# Computer Communication Networks
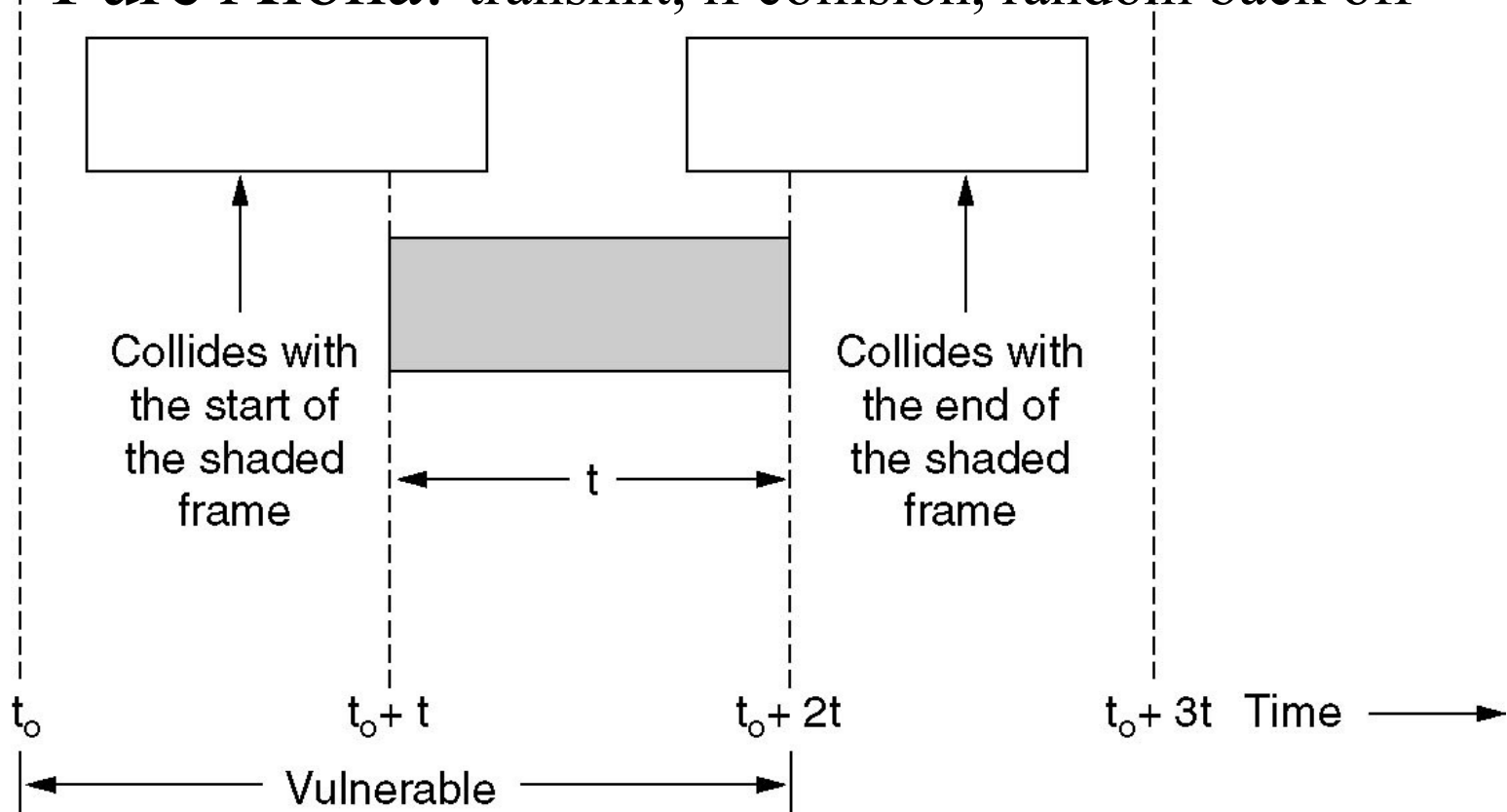
## Medium Access Control

# Review

- Link layer
  - framing
  - error control
  - flow control
- How about you have more than one sender and one receiver share a link?

