Chapter 1 - Introduction to Computer Networking

Sunday, January 17, 2016 7:17 PM

ex. on message transmission, on message reciept, on message error, etc.

PROTOCOL - defines the format and order of messages exchanged and actions to be taken

HOSTS/END-SYSTEMS - interconnected devices (smartphones, computers, servers) running network applications

COMMUNICATION LINK - fiber, copper wire, radio, satellite

PACKET - block of data routed between an origin and a destination

ROUTERS/SWITCHES - devices that forward packets toward destination via links

ISP - Internet Service Provider, how end-systems access the internet

INTERNET PROTOCOL STACK - the protocols of the various layers of the internet

name of packets processed at this layer

5. APPLICATION (message)
   - → supporting network applications (ex. browsers)
   - → FTP, SMTP, HTTP
4. TRANSPORT → EXISTS ON HOSTS (segment)
   - → creates logical communication between two end-systems
   - → TCP, UDP
3. NETWORK (datagram)
   - → routes messages from source to destination
   - → IP, routing protocols
2. LINK → EXISTS ON LINKS (frame)
   - → data transfer between neighbouring network elements
   - → Ethernet, 802.11 (wifi), PPP
1. PHYSICAL
   - → transmission over communication link/medium

INTERNET

"nuts and bolts" view

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- millions of interconnected end-systems, each running network applications
- extremely redundant / robust
- interconnected ISPs, network of networks
- loosely hierarchical

service view

- communication infrastructure that enables distributed applications
  - ↳ multiple end-systems in different places
- reliable data delivery, or "best effort"
- provides application programming interface
  - ↳ ex. an API specifies how to ask for specific information

network edge — hosts (clients and servers)

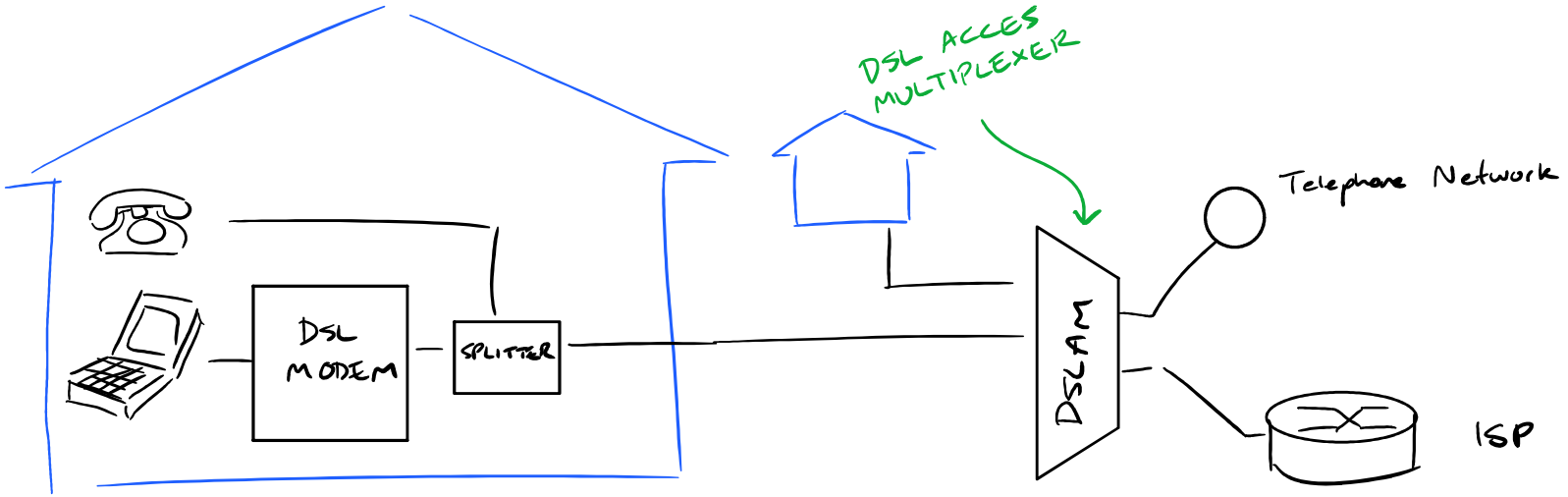
access networks — communication links, what physically connects an end-system to the first router

network core — interconnected routers, networks of networks

edge router — connects residential access nets / school or company access networks / mobile access networks to internet

DSL ACCESS NETS (digital subscriber line)

- uses existing telephone lines infrastructure to provide internet
- phones only need 0–4kHz to provide good signal
- remaining frequency range is used for internet data
  - ↳ separated into uploading/downloading ranges
    ~2.5 Mbps ~25Mbps

