College of Information Studies

University of Maryland Hornbake Library Building College Park, MD 20742-4345

Point-To-Point Links

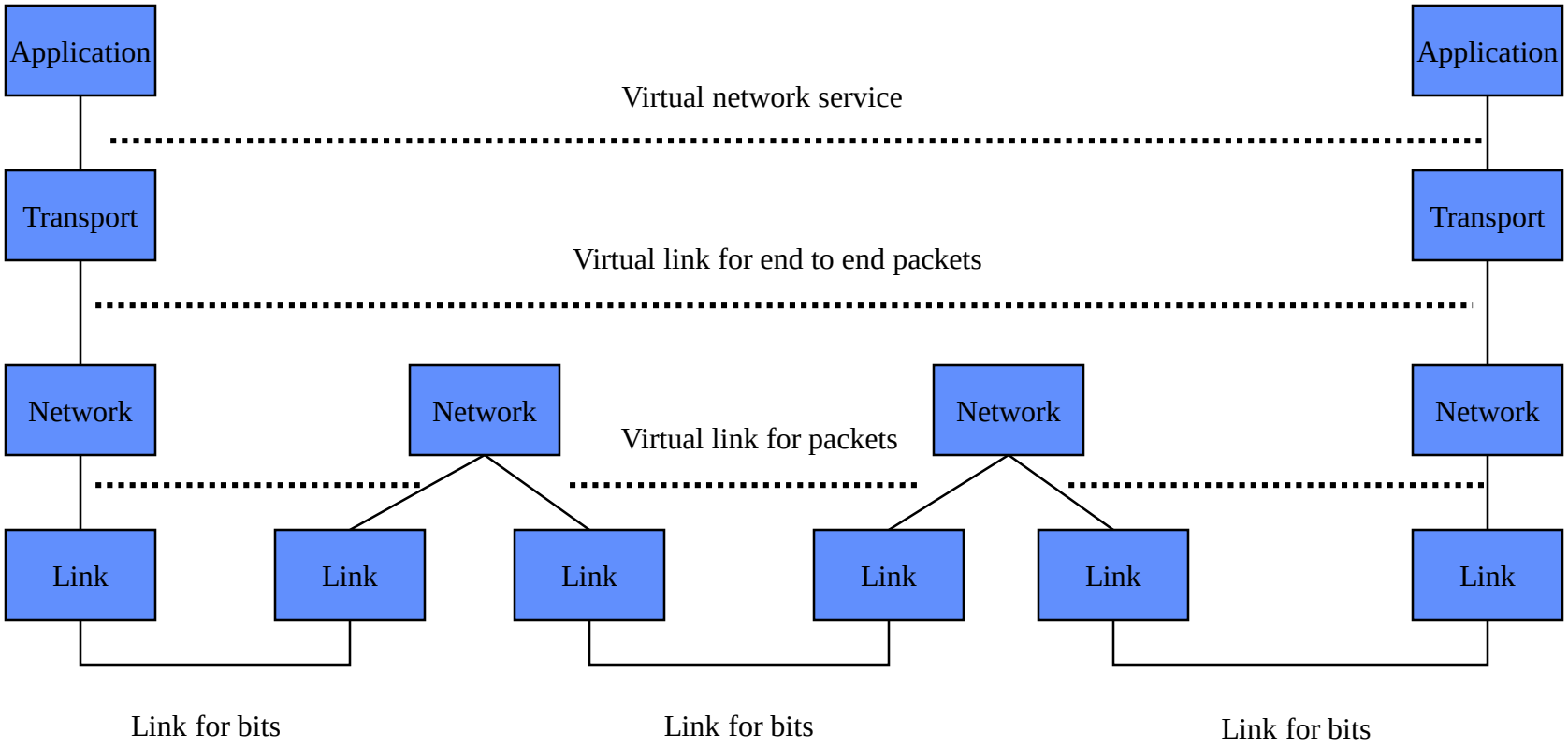
Session 15

INST 346

Goals for Today

- Finishing up Internet overview
- Physical Layer: Point to Point Links
- Link Layer services
- Error Detection and Correction

