

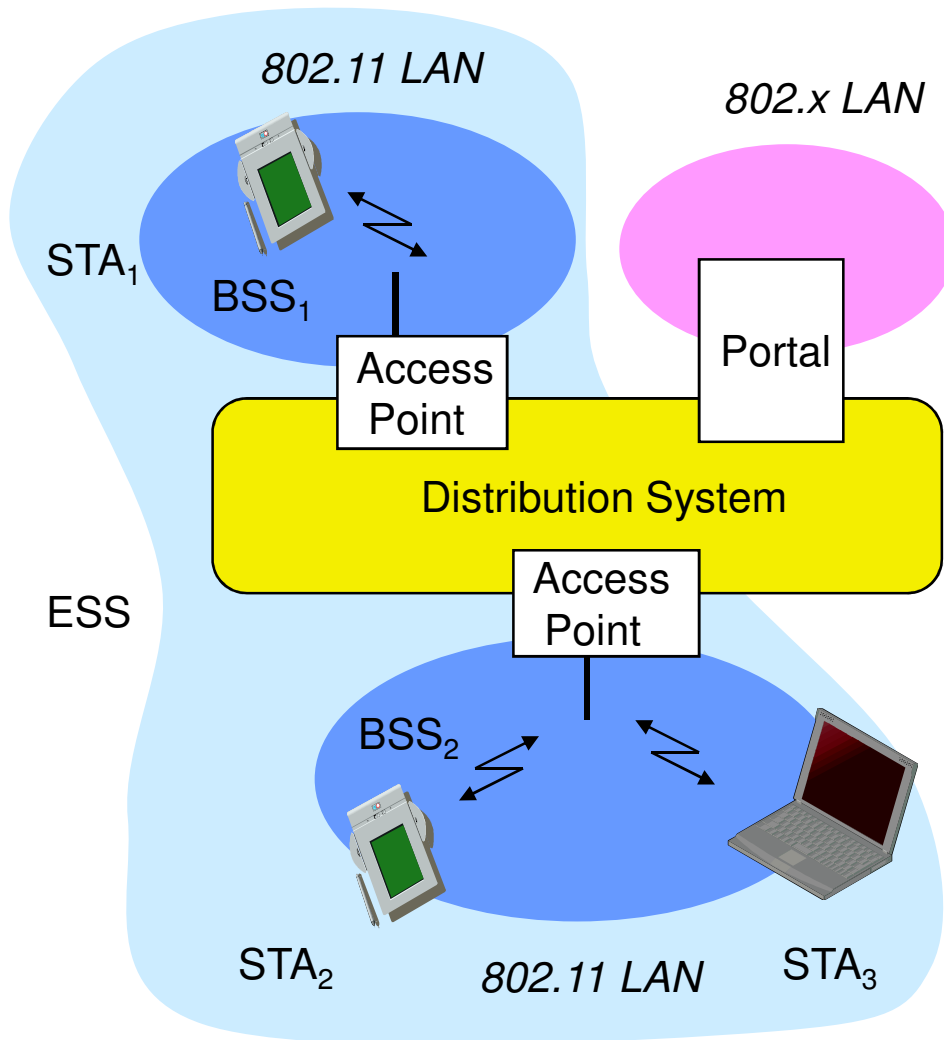
802.11 standard

Acknowledgement: Slides borrowed from Richard Y. Yang @ Yale

IEEE 802.11 Requirements

- Design for small coverage (e.g. office, home)
- Low/no mobility
- High data-rate applications
- Ability to integrate real time applications and non-real-time applications
- Use un-licensed spectrum

