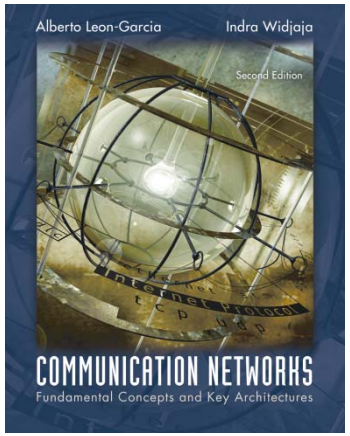
Chapter 6

Medium Access Control Protocols and Local Area Networks



802.11 Wireless LAN

CSE 3213, Winter 2010

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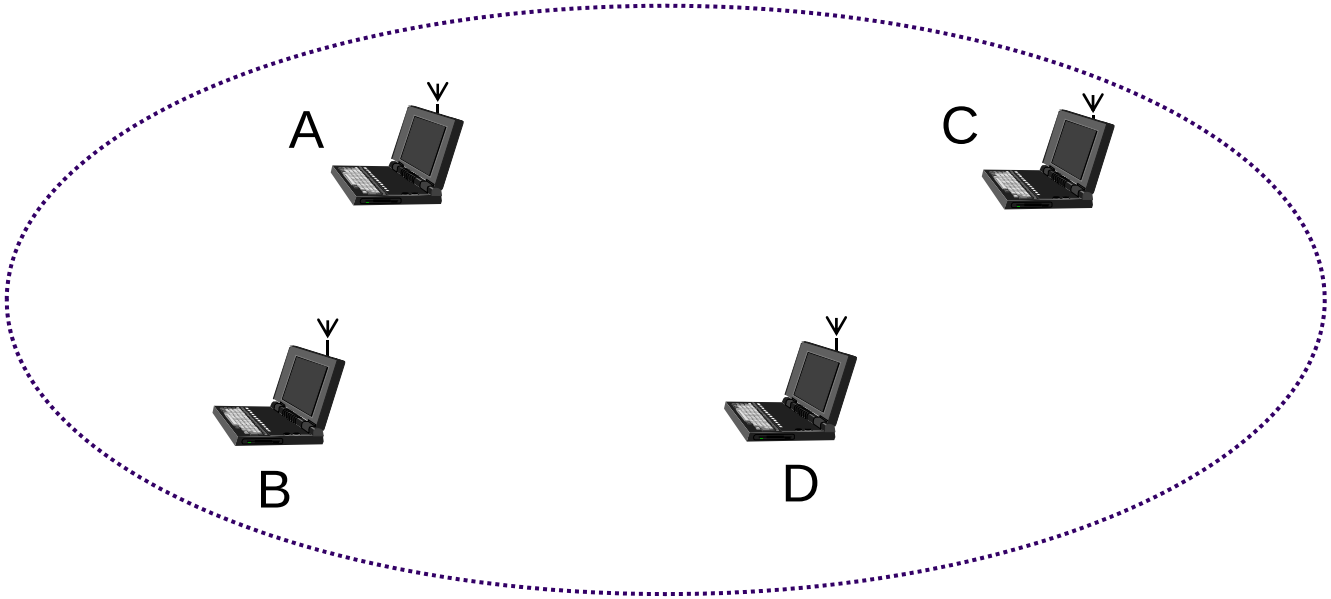
Wireless Data Communications

