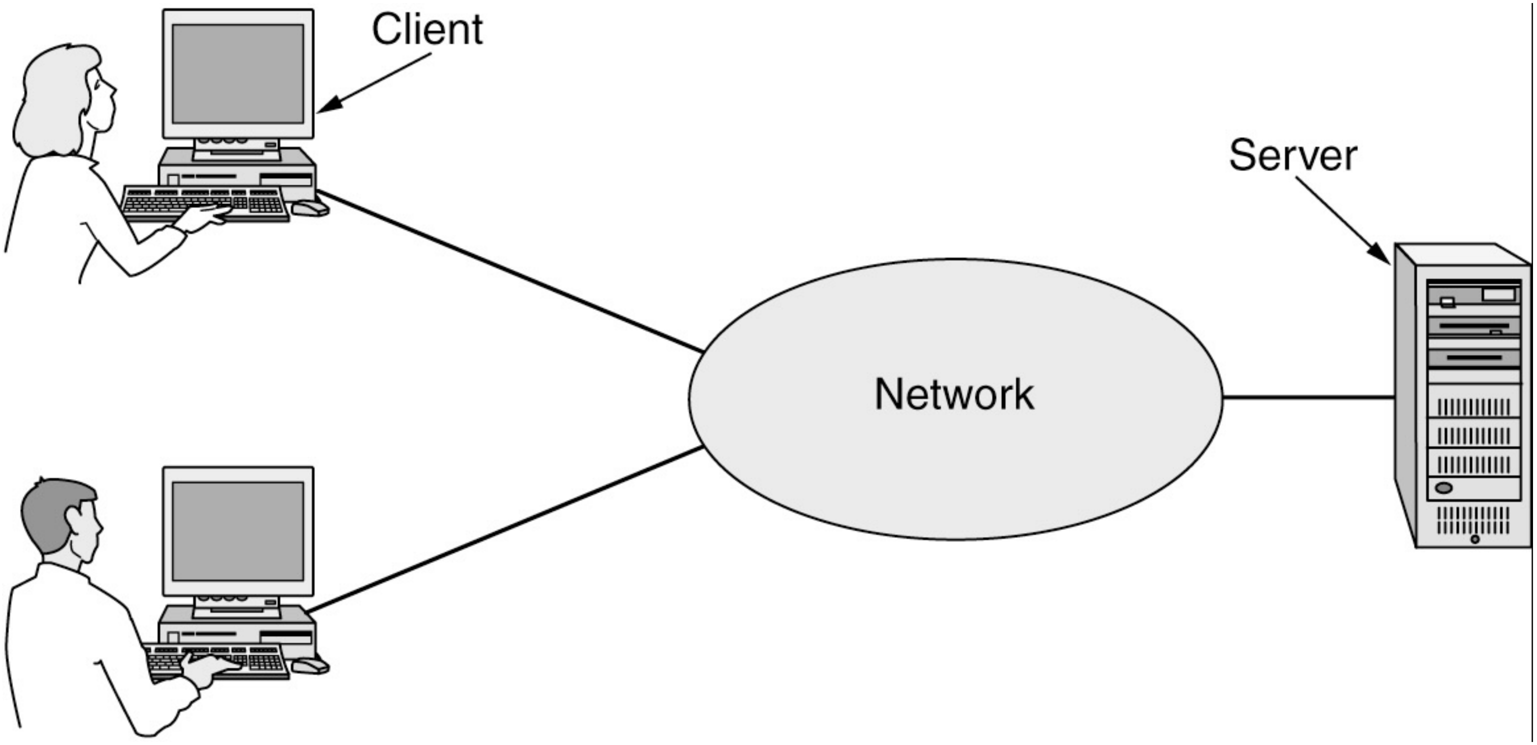
    自治
  - Interconnected computers can exchange information
- Example: the Internet
- Network uses
  - Access to information
  - Person-to-person communication
  - Electronic commerce
  - Entertainment
  - The Internet of Things

1.1.1 √

Access to Information (1 of 4)

- Web browser and smart phones retrieve information from various Web sites
- Social media platforms support targeted behavioral advertising
- Online digital libraries and retail sites host digital content
- Client-server model forms the basis of network usage
- Web applications: Server generates Web pages in response to client requests
- Peer-to-peer communication: Individuals form a loose group to communicate with others in the group

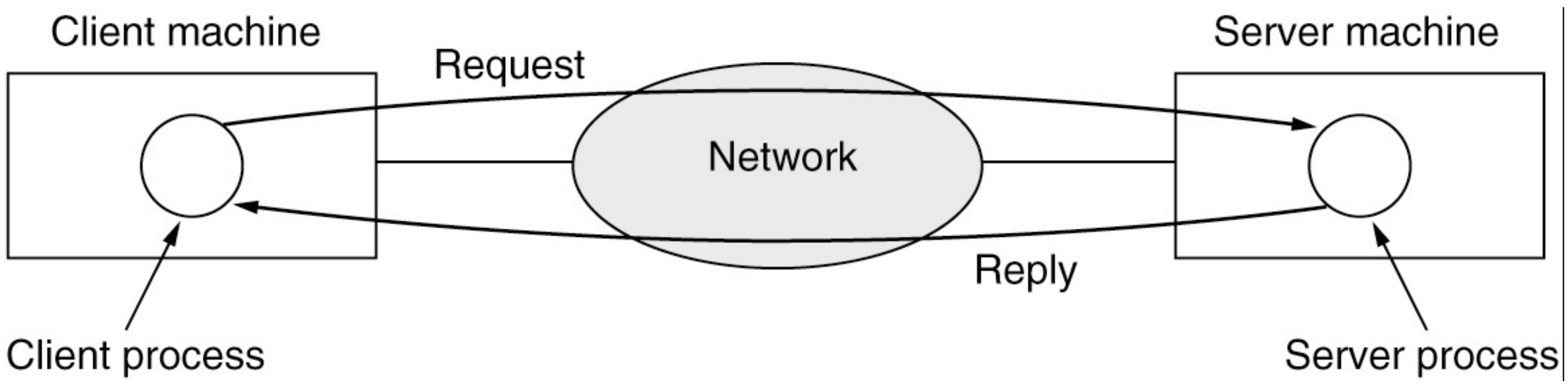
Access to Information (2 of 4)



In the client-server model, a client explicitly requests information from a server that hosts that information.

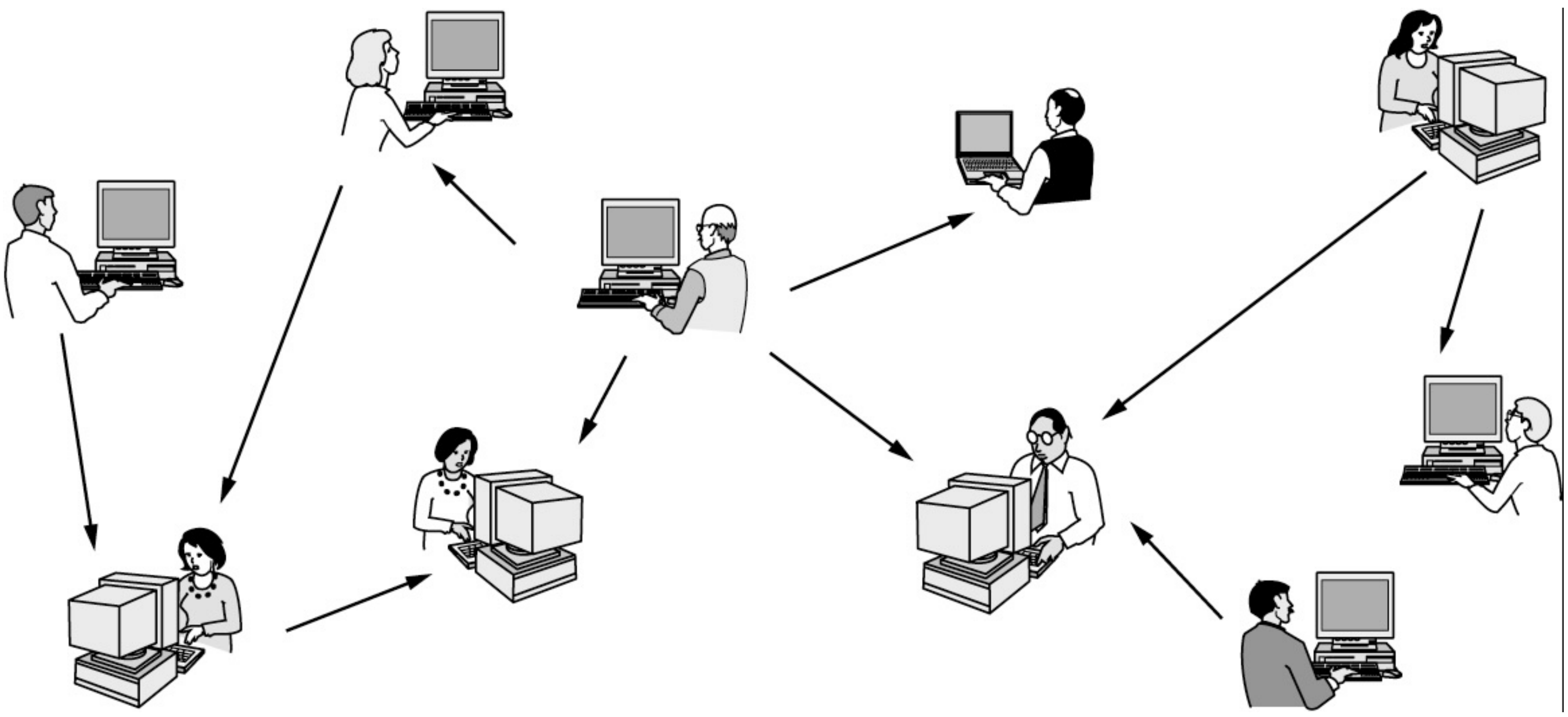
명시적

Access to Information (3 of 4)



Communication takes the form of the client process sending a message over the network to the server process. The client process then waits for a reply message.

Access to Information (4 of 4)



In a peer-to-peer system, there are no fixed clients and servers.

1.1.2 √

Person-to-Person Communication

- Instant messaging
  - Allows two people to type messages at each other in real time
- Twitter multi-person messaging service
  - Allows people to send short messages to their circle of friends or other followers or the whole world
- Social network applications Facebook
  - Information flow driven by the relationships that people declare between each other
- Wiki content is a collaborative Web site the members of a community edit

Wikipedia

1.1.3 √

Electronic Commerce (1 of 2)

- Online shopping and financial institution transactions follow client-server model
- Online auctions follow peer-to-peer model
  - Consumers act as buyers and sellers
  - Central server holds the database of products for sale

Electronic Commerce (2 of 2)

Tag	Full name	Example
B2C	Business-to-consumer	Ordering books online
B2B	Business-to-business	Car manufacturer ordering tires from a supplier
G2C	Government-to-consumer	Government distributing tax forms electronically
C2C	Consumer-to-consumer	Auctioning second-hand products online
P2P	Peer-to-peer	Music or file sharing; Skype

Some forms of e-commerce have acquired little tags based on the fact that “to” and “2” are pronounced the same.

1.1.4 √

Entertainment

- IPTV (IP Television) systems
  - TV shows based on IP technology instead of cable TV or radio transmissions
- Media streaming applications
  - Internet-provided radio stations, TV shows, and movies
  - Content usually moves wirelessly between devices
- Game playing using multi-person real-time simulation

坚持不懈

- Virtual worlds provide a persistent setting
  - Thousands of users experience a shared reality with three-dimensional graphics

1.1.5

The Internet of Things

普适存在

- Ubiquitous computing
  - Computing embedded in everyday life
  - Home security systems wired with door and window sensors
  - Sensors folded into a smart home monitor
  - Smart refrigerators
- IoT (Internet of Things)
  - Sensing and communication take place over the Internet
  - Poised to connect every electronic device to the Internet
- Power-line networks
  - Send information throughout the house over the electric wires

1-2

Types of Computer Networks

宽带

- Mobile and broadband access networks
  - Networks used to access the Internet
- Data-center networks
  - Networks that house data and applications
- Transit networks
  - Networks that connect access networks to data centers
- Enterprise networks
  - Networks used on campuses, in office buildings, or at other organizations

1.2.1

Broadband Access Networks

- Home network use
  - Listen to, look at, and create music, photos, and videos
  - Access information, communicate with other people, buy products and services
- Metcalfe's law

  强劲

  - Explains how tremendous Internet popularity comes from its size
- Broadband access networks

  铜 同轴 电缆 光电 纤维

  - Delivered to homes using copper, coaxial cable, or optical fiber
  - Broadband Internet speeds: gigabit per second to individual homes

Mobile and Wireless Access Networks (1 of 3)

无线~

- Wireless hotspots are based on the 802.11 standard
- Wireless networking and mobile computing
  - Related but not identical 相同~
- Smartphones combine aspects of mobile phones and mobile computers like iphone
- Text messaging or texting short message
- GPS (Global Positioning System): locates a device
- Geo-tagging: annotating photos and videos with the location where they were made

Mobile and Wireless Access Networks (2 of 3)

Wireless	Mobile	Typical applications
No	No	Desktop computers in offices
No	Yes	A laptop computer used in a hotel room
Yes	No	Networks in unwired buildings
Yes	Yes	Store inventory with a handheld computer

Although wireless networking and mobile computing are often related, they are not identical.

Mobile and Wireless Access Networks (3 of 3)

贸易

- M-commerce (mobile-commerce) uses mobile phones
- NFC (Near Field Communication)
  - Allows mobile device to act as an RFID smartcard and interact with a nearby reader for payment

传感器

- Sensor networks use nodes gathering and relaying information about the physical state of the world
  - Nodes may be embedded in familiar devices (cars or phones)
  - Nodes may be small, separate devices
  - Provide a wealth of data on behavior
  - Example: wireless parking meters

表.

(1.2.)

Content Provider Networks

- Data-center network
  - Internet services are served from "the cloud"
  - Serves the increasingly growing demands of cloud computing
  - Moves large amounts of data between servers in the data center
  - Moves data between the data center and the rest of the Internet
- Data center network challenges
  - Network throughput and energy usage scaling
  - "Cross-section bandwidth"
- CDN (Content Delivery Network)
  - Large collection of servers, geographically distributed so content is close to the users requesting it

1-2.4

Transit Networks

- Transit network
  - Carry traffic between the content provider and the ISP (Internet Service Provider) when they are not directly connected
  - Typically charge both the ISP and the content provider for carrying traffic from end-to-end
  - Traditionally called backbone networks because they carry traffic between two endpoints

中枢

- Two trends

[illegible]，巩固.

