

Computer Network

form: NYUx FCS.NET.1 Introduction to Networking

Internet

Connected Computing devices = host

Communication links – fiber, copper, radio, satellite

Transmission rate: bandwidth (how fast we move through Internet)

Packet switcher (forward packets) – routers and switches

Internet is infrastructure that provides services to applications (web, voip, games, email= provides interface to apps)

Protocol defines

- format,
- order
- action on actions

Network edge (end systems, access networks, links)

Hosts: server and clients

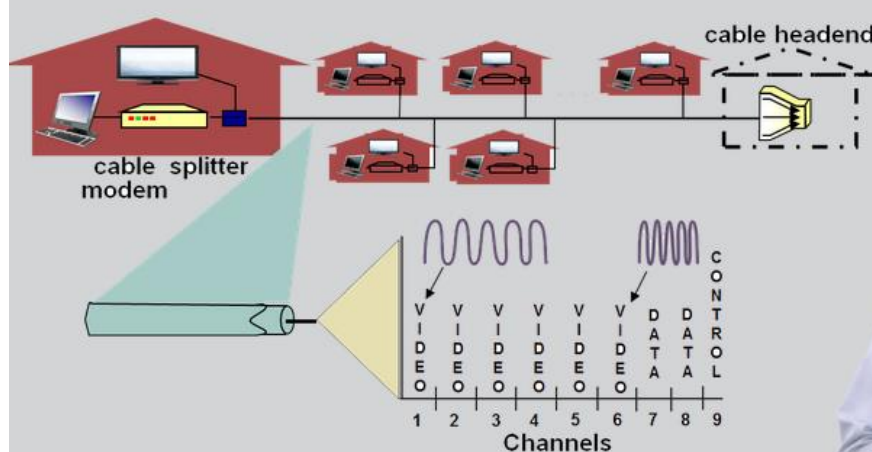
Access network wired. Wireless

Network core; Interconnected routers

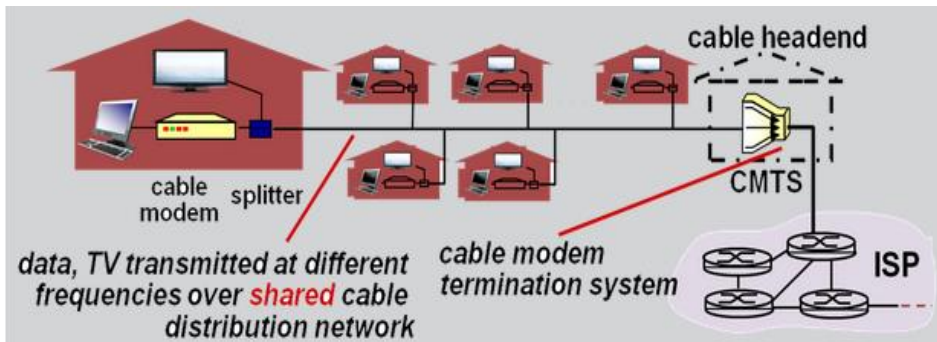
Keep in mind when connecting

- bandwidth (bits per second)
- shared or dedicated

Network Structure



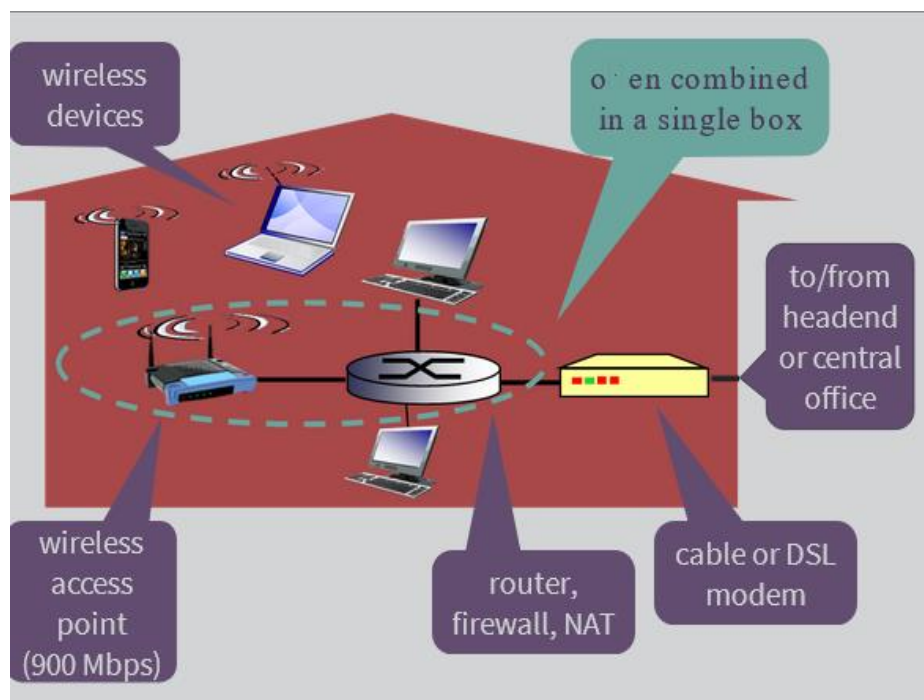