# Medium access control

- Type of links
  - point-to-point link
    - e.g., PPP, switched Ethernet
  - broadcast link (shared medium)
    - e.g., traditional Ethernet, 802.11
    - collision by concurrent transmission
- Medium access
  - deterministic allocation: FDM/TDM/CDM
  - contention-based: ALOHA, CSMA, CSMA/CD

# Aloha

- ## Pure Aloha: transmit, if collision, random back off



Collides with the start of the shaded frame

Collides with the end of the shaded frame

$t$

$t_o$       $t_o + t$       $t_o + 2t$       $t_o + 3t$   Time

Vulnerable

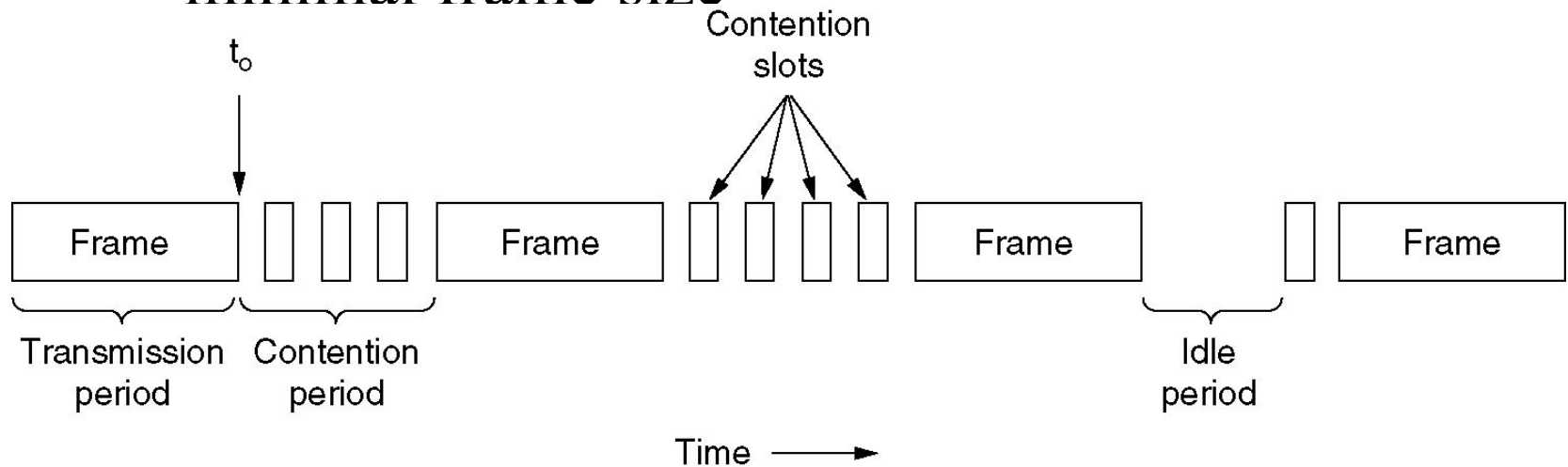- ## Slotted Aloha: transmit in next slot, if collision, …

