COMPUTER ENGINERRING

course

Network simulation

Lecture 1

Introduction

Course Objectives

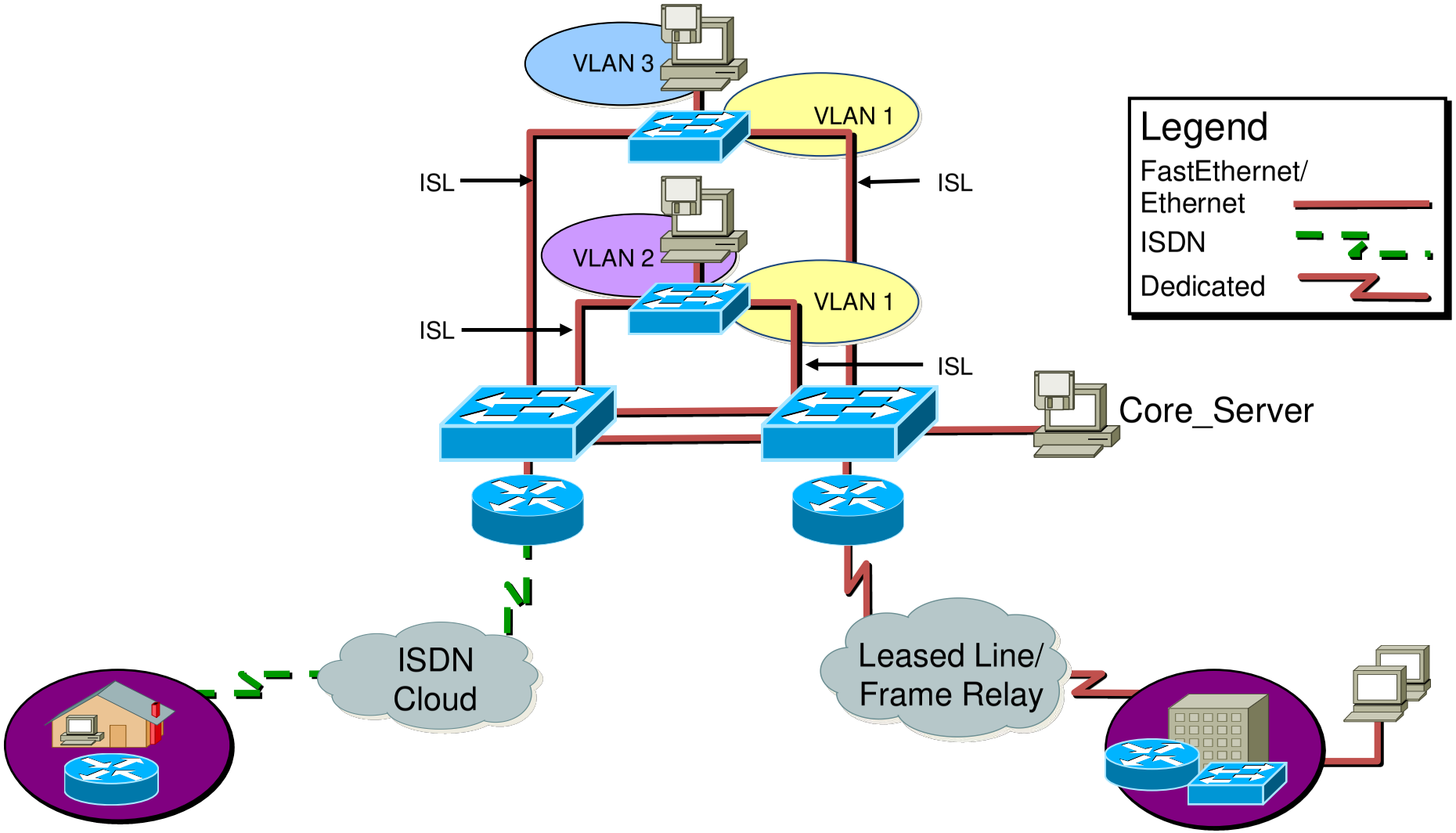
Upon completion of this course, you will be able to perform the following tasks:

- Determine when to use a hub, Ethernet switch, or multiprotocol router
- Use Cisco software to identify interfaces, protocols, addresses, and connectivity
- Interconnect switches and routers according to a specification
- Configure switches and routers to support LAN and WAN services

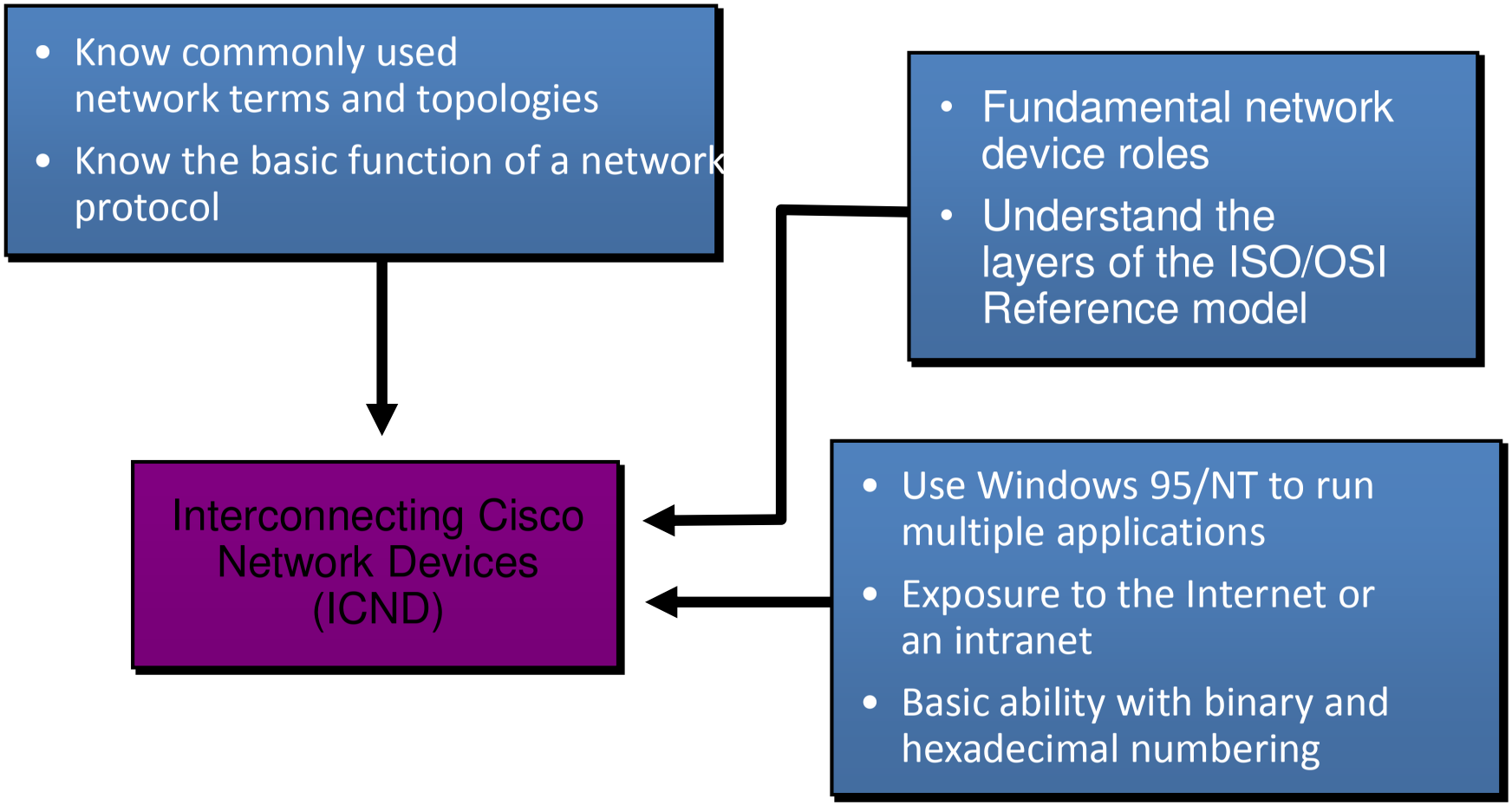
Course Objectives (cont.)

- Set up IP subnet addressing and address utilities for effective network administration
- Configure access lists to control access to devices or network segments
- Verify that switches, routers, and their configured network services operate as intended
- Recognize a network problem, identify the source of the problem, and resolve it

Course Topics



Prerequisites



Sources of Information

- Student kit
- www.cisco.com
- CD-ROM
- Cisco Press

Course Syllabus

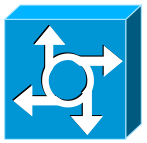
Module 1	Module 2	Module 3	Module 4
Interconnecting Cisco Network Devices Introduction	Catalyst Switch Operations	Interconnecting Networks with TCP/IP	Establishing Serial Point-to-Point Connections
Internetworking Concepts Overview	Extending Switched Networks with Virtual LANs	Determining IP Routes	Completing an ISDN BRI Call
Assembling and Cabling Cisco Devices		Basic IP Traffic Management with Access Lists	Establishing a Frame Relay PVC Connection
Operating and Configuring a Cisco IOS Device		Configuring Novell IPX	
Managing Your Network Environment			

Graphic Symbols

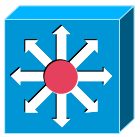

Bridge


Switch

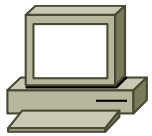

Router


Access server


ISDN switch

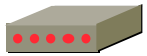

Multi-layer switch


Network switch


Personal computer

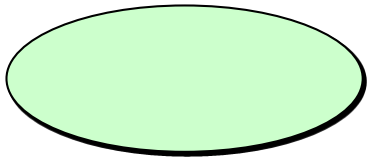

File Server

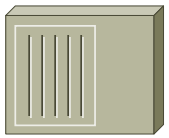
Data Service Unit/ Channel Service Unit

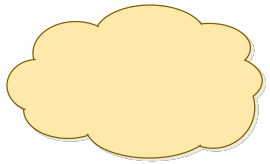

Modem

Web Server


WAN “cloud”


VLAN (Color May Vary)


