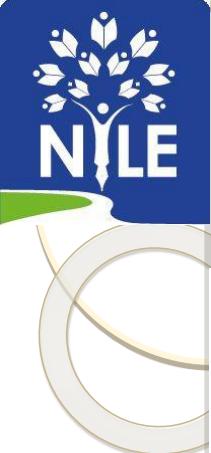




# CSC 815 – Advanced Computer Networking

## Module I :Introduction

Engr. Prof. Steve A. Adeshina



# Course Contents

## CSC 605 Computer Networks and Communications Course Contents

**Week 1:** Introduction. Principles of data networks and communications: Analog and digital transmission, multiplexing (FDM, TDM, statistical multiplexing), transmission impairments, concepts of frequency spectrum and bandwidth, bandwidth efficient modulation techniques.

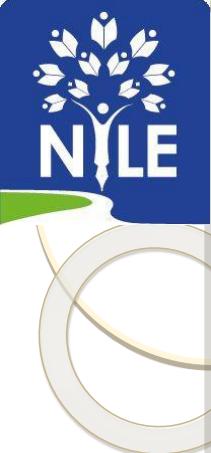
**Week 2** Channels and channel capacity; introduction to information theory; sharing network resources: telecommunication history;

Basics of computer networks: Protocol hierarchies, design issues for the layers, interfaces and services. Concepts of circuit switching and packet switching, connection-oriented and connectionless services.

**Week 3:** Reference models-OSI model and TCP/IP reference model. Modelling data networks: services and protocols; layered architectures; **introduction to queuing theory**.

**Week 4: Physical layer:** Transmission media-twisted pair, coaxial cable, optical fibre. Wireless transmission-radio, microwave, infrared and millimeter waves, telephone systems, cell phones. RS-232C, SONET,modems.

**Week 5 Network topologies.** Local Area Networks. Wide Area Networks Metropolitan Area Networks. Wired media, Wireless media, Hybrid Media. Network and Communications Links: UTP, Co-axial, High speed wireless links- Microwave, High bandwidth fibre links, Fibre optic connections



# Course Contents (Contd)

**Week 6:** Media access control protocols: Concept of LANs and MANs. ALOHA, slotted ALOHA, CSMA, CSMA/CD. Ethernet, token bus, token ring, FDDI. **Channels and channel capacity concepts.**

**Week 7: Broadcast and Routed Transmission** . LAN Contention and permission based Media Access protocols, CSMA/CD, Token ring, token bus slotted ring, Client Server model, RPC, FDDI, WAN – Circuit, message and packet switching, PSDN and ISDN, X.25.

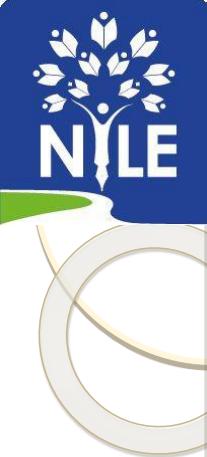
**Week 8: Data link layer:** Services provided to the network layer, framing, error control, flow control. Error detection and correction. Unrestricted simplex protocol, stops-and wait Protocol, sliding window protocols. HOLC

**Week 9 :Network layer:** Design issues. Routing algorithms. Congestion control. Internetworking: concepts of sub network, bridges, etc. X.25 frame relay.

Routing algorithms. Internet traffic: data and multimedia payloads  
Multimedia communication and QoS

**Week 10: Transport layer:** Services provided to the upper layers. Elements of transport control protocols-addressing, establishing a connection, releasing a connection, flow control and buffering, crash recovery. Example of simple protocols using services primitives. TCP and UDP.  
IP: IPV4 datagram, IP addressing. ICMP.

Network Concepts and Protocols. Open system Interconnection (OSI) and Transmission Control Protocol/Internet Protocol (TCP/IP).



# Course Contents (Contd)

ATM: Protocol architecture. ATM logical connections. ATM cells. Transmission of ATM cells. ATM adaptation layer. Traffic and congestion control. Narrowband and broadband ISDN. Application layer: SNMP, SMTP, FTP, TELNET.

**Week 11** : Media access control protocols: Concept of LANs and MANs. ALOHA, slotted ALOHA, CSMA, CSMA/CD. Ethernet, token bus, token ring, FDDI.

ATM: Protocol architecture. ATM logical connections. ATM cells. Transmission of ATM cells. ATM adaptation layer. Traffic and congestion control. Narrowband and broadband ISDN. Application layer: SNMP, SMTP, FTP, TELNET.

**Week 12** :Internet working – resolution of protocols variations. Repeaters , Hubs, Bridges, Routers, Brouters. SNMP protocol operations, Security and administration

**Week 13** Wireless LAN, Wireless Cellular Networks (1G, 2G, 3G, 4LTE, 4G Cellular networks). Optical Communications Networks. Network Management: Infrastructure for Network management, SMI, MIB.

**Week 14:** • Network security: Principles of cryptography, Public Key Encryption, Digital signatures, Authentication, securing emails, Securing TCP Connections, Network layer Security, Firewalls, Intrusion detection system systems. “CIA,” denial-of-service attack, worm attack. Transparent network services: DNS, HTTP, web server design, caching and CDNs. **Cyber space technology: Cyber Crime, Cyber Security and models of Cyber Solution.**



# Grading Policy

Laboratory -	10 marks
Projects -	10 marks
Quizzes -	5 marks
Midterm Exams	15 marks
Final Exams	60 marks



# References

Computer Networking: A top down approach

By

James F. Kurose and Keith W. Ross

Pearson Education

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Data and Communications

By

Williams Stallings

Pearson Education

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Fundamentals of Wireless Networking

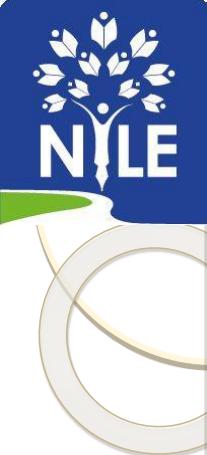
Ron Price

McGraw-Hill



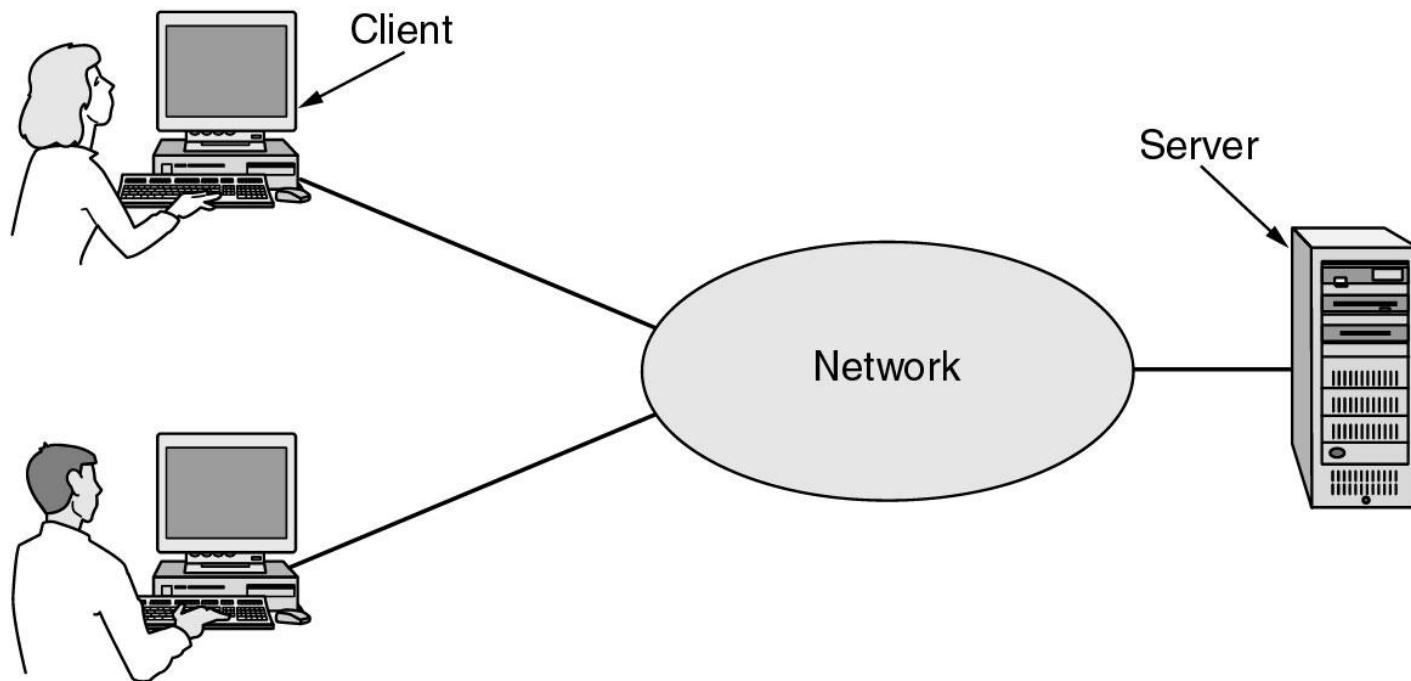
# Uses of Computer Networks

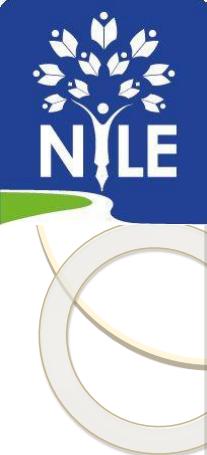
- Business Applications
- Home Applications
- Mobile Users
- Social Issues



# Business Applications of Networks

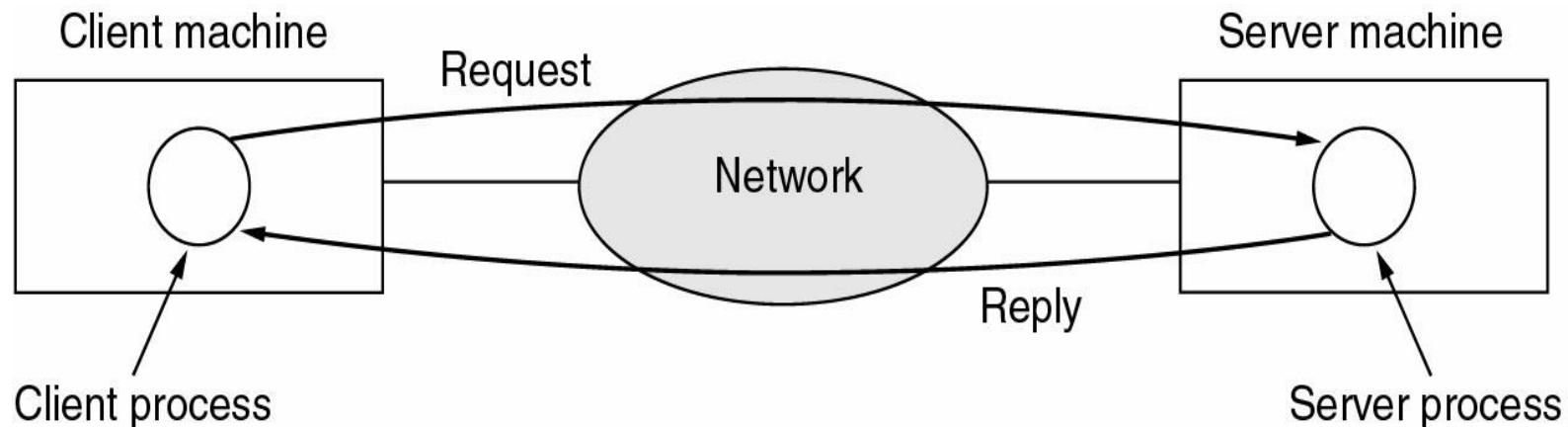
- A network with two clients and one server.





# Business Applications of Networks (2)

- The client-server model involves requests and replies.



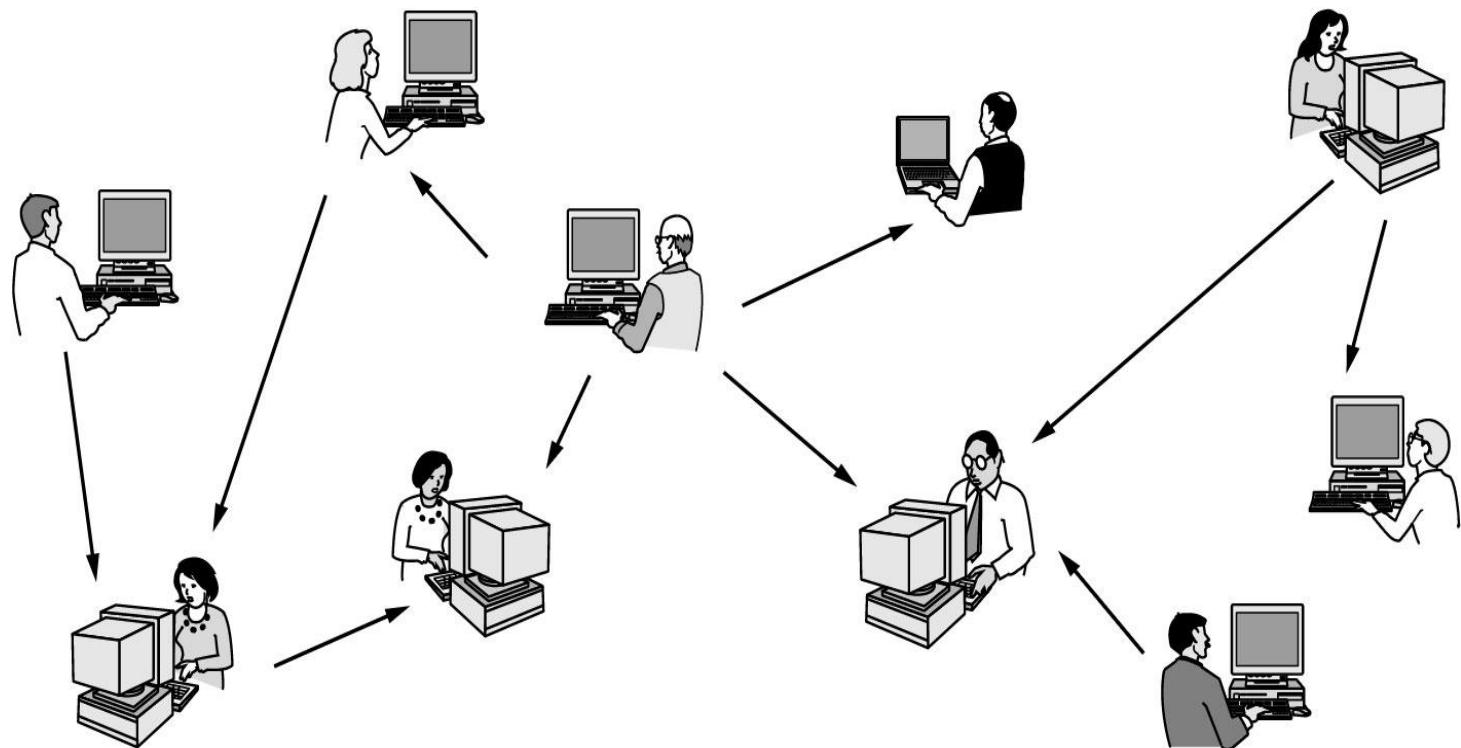


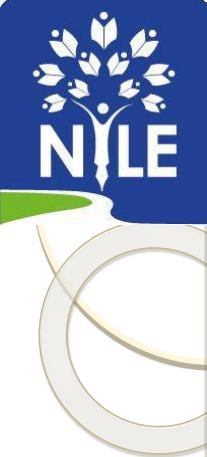
# Home Network Applications

- Access to remote information
- Person-to-person communication
- Interactive entertainment
- Electronic commerce

# Home Network Applications (2)

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





# Home Network Applications (3)

- Some forms of e-commerce.

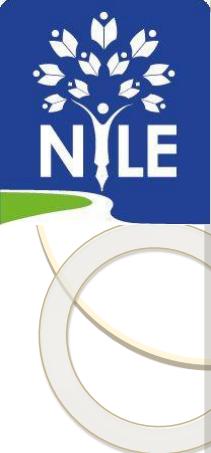
Tag	Full name	Example
B2C	Business-to-consumer	Ordering books on-line
B2B	Business-to-business	Car manufacturer ordering tires from supplier
G2C	Government-to-consumer	Government distributing tax forms electronically
C2C	Consumer-to-consumer	Auctioning second-hand products on-line
P2P	Peer-to-peer	File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



# Mobile Network Users

- Combinations of wireless networks and mobile computing.