# Carrier sense multiple access

- p-persistent CSMA: if busy, wait; if idle, transmit w/ p
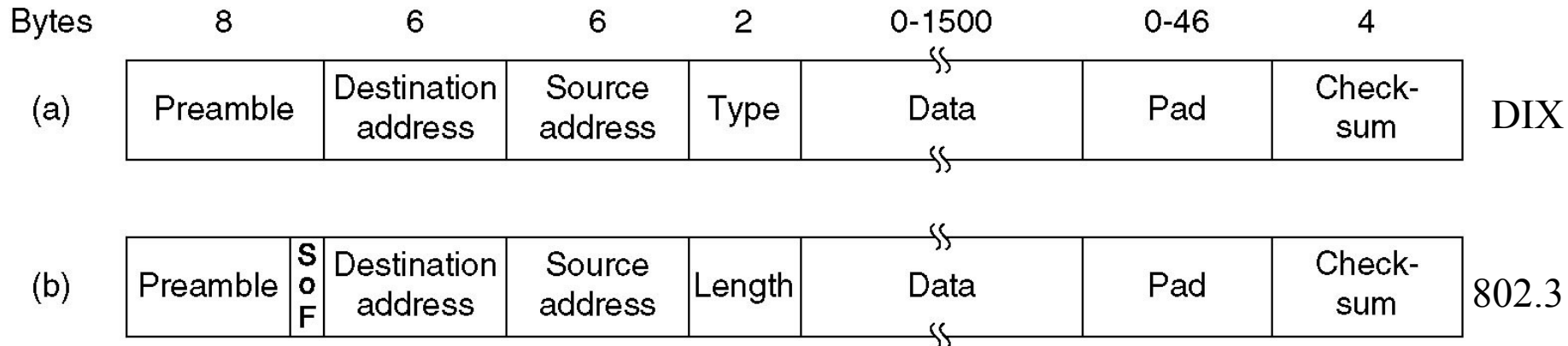- Non-persistent CSMA: if busy, back-off
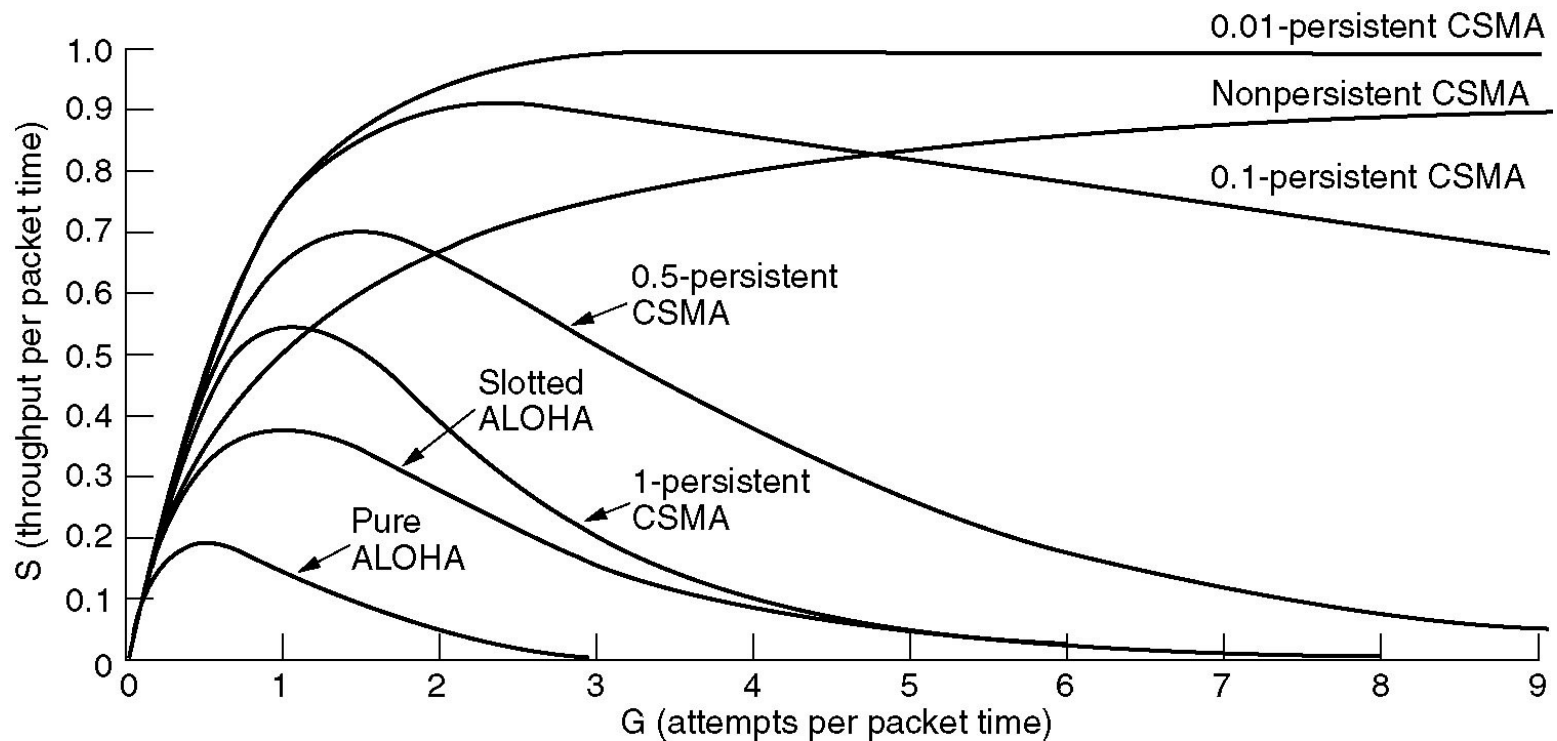
# CSMA/collision detection