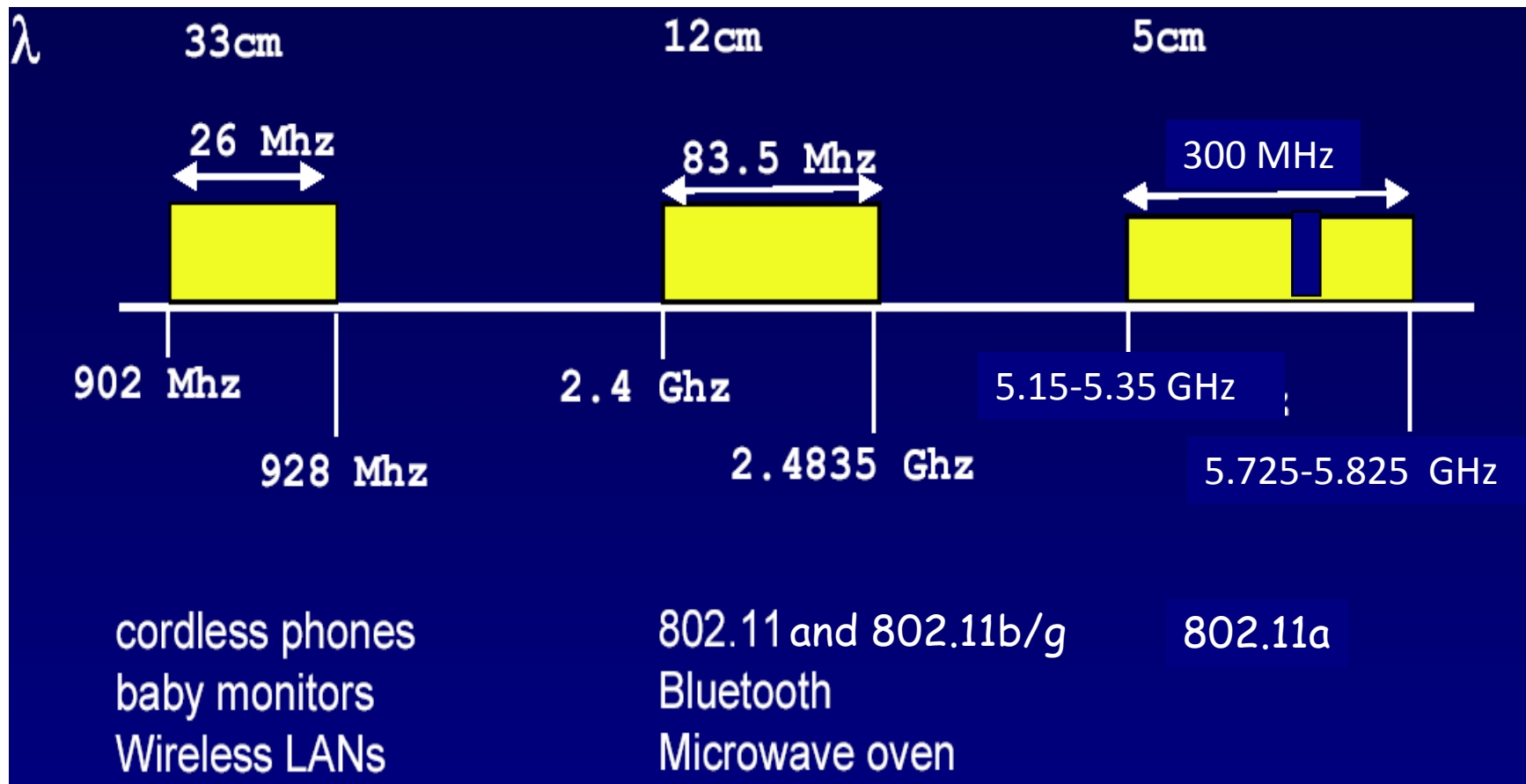
802.11: Infrastructure Mode



- Architecture similar to cellular
 - network station (STA)
 - terminal with access mechanisms to the wireless medium and radio contact to the access point
 - access point (AP)
 - station integrated into the wireless LAN and the distribution system
 - basic service set (BSS)
 - group of stations using the same AP
 - portal
 - bridge to other (wired) networks
 - distribution system
 - interconnection network to form one logical network (ESS: Extended Service Set) based on several BSS

IEEE 802.11 Physical Layer

- Family of IEEE 802.11 standards:
 - unlicensed frequency spectrum: 900Mhz, 2.4Ghz, 5.1Ghz, 5.7Ghz



The IEEE 802.11 Family

Protocol	Release Data	Freq.	Rate (typical)	Rate (max)	Range (indoor)
Legacy	1997	2.4 GHz	1 Mbps	2Mbps	?
802.11a	1999	5 GHz	25 Mbps	54 Mbps	~30 m
802.11b	1999	2.4 GHz	6.5 Mbps	11 Mbps	~30 m
802.11g	2003	2.4 GHz	25 Mbps	54 Mbps	~30 m
802.11n	2008	2.4/5 GHz	200 Mbps	540 Mbps	~50 m

