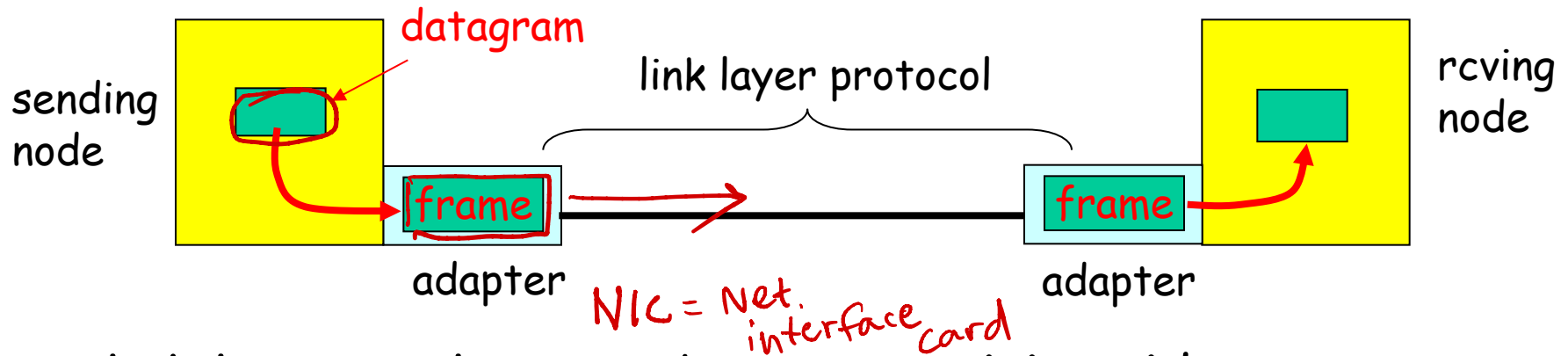
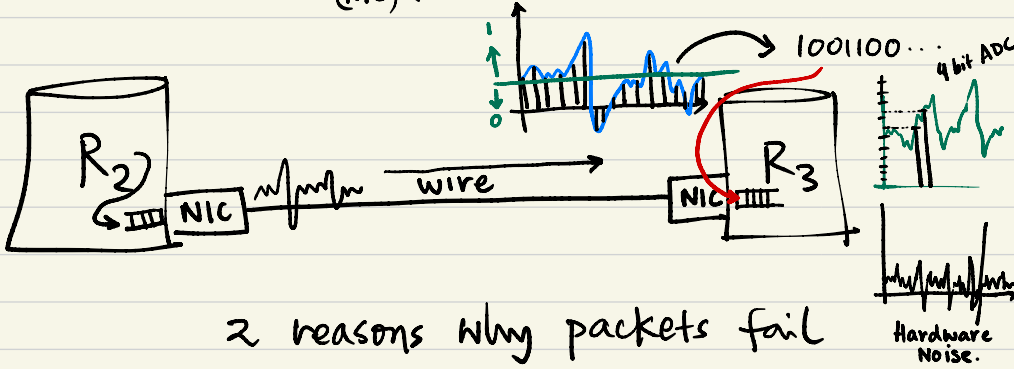
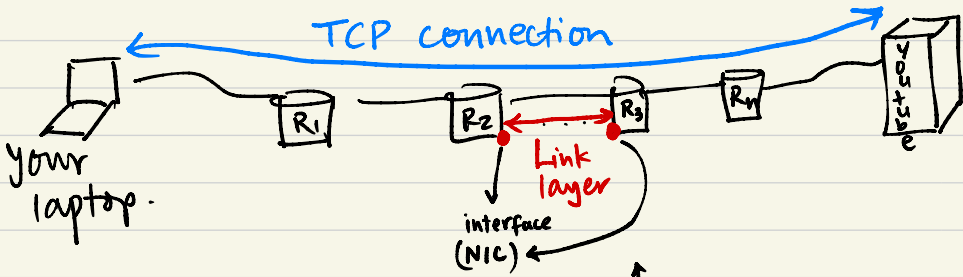


Adaptors Communicating



- ❑ link layer implemented in "adaptor" (aka NIC)
 - Ethernet card, PCMCIA 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 rcvng node
- ❑ adapter is semi-autonomous
- ❑ link & physical layers