TCP/IP layer architecture



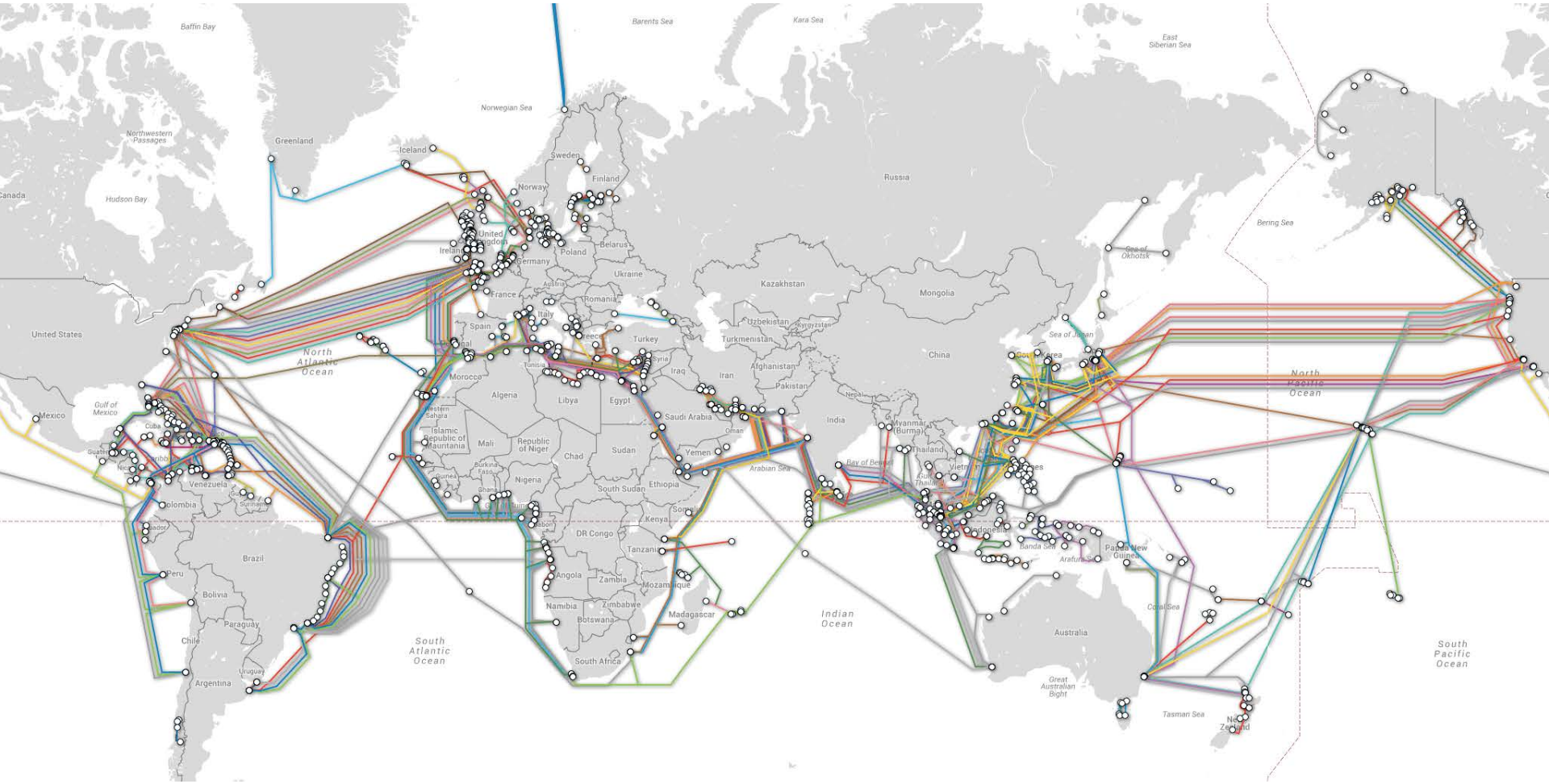
Transmission Control Protocol (TCP)

