بسمه تعالی


School of Computer Engineering

# Advanced Computer Networks

Introduction: Basics of Computer Networks

Part 2

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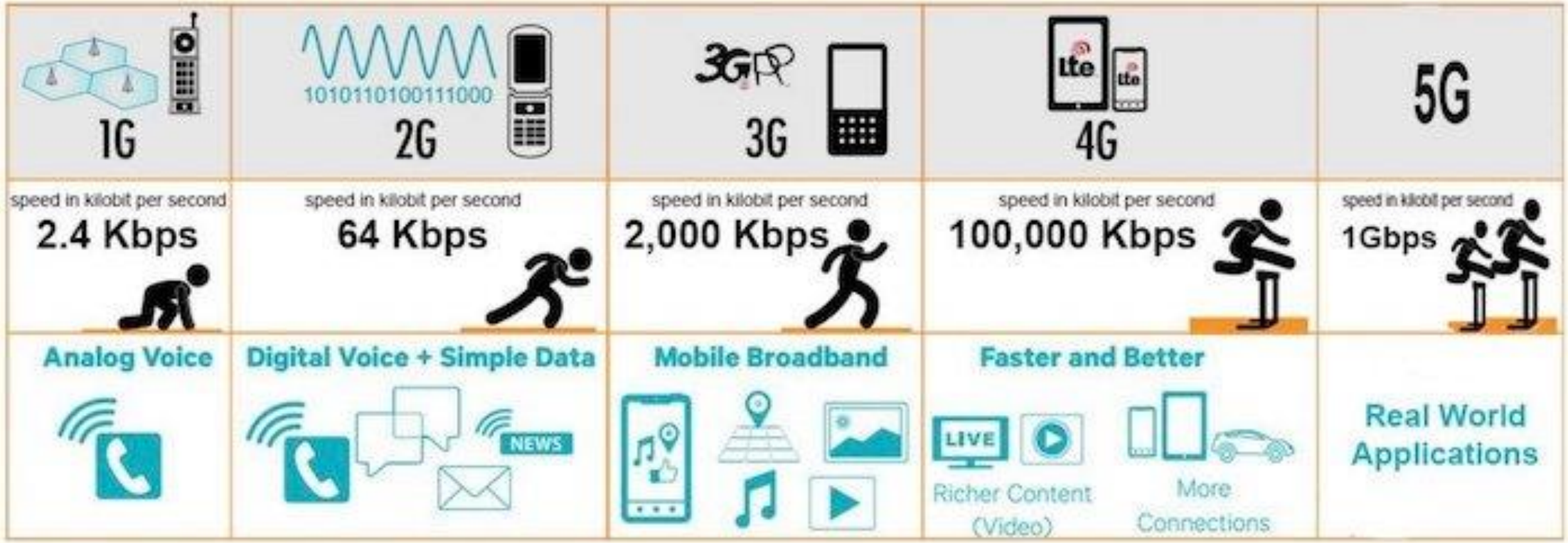
Fall 1401

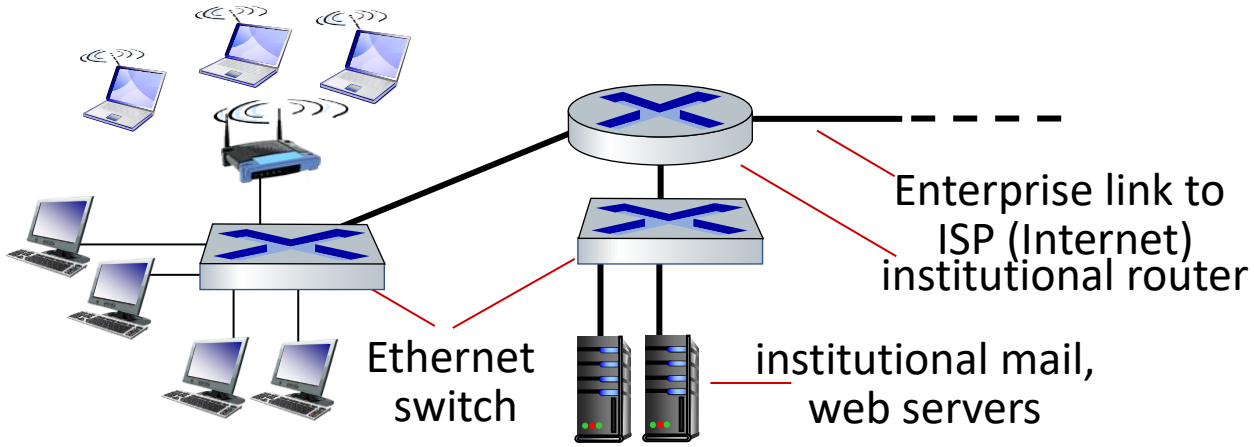
# Wireless access networks

## Cellular Networks and Standards

- Evolution of cellular networks: 3GPP is an important standardization organization here.