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



# Network Hardware

- Local Area Networks
- Metropolitan Area Networks
- Wide Area Networks
- Wireless Networks
- Home Networks
- Internetworks



# Broadcast Networks

- Types of transmission technology
  - Broadcast links
  - Point-to-point links

# Applications of Networks

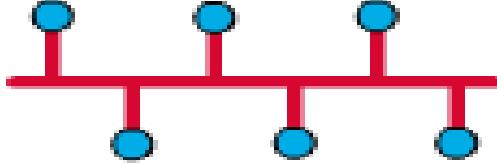
- Resource Sharing
  - Hardware (computing resources, disks, printers)
  - Software (application software)
- Information Sharing
  - Easy accessibility from anywhere (files, databases)
  - Search Capability (WWW)
- Communication
  - Email
  - Message broadcast
- Remote computing
- Distributed processing (GRID Computing)



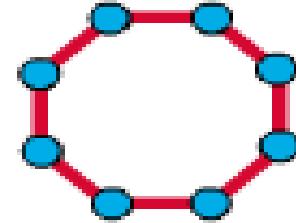
# Network Topologies



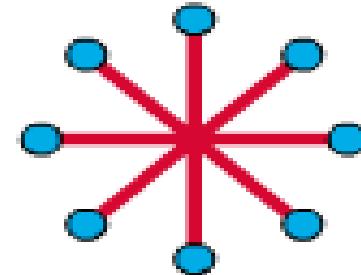
# Network Topology



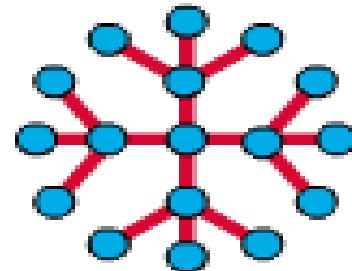
**Bus Topology**



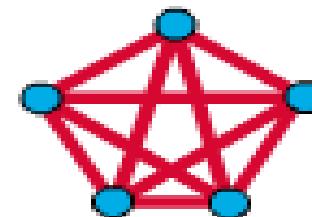
**Ring Topology**



**Star Topology**



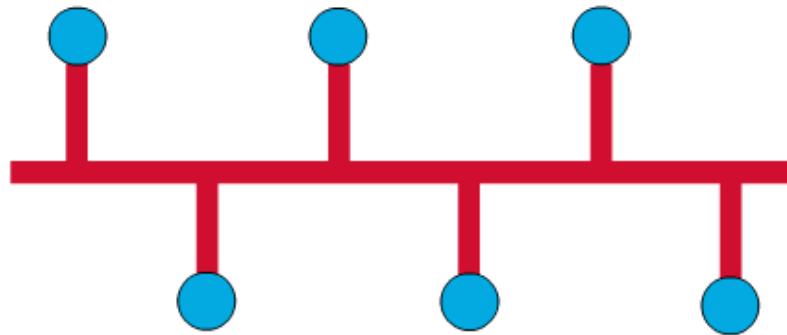
**Extended Star Topology**



**Mesh Topology**

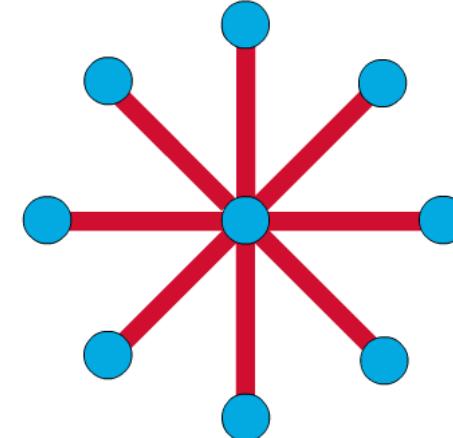


# Bus Topology

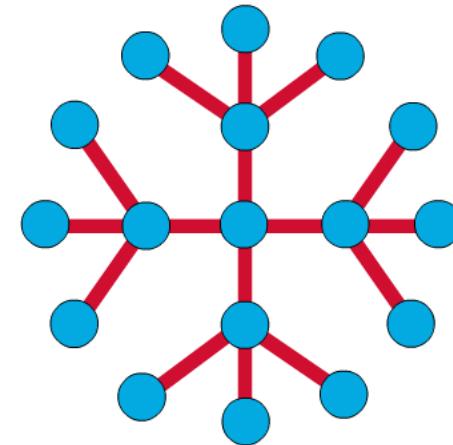


# Star & Tree Topology

- Star

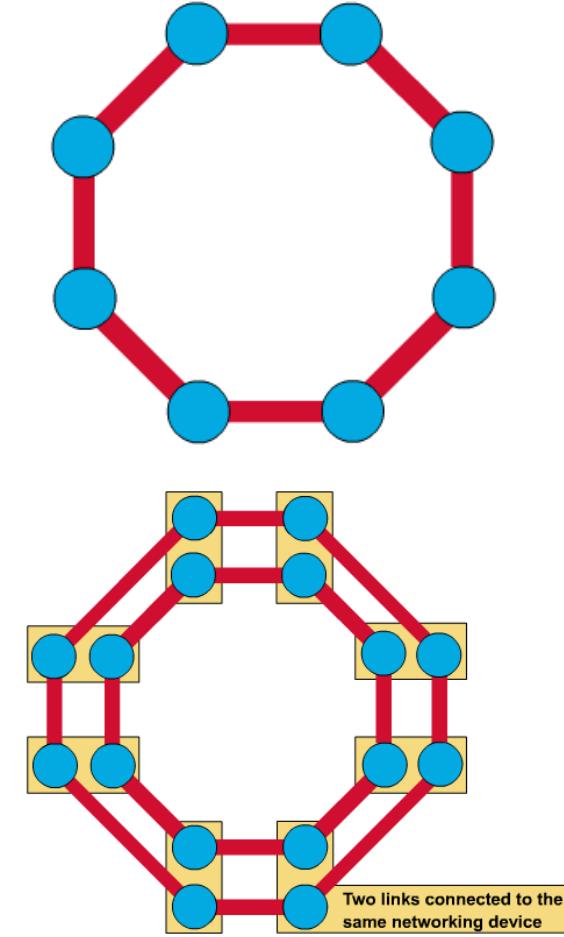


- Extended Star



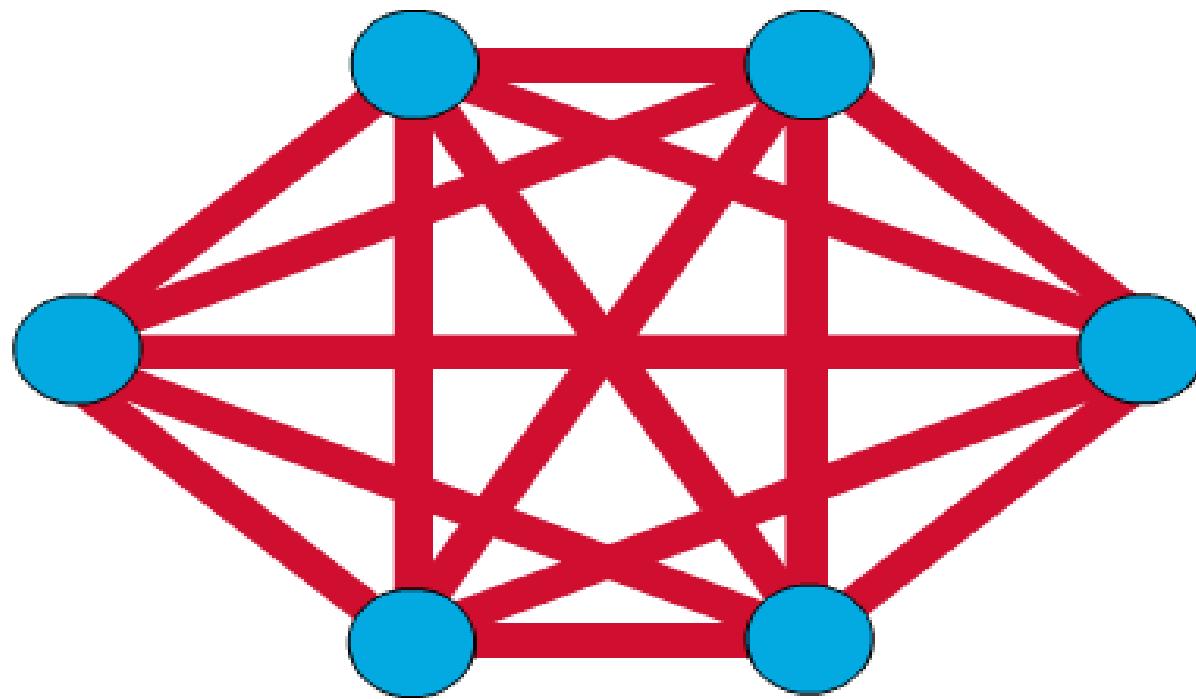
# Ring Topology

- A ring
- A double ring





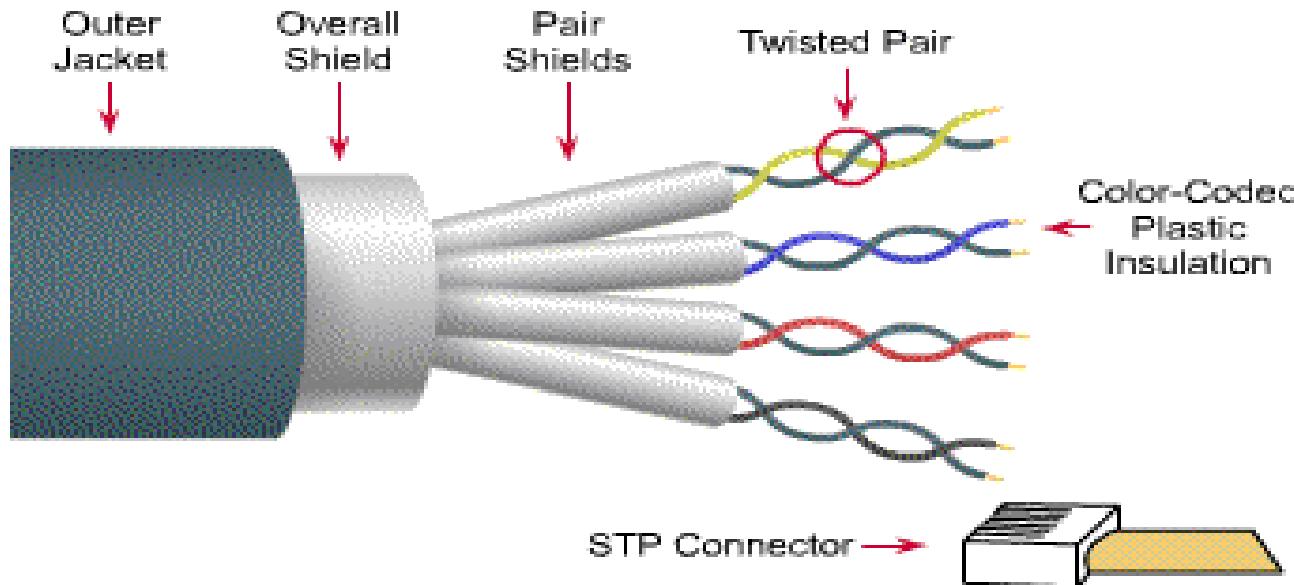
# Mesh Topology



# Network Components

- Physical Media
- Interconnecting Devices
- Computers
- Networking Software
- Applications

# Networking Media



- Speed and throughput: 10-100 Mbps
- Cost per node: Moderately expensive
- Media and connector size: Medium to Large
- Maximum cable length: 100m (short)

# Physical media

- **bit**: propagates between transmitter/receiver pairs
- **physical link**: what lies between transmitter & receiver
- **guided media**:
  - signals propagate in solid media: copper, fiber, coax
- **unguided media**:
  - signals propagate freely, e.g., radio

## *twisted pair (TP)*

- two insulated copper wires
  - Category 5: 100 Mbps, 1 Gbps Ethernet
  - Category 6: 10Gbps



# Physical media: coax, fiber

## *coaxial cable:*

- two concentric copper conductors
- bidirectional
- broadband:
  - multiple channels on cable
  - HFC



## *fiber optic cable:*

- ❖ glass fiber carrying light pulses, each pulse a bit
- ❖ high-speed operation:
  - high-speed point-to-point transmission (e.g., 10' s-100' s Gbps transmission rate)
- ❖ low error rate:
  - repeaters spaced far apart
  - immune to electromagnetic noise

# Physical media: radio

- signal carried in electromagnetic spectrum
- no physical “wire”
- bidirectional
- propagation environment effects:
  - reflection
  - obstruction by objects
  - interference

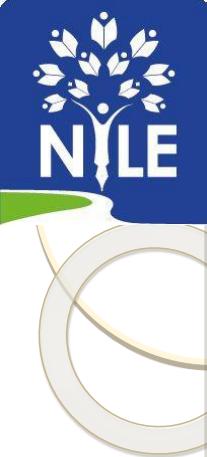
## *radio link types:*

- ❖ terrestrial microwave
  - e.g. up to 45 Mbps channels
- ❖ LAN (e.g., WiFi)
  - 11Mbps, 54 Mbps
- ❖ wide-area (e.g., cellular)
  - 3G cellular: ~ few Mbps
- ❖ satellite
  - Kbps to 45Mbps channel (or multiple smaller channels)
  - 270 msec end-end delay
  - geosynchronous versus low altitude

# Networking Devices

- HUB,
- Switches,
- Routers,
- Wireless Access Points,  
Modems etc.



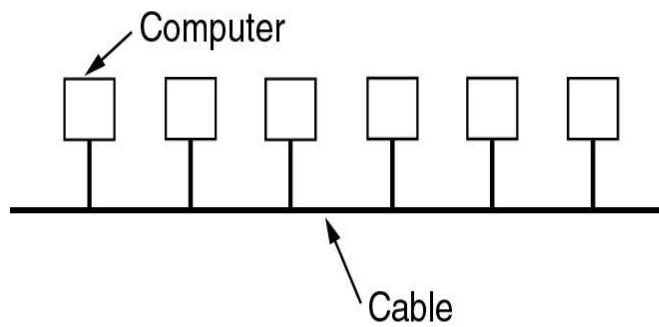


# Broadcast Networks (2)

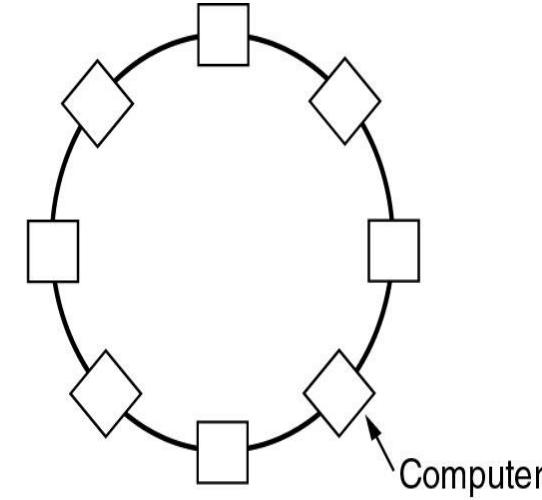
- Classification of interconnected processors by scale.