Hub


Network Cloud or Broadcast Domain


Ethernet


Fast Ethernet


Serial Line

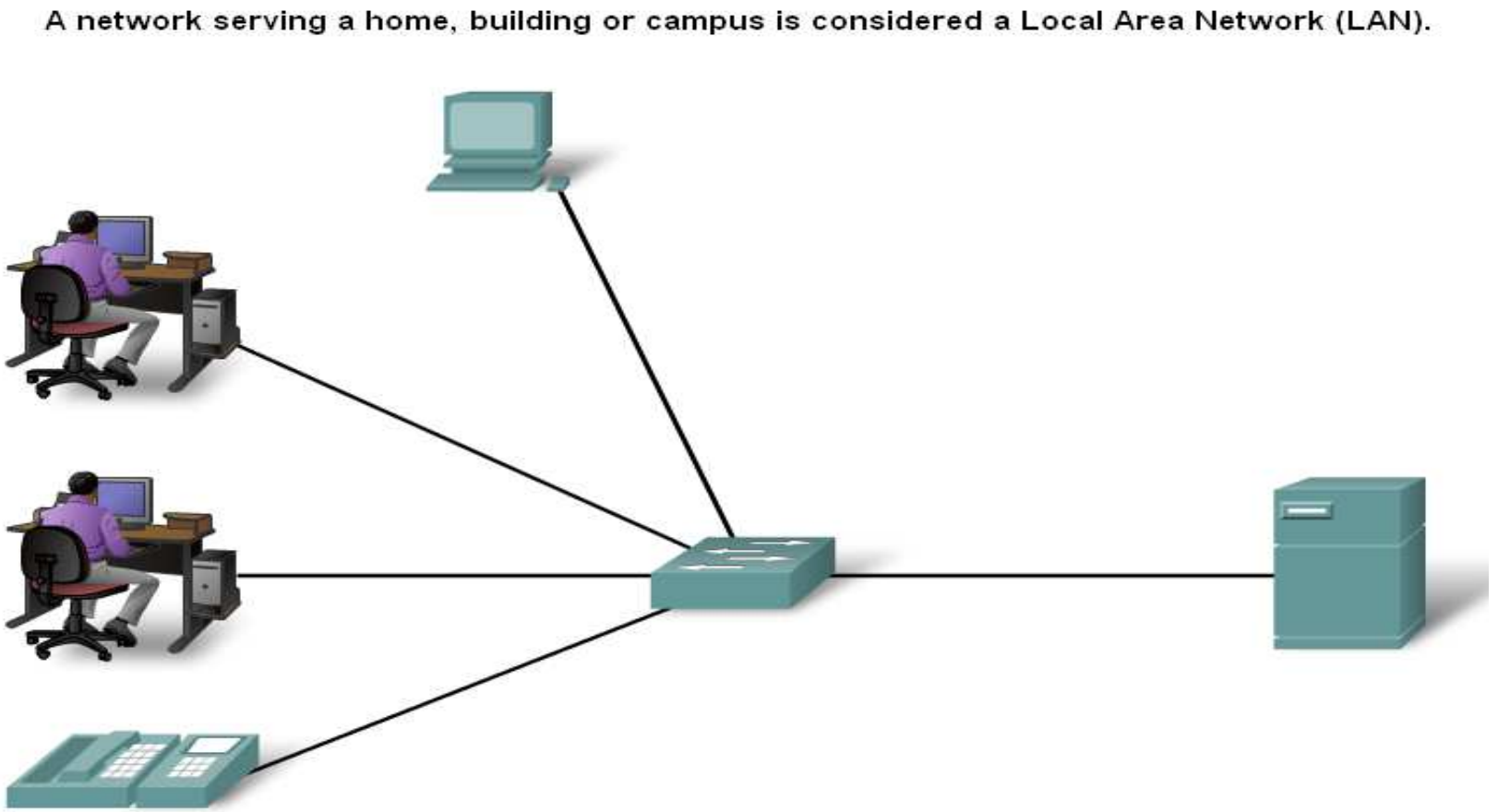

Circuit Switched Line

Lecture 2

Network types

Network type

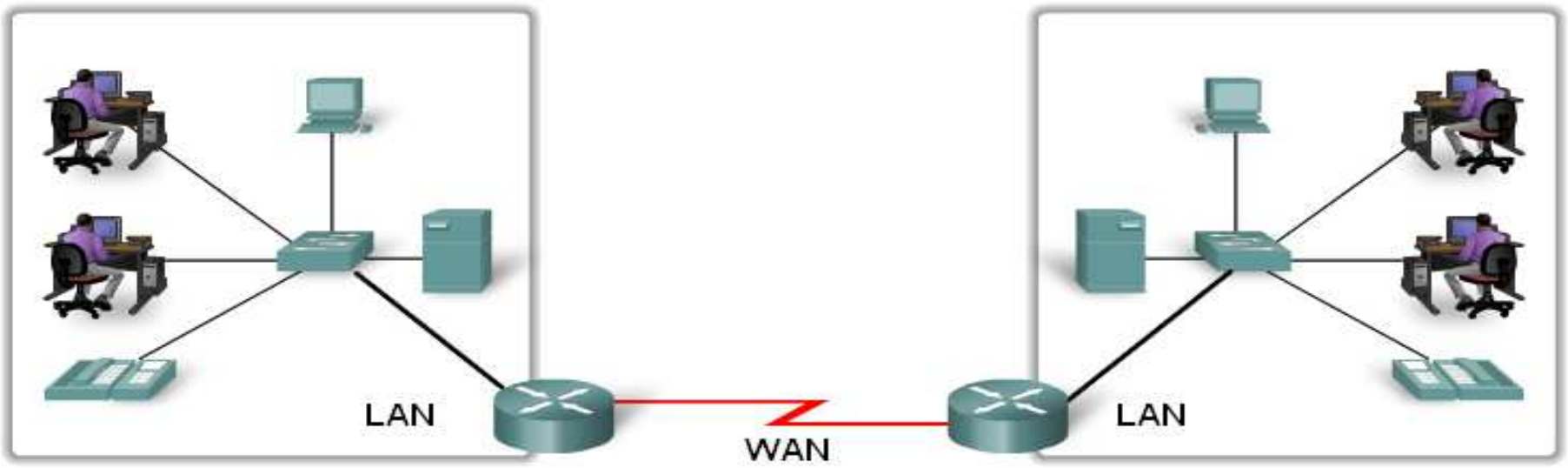
1. LAN: local area network ‘single organization