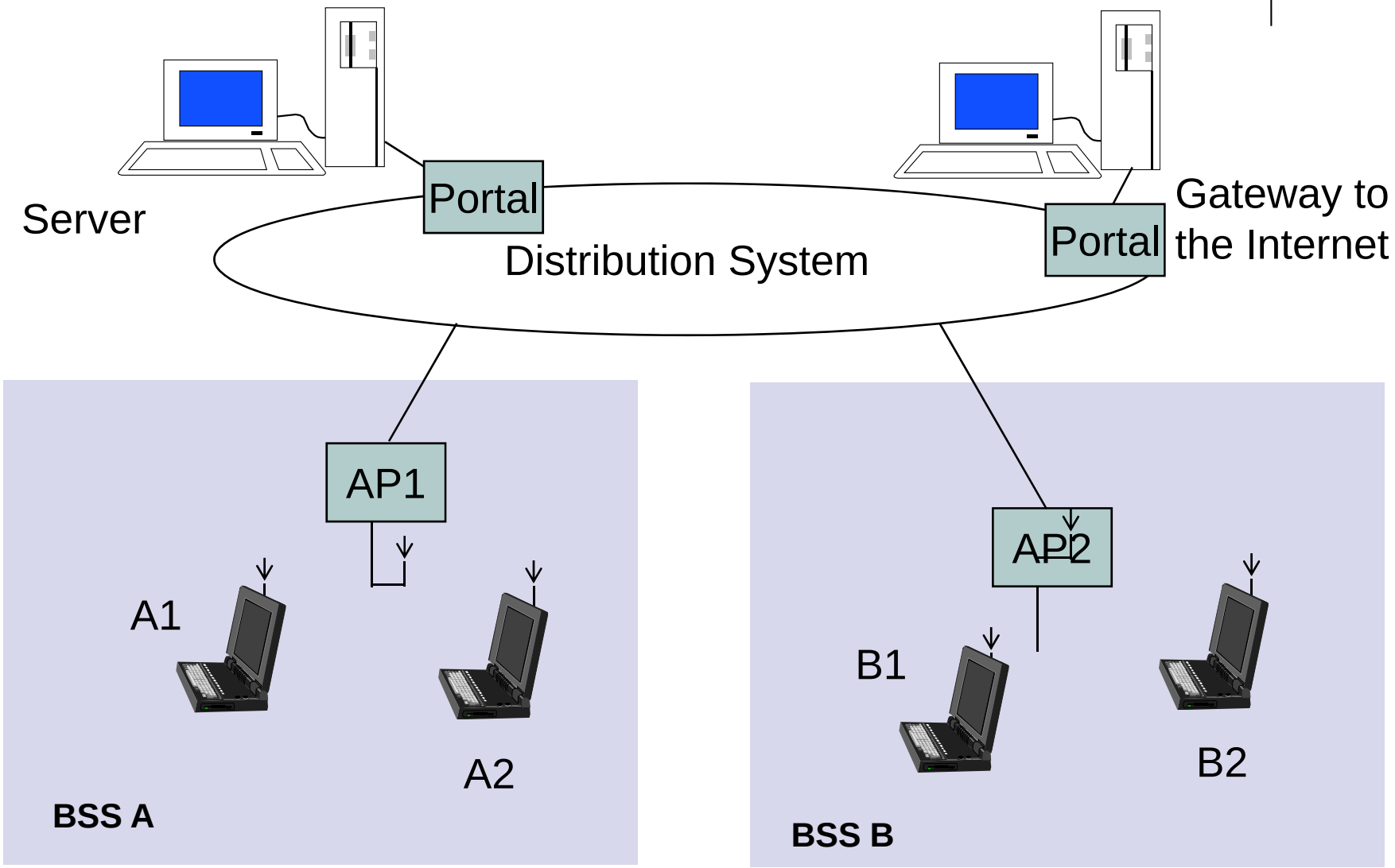
- Wireless communications compelling
  - ✓ Easy, low-cost deployment
  - ✓ Mobility & roaming: Access information anywhere
  - ✓ Supports personal devices
    - ✓ PDAs, laptops, data-cell-phones
  - ✓ Supports communicating devices
    - ✓ Cameras, location devices, wireless identification
  - × Signal strength varies in space & time
  - × Signal can be captured by snoopers
  - × Spectrum is limited & usually regulated