- Guarantees delivery all data
  - Retransmits missing data
- Guarantees data will be delivered in order
  - “Buffers” subsequent packets if necessary
- No guarantee of delivery time
  - Long delays may occur without warning

User Datagram Protocol (UDP)

- The Internet's basic transport service
  - Sends every packet immediately
  - Passes received packets to the application
- No delivery guarantee
  - Collisions can result in packet loss
- Example: sending clicks on web browser

“Submarine” Fiber Optic Cables



Physical media: Fiber optics

fiber optic cable:

- 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:
  - repeaters spaced far apart
  - immune to electromagnetic noise

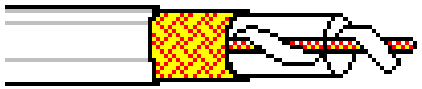
Physical media: wired

twisted "pair" (TP)

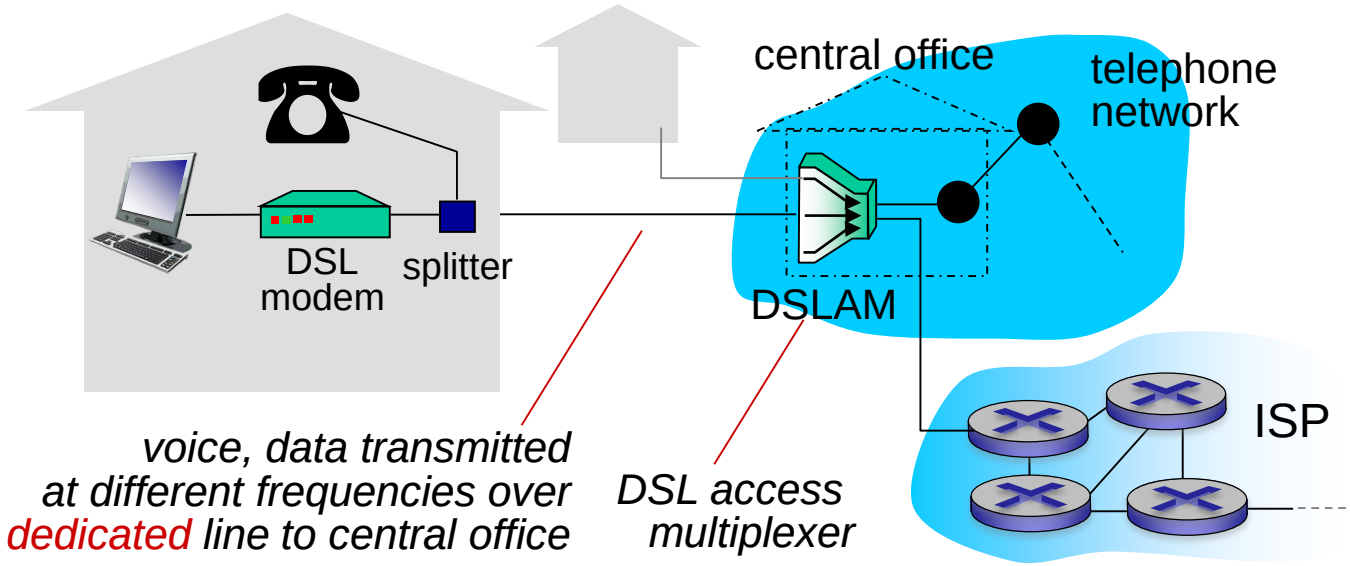
- two (or more) insulated copper wires
  - Category 5: 100 Mbps, 1 Gbps Ethernet
  - Category 6: 10Gbps

coaxial cable:

- two concentric copper conductors
- broadband:
  - Used to send multiple channels on cable TV

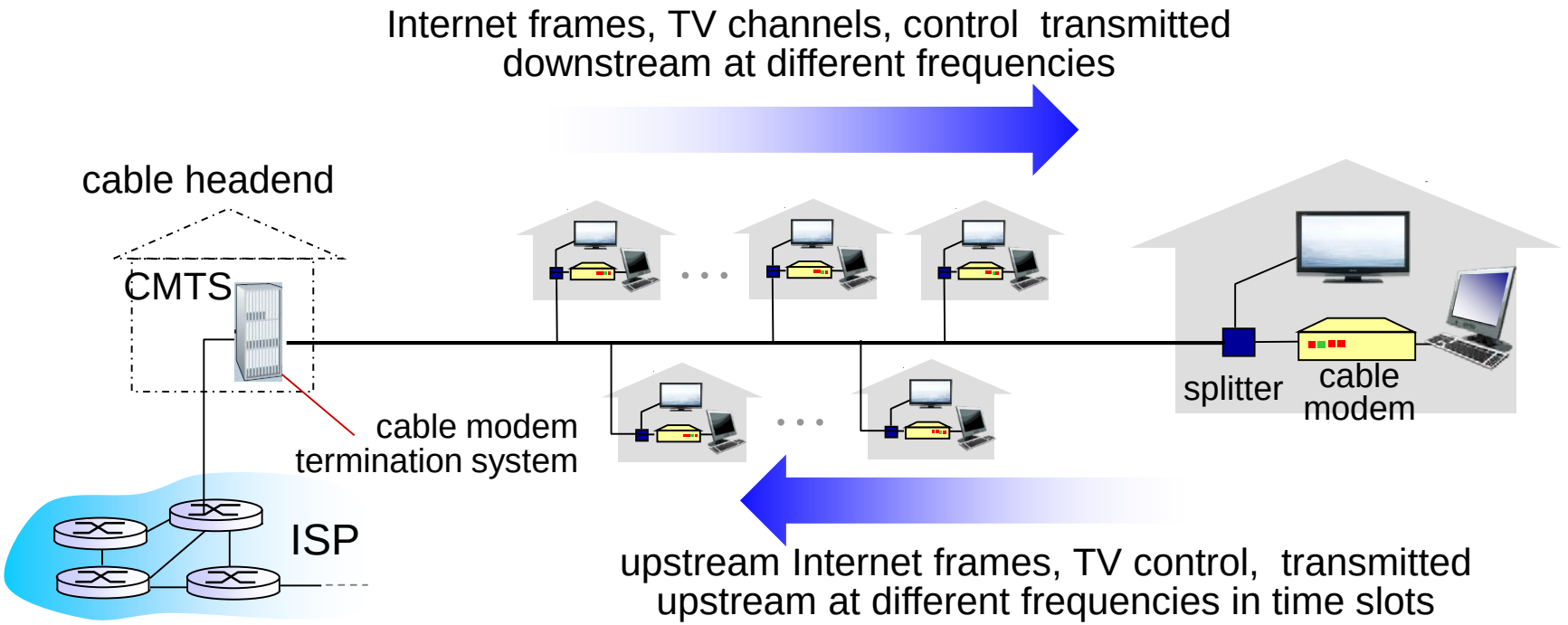


Digital subscriber line (DSL)



- use *existing* telephone line to central office DSL access multiplexer
  - data over DSL phone line goes to Internet
  - voice over DSL phone line goes to telephone net
- < 2.5 Mbps upstream transmission rate (typically < 1 Mbps)
- < 24 Mbps downstream transmission rate (typically < 10 Mbps)

Cable access network



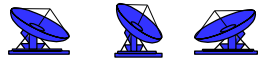
- multiple 40Mbps downstream (broadcast) channels
  - single CMTS transmits into channels
- multiple 30 Mbps upstream channels
  - multiple access: all users contend for certain upstream channel time slots (others assigned)

