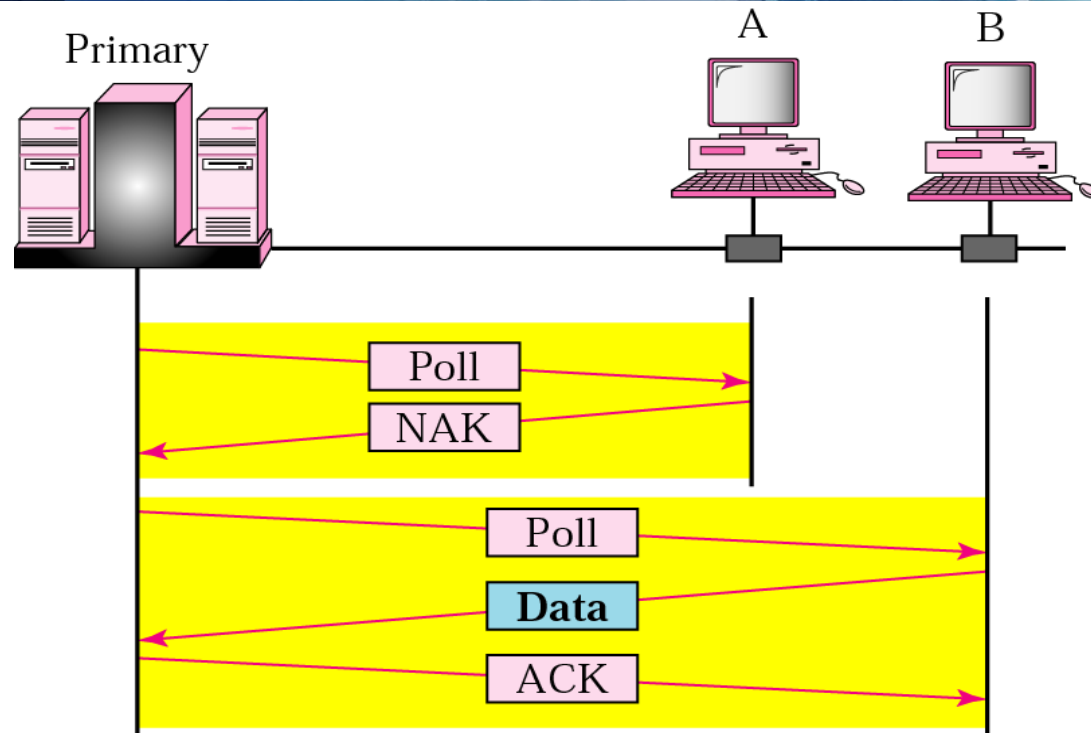


# Overview of Today's Topics

- 802.11
- Ethernet
- Discussion of Sample Code
- Discussion of Assignment
- Discussion of Report

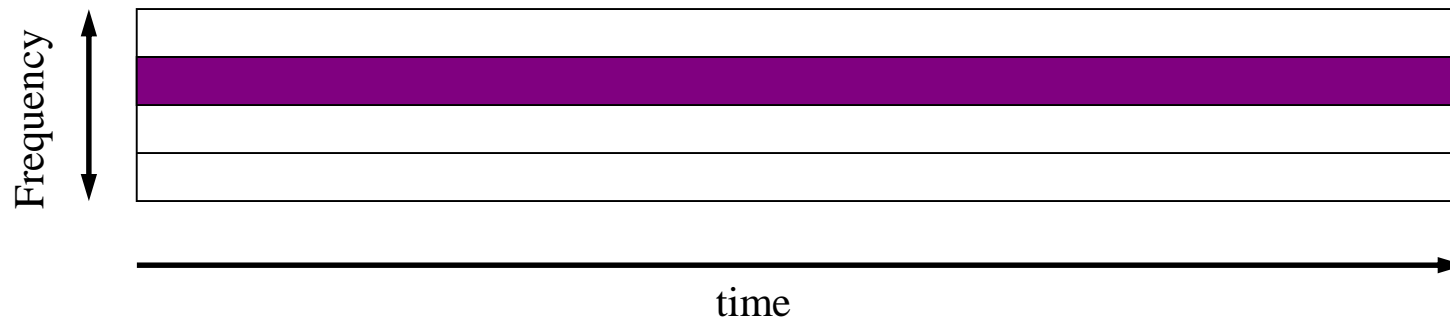
# Poll



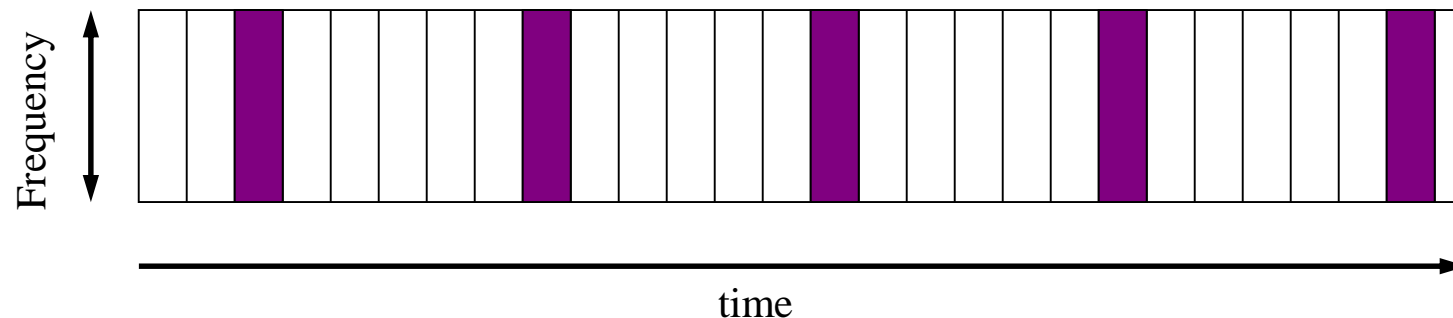
- Primary contacts stations to determine if they have data to transmit

# Static Channel Allocation

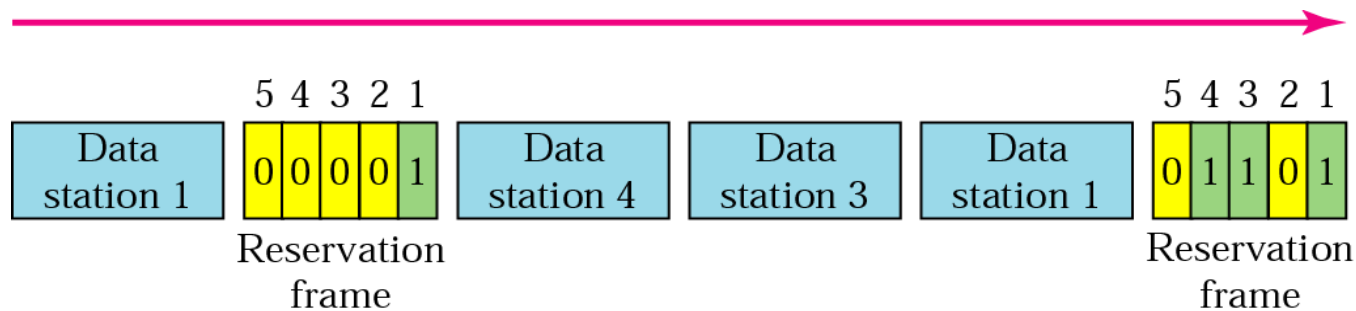
- Frequency Division Multiplexing (FDM)



- Time Division Multiplexing (TDM)

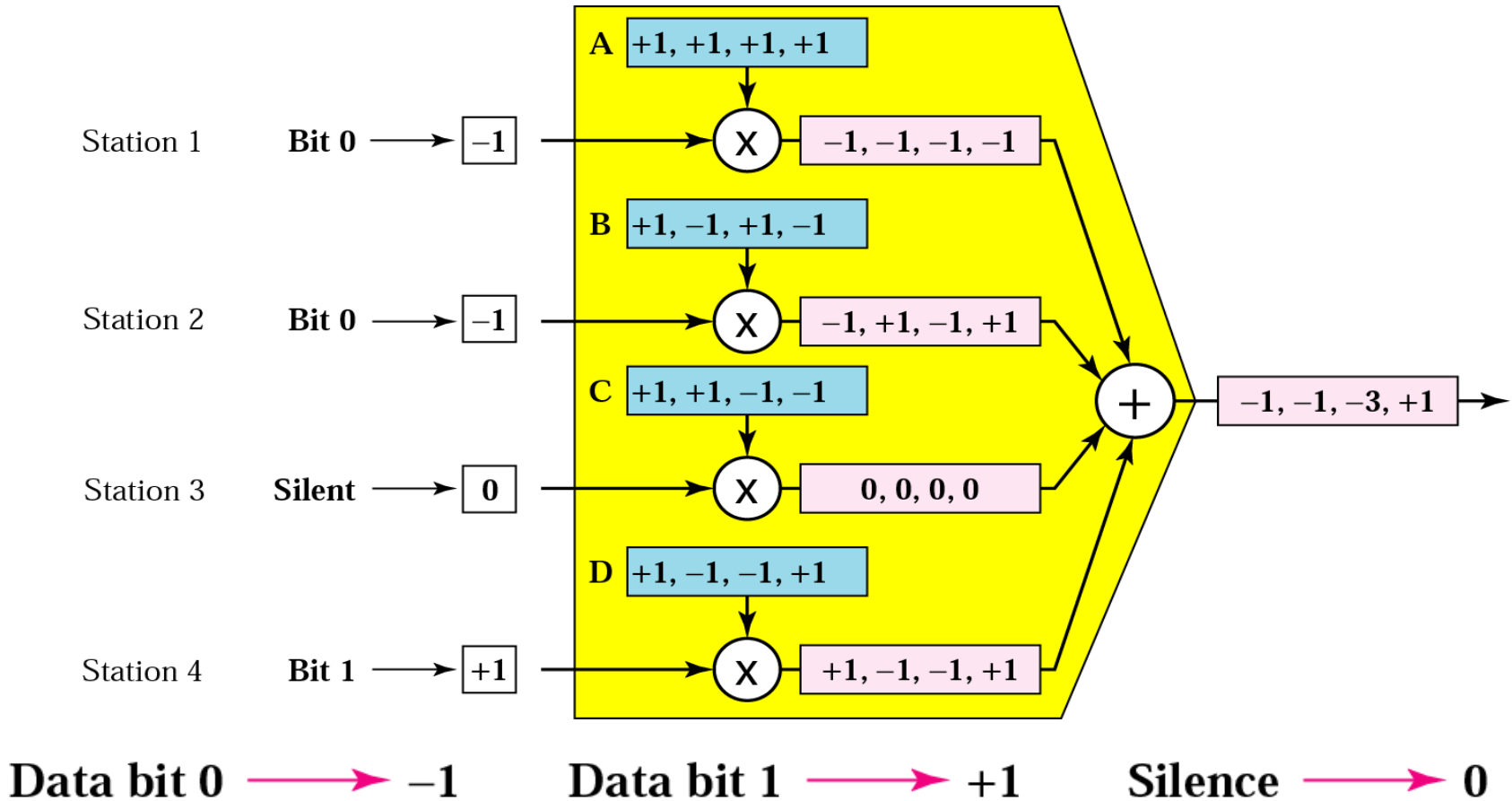


# Reservation Access Method



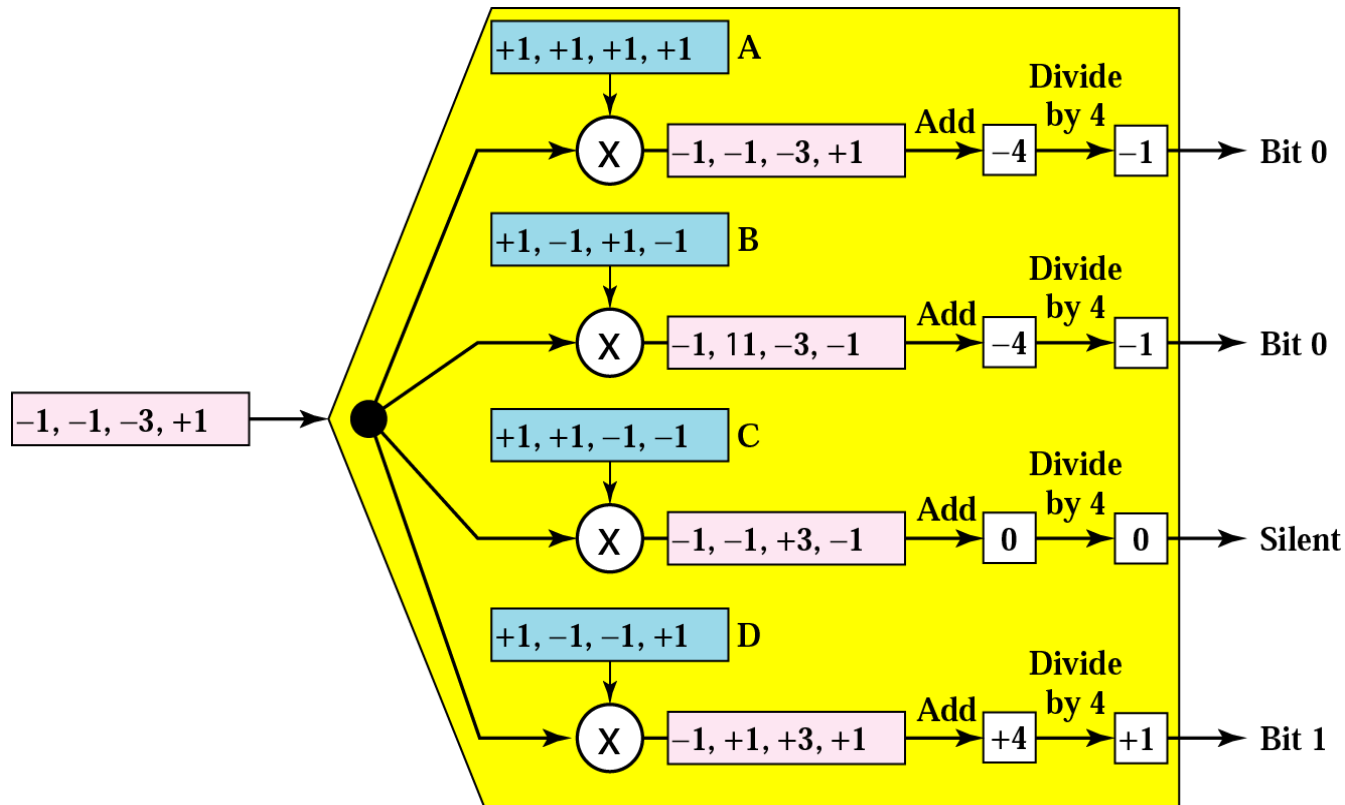
- Station that wants to transmit data
  - transmits 1 during its slot in the reservation frame
- All stations are informed about all planned communication
- Limited number of pre-allocated slots/stations

