Chapter 5
Data Link Layer

Reti di Elaboratori

Corso di Laurea in Informatica

Università degli Studi di Roma "La Sapienza"

Canale A-L

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Chapter 5: The Data Link Layer

Our goals:

- understand principles behind data link layer services:
  - error detection, correction
  - sharing a broadcast channel: multiple access
  - link layer addressing
  - reliable data transfer, flow control: *done!*
- instantiation and implementation of various link layer technologies

5a: Data Link Layer 5-2

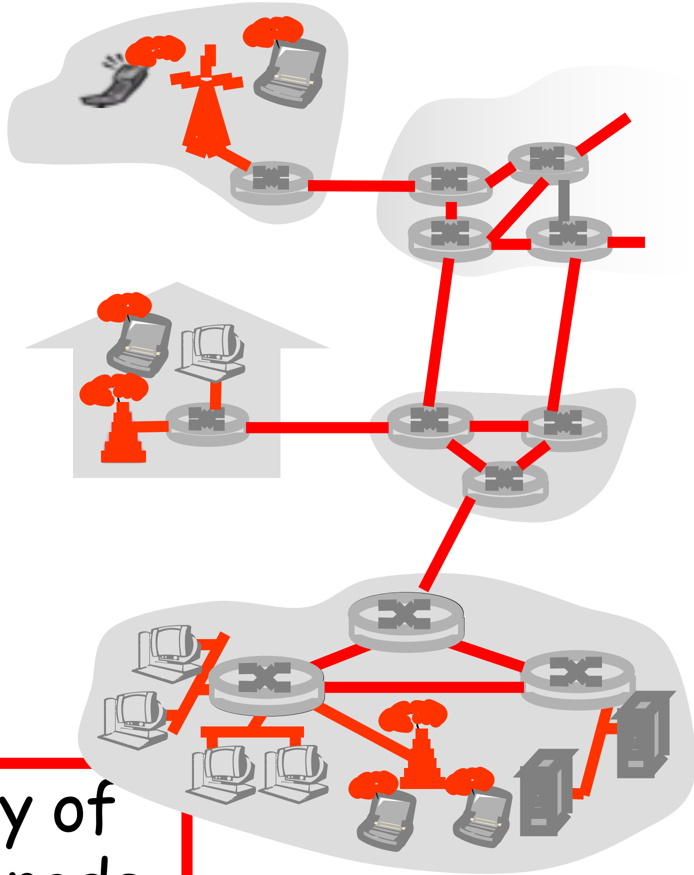
Link Layer

- 5.1 Introduction and services
- 5.2 Error detection and correction
- 5.3Multiple access protocols
- 5.4 Link-layer Addressing
- 5.5 Ethernet
- 5.6 Link-layer switches
- 5.7 PPP
- 5.8 Link virtualization: MPLS
- 5.9 A day in the life of a web request

Link Layer: Introduction

Some terminology:

- hosts and routers are **nodes**
- communication channels that connect adjacent nodes along communication path are **links**
  - wired links
  - wireless links
  - 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 link

5a: Data Link Layer 5a-4

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 link

transportation analogy

- trip from Princeton to Lausanne
    - limo: Princeton to JFK
    - plane: JFK to Geneva
    - train: Geneva to Lausanne
- tourist = datagram
- transport segment = communication link
- transportation mode = link layer protocol
- travel agent = routing algorithm

Link Layer Services

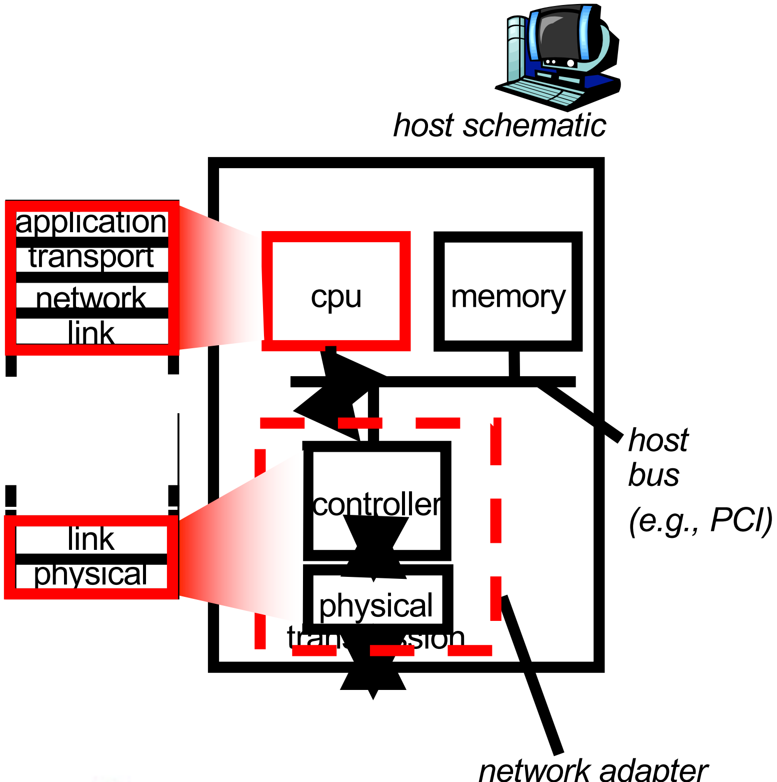
- *Framing:* understand where a frame starts and ends
- *link access*
  - **channel access if shared medium**
    - **avoids or limits the effect of collisions over a broadcast channel**
- addressing
  - "MAC" addresses used in frame headers to identify source, dest
    - different from IP address!
- *error detection*:
  - errors caused by signal attenuation, noise.
  - receiver detects presence of errors:
    - 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