  - Consolidation of content in a handful of large content providers
  - Expansion of the footprint of individual access ISP networks

[illegible]范围

1.2.5

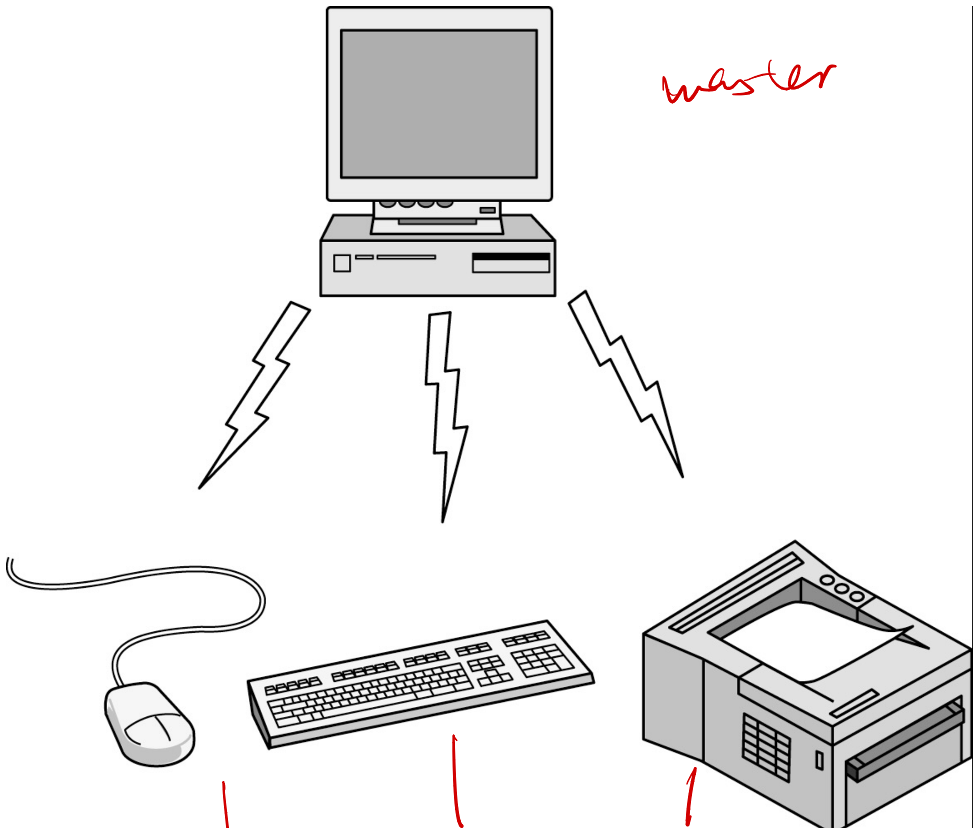
Enterprise Networks

- Allows resource sharing for devices and information
- VPNs (Virtual Private Networks)
  - Connect individual networks at different sites into one logical network
  - 媒介
  - Act as a communication medium among employees
- 电话通讯
- Allows IP telephony or VoIP (Voice over IP)
  - Internet technology and computer networks for telephone calls
- Allows desktop sharing
  - Remote workers can see and interact with a computer screen
- Allows electronic business communication

1.3.1

画图 and Read book

Personal Area Networks



master

slave

PANs (Personal Area Networks) let devices communicate over the range of a person. Bluetooth is a short-range wireless network used to connect components without wires.

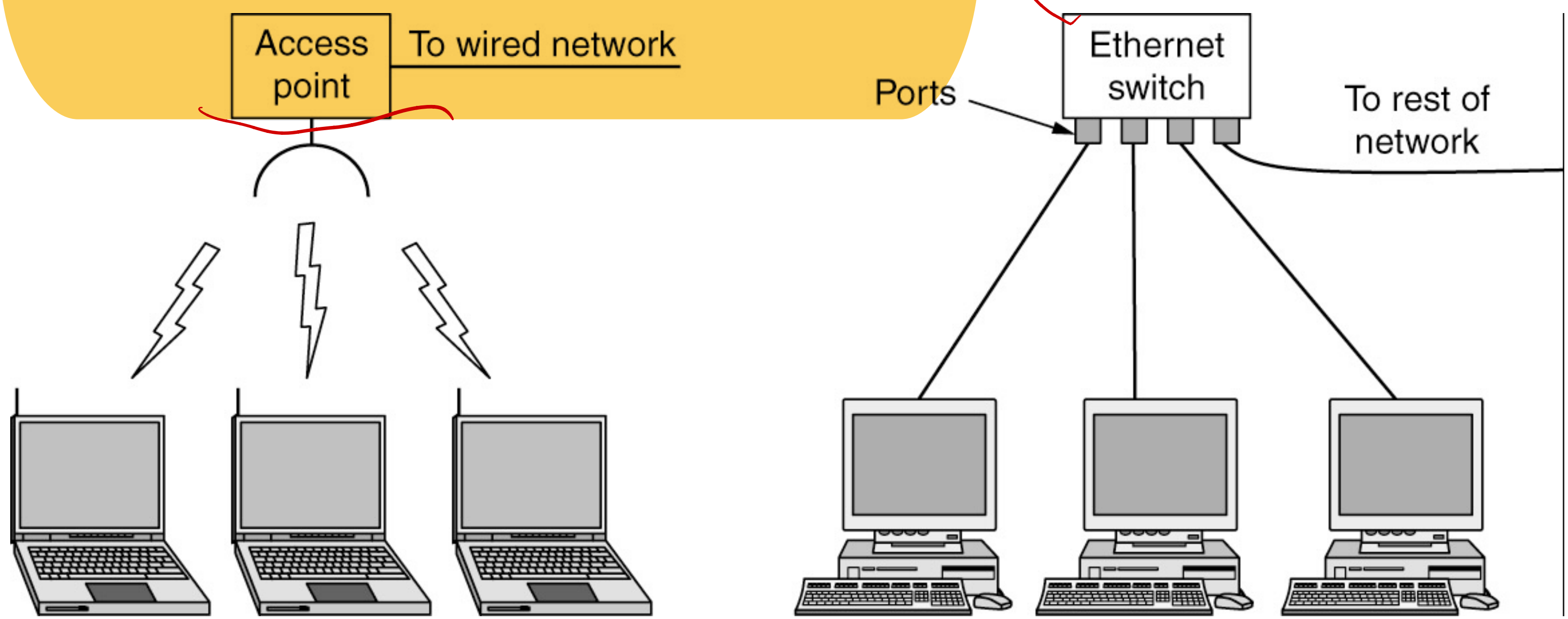
1.3.2

Local Area Networks

wireless router, or base station

以太网

IEEE 802.3



WIFI

The configuration on the left represents a wireless 802.11 network. The configuration on the right represents a wired switched Ethernet network.

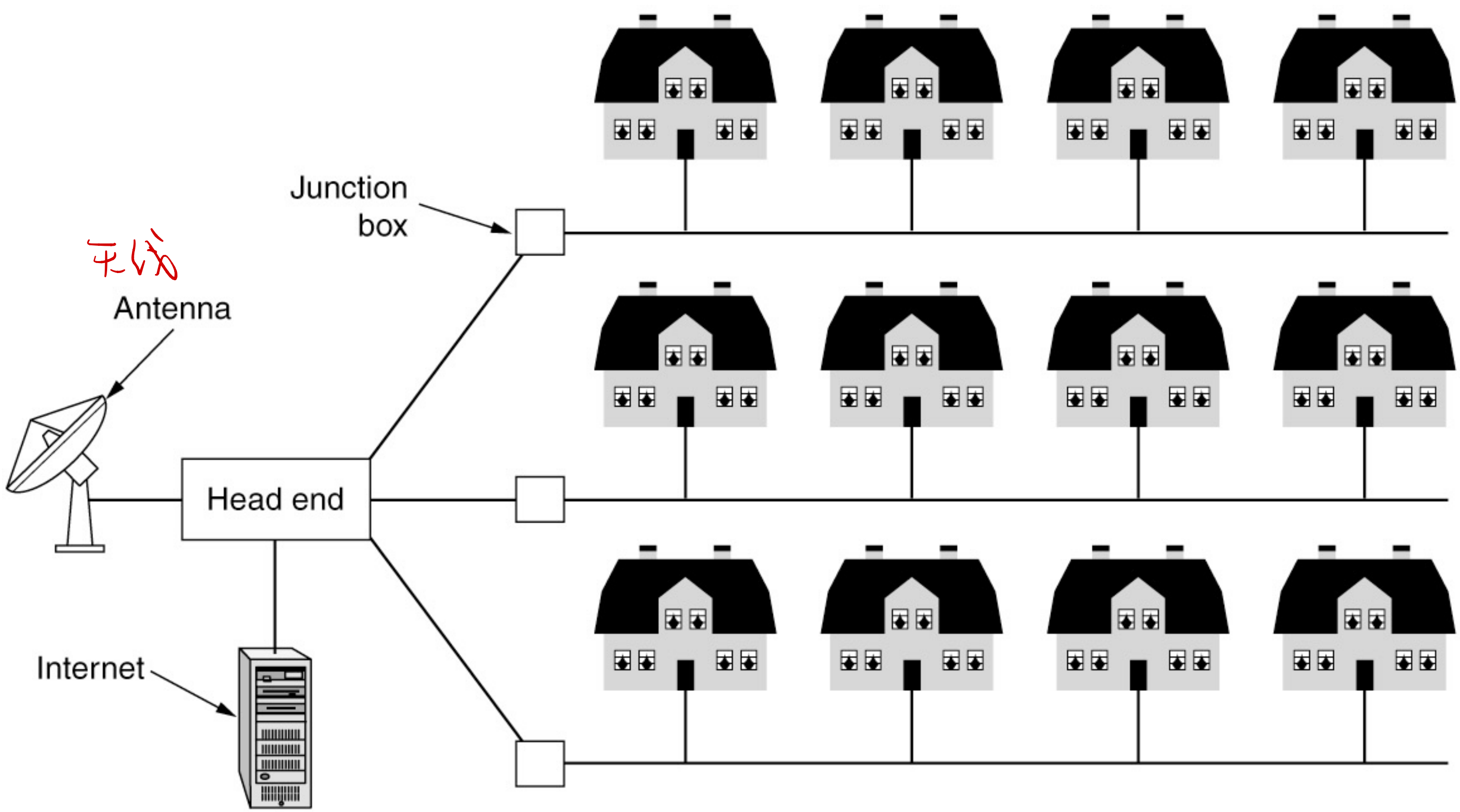
1.3.2

Home Networks

- Home network LAN
  - Broad, diverse range of Internet-connected devices
  - Characteristics: manageable, dependable, and secure
- Internet of things
  - Allows almost any device to connect
- Required home network properties
  - Easy to install
  - Secure and reliable
  - Interfaces work between all products
  - Reduced consumer device costs

大都市

Metropolitan Area Networks



A MAN (metropolitan area network) where both television signals and the Internet are being fed into the centralized cable head-end (or cable modem termination system) for subsequent distribution to people’s homes.

1.3.5

The rest of the network that connects these hosts is often called the communication subnet, or just subnet for short.

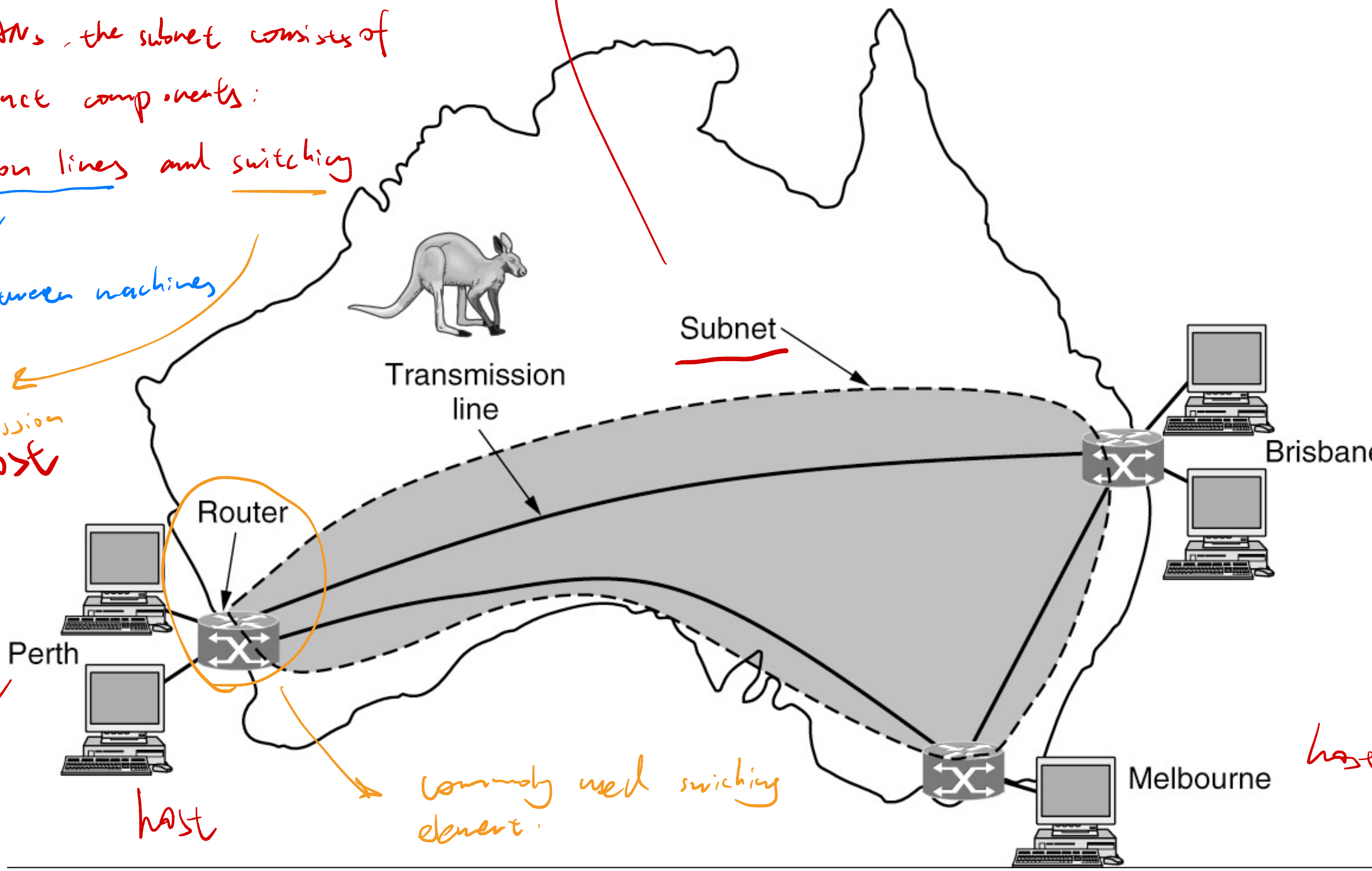
cable under the sea.

Wide Area Networks (1 of 3)

In most WANs, the subnet consists of two distinct components: transmission lines and switching elements.

move bits between machines

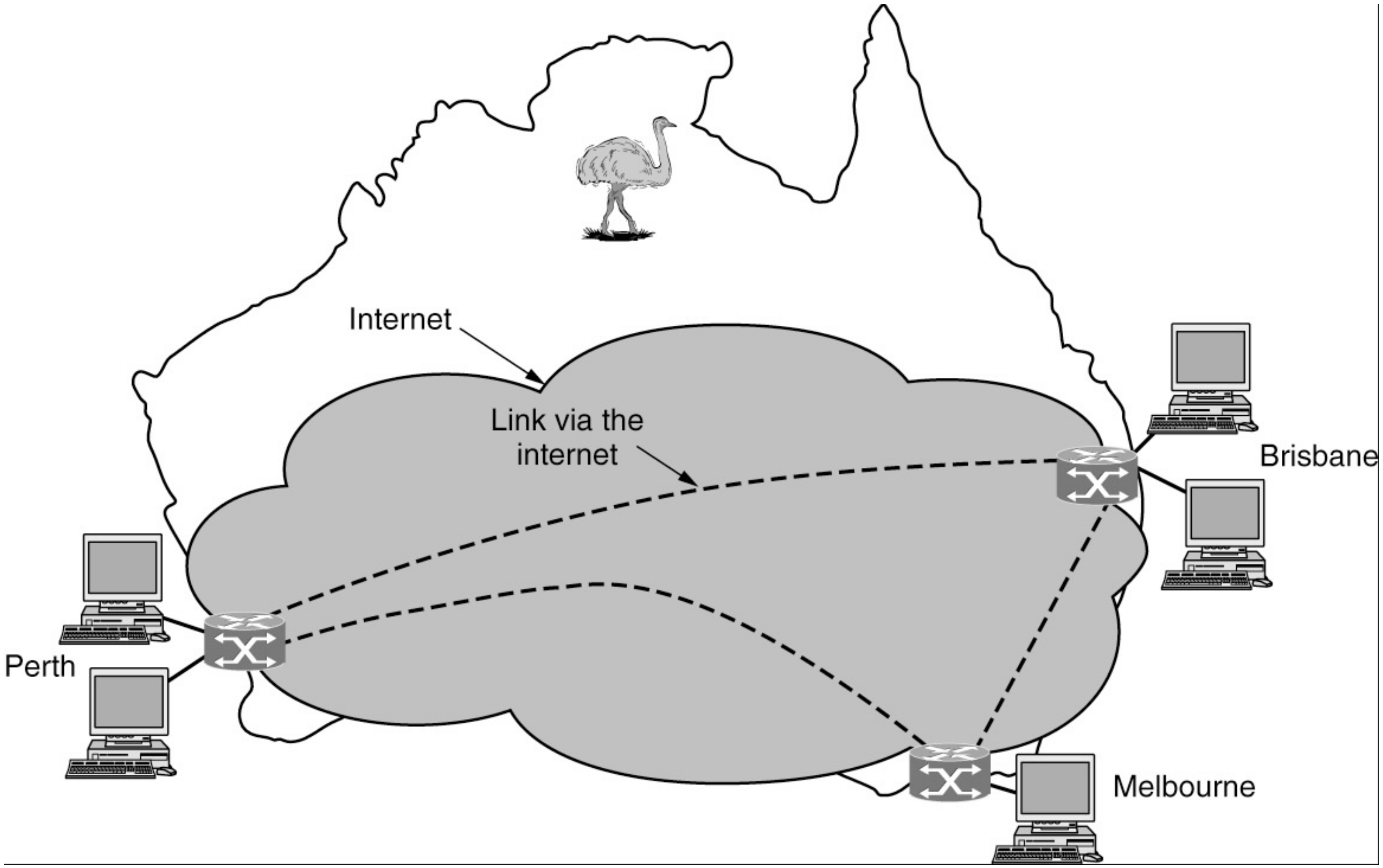
connect two or more transmission lines.