Reliability at link layer



2 reasons why packets fail

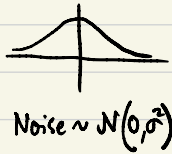
Transmission Error

Congestion

Interference from noise

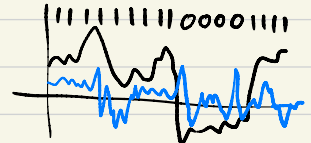
env. / cosmic interference

Hardware / thermal noise (AWGN)

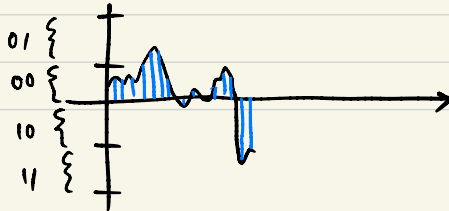


σ^2 Variance
0 - mean.

Additive Gaussian Noise (AWGN)



moves the sample to the wrong side of the decision boundary
↓
Bit flips.



Link Layer

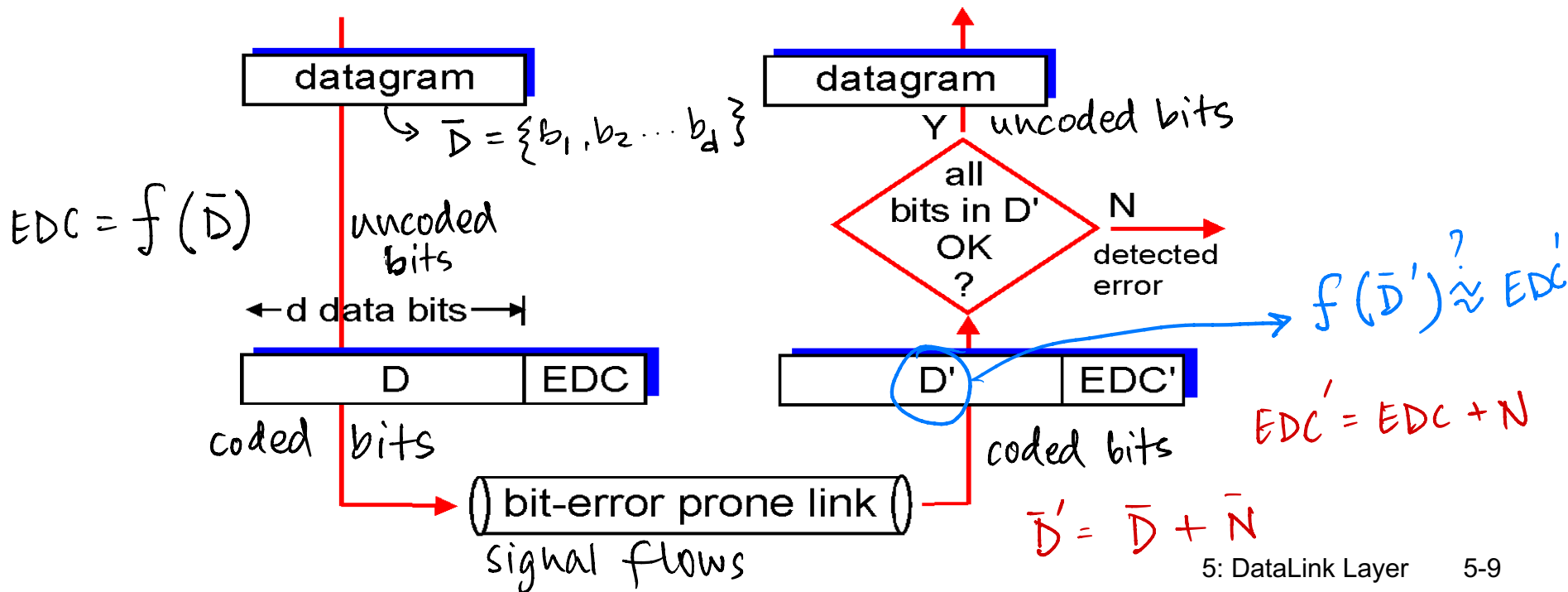
- ❑ 5.1 Introduction and services
- ❑ 5.2 Error detection and correction }
- ❑ 5.3 Multiple access protocols
- ❑ 5.4 Link-Layer Addressing
- ❑ 5.5 Ethernet
- ❑ 5.6 Hubs and switches
- ❑ 5.7 PPP
- ❑ 5.8 Link Virtualization: ATM