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	Metropolitan area network
1000 km	Continent	
10,000 km	Planet	

# Local Area Networks



(a)

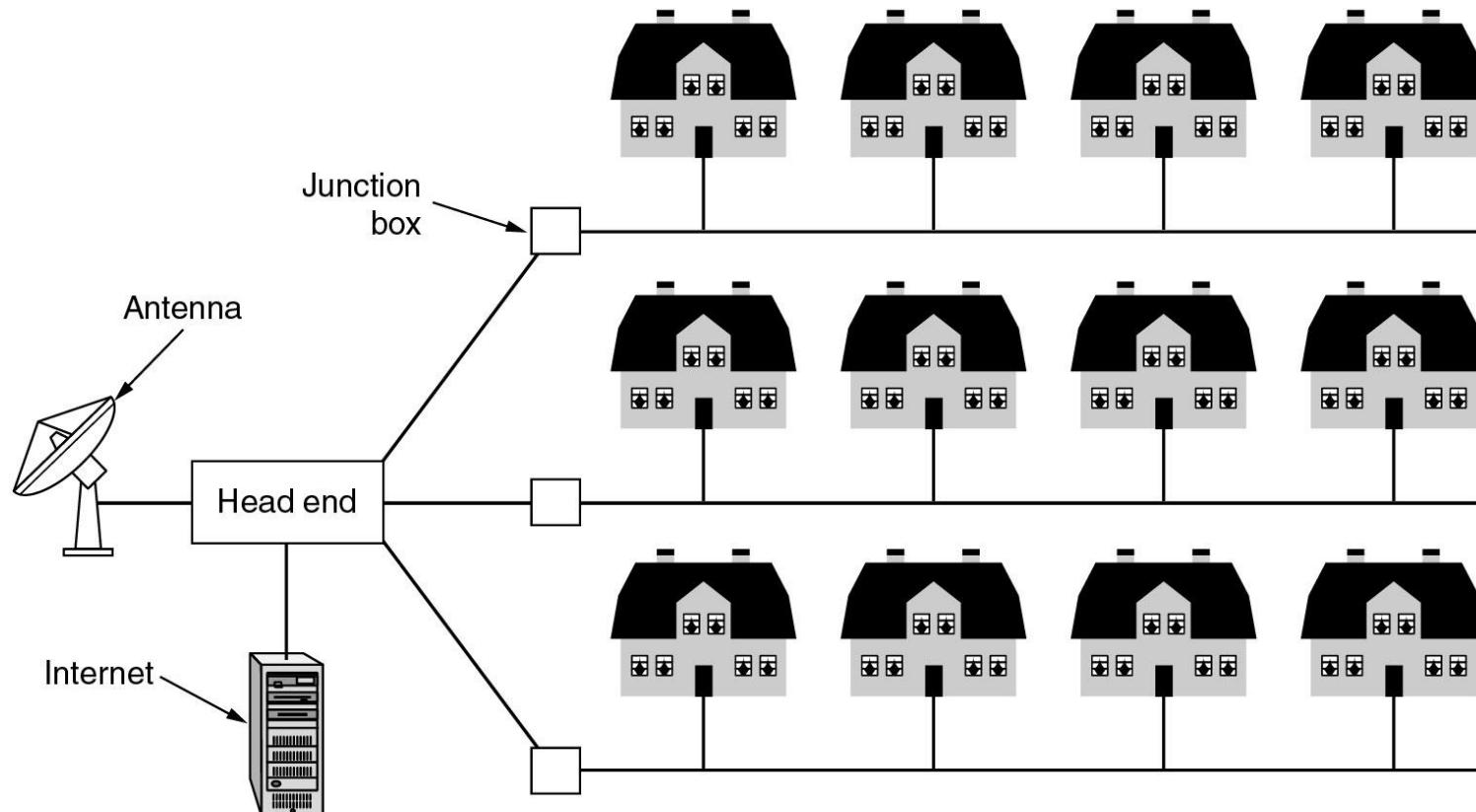


(b)

- Two broadcast networks
- (a) Bus
- (b) Ring

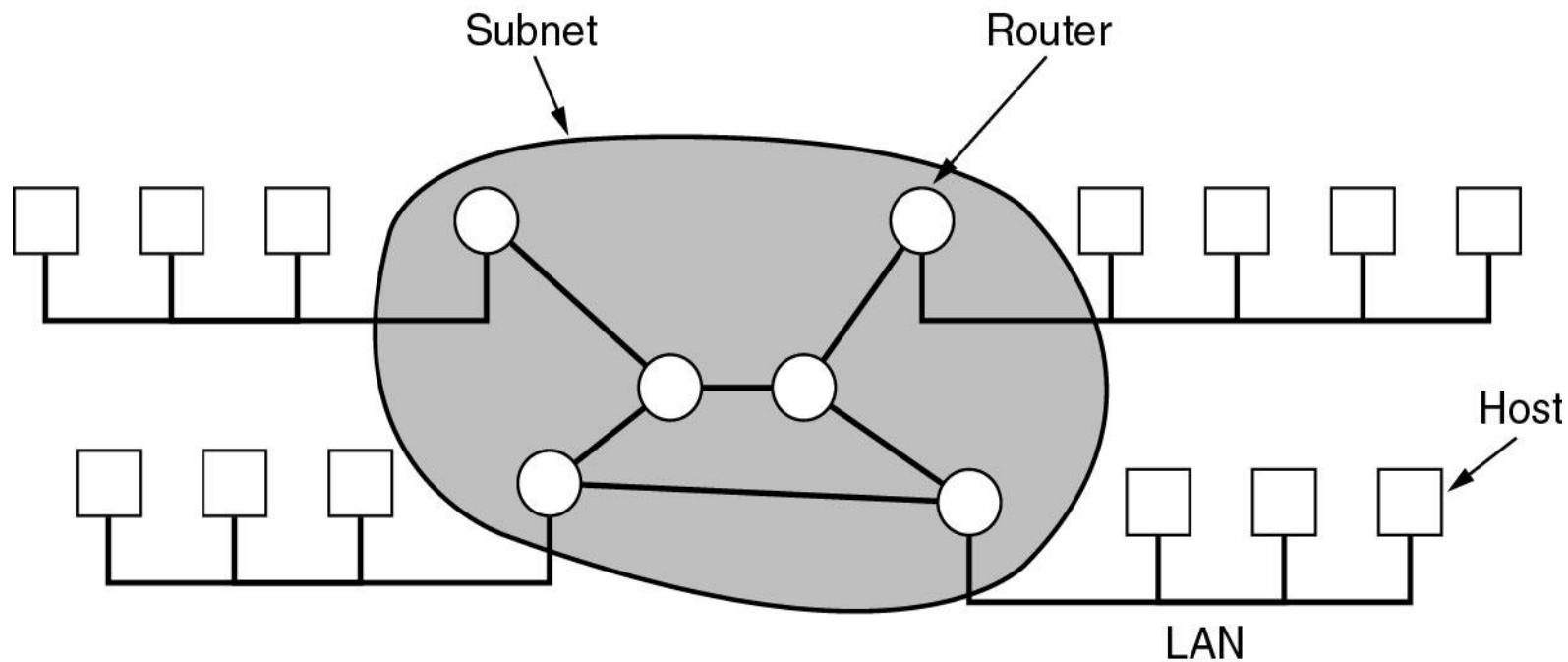
# Metropolitan Area Networks

- A metropolitan area network based on cable TV.



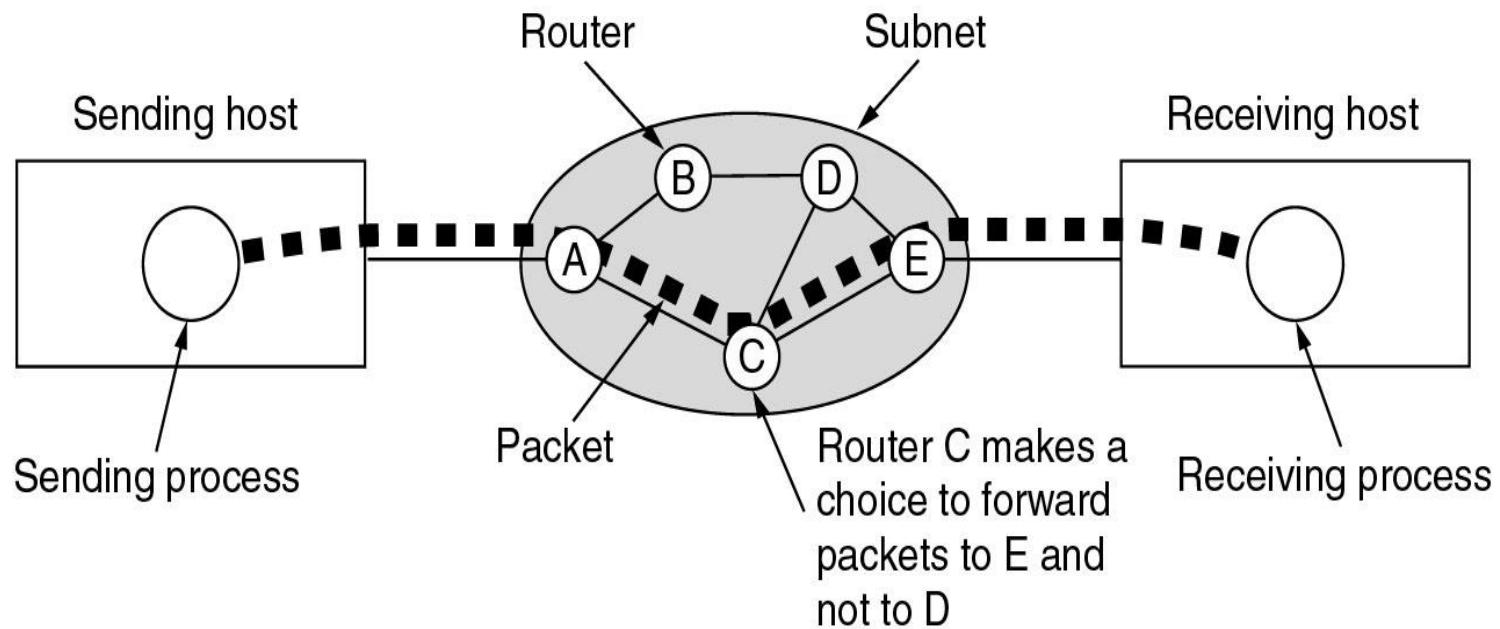
# Wide Area Networks

- Relation between hosts on LANs and the subnet.



# Wide Area Networks (2)

- A stream of packets from sender to receiver.

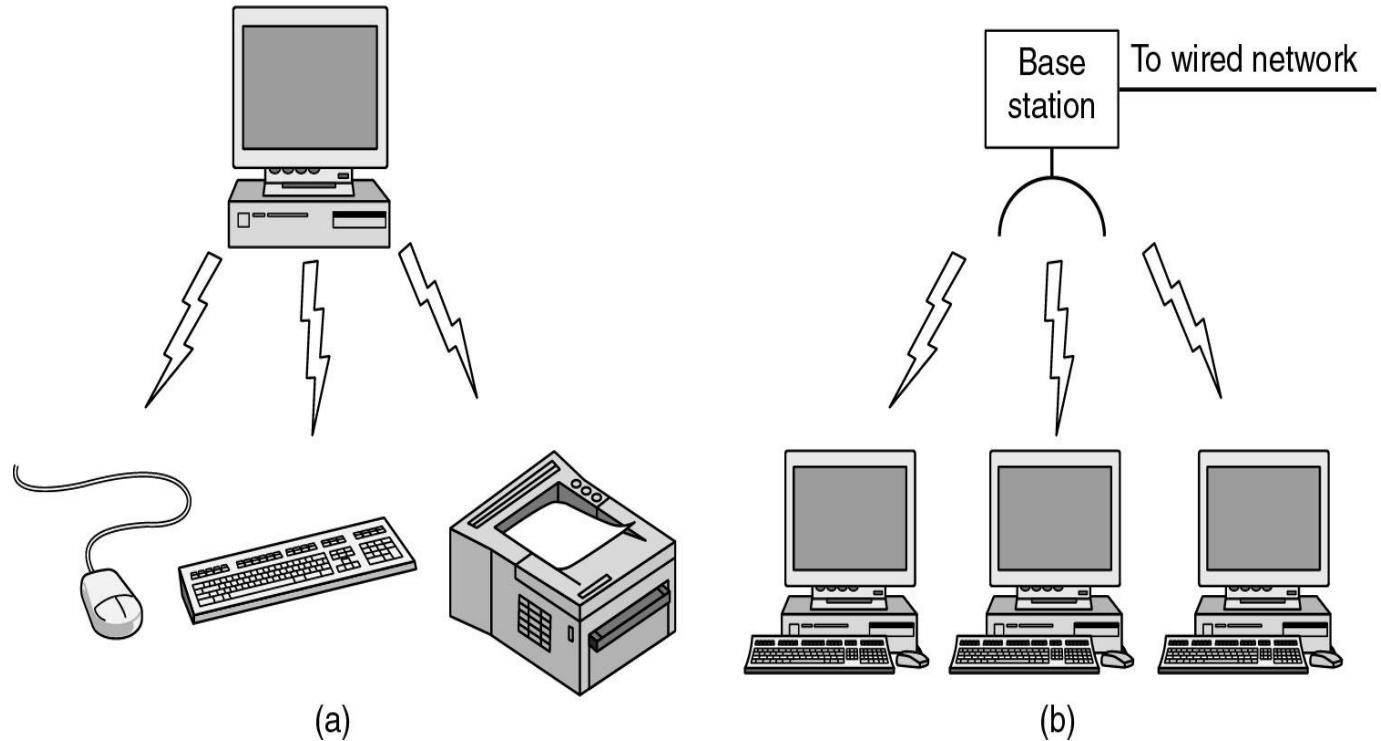




# Wireless Networks

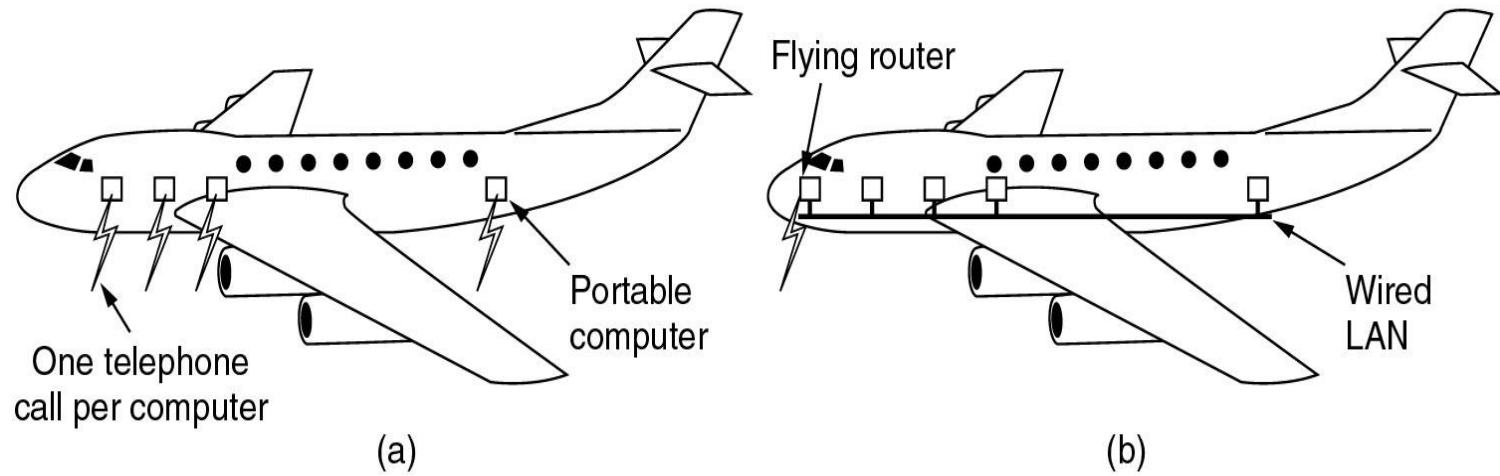
- Categories of wireless networks:
  - System interconnection
  - Wireless LANs
  - Wireless WANs

# Wireless Networks (2)



- (a) Bluetooth configuration**
- (b) Wireless LAN**

# Wireless Networks (3)

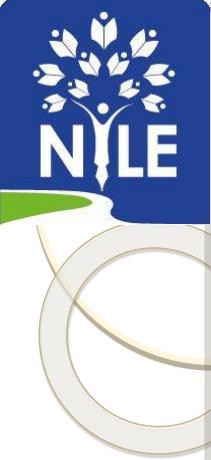


- (a) Individual mobile computers
- (b) A flying LAN



# Home Network Categories

- Computers (desktop PC, PDA, shared peripherals)
- Entertainment (TV, DVD, VCR, camera, stereo, MP3)
- Telecomm (telephone, cell phone, intercom, fax)
- Appliances (microwave, fridge, clock, furnace, airco)
- Telemetry (utility meter, burglar alarm, babycam).



