

National University of Computer & Emerging Sciences

CS 3001 - COMPUTER NETWORKS

Lecture 03 Chapter 1

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Office Hours: 02:30 pm till 06:00 pm (Every Tuesday & Thursday)

Chapter 1: roadmap

1.1 what is the Internet?

1.2 network edge

- end systems, access networks, links

1.3 network core

- packet switching, circuit switching, network structure

1.4 delay, loss, throughput in networks

1.5 protocol layers, service models

1.6 networks under attack: security

1.7 history

A closer look at network structure:

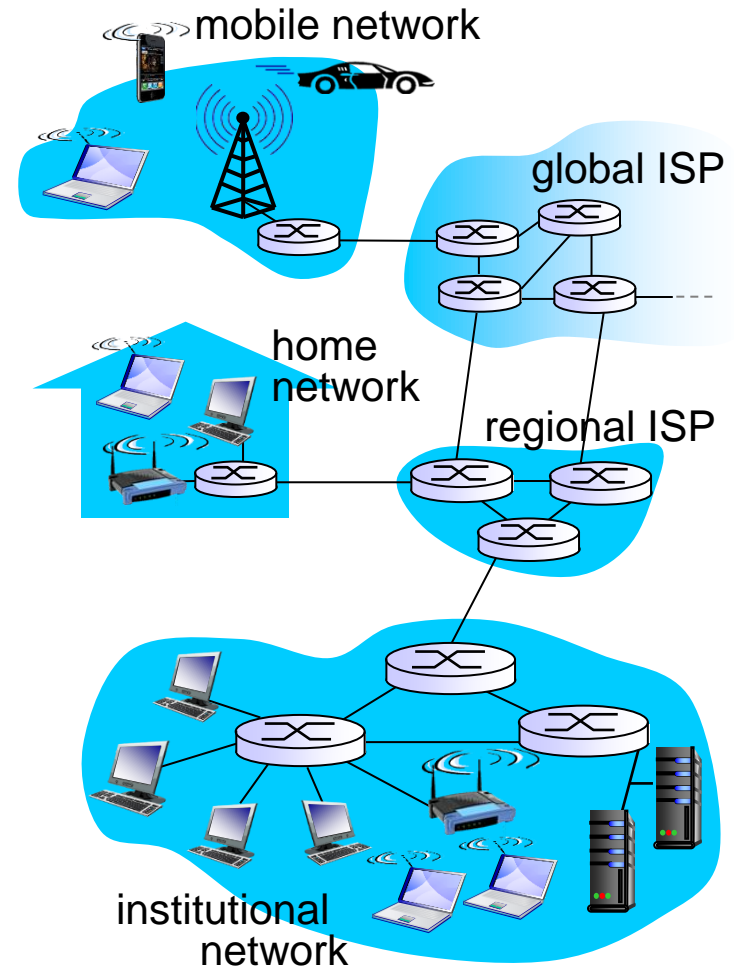
❖ *network edge:*

- hosts: clients and servers
- servers often in data centers

❖ *access networks, physical media:* wired, wireless communication links

❖ *network core:*

- interconnected routers
- network of networks



Network Edge (Client, Server, Peer)

Network edge comprises of the millions and billions of end systems / hosts and applications which reside in them

An end system (or host) can either request service (**client**) or provide service (**server**) or act as both interchangeably (**peer**).

Server

- A server is a service provider providing access to network resources:
 - A server can have multiple roles (e.g web servers, mail servers, print servers, Remote Access Servers (RAS), Directory Servers (DNS) etc)
 - Always on host
 - Permanent IP address
 - Most servers reside in large data centres

Client

- A client is a requestor of these services
 - May be intermittently on
 - may have dynamic IP address
 - do not communicate directly with each other

Peer

- A Peer-to-Peer network doesn't have dedicated servers. All hosts are equal and they both provide and request service i.e. they have both client & server functionalities.
 - Not always on server
 - arbitrary end systems directly communicate
 - peers are intermittently connected and change IP addresses
 - complex management
 - Examples are Skype, BitTorrent, Napster

