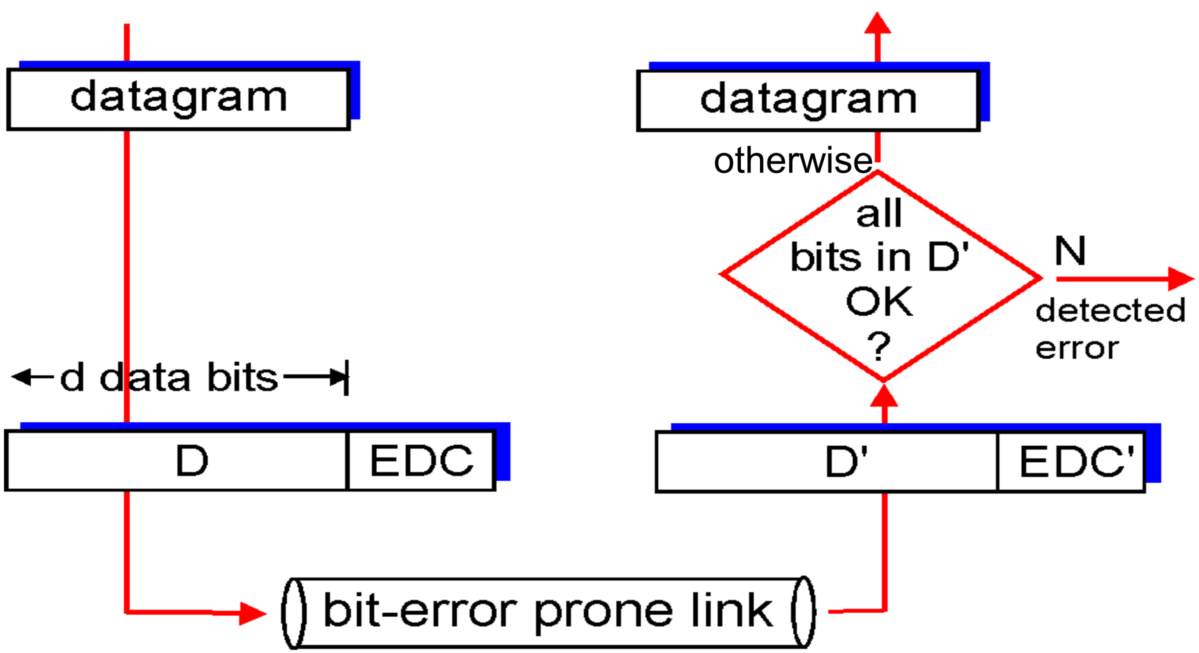
Error detection

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

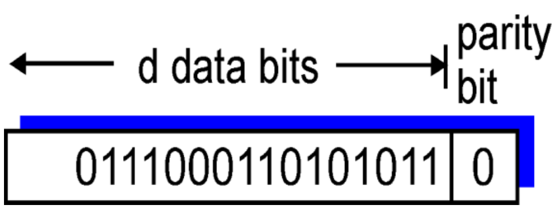
- Error detection not 100% reliable!
  - protocol may miss some errors, but rarely
  - larger EDC field yields better detection and correction



Parity checking

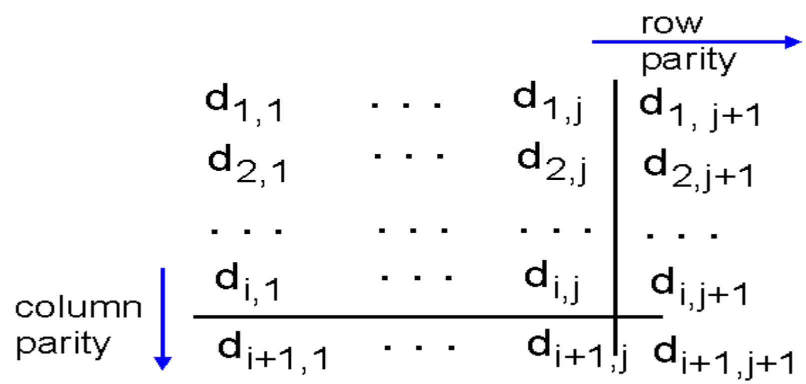
single bit parity:

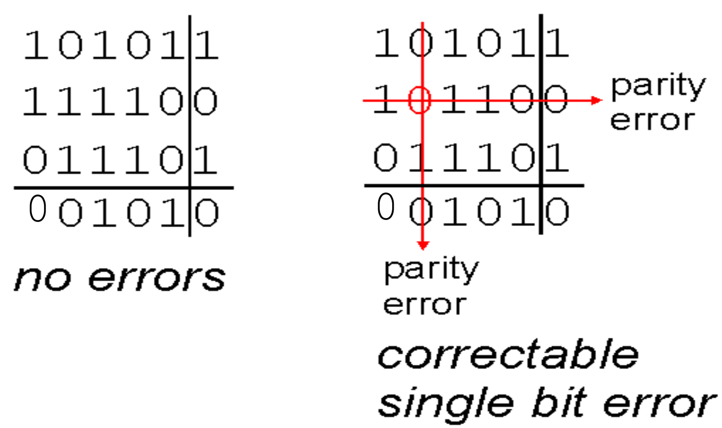
- *detect* single bit errors



two-dimensional bit parity:

- detect and correct single bit errors





P1

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

4×4 → 4 row parities + 4 column parities + 1 corner = 9 parity bits ← fewest

Even Parity scheme: Make the total number of 1s in a group of bits (including the parity bit) even.

Count number of 1s
odd → parity = 1
even → parity = 0

Slotted ALOHA: efficiency

efficiency: long-run fraction of successful slots (many nodes, all with many frames to send)

- *suppose: N* nodes with many frames to send, each transmits in slot with probability *p*
- prob that given node has success in a slot $= p(1-p)^{N-1}$
- prob that *any* one of the *N* nodes has a success $= Np(1-p)^{N-1}$

- max efficiency: find p* that maximizes $Np(1-p)^{N-1}$
- for many nodes, take limit of $Np^*(1-p^*)^{N-1}$ as N goes to infinity, gives:

max efficiency = 1/e = .37

at best: channel used for useful transmissions 37% of time!

!

P2

- a) A's average throughput is given by $p_A(1-p_B)$.

Total efficiency is $p_A(1-p_B) + p_B (1- p_A)$.

- b) A's throughput is $p_A(1-p_B)=2p_B (1-p_B)= 2p_B- 2(p_B)^2$.

B's throughput is $p_B (1- p_A)=p_B (1-2p_B)= p_B- 2(p_B)^2$.
Clearly, A's throughput is not twice as large as B's.

- In order to make $p_A(1-p_B)= 2 p_B (1-pA)$ => pA − pA pB = 2 pB − 2 pA pB
  - pA = 2 pB − pA pB
  - pA + pA pB = 2 pB
  - pA (1 + pB) = 2 pB
  - pA = 2 pB / (1 + pB)

- c) A's throughput is $2p(1-p)^{N-1}$, and any other node has throughput $p(1-p)^{N-2}(1-2p)$.

CSMA (carrier sense multiple access)

CSMA: listen before transmit:

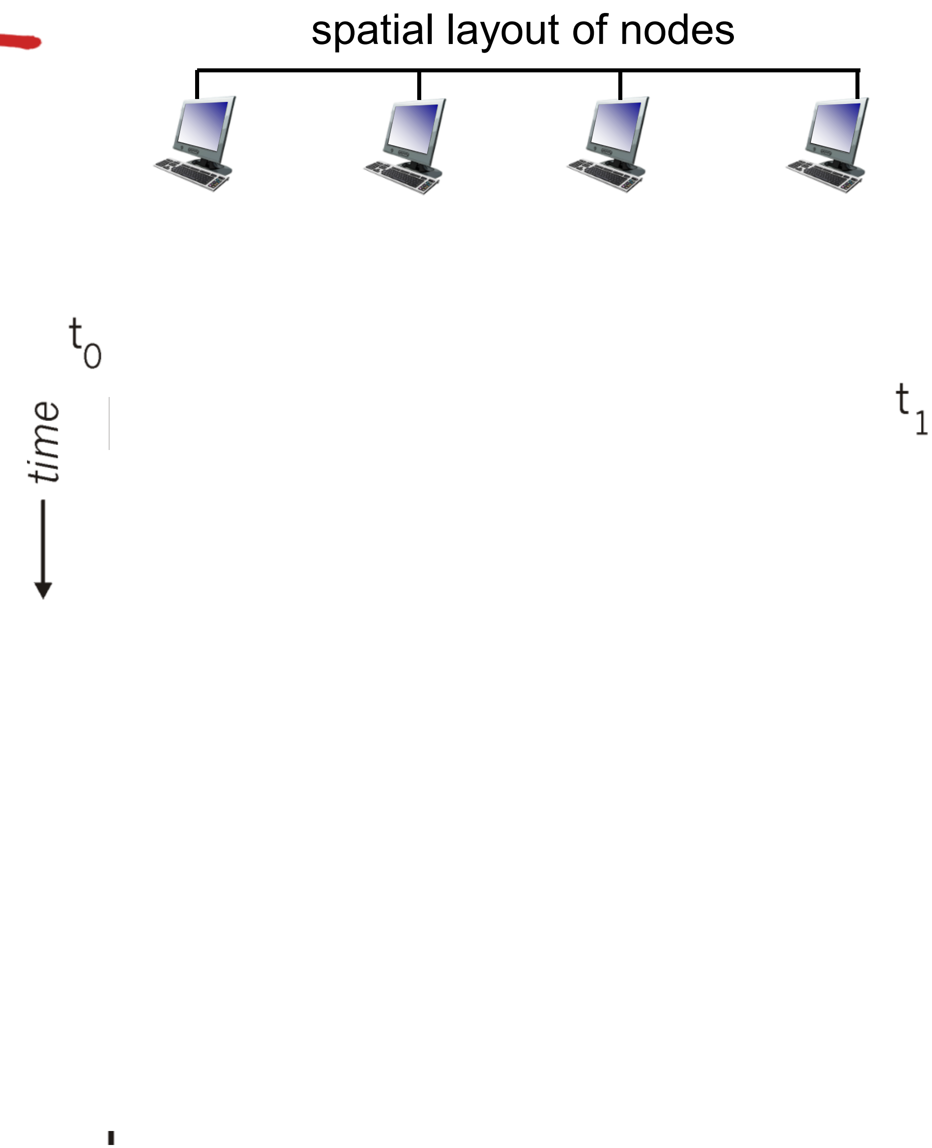
if channel sensed idle: transmit entire frame

- if channel sensed busy, defer transmission

- human analogy: don't interrupt others!

CSMA collisions

- collisions *can* still occur: propagation delay means two nodes may not hear each other's transmission
- collision: entire packet transmission time wasted
  - distance & propagation delay play role in in determining collision probability