# CDMA Multiplexer



\* Figure is courtesy of B. Forouzan

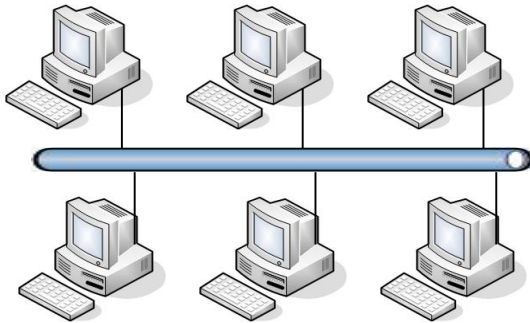
# CDMA De-Multiplexer



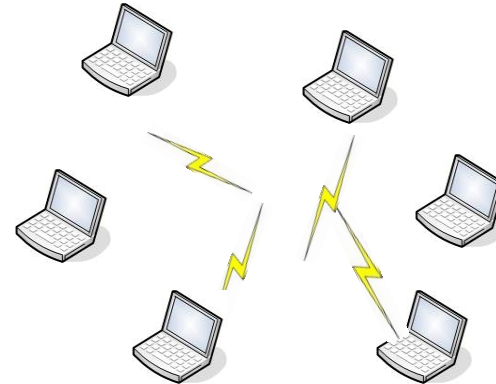
Decoding of received signal

\* Figure is courtesy of B. Forouzan

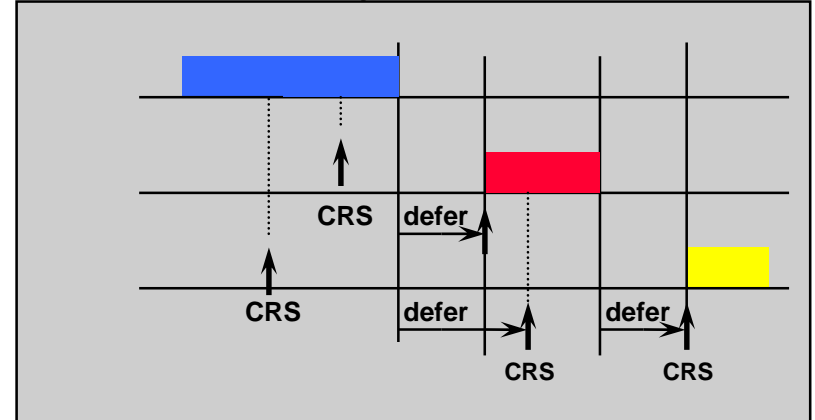
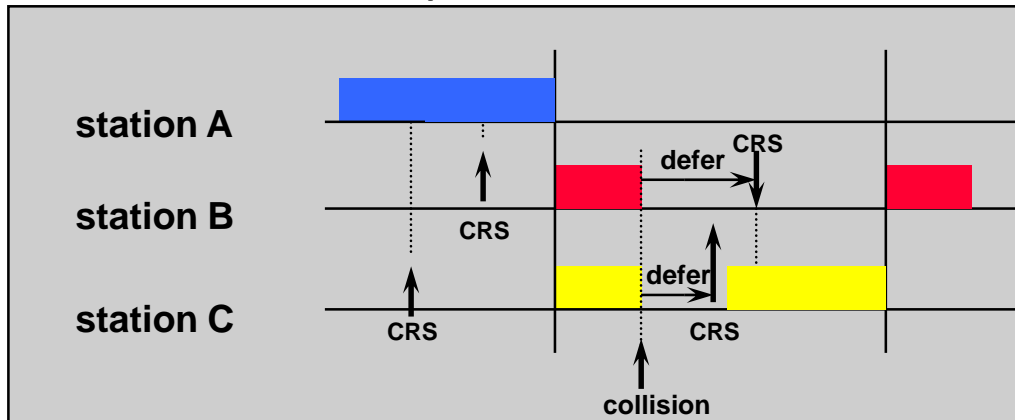
# Collision Detection vs Collision Avoidance



CSMA/CD



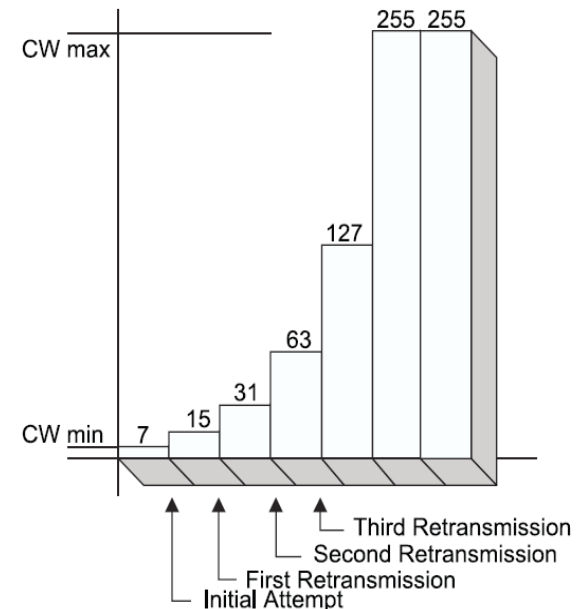
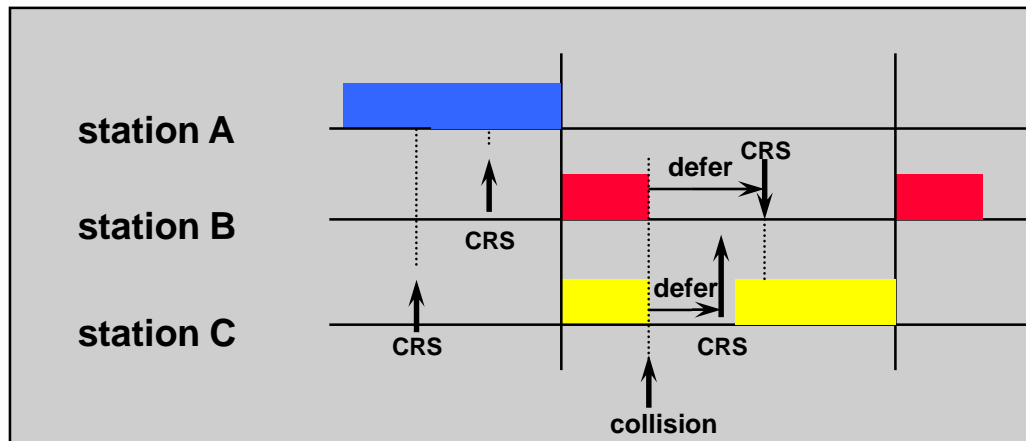
CSMA/CA



CRS = Carrier Sense

\* Figure is courtesy of Avaya Communications Inc

# Binary Exponential Backoff



$$\text{Backoff Time} = \text{Random()} \times \text{aSlotTime}$$

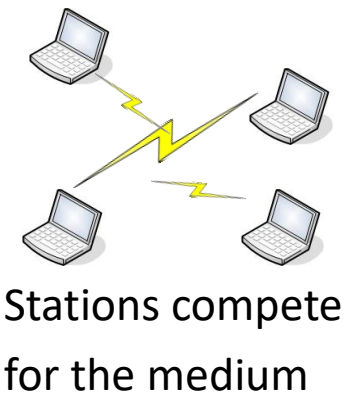
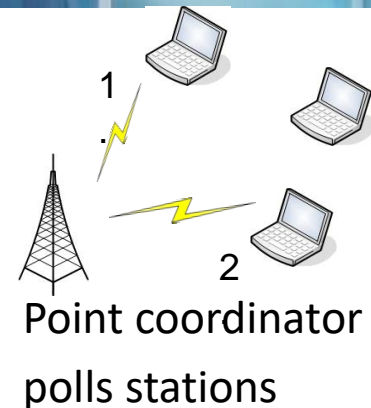
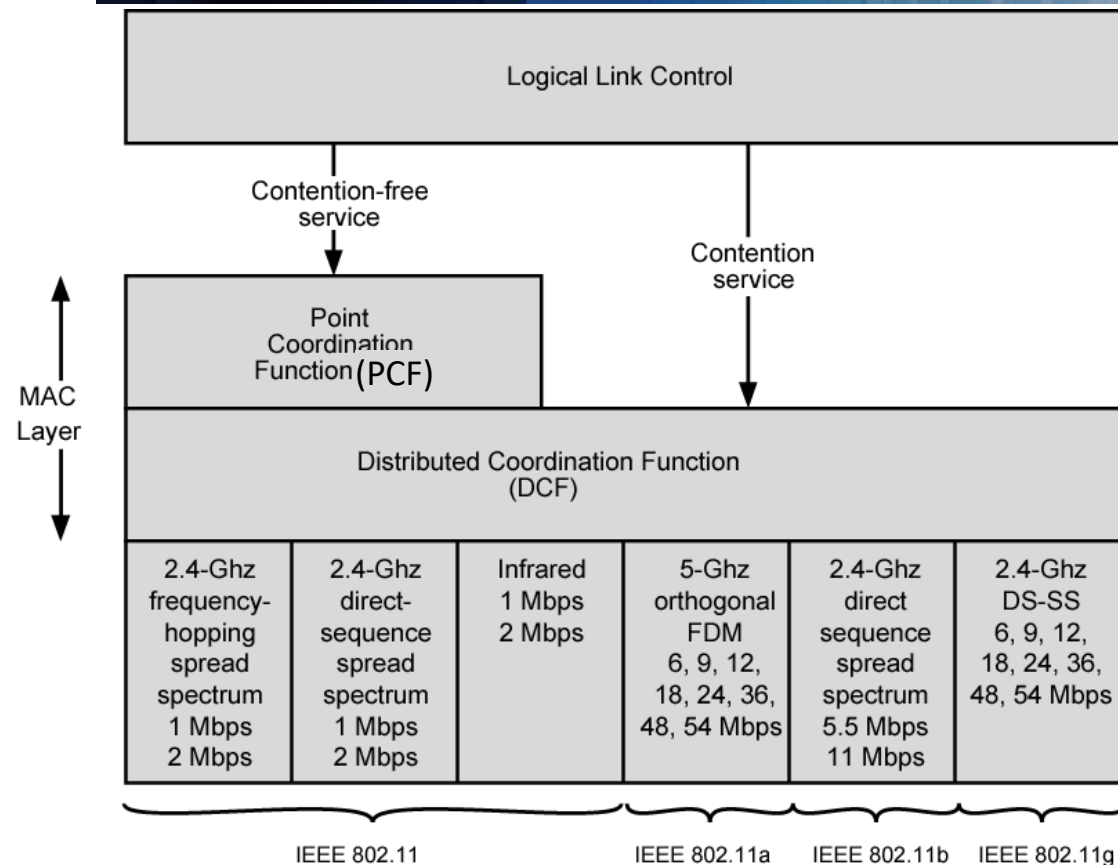
where

$\text{Random()}$  = Pseudorandom integer drawn from a uniform distribution over the interval  $[0, \text{CW}]$ , where CW is an integer within the range of values of the PHY characteristics  $\text{aCWmin}$  and  $\text{aCWmax}$ ,  $\text{aCWmin} \leq \text{CW} \leq \text{aCWmax}$ . It is important that designers recognize the need for statistical independence among the random number streams among STAs.

$\text{aSlotTime}$  = The value of the correspondingly named PHY characteristic.



# 802.11 DCF & PCF



- PCF – Point Coordination Function – Access Points
- DCF – Distributed Coord. Function – between Stations

\* Figure is courtesy of W. Stallings

# CS2031

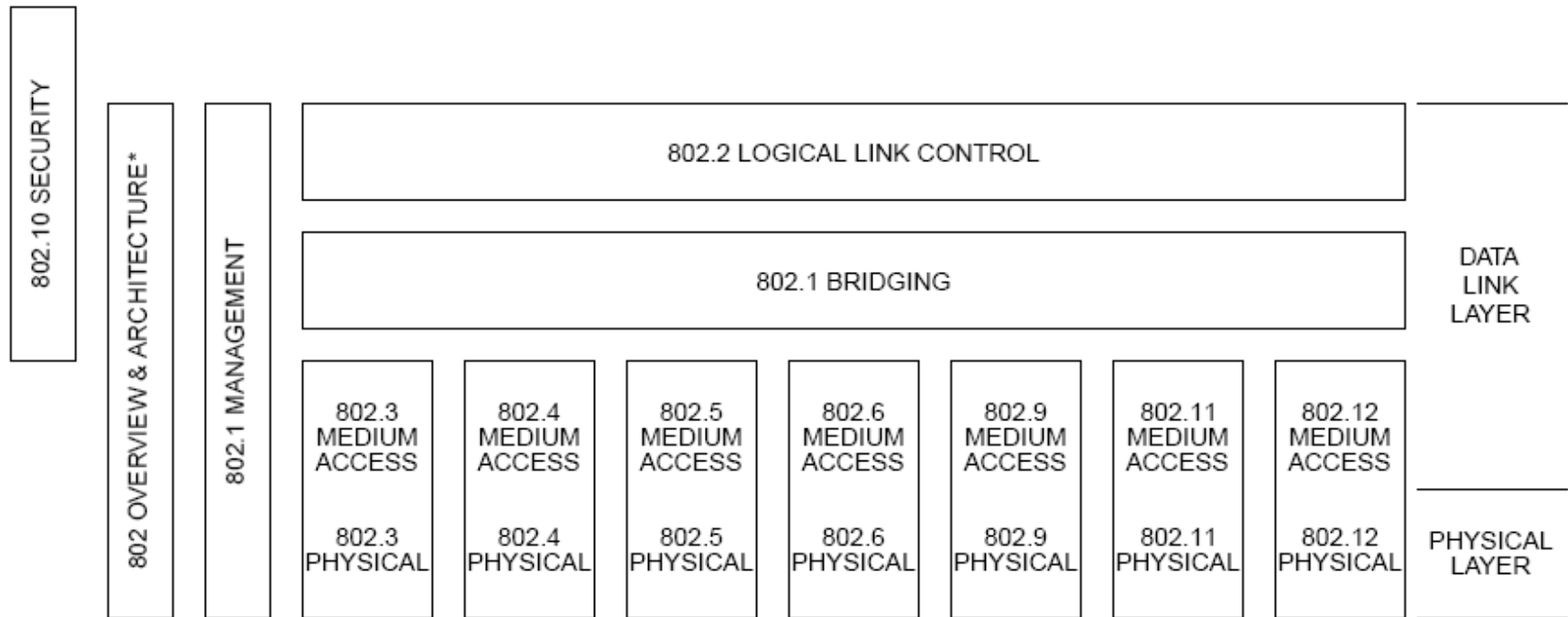
## Telecommunications II

802.11

# 802.11

- DCF  $\Rightarrow$  Distributed Coordination Function
  - Stations compete for access to the medium
  - Hidden Station / Expose Station Problem
  - CSMA/CA + RTS/CTS
- PCF  $\Rightarrow$  Point Coordination Function
  - Access point polls stations
- IFS  $\Rightarrow$  Inter-Frame Space
  - Time between frames