Physical media: radio

- signal carried in electromagnetic spectrum
- no physical wire
- propagation environment effects:
  - reflection
  - obstruction by objects
  - interference

radio link types:

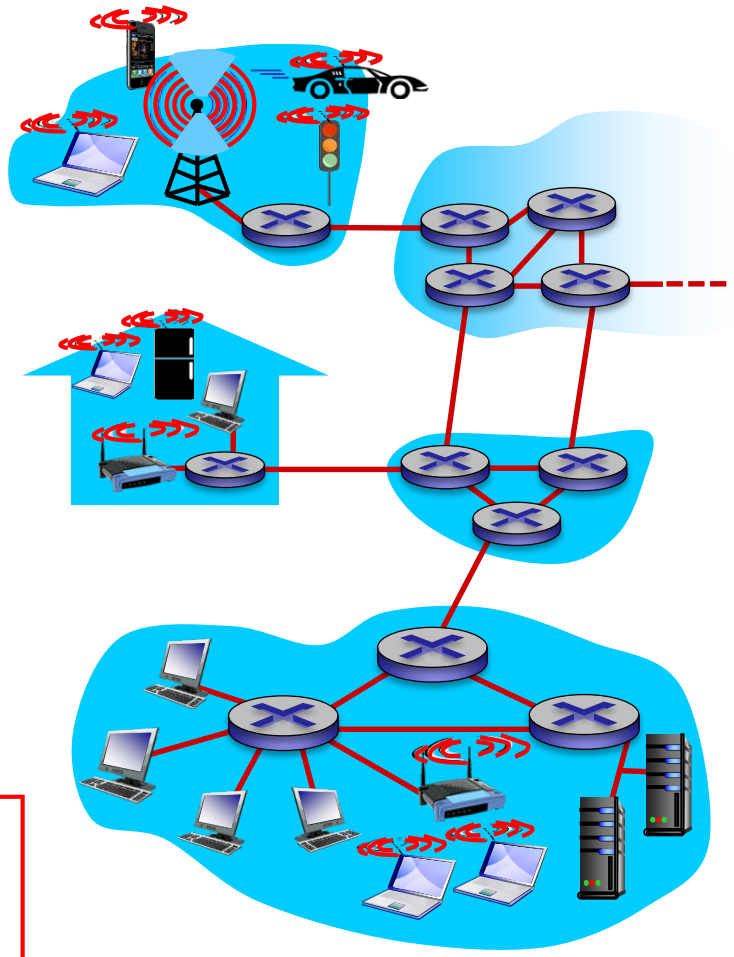
- terrestrial microwave
  - e.g. up to 45 Mbps channels
- LAN (e.g., WiFi)
  - 54 Mbps
- wide-area (e.g., cellular)
  - 4G cellular: ~ 10 Mbps
- satellite
  - Up to 45Mbps channels (or multiple smaller channels)
  - Two types
    - 270 msec end-end delay for geosynchronous
    - Low-earth orbit