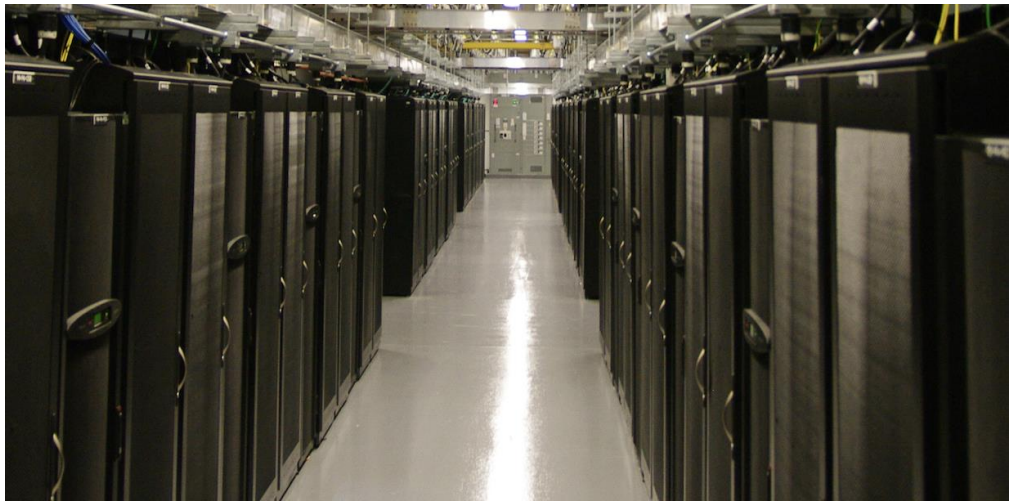
# Access networks: enterprise networks



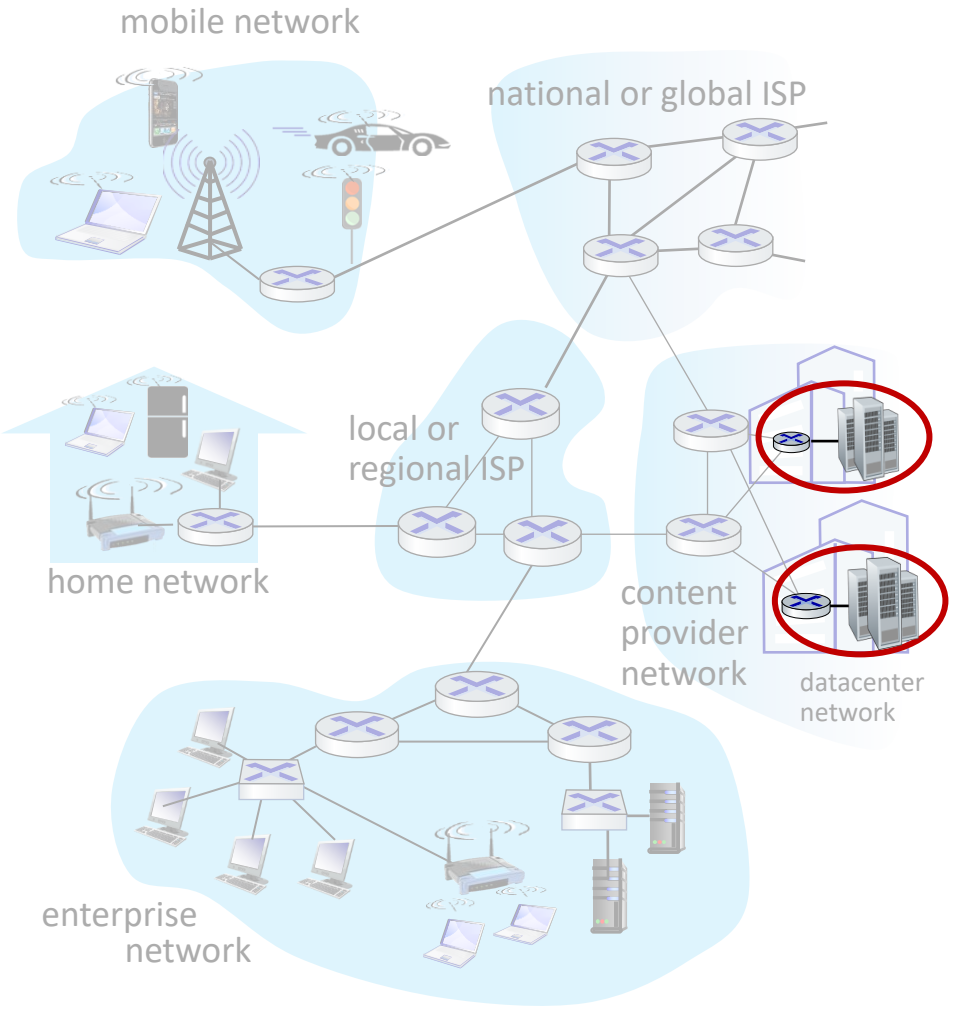

- companies, universities, etc.
- mix of wired, wireless link technologies, connecting a mix of switches and routers
  - Ethernet: wired access at 100Mbps, 1Gbps, 10Gbps
  - WiFi: wireless access points at 11, 54, 450 Mbps

# Access networks: data center networks

- high-bandwidth links (10s to 100s Gbps) connect hundreds to thousands of servers together, and to Internet



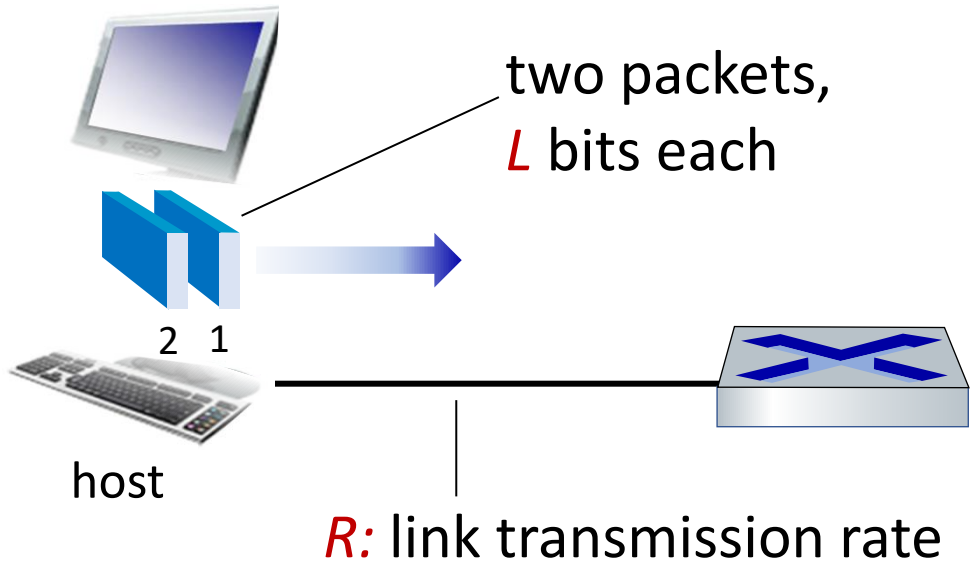
*Courtesy:* Massachusetts Green High Performance Computing Center (mghpcc.org)



# Host: sends *packets* of data

host sending function:

- takes application message
- breaks into smaller chunks, known as *packets*, of length *L* bits
- transmits packet into access network at *transmission rate R*
  - link transmission rate, aka link *capacity, aka link bandwidth*



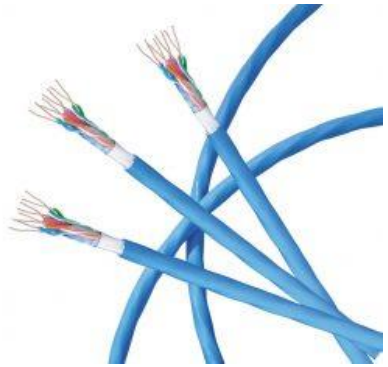

$$\text{packet transmission delay} = \text{time needed to transmit } L\text{-bit packet into link} = \frac{L \text{ (bits)}}{R \text{ (bits/sec)}}$$