- ## CSMA

- ## CD: if collision, abort! and back off

  - ### need: receiving while sending

  - ### minimal frame size

Contention slots

$t_o$

| Frame | | | | Frame | | | | | Frame | | Frame |

Transmission period · Contention period

Idle period

Time $\longrightarrow$

# Ethernet

- Pervasive!
  - speed: 10Mbps, 100Mbps, 1Gbps, 10Gbps
  - medium: coaxial, twist-pair, fiber
  - topology: bus, tree, star; range: LAN, MAN

| Bytes | 8 | 6 | 6 | 2 | 0-1500 | 0-46 | 4 | |
|---|---|---|---|---|---|---|---|---|
| (a) | Preamble | Destination address | Source address | Type | Data | Pad | Check-sum | DIX |

| Bytes | | | 6 | 6 | | 0-1500 | 0-46 | 4 | |
|---|---|---|---|---|---|---|---|---|---|
| (b) | Preamble | S O F | Destination address | Source address | Length | Data | Pad | Check-sum | 802.3 |

7

# Ethernet frame

- Destination/source addresses (6-byte each)
- Type (2-byte): e.g., 0x0800 (IP)
  - length in 802.3 frame with 802.2 LLC
- Data: 0~1500 bytes
- Pad: 0~46 bytes
  - minimal frame length
- CRC: 4-byte
- CSMA/CD with binary exponential backoff

# Wireless LAN

- Very popular!
  - 802.11a: 5GHz, 54Mbps, 30ft
  - 802.11b: 2.4GHz, 11Mbps, 100ft
  - 802.11g: 2.4GHz, 54Mbps, 100ft
  - 802.11n: MIMO, 2.4GHz, 540Mbps
- Infrastructure mode
  - access point
- Ad-hoc mode

# CSMA/CA

- CSMA
- CA: collision avoidance
  - if idle for DIFS, transmit
  - if busy, random backoff
    - count down when idle
    - transmit when count to 0
  - if no ack, collision or corruption
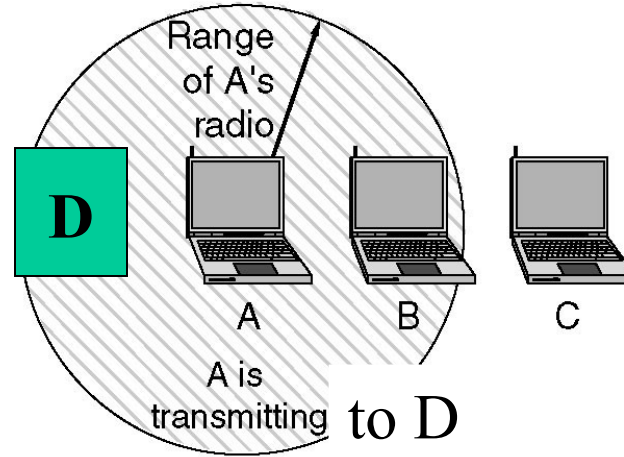    - exponential backoff
    - CW: contention window