802.11a Modulation

- 3 different physical layer implementation
 - Frequency hopping spread spectrum
 - Direct sequence spread spectrum
 - IR
- Adaptive modulation
 - BPSK: 6, 9 Mbps
 - QPSK: 12, 18 Mbps
 - 16-QAM: 24, 36 Mbps
 - 64-QAM: 48, 54 Mbps

802.11 - MAC Layer

□ Traffic services

- Asynchronous Data Service (mandatory)
 - exchange of data packets based on “best-effort”
 - support of broadcast and multicast
- Time-Bounded Service (optional)
 - exchange of bounded delay service

802.11 MAC Layer: Access Methods

- DFWMAC-DCF CSMA/CA (mandatory)
 - collision avoidance via randomized “back-off”
 - ACK packet for acknowledgements
- DFWMAC-DCF w/ RTS/CTS (optional)
 - additional virtual “carrier sensing: to avoid hidden terminal problem
- DFWMAC- PCF (optional)
 - access point polls terminals according to a list

802.11 CSMA/CA

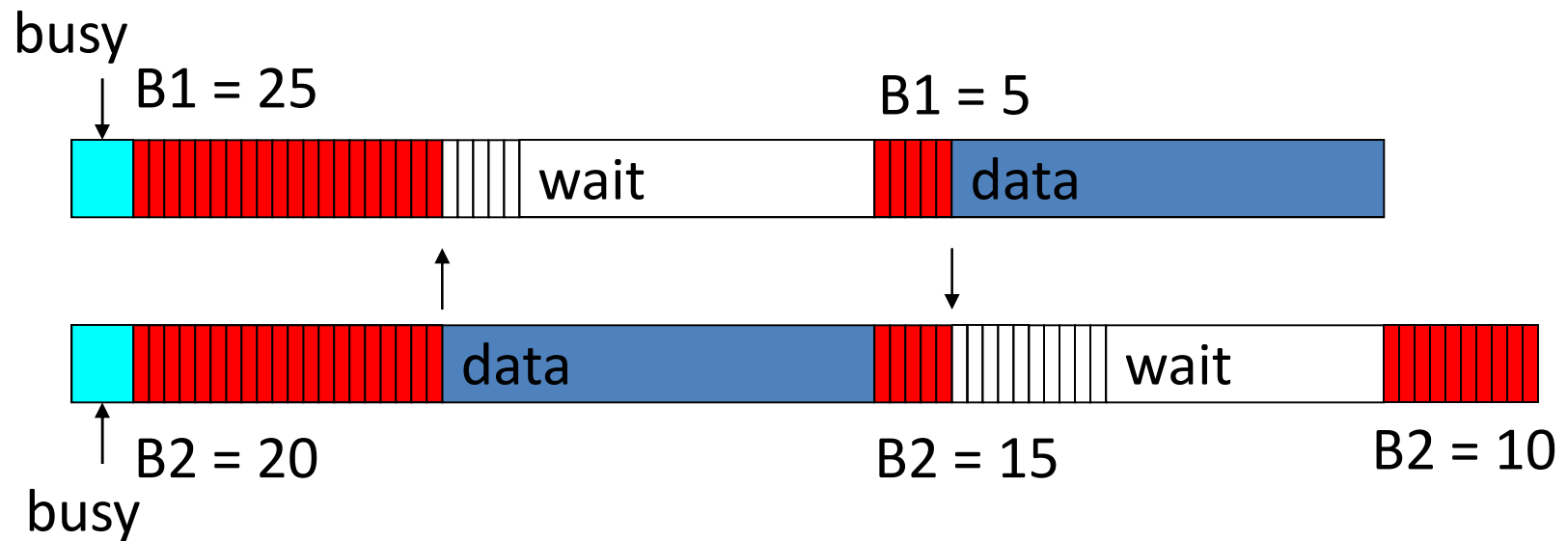
- CSMA: Listen before transmit
- Collision avoidance
 - when transmitting a packet, choose a backoff interval in the range $[0, CW]$
 - CW is contention window
- Count down the backoff interval when medium is idle
 - count-down is suspended if medium becomes busy
- Transmit when backoff interval reaches 0