This wide area network illustrates how hosts in Perth, Brisbane, and Melbourne can communicate using leased lines.

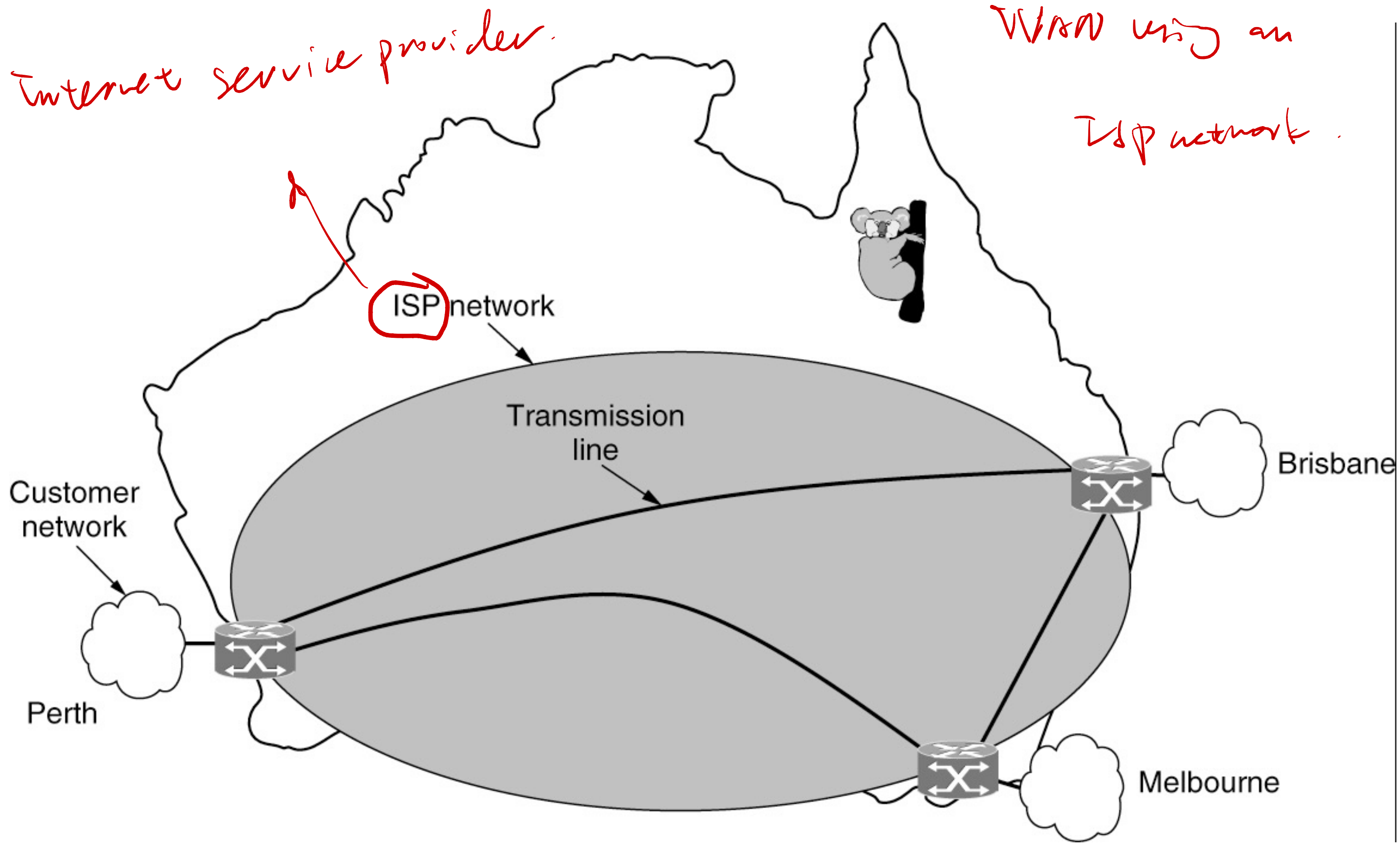
Wide Area Networks (2 of 3)

VPN



This wide area network illustrates how hosts in Perth, Brisbane, and Melbourne can communicate via the Internet.

Wide Area Networks (3 of 3)



This wide area network illustrates how hosts in Perth, Brisbane, and Melbourne can communicate via an ISP.

Internetworks

- Internetwork or internet 相互连接
  - A collection of interconnected networks
- Network combines subnets and hosts
  - Subnet can be described as a ISP network (Figure 1-11)
  - Internetwork might be described as a WAN network (Figure 1-9)
- An internet
  - Interconnection of distinct, independently operated networks
  - Connecting a LAN and a WAN or connecting two LANs
  - Gateway device makes a connection between two or more networks

网关

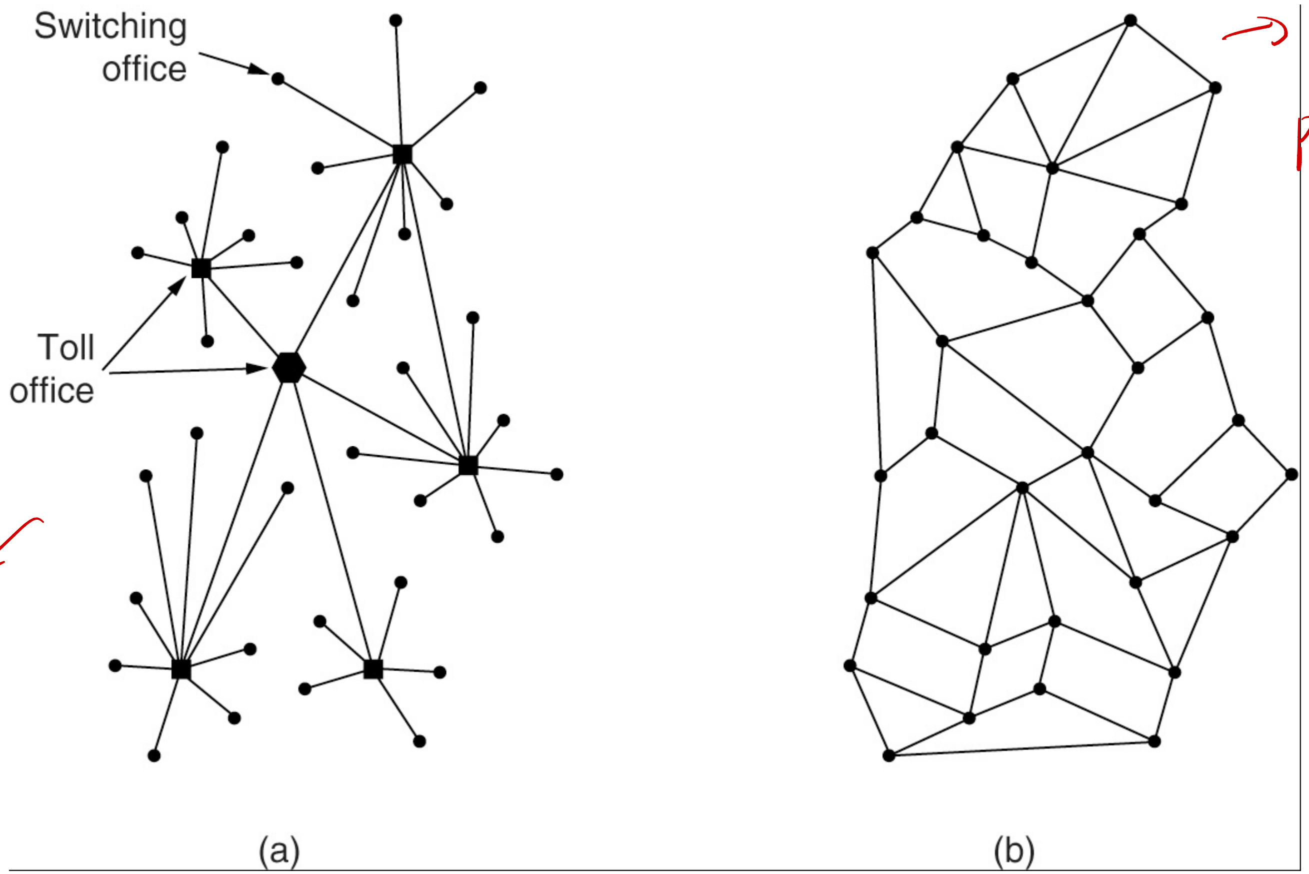
1.4

Examples of Networks (1 of 9)

- The Internet history
  - The ARPANET IBM
  - NSFNET National Science Foundation Network
  - The Internet architecture — design
- Mobile networks
  - Mobile network architecture
  - Packet switching and circuit switching
  - Early generation mobile networks: 1G, 2G, and 3G
  - Modern mobile networks: 4G and 5G
- Wireless networks (WiFi)

Examples of Networks (2 of 9)

structure of the telephone system



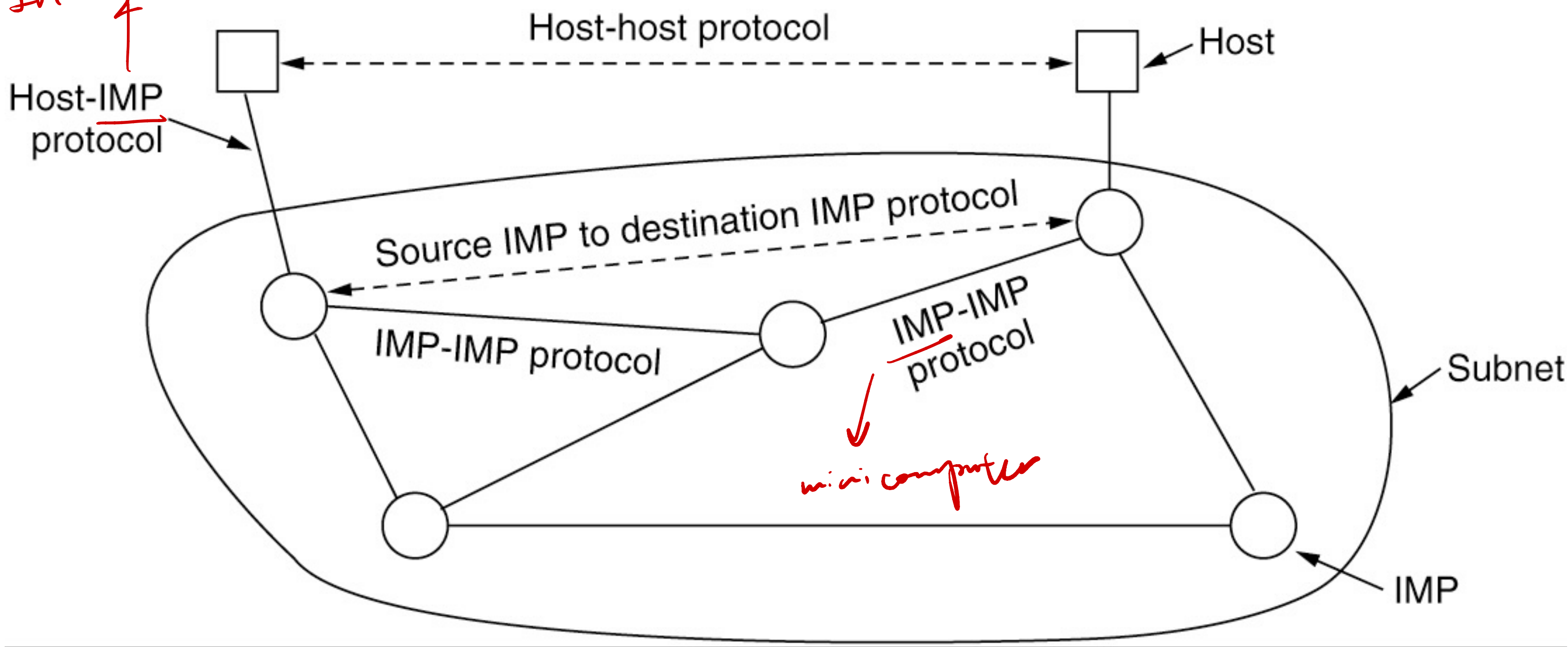
Baran's proposal

Figure (a) represents an unsecure network with little redundancy. Figure (b) illustrates a more secure packet-switched network that was initially dismissed as a solution.

Examples of Networks (3 of 9)