# Network Software

- Protocol Hierarchies
- Design Issues for the Layers
- Connection-Oriented and Connectionless Services
- Service Primitives
- The Relationship of Services to Protocols

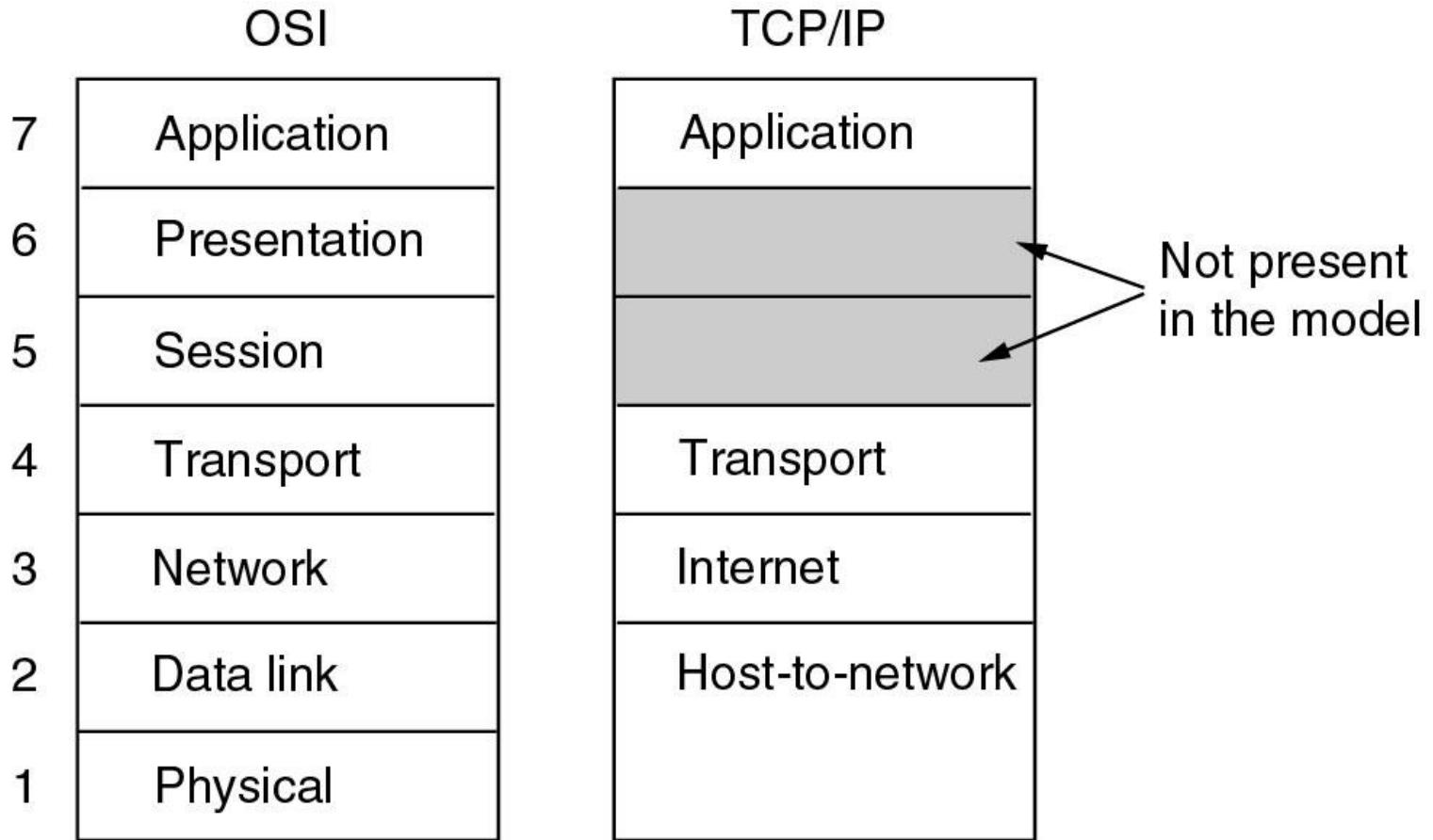


# Reference Models (to dealt with Module 2)

- The OSI Reference Model
- The TCP/IP Reference Model
- A Comparison of OSI and TCP/IP

# Reference Models (2)

- The TCP/IP reference model.

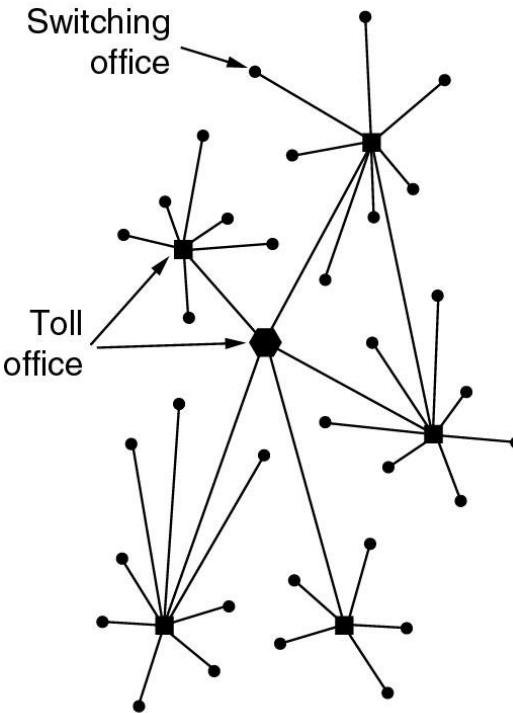




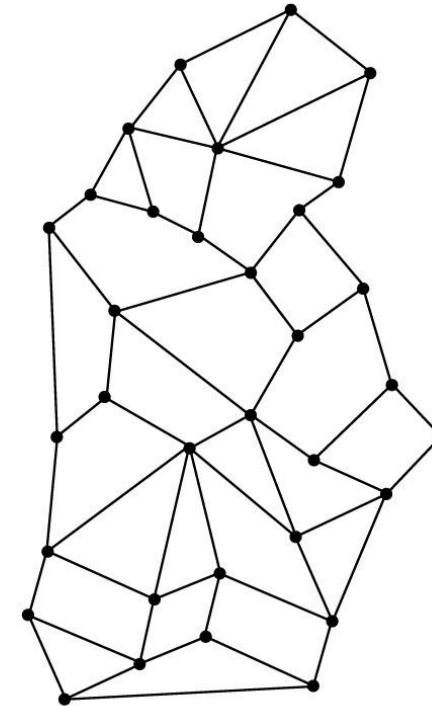
# Example Networks

- The Internet
- Connection-Oriented Networks:  
X.25, Frame Relay, and ATM
- Ethernet
- Wireless LANs: 802:11

# The ARPANET



(a)

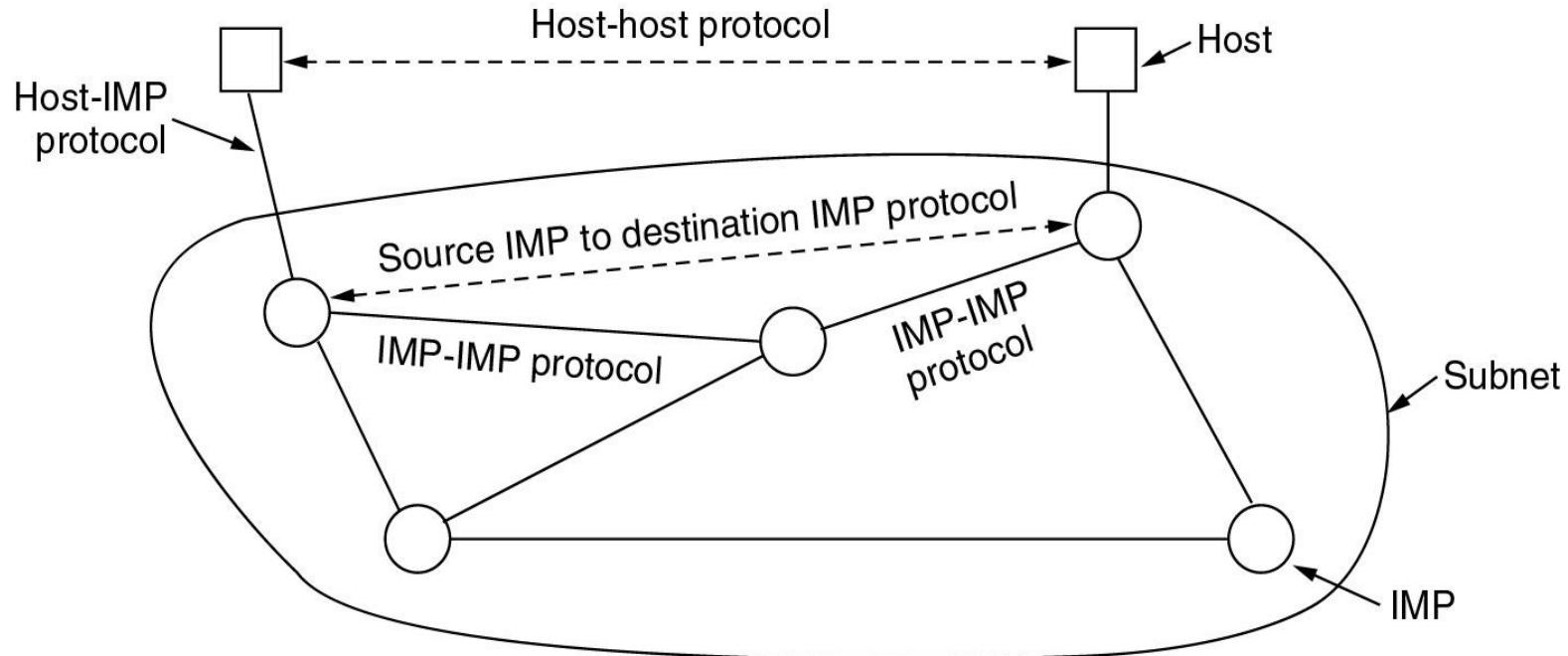


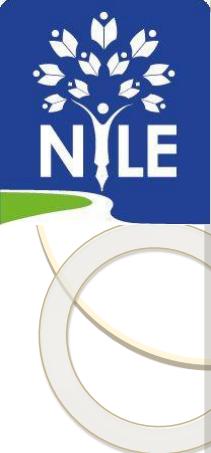
(b)

- (a) Structure of the telephone system.
- (b) Baran's proposed distributed switching system.

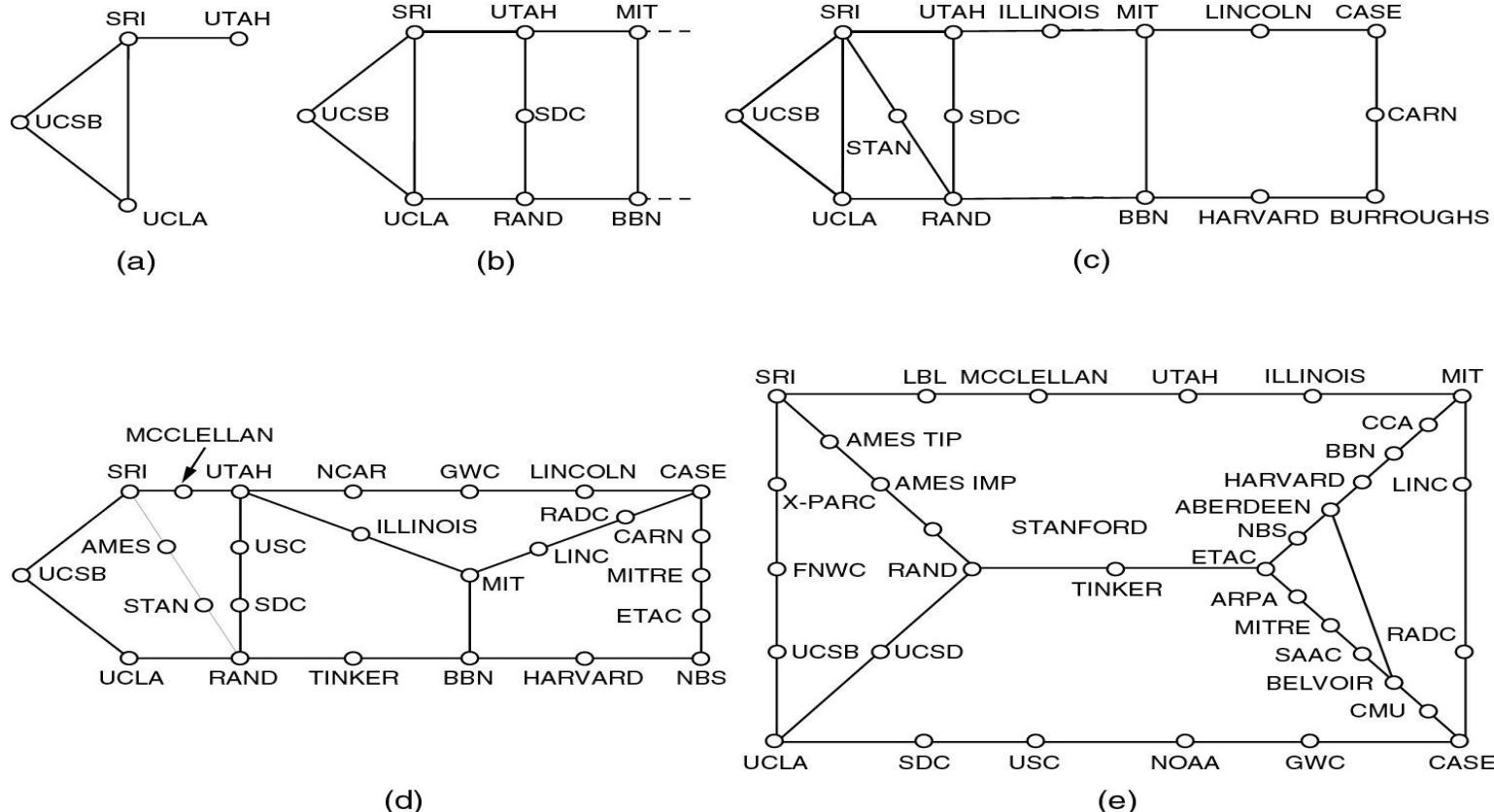
# The ARPANET (2)

- The original ARPANET design.





# The ARPANET (3)

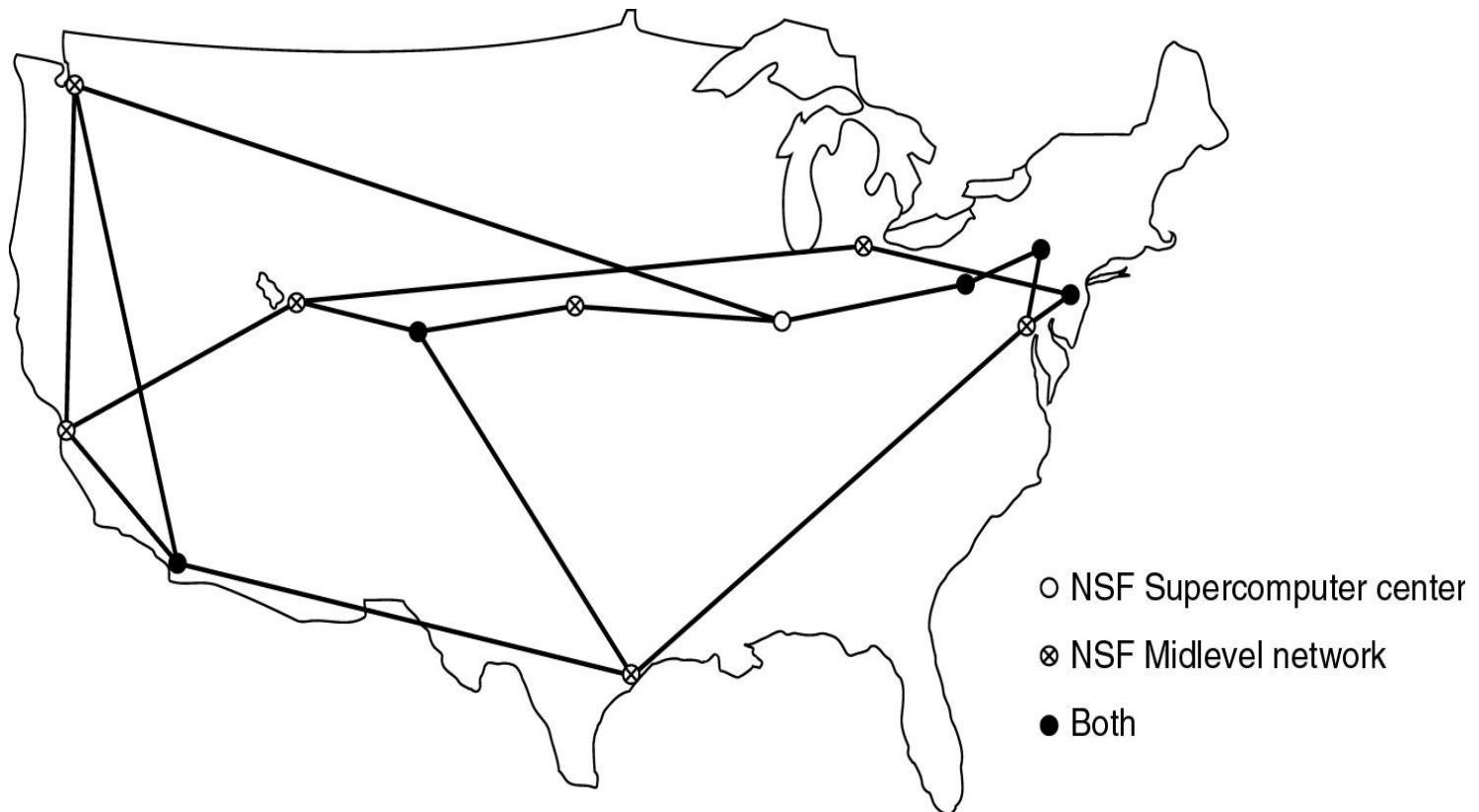


Growth of the ARPANET (a) December 1969. (b) July 1970.  
(c) March 1971. (d) April 1972. (e) September 1972.



# NSFNET

- The NSFNET backbone in 1988.