Frequency division multiplexing: different channels transmitted in different frequency bands



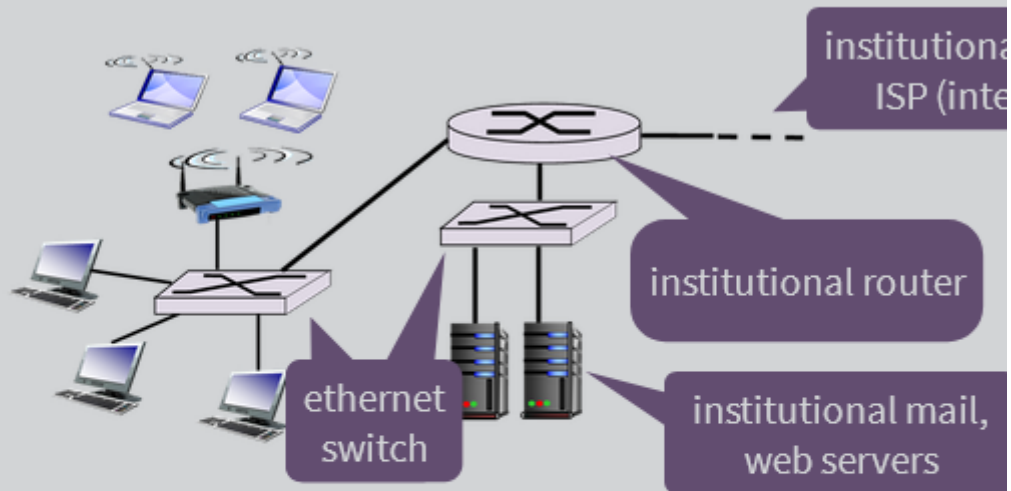
HFC: hybrid fiber coax

Asymmetric: up to 30Mbps downstream transmission rate, 2 Mbps upstream transmission rate

network of cable, fiber attaches homes to ISP router



Enterprise Access Networks (Ethe



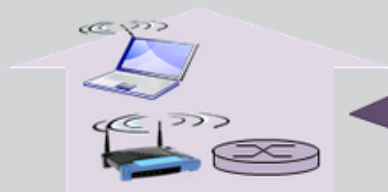
- 10 Mbps, 100Mbps, 1Gbps, 10Gbps transmission rates
- Today, end systems typically connect into Ethernet switch

Wireless Access Networks

Shared *wireless* access network connects end system to router

- Via base station aka “access point”

wireless LANs



within building (100 ft)
802.11a/b/g/n (WiFi): 11,
54...900 Mbps
transmission rate

wide-area wireless access



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

Physical Media

Guided where signals propagate in solid media (copper, fiber, coax)