# Links: 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 Ethernet



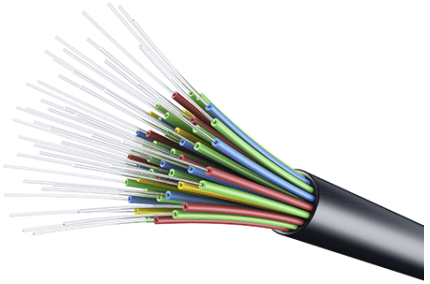
# Links: physical media

## Coaxial cable:

- two concentric copper conductors
- bidirectional
- broadband:
  - multiple frequency channels on cable
  - 100's Mbps per channel

## Fiber optic cable:

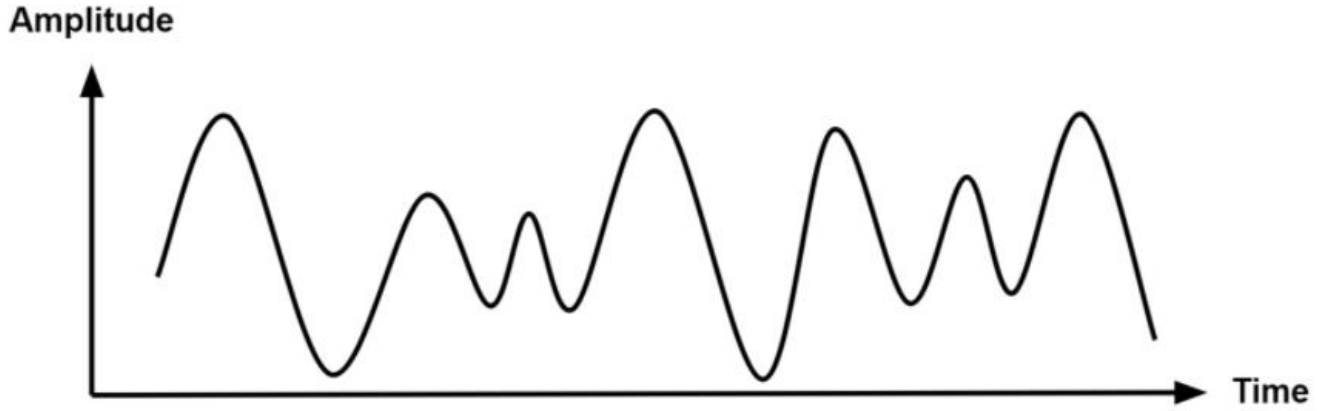
- glass fiber carrying light pulses, each pulse a bit
- high-speed operation:
  - high-speed point-to-point transmission (10's-100's Gbps)
- low error rate:
  - repeaters spaced far apart
  - immune to electromagnetic noise



# Links: physical media

## Wireless radio: Frequency

- An electrical signal can be presented in time.
- The amplitude of a signal in time completely defines that signal.
- So why define another concept of *frequency*?



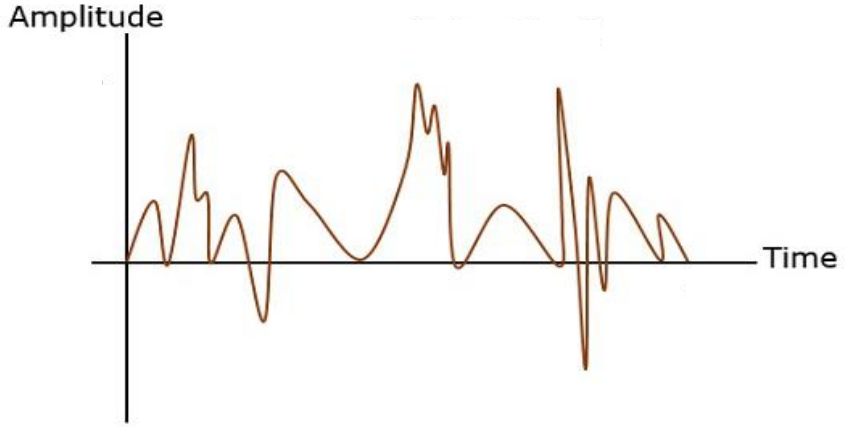
# Links: physical media

## Wireless radio: Frequency

- Time is an obvious, independent and easily sensible phenomena.
- How about frequency?
- In general, frequency is defined as the rate of change of a signal in time.

