CSCI 491-01
Topics: Internet Programming
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Data-link Layer

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Chapter 5: The Data Link Layer

Our goals:

- Understand principles behind data-link layer services:
  - Sharing a broadcast channel: multiple access
  - Link layer addressing
  - How does Ethernet work?
- Instantiation and implementation of various link layer technologies
- Note: chapter 5 is only partially covered

Link Layer

5.1 Introduction and services

5.2 Error detection and correction

5.3 Multiple access protocols

5.4 Link-Layer Addressing

5.5 Ethernet

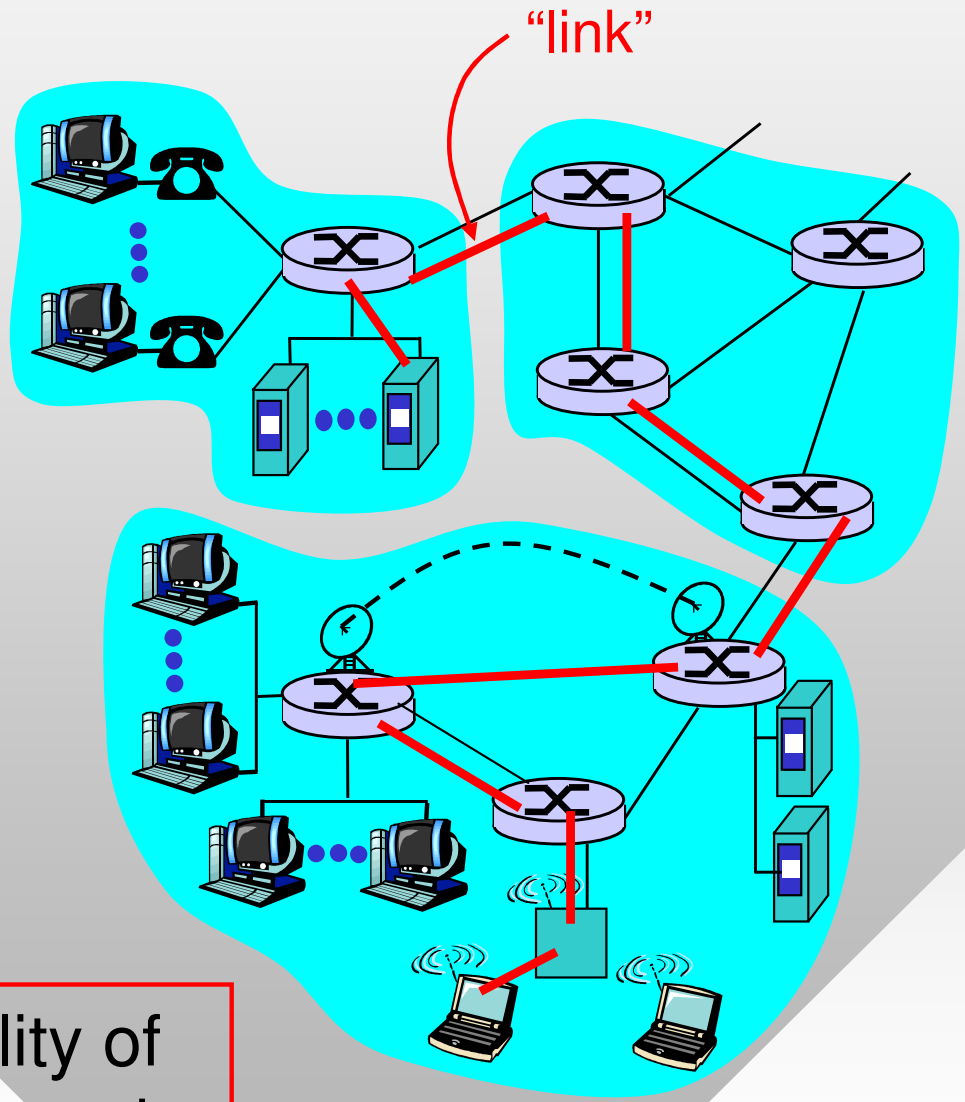
5.6 Hubs and switches

Summary

Link Layer: Introduction

Terminology:

- Hosts and routers are **nodes**
- Communication channels that connect adjacent nodes along communication path are **links**
  - Wired links
  - Wireless links
  - Shared media (LANs)
- Layer-2 packet is a **frame**, encapsulates datagram



Data-link layer has responsibility of transferring datagram from one node to adjacent node over a single link

Link Layer: Context

- Datagram transferred by different link protocols over different links:
  - e.g., Ethernet on first link, frame relay on intermediate links, 802.11 on last link
- Each link protocol provides different services
  - e.g., may or may not provide rdt over the link

Transportation analogy

- Trip from Princeton to Paris
  - Limo: Princeton to JFK
  - Plane: JFK to Geneva
  - Train: Geneva to Paris
- Tourist = datagram
- Transport segment = communication link
- Transportation mode = link layer protocol
- Travel agent = routing algorithm

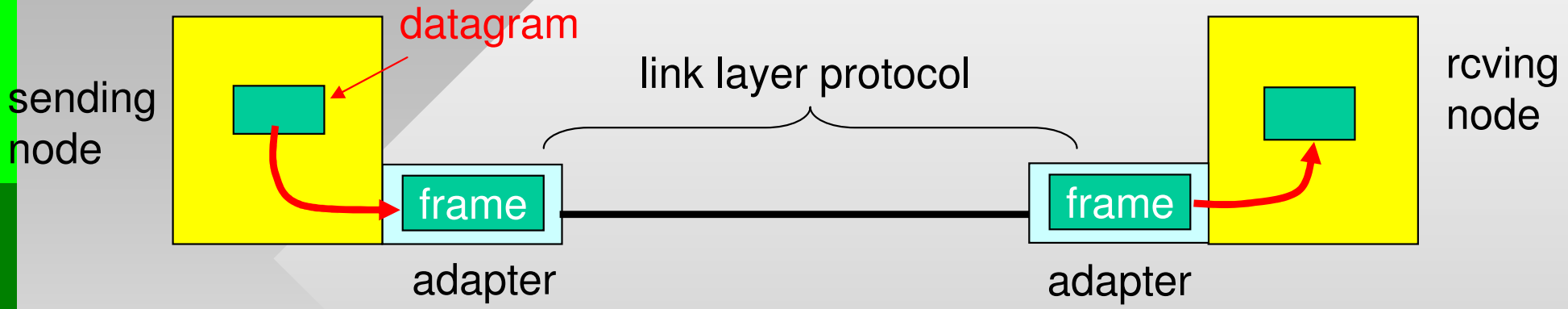
Link Layer Services

- Framing, link access:
  - Encapsulate datagram into frame, adding header, trailer
  - Channel access if shared medium
  - “MAC” addresses used in frame headers to identify source, dest (different from IP address)
- Reliable delivery between adjacent nodes
  - We learned how to do this already (chapter 3)
  - Seldom used on low bit error link (fiber, some twisted pair)
  - Wireless links: high error rates
- Q: Why both link-level and end-end reliability?

Link Layer Services (more)

- Flow Control:
  - Pacing between adjacent sending and receiving nodes
- Error Detection:
  - Errors caused by signal attenuation, noise
  - Receiver detects presence of errors and signals sender for retransmission or drops frame
- Error Correction:
  - Receiver identifies *and corrects* bit error(s) without resorting to retransmission
- Half-duplex and full-duplex
  - With half duplex, nodes at both ends of link can transmit, but not at same time