sender     receiver

DIFS {

data

SIFS

ACK

10
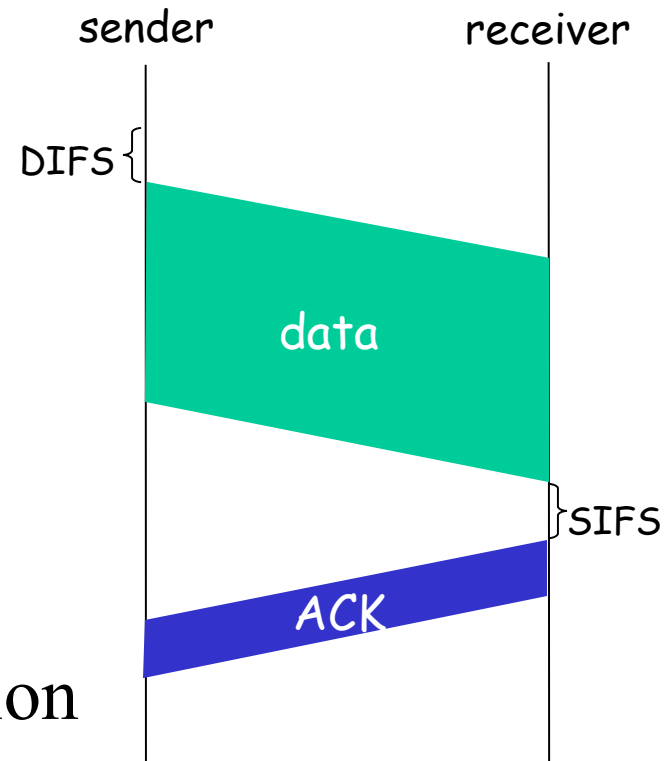
A wants to send to B but cannot hear that B is busy
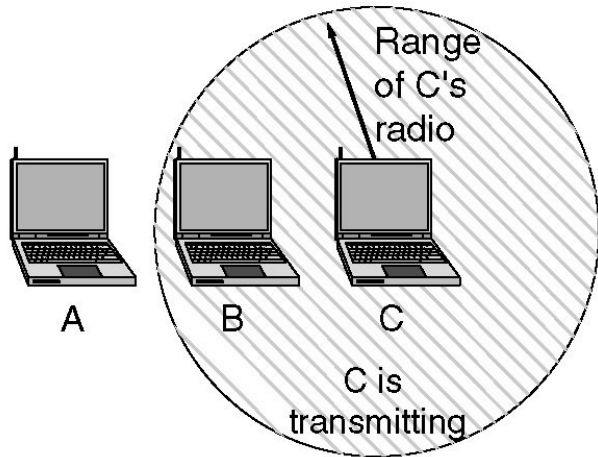
B wants to send to C but mistakenly thinks the transmission will fail

Range of C's radio

Range of A's radio

D

A   B   C

A   B   C

C is transmitting

A is transmitting to D

Hidden vs exposed terminal

(a)   (b)