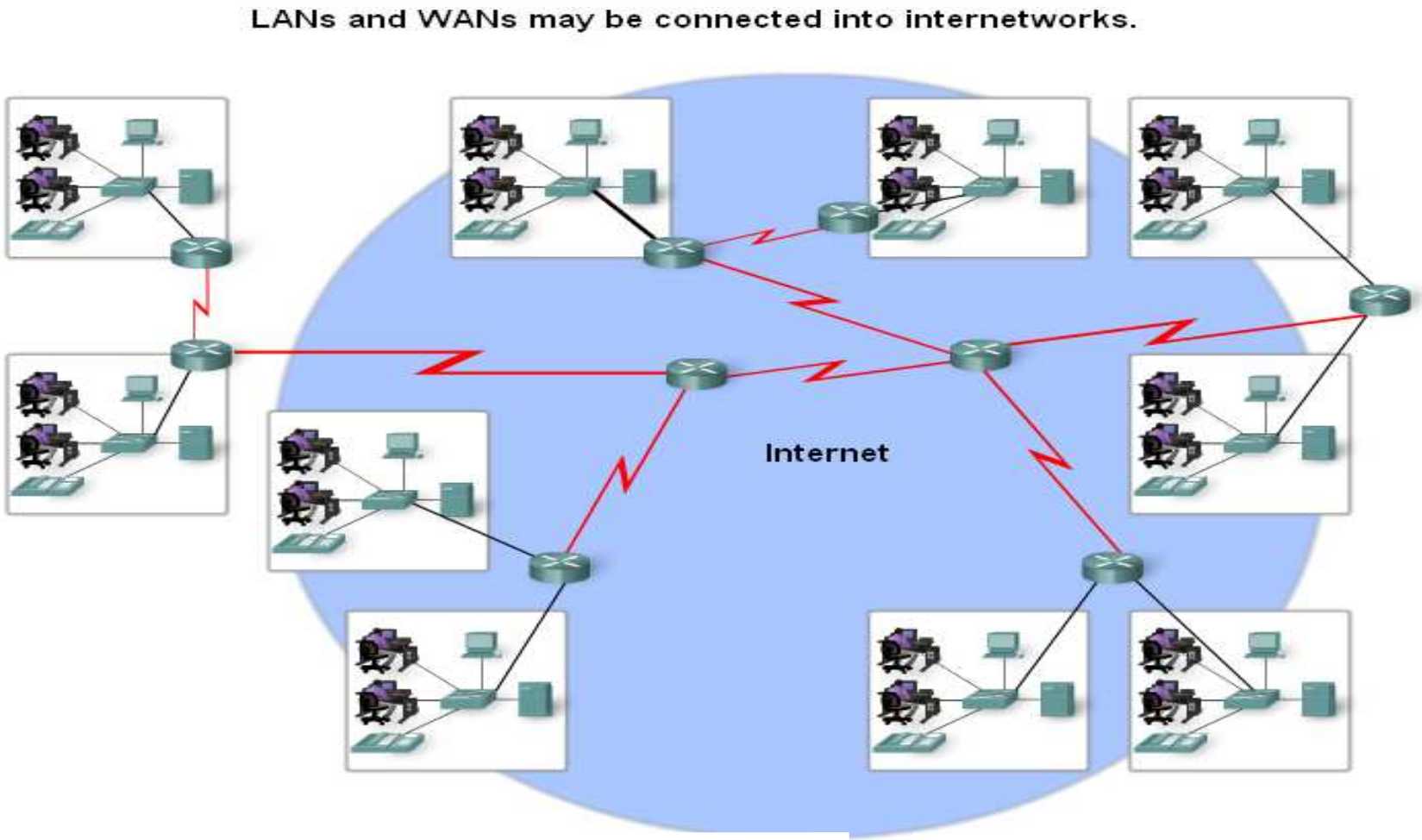
Network type

2. ***Wide Area Network WAN***

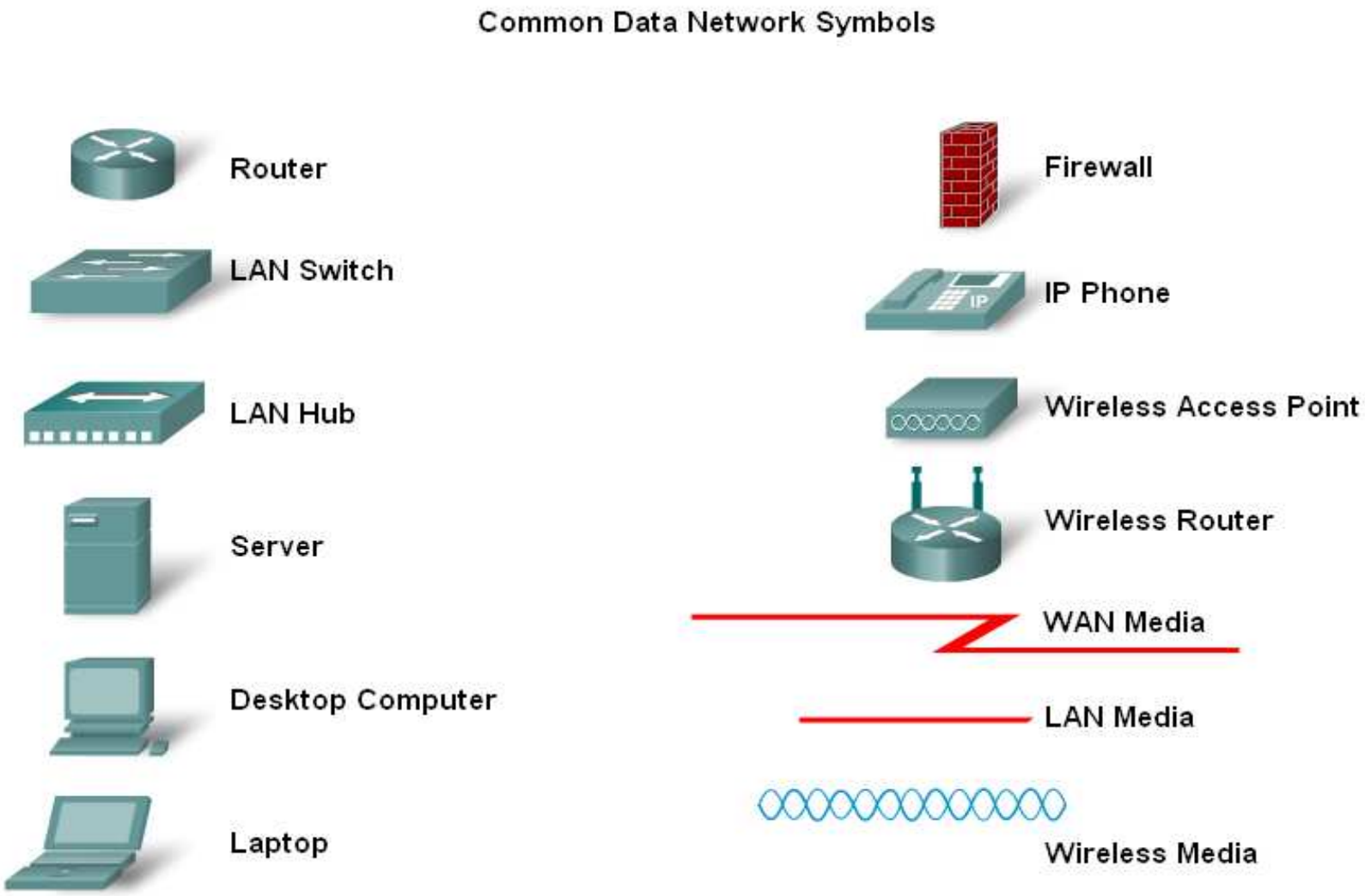
LANs separated by geographic distance are connected by a network known as a Wide Area Network (WAN).



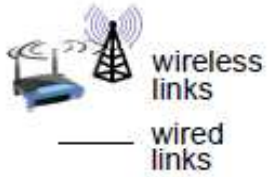
INTERNET A global mesh of interconnected networks (internetworks)



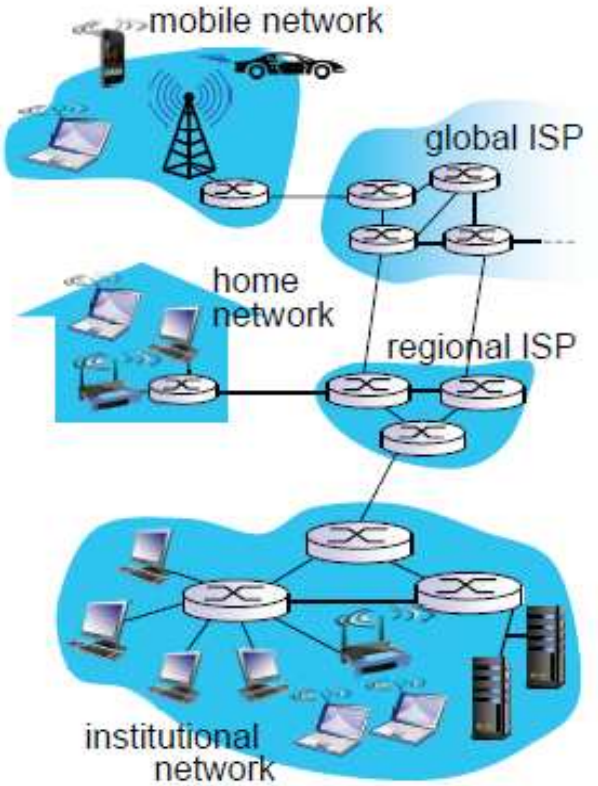
Network Representation



What's the Internet: "nuts and bolts" view

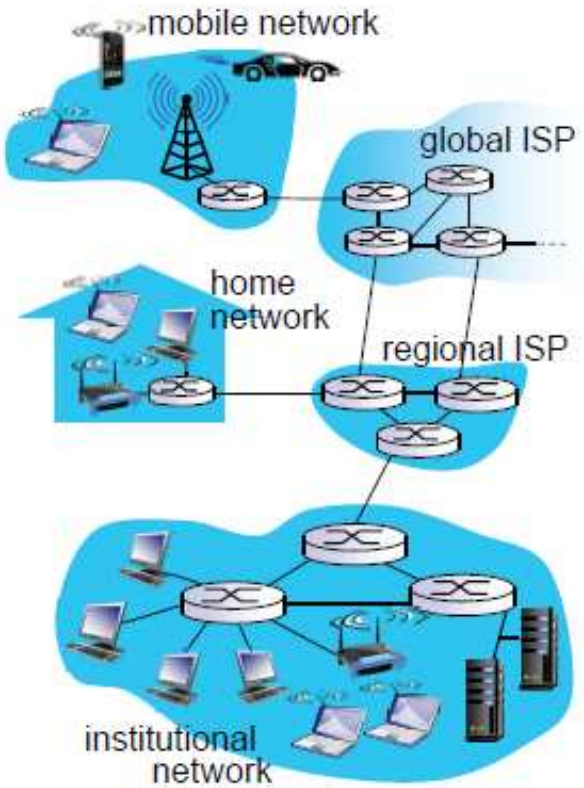


- Hosts
- Links
- Routers
- Protocols



What's the Internet: a service view

- *Comm Infrastructure*
  - Web, VoIP, email, games, e-commerce, social nets, …
- *Comm Service*
  - hooks that allow sending and receiving app programs to "connect" to Internet
  - provides service options, analogous to postal service



What's a protocol?

Protocol in a general sense:

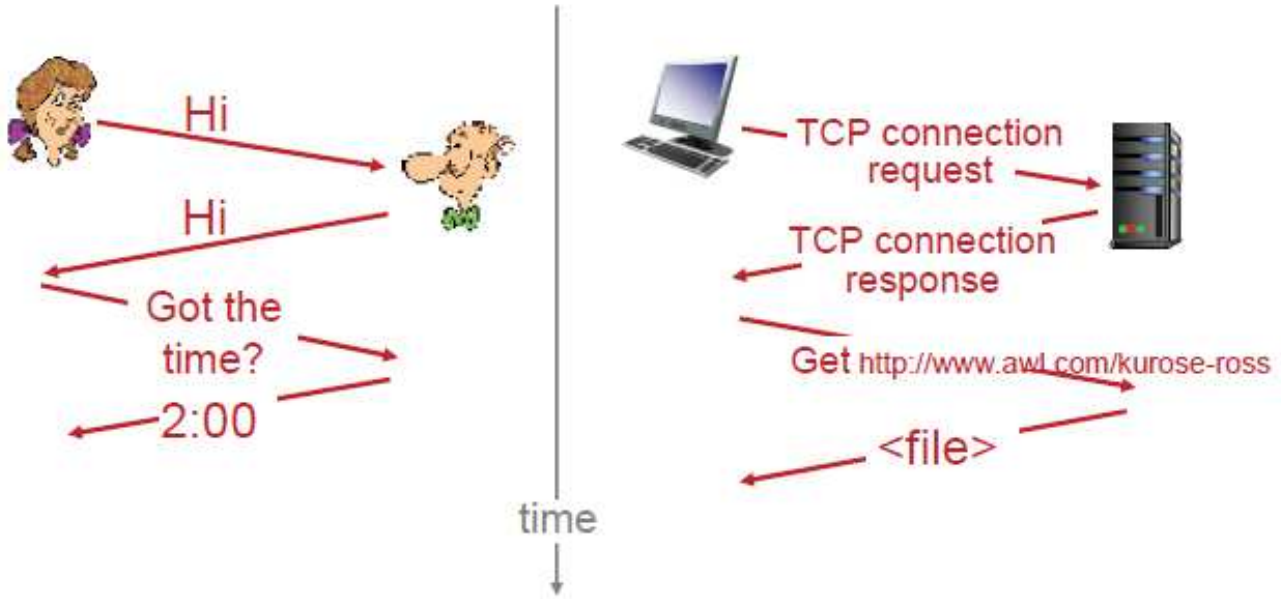
Rules of interaction

Network protocol:

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

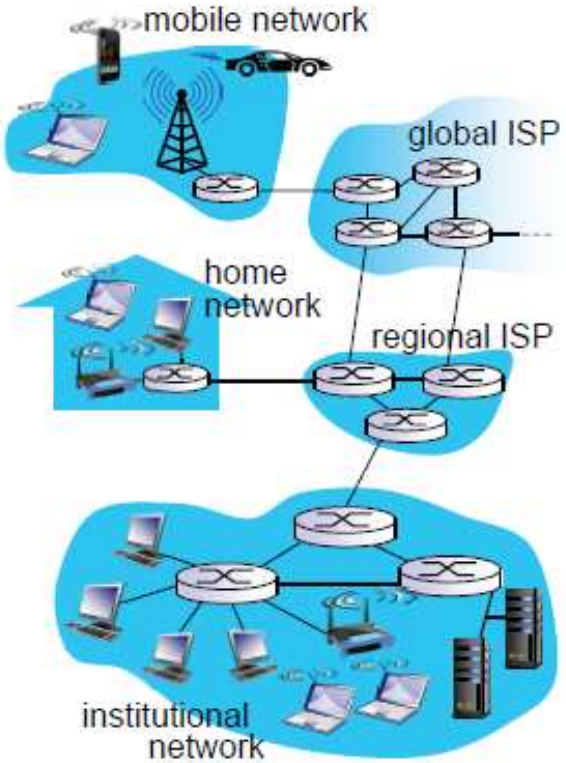
What's a protocol?

a human protocol and a computer network protocol:



A closer look at network structure:

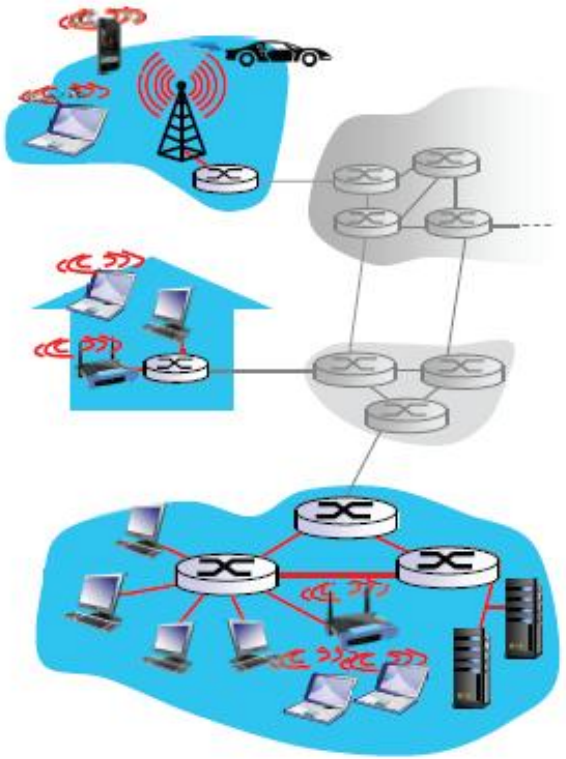
- *network edge:*
  - hosts: clients and servers
- *access networks*
  - *PHY links that connects hosts to edge routers*
- *network core:*
  - interconnected routers
  - network of networks



Access networks and physical media

Q: How to connect end systems to edge router?

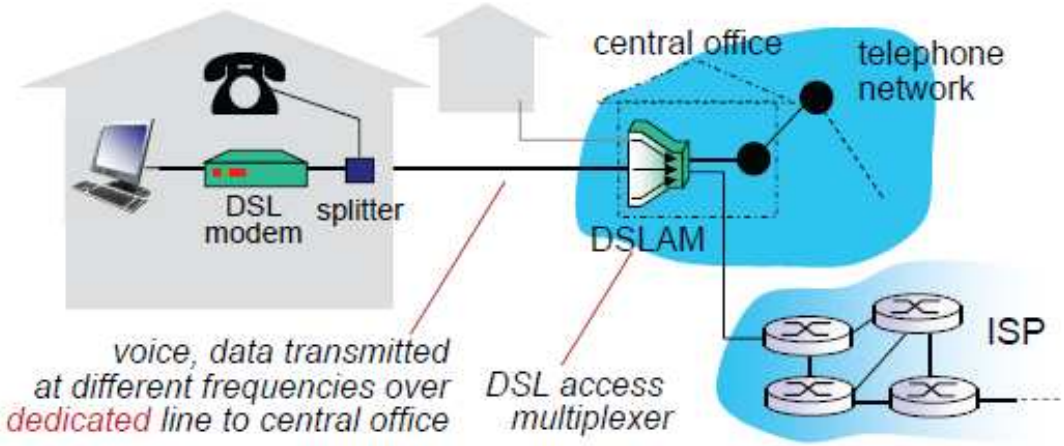
- residential access nets
- institutional access networks (school, company)
- mobile access networks



Lecture 3

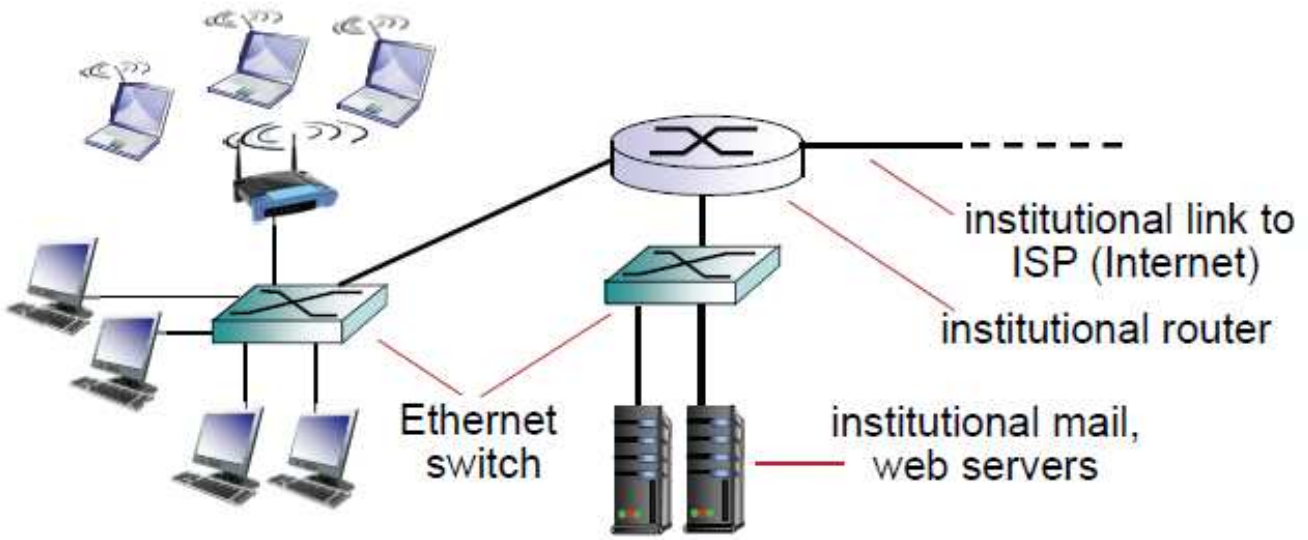
Connections

Residential Access: DSL



- use *existing* telephone line to central office DSL access multiplexer (DSLAM)
  - data over DSL phone line goes to Internet
  - voice over DSL phone line goes to telephone net

Enterprise access networks: Ethernet



- typically used in companies, universities, etc
- 10 Mbps, 100Mbps, 1Gbps, 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

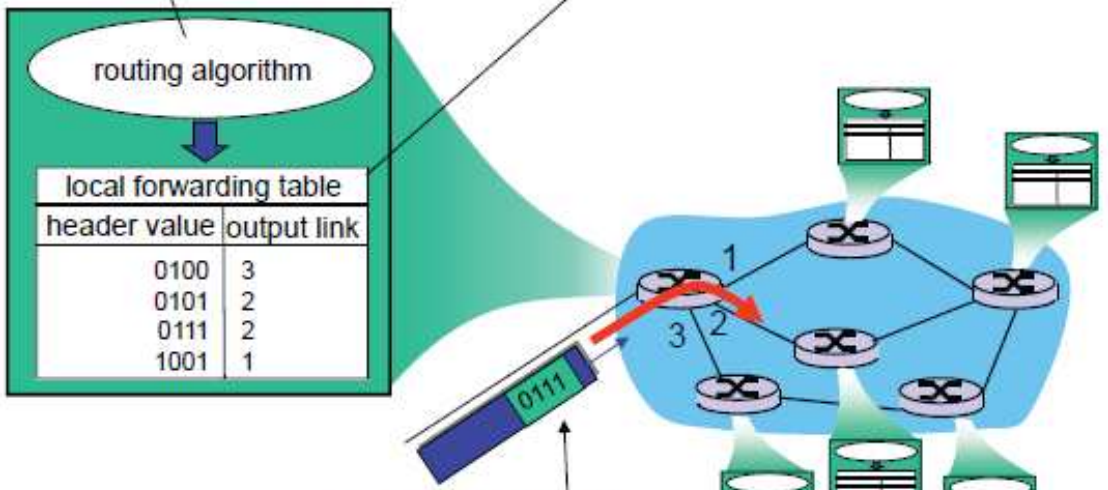
- provided by telco (cellular) operator, 10's km
- between 1 and 10 Mbps
- 3G, 4G: LTE

Two key network-core functions

routing: determines source-destination route taken by packets

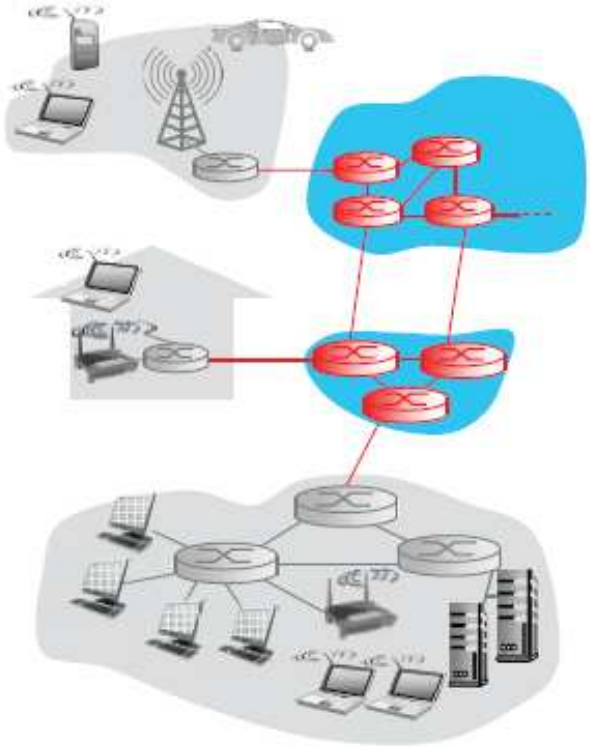
- *routing algorithms*

forwarding: move packets from router's input link to appropriate router output link

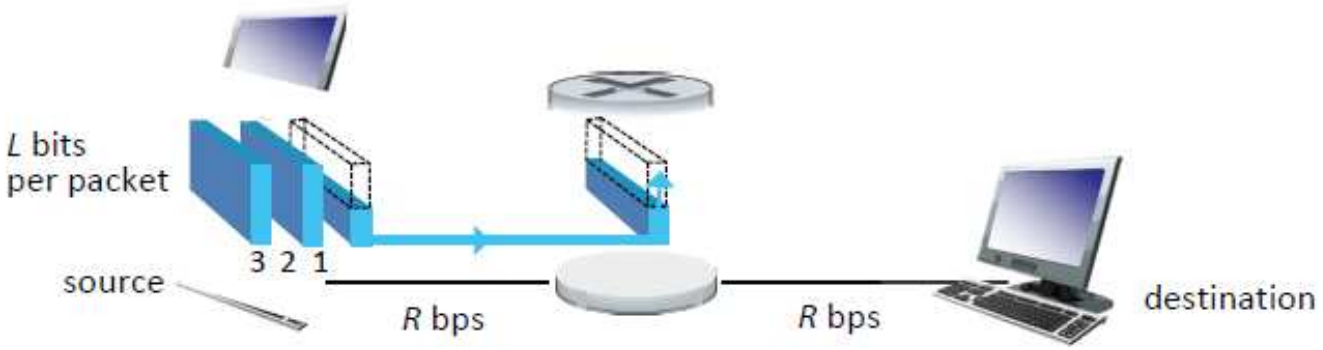


The network core

- Q: How is data transferred?
- Circuit Switching: Circuit is setup and reserved before communication
- **Packet Switching**: hosts break application-layer messages into *packets*