Unguided media where signals propagate freely (radio)

Physical link – what lies between transmitter and receiver

- **Twisted pair (TP)**

Two insulated copper wires

Category 5: 100 Mbps, 1 Gpbs Ethernet

Category 6: 10Gbps



- ***Coaxial cable***

- Two concentric copper conductors

- Bidirectional

- Broadband:

- Multiple channels on cable

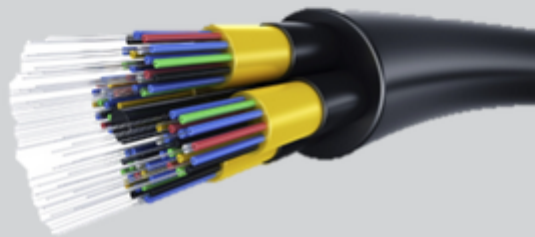
- HFC



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

Network core is mesh of interconnected routed

Packet – switching: host break application layer messaged into packages forward packets from one

router to the next across links on path to the next across links on path from source to destination

Store and Forward technique in packet switching

Entire packet must arrive at router before it can be transmitted on next link

L – dužina poruke

R – brzina kroz žicu

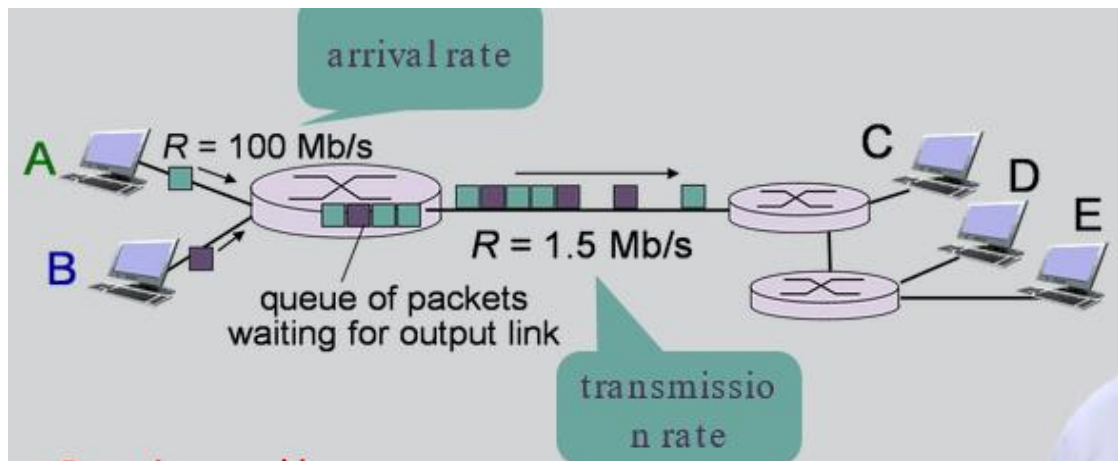
formula : $2L/R$ (assuming zero propagation delay)

Queuing delay and loss

If arrival rate in bits to link exceeds transmission rate of link for a period of time

