CS 372 Lecture #34

Data-link Layer

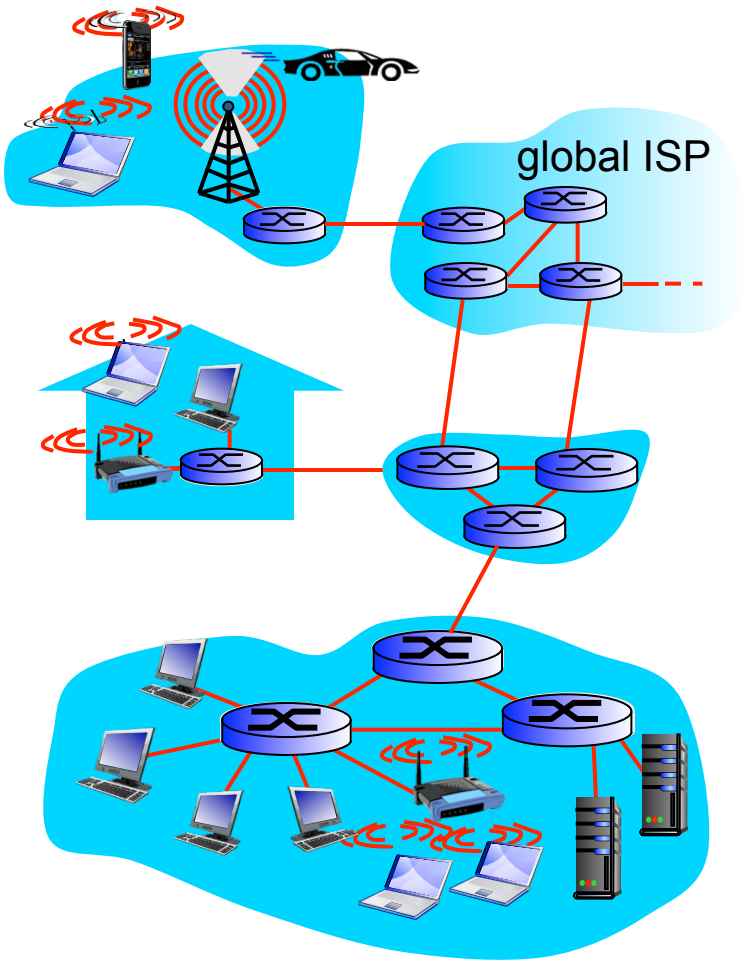
- abstraction
- responsibilities
- hardware
  - NIC

Note: Many of the lecture slides are based on presentations that accompany *Computer Networking: A Top Down Approach,* 6th edition, by Jim Kurose & Keith Ross, Addison-Wesley, 2013.

Link layer: introduction

Terminology:

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

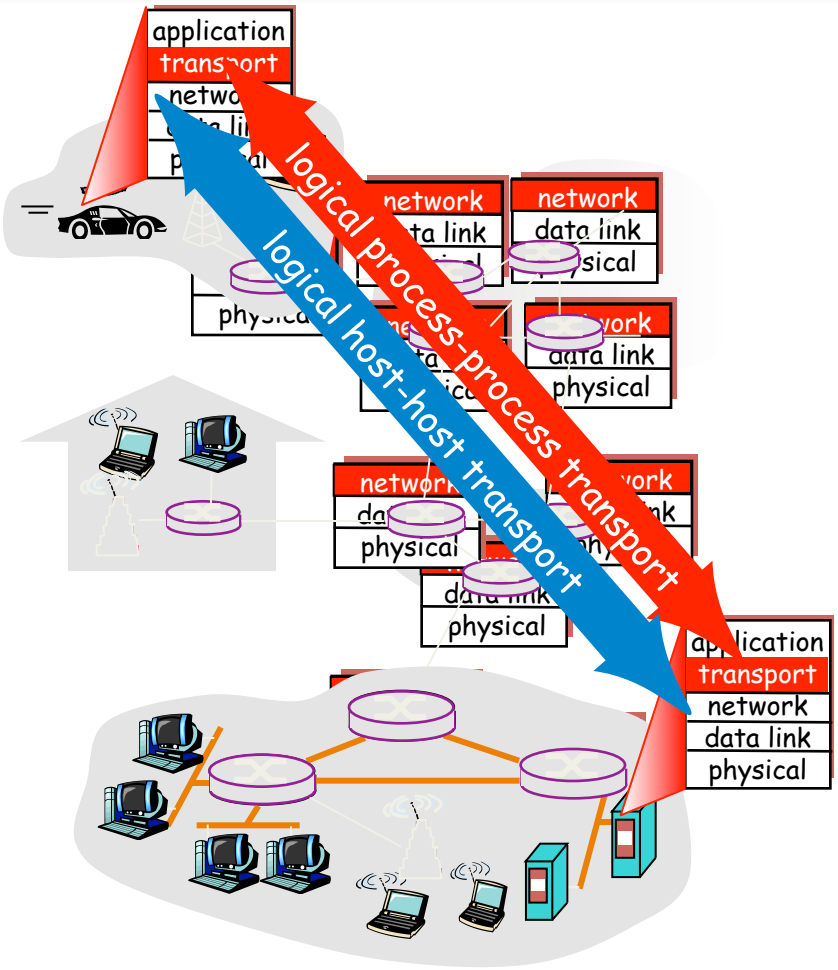


Layering abstractions

- ***transport layer***: logical communication between processes
  - relies on, enhances, **network** layer services
  - the transport-layer unit is called a **segment**

- ***network layer***: logical communication between hosts
  - relies on, enhances, **link** layer services
  - the network-layer unit is called a **datagram**

- ***data-link layer***: logical communication between adjacent nodes
  - relies on, enhances, **network** layer services
  - the link-layer unit is called a **frame**



Link layer responsibilities

- provide hardware addresses used in frame headers
  - identify source, destination
  - different from IP address!
- encapsulate datagram into frame
  - add header/trailer
- get access to shared medium
- control flow between adjacent sending and receiving nodes
  - detect / avoid / resolve collisions
- detect/correct errors (bit-level at receiver)
  - errors caused by signal attenuation, noise.
  - some link-layer technologies: receiver detects presence of errors
    - signals sender for retransmission and/or drops frame
  - other link-layer technologies: receiver identifies *and corrects* bit error(s) without resorting to retransmission

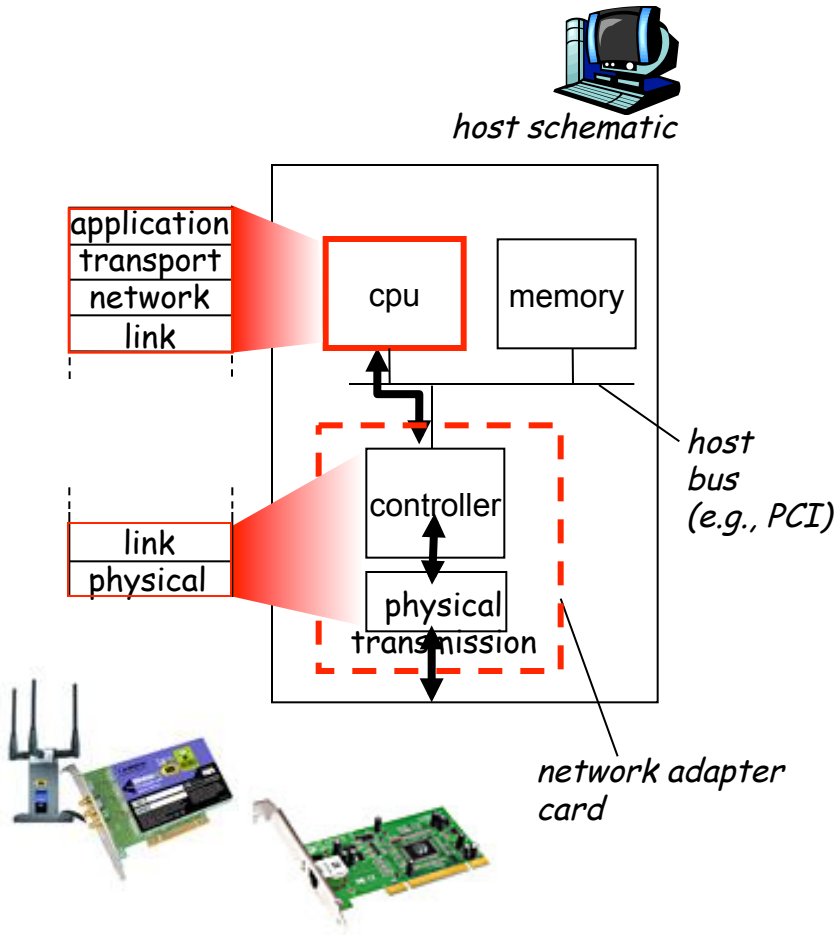
Link layer protocols

- Frames may be delivered by different link-layer protocols over different links:
  - e.g., “Ethernet” on first link, “frame relay” on intermediate links, “802.11” on last link
- Link-layer protocols may provide different services
  - e.g., may or may not provide reliable data transfer over link