RTS/CTS

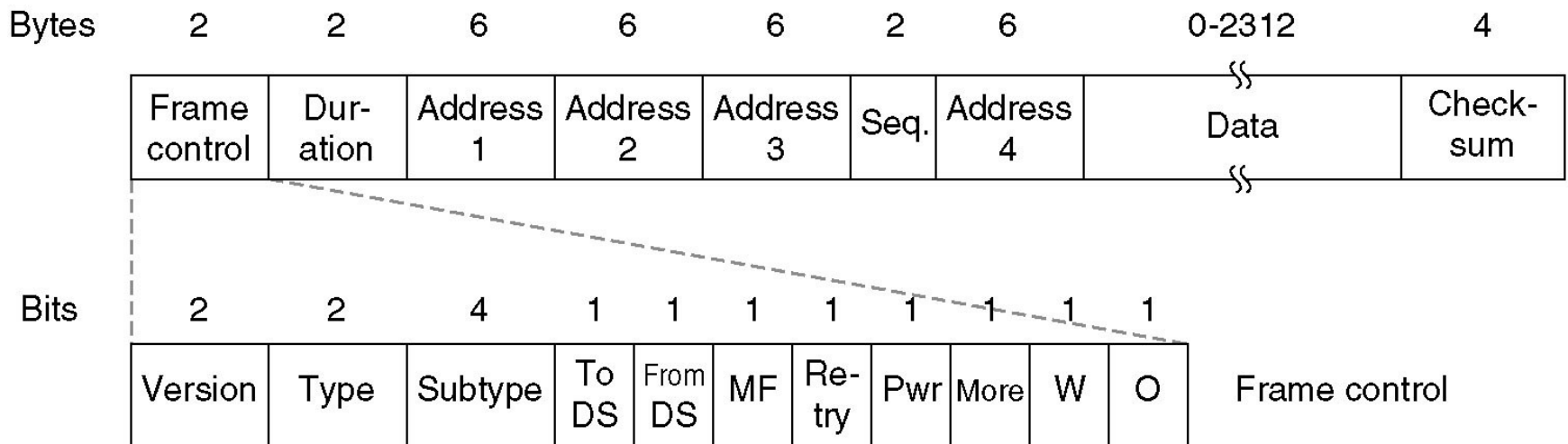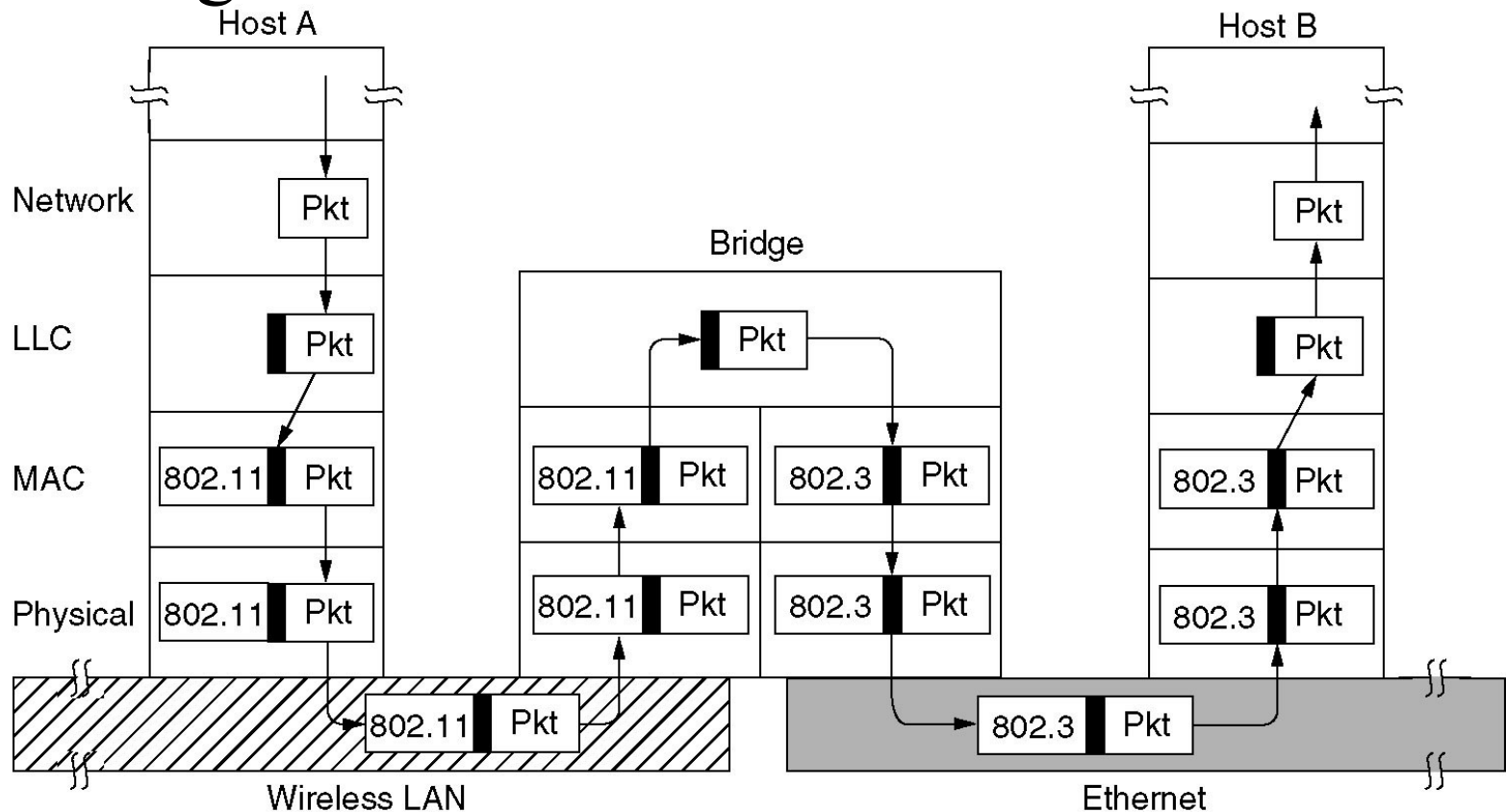DIFS   RTS