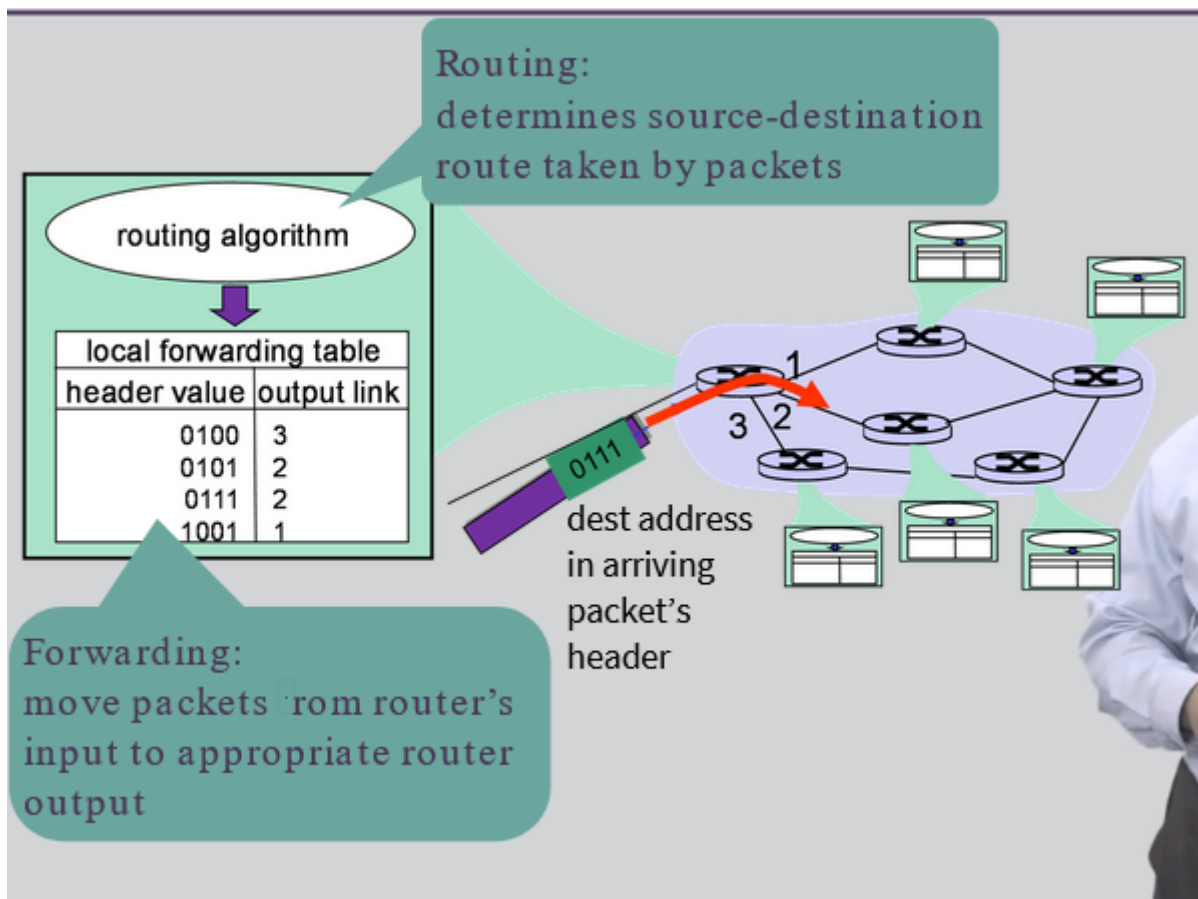
-> packets will queue (wait to be transmitted on link)