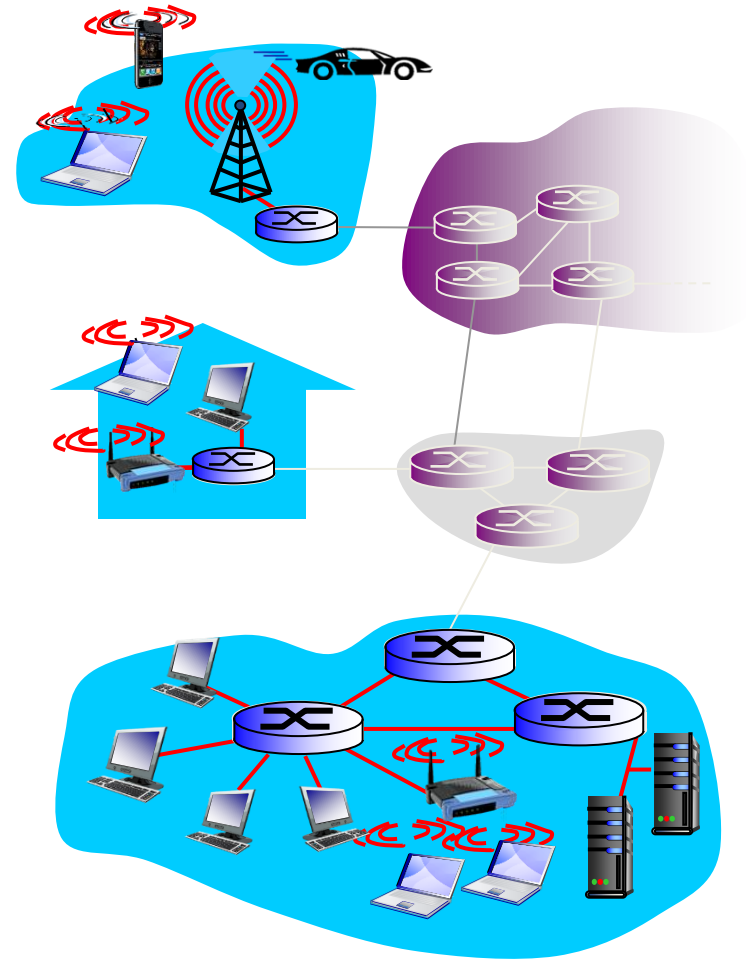
Access networks and physical media

Q: How to connect end systems to first / edge router?

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

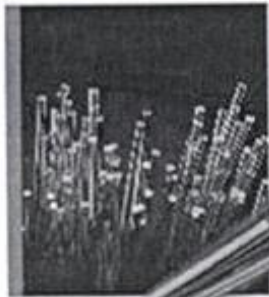
keep in mind:

- bandwidth (bits per second) of access network?
- shared or dedicated?