SIFS   Data

A

SIFS   CTS

SIFS   ACK

B

NAV

C

NAV

D

Time

11
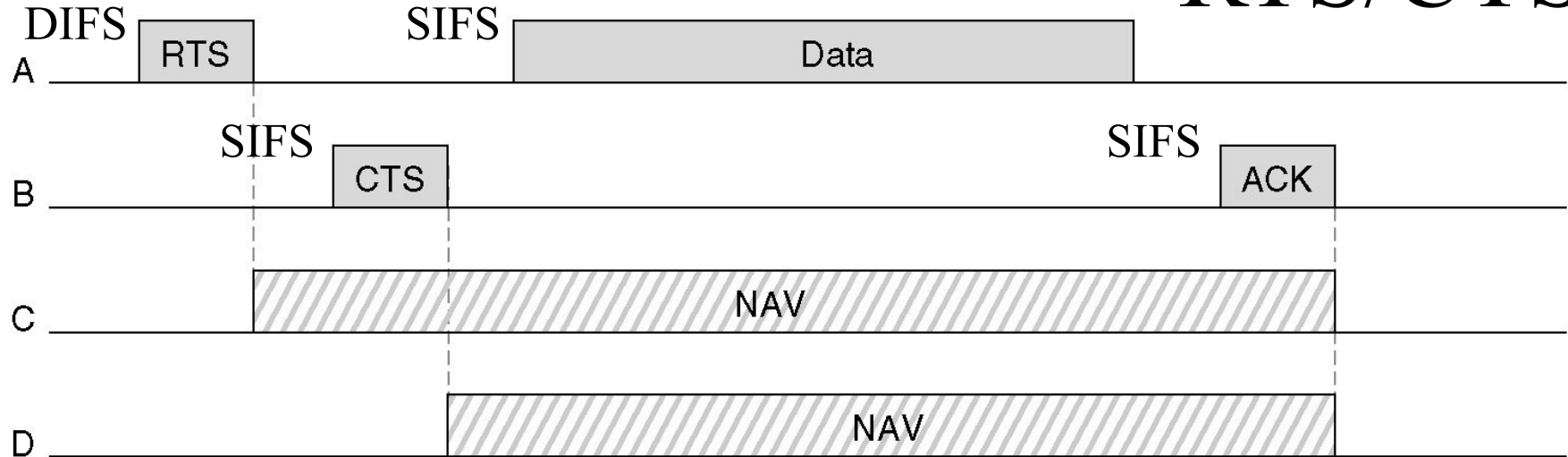
# 802.11 frame

- Frame control

- Duration: NAV (network allocation vector)

- Addresses: dst, src, receiving, transmitting

| Bytes | 2 | 2 | 6 | 6 | 6 | 2 | 6 | 0-2312 | 4 |
|---|---|---|---|---|---|---|---|---|---|
| | Frame control | Dur-ation | Address 1 | Address 2 | Address 3 | Seq. | Address 4 | Data | Check-sum |

| Bits | 2 | 2 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Version | Type | Subtype | To DS | From DS | MF | Re-try | Pwr | More | W | O | Frame control |

12

# Layer 2 internetworking

- Bridge

# How bridge works

· Objectives: plug-and-play

  No hardware change, no software update, no setting of address, no downloading of routing tables or parameters.

· How

1. Each bridge connects with a number of LANs with a port connecting to a single LAN

2. Assume a packet is broadcasting in LAN1, bridge A needs to decide whether to forward it to its other ports, depending on the destination address. If the destination address in a hash table is in LAN1, no need; otherwise, forwards it.

3. Initially, the hash table is empty, then using flooding algorithm .

4. Anytime it hears a frame from a LAN, it adds the destination LAN for the source node, associated with the time. (backward learning).

# Spanning tree
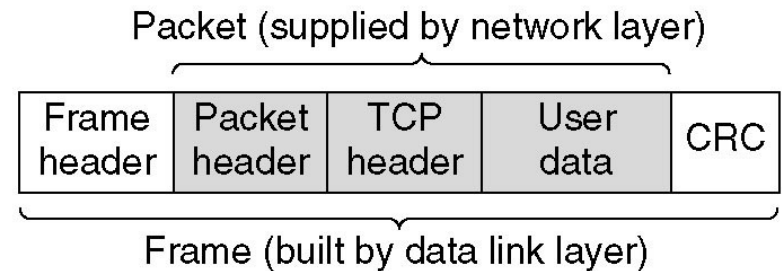
- A tree of shortest paths



(a)                    (b)