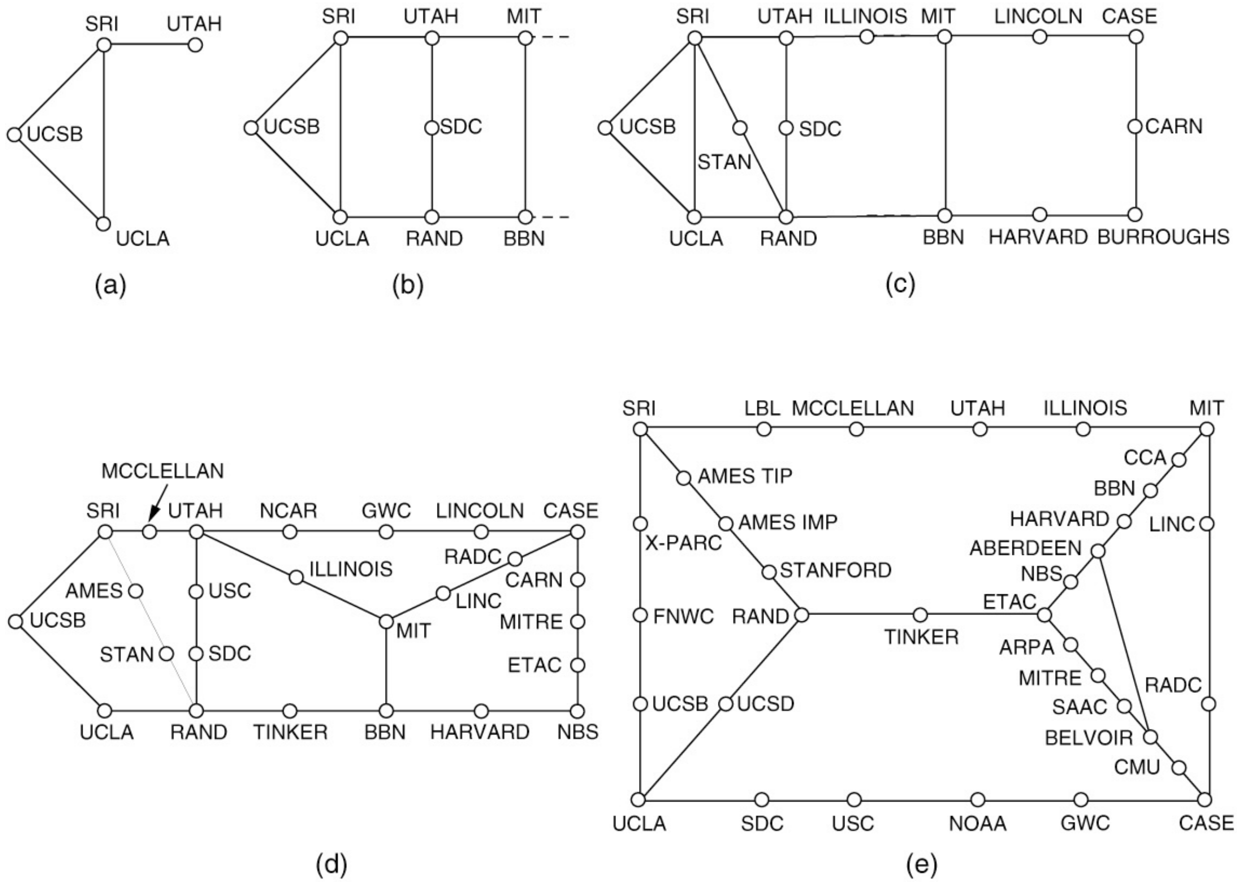
protocol = rules

Interface message processors



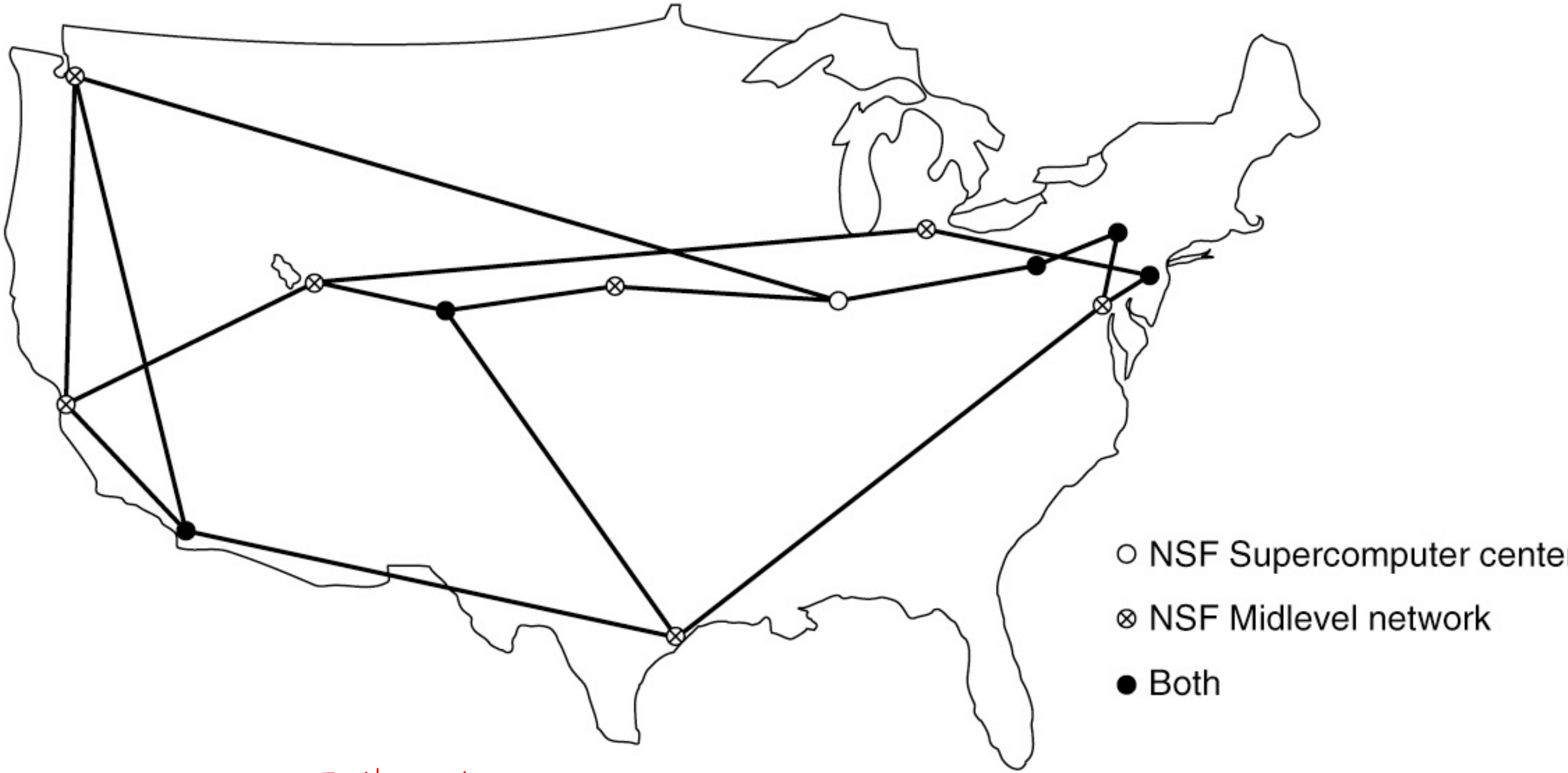
The original ARPANET software was split into two parts: subnet and host. The subnet software consisted of the IMP end of the host-IMP connection, the IMP-IMP protocol, and a source IMP to destination IMP protocol designed to improve reliability.

Examples of Networks (4 of 9)



Growth of the number of nodes on ARPANET. (a) December 1969. (b) July 1970. (c) March 1971. (d) April 1972. (e) September 1972.

Examples of Networks (5 of 9)



网络中枢

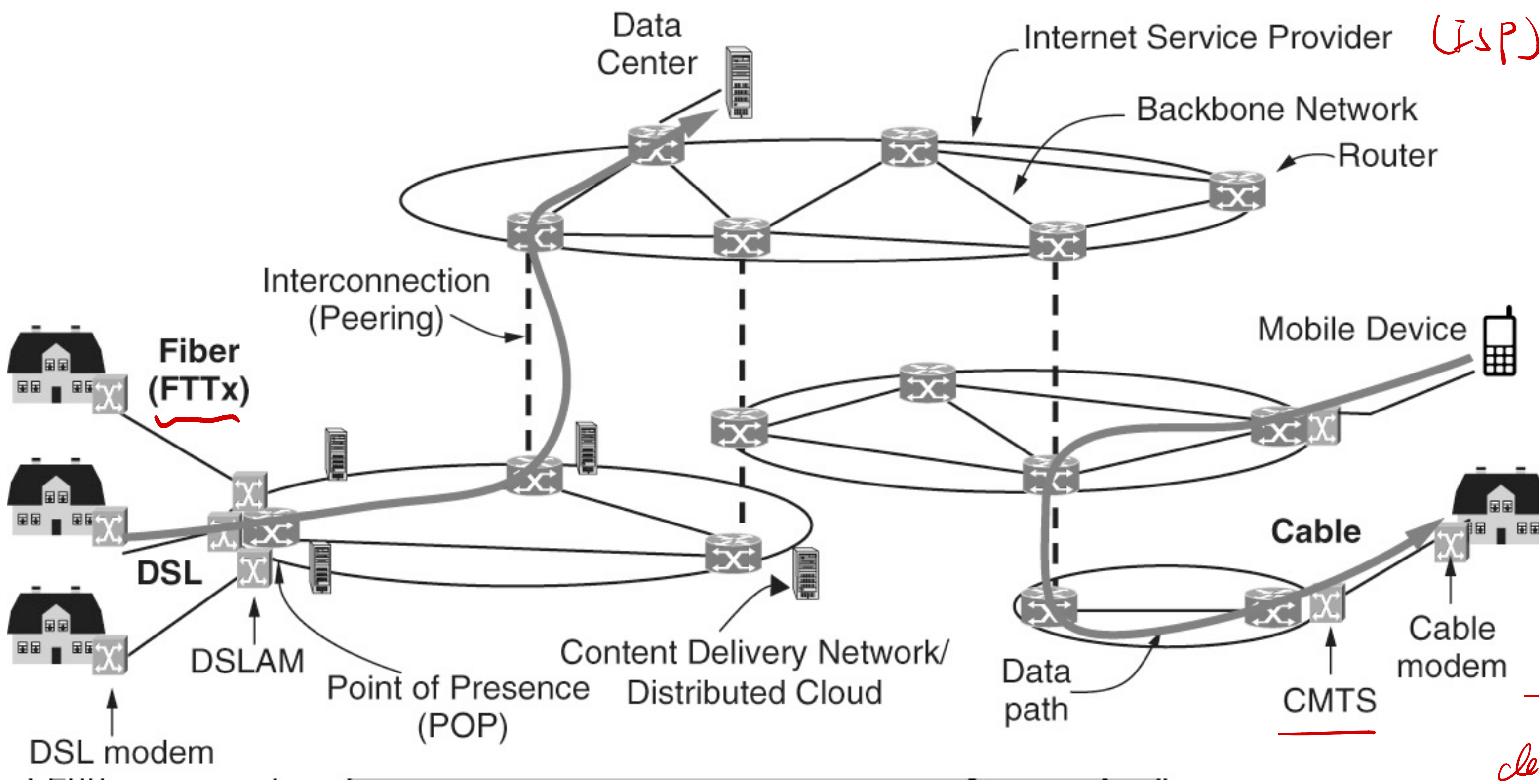
NSFNET was a backbone network designed to be a successor to the ARPANET that would be open to all university research groups, allowing them to communicate without having to contract with the Department of Defense.

Examples of Networks (6 of 9)

- Cable television infrastructure connects to the Internet
- HFC (Hybrid Fiber-Coaxial) network is a single integrated infrastructure
  - Uses packet-based transport called DOCSIS (Data Over Cable Service Interface Specification)
- DOCSIS transmits a variety of data services, including television channels, high-speed data, and voice
  - Device at the home end is called a cable modem
  - Device at the cable headend is called the CMTS (Cable Modem Termination System)
  - Modem is short for “**mo**dulator **dem**odulator”

Examples of Networks

Overview of the Internet architecture.

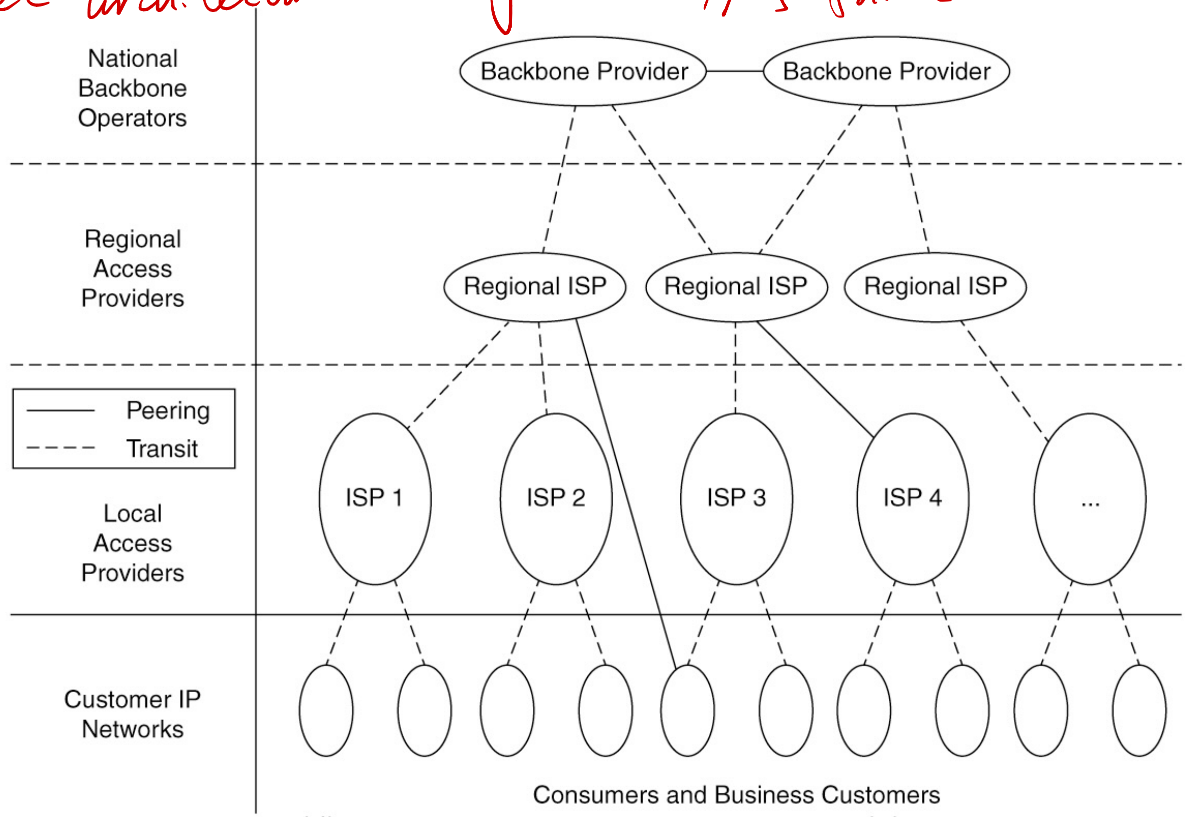


A common method for connecting to the Internet from your home is to send signals over the cable television infrastructure.

CMTS (Cable Modem Termination System)

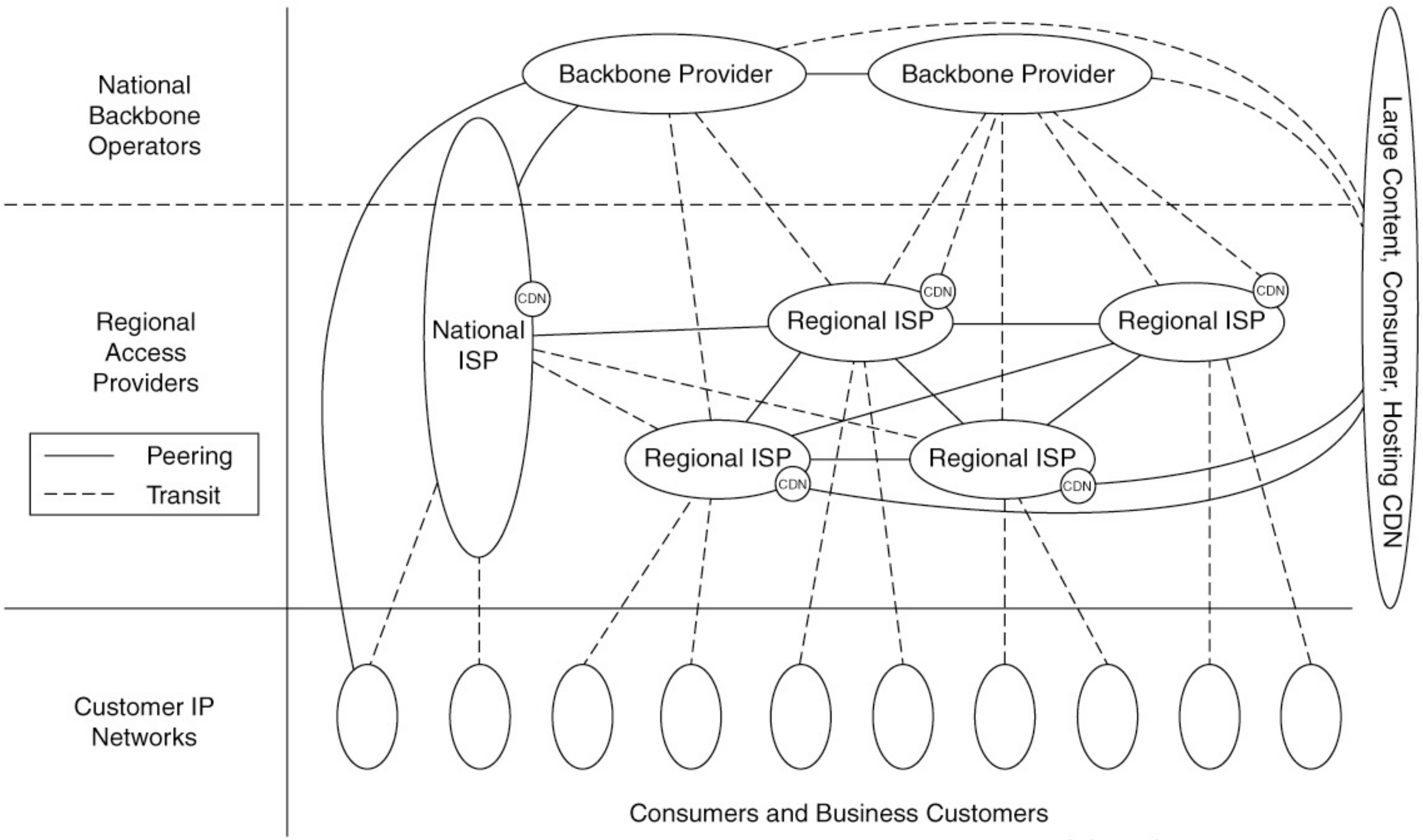
Examples of Networks (8 of 9)

The Internet architecture through the 1990s followed a hierarchical structure.