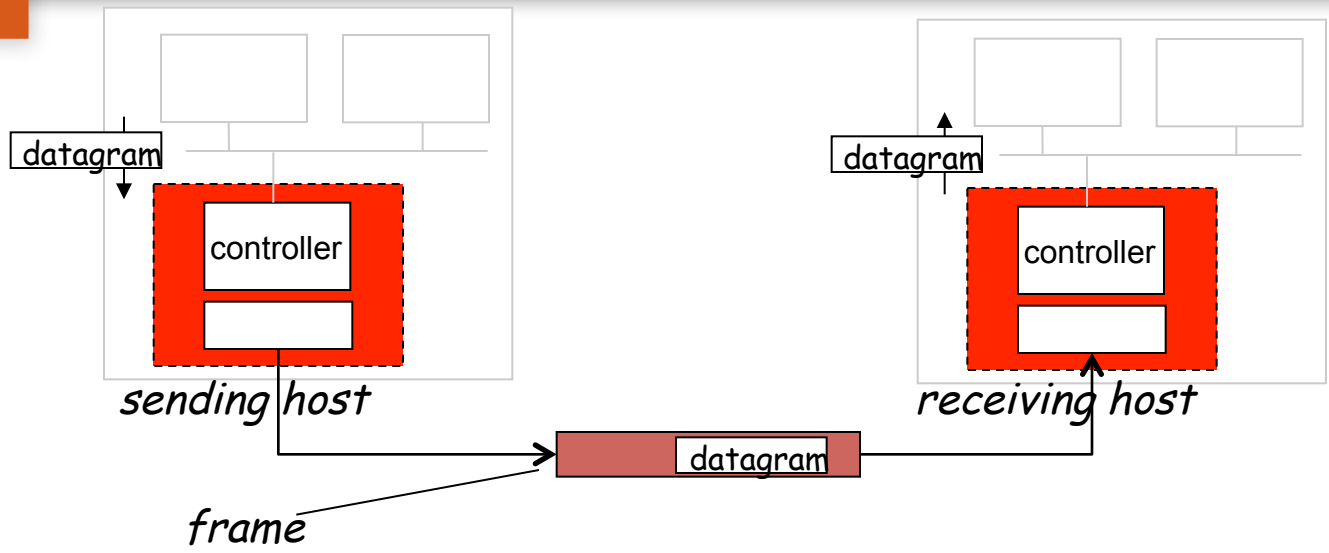
- Reliable delivery between adjacent nodes
  - similar to what is done at transport layer (ACK, timeout, etc.)
  - rarely used on low bit-error link (fiber, most twisted pair)
  - often used on wireless links because of high error rates

Link layer implementation

- Required in all hosts
- Implemented in network adapter (NIC *network interface controller*)
  - Ethernet card, PCMCI card, 802.11 card, etc.
  - implements interface to physical layer
  - attaches into host's system buses
  - combination of hardware, software, firmware
- Some network/transport layer functions are being added to NIC
  - Direct Memory Access (DMA) sends application data to memory without interrupting CPU.
  - checksum processing
  - etc.



NIC's communicating (node-to-node)



Sender

- encapsulates datagram in hardware frame
- adds address info, error checking bits, reliable data transfer, flow control, etc.
- sends to all hosts that are directly connected