Ad Hoc Communications



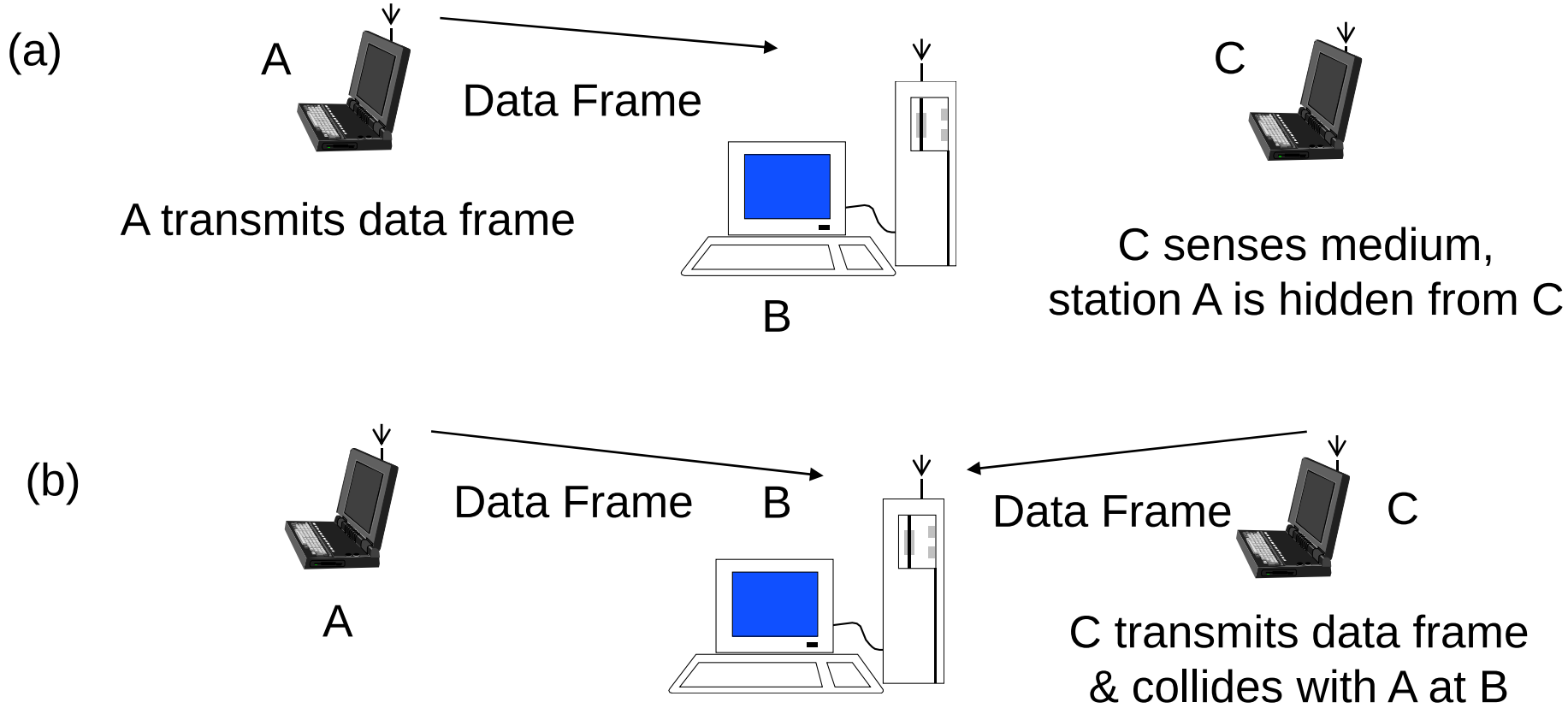
- Temporary association of group of stations
  - Within range of each other
  - Need to exchange information
  - E.g. Presentation in meeting, or distributed computer game, or both