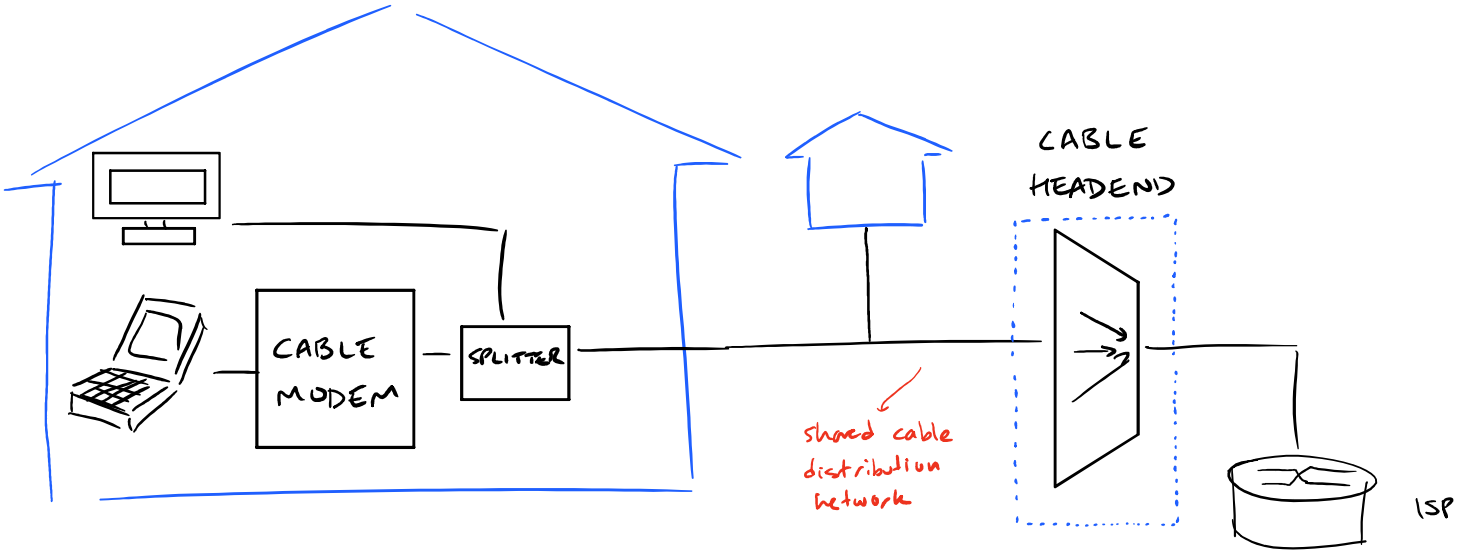


BOTH DSL & CABLE NEED MODEMS (DATA MODULATION) TO SEPARATE CHANNELS/FREQUENCIES.

CABLE ACCESS NETWORK

- uses frequency division multiplexing
  - ↳ different channels are transmitted through different bands
- lower frequency channels 1-6 transmit video
- higher frequency channels 7-8 transmit data
- highest frequency channel 9 is control channel
- cable share access network to headend
  - ↳ better because non-used bandwidth can be used by other people on your network
  - ↳ worse because less-secure → DSL has dedicated access to central office

~30Mbps d/l, 2Mbps u/l



WIRELESS ACCESS NETWORK

- connects end system to router via access point
- LANs
  - → with building (~100ft)
  - → 802.11 b/g/n (wifi)
  - → 11, 54, 72 Mbps
- wide-area wireless access
  - provided by cellular operator
  - 1-10 Mbps
  - 3G, 4G LTE, WiMax

HOSTS

Sending packets of data

1. takes message from application
2. breaks it into packets of length L bits
3. transmits packets through access network at transmission rate, R

$$\text{transmission delay} = \text{time needed to send bits into the link} = \frac{L\ (\text{bits})}{R\ (\text{bits/sec})}$$

not the time to physically transmit the signal through

the wire

LINK
- what lies between transmitter and reciever

Guided media
→ signals propagate in solid media (copper, fiber, coaxial)

Twisted Pair (TP)
- two insulated copper wires
- twisted to minimize noise
- much cheaper than optical
- category 5: 100 Mbps, 1 Gbps ethernet
- category 6: 10 Gbps

Coaxial cable
- two concentric copper conductors
- bidirectional

- broadband
  ↳ multiple channels on cable

Fiber optic cable
- glass fiber carrying light pulses, each pulse a bit
- very high speed, 10-100 Gbps
- low error rate
  ↳ repeaters spaced far apart
  ↳ immune to electromagnetic noise/interference

