Welcome to

***CS 3516*:**
Computer Networks

Prof. Yanhua Li

Time: 9:00am -9:50am M, T, R, and F
Location: AK219
Fall 2018 A-term

*Extra office hour on next **Monday***

10:30AM-11:30AM in AK 130

*Regular office hours on Next **Monday***

10-10:30AM AK 130

1-3PM TA office

Chapter 6: Link layer

our goals:

- understand principles behind link layer services:

6.1 introduction, services

6.2 error detection, correction

6.3 multiple access protocols

6.4 LANs

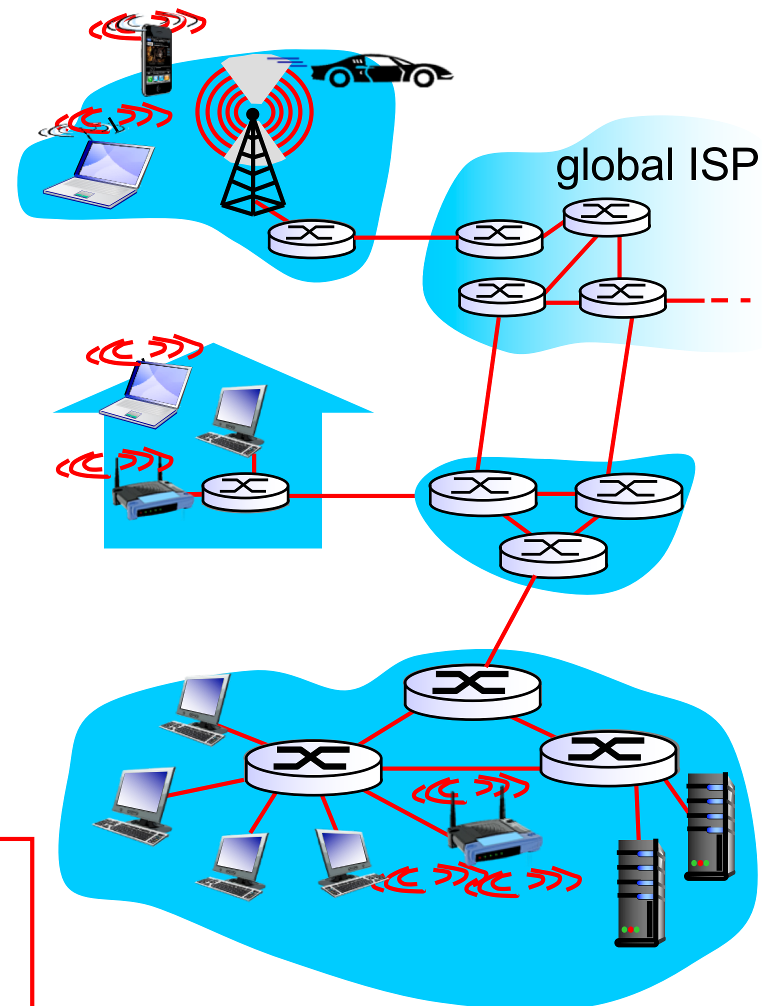
  - addressing, ARP (address resolution protocol)
  - Ethernet

Link layer: introduction

terminology:

- hosts and routers: nodes
- communication channels that connect adjacent nodes along communication path: links
  - wired links
  - wireless links
  - LANs
- layer-2 packet: frame, encapsulates datagram

data-link layer has responsibility of transferring datagram from one node to *physically adjacent* node over a link