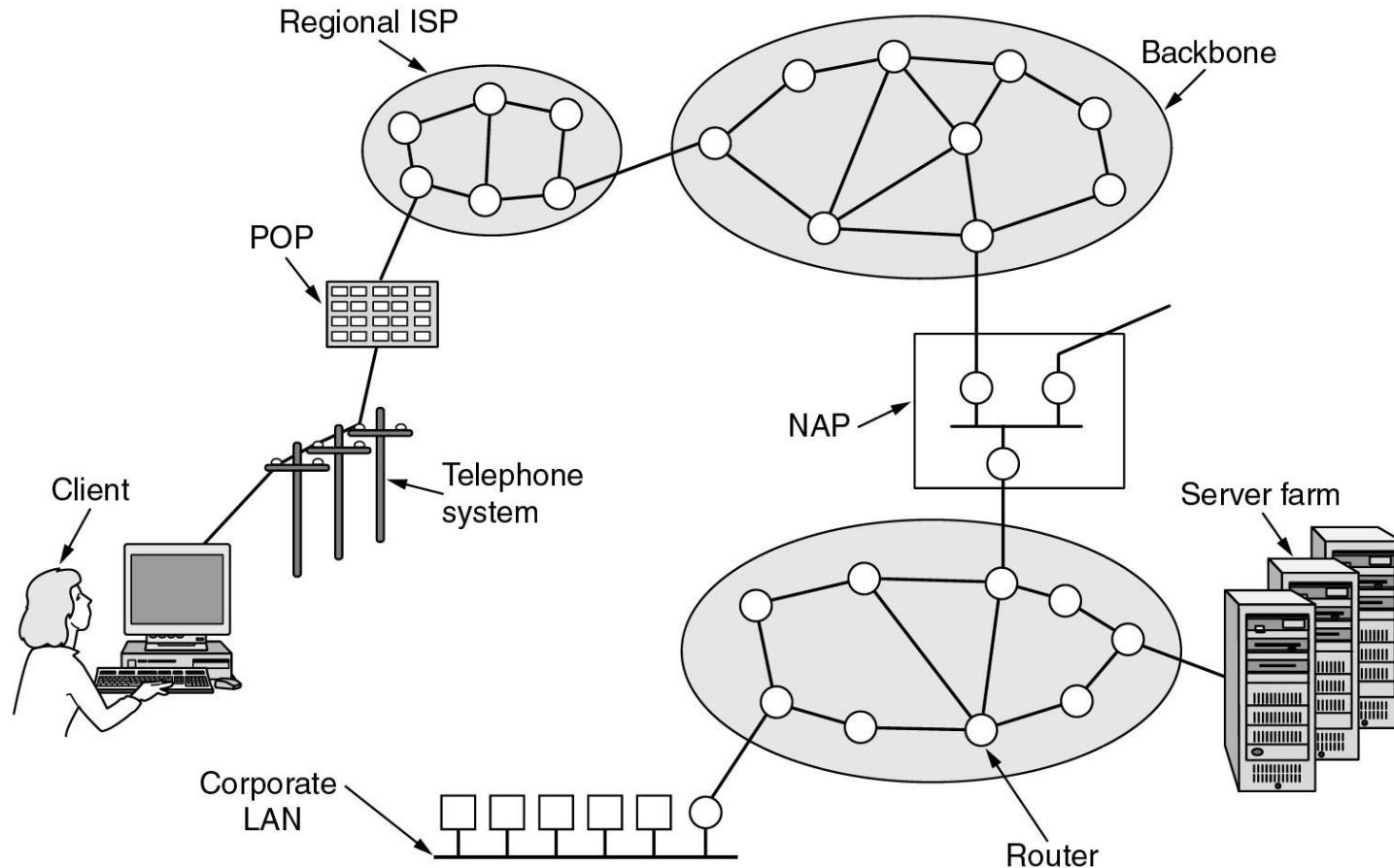


# Internet Usage

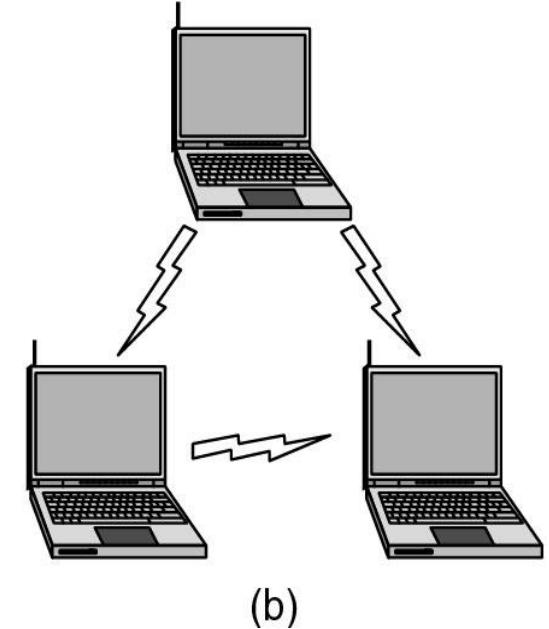
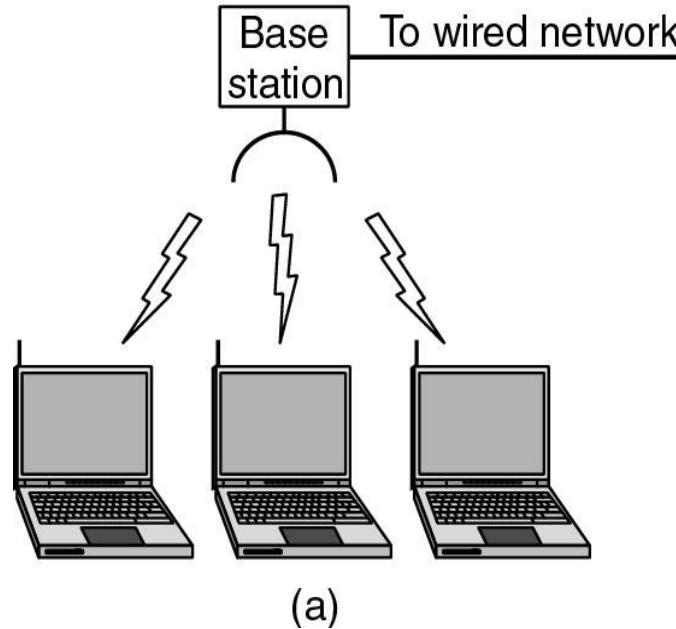
- Traditional applications (1970 – 1990)
  - E-mail
  - News
  - Remote login
  - File transfer

# Architecture of the Internet

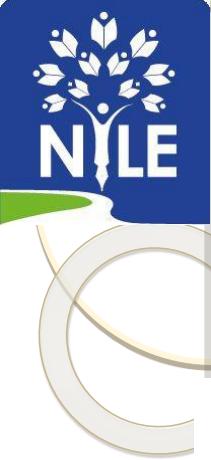
- Overview of the Internet.



# Wireless LANs

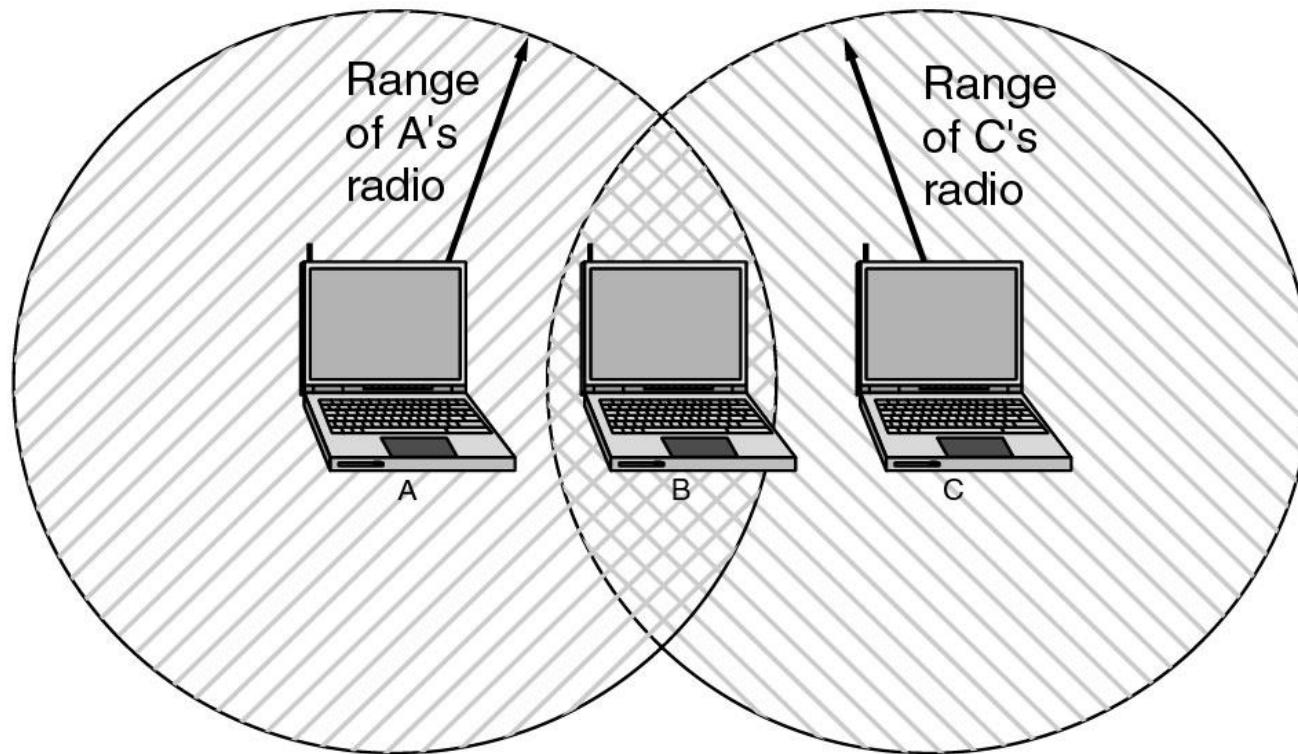


- (a) Wireless networking with a base station.
- (b) Ad hoc networking.



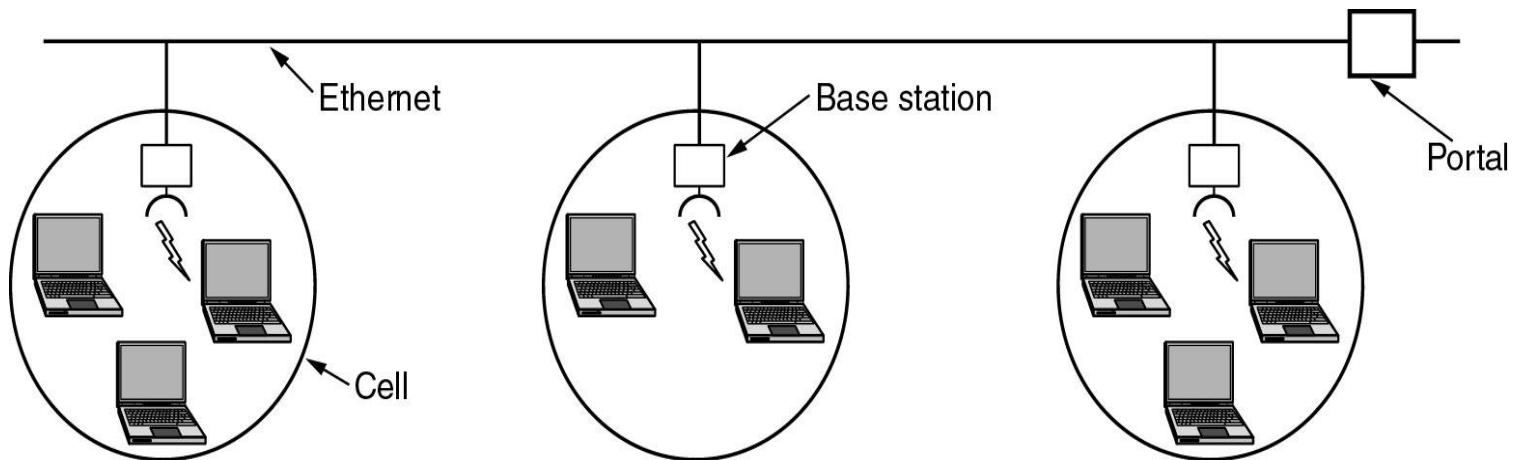
# Wireless LANs (2)

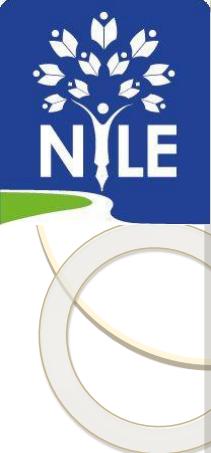
- The range of a single radio may not cover the entire system.



# Wireless LANs (3)

- A multicell 802.11 network.





# Network Standardization

- Who's Who in the Telecommunications World
- Who's Who in the International Standards World
- Who's Who in the Internet Standards World

# IEEE 802 Standards

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

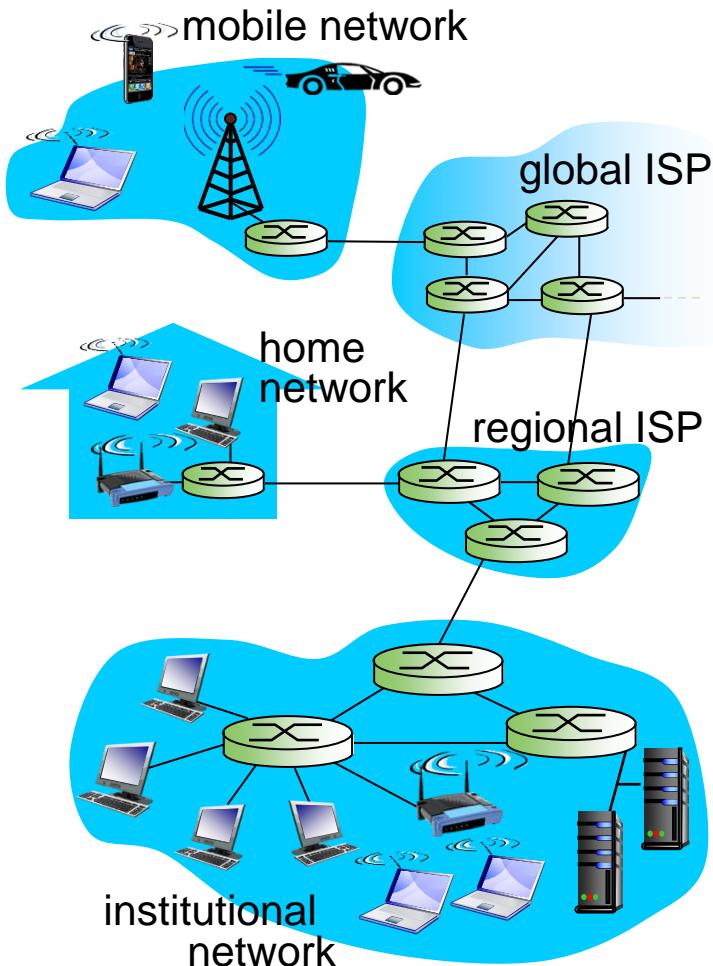
The 802 working groups. The important ones are marked with \*. The ones marked with ↓ are hibernating. The one marked with † gave up.