# IEEE 802



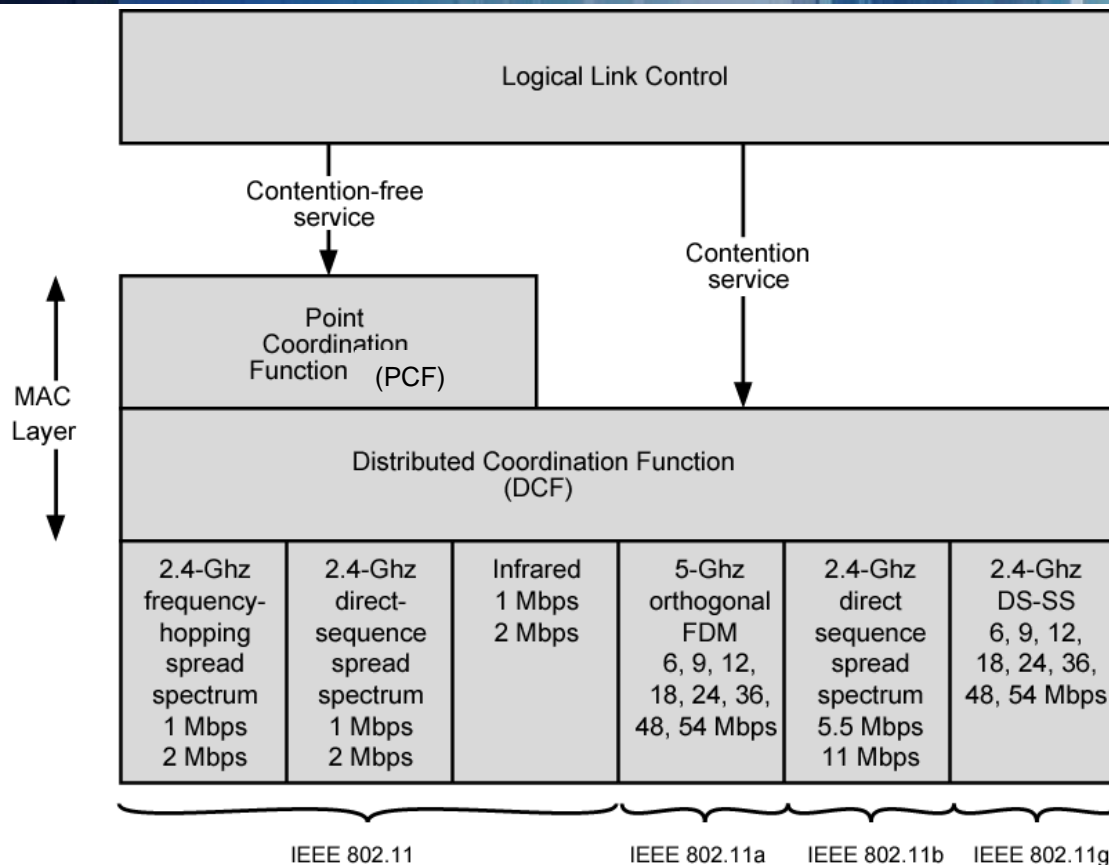
- 802.3: Ethernet
- 802.5: Token Ring
- 802.11: Wifi
- 802.16: WiMAX
- 802.15.1: Bluetooth
- 802.15.4: ZigBee

\* Figure is courtesy of ANSI/IEEE Std 802.11

# IEEE 802.11 Standards

- **IEEE 802.11** - The original 1 Mbit/s and 2 Mbit/s, 2.4 GHz RF and IR standard
- **IEEE 802.11a** - 54 Mbit/s, 5 GHz standard
- **IEEE 802.11b** - Enhancements to 802.11 to support 5.5 and 11 Mbit/s
  - IEEE 802.11c - Bridge operation procedures; included in the IEEE 802.1D standard
  - IEEE 802.11d - International (country-to-country) roaming extensions
  - IEEE 802.11e - Enhancements: QoS
  - IEEE 802.11F - Inter-Access Point Protocol
- **IEEE 802.11g** - 54 Mbit/s, 2.4 GHz standard
  - IEEE 802.11h - Spectrum Managed 802.11a (5 GHz)
  - IEEE 802.11i - Enhanced security
  - IEEE 802.11j - Extensions for Japan
  - IEEE 802.11k - Radio resource measurement enhancements
  - IEEE 802.11m - Maintenance of the standard; odds and ends.
- **IEEE 802.11n** - Higher throughput improvements
  - IEEE 802.11p - WAVE - Wireless Access for the Vehicular Environment
  - IEEE 802.11r - Fast roaming
  - **IEEE 802.11s** - ESS Mesh Networking
  - IEEE 802.11t - Wireless Performance Prediction (WPP)
  - IEEE 802.11u - Interworking with non-802 networks
  - IEEE 802.11v - Wireless network management
  - IEEE 802.11w - Protected Management Frames

# 802.11 Structure

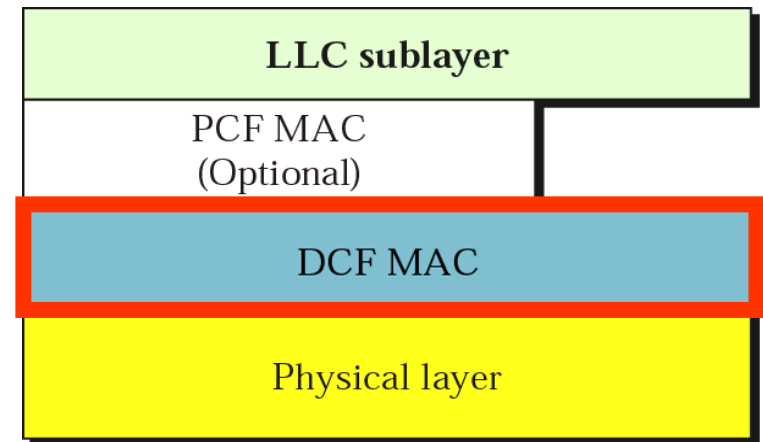


- PCF – Point Coordination Function – Access Points
- DCF – Distributed Coord. Function – between Stations

\* Figure is courtesy of W. Stallings

# Distributed Coordination Function (DCF)

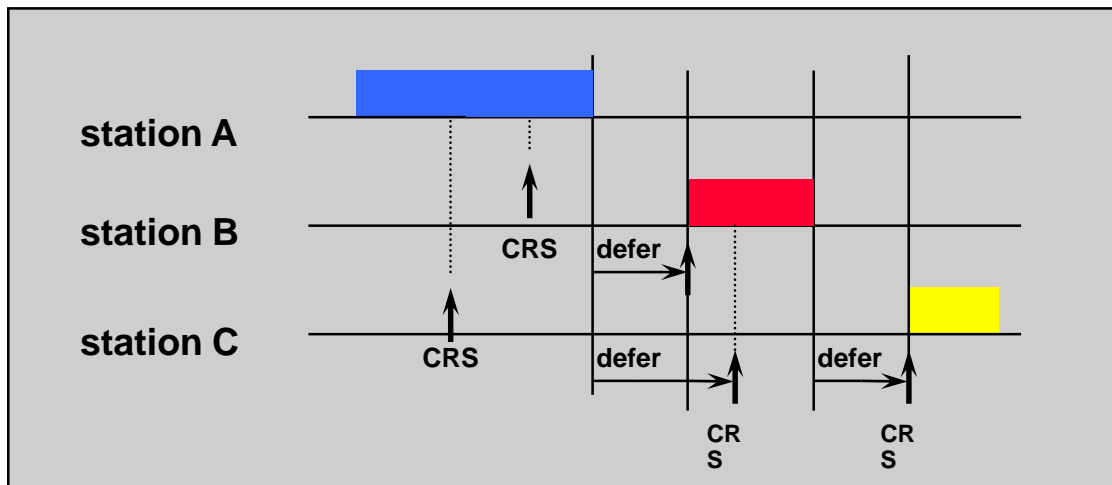
- Stations compete for access to the medium
- Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA)
- No collision detection
  - Not practical on wireless network
  - Transmitting station cannot distinguish incoming weak signals from noise and effects of own transmission



# CSMA in Wireless Media



**Collision is at  
the receiver !!!**

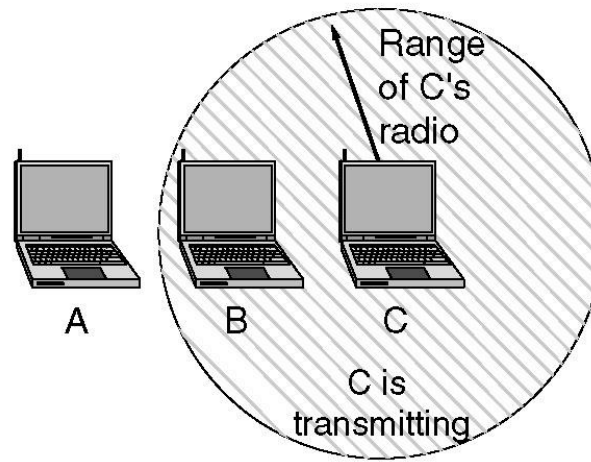


- Sense carrier to determine if medium is free
- Once free pick a random number
  - then start sending



# Hidden Station Problem

A wants to send to B  
but cannot hear that  
B is busy

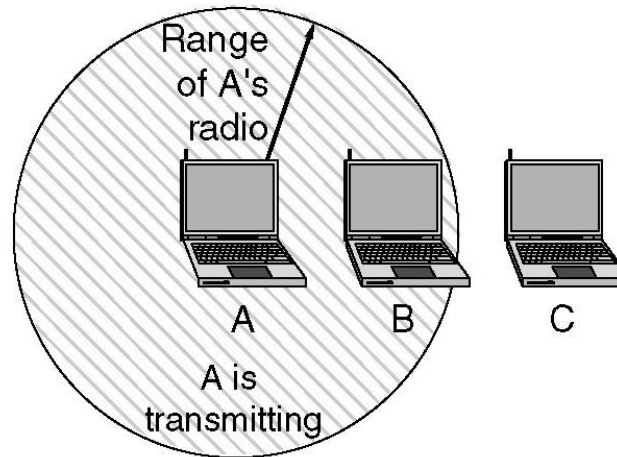


(a)

**(a)** Hidden Station Problem

# Exposed Station Problem

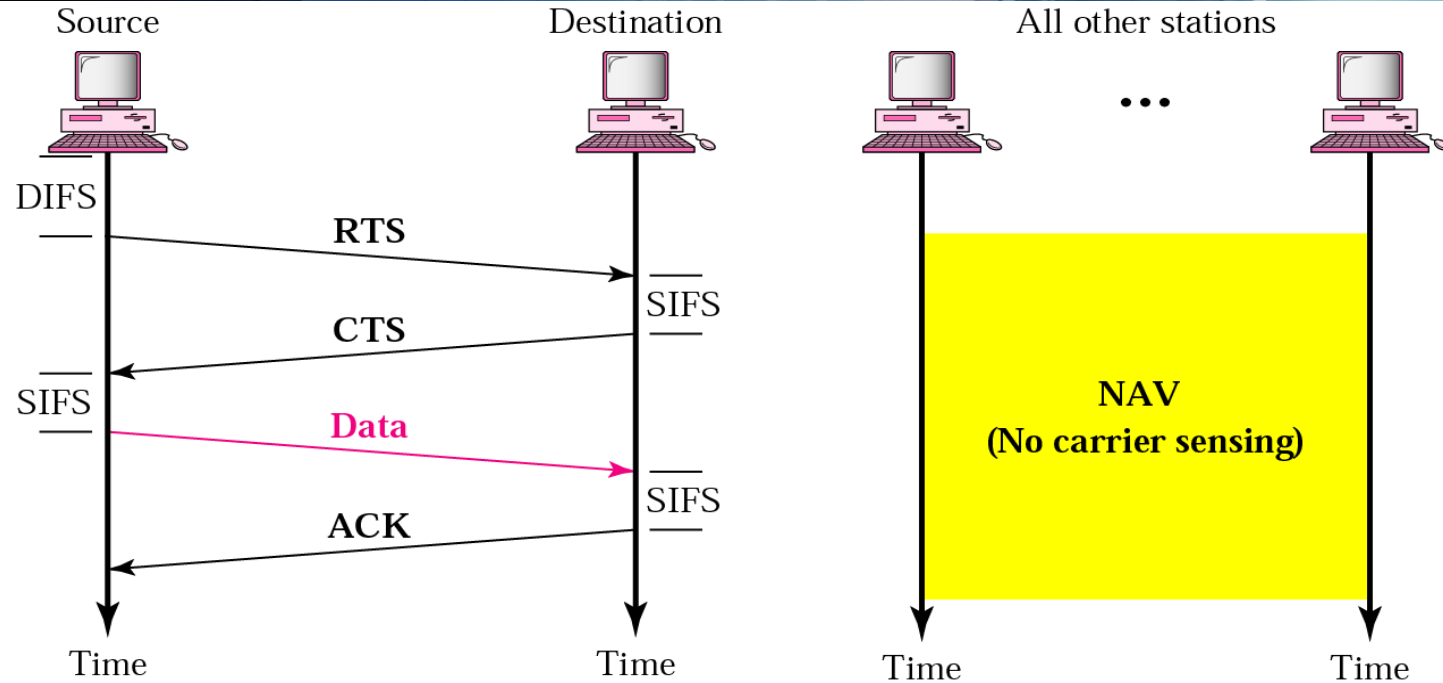
B wants to send to C  
but mistakenly thinks  
the transmission will fail



(b)