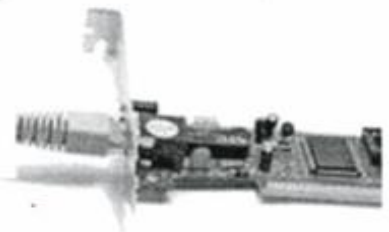


Links: Medium + Adapter Cards

Communication Medium



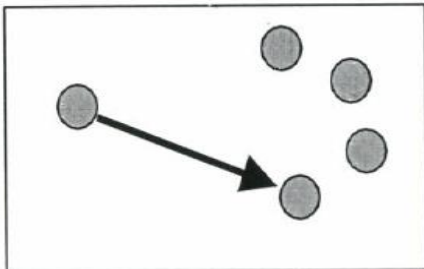
Network Adapter



Transmission Modes

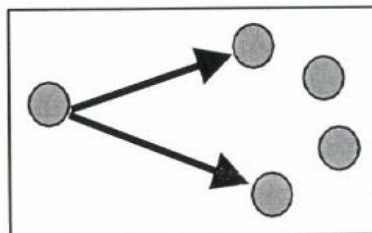
Unicast

One-to-one



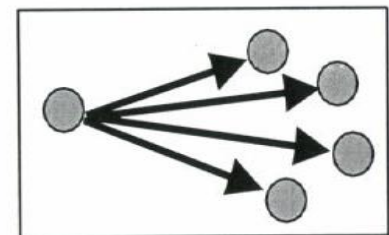
Multicast

One-to-selected group

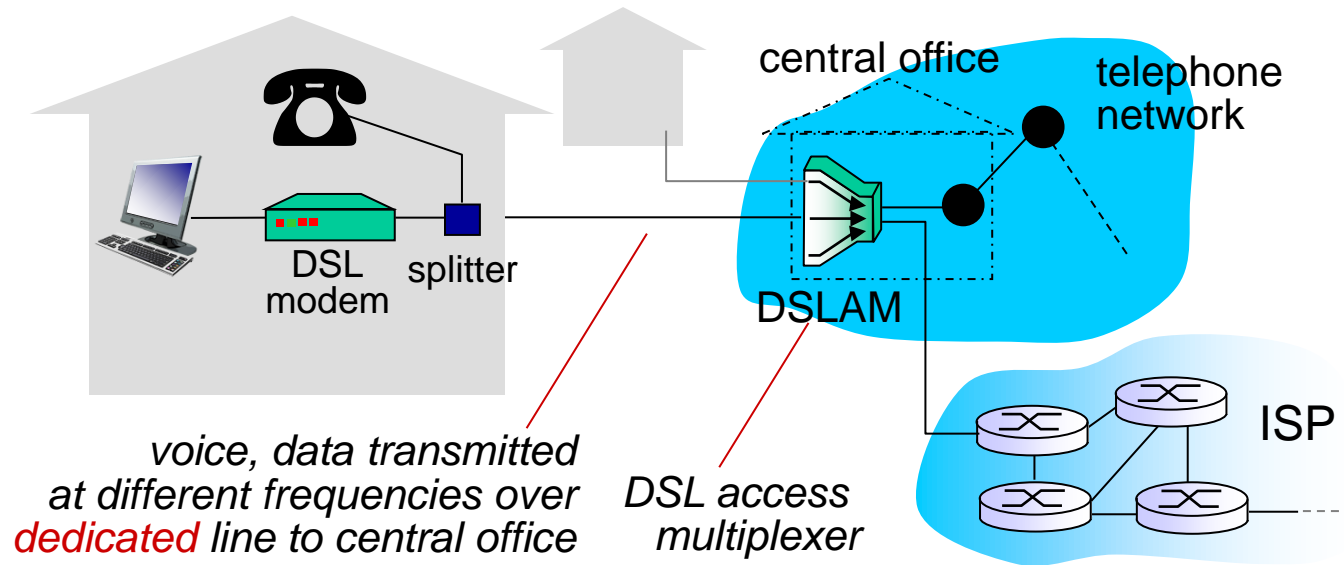


Broadcast

One-to-all



Access net: digital subscriber line (DSL)