# More on the Internet

# What's the Internet: “nuts and bolts” view



- millions of connected computing devices:
  - *hosts = end systems*
  - running *network apps*
- ❖ *communication links*
  - fiber, copper, radio, satellite
  - transmission rate: *bandwidth*
- ❖ *Packet switches*: forward packets (chunks of data)
  - *routers and switches*



# “Fun” internet appliances



Internet  
refrigerator



IP picture frame  
<http://www.ceiva.com/>



Web-enabled toaster +  
weather forecaster



Tweet-a-watt:  
monitor energy use



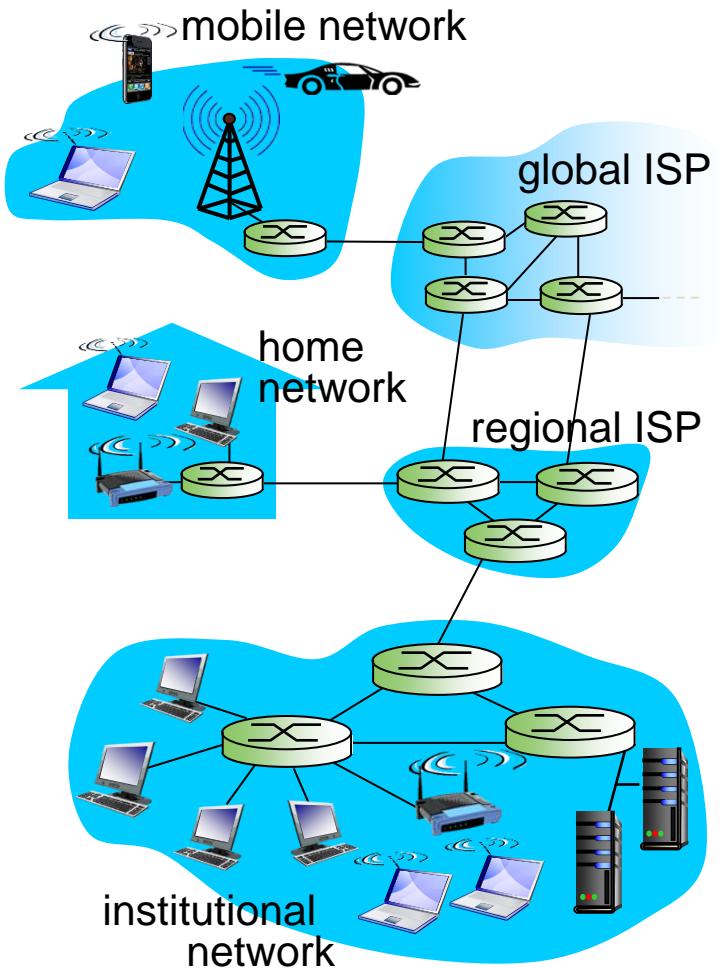
Slingbox: watch,  
control cable TV remotely



Internet phones

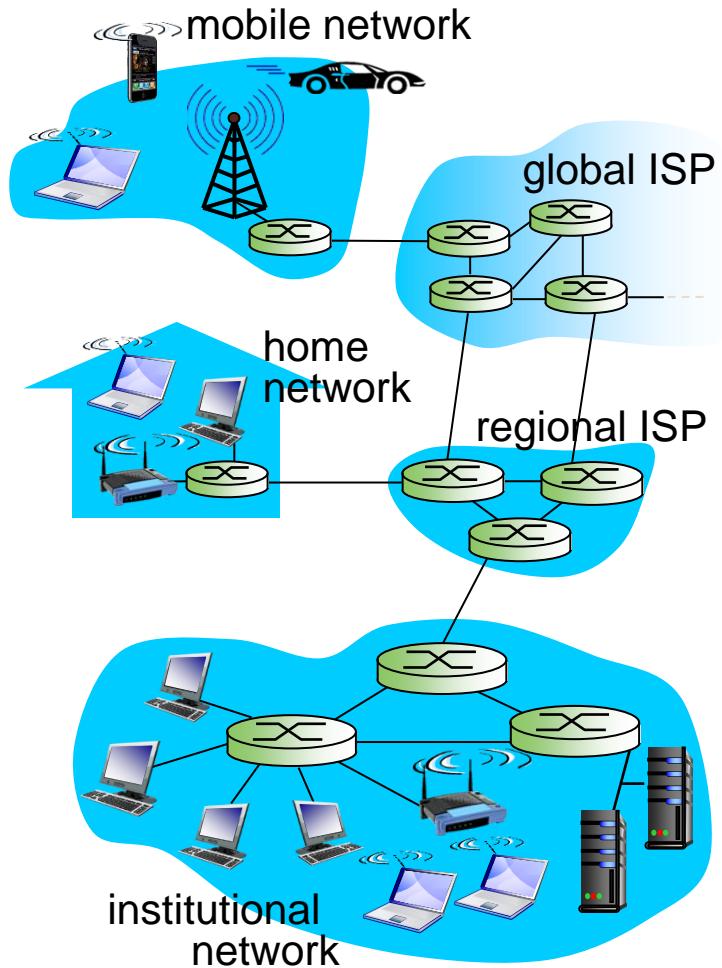
# What's the Internet: “nuts and bolts” view

- *Internet: “network of networks”*
  - Interconnected ISPs
- *protocols* control sending, receiving of msgs
  - e.g., TCP, IP, HTTP, Skype, 802.11
- *Internet standards*
  - RFC: Request for comments
  - IETF: Internet Engineering Task Force



# What's the Internet: a service view

- *Infrastructure that provides services to applications:*
  - Web, VoIP, email, games, e-commerce, social nets, ...
- *provides programming interface to apps*
  - hooks that allow sending and receiving app programs to “connect” to Internet
  - provides service options, analogous to postal service

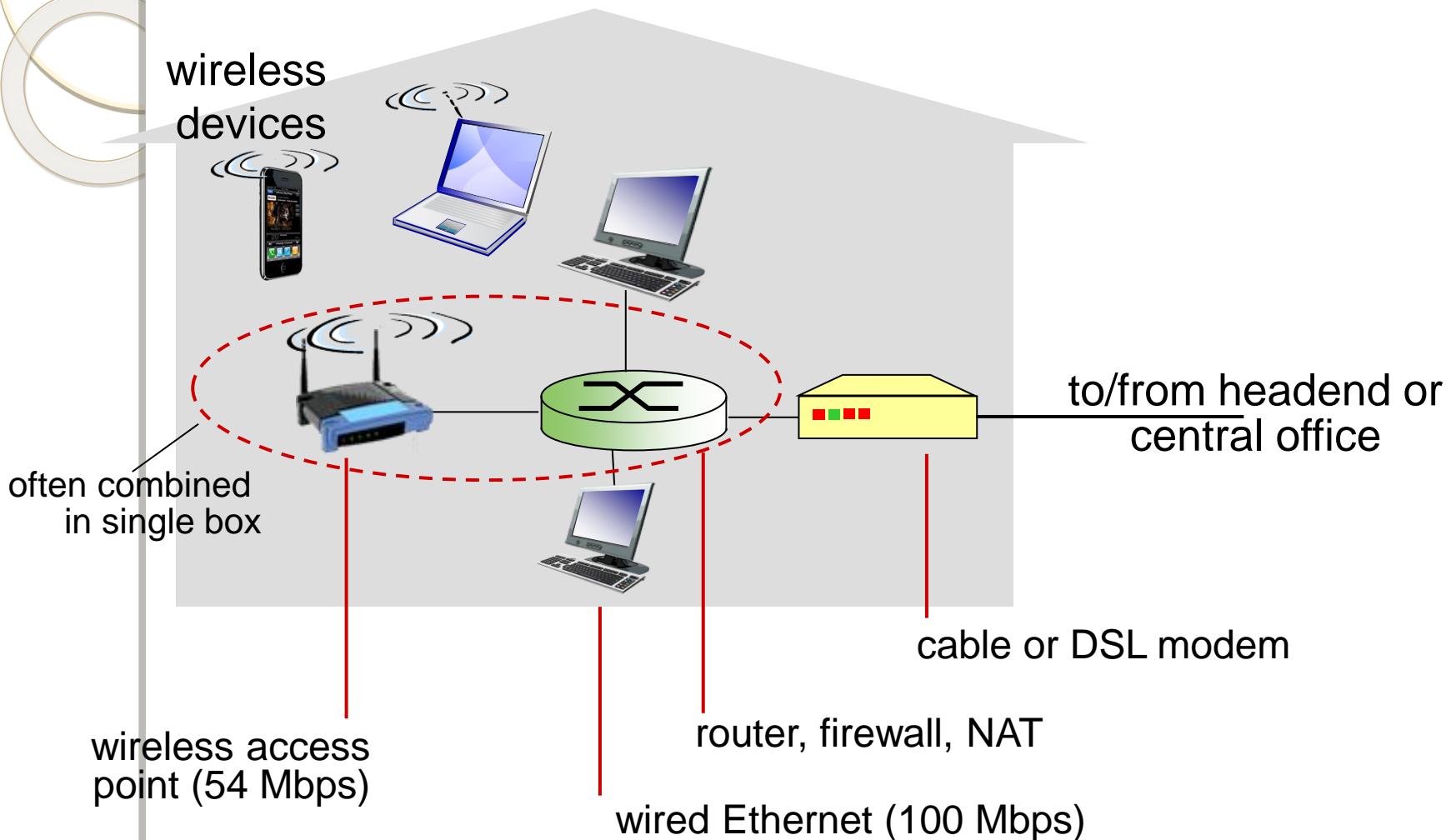




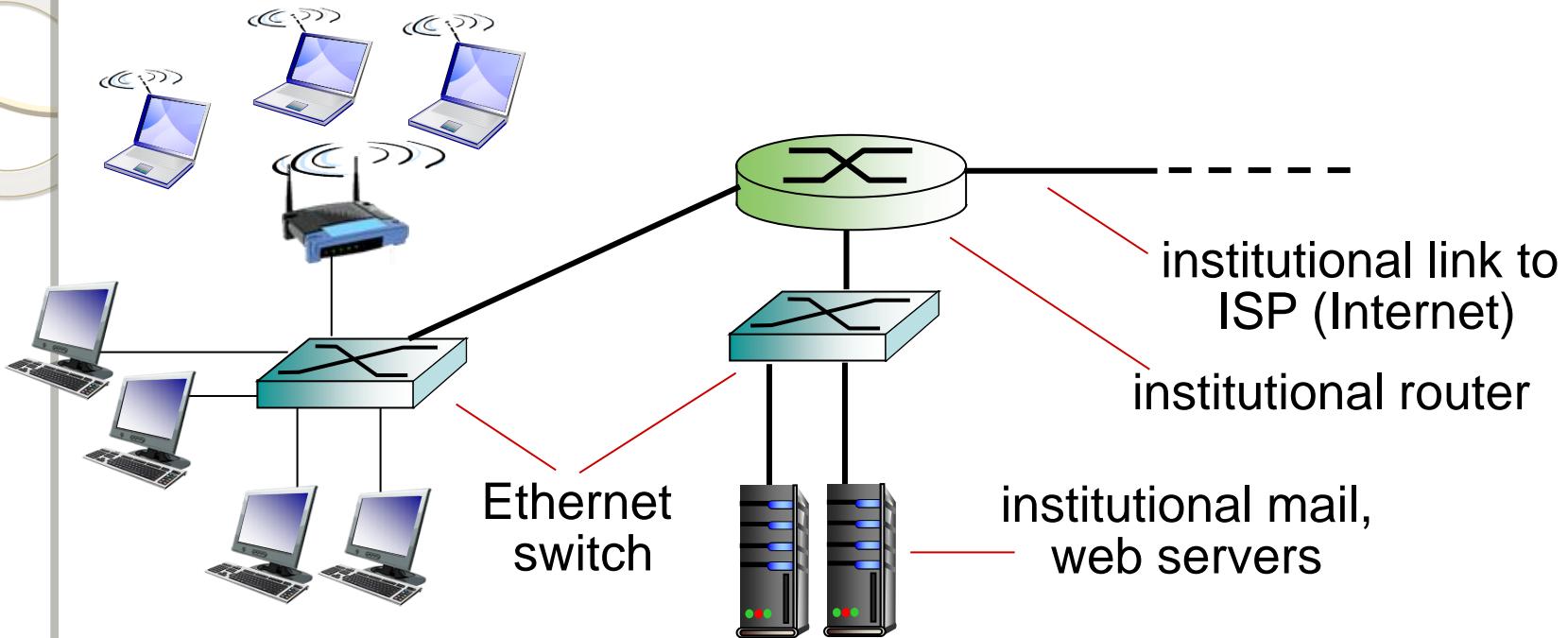
# What's a protocol?

*protocols define format, order of msgs sent and received among network entities, and actions taken on msg transmission, receipt*

# Access net: home network



# Enterprise access networks (Ethernet)



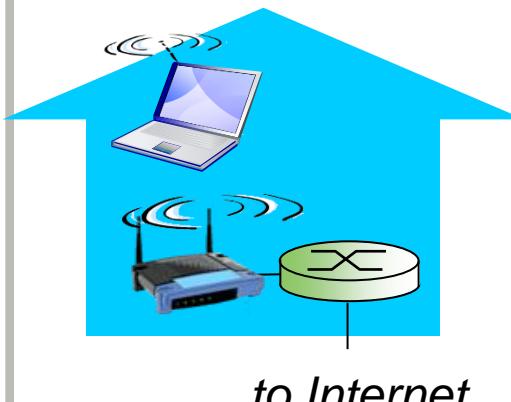
- typically used in companies, universities, etc
- ❖ 10 Mbps, 100Mbps, 1 Gbps, 10Gbps transmission rates
- ❖ today, end systems typically connect into Ethernet switch

# Wireless access networks

- shared wireless access network connects end system to router
  - via base station aka “access point”

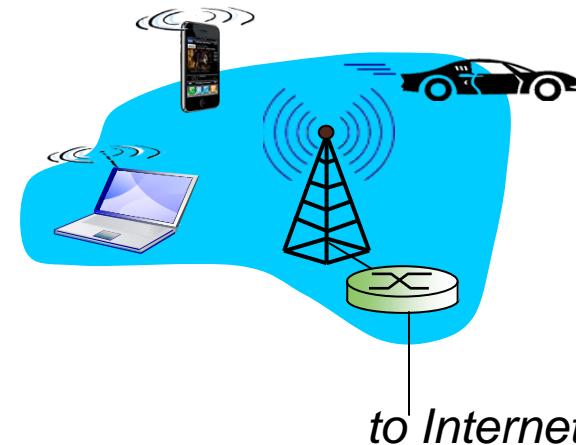
## wireless LANs:

- within building (100 ft)
- 802.11b/g (WiFi): 11, 54 Mbps transmission rate



## wide-area wireless access

- provided by telco (cellular) operator, 10's km
- between 1 and 10 Mbps
- 3G, 4G: LTE



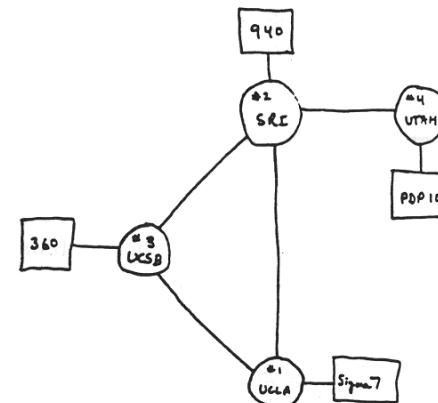
# Internet history

## 1961-1972: Early packet-switching principles

- 1961: Kleinrock - queueing theory shows effectiveness of packet-switching
- 1964: Baran - packet-switching in military nets
- 1967: ARPAnet conceived by Advanced Research Projects Agency
- 1969: first ARPAnet node operational

- 1972:

- ARPAnet public demo
- NCP (Network Control Protocol) first host-host protocol
- first e-mail program
- ARPAnet has 15 nodes



THE ARPANET WORK



# 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
- **late 70's:** proprietary architectures: DECnet, SNA, XNA
- **late 70's:** switching fixed length packets (ATM precursor)
- **1979:** ARPAnet has 200 nodes



# 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 protocol defined
- 1988: TCP congestion control
- new national networks: Csnet, BITnet, NSFnet, Minitel
- 100,000 hosts connected to confederation of networks

# 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



# Internet history

## 2005-present

- ~750 million hosts
  - Smartphones and tablets
- Aggressive deployment of broadband access
- Increasing ubiquity of high-speed wireless access
- Emergence of online social networks:
  - Facebook: soon one billion users
- Service providers (Google, Microsoft) create their own networks
  - Bypass Internet, providing “instantaneous” access to search, email, etc.
- E-commerce, universities, enterprises running their services in “cloud” (eg, Amazon EC2)

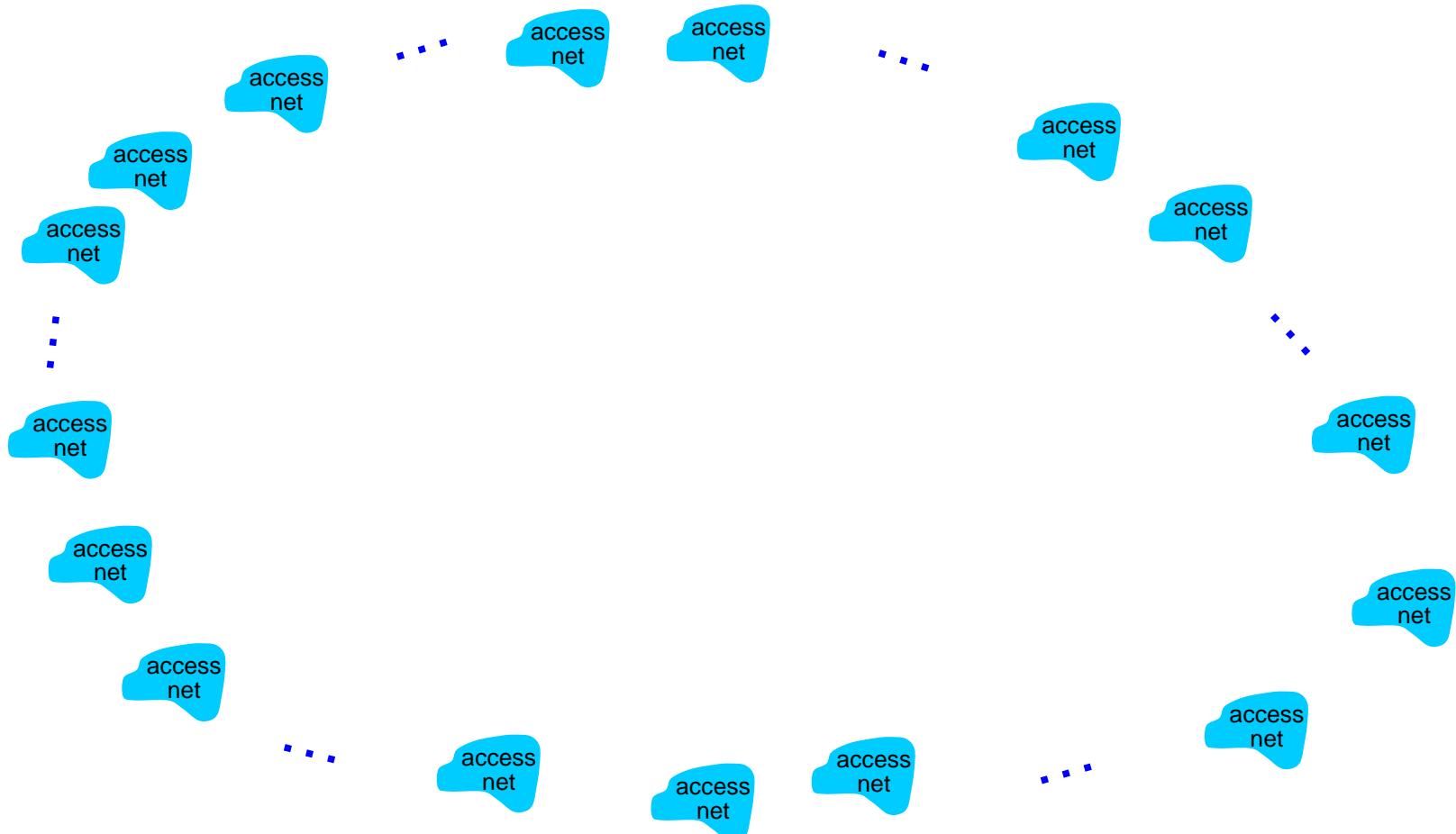


# Internet structure: network of networks

- ❖ End systems connect to Internet via **access ISPs** (Internet Service Providers)
  - Residential, company and university ISPs
- ❖ Access ISPs in turn must be interconnected.
  - ❖ So that any two hosts can send packets to each other
- ❖ Resulting network of networks is very complex
  - ❖ Evolution was driven by **economics** and **national policies**
- ❖ Let's take a stepwise approach to describe current Internet structure

