ECE 356/COMPSI 356 Computer Network Architecture Physical Layer and Hardware Monday September 2nd, 2019



Lecture Outline

- What happens when you communicate on a link
- Link capacity: Shannon-Hartley theorem
- Link properties

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Different types of physical links

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What Actually Happened: Sender Side

- Payload ("Hi Alice") is encapsulated into a packet
- The packet is encapsulated into a frame
 Frame: a block of data
- The frame is transmitted from main memory to the network adaptor
- At the adaptor, the frame is encoded into a bit stream
- The encoded bit stream is modulated into signals and put on the wire

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At the Receiver: Reverse Process

- Signals demodulated into a bit stream
- · The bit stream decoded into a frame
- The frame is delivered to a node's main memory
- Payload is decapsulated from the frame

Hi Alice!



Lecture Outline What happens when you communicate on a link Link capacity: Shannon-Hartley theorem Link properties Different types of physical links

Link Capacity: Shannon-Hartley Theorem (1/2)

- One of the most famous formulas in communications
 - Domain of information theory
- <u>Theoretical upper bound</u> of the capacity of a link
 - ≻ Any link
 - Capacity: a function of the bandwidth and the signalto-noise ratio of the link

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Link Capacity: Shannon-Hartley Theorem (2/2)

- C = B*log₂(1+S/N)
 C in bps, B in Hz, S avg. signal power, N avg. noise power
 Example: voice-grade phone line
 > B = 3300 Hz 300 Hz = 3000Hz
 - > SNR in dB = $10^{10}(S/N)$
 - >E.g., SNR 30dB → S/N = 1000
 - > C = 3000 x log₂(1001) = 30 kbps

Shannon-Hartley Theorem: Take-Away

- $C = B * log_2(1 + S/N)$
- Only two ways to build a high-capacity link:
 > Have a high-bandwidth channel
 - > Achieve a high signal-to-noise ratio

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Guided Media: Twisted Pair and Coaxial Cables

Twisted pair (TP)

- Two insulated copper wires
 - Category 5: 100 Mbps, 1 Gbps Ethernet
 - ➤ Category 6a: 10 Gbps

Coaxial cable:

- Two concentric copper conductors
- Commonly used for cable TV



Glass fiber carrying light pulses, each pulse a bit High-speed operation: > High-speed point-to-point transmission (e.g., 10' s-100' s Gbps transmission rate)

- Low error rate:
 - ➤ Low signal attenuation up to 100 km
 - Immune to electromagnetic noise
- Long-distance links are <u>almost exclusively fiber</u>
 - Expensive optical transmitters, receivers, switches hinder deployment for short-haul communications



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<section-header> Wireless links transmit electromagnetic signals through space – unguided media Used also by radio, TV broadcasting, satellite communications Affected by noise, e.g., microwave ovens Shared media Divided by frequency and space Different communication types: Very short range (1-2 m) Local-area (10-100 m) Wide-area (kms)

Wireless Links: Spectrum Allocation

- Unlicensed spectrum
 > WiFi, Bluetooth, Infrared
- FCC determines who can use a spectrum in a geographic area, i.e., "licensing"
 - Auction is used to determine the allocation
 - Expensive to become a cellular carrier
- More about wireless communications starting next week

Lecture Summary

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Next Lecture

• Link layer

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