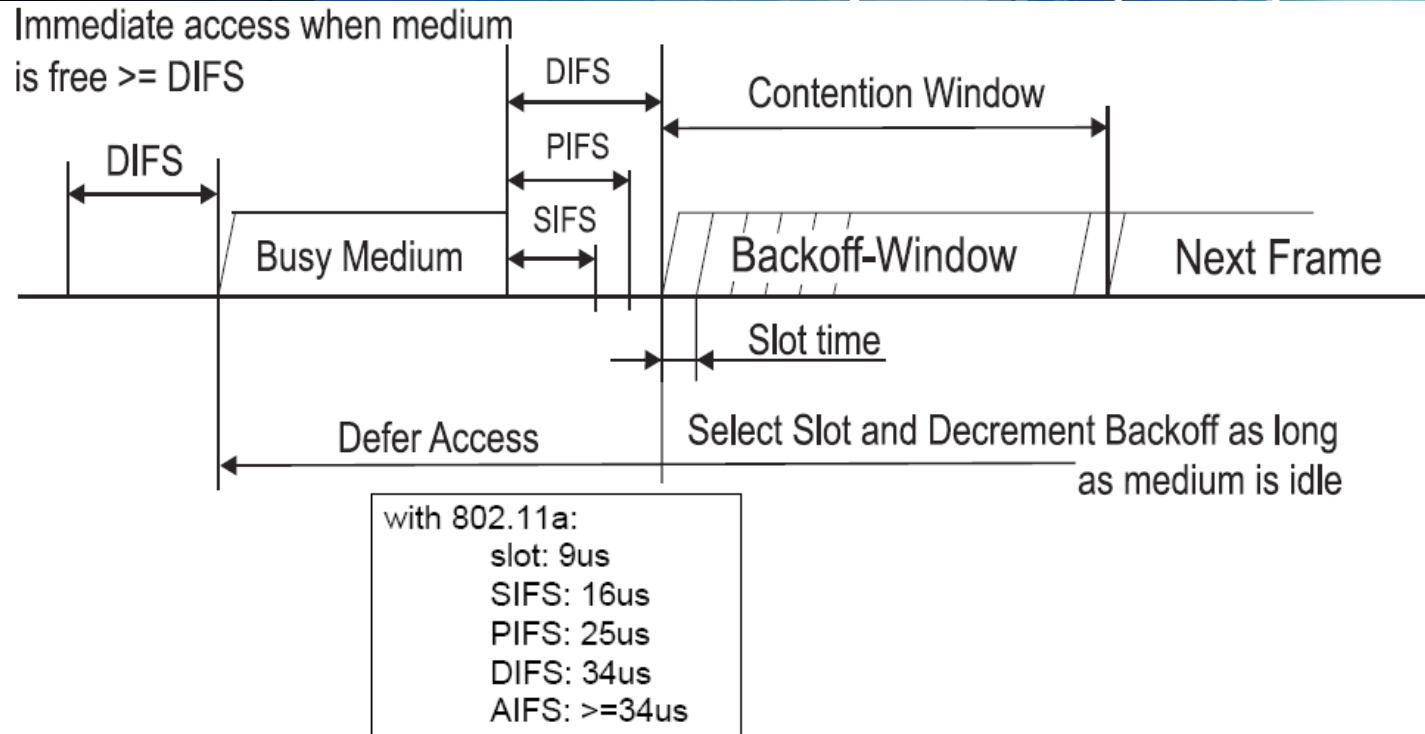
**(b)** Exposed Station Problem

# CSMA/CA and NAV



- Ready-To-Send (RTS) announces the intention to send traffic
- Clear-To-Send (CTS) announces that the receiving station is ready
- SIFS is the smallest possible Inter-Frame Space that separates two transmissions
- The Network Allocation Vector (NAV) as part of RTS/CTS announces the length of the subsequent transmission

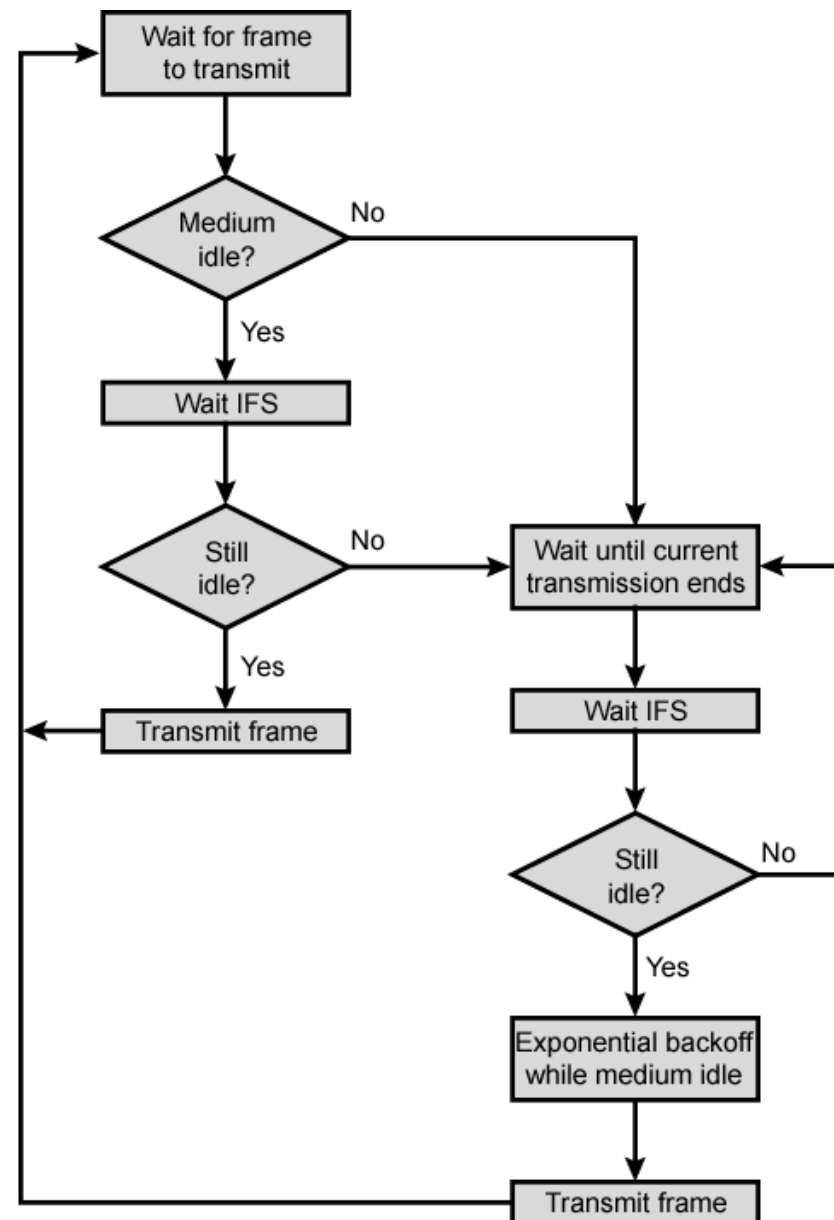
# Inter-Frame Space (IFS)



- Short IFS (SIFS) defines the minimum time between frames
- DCF IFS (DIFS) defines the time between the end of one transmission and the beginning of a subsequent transmission

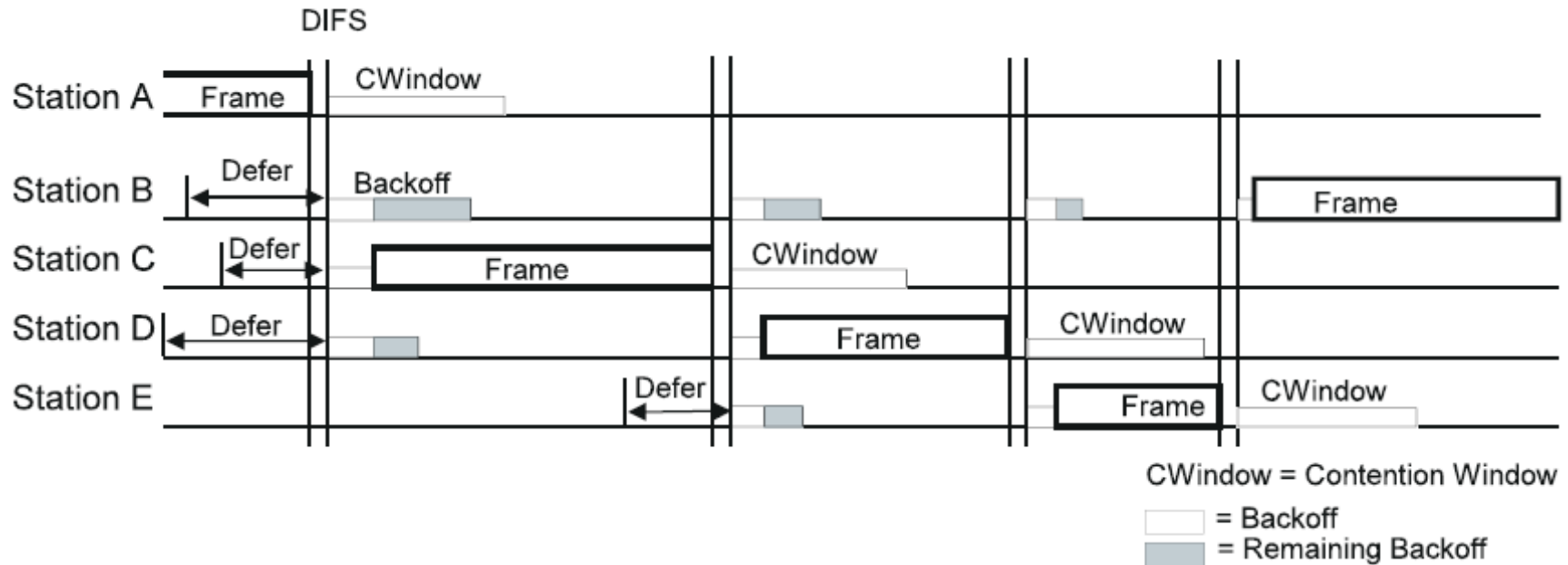
# 802.11 MAC

- Station with frame senses medium
  - If idle, wait to see if remains idle for one IFS.
  - If so, may transmit immediately
- If busy - either initially or becomes busy during IFS - station defers transmission
  - Continue to monitor until current transmission is over
- Once current transmission over, delay for another IFS
  - If remains idle, back off random time and again sense
  - If medium still idle, station may transmit
  - During backoff time, if becomes busy, backoff timer is halted and resumes when medium becomes idle



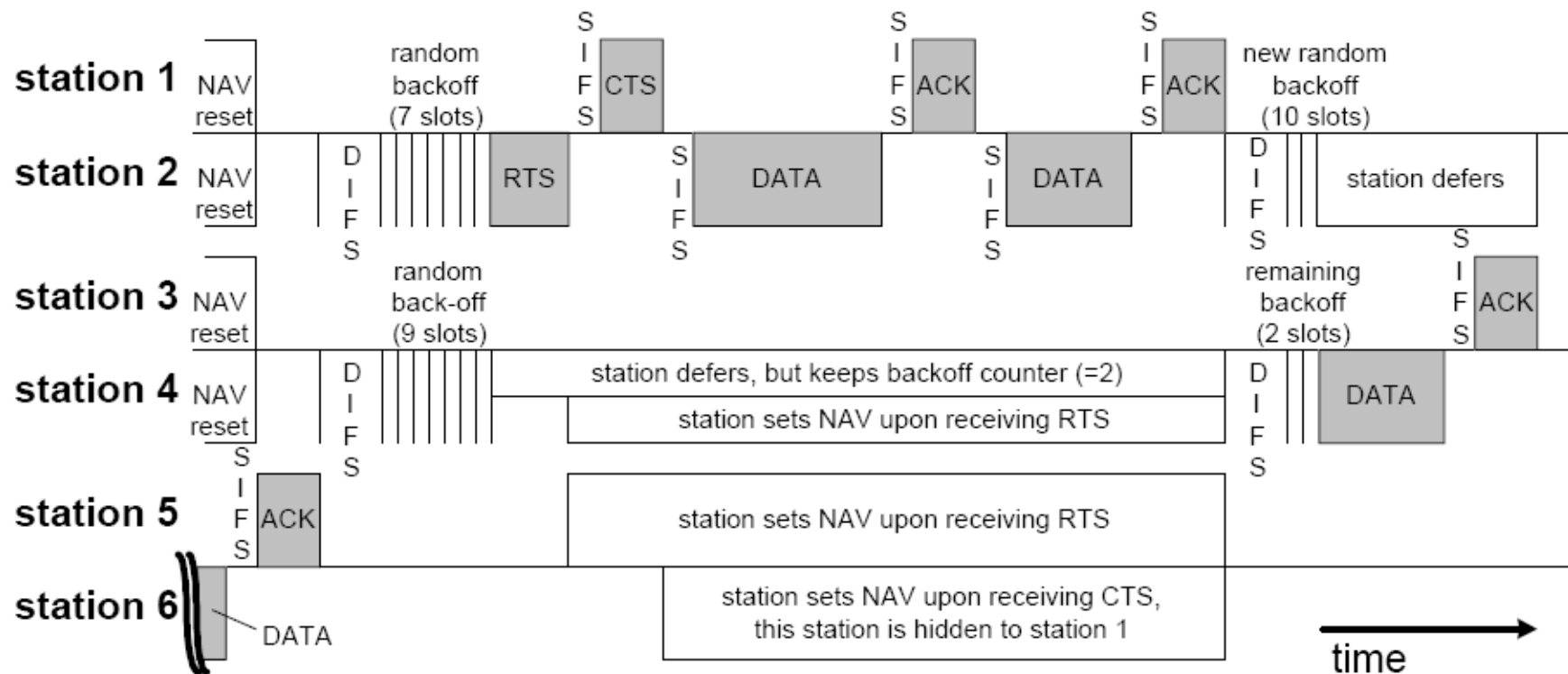
\* Figure is courtesy of W. Stallings

# Contention & Backoff



- DIFS defines the minimum time between the end of one transmission and the beginning of a subsequent transmission
- All stations that want to send sense the medium
- Once the sending station is silent all stations start their DIFS timer
- After the DIFS timer every station starts a random exponential backoff