Link Layer Services (more)

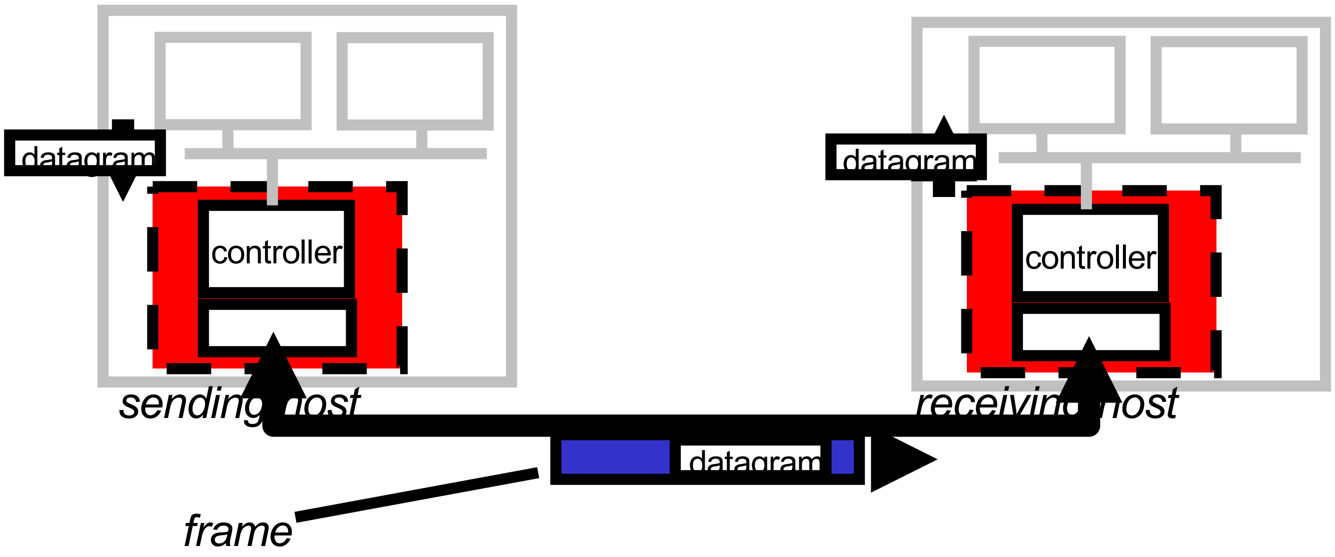
- *reliable delivery between adjacent nodes*
  - we learned how to do this already (chapter 3)!
  - seldom used on low bit-error link (fiber, some twisted pair)
  - wireless links: high error rates
    - Q: why both link-level and end-end reliability?
- *flow control:*
  - pacing between adjacent sending and receiving nodes

Where is the link layer implemented?

- in each and every host
- link layer implemented in “adaptor” (aka *network interface card* NIC)
  - Ethernet card, PCMCI card, 802.11 card
  - implements link, physical layer
- attaches into host’s system buses
- combination of hardware, software, firmware



Adaptors Communicating



- sending side:
  - encapsulates datagram in frame
  - adds error checking bits, rdt, flow control, etc.
- receiving side
  - looks for errors, rdt, flow control, etc
  - extracts datagram, passes to upper layer at receiving side

Link Layer Services--framing

- PHY layer accepts only a raw bit stream and attempts to deliver to destination

  0110001100001100000000100110000000100001

  - Communication is not necessarily error free
  - Multiplexing of different flows of information
    - → Data link layer breaks the bit stream up into discrete frames (FRAMING) and computes the checksum for each frame (ERROR DETECTION)

5a: Data Link Layer 5a-10

Link Layer Services

Framing:

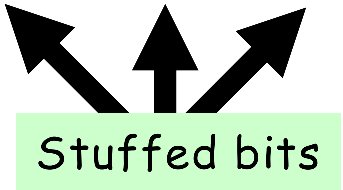
- encapsulate datagram into frame, adding header, trailer
- How to delimit frames:
  - We cannot count on some time gap (strong synch requirement and jitter requirement)
  - Character count: A field in the header specifies the number of characters in the frame (OK but loose synch in case of transmission error)
  - Starting and ending characters with character stuffing
    - ES ASCII character sequence DLE STX (Data Link Escape Start of TeXt)…DLE ETX (ETX=End of TeXt)
    - What if binary data are transmitted with sequences corresponding to DLE STX or SLE ETX occurring in the data?
    - Character stuffing: before transmitting add DLE before each of
      - such sequences in the data: DLE STX→DLE DLE STX

5: DataLink Layer 5-11

Link Layer Services

Framing:

- encapsulate datagram into frame, adding header, trailer
- How to delimit frames:
  - Starting and ending flags with bit stuffing
    - Each frame begins and ends with a special bit pattern, e.g. 01111110 (**flag** sequence)
    - Techniques to avoid problems in case the flag sequence appears in data: whenever data link layer encounters five consecutive ones in the data add a 0 bit in the outgoing bit stream (removed at the other end of the link)→bit stuffing
    - Es.: (a) 011011111111111111110010
    - (b) 011011111**0**11111**0**11111**0**10010


Stuffed bits

Link Layer Services

Framing:

- encapsulate datagram into frame, adding header, trailer
- How to delimit frames:
  - Physical layer coding variations
    - For instance if Manchester encoding used a High-High or Low-Low sequence
  - A combination of character count and one of the other typically used

5a: DataLink Layer 5a-13