802.11 Backoff

- IEEE 802.11 contention window **CW** is adapted dynamically depending on collision occurrence
 - after each collision, CW is doubled
 - thus CW varies from CWmin to CWmax

	802.11b	802.11a	802.11g
<i>aSlotTime</i>	20 usec	9 usec	20 usec (mixed); 9 usec (g-only)
<i>aCWmin</i>	31 slots	15 slots	15 slots

Congestion Avoidance: Example



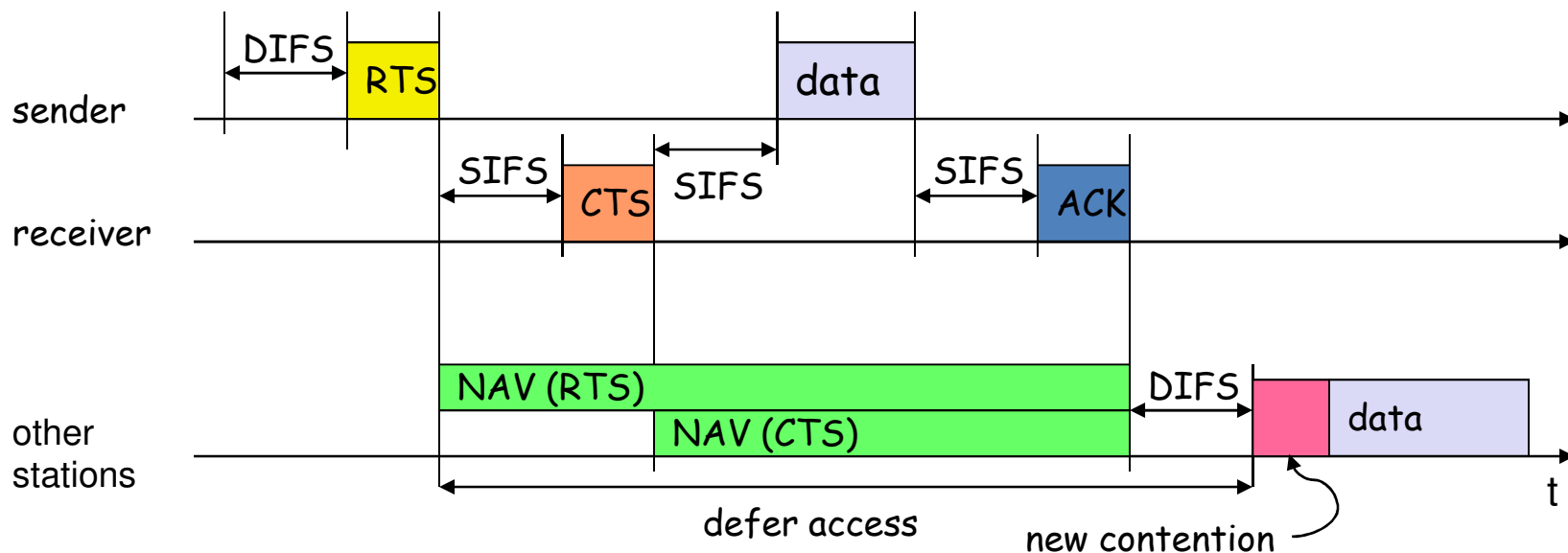
$cw = 31$

**B1 and B2 are backoff intervals
at nodes 1 and 2**

Q: how is the performance of a mixed mode 802.11b/g network?