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 services

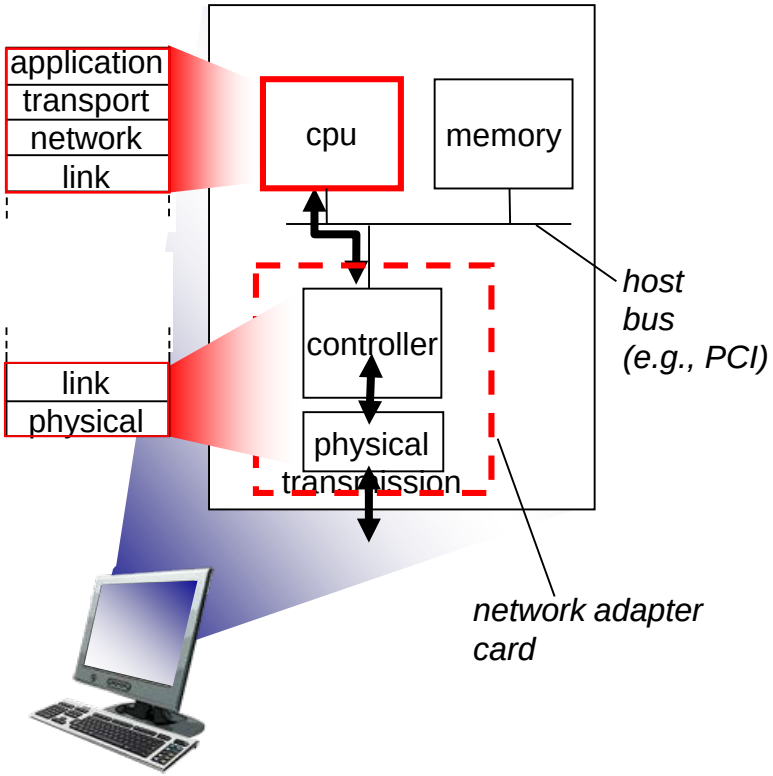
- *framing, link access:*
  - encapsulate datagram into frame, adding header, trailer
  - channel access if shared medium
  - "MAC" addresses used in frame headers to identify source, destination
    - different from IP address!
- *reliable delivery between adjacent nodes*
  - we learned how to do this 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)

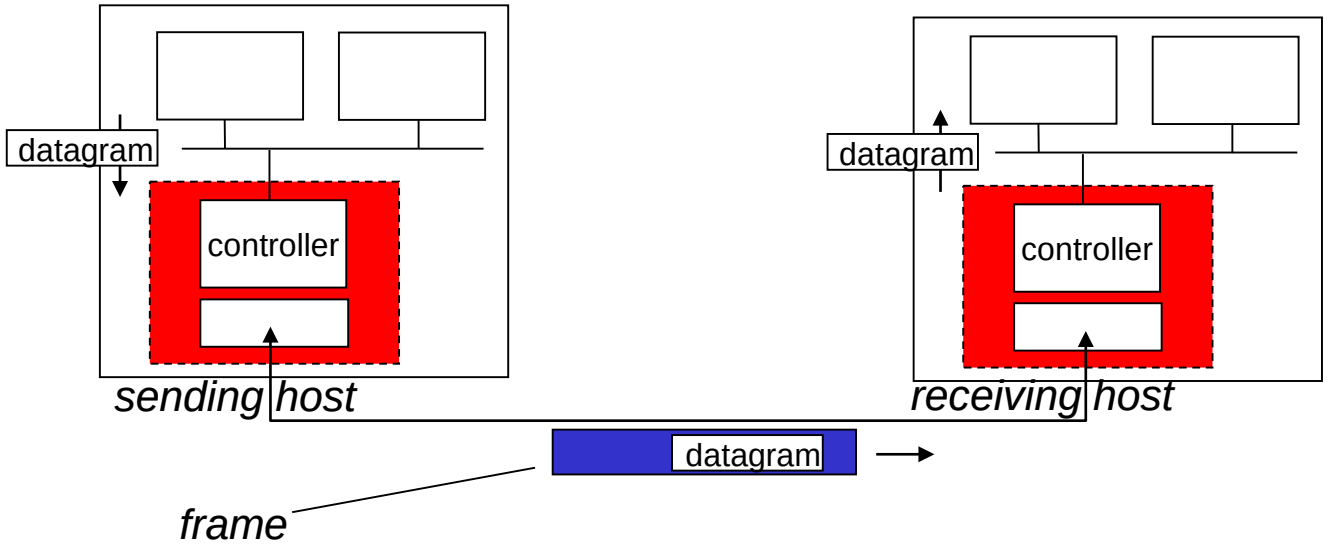
- *flow control:*
  - pacing between adjacent sending and receiving nodes
- *error detection:*
  - errors caused by signal attenuation, noise.
  - receiver detects presence of errors:
    - signals sender for retransmission or drops frame
- *error correction:*
  - receiver identifies *and corrects* bit 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

Where is the link layer implemented?