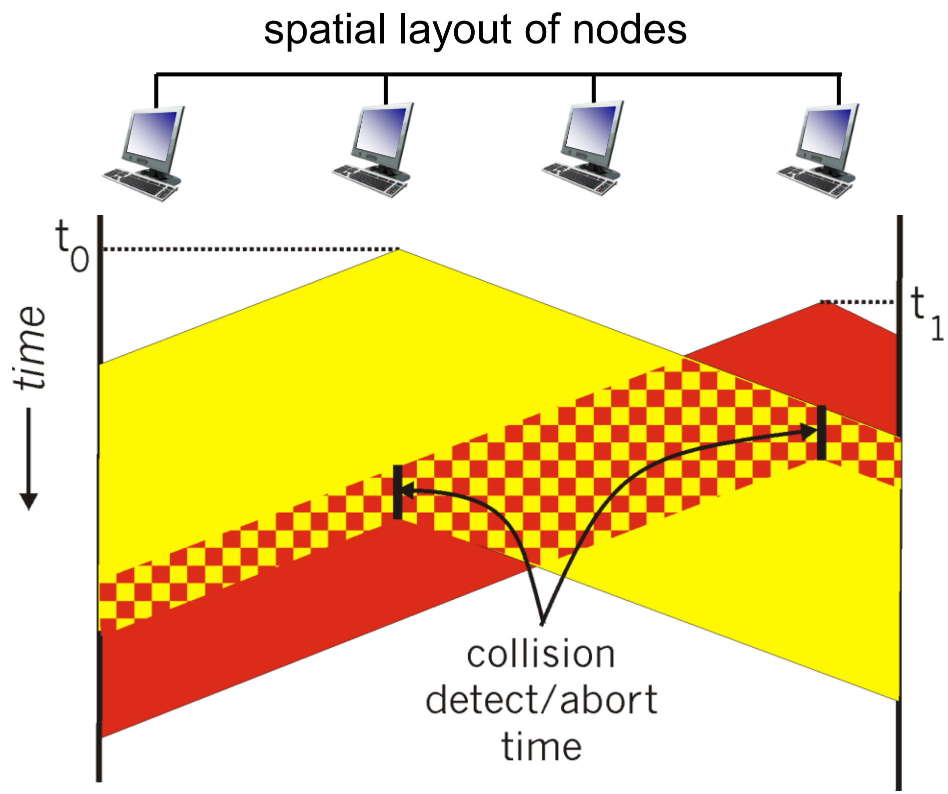
CSMA/CD (collision detection)

CSMA/CD: carrier sensing, deferral as in CSMA

- collisions *detected* within short time
- colliding transmissions aborted, reducing channel wastage

- collision detection:
  - easy in wired LANs: measure signal strengths, compare transmitted, received signals
  - difficult in wireless LANs: received signal strength overwhelmed by local transmission strength
- human analogy: the polite conversationalist

CSMA/CD (collision detection)



P3

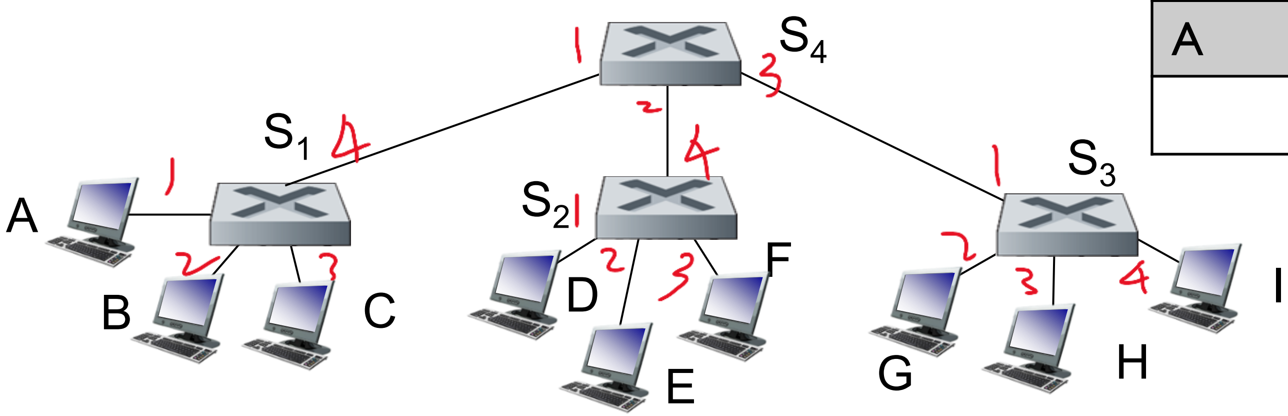
- When the bits transmitted by a node A have yet to reach another node B, the latter senses the channel idle and in accordance with the CSMA protocol begins transmitting its frame. A short time later, B’s transmission begins to interfere with A’s transmission.

P4: Self-learning multi-switch example

- A sends frame to G: Flooding through S_1, S_4, S_3
- G responds to A: Selectively send through S_3, S_4, S_1

S_2

MAC address	Interface
A	4



S_1

MAC address	Interface
A	1
G	4

S_4

MAC address	Interface
A	1
G	3

S_3

MAC address	Interface
A	1
G	2