# DCF & RTS/CTS

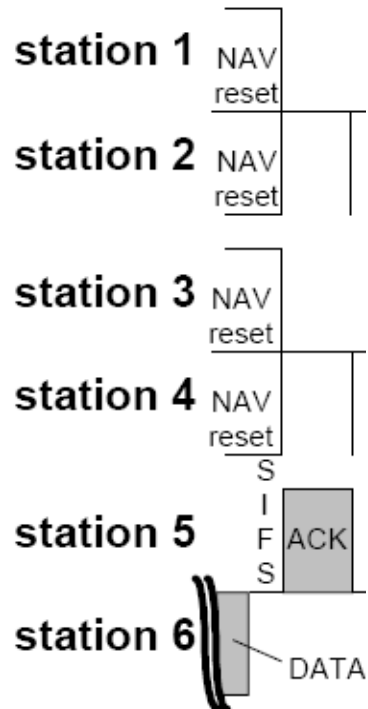


with 802.11a:  
 slot: 9us  
 SIFS: 16us  
 PIFS: 25us  
 DIFS: 34us  
 AIFS: >=34us

\* Figure is courtesy of W. Stallings



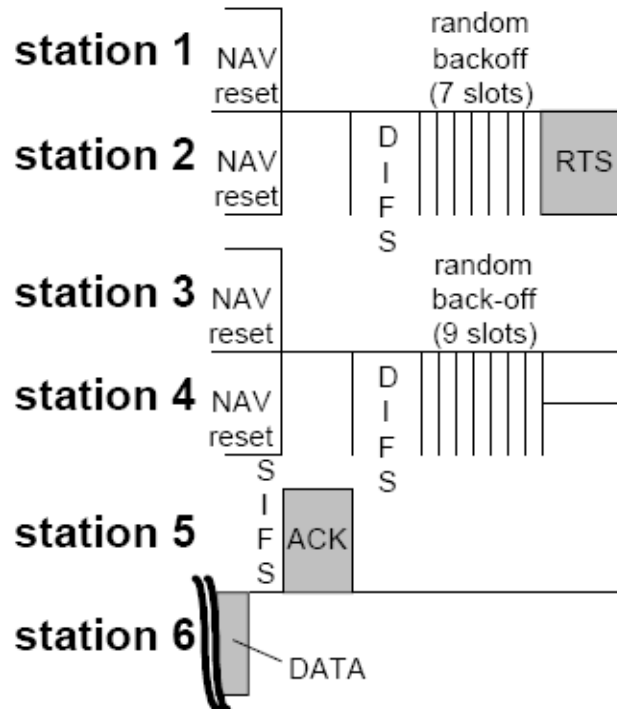
# DCF



with 802.11a:  
 slot: 9us  
 SIFS: 16us  
 PIFS: 25us  
 DIFS: 34us  
 AIFS:  $\geq 34\mu s$

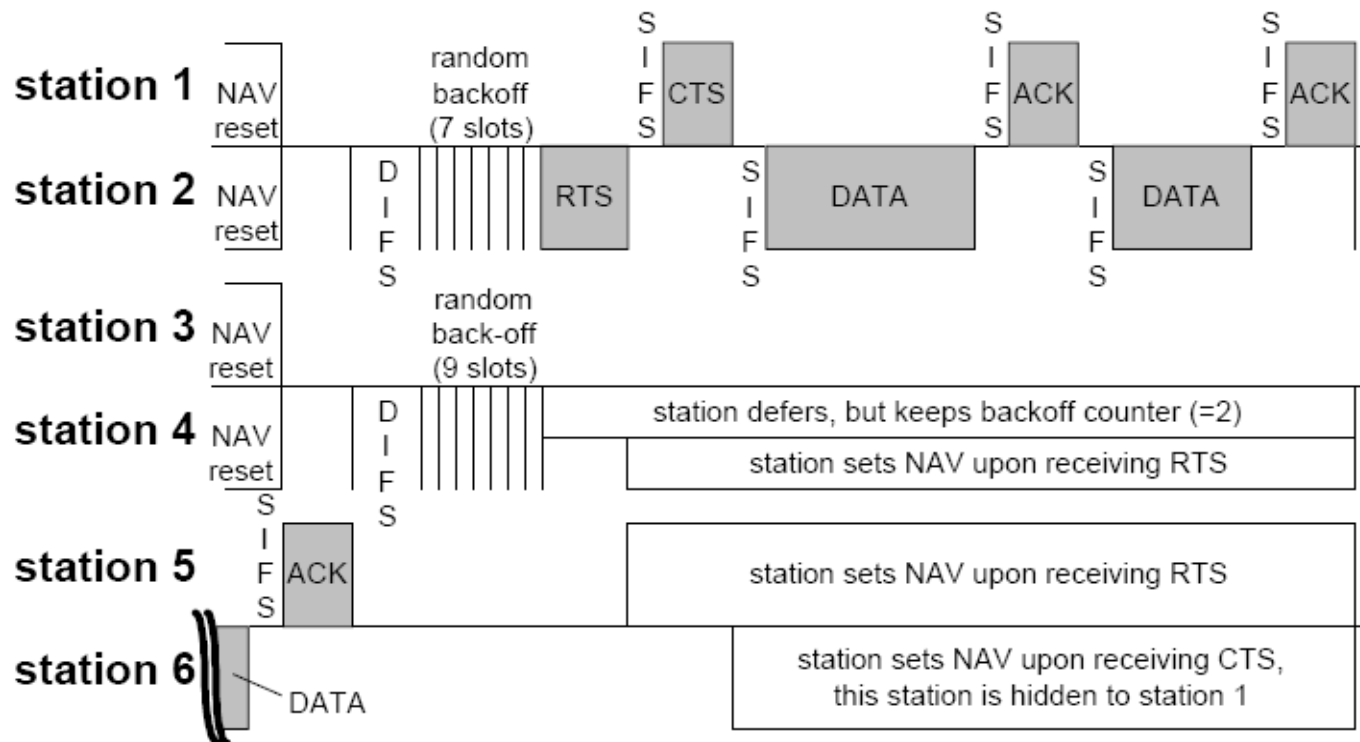


# DCF



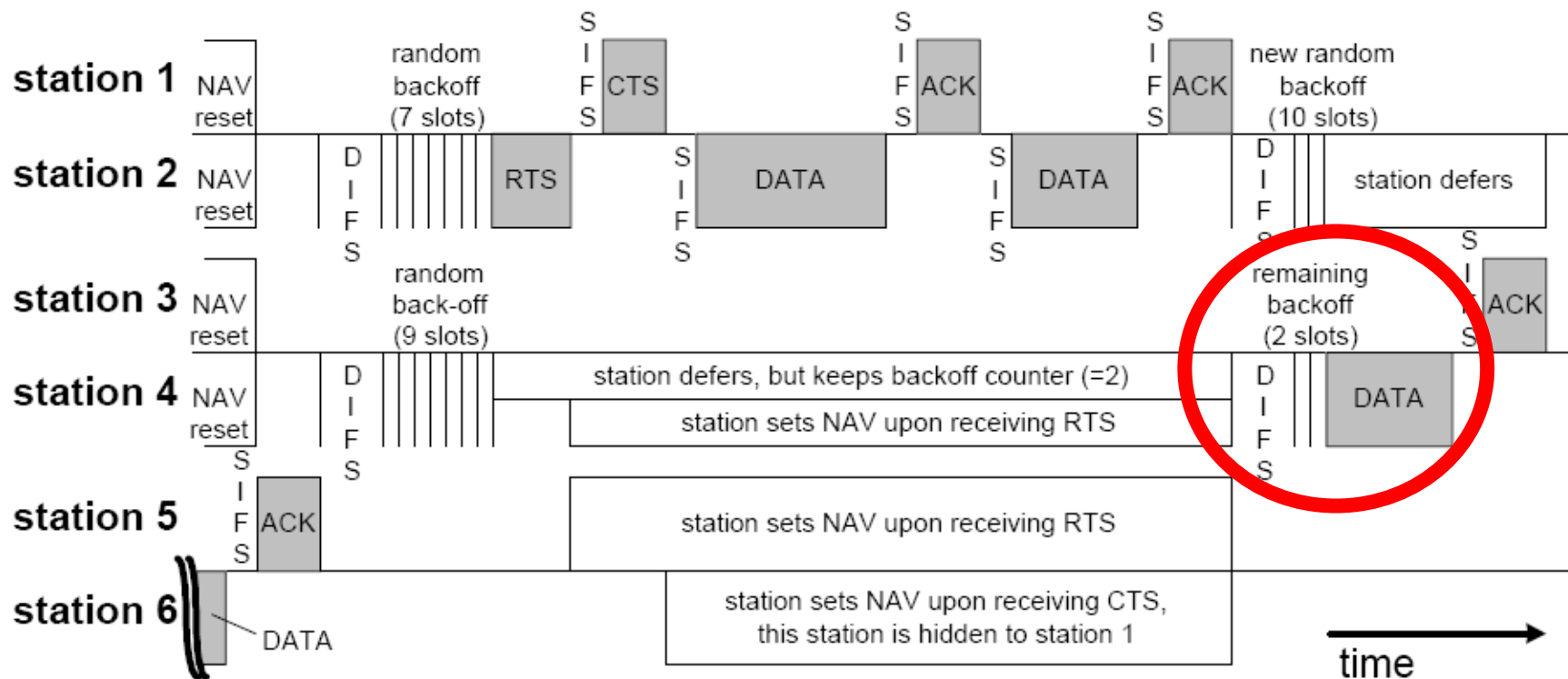
with 802.11a:  
 slot: 9us  
 SIFS: 16us  
 PIFS: 25us  
 DIFS: 34us  
 AIFS:  $\geq 34\mu s$

# DCF



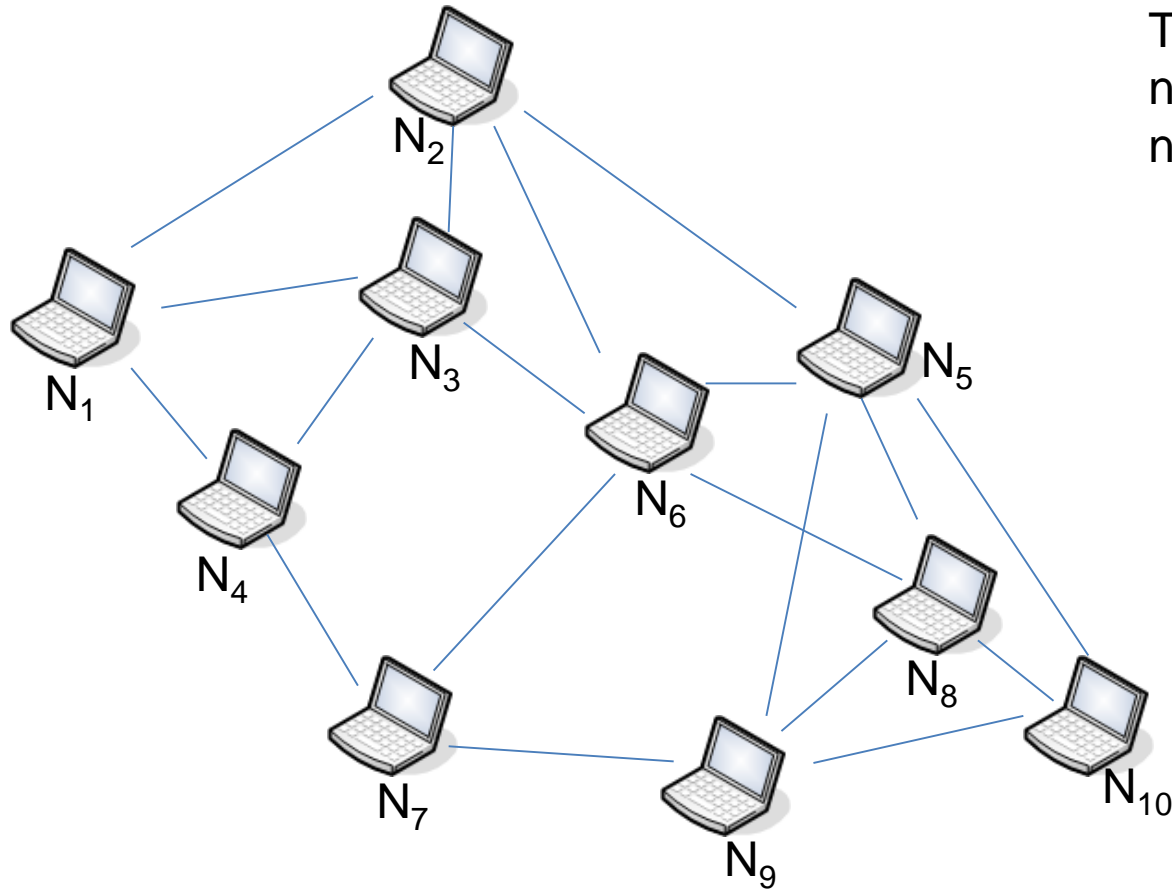
with 802.11a:  
 slot: 9us  
 SIFS: 16us  
 PIFS: 25us  
 DIFS: 34us  
 AIFS: >=34us

# DCF



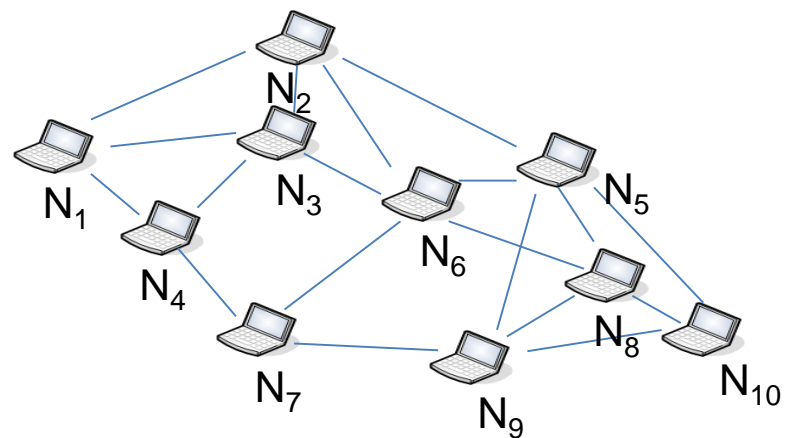
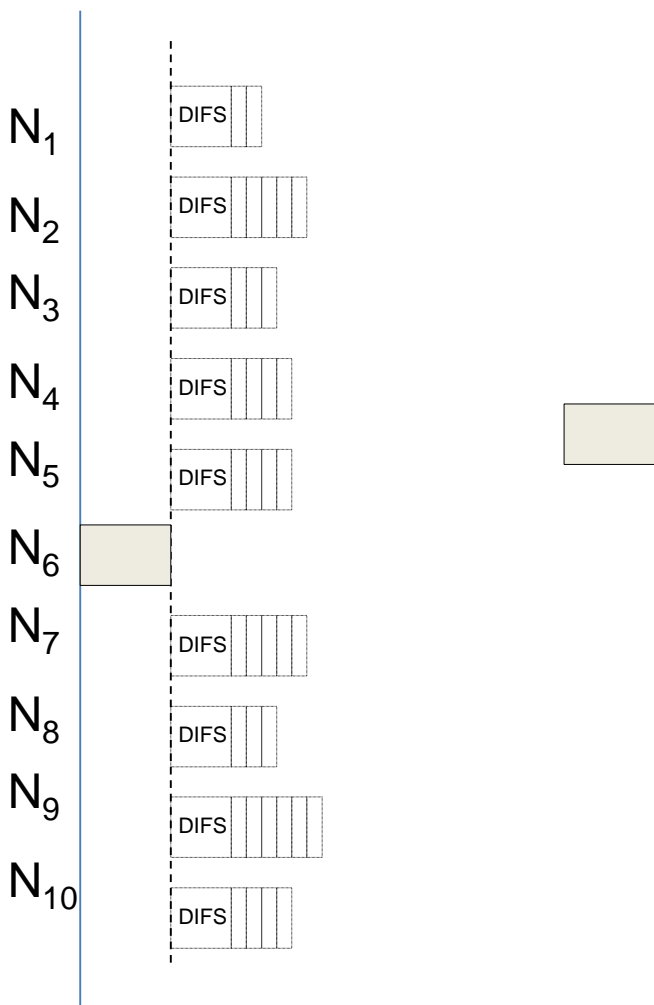
with 802.11a:  
 slot: 9us  
 SIFS: 16us  
 PIFS: 25us  
 DIFS: 34us  
 AIFS: >=34us