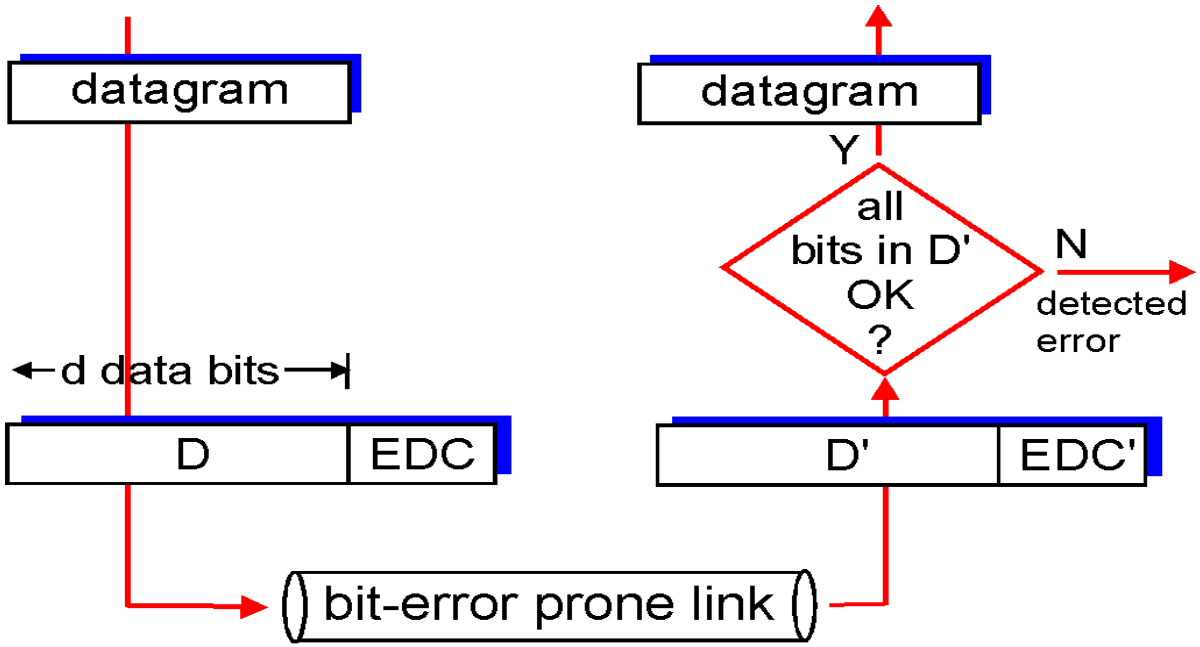
Receivers

- check address
  - accept if match (or sniffing)
    - handles errors, reliable data transfer, flow control, etc.
    - If OK, extracts datagram from hardware frame, and passes it up to network layer
  - reject otherwise

Error detection

D = Data protected by error checking, may include header fields
EDC= Error Detection and Correction bits

- error detection not 100% reliable
- larger EDC field yields better detection and correction

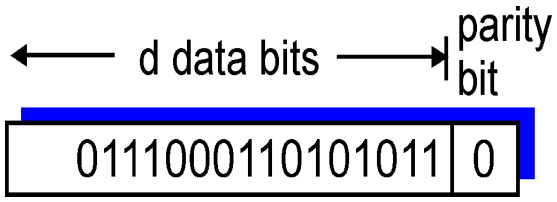


Parity checking

Very fast … easily implemented in hardware

single bit even-parity:

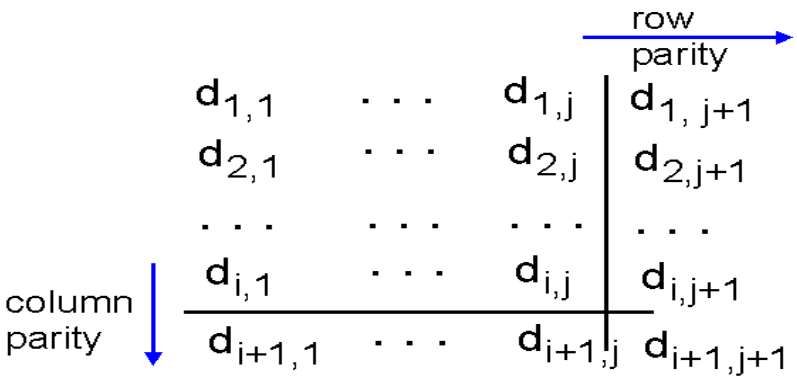
- detect single bit errors

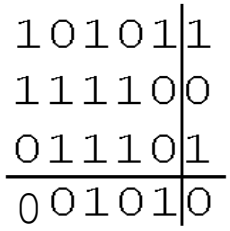


even-parity error

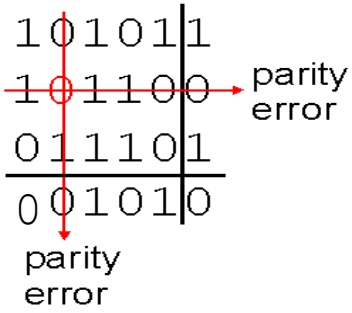
two-dimensional bit even-parity:

- detect and correct *single-bit* errors





no errors



correctable single-bit error

Error detection/correction

- Parity check
  - 1- dimensional / 2-dimensional
- Checksum
- Cyclic redundancy check (CRC)
- Hamming codes?

Summary Lecture #34

- Definitions:
  - node, link
  - frame
  - NIC
- Link layer responsibilities
  - hardware addressing
  - encapsulation (frame)
  - access shared transmission medium
  - control flow
  - detect/correct errors