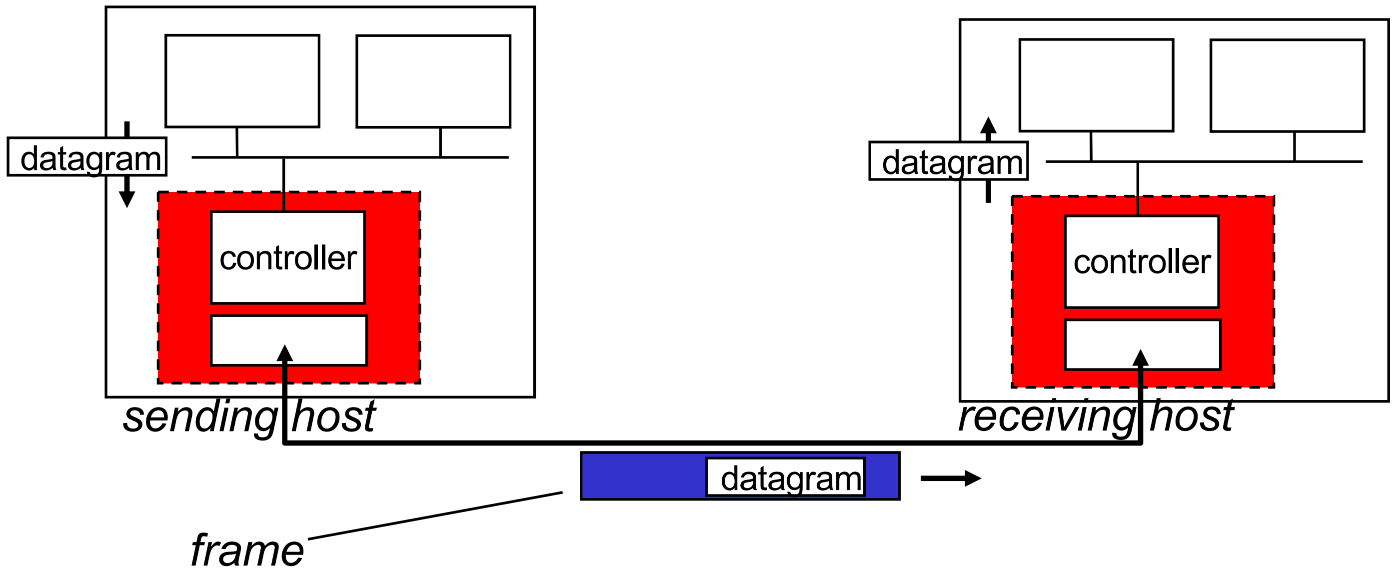
Link layer: context

- 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 link

transportation analogy:

- trip from Worcester to Minneapolis
  - limo: Worcester to BOS
  - plane: BOS to MSP
  - train: MSP to Minneapolis
- tourist = datagram
- transport segment = communication link
- transportation mode = link layer protocol
- travel agent = routing algorithm

Adaptors communicating



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

Link layer, LANs: outline

6.1 introduction, services

6.2 error detection, correction

6.3 multiple access protocols

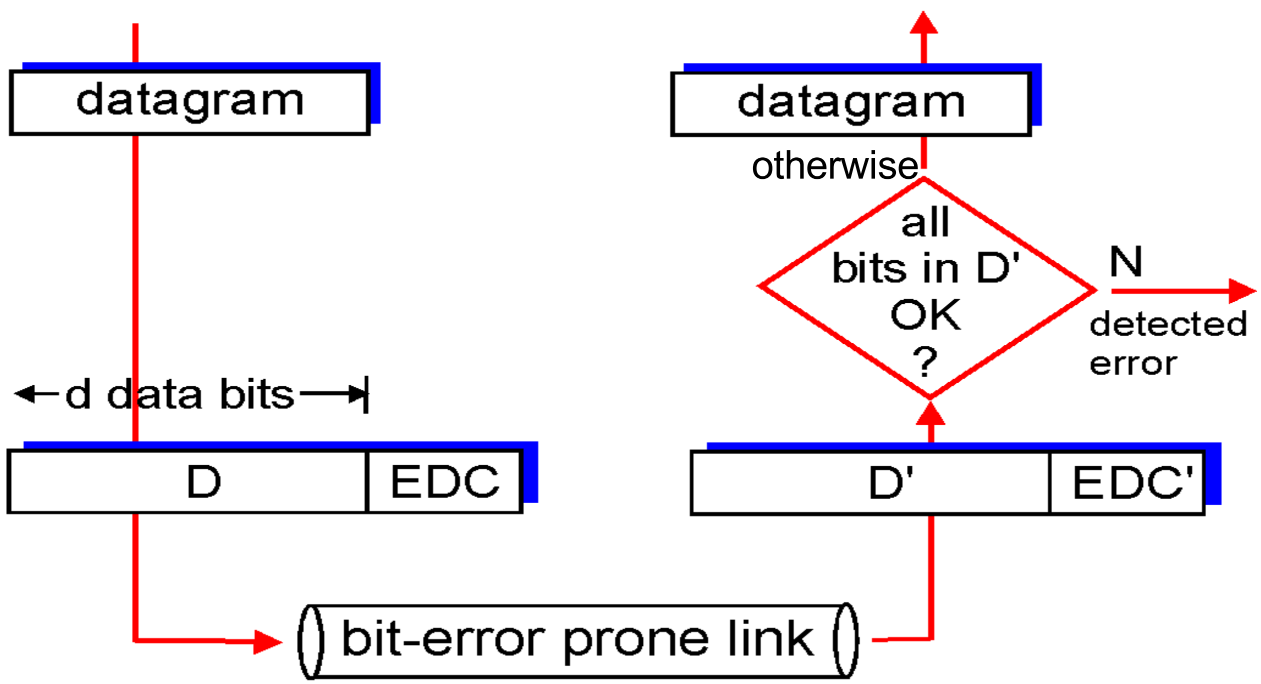
6.4 LANs

- addressing, ARP
- Ethernet
- switches
- VLANS

Error detection

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

- Error detection not 100% reliable!
  - protocol may miss some errors, but rarely
  - larger EDC field yields better detection and correction



Internet checksum (review)

goal: detect "errors" (e.g., flipped bits) in transmitted packet (note: used at transport layer *only*)

sender:

- treat segment contents as sequence of 16-bit integers
- checksum: addition (1's complement sum) of segment contents
- sender puts checksum value into UDP checksum field

receiver:

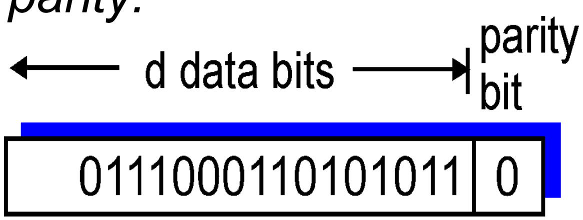
- compute checksum of received segment
- check if computed checksum equals checksum field value:
  - NO - error detected
  - YES - no error detected. *But maybe errors nonetheless?*

Parity checking

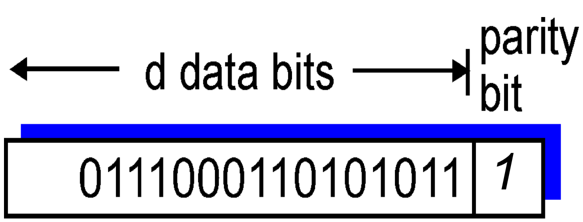
single bit parity:

- *d*etect single bit errors

Odd parity:

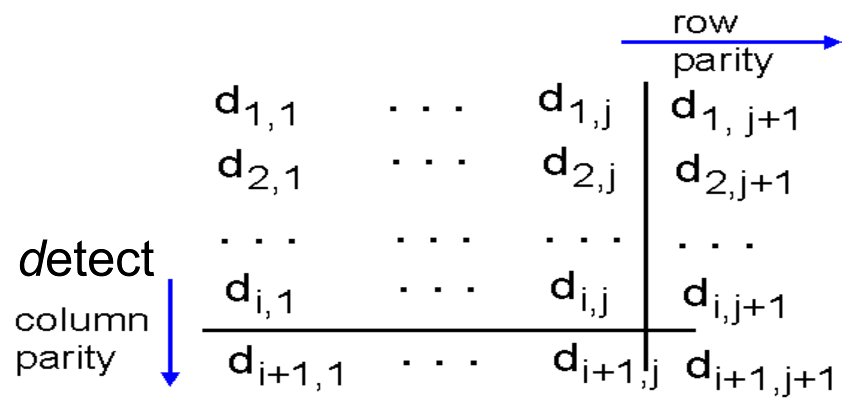


Even parity:

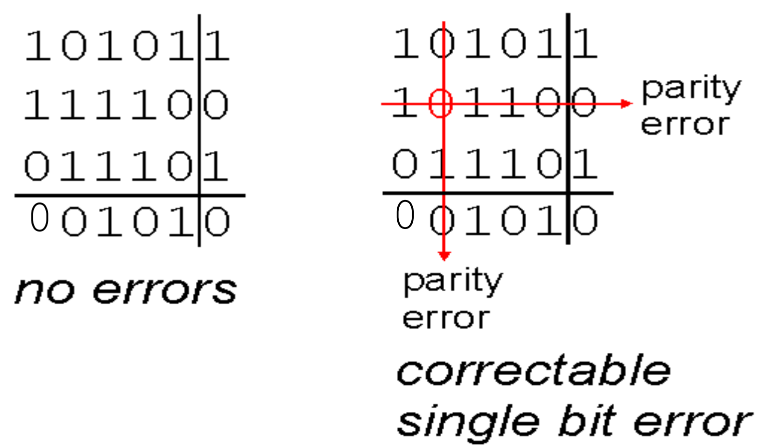


two-dimensional bit parity:

- detect and correct single bit errors



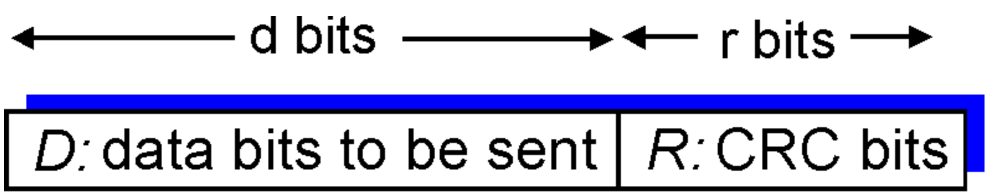
Even parity:



Q?

Cyclic redundancy check

- more powerful error-detection coding
- view data bits, D, as a binary number
- choose r+1 bit pattern (generator), G
- goal: choose r CRC bits, R, such that
  - <D,R> exactly divisible by G (modulo 2)
  - receiver knows G, divides <D,R> by G. If non-zero remainder: error detected!
  - can detect all burst errors less than r+1 bits
- widely used in practice (Ethernet, 802.11 WiFi)



bit pattern

$$D * 2^r \quad \text{XOR} \quad R$$

mathematical formula

CRC example

Dividing $D \cdot 2^r$ by G yields R

Let D=101111, d=6
Let G=1001, r=3

R=?

R= 111, [D,G]=[101111 111]

$$R = remainder[\frac{D \cdot 2^r}{G}]$$

Questions?