-> packets can be dropped (lost) if memory (buffer) fills up

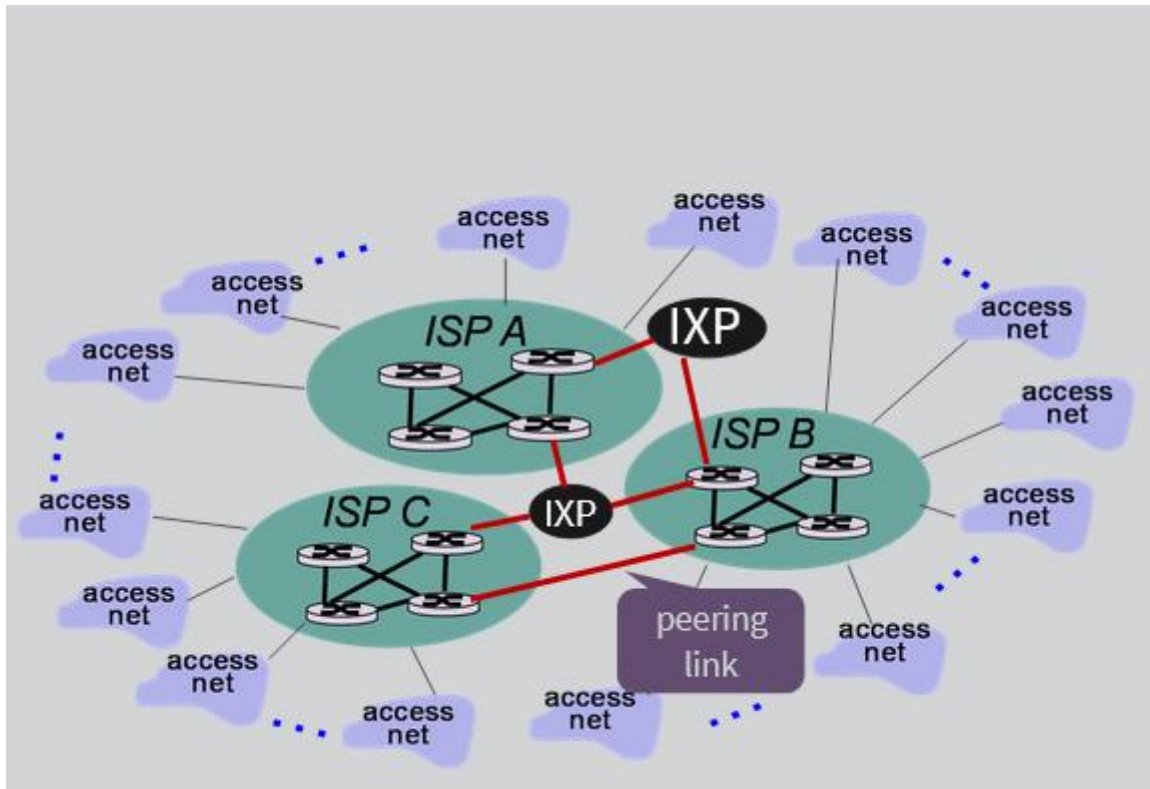


Routing: determines source-destination route taken by packets.

Forwarding: move packets from router's input to appropriate router output

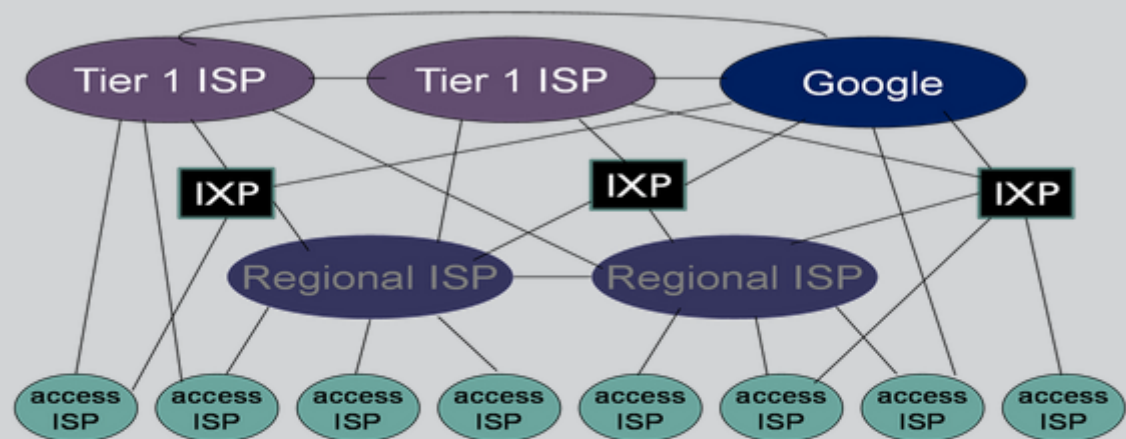


Network of Networks



IXP – internat exgcange ips

Internet Structure: Network of Networks



- “Tier-1” commercial ISPs (e.g., Level 3, Sprint, AT&T, NTT), national & international coverage
- Content provider network (e.g, Google): private network that connects it data centers to Internet, often bypassing tier-1, regional ISPs

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