Packet-switching: store-and-forward



- takes *L*/*R* seconds to transmit (push out) *L*-bit packet into link with transmission rate *R* bps
- ***store and forward***: entire packet must arrive at router before it can be transmitted on next link

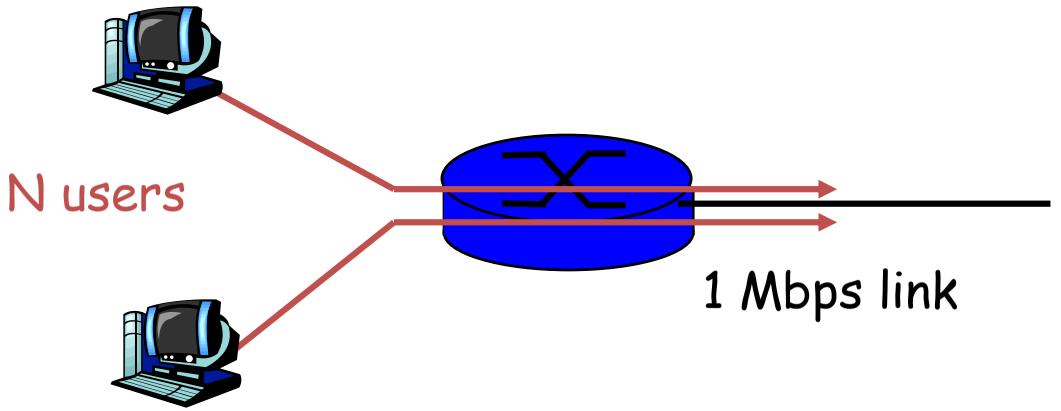
one-hop numerical example:

- *L* = 7.5 Mbits
- *R* = 1.5 Mbps
- one-hop transmission delay = 5 sec

Packet switching versus circuit switching

Packet switching allows more users to use network!

- 1 Mb/s link
- each user:
  - 100 kb/s when "active"
  - active 10% of time

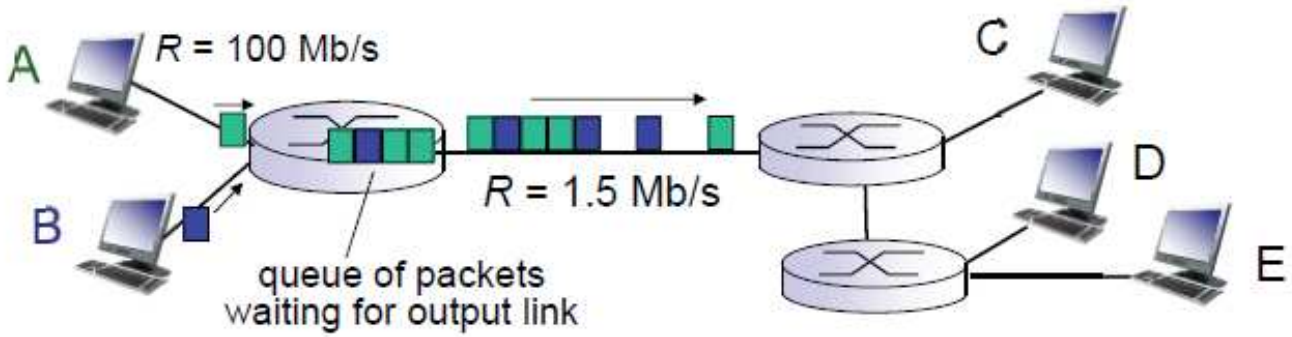


- *circuit-switching:*
  - 10 users
- *packet switching:*
  - with 35 users, probability > 10 active at same time is

Lecture 4

Internet delay Dellay

Packet Switching: queueing delay, loss



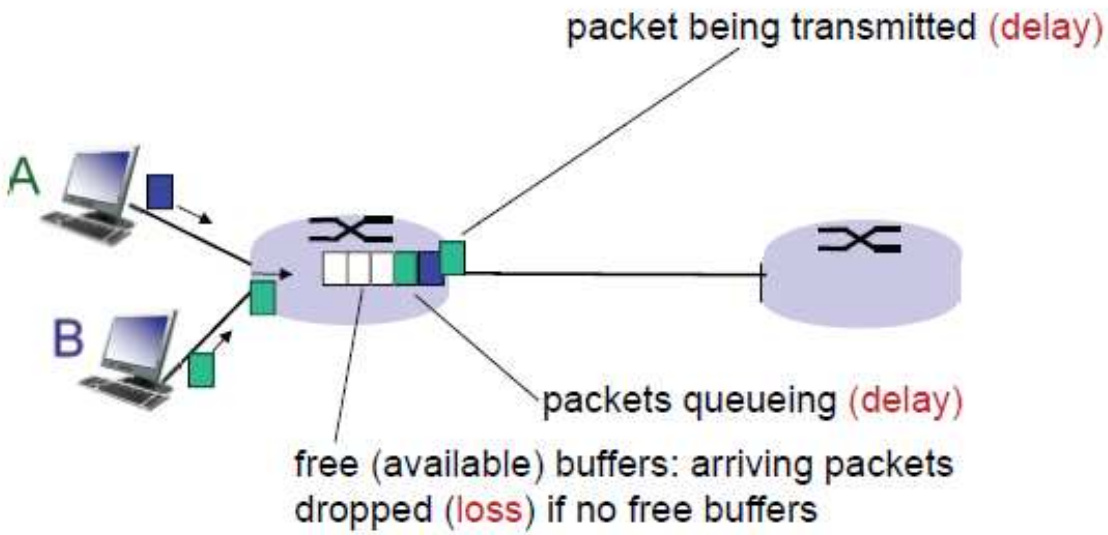
queuing and loss:

- If arrival rate (in bits) to link exceeds transmission rate of link for a period of time:
  - packets will queue, wait to be transmitted on link
  - packets can be dropped (lost) if memory (buffer) fills up

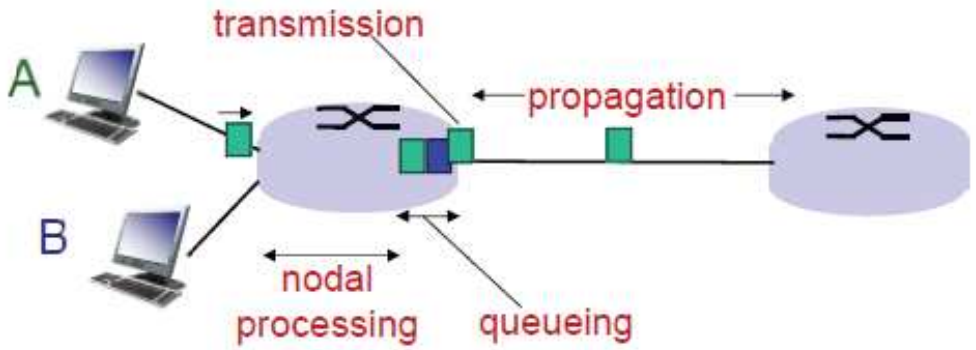
How do loss and delay occur?

packets *queue* in router buffers

- packet arrival rate to link (temporarily) exceeds output link capacity
- packets queue, wait for turn



Four sources of packet delay



$$d_{nodal} = d_{proc} + d_{queue} + d_{trans} + d_{prop}$$

1. *Processing*
2. *Queuing*
3. *Transmission*
4. *Propagation*

Nodal delay

$$d_{\text{nodal}} = d_{\text{proc}} + d_{\text{queue}} + d_{\text{trans}} + d_{\text{prop}}$$

- d_{proc} = processing delay

  dependes on time checking error, packet forwarding algorithem.
- d_{queue} = queuing delay
  - depends on congestion and packet on the link.
- d_{trans} = transmission delay
  - = L/R, significant for low-speed links
- d_{prop} = propagation delay
  - The propagation speed depends on the physical medium of the link (that is, fibre optics, twisted-pair copper wire, and so on = *d/s*

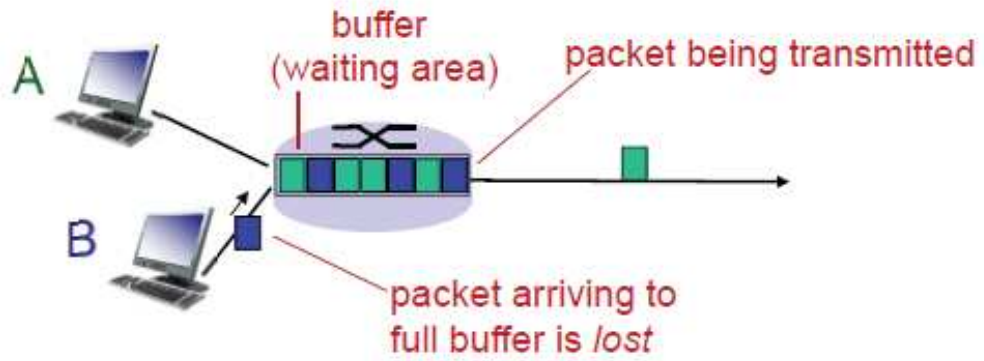
"Real" Internet delays and routes

- what do "real" Internet delay & loss look like?
- `traceroute` program: provides delay measurement from source to router along end-end Internet path towards destination. For all *i*:
  - sends three packets that will reach router *i* on path towards destination
  - router *i* will return packets to sender
  - sender times interval between transmission and reply.