Conventionally, the Internet architecture has been viewed as a hierarchy, with the tier-1 providers at the top of the hierarchy and other networks further down the hierarchy, depending on whether they are large regional networks or smaller access networks.

Examples of Networks (9 of 9)

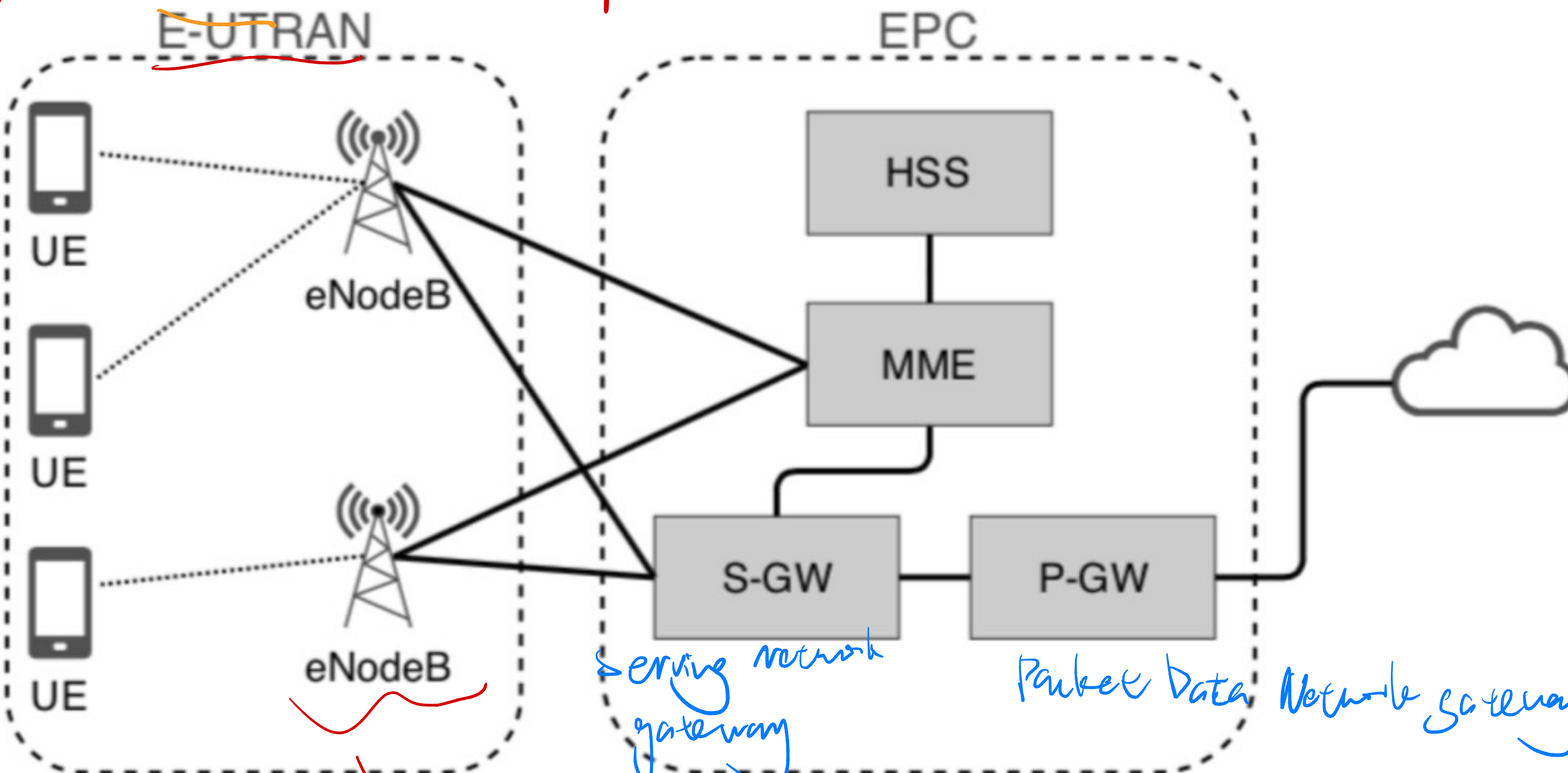


Over the past decade, the conventional hierarchy has evolved and “flattened” dramatically.

universal mobile Telecommunications system

Mobile Networks (1 of 6)

Evolved UMTS Terrestrial Radio Access Network.



serving network gateway

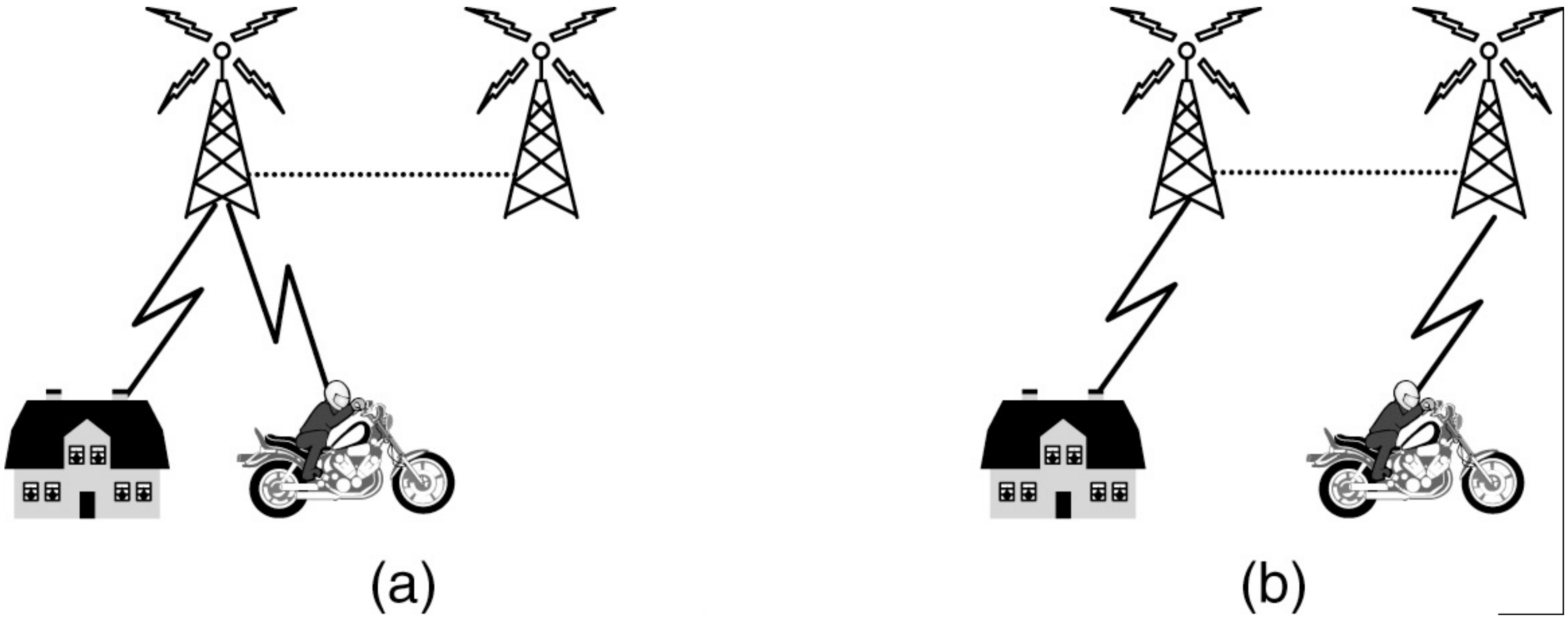
Packet Data Network gateway

the cellular base station

The architecture of the mobile phone network has several parts.

Simplified 4G LTE network architecture

Mobile Networks (2 of 6)



When a user moves out of the range of one cellular base station and into the range of another one, the flow of data must be re-routed from the old to the new cell base station.

handover or hand off 移交

Mobile Networks (3 of 6)

- Packet switching comes from the Internet community

  无连接

  找道路

  - Connectionless networks
  - Every packet is routed independently

    一段会话

  - If some routers go down during a session, no harm will be done as long as the system can dynamically reconfigure itself

电路

- Circuit switching comes from telephone companies
  - Connection-oriented networks
  - Caller must dial the called party’s number and wait for a connection before talking or sending data
  - Route maintained until call is terminated
  - Can support quality of service more easily

Mobile Networks (4 of 6)

- First-generation mobile phone systems
  - Transmitted voice calls as continuously varying (analog) signals
  - AMPS (Advanced Mobile Phone System)
- Second-generation (2G) mobile phone systems
  - Transmitted voice calls in digital form to increase capacity, improve security, and offer text messaging
  - GSM (Global System for Mobile communications)
- Third generation (3G) offer digital voice and broadband digital data services

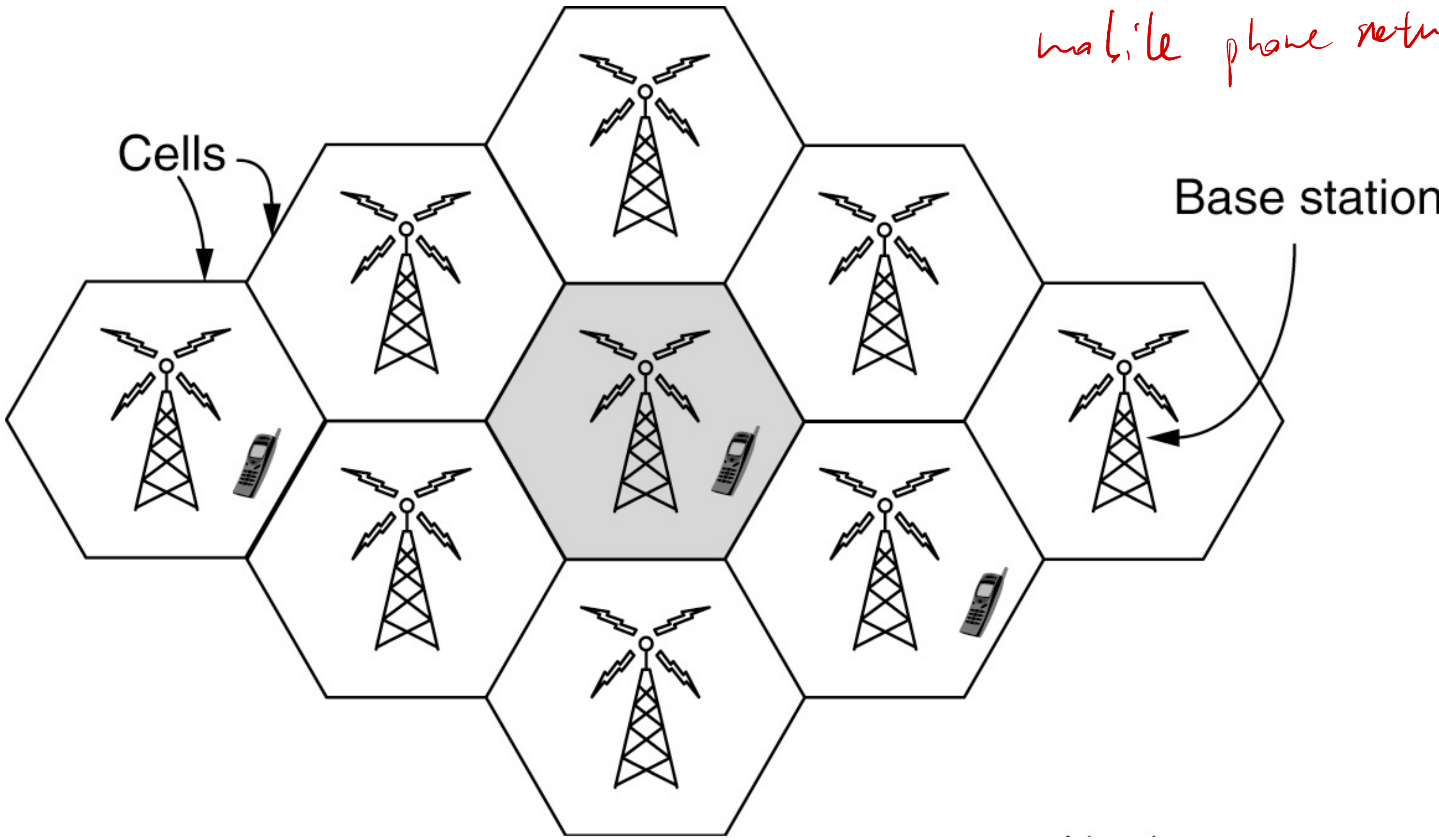
宽带

- Spectrum scarcity led to today's cellular network design

范围·频谱 稀缺

Mobile Networks (5 of 6)

Cellular design of mobile phone network



To manage the radio interference between users, the coverage area is divided into cells.

Mobile Networks (6 of 6)

- 4G
  - Later 4G known as LTE (Long Term Evolution) technology
  - Offers faster speeds
  - Emerged in the late 2000s
  - Quickly became the predominant mode of mobile Internet access in the late 2000s
  - Outpacing competitors like 802.16 (WiMiMax)
- 5G technologies are promising faster speeds
  - Up to 10 Gbps
  - Set for large-scale deployment in the early 2020s
- Main distinction: frequency spectrum they rely on

区别

4G 20MHz 5G. 6GHz

1.4.3

Wireless Networks (WiFi) (1 of 6)

- IEEE created a wireless LAN standard
  - Wireless LAN standard was dubbed 802.11
  - Common slang name for it is WiFi
  - 802.11 systems operate in unlicensed bands
  - Example: ISM (Industrial, Scientific, and Medical) bands defined by ITU-R
  - 802.11 radios compete with cordless phones, garage door openers, and microwave ovens
- 802.11 network modes: Ad hoc and access point (AP)
- Multipath fading causes received signals to fluctuate greatly

摇动.