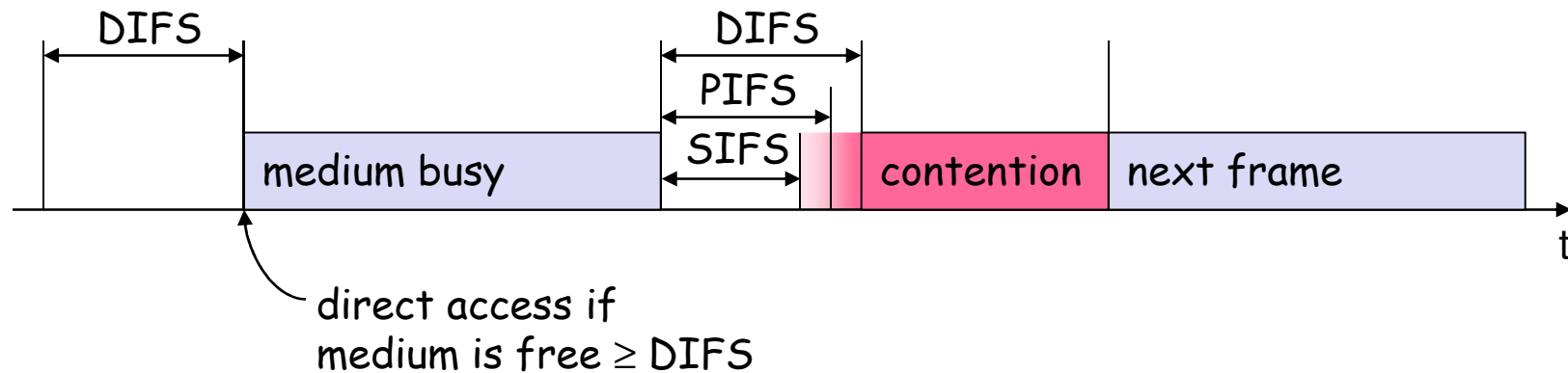
802.11 – RTS/CTS + ACK

- ❑ Sender sends RTS with NAV (Network allocation Vector, i.e. reservation parameter that determines amount of time the data packet needs the medium)
- ❑ Receiver acknowledges via CTS (if ready to receive)
 - CTS reserves channel for sender, notifying possibly hidden stations
- ❑ Sender can now send data at once, acknowledgement via ACK
- ❑ Other stations store NAV distributed via RTS and CTS



802.11 - Inter Frame Spacing

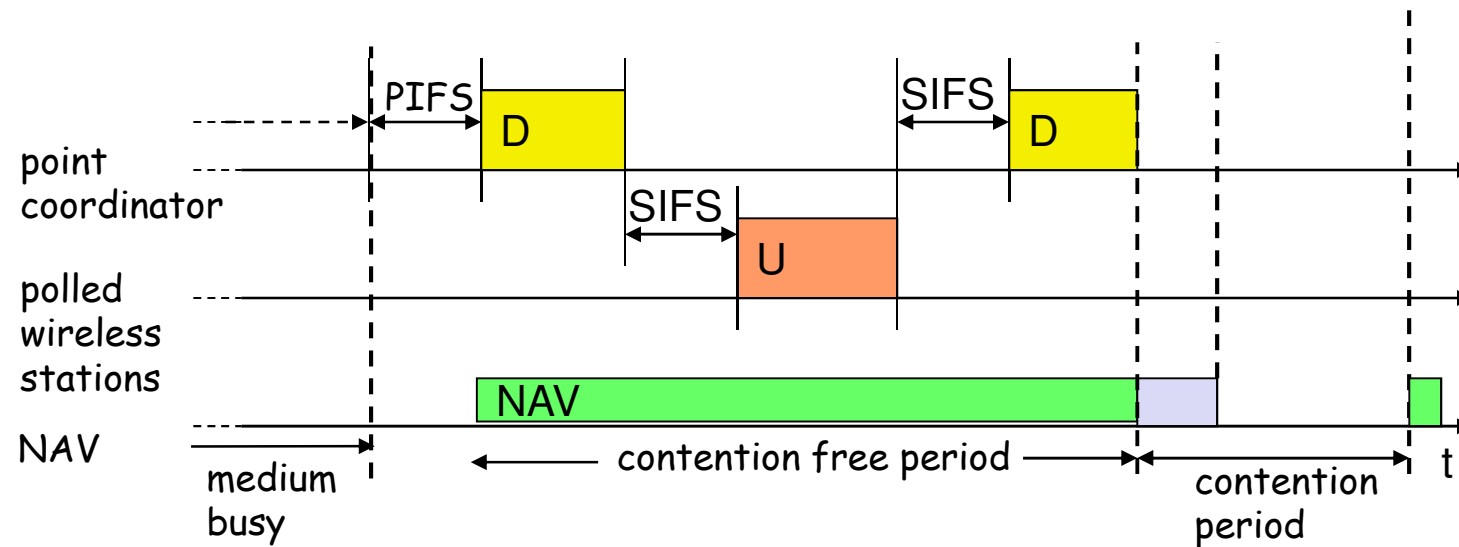
- ❑ Defined different inter frame spacing
- ❑ SIFS (Short Inter Frame Spacing); 10 us in 802.11b
 - highest priority, for ACK, CTS, polling response
- ❑ PIFS (PCF IFS); 30 us in 802.11b
 - medium priority, for time-bounded service using PCF
- ❑ DIFS (DCF, Distributed Coordination Function IFS); 50 us in 802.11b
 - lowest priority, for asynchronous data service