Infrastructure Network



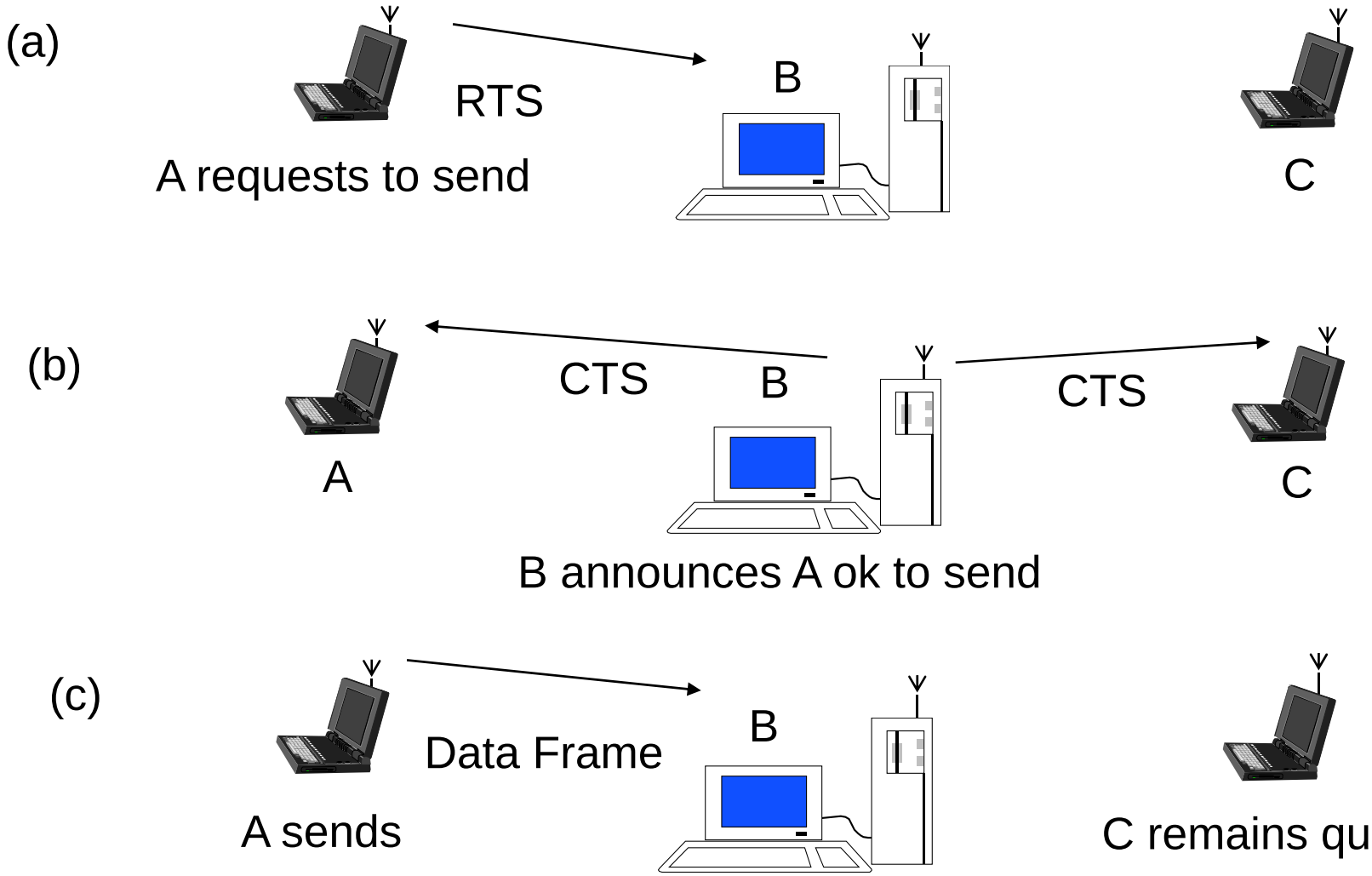
- Permanent Access Points provide access to Internet