Wireless Networks (WiFi) (2 of 6)

- Path diversity overcomes variable wireless conditions
- Versions of 802.11
  - Original 802.11 ran at either 1 Mbps or 2 Mbps
  - 802.11b used spread spectrum for rates up to 11 Mbps
  - 802.11a/g rates were boosted to 54 mbps using OFDM (Orthogonal Frequency Division Multiplexing) modulation
  - 802.11ac can run at 3.5 Gbps
  - 802.11ad can run at 7 Gbps (only indoors within a single room)
- CSMA (Carrier Sense Multiple Access) scheme
  - Handles transmission collision

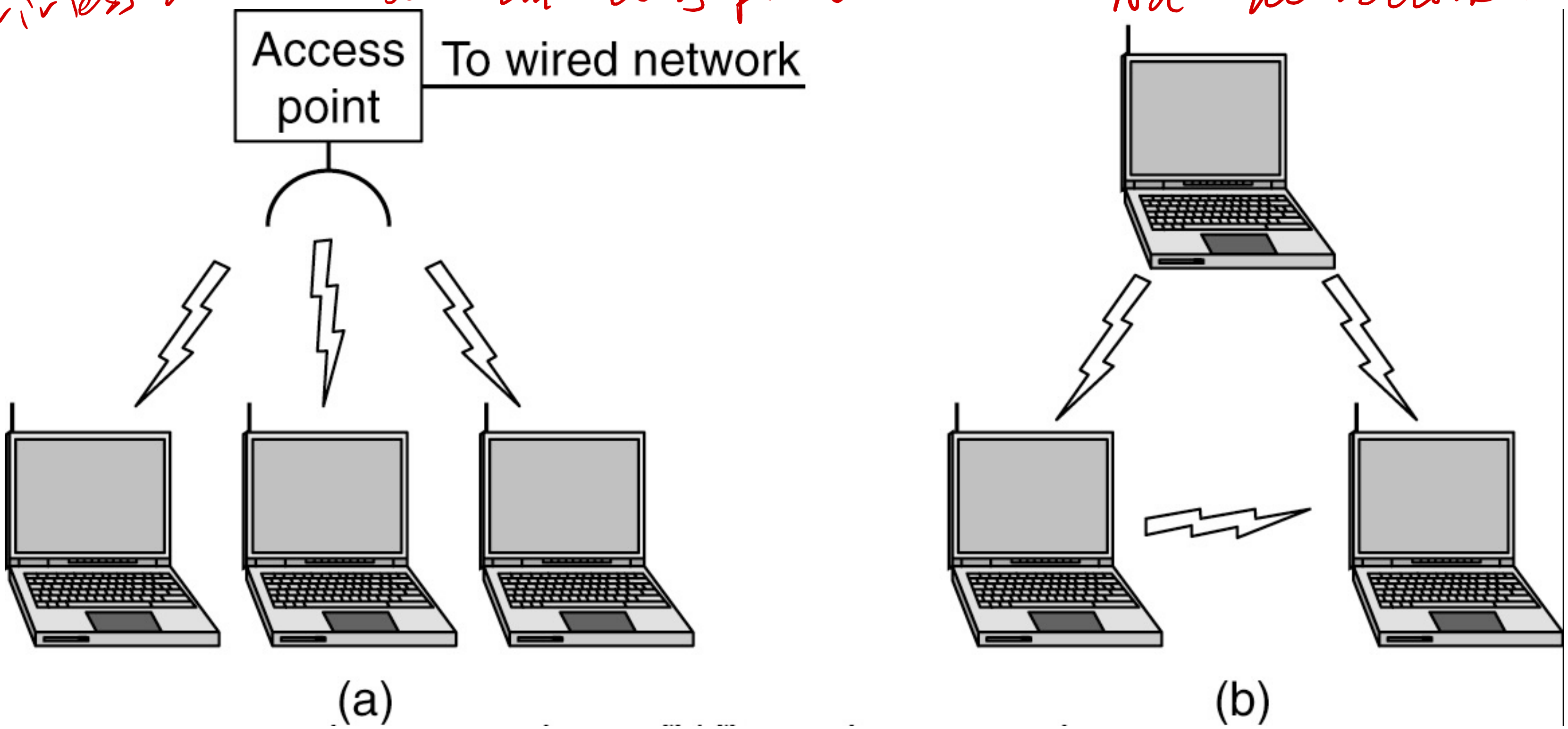
Wireless Networks (WiFi) (3 of 6)

- 802.11 mobility
  - Of limited value compared to mobility in mobile phone networks
- 802.11 security
  - WEP (Wired Equivalent Privacy)
  - WEP replaced by WiFi Protected Access (initially called WPA)
  - WiFi Protected Access (WPA) replaced by WPA2 and 802.1X

Wireless Networks (WiFi) (4 of 6)

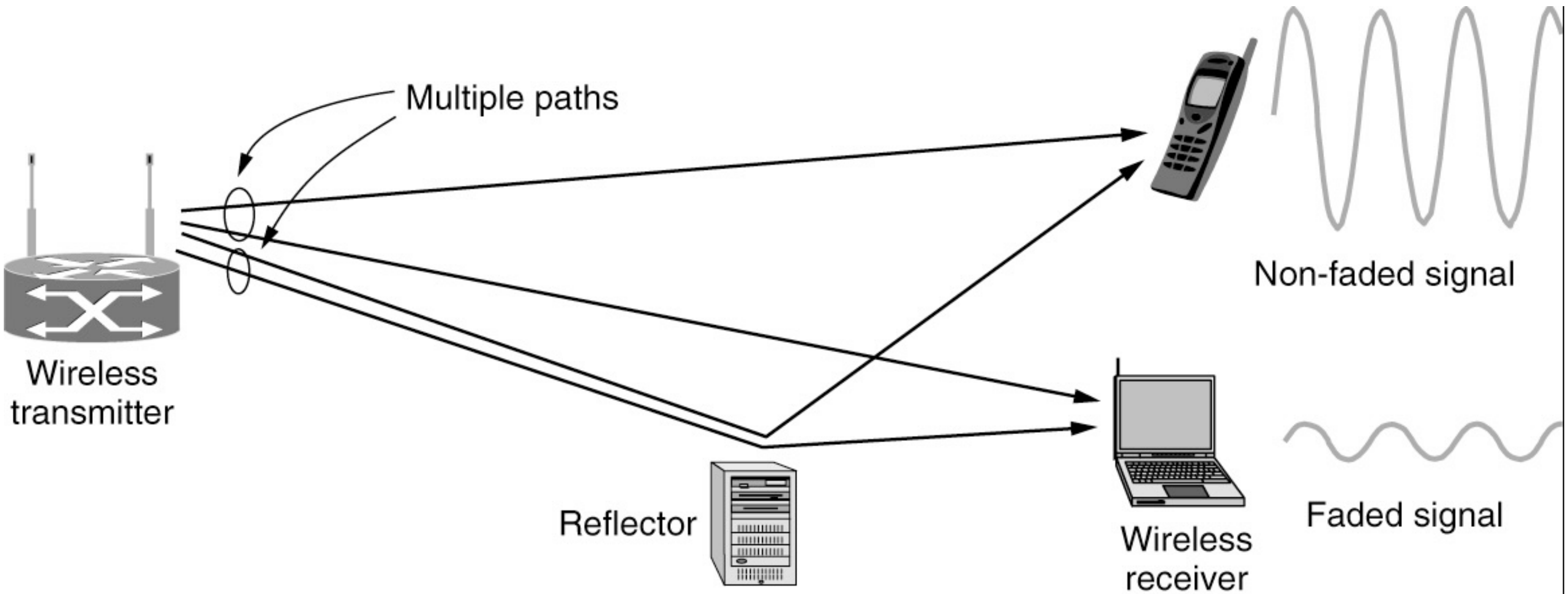
Wireless network with an access point

Ad hoc network.



Access points connect to the wired network, and all communication between clients goes through the access point. In an ad hoc network, clients that are in radio range talk directly without an access point.

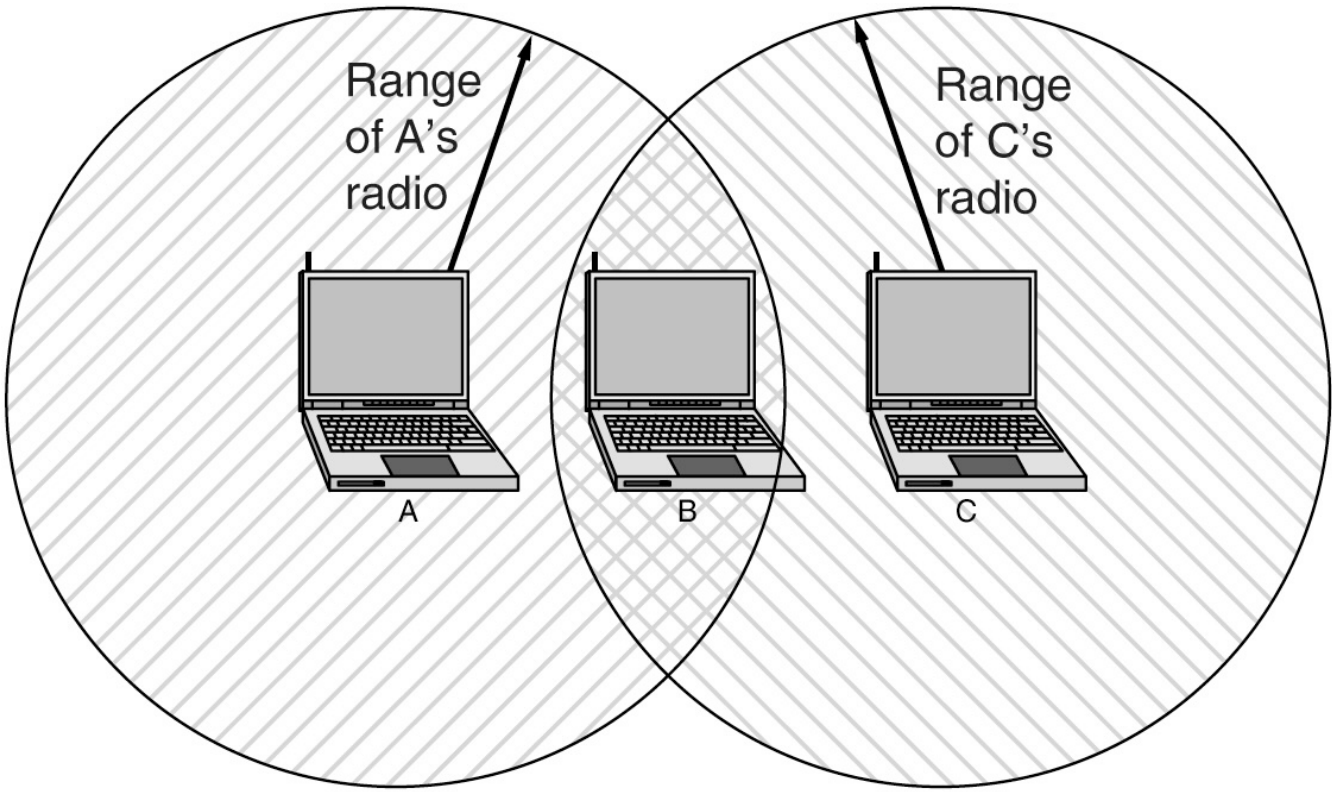
Wireless Networks (WiFi) (5 of 6)



固体

At the frequencies used for 802.11, radio signals can be reflected off solid objects so that multiple echoes of a transmission may reach a receiver along different paths. The echoes can cancel or reinforce each other, causing the received signal to fluctuate greatly – a phenomenon known as multipath fading.

Wireless Networks (WiFi) (6 of 6)



The range of a single radio may not cover the entire system.

Network Protocols

- Design goals
  - Reliability (ability to recover from errors, faults, or failures)
  - Resource allocation (sharing access to a common, limited resource)
  - 演化能力 Evolvability (allowing for incremental deployment of protocol improvements over time)
  - Security (defending the network against various types of attacks)
- Network protocol design: layering
- Connection-oriented vs. connectionless service
- Specific service primitives

Design Goals (1 of 4)

keep in mind

- Reliability
  - Make a network operate correctly even though it is comprised of a collection of components that are themselves unreliable
    - Error detection finds errors in received information
    - Error correction corrects a message by recovering the possibly incorrect bits
  - Find a working path through a network using routing
    - Routing allows network to automatically make the decision

Design Goals (2 of 4)

- Resource allocation
  - Scalable designs continue to work well when network gets large
  - Statistical multiplexing: sharing based on the statistics of demand
- An allocation problem that occurs at every level
  - Keeping a fast sender from swamping a slow receiver with data
  - Use flow control
- Congestion problem

拥挤

  - Occurs when too many computers want to send too much traffic, and the network cannot deliver it all
- Quality of service reconciles competing demands

使……一致

Design Goals (3 of 4)

- Evolvability [illegible]
  - Design issue concerns the evolution of the network
  - Over time, networks grow larger and new designs emerge that need to be connected to the existing network
  - Use protocol layering structuring mechanism to support change by dividing the overall problem and hiding implementation details
  - Use addressing or naming mechanism to identify the senders and receivers involved in a particular message
  - Different network technologies often have different limitations
  - Overall topic is called internetworking

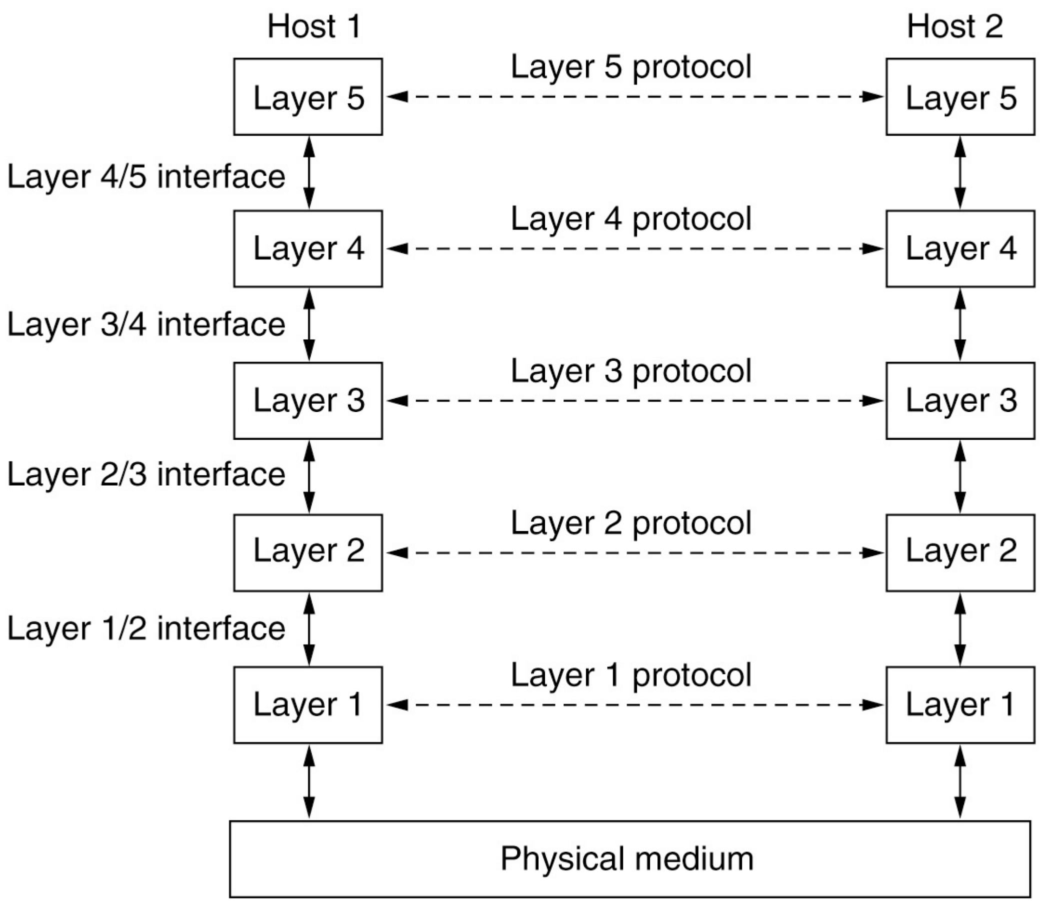
Design Goals (4 of 4)

- Security
  - Confidentiality mechanisms defend against eavesdropping on communications
  - Authentication mechanisms prevent someone from impersonating someone else
  - Integrity mechanisms prevent surreptitious changes to messages

Protocol Layering (1 of 4)

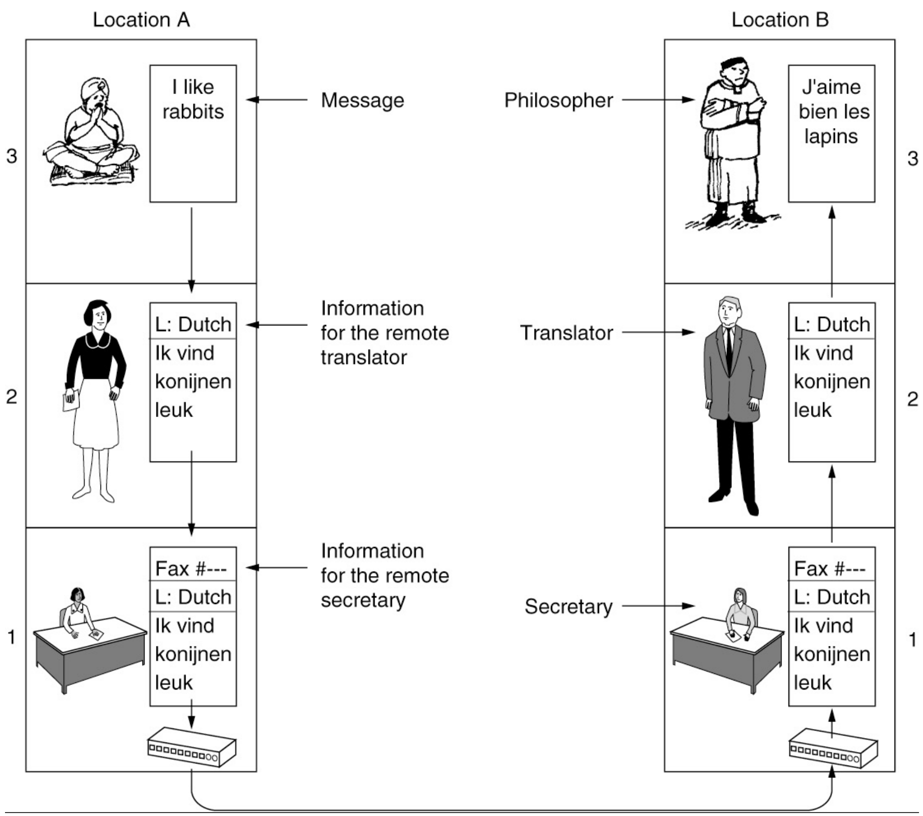
- Networks organized as a stack of layers or levels
  - Each layer built upon the one below it
- Communication between corresponding layers
  - Use a common protocol referred to as a "layer n protocol"
  - Below layer 1 is the physical medium through which actual communication occurs
  - Interface lies between each pair of adjacent layers
- Network architecture: a set of layers and protocols
- Protocol stack: a list of the protocols used by a certain system, one protocol per layer