# DCF Example

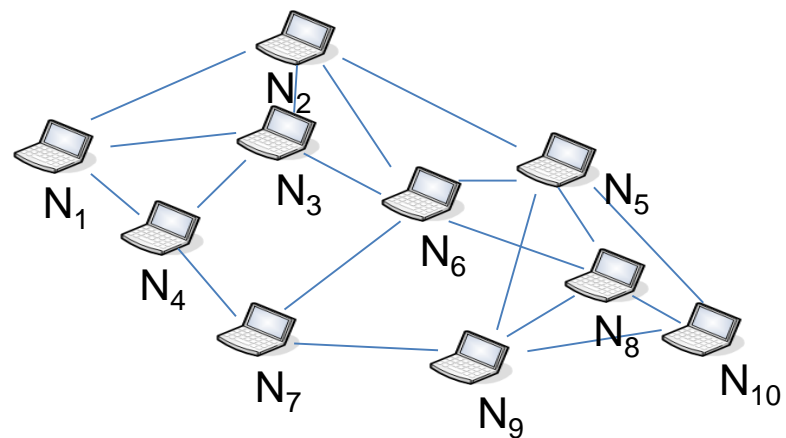
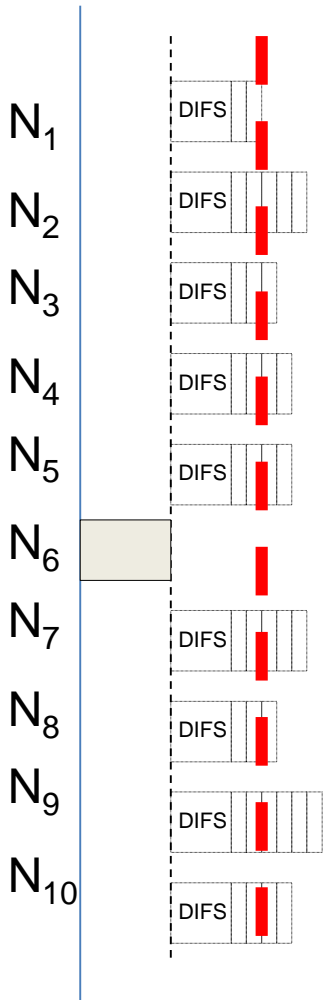


The lines indicate which nodes will receive their neighbours signals

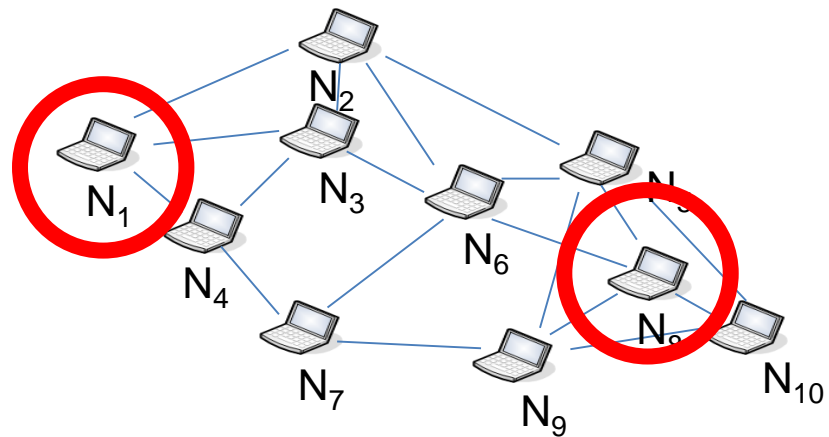
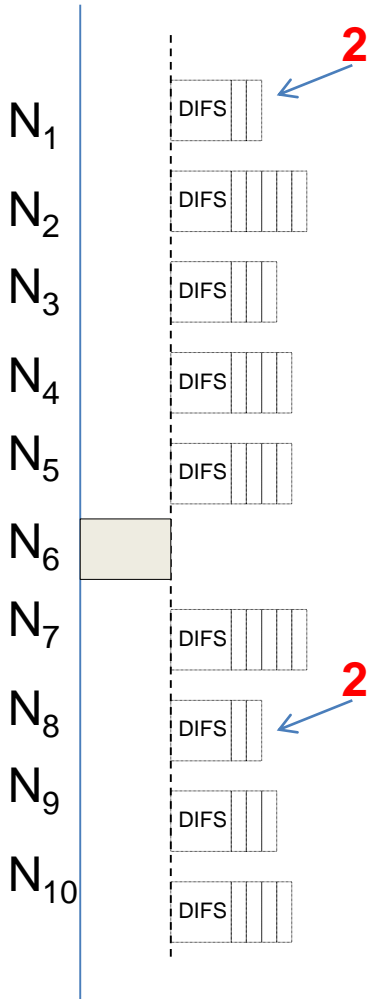
# DCF Example



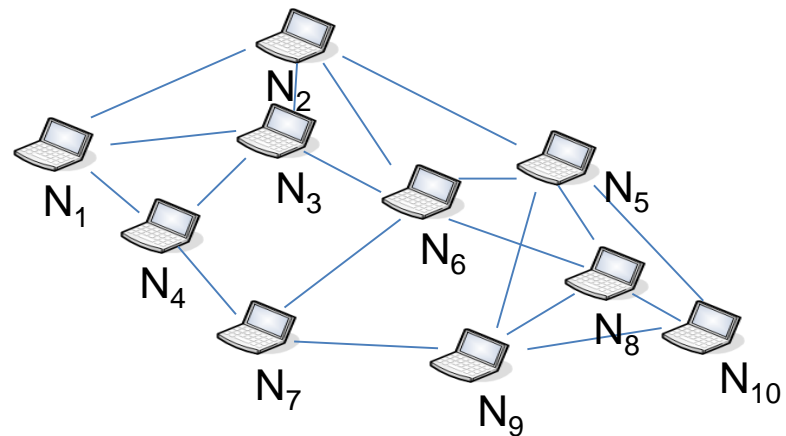
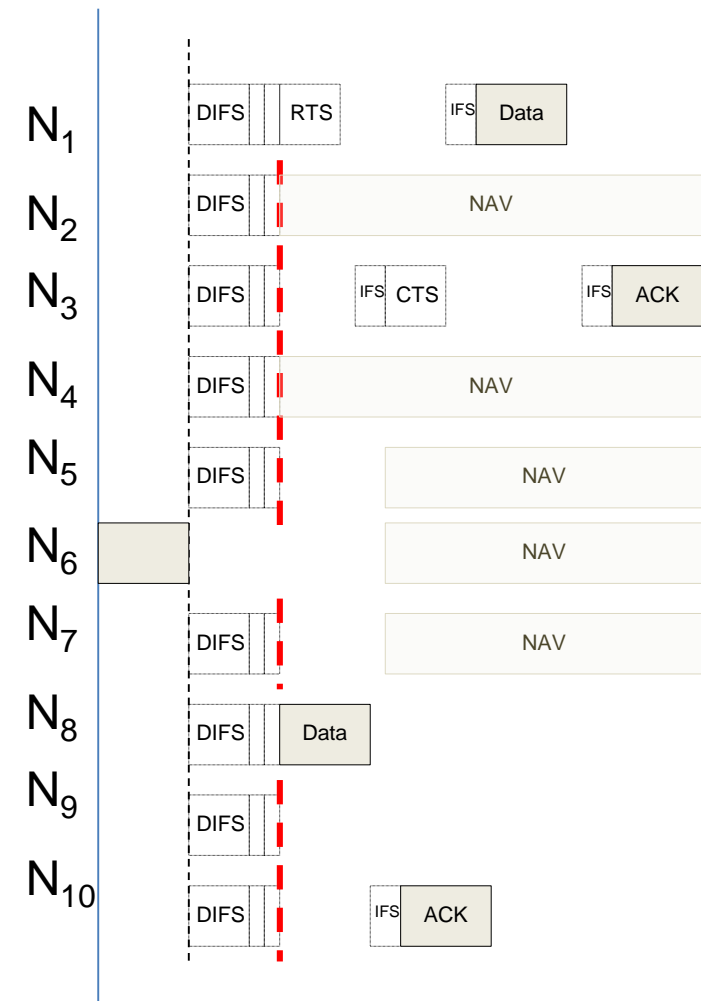
# DCF Example



# DCF Example

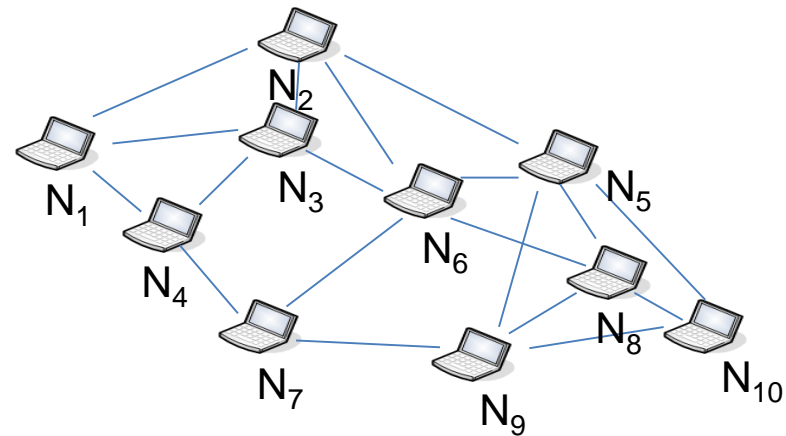
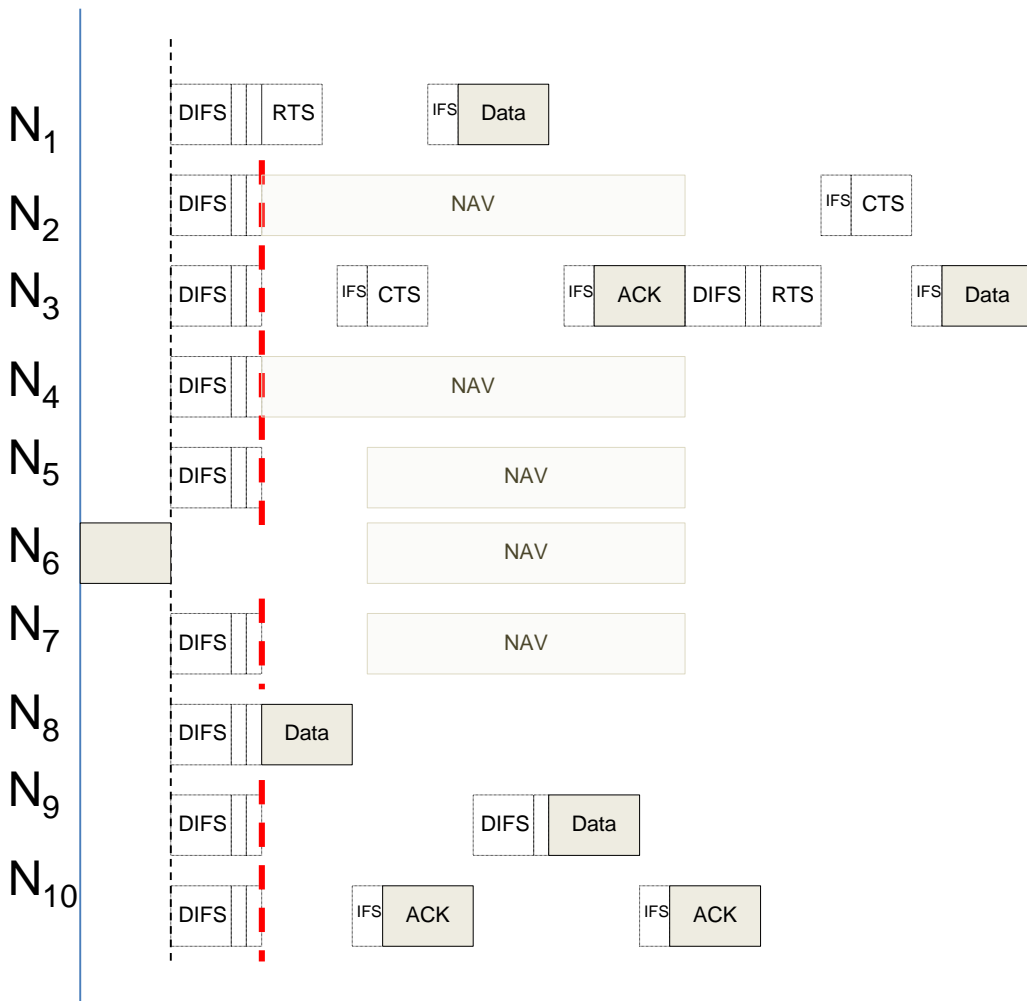