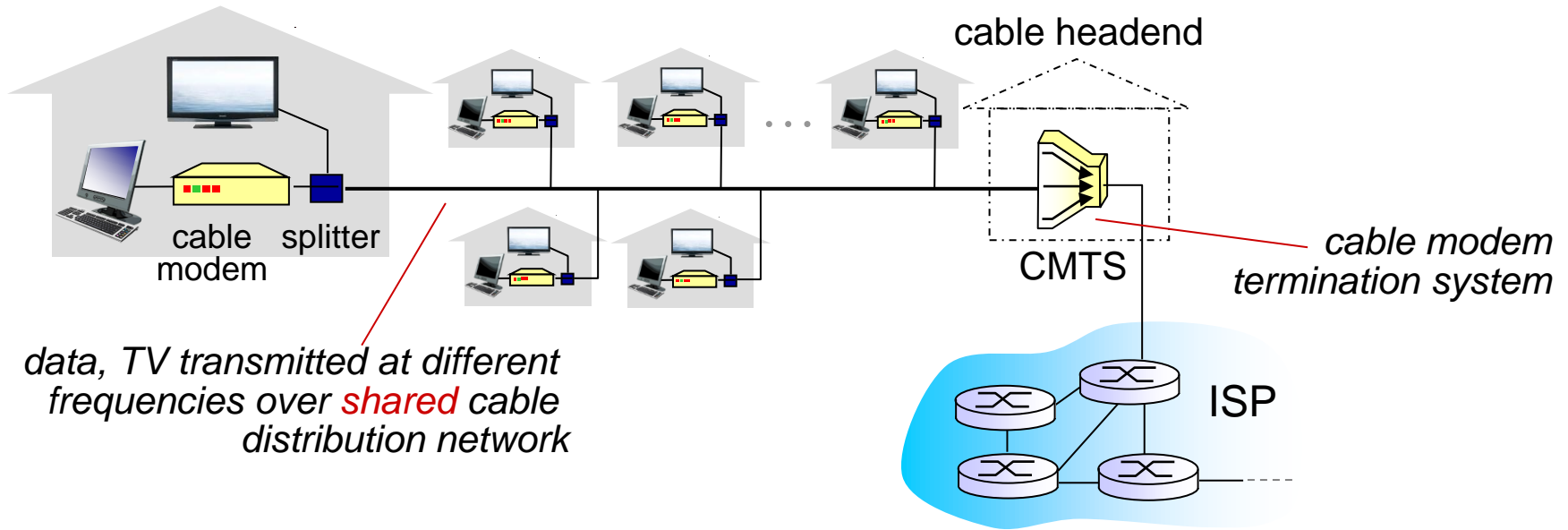


- ❖ use *existing* telephone line to central office DSLAM
 - data over DSL phone line goes to Internet
 - voice over DSL phone line goes to telephone net
- ❖ < 2.5 Mbps upstream transmission rate (typically < 1 Mbps)
- ❖ < 24 Mbps downstream transmission rate (typically < 10 Mbps)



frequency division multiplexing: different channels transmitted in different frequency bands