Protocol Layering (2 of 4)



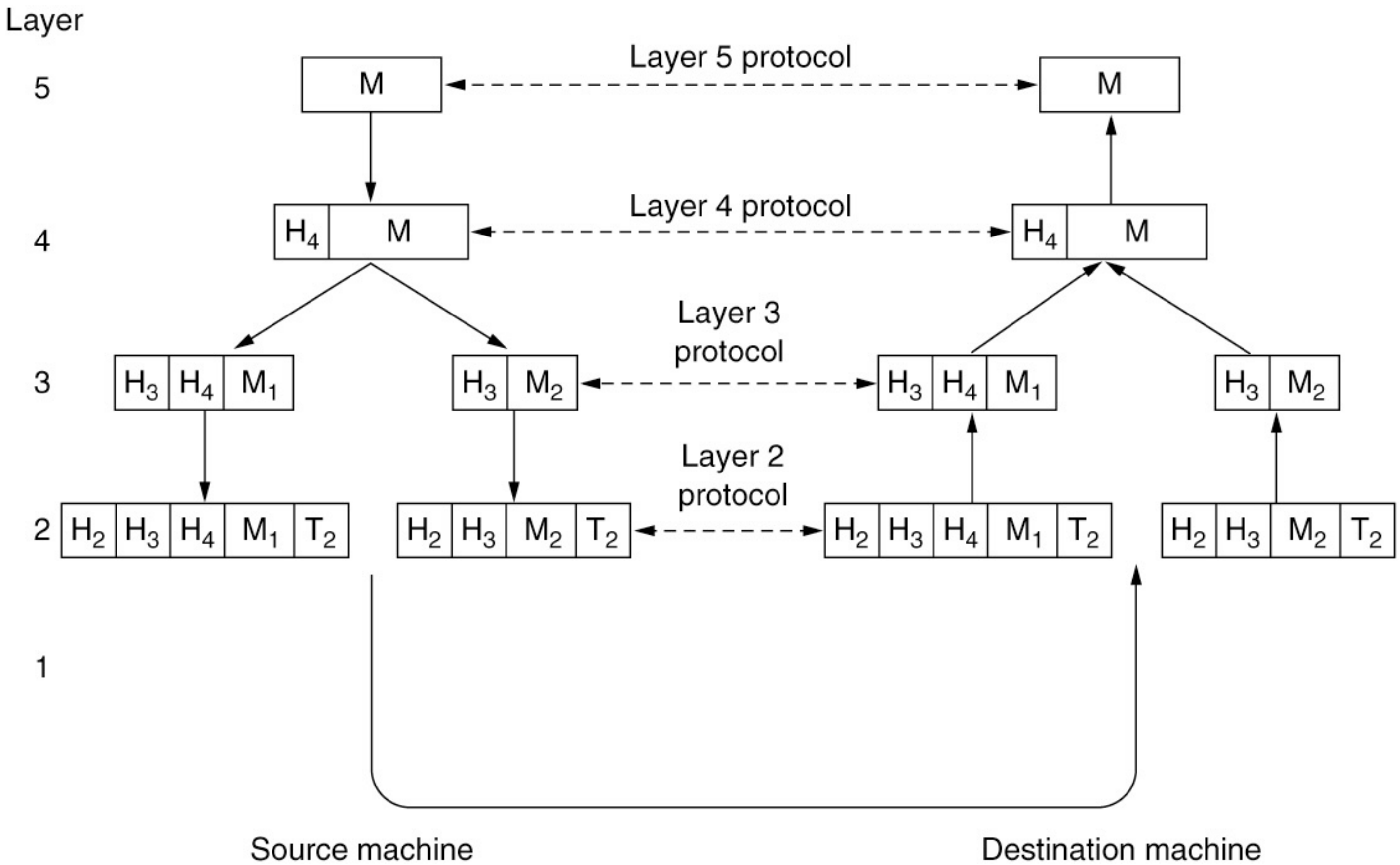
A five-layer network where the entities comprising the corresponding layers on different machines are called peers.

Protocol Layering (3 of 4)



The philosopher-translator-secretary architecture. This figure provides an analogy to explain the idea of multilayer communication.

Protocol Layering (4 of 4)



An example of information flow supporting virtual communication in layer 5.

1.5.3

Connections and Reliability (1 of 4)

- Connection-oriented service
  - Modeled after the telephone system
  - Service user first establishes a connection, uses the connection, and then releases the connection
  - Can conduct a negotiation about the parameters to be used

议[illegible]

Connections and Reliability (2 of 4)

- Connectionless service
  - Modeled after the postal system
  - Packet is a message at the network layer
  - Store-and-forward switching: intermediate nodes receive a message in full before sending it on to the next node
  - Cut-through switching: transmission of a message at a node starts before it is completely received by the node
  - Datagram service: Unreliable (not acknowledged) connectionless service
- Reliability characterizes connection-oriented and connectionless services

Connections and Reliability (3 of 4)

- Connection-oriented systems
  - Reliable message stream (sequence of pages)
  - Reliable byte stream (movie download)
  - Unreliable connection (voice over IP)
- Connectionless systems
  - Reliable message stream (electronic junk mail)
  - Reliable byte stream (text messaging)
  - Unreliable connection (database query)

Connections and Reliability (4 of 4)

	Service	Example
Connection-oriented	Reliable message stream	Sequence of pages
	Reliable byte stream	Movie download
	Unreliable connection	Voice over IP
Connection-less	Unreliable datagram	Electronic junk mail
	Acknowledged datagram	Text messaging
	Request-reply	Database query

Six common connection-oriented and connectionless services.

原始—，平级—

Service Primitives (1 of 4)

- Service
  - Formally specified by a set of primitives (operations) available to user processes to access the service
  - Primitives tell the service to perform some action or report on an action taken by a peer entity
- Six core primitives
  - 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)

Service Primitives (2 of 4)

Six service primitives that provide a simple connection-oriented service.

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

A minimal example of the service primitives that might provide a reliable byte stream.

Service Primitives (3 of 4)

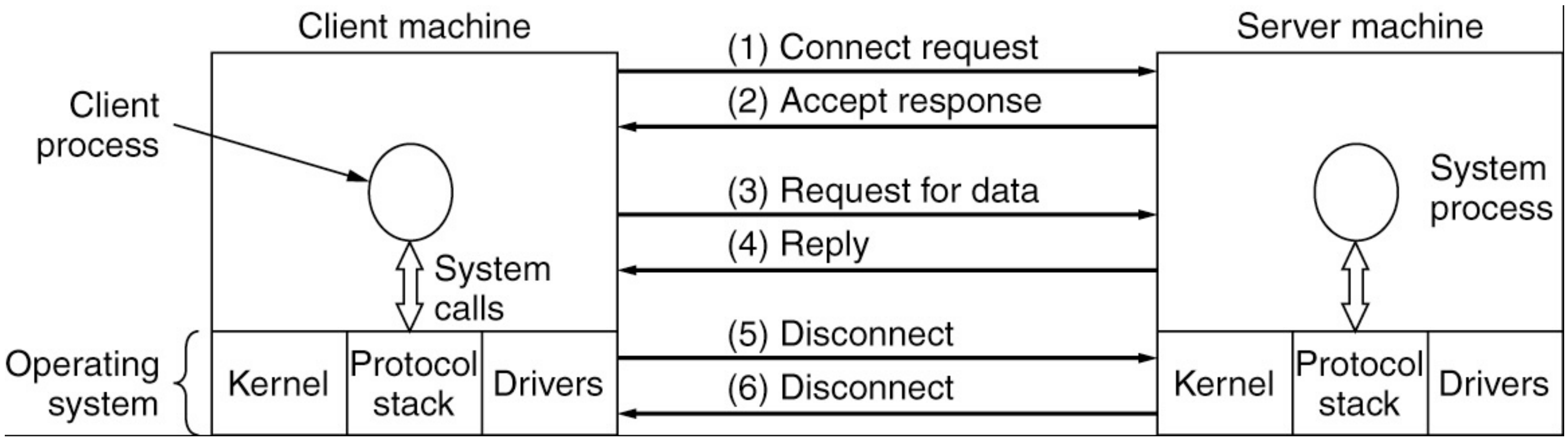
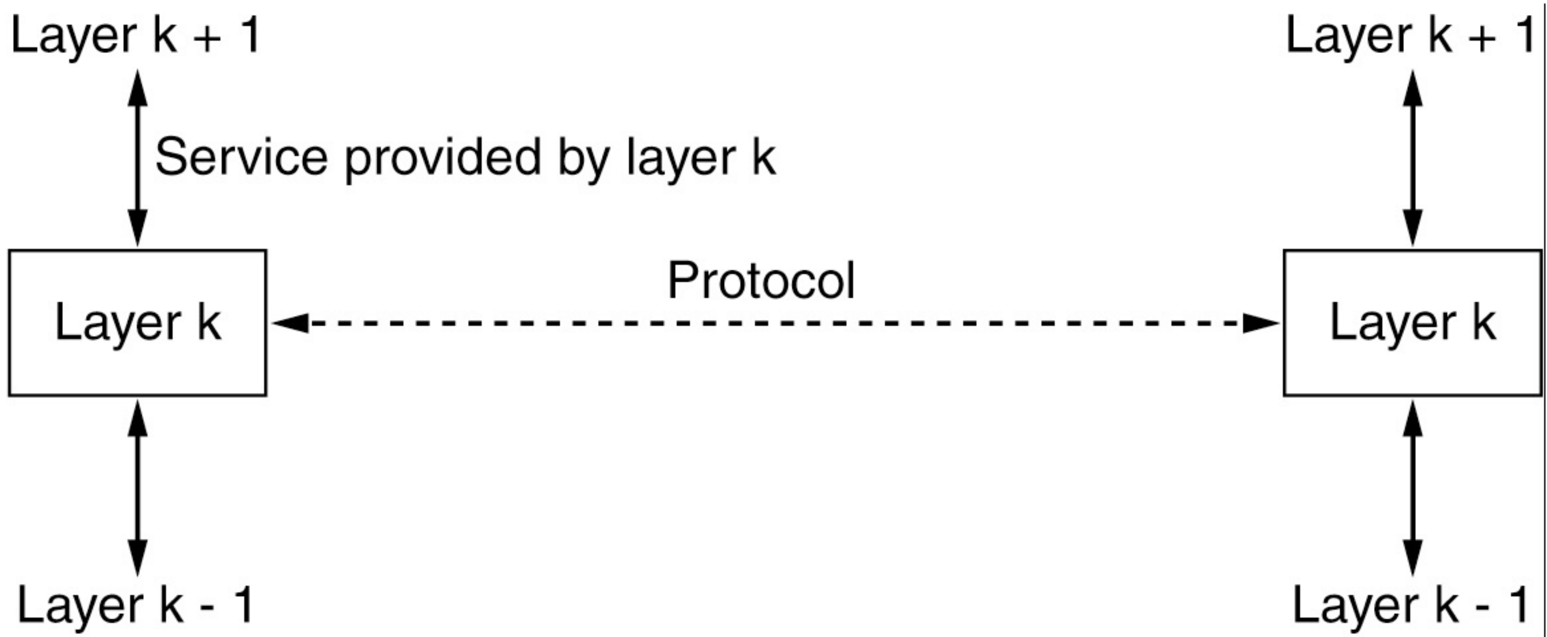


Figure 1-30 briefly summarizes how client-server communication might work with acknowledged datagrams so that we can ignore lost packets.

Service Primitives (4 of 4)



Entities use protocols in order to implement their service definitions.

Reference Models

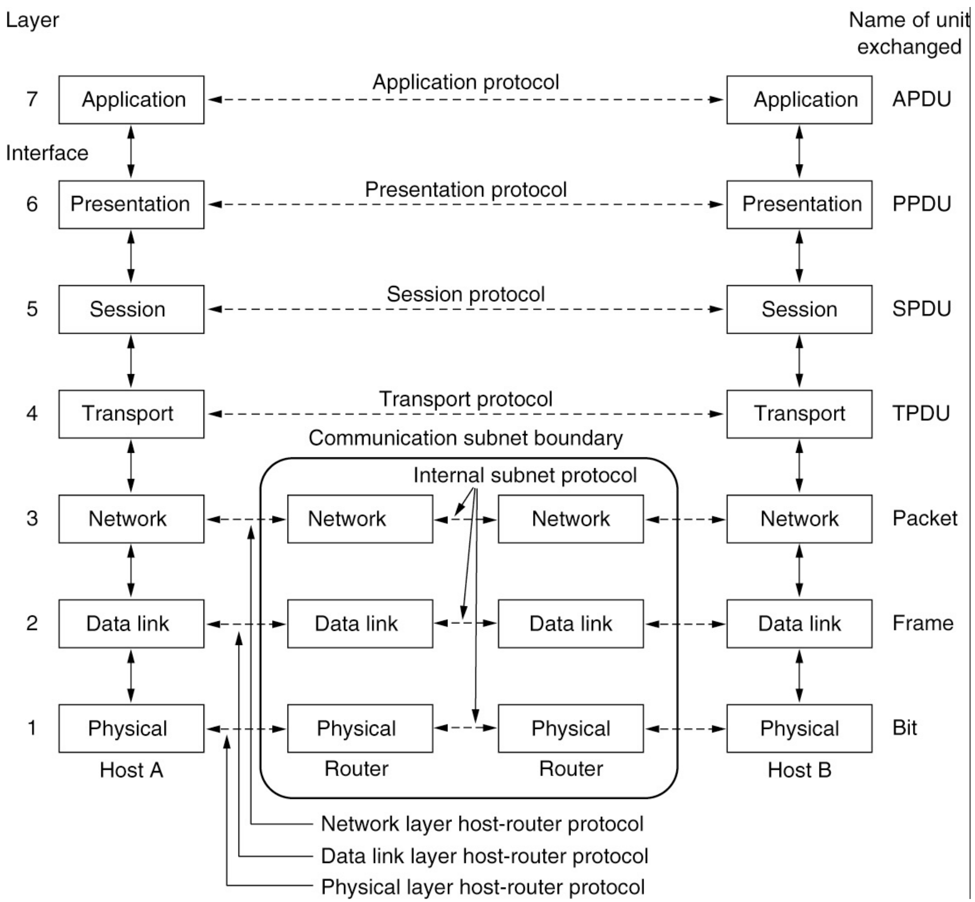
open systems Interconnection

- The OSI Reference Model
- The TCP/IP Reference Model
  - The Link Layer
  - The Internet Layer
  - The Transport Layer
  - The Application Layer
- A critique of the OSI model and protocols
- Critique of the TCP/IP reference model and protocols
- The model used in this book

The OSI Reference Model (1 of 2)

- Principles for the seven layers
  - Layers created for different abstractions
  - Each layer performs well-defined function
  - Function of layer chosen with definition of international standard protocols in mind
  - Minimize information flow across interfaces between boundaries
  - Number of layers should be optimum
- Three concepts central to the OSI model:
  - Services
  - Interfaces
  - Protocols

The OSI Reference Model (2 of 2)



The OSI model has seven layers.