- in each and every host
- link layer implemented in "adaptor" (aka *network interface card* NIC) or on a chip
  - Ethernet card, 802.11 card; Ethernet chipset
  - implements link, physical layer
- attaches into host's system buses
- combination of hardware, software, firmware



Adaptors communicating

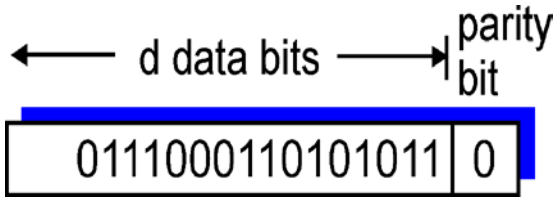


- sending side:
  - encapsulates datagram in frame
  - adds error checking bits, rdt, flow control, etc.
- receiving side
  - looks for errors, rdt, flow control, etc.
  - extracts datagram, passes to upper layer at receiving side

Parity checking

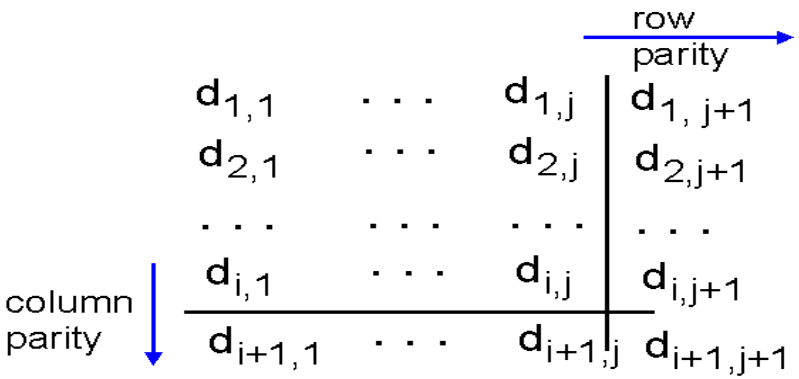
single bit parity:

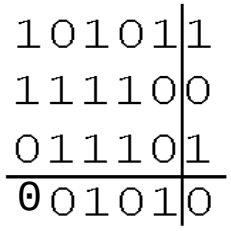
- *d*etect single bit errors



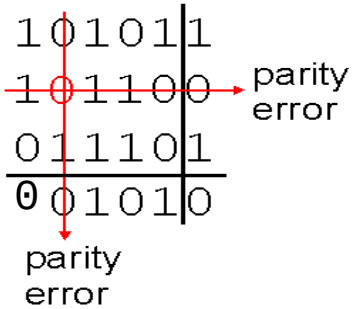
two-dimensional bit parity:

- detect and correct single bit errors





no errors

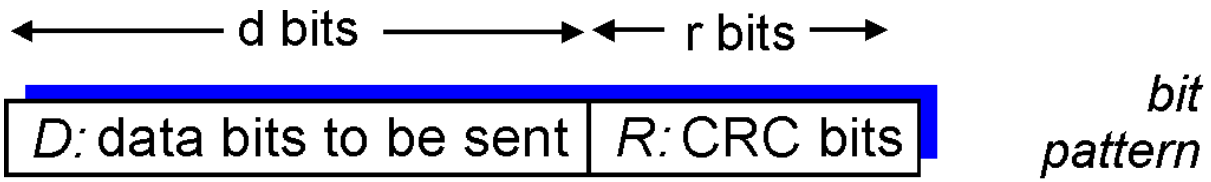


correctable single bit error

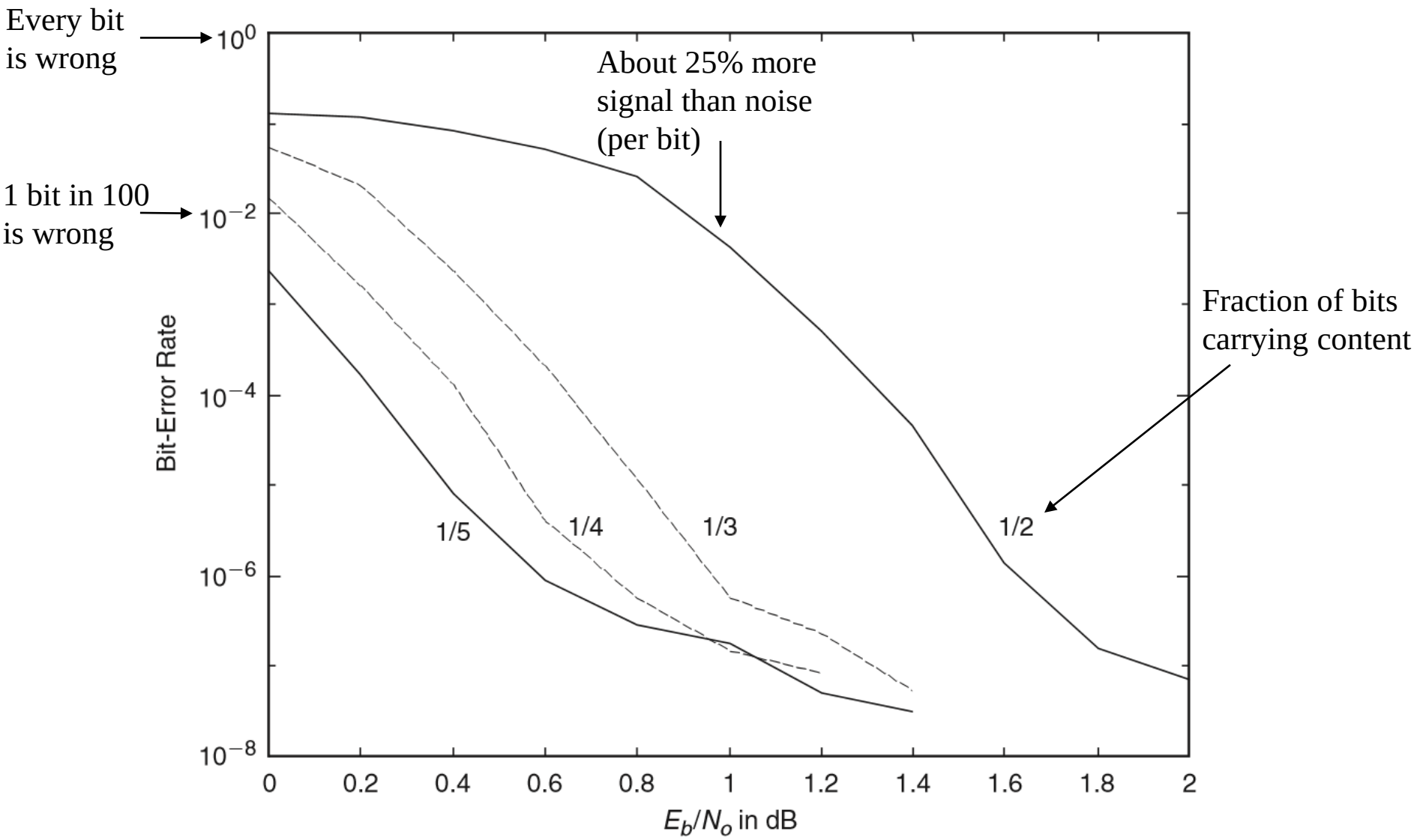
* Check out the online interactive exercises for more examples: http://gaia.cs.umass.edu/kurose_ross/interactive/

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)



Turbo Codes: Forward Error Correction



Before You Go

On a sheet of paper, answer the following (ungraded) question (no names, please):

What one thing could the instructor change to improve your learning?