# DCF Example

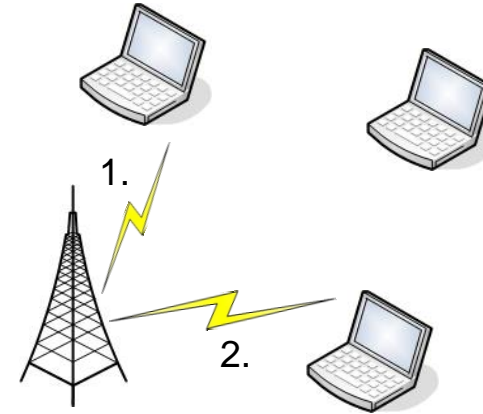
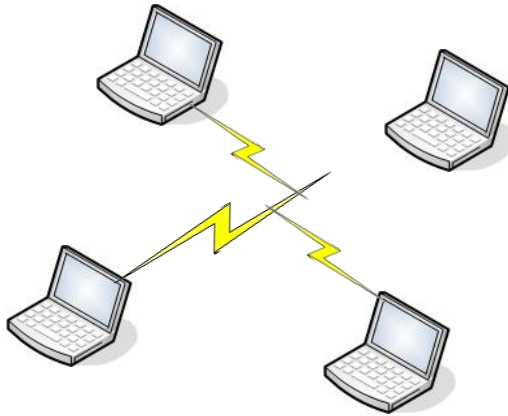




# DCF Example



# DCF vs. PCF



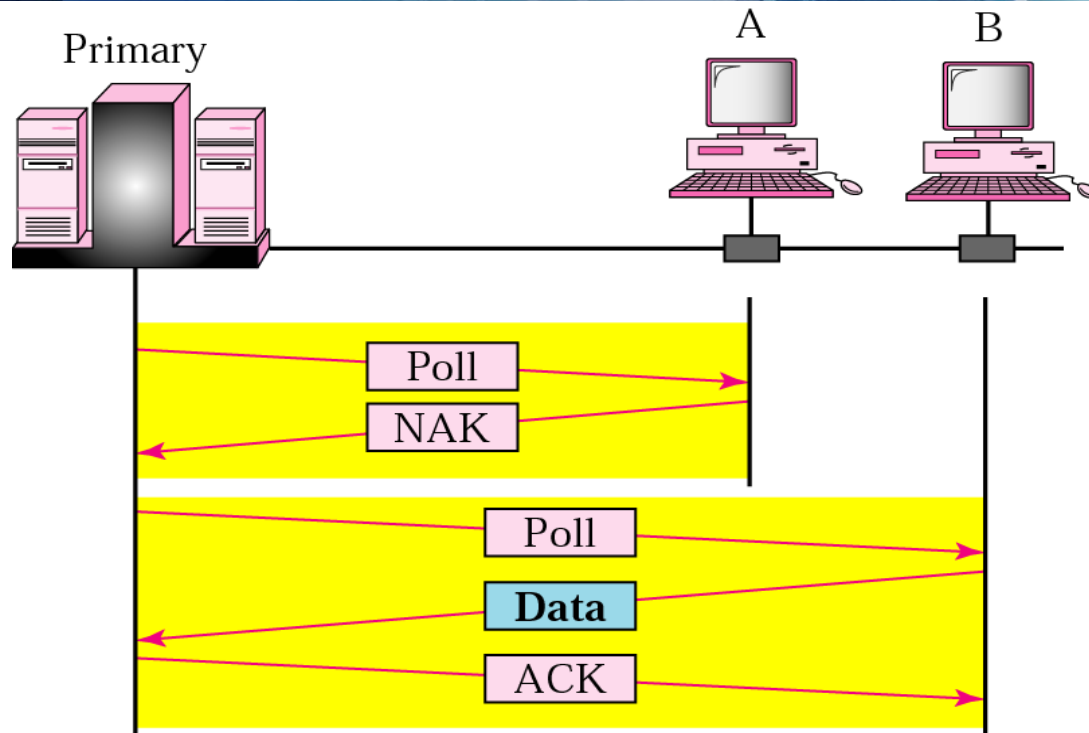
- Stations compete for the medium

- Point coordinator polls stations

# Point Coordination Function (PCF)

- Used by access points
- Polling by centralized polling master – or point coordinator
- Uses PIFS
  - PIFS smaller than DIFS
  - Gives coordinator priority over individual stations
- Point coordinator polls in round-robin to stations configured for polling
  - When poll issued, polled station may respond within SIFS
  - If point coordinator receives response, it issues another poll

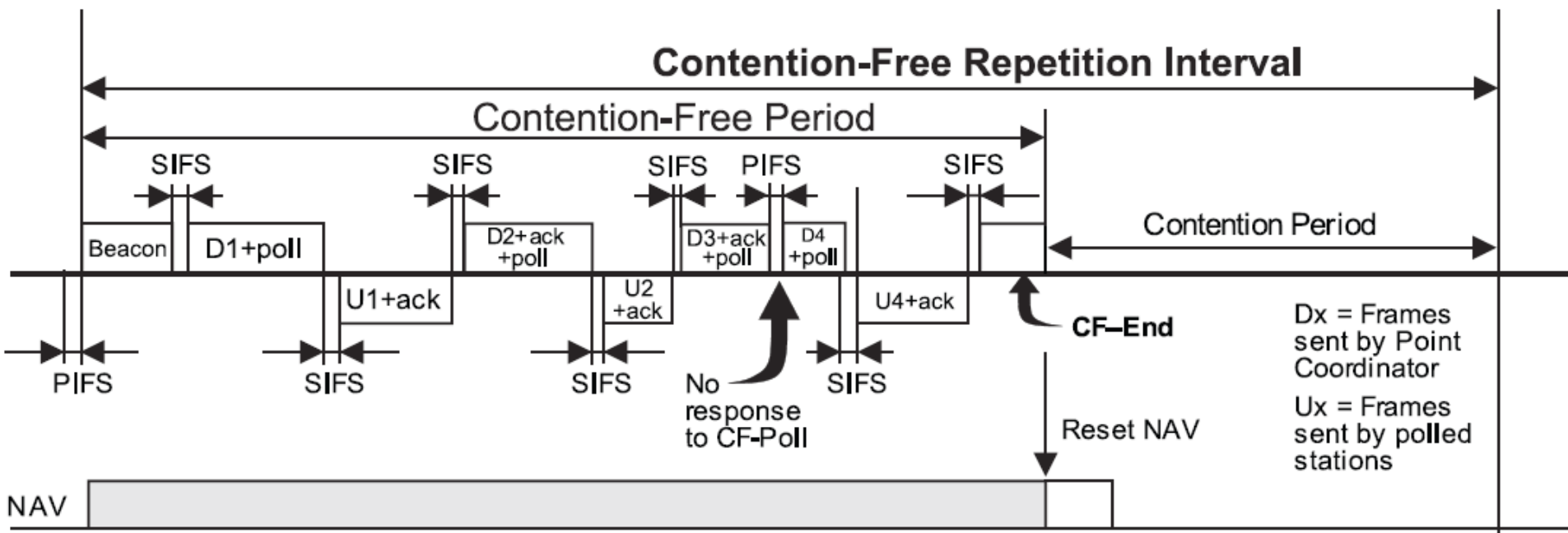
# Poll



- Primary contacts stations to determine if they have data to transmit

# Contention Free Period

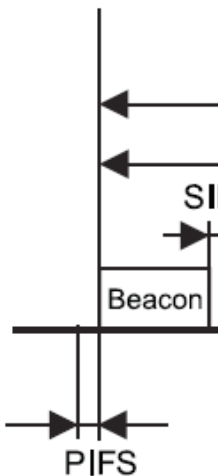
- Time= Contention Period + Contention Free Period
  - Contention Period: All stations compete for the medium
  - Contention Free Period: The AP coordinates communication



\* Figure is courtesy of ANSI/IEEE Std 802.11

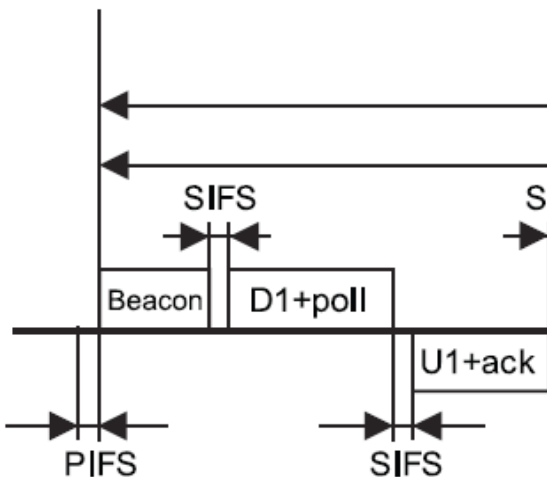
# PCF

- Time= Contention Period + Contention Free Period
  - Contention Period: All stations compete for the medium
  - Contention Free Period: The AP coordinates communication



# PCF

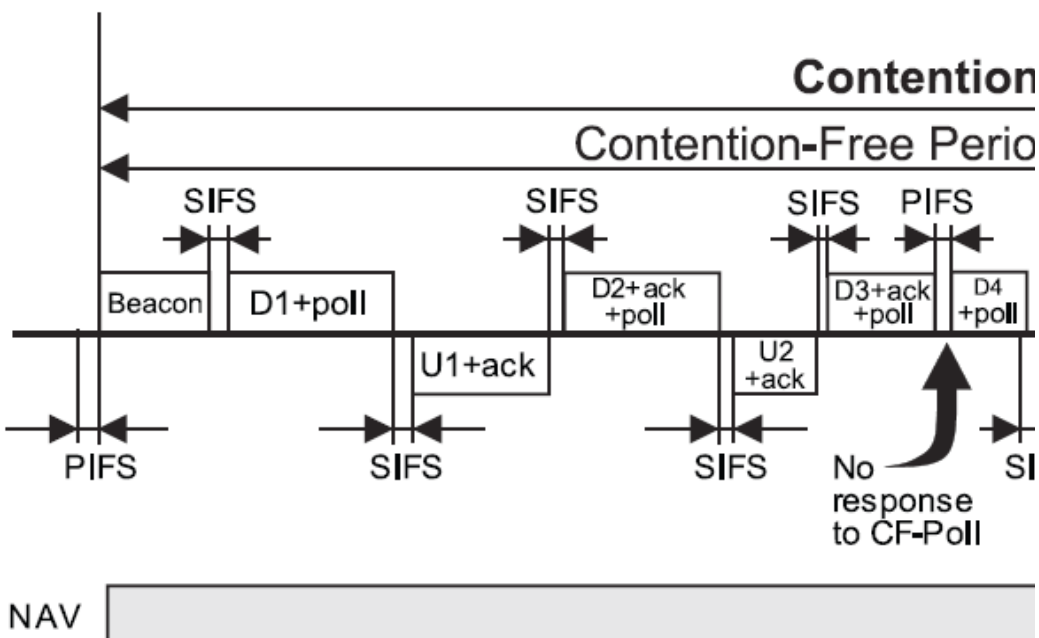
- Time= Contention Period + Contention Free Period
  - Contention Period: All stations compete for the medium
  - Contention Free Period: The AP coordinates communication



NAV 

# PCF

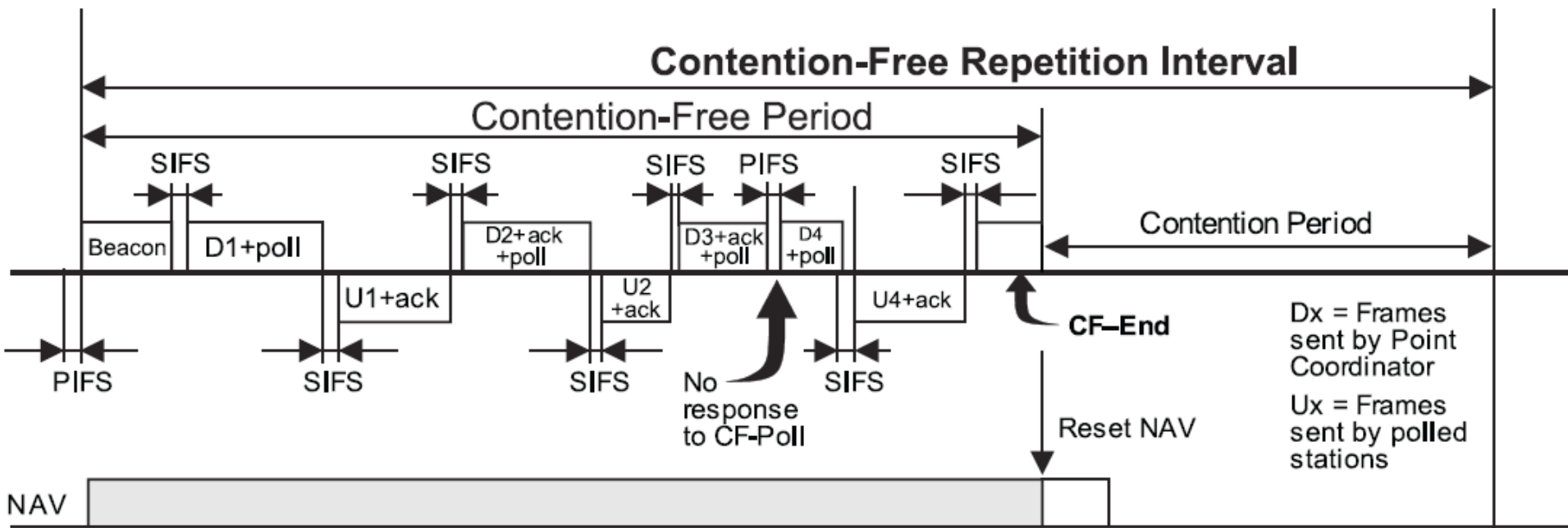
- Time= Contention Period + Contention Free Period
  - Contention Period: All stations compete for the medium
  - Contention Free Period: The AP coordinates communication