The TCP/IP Reference Model (1 of 4)

- The Link Layer
  - Lowest layer in the model
  - Describes what links must do to meet the needs of this connectionless internet layer
- The Internet Layer

  引入
  - Permits hosts to inject packets into any network and have them travel independently to the destination
  - Defines an official packet format and protocol called IP (Internet Protocol)
  - Defines a companion protocol called ICMP (Internet Control Message Protocol) that helps IP function

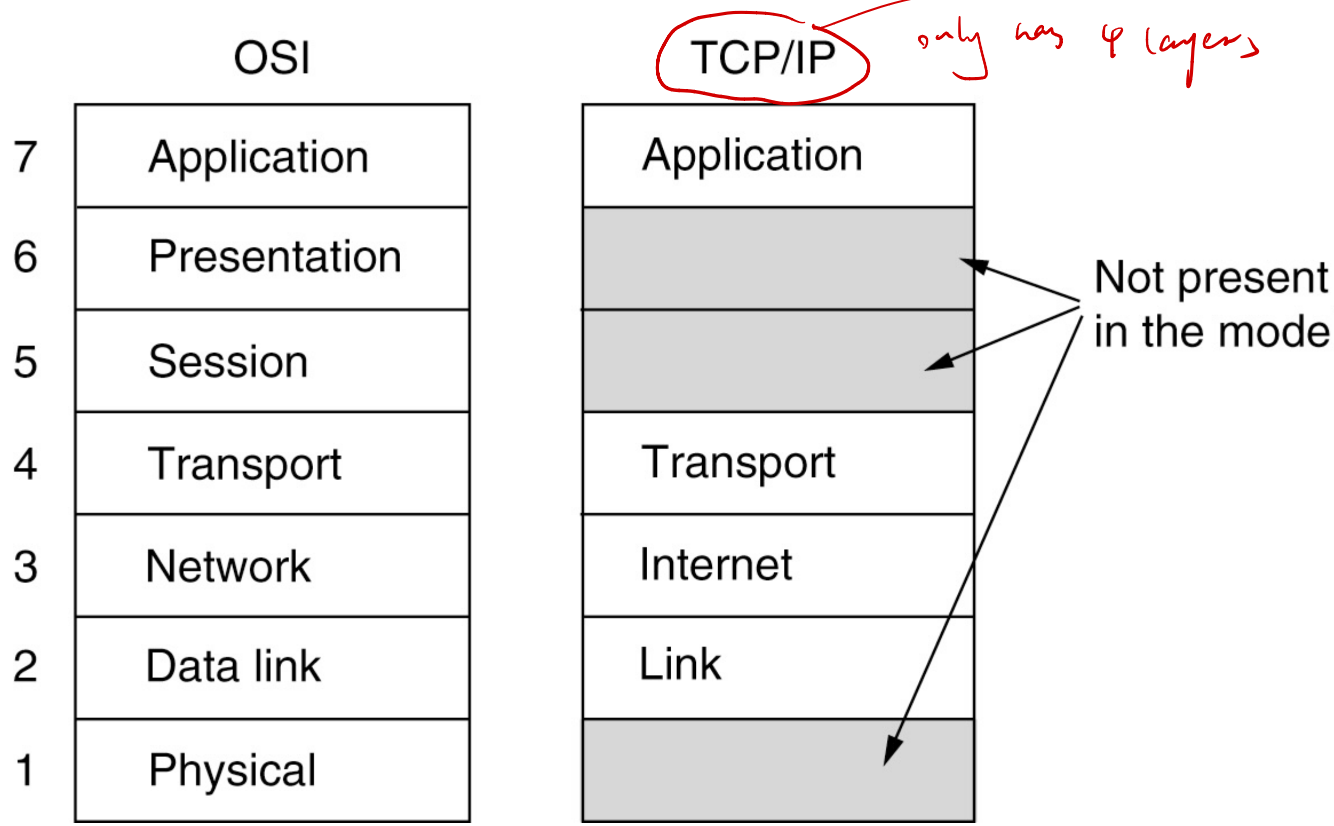
The TCP/IP Reference Model (2 of 4)

- The Transport Layer
  - The layer above the internet layer in the TCP/IP model
  - Uses two end-to-end transport protocols
    - TCP (Transmission Control Protocol)
    - UDP (User Datagram Protocol) like TV.
- The Application Layer
  - Contains all the higher-level protocols

The TCP/IP Reference Model (3 of 4)

has market.

only has 4 layers

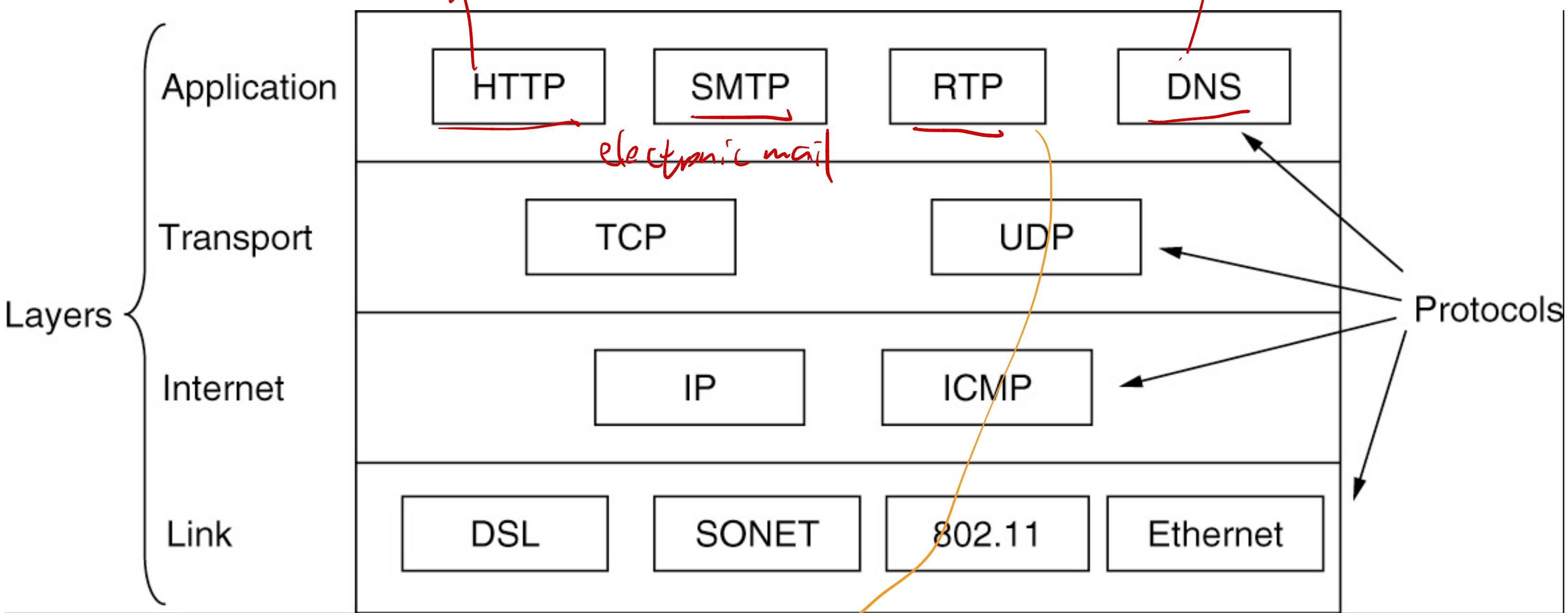


The TCP/IP layers loosely align with the OSI model.

on the World Wide Web.   for mapping host names onto their network addresses,

The TCP/IP Reference Model (4 of 4)

the protocol for fetching pages   Domain name system



The relation of IP, TCP, and UDP protocols are illustrated. We will study these.

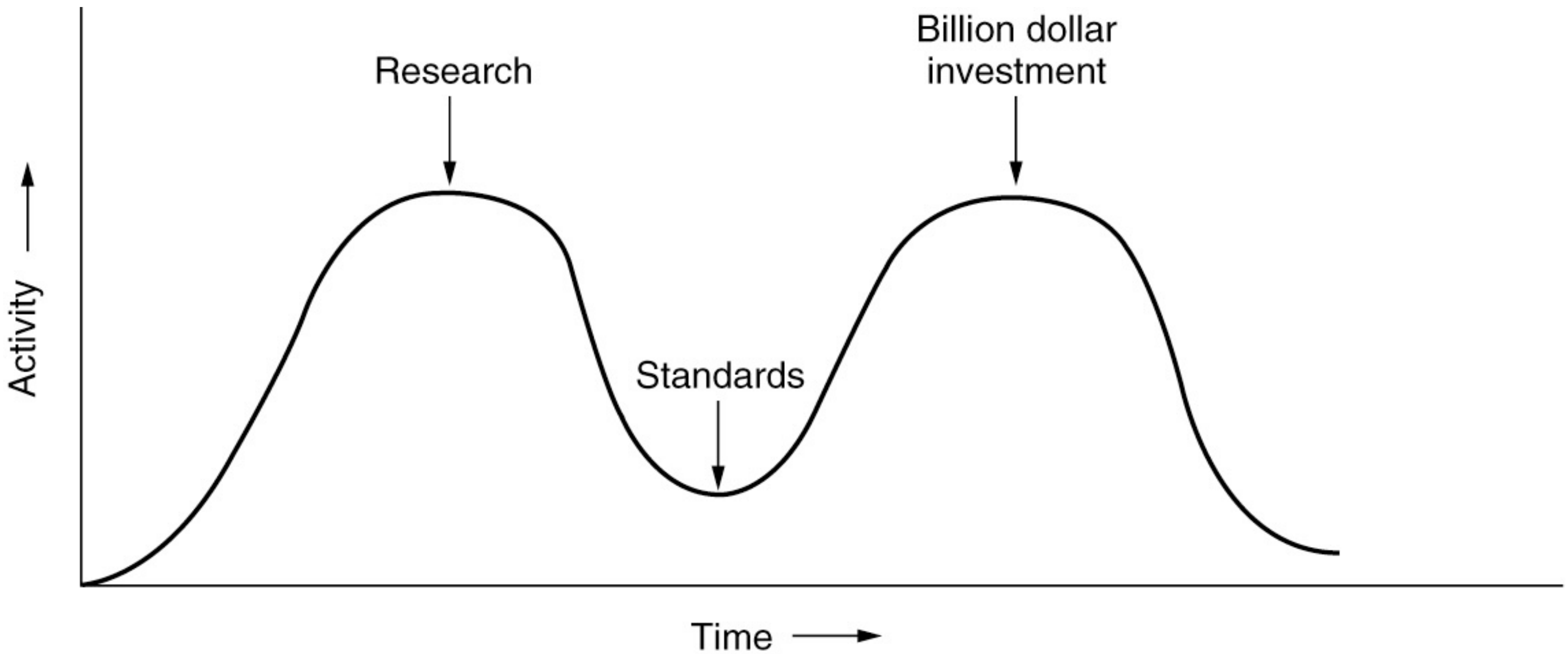
the protocol for delivering real-time media such as voice or movies

A Critique of the OSI Model and Protocols (1 of 2)

评论

- Bad timing
  - Competing TCP/IP protocols were already in widespread use
- Bad design
  - Both the model and the protocols are flawed 缺陷
- Bad implementations
  - Initial implementations were huge, unwieldy, and slow
- Bad politics
  - Widely thought to be the creature of the European telecommunication ministries, the European Community, and later the U.S. Government

A Critique of the OSI Model and Protocols (2 of 2)



To prevent bad timing, it is essential that the standards be written in the trough in between the tops of the waves known as the two “elephants."

A Critique of the TCP/IP Reference Model and Protocols

- Model does not clearly distinguish the concepts of services, interfaces, and protocols
- Model is not at all general
  - Poorly suited to describing any other protocol stack

Trying to use the TCP/IP model to describe Bluetooth, for example, is completely impossible.

- The link layer is not really a layer at all in the normal sense of the term
- Model does not distinguish between the physical and data link layers
- Other protocol implementations were distributed free

The Model Used in This Book

5	Application
4	Transport
3	Network
2	Link
1	Physical

This model has five layers, running from the physical layer up through the link, network and transport layers to the application layer.

~~Standardization~~

- ~~Standardization and open source~~
- ~~Who’s who in the telecommunications world~~
- ~~Who’s who in the international standards world~~
- ~~Who’s who in the Internet standards world~~

~~Standardization and Open Source~~

- ~~Standards define what is needed for interoperability~~
  - No more, no less

互操作性

- WiFi Alliance
  - Interoperability within the 802.11 standard
- ONF (Open Networking Foundation)
  - Interoperability of protocols to control programmable network switches
- Two categories of standards

HTTP ..

  - De facto standards just happened, without any formal plan

fact

  - De jure standards are a~~dopted through the rules of some formal~~ standardization body

by law

IEEE ...

Who's Who in the Telecommunications World

- Two extremes
  - Small privately owned telephone companies
  - National government has a complete legal monopoly on all communication

垄断

- PTT (Post, Telegraph & Telephone administration)
  - Branch of government having telecommunication authority
- ITU (International Telecommunication Union)
  - United Nations agency
  - ITU-T: Telecommunications Standardization Sector

行业

Who's Who in the International Standards World (1 of 2)

- ISO (International Standards Organization)
  - Publishes and produces international standards
- NIST (National Institute of Standards and Technology)
  - Part of the U.S. Department of Commerce 贸易
- IEEE (Institute of Electrical and Electronics Engineers)
  - The largest professional organization in the world
  - IEEE's 802 committee has standardized many kinds of LANs

a local area network (LAN) connects devices that are physically close to each other by using connectors like router and switches.

Who's Who in the International Standards World (2 of 2)

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 (WiFi)
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, Zigbee)
802.16 †	Broadband wireless (WiMAX)
802.17 †	Resilient packet ring
802.18	Technical advisory group on radio regulatory issues
802.19	Technical advisory group on coexistence of all these standards
802.20	Mobile broadband wireless (similar to 802.16e)
802.21	Media independent handoff (for roaming over technologies)
802.22	Wireless regional area network

The important ones are marked with *. The ones marked with † gave up and stopped.

Who’s Who in the Internet Standards World

- IAB (Internet Activities Board) oversaw ARPANET
  - Renamed Internet Architecture Board
  - Communicated with RFCs (Request For Comments)
  - IRTF (Internet Research Task Force) subsidiary to IAB
  - IETF (Internet Engineering Task Force) subsidiary to IAB
  - More formal standardization process was adopted
- Internet Society
  - Created, populated by people interested in the Internet
- World Wide Web Consortium (W3C)
  - Develops protocols and guidelines to facilitate long-term growth of the Web

Policy, Legal, and Social Issues (1 of 3)

- Online speech
  - Communications Decency Act protects some platforms from federal criminal prosecution
  - DMCA takedown notices (after the Digital Millennium Copyright Act) threaten legal action
- Net neutrality 中立
  - ISPs should provide equal quality of service to a given type of application traffic, regardless of who is sending that content
  - No blocking, no throttling, no paid prioritization, transparency 透明
  - Does not prevent an ISP from prioritizing any traffic
  - Zero rating: ISP might charge its subscribers according to data usage but grant an exemption for a particular service

豁免

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Policy, Legal, and Social Issues (2 of 3)

- Security
  - DDoS (Distributed Denial of Service) attack
  - Botnets
  - Spam email 垃圾邮件
  - Phishing 网络诱骗
- Privacy
  - Profiling and tracking users by collecting data about their network behavior over time
  - Storing cookies in Web browser
  - Browser fingerprinting
  - Mobile services location privacy

Policy, Legal, and Social Issues (3 of 3)

- Disinformation
  - Ill-considered, misleading, or downright wrong information
  - Fake news
  - Challenges
    - How does one define disinformation in the first place?
    - Can disinformation be reliably detected?
    - What should a network or platform operator do about it once it is detected?

Metric Units

Exp.	Explicit	Prefix	Exp.	Explicit	Prefix
10^{-3}	0.001	milli	10^{3}	1,000	Kilo
10^{-6}	0.000001	micro	10^{6}	1,000,000	Mega
10^{-9}	0.000000001	nano	10^{9}	1,000,000,000	Giga
10^{-12}	0.000000000001	pico	10^{12}	1,000,000,000,000	Tera
10^{-15}	0.000000000000001	femto	10^{15}	1,000,000,000,000,000	Peta
10^{-18}	0.000000000000000001	atto	10^{18}	1,000,000,000,000,000,000	Exa
10^{-21}	0.000000000000000000001	zepto	10^{21}	1,000,000,000,000,000,000,000	Zetta
10^{-24}	0.000000000000000000000001	yocto	10^{24}	1,000,000,000,000,000,000,000,000	Yotta

The principal metric prefixes.

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