TTL1,TTL2,TTL3
RTT,RTD (ROUND TRIP TIME, DELAY)

Packet loss

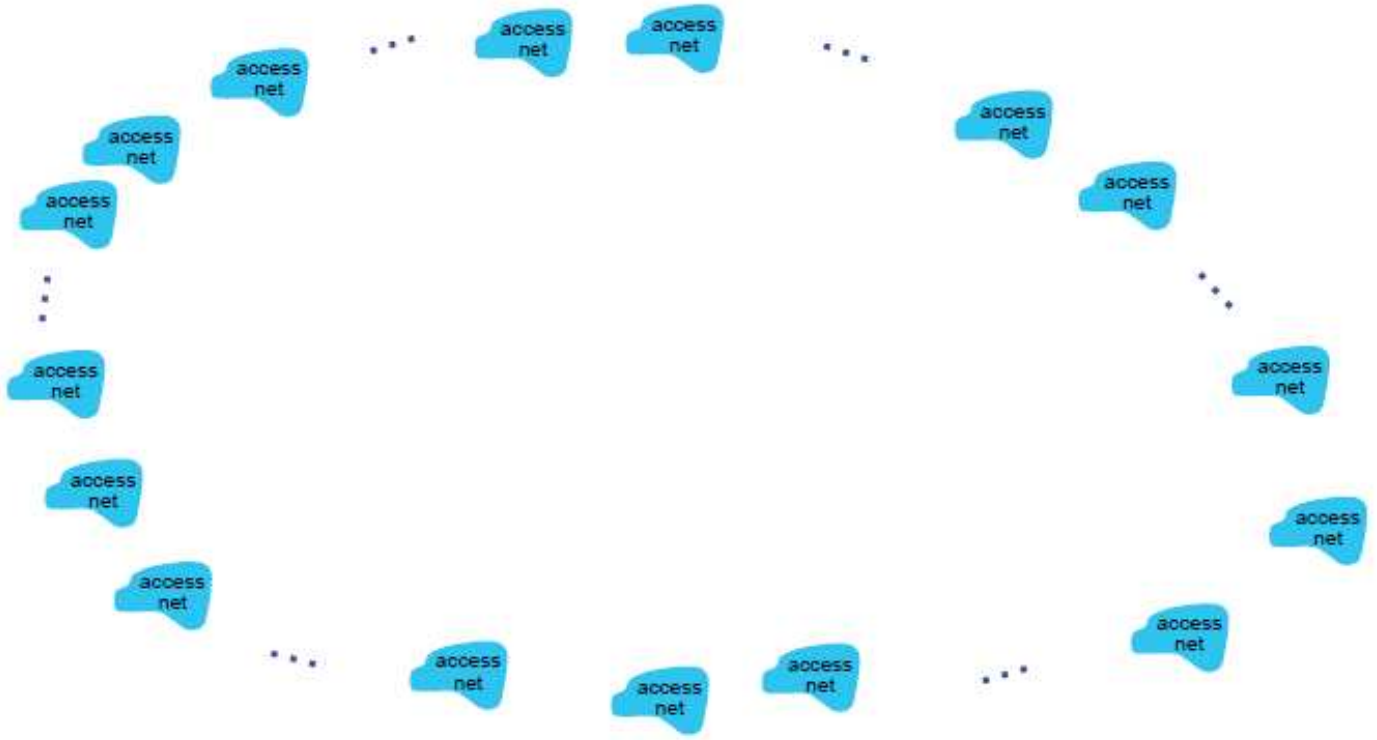
- queue (aka buffer) preceding link in buffer has finite capacity
- packet arriving to full queue dropped (aka lost)
- lost packet may be retransmitted by previous node, by source end system, or not at all