Hidden Terminal Problem



- New MAC: CSMA with *Collision Avoidance*

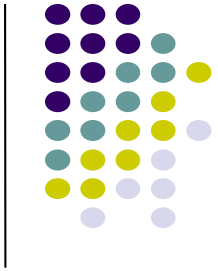
CSMA with Collision Avoidance



IEEE 802.11 Wireless LAN

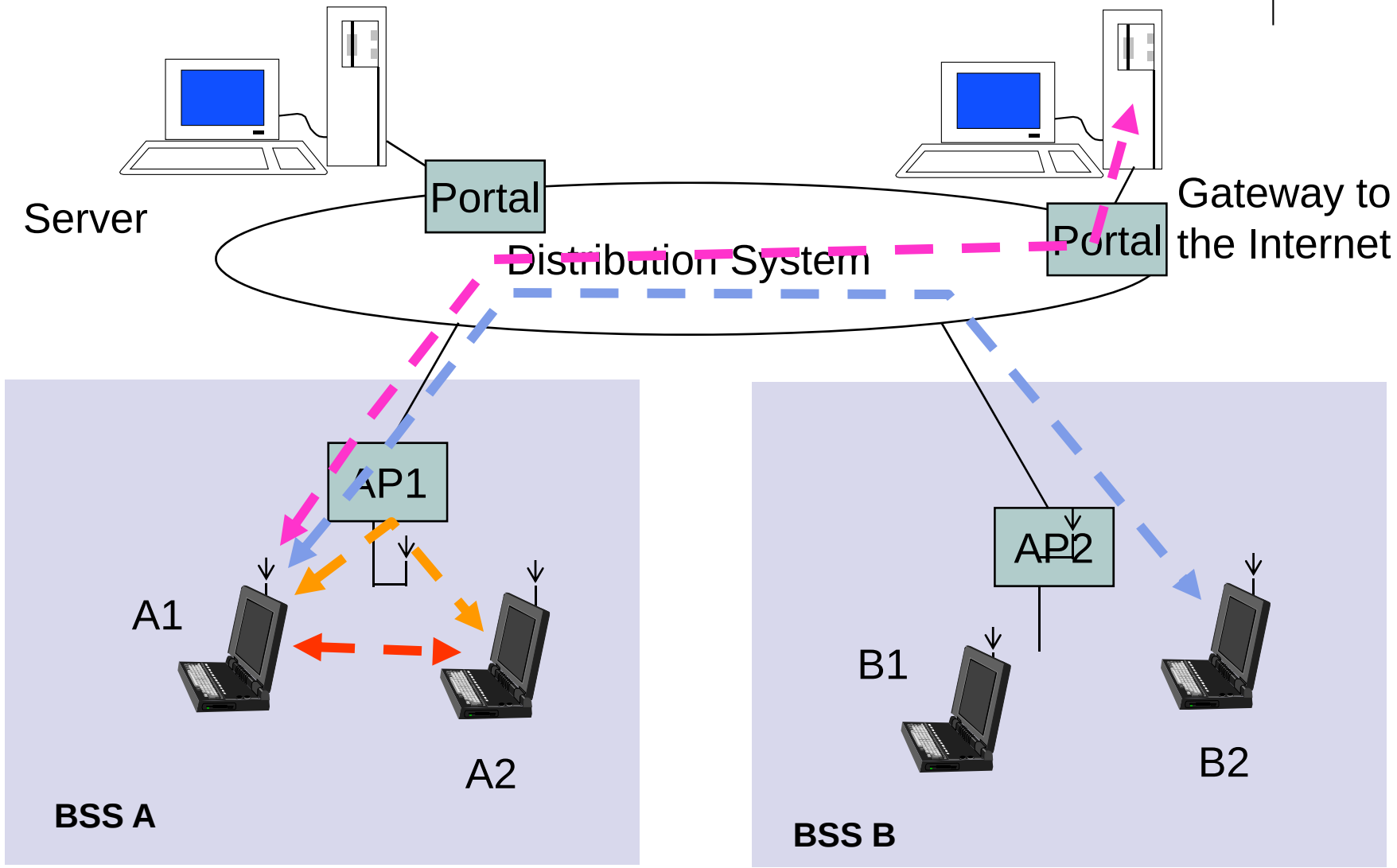
- Stimulated by availability of *unlicensed spectrum*
  - U.S. Industrial, Scientific, Medical (ISM) bands
  - 902-928 MHz, 2.400-2.4835 GHz, 5.725-5.850 GHz
- Targeted wireless LANs @ 20 Mbps
- MAC for high speed wireless LAN
- Ad Hoc & Infrastructure networks
- Variety of physical layers

802.11 Definitions

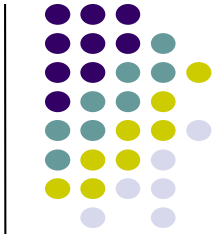


- *Basic Service Set* (BSS)
  - Group of stations that *coordinate their access* using a given instance of MAC
  - Located in a *Basic Service Area* (BSA)
  - Stations in BSS can communicate with each other
  - Distinct collocated BSS's can coexist
- *Extended Service Set* (ESS)
  - Multiple BSSs interconnected by *Distribution System (DS)*
  - Each BSS is like a cell and stations in BSS communicate with an *Access Point* (AP)
  - *Portals* attached to DS provide access to Internet