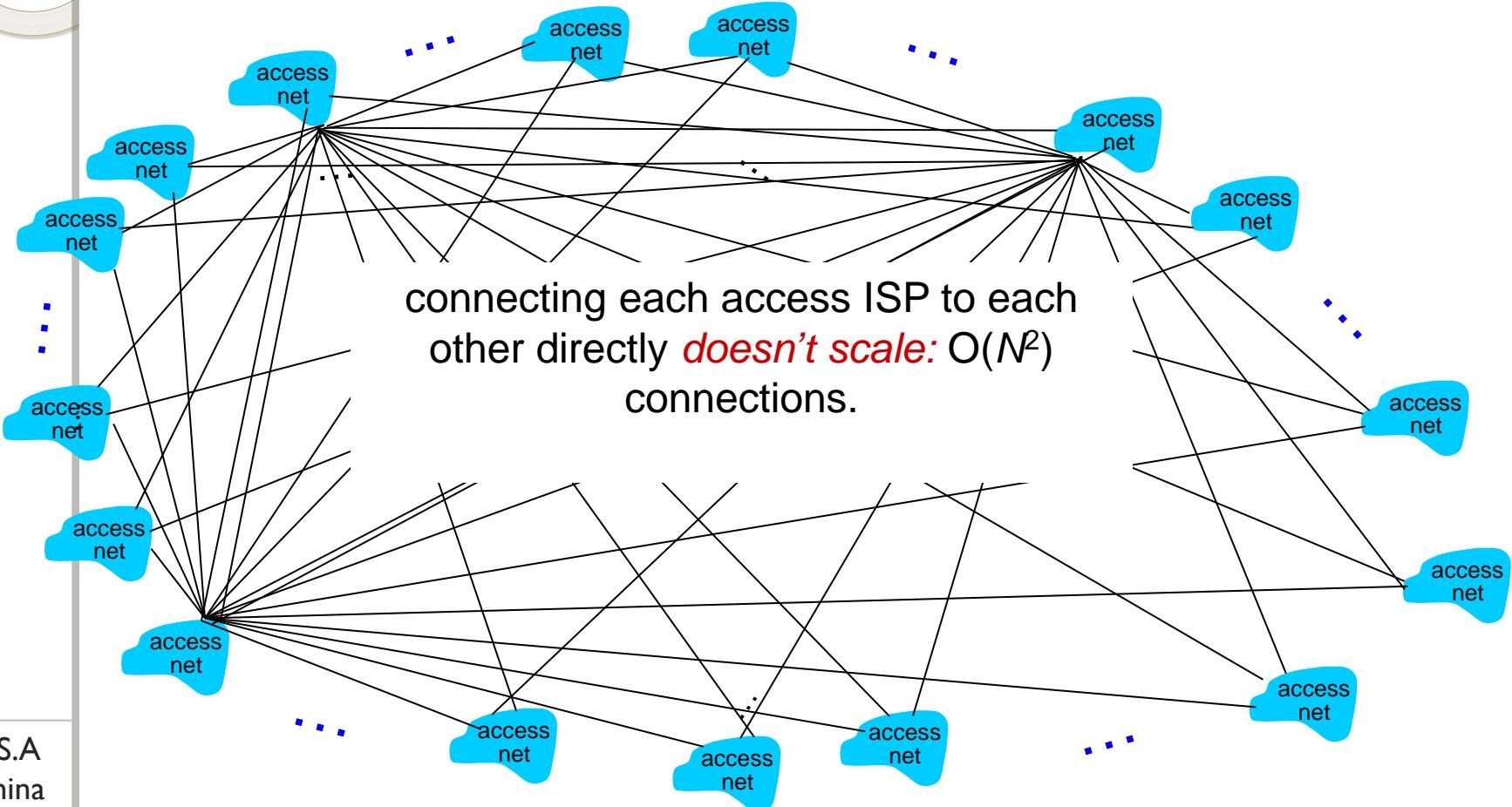
# Internet structure: network of networks

**Question:** given *millions* of access ISPs, how to connect them together?



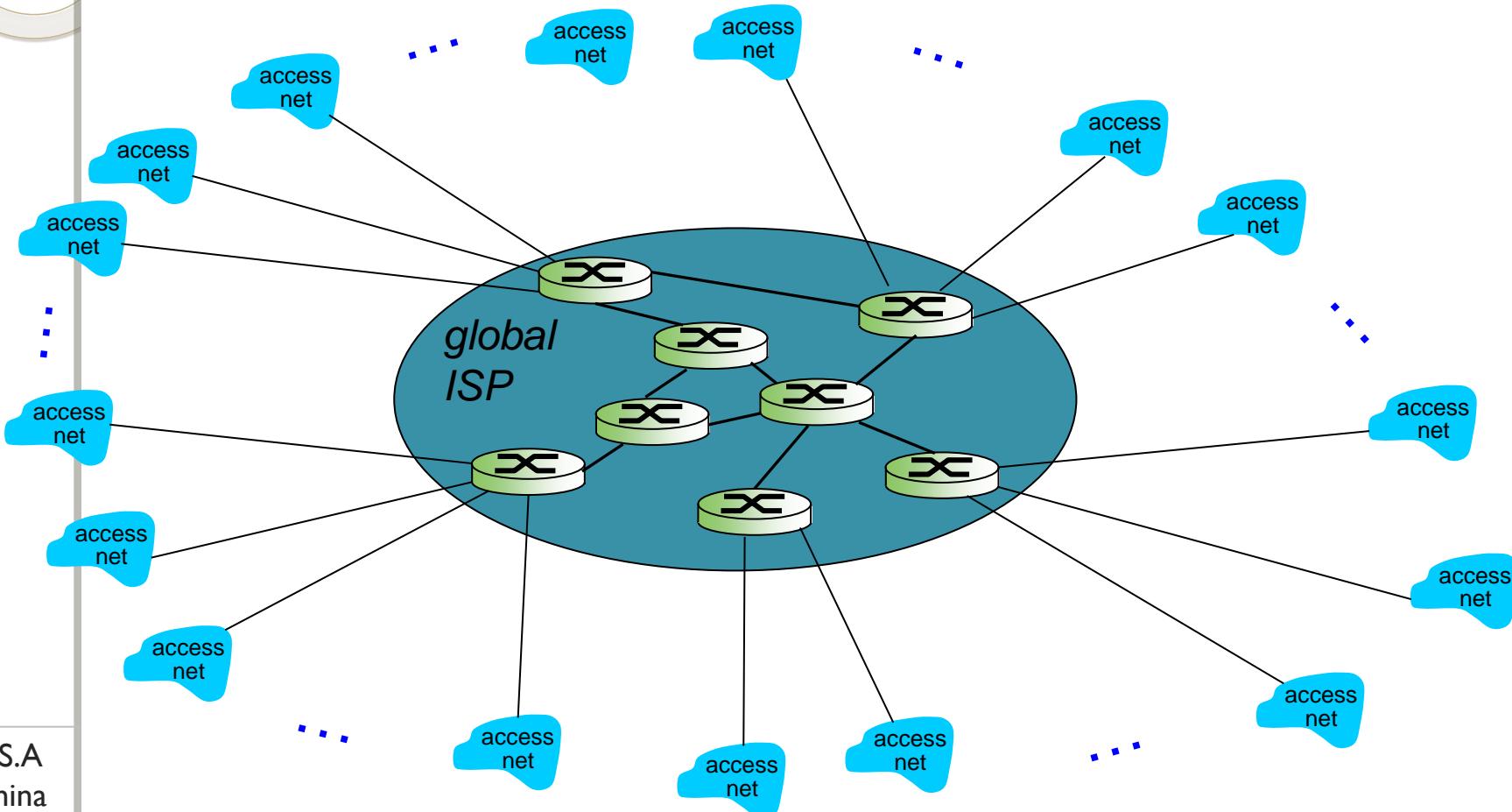
# Internet structure: network of networks

*Option: connect each access ISP to every other access ISP?*



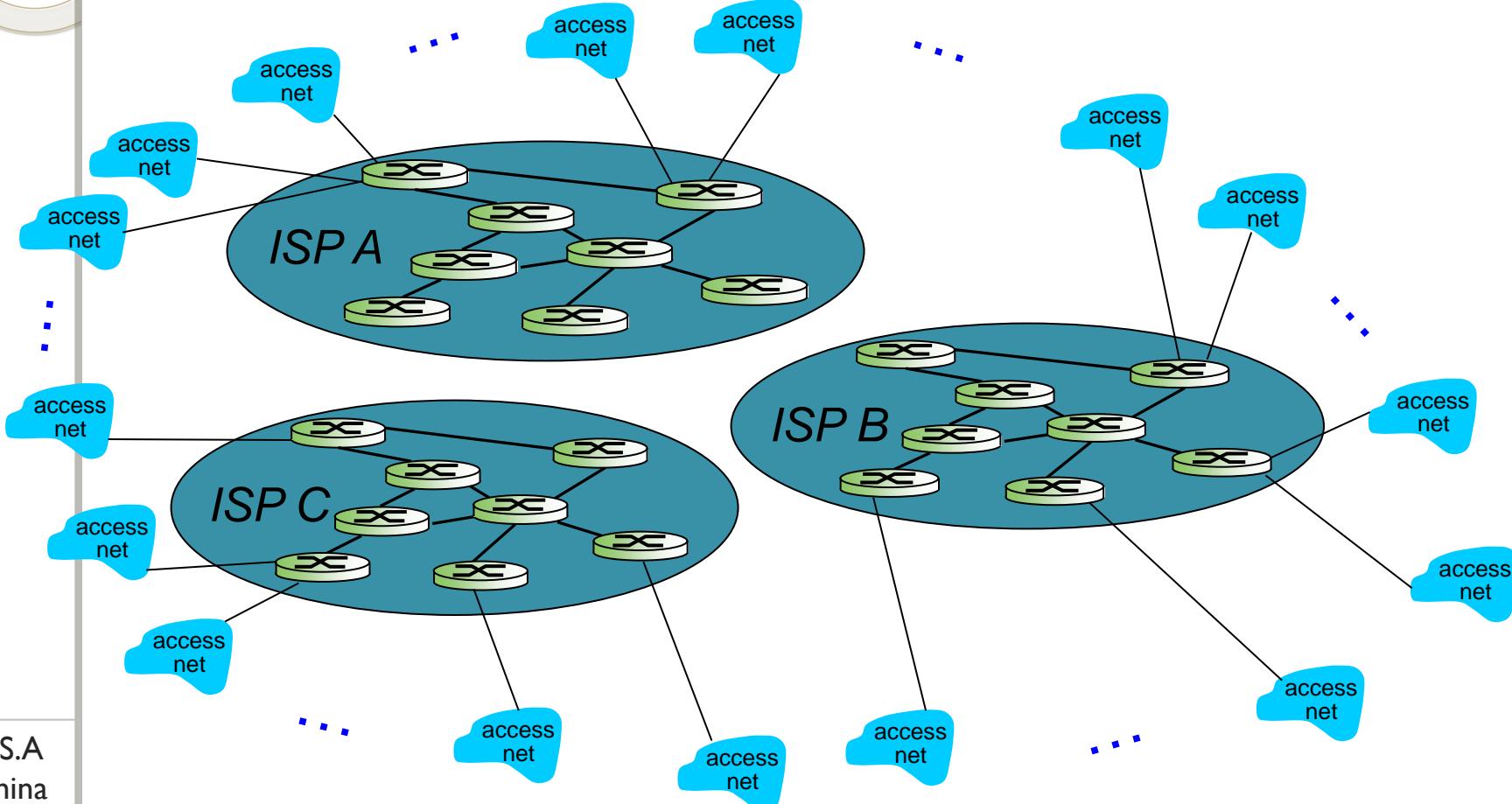
# Internet structure: network of networks

**Option:** connect each access ISP to a global transit ISP? **Customer and provider** ISPs have economic agreement.



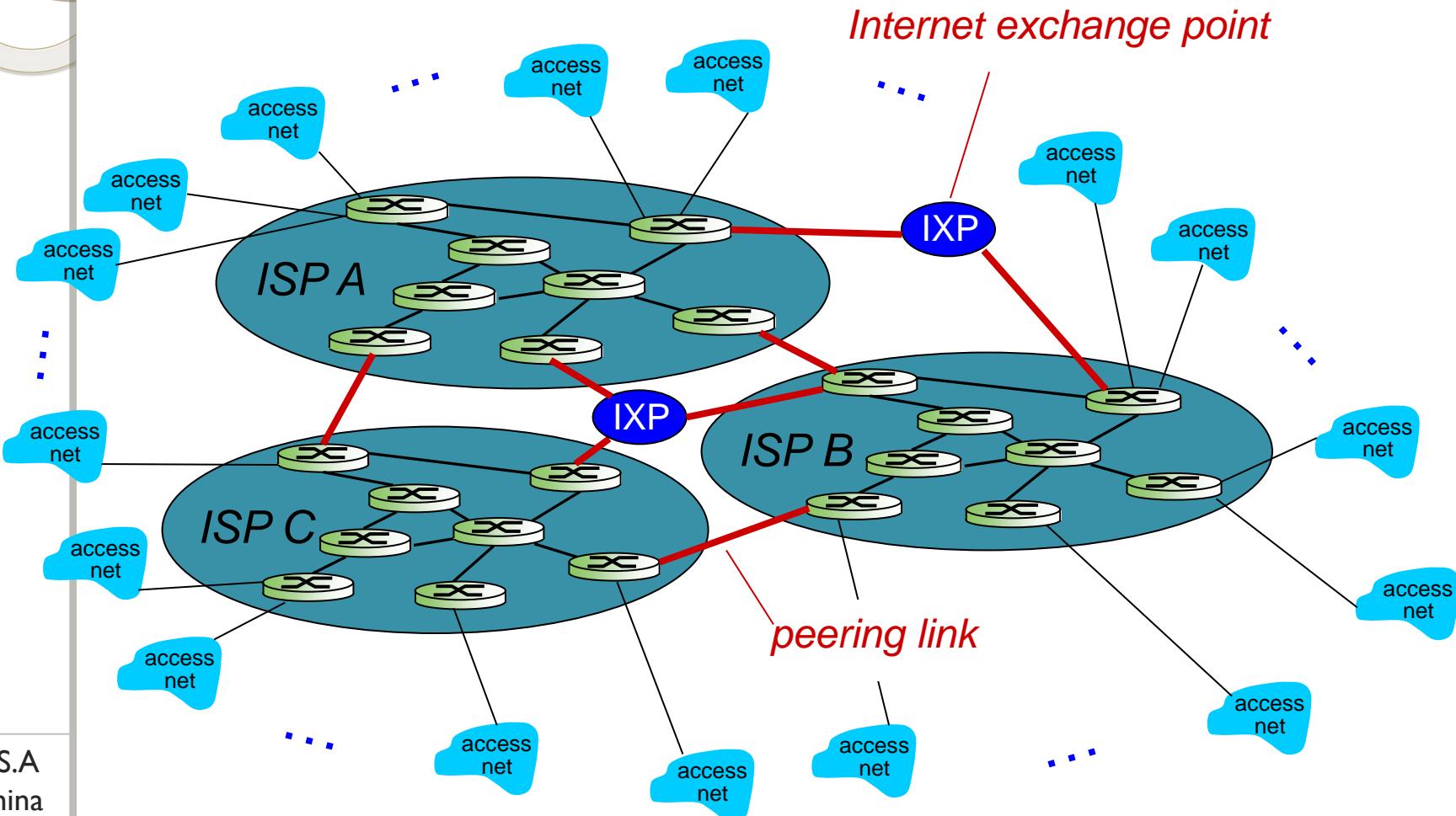
# Internet structure: network of networks