Unguided media
→ signals propagate freely (radio)

Radio
- signal carried in electromagnetic spectrum
- no physical wire
- bidirectional

- propagation environment effected by:
  - reflection
  - obstruction by objects
  - interference

TYPES
- terrestrial microwave, ~45Mbps
- LAN (wifi), 11Mbps, 54Mbps
- wide-area (cellular), 3G ~3 Mbps
- satellite, kbps - 45Mbps
  - ↳ 270msec end-to-end delay
- bluetooth

routing – determining route packet takes from source to destination

forwarding – moving an incoming packet from a router's input to the appropriate router output (link)

NETWORK CORE

- mesh of interconnected packet switches/routers

PACKET SWITCHING (on-demand resource allocation)

- how most of the internet transmits data
- hosts break messages into packets
  - ↳ packets are forwarded from one router to the next across links from source to destination
  - ↳ each packet transmitted at full link capacity
- store and forward
  - ↳ every message is recieved entirely before it is forwarded to the next router (∴ delay)
- simple
- very good for resource sharing, but no guarantee of bandwidth

↳ can become congested, but can support more users

CIRCUIT SWITCHING (reserved resource allocation)

- you send signals to set up an actual direct circuit from the sender to the reciever
- end-to-end resources allocated to and reserved for communication b/w source & destination

- has dedicated resources and guaranteed performance for each user
- however, no sharing of resources & unused circuits are wasted while inactive

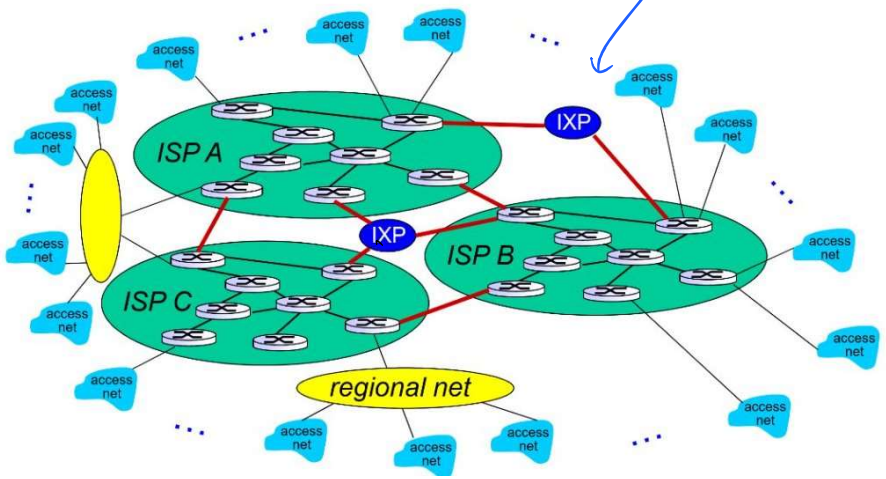
FDM (frequency division multiplexing)
frequency spectrum of a link is divided among the connections (users)

TDM (time division multiplexing)
time is divided into slots (grouped in frames) and the network dedicates one slot per frame to each connection

ISPS

- even competing ISPs must be interconnected

Internet Exchange Points are high-end routers provided by third parties.



There are also Regional Networks

Content provider networks (by Microsoft, Google, etc.) may run their own networks to bring content close to end users, bypassing regional ISPs and typical ISPs

LOSS

if router queue becomes full due to congestion, any newly arriving packets will be lost
↳ if so, the router may send a signal back to the sender notifying them

DELAY (packet-switching)

Total nodal delay (end-to-end) consists of 4 delays:

1. QUEUING DELAY
   - packet arrival rate exceeds output rate
   - only one packet may be processed at a time
   - depends on route congestion
   - La/R, where R is link transmission rate (bits/second), L is packet length (bits), a is average packet arrival rate (packet/second)
   - ↑ must be <1 or you are dropping packets

2. PROCESSING DELAY
   - router has to read data to know where to forward it (determine output link)
   - does data integrity check for bit errors

3. TRANSMISSION DELAY
   - time it takes for router to send each packet
   - L/R, where L is the packet length (bits) & R is the transmission rate (bits/second)
   - if not a congested router, this takes the longest

4. PROPAGATION DELAY
   - time to actually transmit the electrical signal through the medium
   - d/s, where d is the length of the link (m) and s is the propagation speed in medium (m/s → $\simeq 2 \cdot 10^8$ m/s)

throughput - rate at which bits can be transferred b/w sender & reciever, bits/second
- bottlenecks usually happen close to edge, like wifi
- the smallest transmission rate in a path of links a packet takes