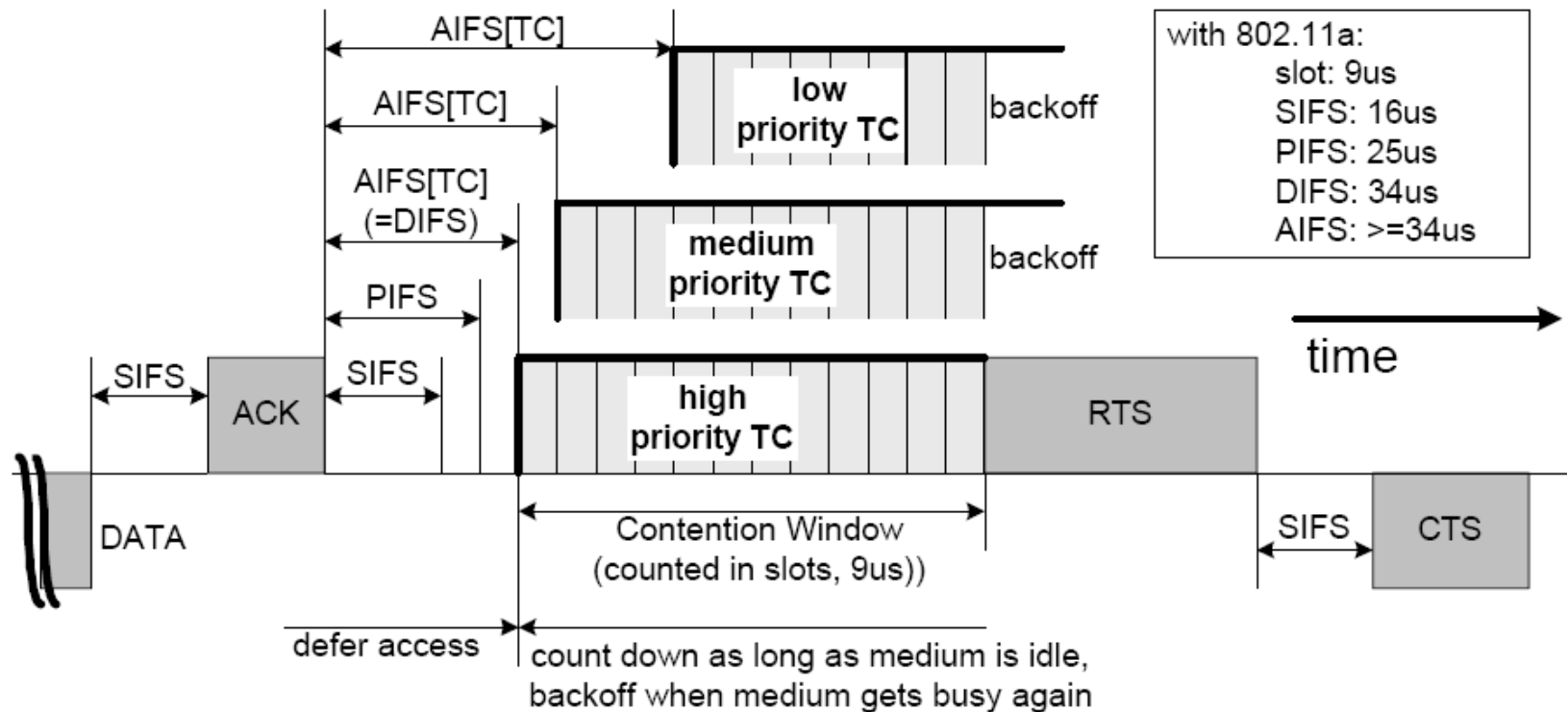


# PCF

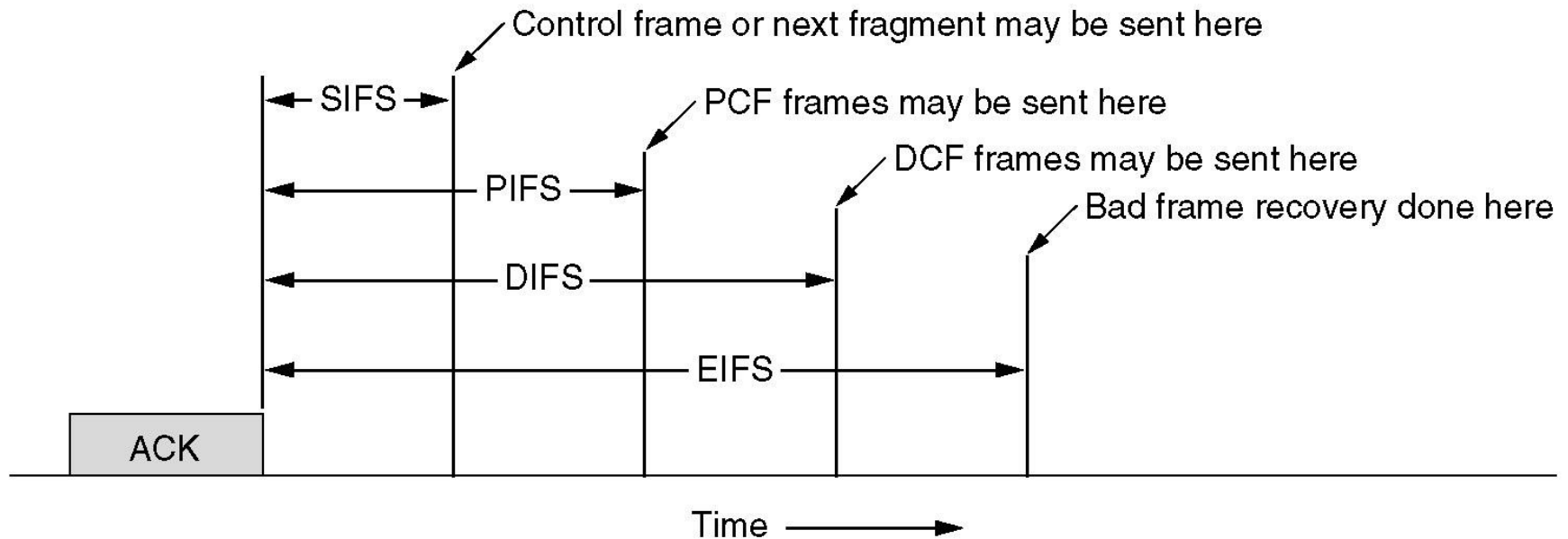
- Time= Contention Period + Contention Free Period
  - Contention Period: All stations compete for the medium
  - Contention Free Period: The AP coordinates communication



# Example of IFSs for 802.11a

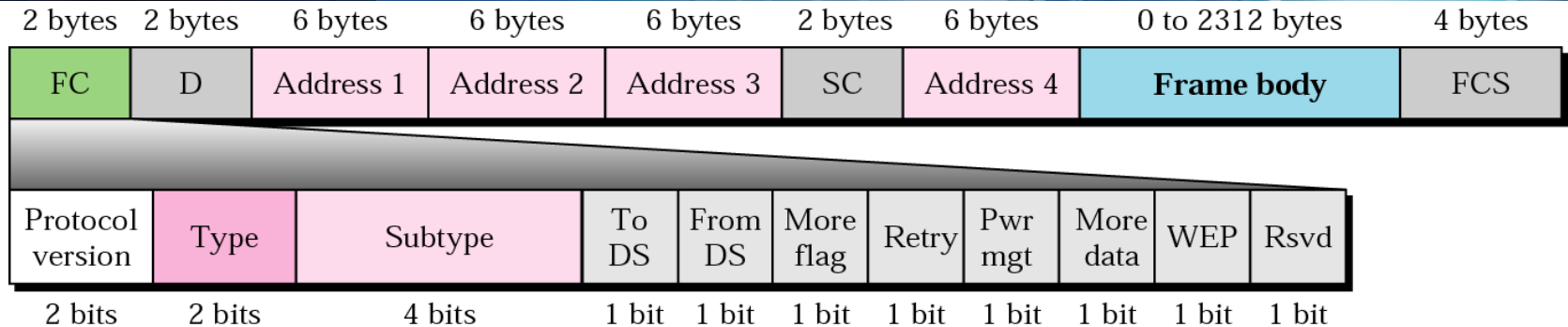


# IFS in 802.11



- SIFS influences replies
- PIFS gives PCF priority over DCF
- DIFS is the time between two DCF communications

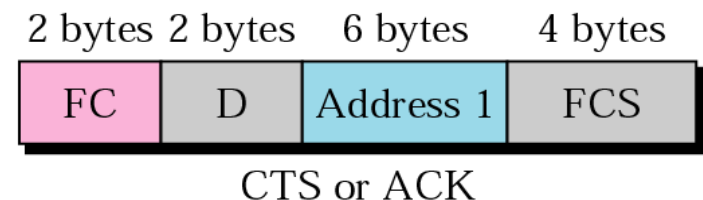
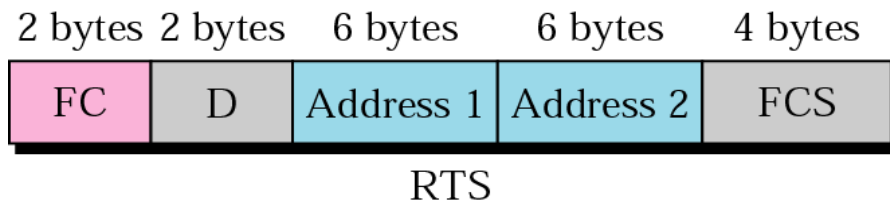
# Frame Format



## Control Frames

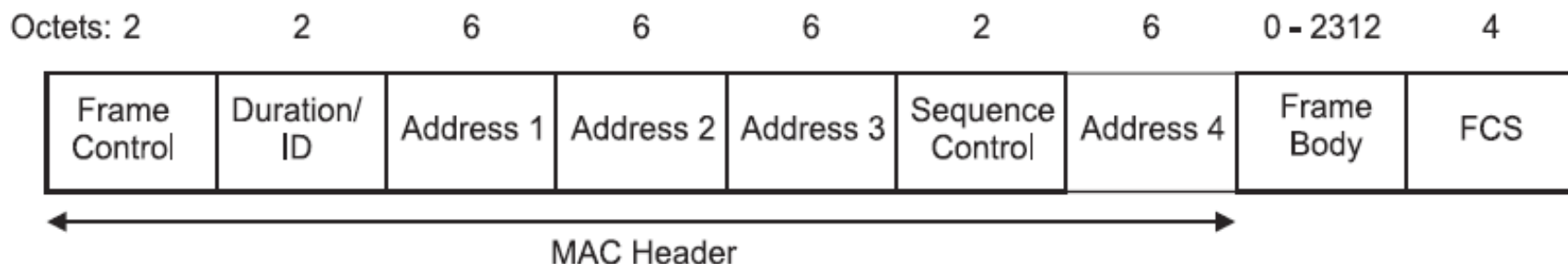
Type: management (00), control (01), or data (10).

Subtype	Meaning
1011	Request to send (RTS)
1100	Clear to send (CTS)
1101	Acknowledgment (ACK)

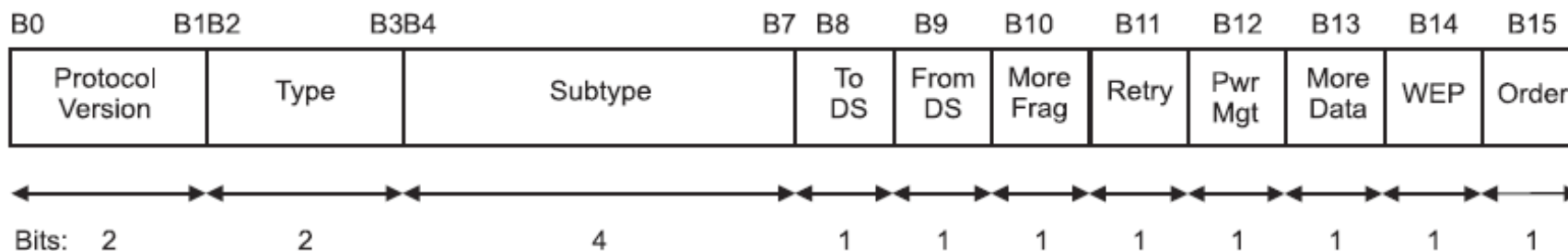


# IEEE 802.11 MAC Frame Format

- Frame format as described in the standard:



**Figure 12—MAC frame format**



**Figure 13—Frame Control field**

\* Figure is courtesy of ANSI/IEEE Std 802.11

# Types of Frames

Type value b3 b2	Type description	Subtype value b7 b6 b5 b4	Subtype description
00	Management	0000	Association request
00	Management	0001	Association response
00	Management	0010	Reassociation request
00	Management	0011	Reassociation response
00	Management	0100	Probe request
00	Management	0101	Probe response
00	Management	0110–0111	Reserved
00	Management	1000	Beacon
00	Management	1001	Announcement traffic indication message (ATIM)
00	Management	1010	Disassociation
00	Management	1011	Authentication
00	Management	1100	Deauthentication
00	Management	1101–1111	Reserved
01	Control	0000–1001	Reserved
01	Control	1010	Power Save (PS)-Poll

# Types of Frames

01	Control	1011	Request To Send (RTS)
01	Control	1100	Clear To Send (CTS)
01	Control	1101	Acknowledgment (ACK)
01	Control	1110	Contention-Free (CF)-End
01	Control	1111	CF-End + CF-Ack
10	Data	0000	Data
10	Data	0001	Data + CF-Ack
10	Data	0010	Data + CF-Poll
10	Data	0011	Data + CF-Ack + CF-Poll
10	Data	0100	Null function (no data)
10	Data	0101	CF-Ack (no data)
10	Data	0110	CF-Poll (no data)
10	Data	0111	CF-Ack + CF-Poll (no data)
10	Data	1000–1111	Reserved
11	Reserved	0000–1111	Reserved



# Control Frames

- Assist in reliable data delivery
- Power Save-Poll (PS-Poll)
  - Sent by any station to station that includes AP
  - Request AP transmit frame buffered for this station while station in power-saving mode
- Request to Send (RTS)
  - First frame in four-way frame exchange
- Clear to Send (CTS)
  - Second frame in four-way exchange
- Acknowledgment (ACK)
- Contention-Free (CF)-end
  - Announces end of contention-free period part of PCF
- CF-End + CF-Ack:
  - Acknowledges CF-end
  - Ends contention-free period and releases stations from associated restrictions



# Data Frames – Data Carrying

- Eight data frame subtypes, in two groups
- First four carry upper-level data from source station to destination station
- Data
  - Simplest data frame
  - May be used in contention or contention-free period
- Data + CF-Ack
  - Only sent during contention-free period
  - Carries data and acknowledges previously received data
- Data + CF-Poll
  - Used by point coordinator to deliver data
  - Also to request station send data frame it may have buffered
- Data + CF-Ack + CF-Poll
  - Combines Data + CF-Ack and Data + CF-Poll

# Management Frames

- Used to manage communications between stations and APs
- E.g. management of associations
  - Requests, response, reassociation, dissociation, and authentication

## Summary: 802.11

- Hidden Station / Expose Station
- DCF  $\Rightarrow$  Distributed Coordination Function
  - Stations compete for access to the medium
- CSMA/CA + RTS/CTS
- PCF  $\Rightarrow$  Point Coordination Function
  - Access point polls stations
- IFS  $\Rightarrow$  Inter-Frame Space
  - Time between frames
- Three types of frames:
  - Control frames
  - Data frames
  - Management frames



That's all  
folks