Low frequency

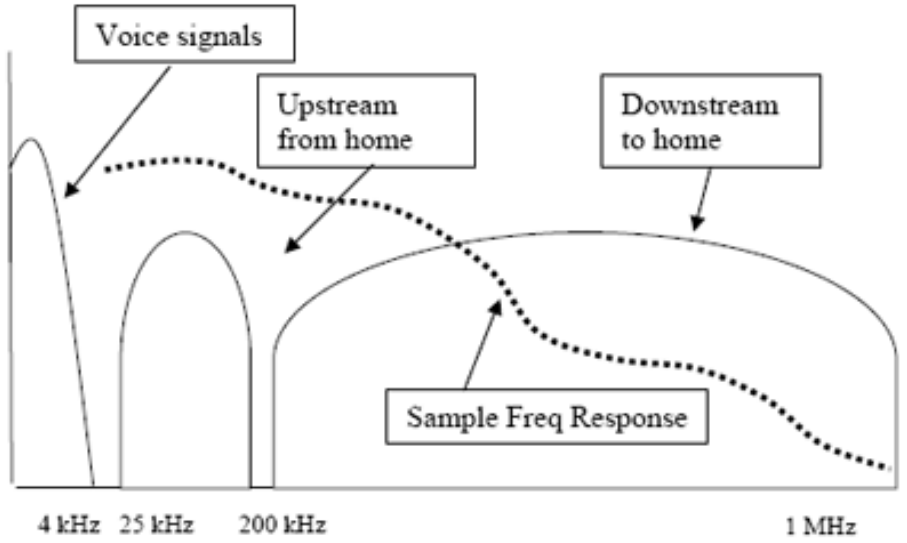

High Frequency



# Links: physical media

## Wireless radio: Frequency

- The characteristics of transmission medias are more dependable on frequency rather than time.
- Example: Copper wire in fixed telephone

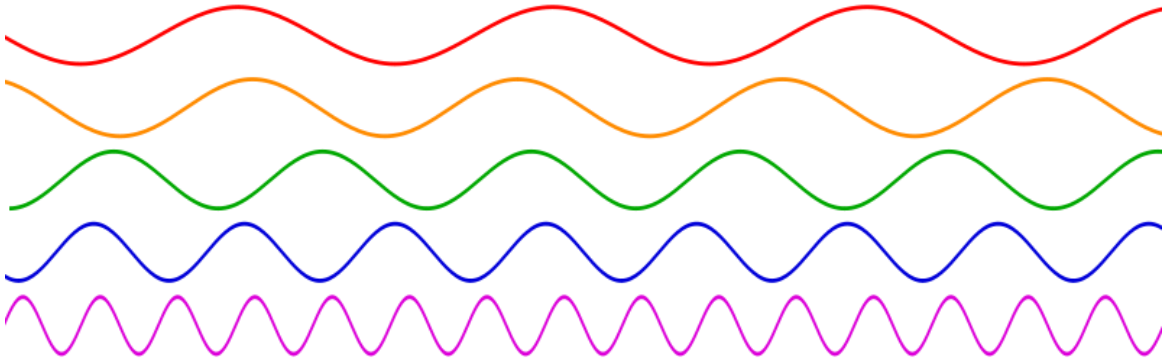



- Two important reasons:
  - Systems (transmitter-receiver pairs) support a specified range of frequencies.
  - Many systems are easier to analyze in frequency than time.

# Links: physical media

## Wireless radio: Frequency

- Family of sine waves are used to precisely model and describe systems in frequency.
- The reason behind this is the direct relation of changes of this signals by decreasing their period duration, i.e. by increasing frequency.
- On the other hand, analyzing the system under this signals is well-established.



# Links: physical media

## Wireless radio

- signal carried in various “bands” in electromagnetic spectrum
- no physical “wire”
- broadcast, “half-duplex” (sender to receiver)
- propagation environment effects:
  - reflection
  - obstruction by objects
  - Interference/noise

## Radio link types:

- Wireless LAN (WiFi)
  - 10-100’s Mbps; 10’s of meters
- wide-area (e.g., 4G cellular)
  - 10’s Mbps over ~10 Km
- Bluetooth: cable replacement
  - short distances, limited rates
- terrestrial microwave
  - point-to-point; 45 Mbps channels
- satellite
  - up to 45 Mbps per channel
  - 270 msec end-end delay