

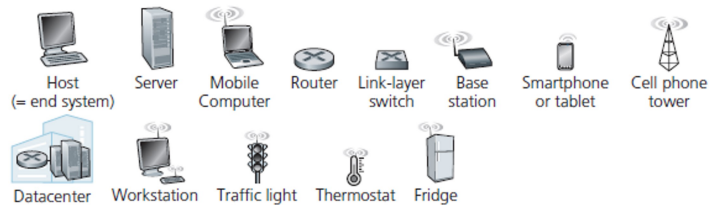
# Chapter 1 Computer Networks and the Internet

Wednesday, February 3, 2021 12:33 AM

## 1.1 What is the Internet

### - A Nuts and Bolts Description

- computer network that interconnects billions of computing devices



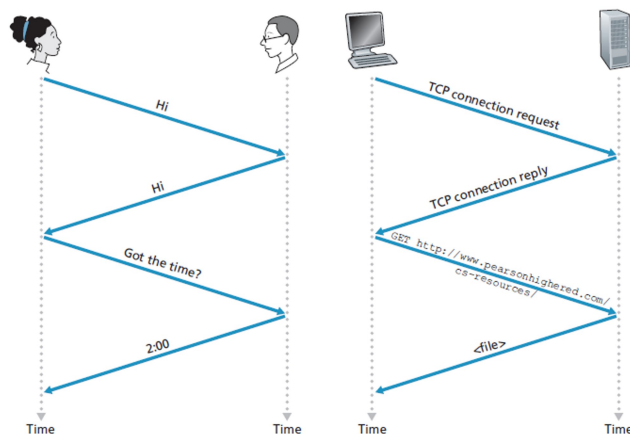
- end systems connected by network of communication links and packet switches
- links transmit at diff rates, trans rate in bits/sec
- when sys sends data to other end sys, sending sys segments data and adds header bytes to each segment (packets)
- packet switch** takes packet and forwards to one of outgoing communication links
  - routers, link-layer switches
  - routers used in network core
- sequence of communication links and packet switches traversed by packet = route or path
- systems access internet through **Internet Service Providers ISPs** including residential, university, and cellular ISPs
  - network of packet switches and com links
- Systems, packet switches, and other internet pieces run **protocols** that control sending and receiving of information within Internet
  - Transmission Control Protocol TCP
  - Internet Protocol IP

### - Services Description

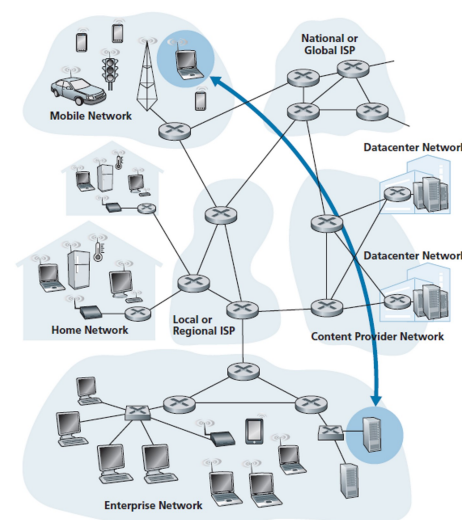
- Internet: an infrastructure that provides services to applications
- end systems attached to internet provide socket interface, specifies how program running on one end system asks internet to deliver data to specific dest program on other system

### - Protocol

- 2+ communicating entities running same protocol to accomplish task



- transmission and receipt of message and action taken when messages are sent and received

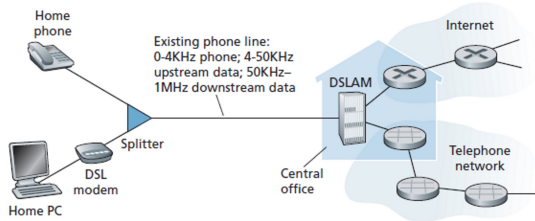


## 1.2 The Network Edge

- computers and other devices

### - Access networks

- Home access: DSL, cable, FITH, 5G Wireless
- broadband res access = digital subscriber line DSL
- phone call and internet connection can share DSL link at same time
  - phone line carries both data and traditional phone signals encoded at different frequencies

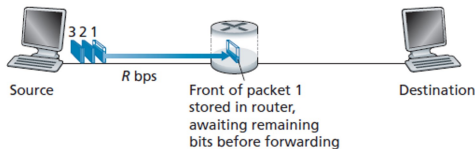


### - Physical Media

- for transmitter-receiver pair, bit is sent by propagating EM waves or optical pulses across a physical medium
- **guided media**
  - waves guided along solid medium such as a fiber optic cable, twisted pair copper wire, coaxial cable
- **unguided media**
  - waves propagate in atmosphere and outer space with wireless LAN or digital satellite channel

## 1.3 Network Core

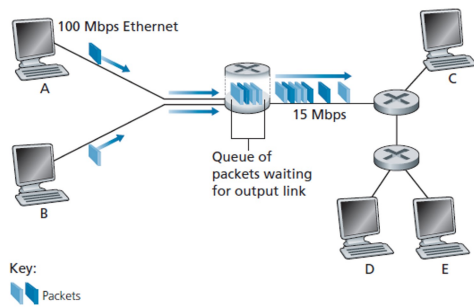
- mesh of packet switches and links that interconnects internet end systems
- **Packet Switching**
  - to send message from source to destination, source breaks msg into packets
  - each packet travels through communication links and packet switches (routers and link layer switches)
  - packets are transmitted over each communication link at rate = full transmission rate of link
    - if source or packet switch sending a packet of L bits over link w/ trans rate of R bits/sec,  $d_{trans} = L/R \text{ sec}$
  - **Store and Forward Transmission**



- packet switches use store and forward SAF at inputs to the links
- switch must **receive entire packet** before it can begin to transmit first bit of packet onto outbound link
  - ex. source transmitted some of packet 1, front of packet 1 has already arrived at the router
  - since router uses SAF, cant transmit bits received, need to buffer and store packet bits
  - after router receives all of packet bits, can transmit packet onto outbound link
- routers need to receive, store and process entire packet before forwarding
  - source transmits at  $t=0$ , at  $t=L/R$ , source transmits entire packet, and has been received and stored at router (if no propagation delay)
  - at  $t= L/R$ , router transmits packet onto outbound link
  - at  $t=2*L/R$ , router has transmitted entire packet, entire packet received by destination
- sending one packet from source to destination over a path of N links of rate R (N-1 routers b/w source and dest)

$$d_{\text{end-to-end}} = N \frac{L}{R}$$

- **Queuing Delays and Packet Loss**
  - each packet switch has an output buffer, stores packets that router is about to send into link
  - if arriving packet needs to be transmitted onto link but link is busy with transmission of another packet, packet waits in output buffer
  - in addition of SAF delays, packets have queuing delays



- packets arriving to full buffer = packet loss, arriving packet or one of already queued packets will be dropped
- **Forwarding Tables and Routing Protocols**
  - how does router determine which link it should forward packet onto
  - **Packet forwarding**
    - end system has IP address
    - source includes destination IP address in packet's header
    - router examines packet destination address and forwards packet to adjacent router using a forwarding table that maps destination addresses to router's outbound links