15
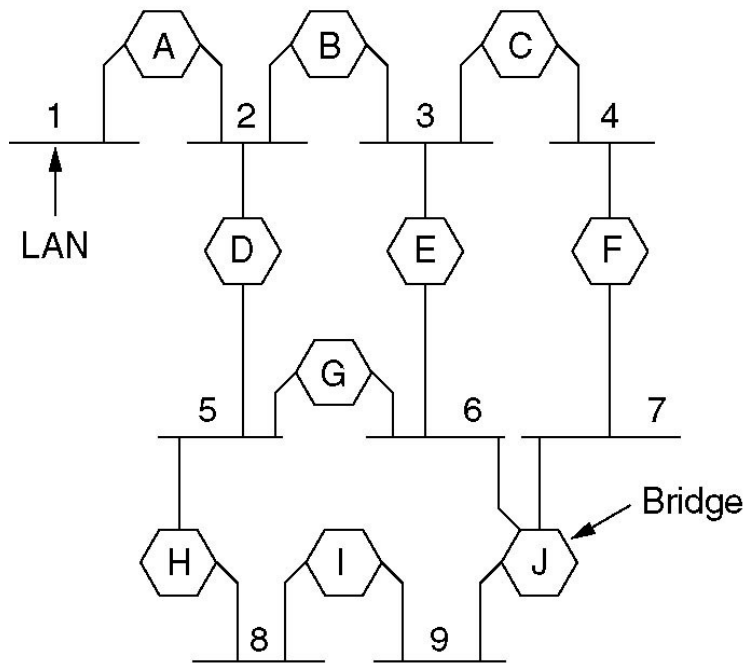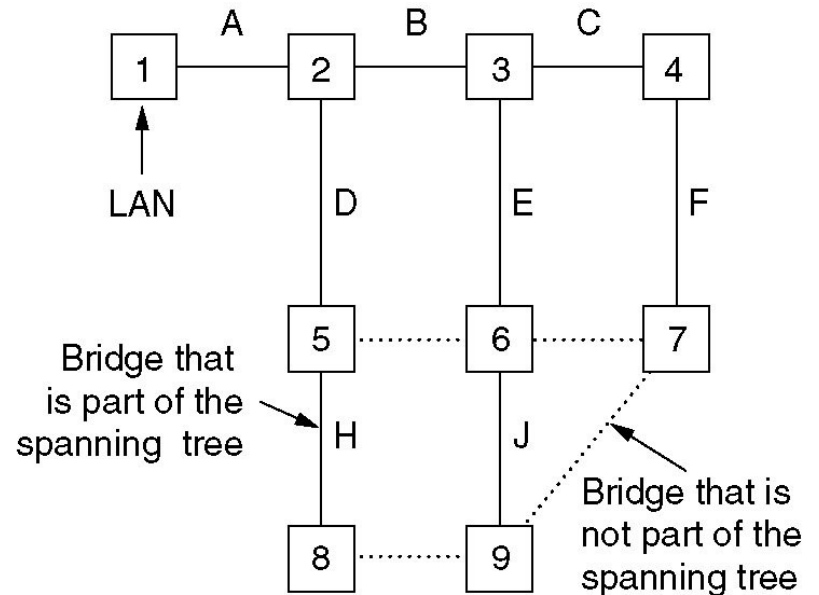
# Architecture, again!

- Network architecture
  - services
  - protocols

| | |
|---|---|
| Application layer | Application gateway |
| Transport layer | Transport gateway |
| Network layer | Router |
| Data link layer | Bridge, switch |
| Physical layer | Repeater, hub |

(a)

Packet (supplied by network layer)

| Frame header | Packet header | TCP header | User data | CRC |
|---|---|---|---|---|

Frame (built by data link layer)

(b)

16

# Summary

- MAC
  - Ethernet
    - Aloha, slotted Aloha
    - CSMA, CSMA/CD
  - 802.11
    - CSMA/CA
    - RTS/CTS
  - internetworking
    - spanning tree

# Some other algorithms

- Tree protocols
  - Collisions are resovled using divide-and-conquer, collision resolution algorithm (CRA)
  - Assume:
    - Synchronous channel
    - Users are able to detect {idle, collision, success}
    - A user corresponds to a leaf of a binary tree.

# Tree protocols (cont'd)

- Static tree algorithm
  - Admission rule: newly arriving packets are admitted only after all the packets arrived during the previous collision resolution interval (CRI) are successfully transmitted
  - Retransmission rule: When a collision occurs, try to divide the users involved in the collision into two groups and resolve the collision among one group of users at a time

- Dynamic tree algorithm
  - At each CRI, the level of initial node is adjusted based on the throughput and the length of the previous cycle