802.11 - Inter Frame Spacing

	802.11b	802.11a	802.11g
<i>aSIFSTime</i>	10 usec	16 usec	10 usec
<i>aSlotTime</i>	20 usec	9 usec	20 usec (mixed); 9 usec (g only)
<i>aDIFSTime</i> (<i>2xSlot+SIFS</i>)	50 usec	34 usec	50 usec; 28 usec

802.11: PCF for Polling (Infrastructure Mode)

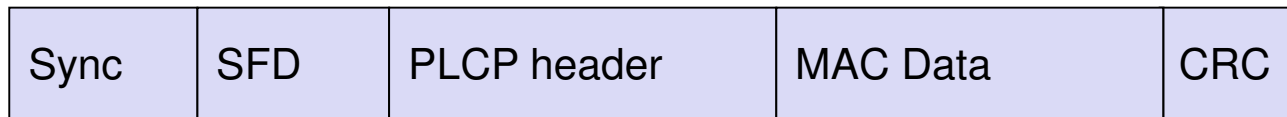


D: downstream poll, or data from point coordinator
U: data from polled wireless station

802.11b Frame Format

preamble

2



Preamble (192 usec; or optional 96 short version)

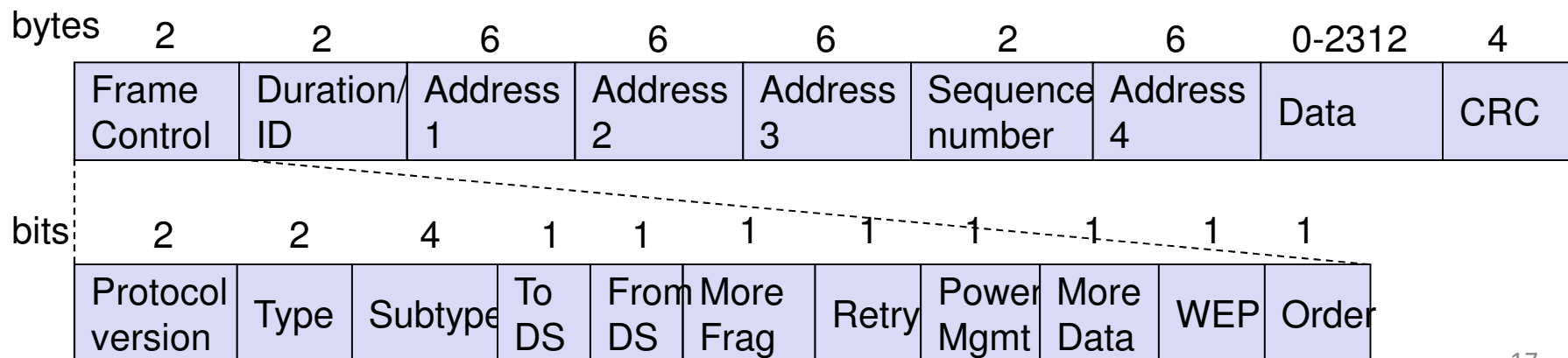
- Sync: alternating 0s and 1s (DSSS 128 bits)
- SFD: Start Frame delimiter: 0000 1100 1011 1101

PLCH (Physical Layer Convergence Procedure) Header

- payload length
- signaling field: the rate info.
- CRC: 16 bit protection of header

802.11 - MAC Data Format

- ❑ Types
 - control frames, management frames, data frames
- ❑ Sequence numbers
 - important against duplicated frames due to lost ACKs
- ❑ Addresses
 - receiver, transmitter (physical), BSS identifier, sender (logical)
- ❑ Miscellaneous
 - sending time, checksum, frame control, data



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	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	PS-Poll
01	Control	1011	RTS
01	Control	1100	CTS
01	Control	1101	ACK
01	Control	1110	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

A Testbed Result

- USRPs
- 802.11a

- 10% HT, 10% partial HT, 80% perfectly sense each other
- Each run randomly picks an AP and two clients



Throughput Comparison