* Check out the Java applet for an interactive animation on queuing and loss

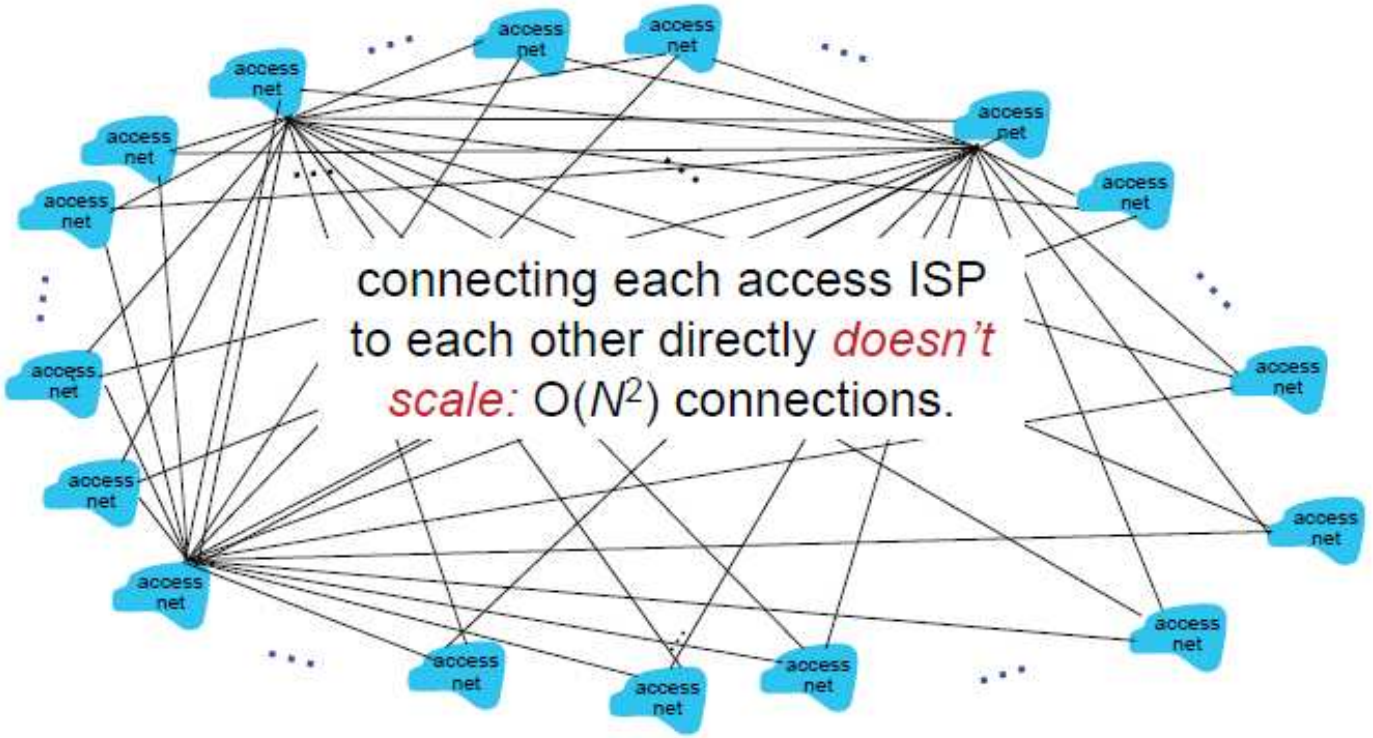
Internet structure: network of networks

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



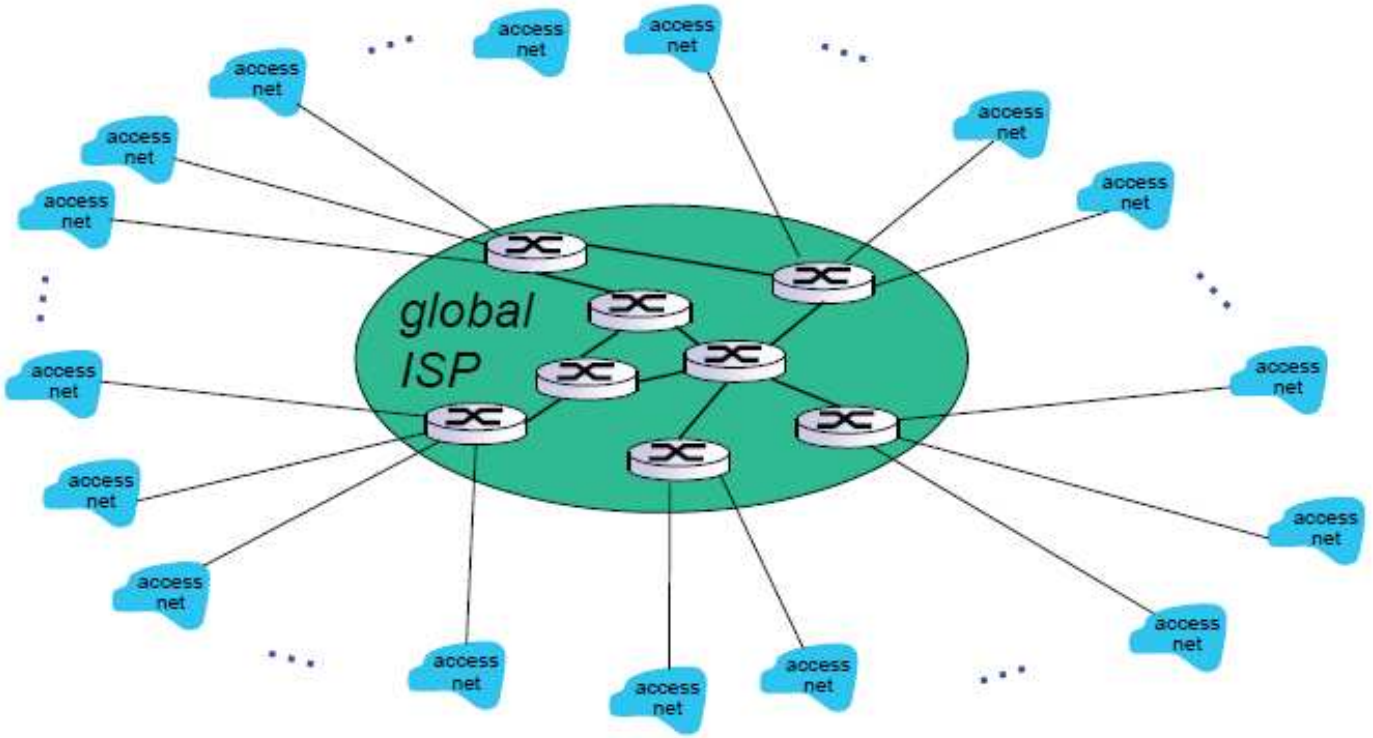
Internet structure: network of networks

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



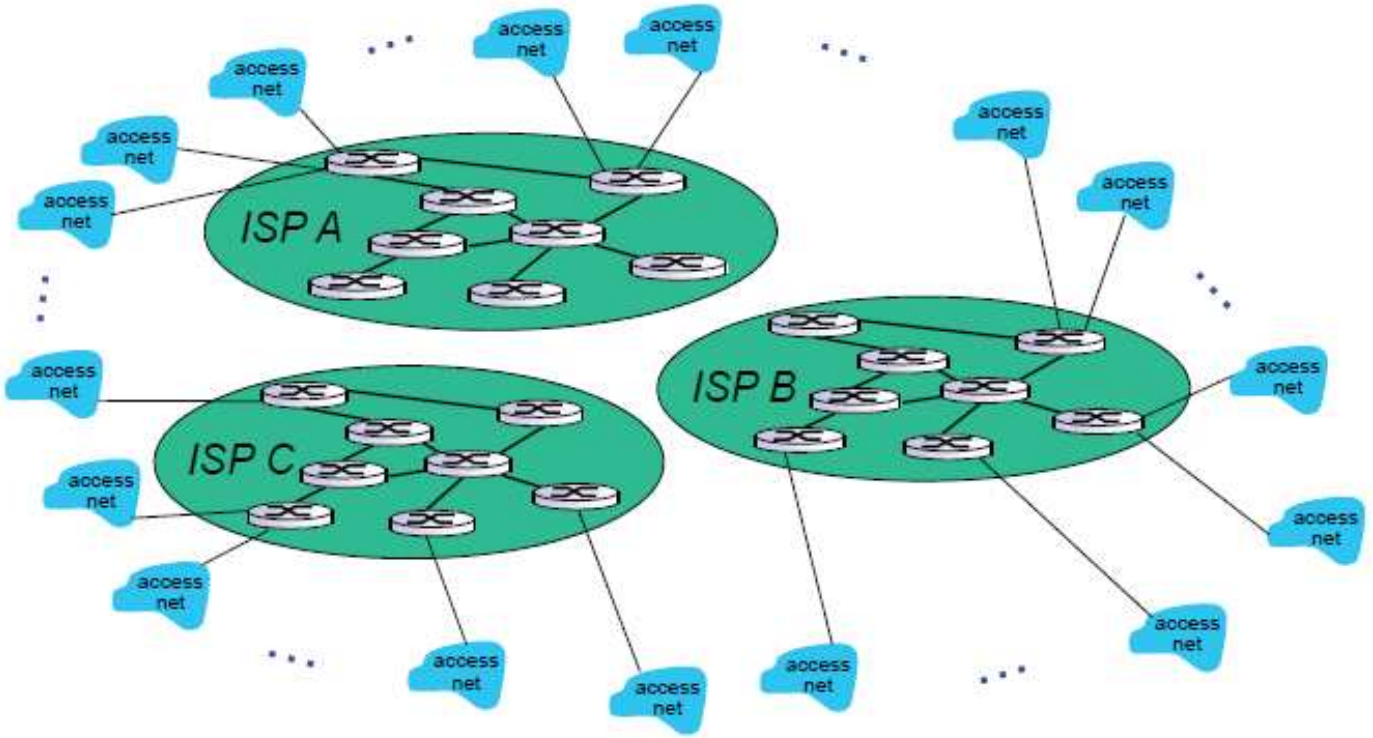
Internet structure: network of networks

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



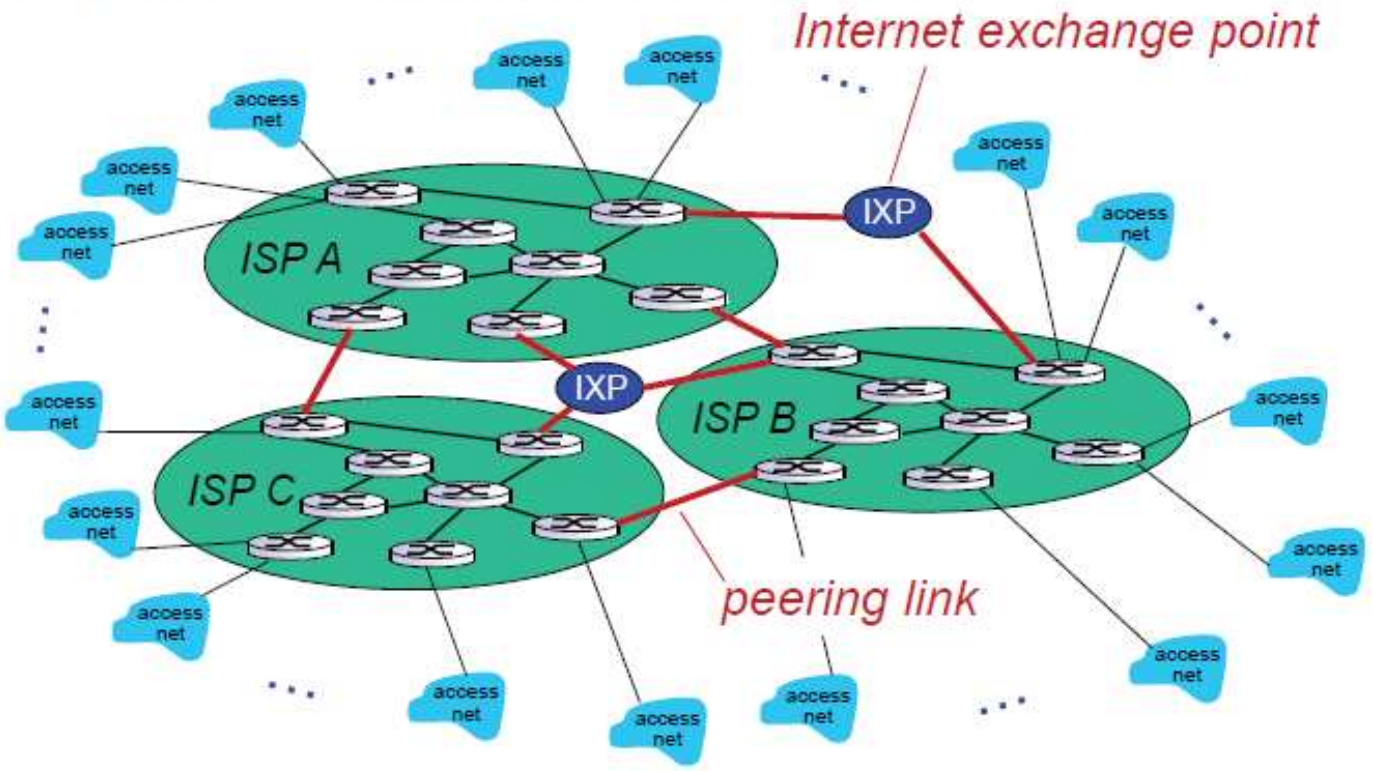
Internet structure: network of networks

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



Internet structure: network of networks

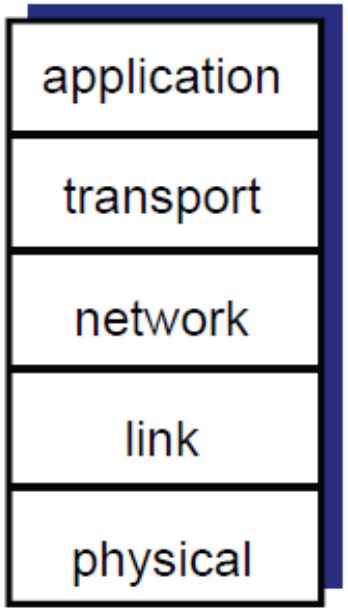
But if one global ISP is viable business, there will be competitors …. which must be interconnected



Internet protocol stack

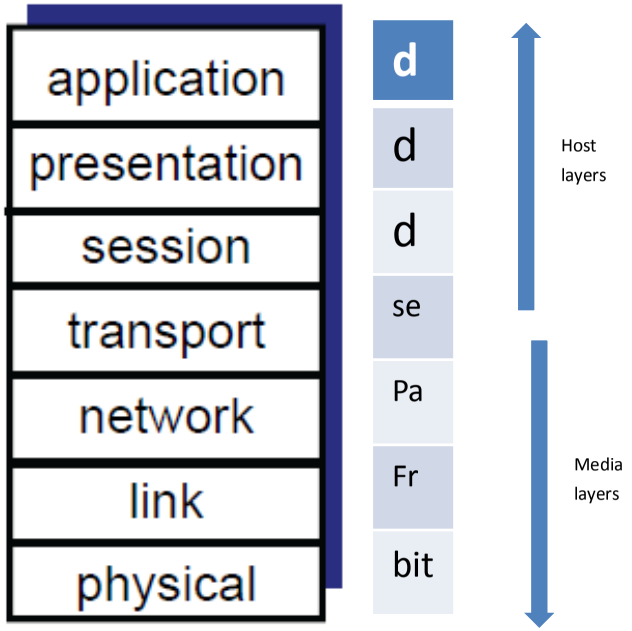
- *application:* supporting network applications
  - FTP, SMTP, HTTP
- *transport:* process-process data transfer
  - TCP, UDP
- *network:* routing of datagrams from source to destination
  - IP, routing protocols
- *link:* data transfer between neighboring network elements
  - Ethernet, 802.111 (WiFi), PPP
- *physical:* bits "on the wire"

Usb,bluetooth,binary trans.



ISO/OSI reference model

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

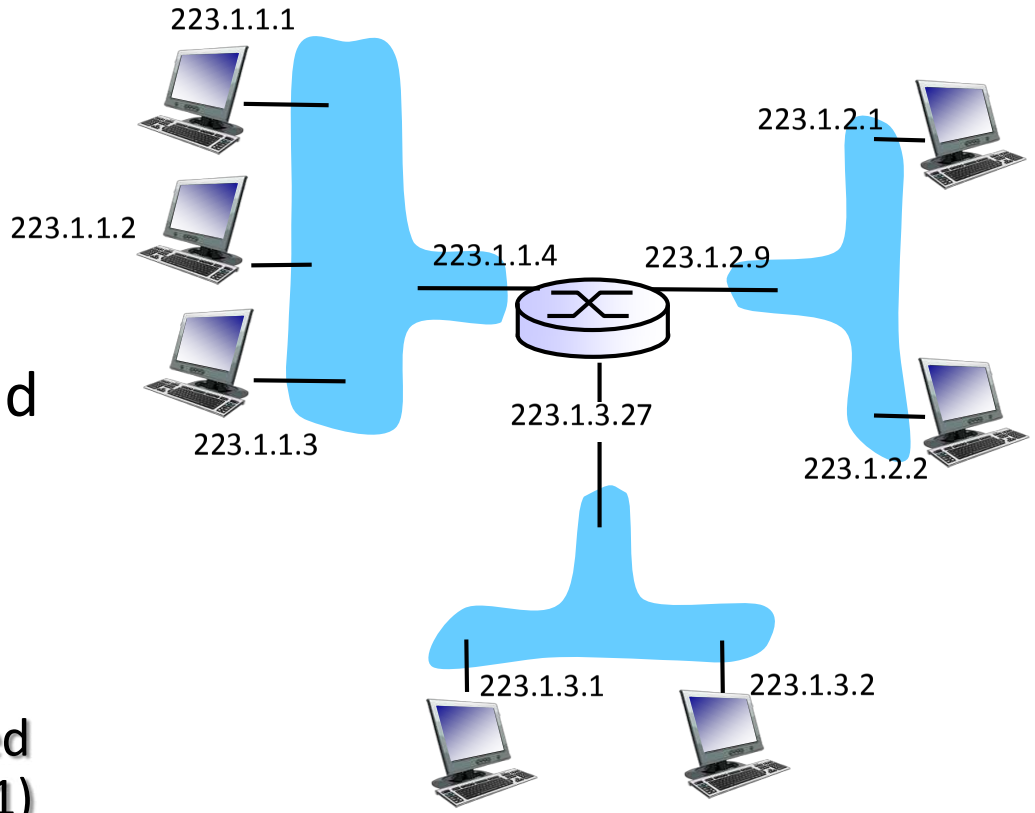


Lecture 5

Addressing

IP addressing

- *IP address:* 32-bit (identifier for host, router *interface)*
- *interface:* connection between host/router and physical link
  - router's typically have multiple interfaces
  - host typically has one or two interfaces (e.g., wired Ethernet, wireless 802.11)
- *IP addresses associated with each interface*