Error Detection

EDC= Error Detection and Correction bits (redundancy)

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

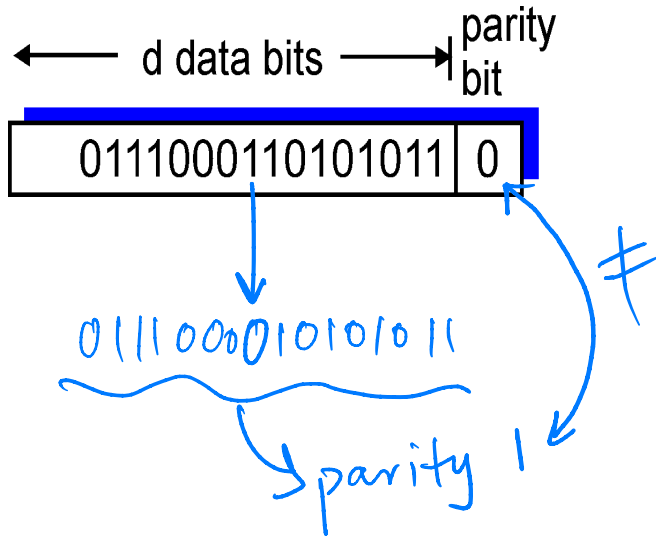


Parity Checking

Error Detection

Single Bit Parity:

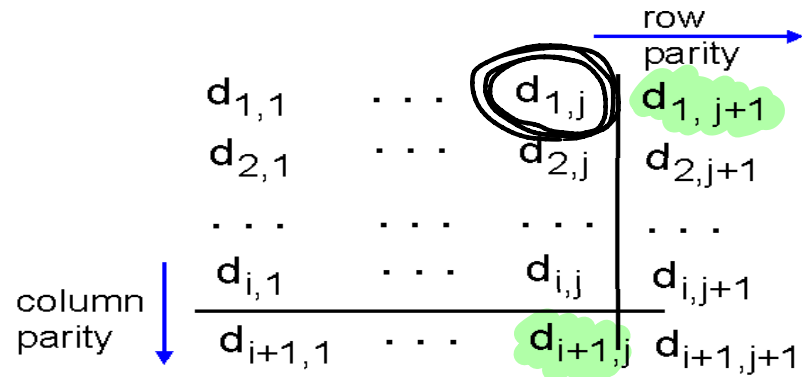
Detect single bit errors



Error correcting codes (ECC)

Two Dimensional Bit Parity:

Detect and correct single bit errors



1	0	1	0	1	1
1	1	1	1	0	0
0	1	1	1	0	1
0	0	1	0	1	0

no errors

1	0	1	0	1	1
1	0	1	1	0	0
0	1	1	1	0	1
0	0	1	0	1	0

parity error

correctable
single bit error

Internet checksum

Goal: detect "errors" (e.g., flipped bits) in transmitted segment (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