Adaptors Communicating



- Link layer implemented in “adaptor” (aka NIC)
  - Ethernet card, PCMCI card, 802.11 card
- Sending side:
  - Encapsulates datagram in a frame
  - Adds error checking bits, rdt, flow control, etc.
- Receiving side
  - Looks for errors, rdt, flow control, etc
  - Extracts datagram, passes to rcving node
- Adapter is semi-autonomous
- Link & physical layers

Link Layer

5.1 Introduction and services

5.2 Error detection and correction

5.3 Multiple access protocols

5.4 Link-Layer Addressing

5.5 Ethernet

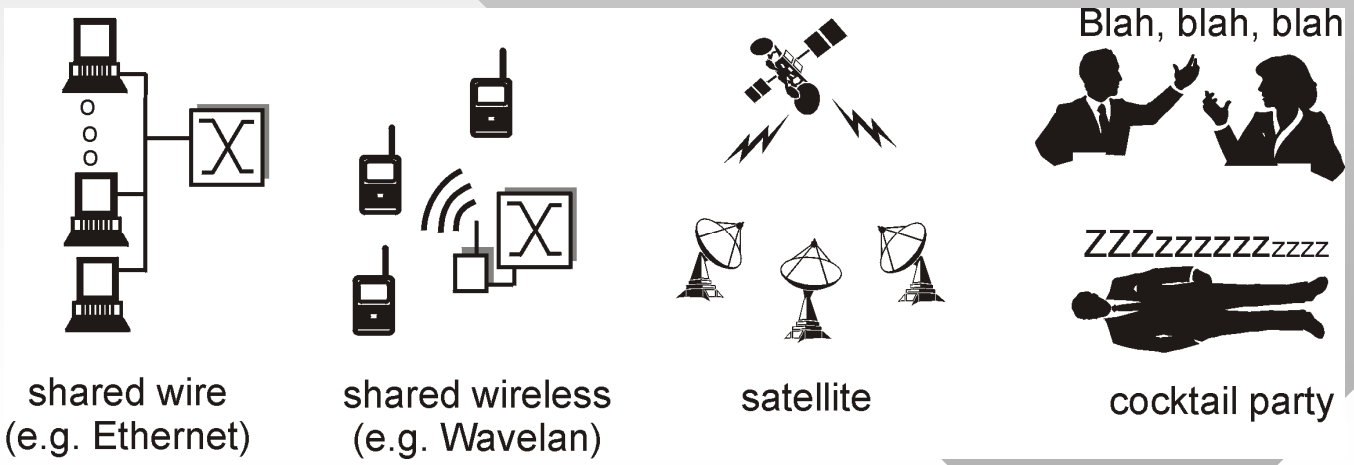
5.6 Hubs and switches

Summary

Multiple Access Links and Protocols

Two types of “links”:

- Point-to-point
  - PPP for dial-up access
  - Point-to-point link between Ethernet switch and host
- Broadcast (shared wire or medium)
  - Traditional Ethernet
  - Upstream HFC
  - 802.11 wireless LAN, satellite



Multiple Access Protocols

- Single shared broadcast channel
- Two or more simultaneous transmissions by nodes is called interference
  - Collision if node receives two or more signals at the same time

Multiple access protocol

- Distributed algorithm that determines how nodes share channel, i.e., determine when node can transmit
- Communication about channel sharing must use channel itself!
  - No out-of-band channel for coordination

Ideal Multiple Access Protocol

Desired properties

1. Single node can achieve full channel rate R
2. When M nodes want to transmit, each can send at average rate R/M
3. Fully decentralized:
   - No special node to coordinate transmissions
   - No synchronization of clocks, slots
4. Simple

MAC Protocols: A Taxonomy

Three broad classes:

- Channel Partitioning
  - Divide channel into smaller “pieces” (time slots, frequency, code)
  - Allocate piece to node for exclusive use
- Random Access
  - Channel not divided, allow collisions
  - “Recover” from collisions
- “Taking turns”
  - Nodes take turns, but nodes with more to send can take longer turns