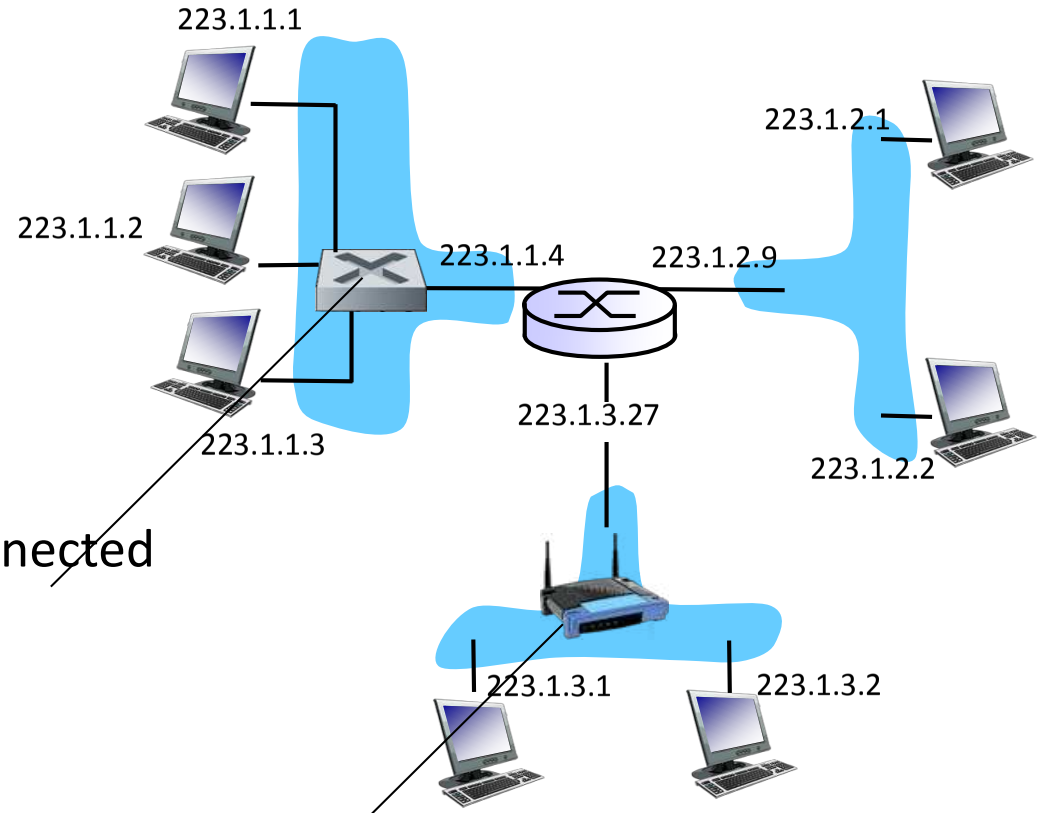
223.1.1.1 = 11011111 00000001 00000001 00000001

223 1 1 1

IP addressing: introduction

Q: how are interfaces actually connected?

A: we'll learn about that in. PRACTICAL

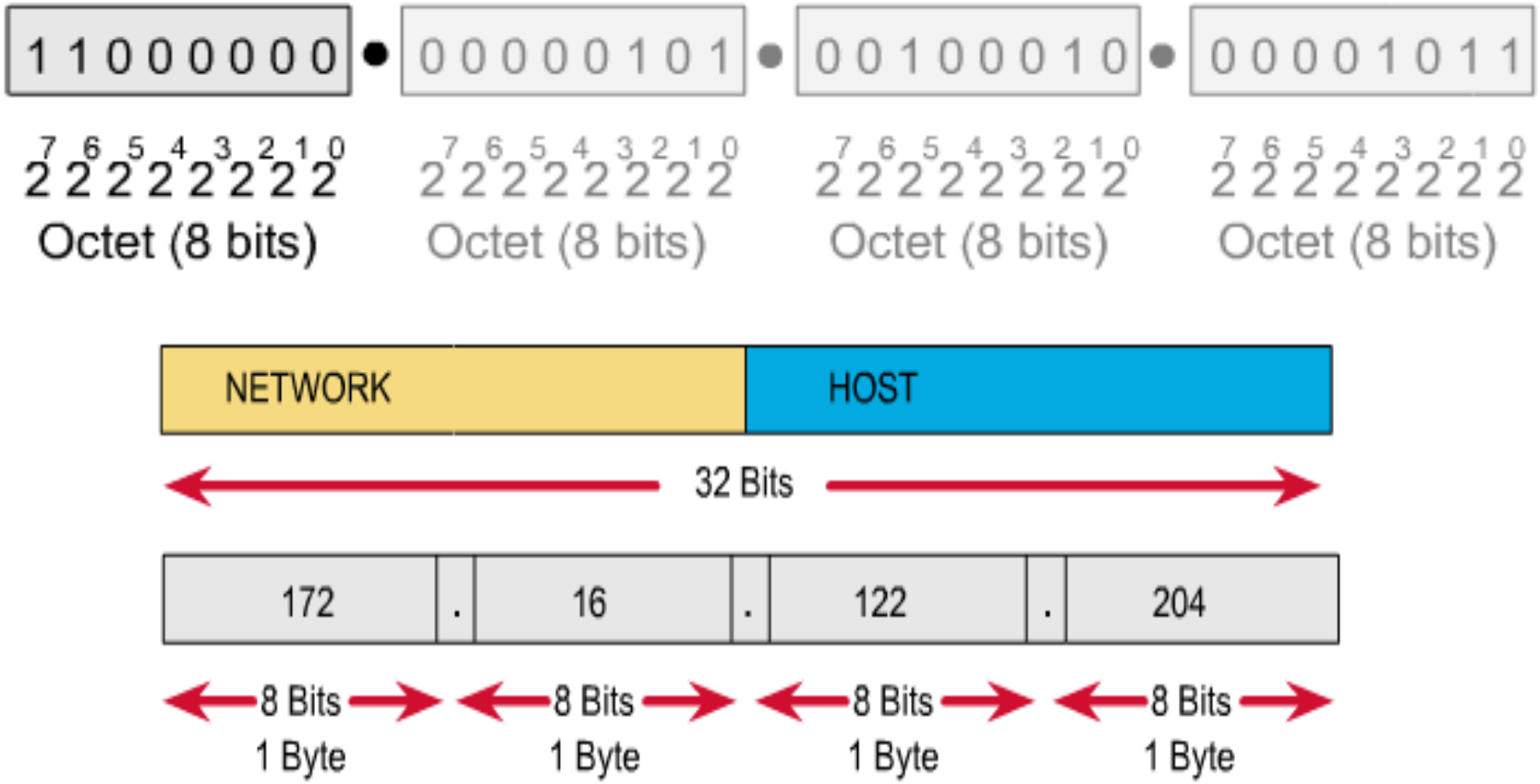


A: wired Ethernet interfaces connected by Ethernet switches

A: wireless WiFi interfaces connected by WiFi base station

Internet IP Addresses

IP Address as a 32-Bit Binary Number



Decimal To Binary

Decimal Equivalents of 8-Bit Patterns

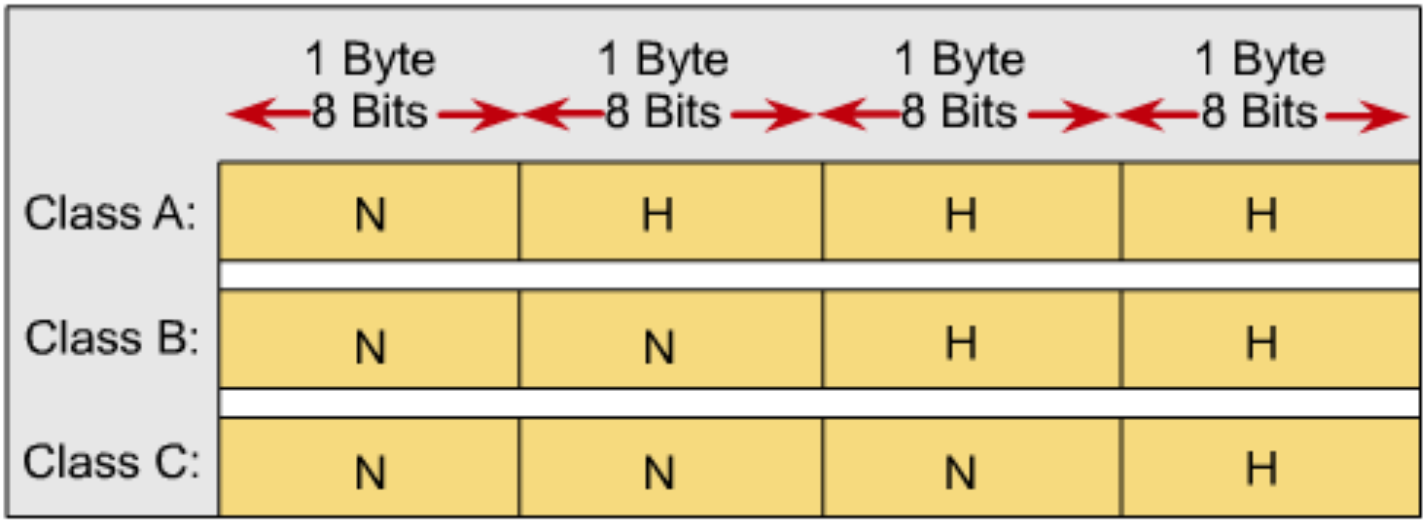
128	64	32	16	8	4	2	1	
1	0	0	0	0	0	0	0	= 128
1	1	0	0	0	0	0	0	= 192
1	1	1	0	0	0	0	0	= 224
1	1	1	1	0	0	0	0	= 240
1	1	1	1	1	0	0	0	= 248
1	1	1	1	1	1	0	0	= 252
1	1	1	1	1	1	1	0	= 254
1	1	1	1	1	1	1	1	= 255

Binary and Decimal Conversion

$2^{(7)}$	$2^{(6)}$	$2^{(5)}$	$2^{(4)}$	$2^{(3)}$	$2^{(2)}$	$2^{(1)}$	$2^{(0)}$
128	64	32	16	8	4	2	1

192.57.30.224
11000000.00111001.00011110.11100000

IP Address Classes



- N = Network number assigned by ARIN
- H = Host number assigned by administrator

IP Address Classes