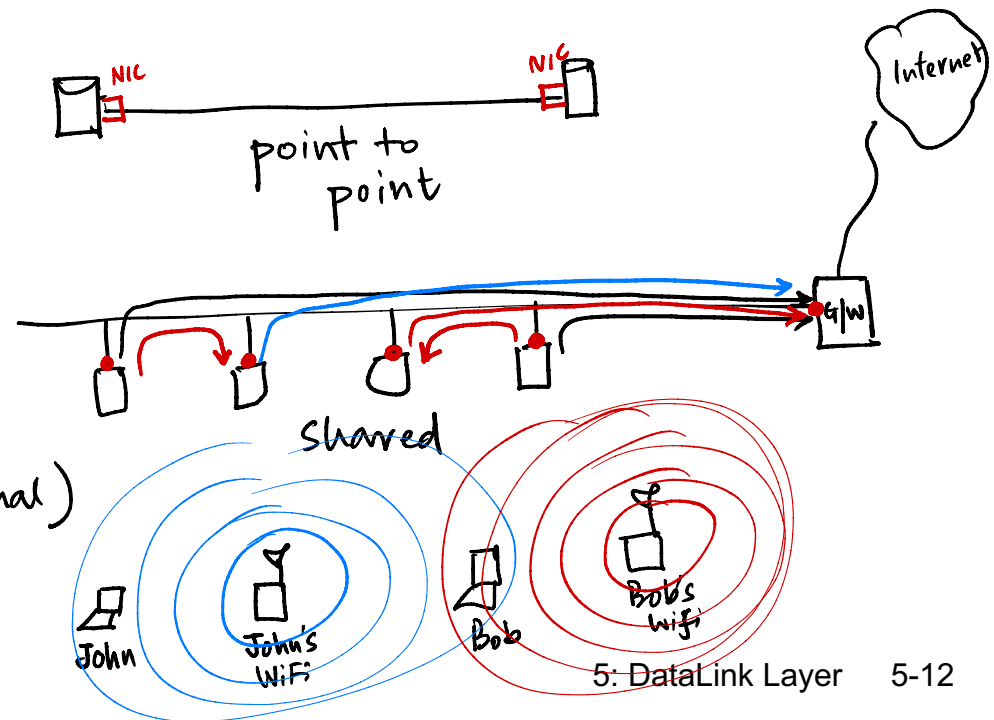
Receiver:

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

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

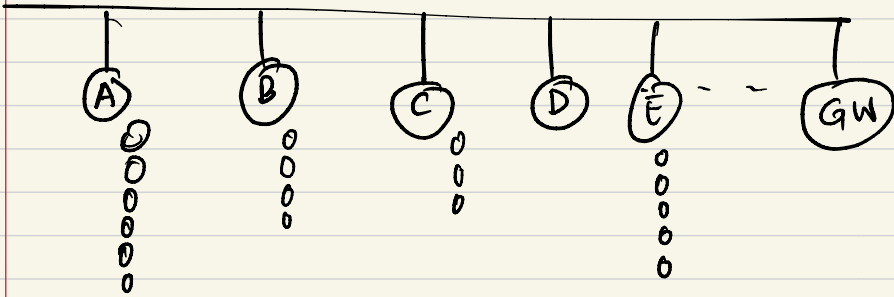
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Bob's SINR = Signal to interference + noise ratio

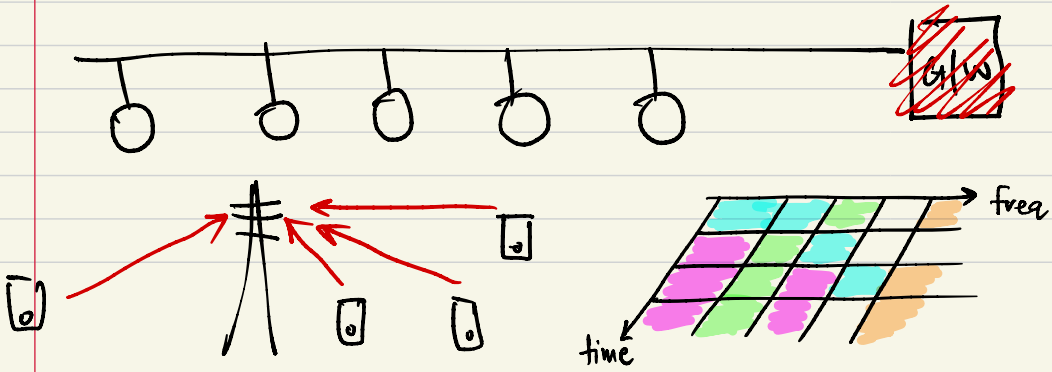
$$= \frac{\text{Red signal power}}{\text{Blue signal power} + \text{Bob's H/W noise power}}$$

MAC protocols task is to schedule transmissions
 S.t. collisions don't happen \Rightarrow maximize
 efficiency or channel utilization



under constraints of fairness.

Arbitration / Centralized protocols.



Decentralized / Distributed MAC protocol