But if one global ISP is viable business, there will be competitors



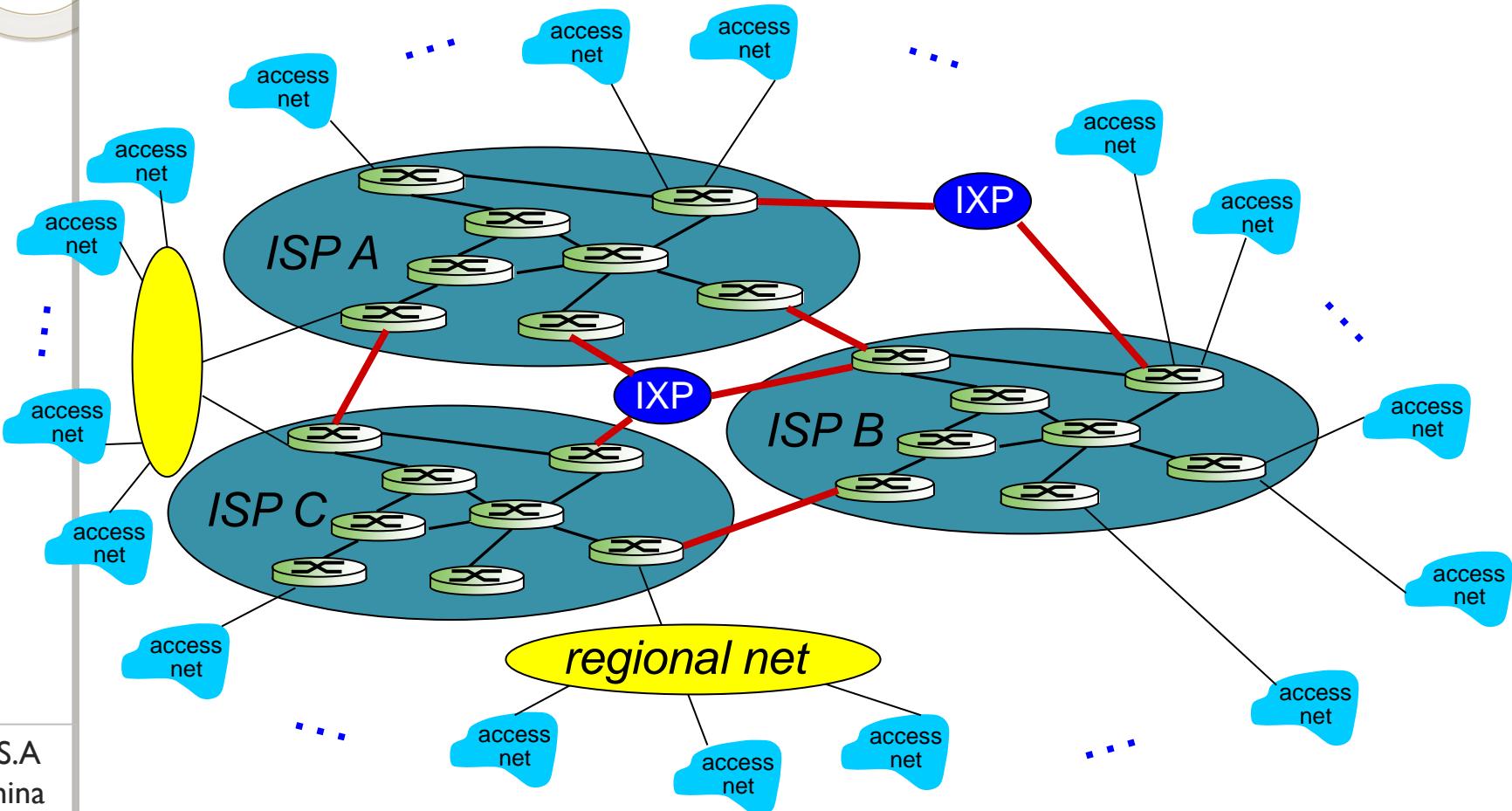
# Internet structure: network of networks

But if one global ISP is viable business, there will be competitors  
.... which must be interconnected



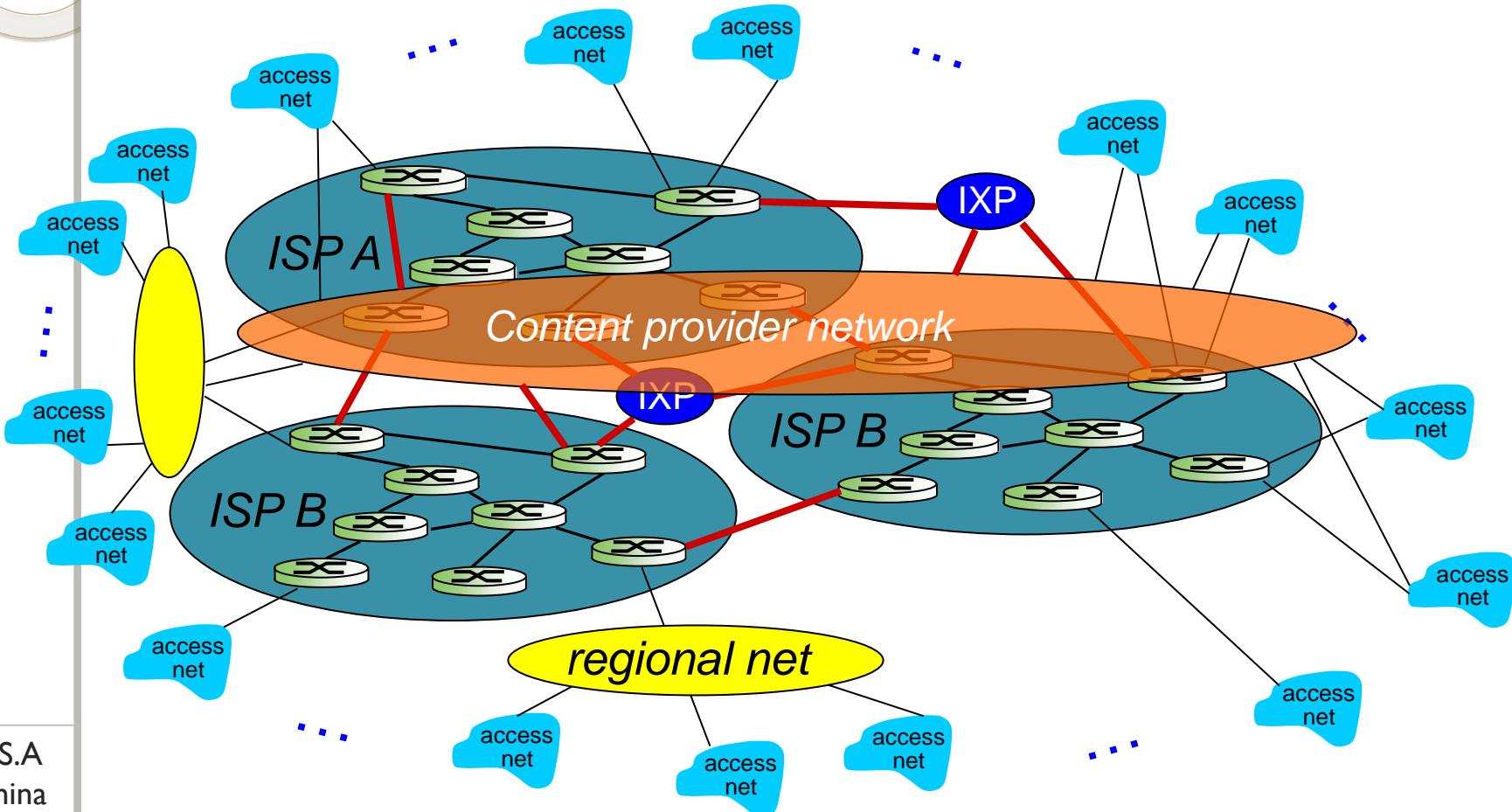
# Internet structure: network of networks

... and regional networks may arise to connect access nets to ISPS

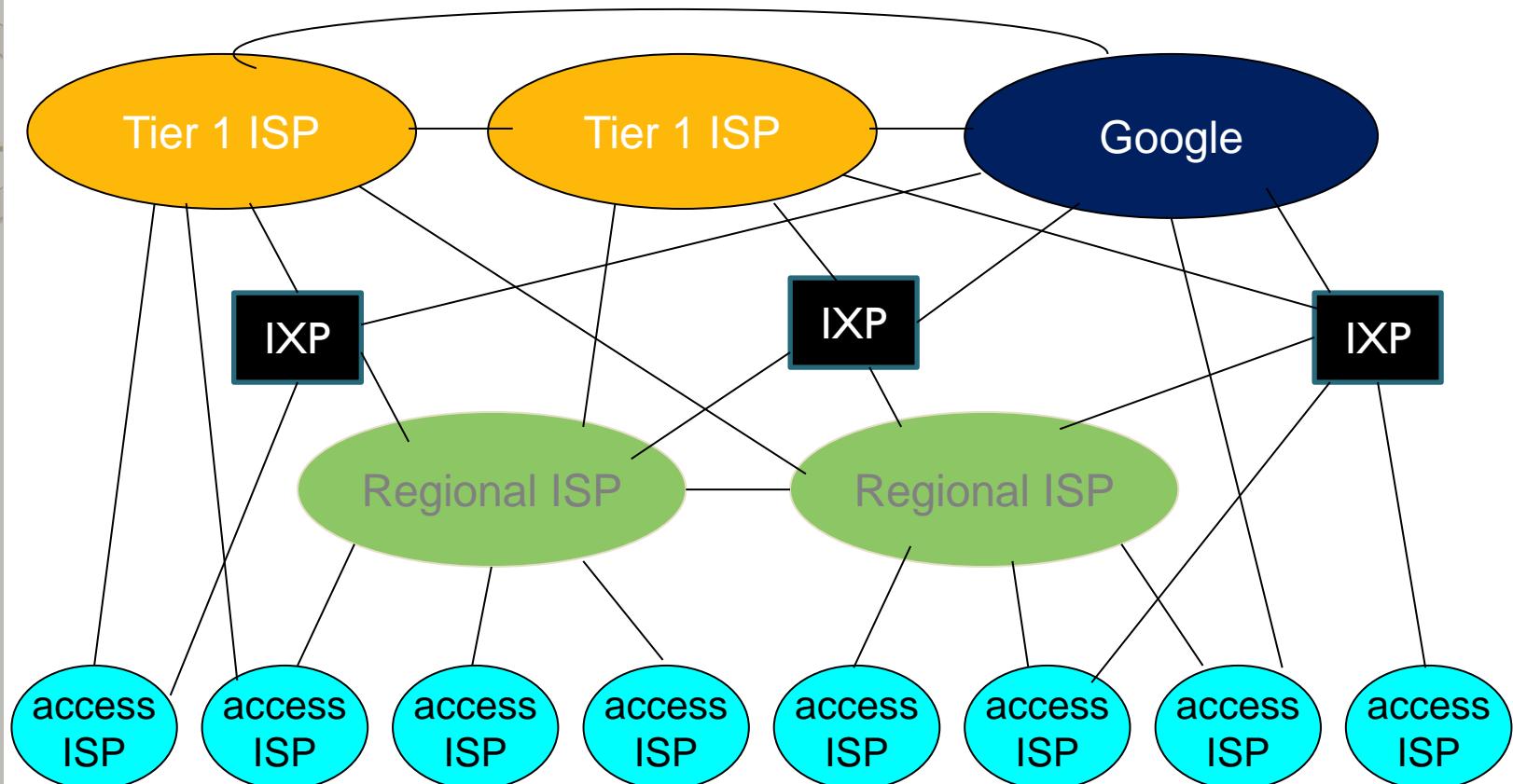


# Internet structure: network of networks

... and content provider networks (e.g., Google, Microsoft, Akamai ) may run their own network, to bring services, content close to end users

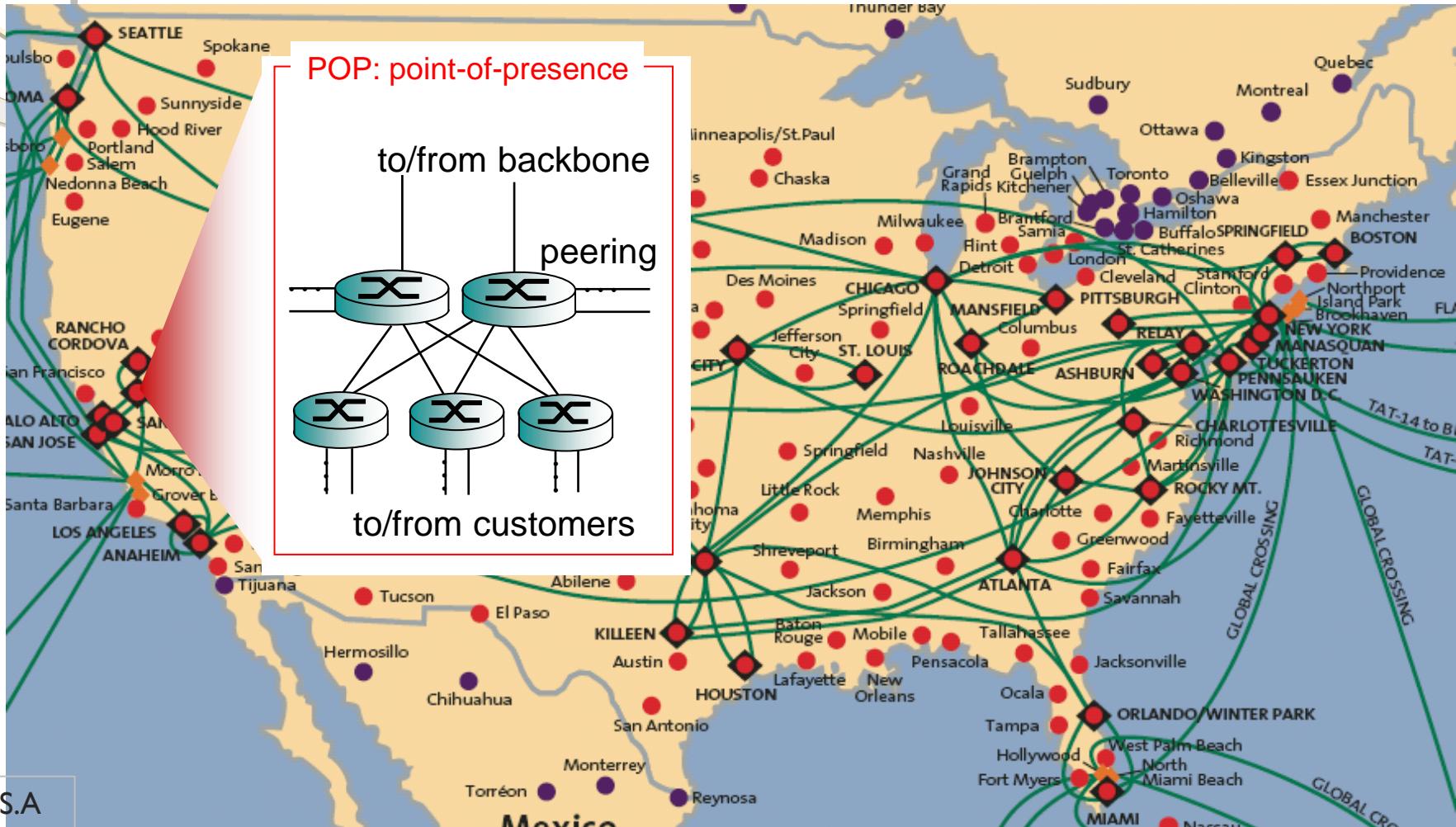


# Internet structure: network of networks



- at center: small # of well-connected large networks
  - “tier-1” commercial ISPs (e.g., Level 3, Sprint, AT&T, NTT), national & international coverage (about a dozen)
  - content provider network (e.g, Google): private network that connects its data centers to Internet, often bypassing tier-1, regional ISPs (Google 30-50 DC – over 100,000 others are hundreds of servers – Google’s private TCP/IP)

# Tier-1 ISP: e.g., Sprint





# End of Module