Access net: cable network



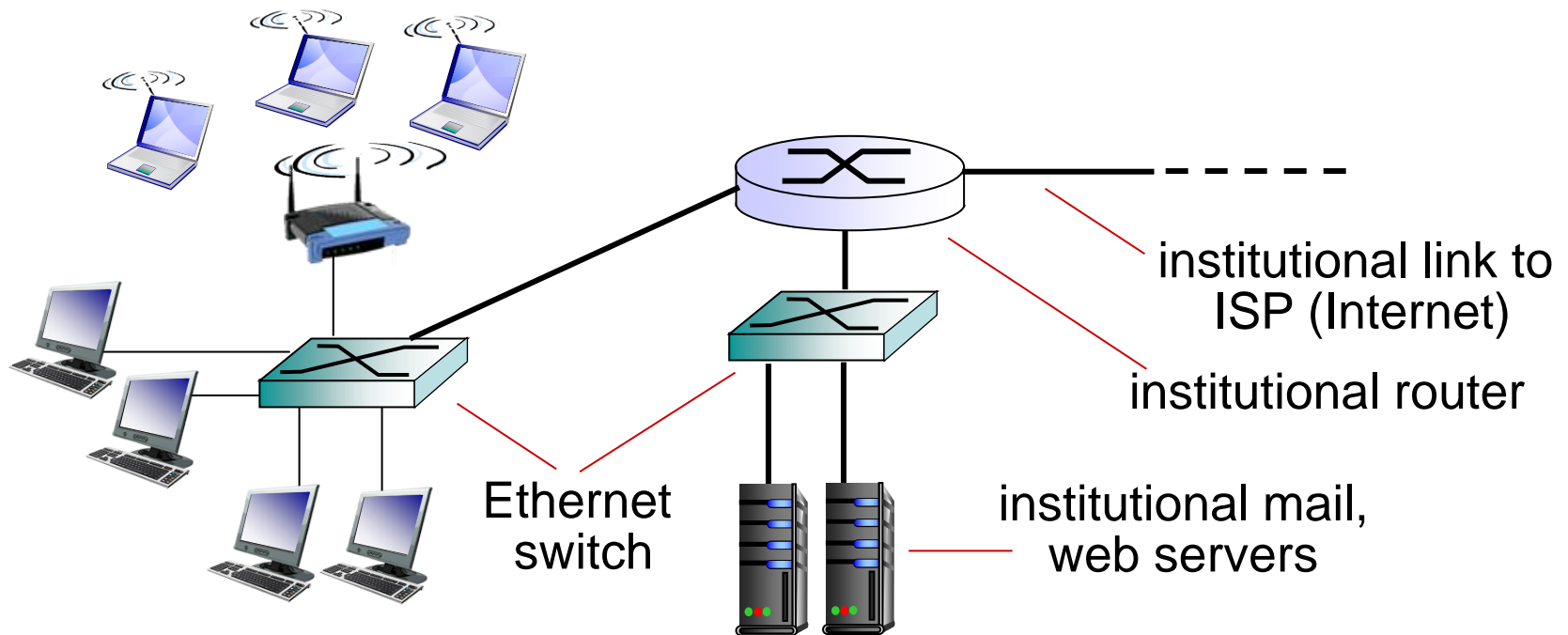
❖ HFC: hybrid fiber coax

- asymmetric: up to 30Mbps downstream transmission rate, 2 Mbps upstream transmission rate

❖ network of cable, fiber attaches homes to ISP router

- homes *share access network* to cable headend
- unlike DSL, which has dedicated access to central office

Enterprise access networks (Ethernet)



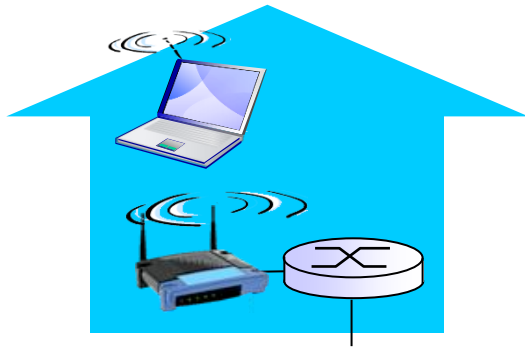
- ❖ typically used in companies, universities, etc
- ❖ 10 Mbps, 100Mbps, 1Gbps, 10Gbps transmission rates
- ❖ today, end systems typically connect into Ethernet switch

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



to Internet

wide-area wireless access

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



to Internet

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)

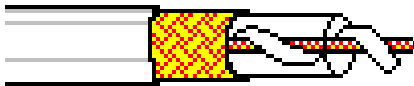
- ❖ two insulated copper wires
 - Category 5: 100 Mbps, 1 Gbps Ethernet
 - Category 6: 10Gbps



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 Gpbs 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)
 - 11 Mbps, 54 Mbps
- ❖ **wide-area** (e.g., cellular)
 - 3G , 4G cellular : ~ few Mbps
- ❖ **satellite**
 - Kbps to 45Mbps channel (or multiple smaller channels)
 - 270 msec end-end delay
 - geosynchronous versus low altitude

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Two approaches to sharing

- ▶ Reservations
- ▶ On demand

How are these implemented?

Two approaches to sharing

- ▶ Reservations → circuit switching
- ▶ On demand → packet switching

How are these implemented?

Two approaches to sharing

- ▶ Packet switching
 - packets treated on demand
 - admission control: per packet
- ▶ Circuit switching
 - resources reserved per active "connection"
 - admission control: per connection
- ▶ A hybrid: virtual circuits
 - emulating circuit switching with packets