Infrastructure Network

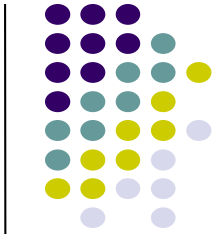


Distribution Services



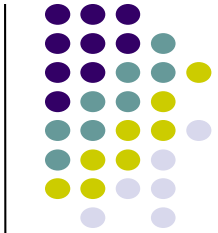
- Stations within BSS can communicate directly with each other
- DS provides *distribution services*:
  - Transfer MAC SDUs between APs in ESS
  - Transfer MSDUs between portals & BSSs in ESS
  - Transfer MSDUs between stations in same BSS
    - Multicast, broadcast, or stations's preference
- ESS looks like single BSS to LLC layer

Infrastructure Services



- Select AP and establish *association* with AP
  - Then can send/receive frames via AP & DS
- *Reassociation service* to move from one AP to another AP
- *Dissociation service* to terminate association
- *Authentication service* to establish identity of other stations
- *Privacy service* to keep contents secret

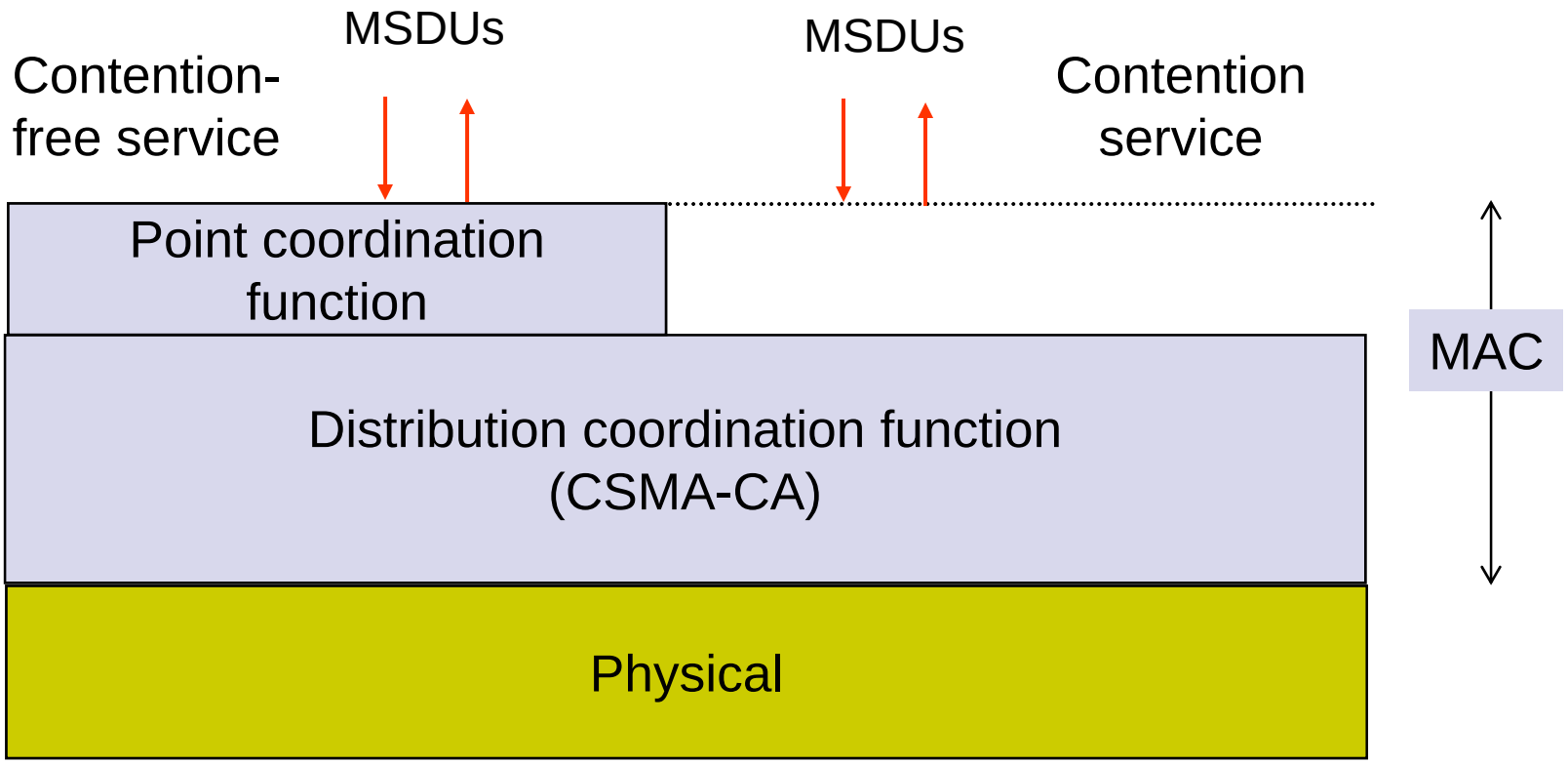
IEEE 802.11 MAC



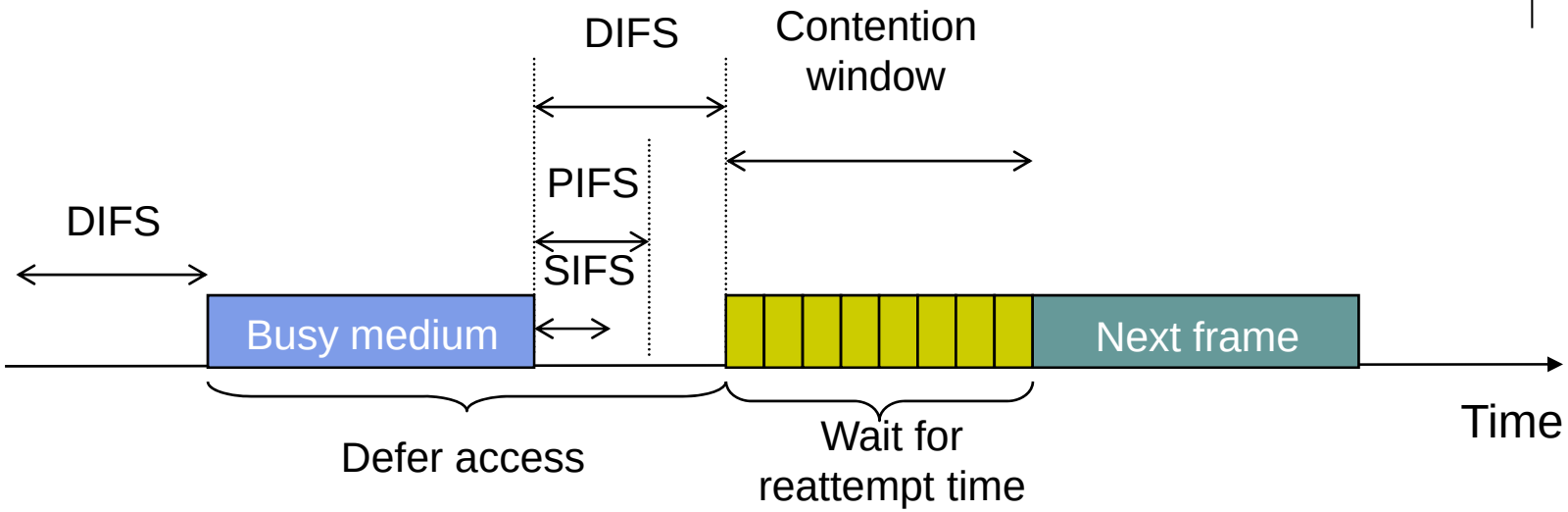
- MAC sublayer responsibilities
  - Channel access
  - PDU addressing, formatting, error checking
  - Fragmentation & reassembly of MAC SDUs
- MAC security service options
  - Authentication & privacy
- MAC management services
  - Roaming within ESS
  - Power management

MAC Services

- Contention Service: Best effort
- Contention-Free Service: time-bounded transfer
- MAC can alternate between Contention Periods (CPs) & Contention-Free Periods (CFPs)

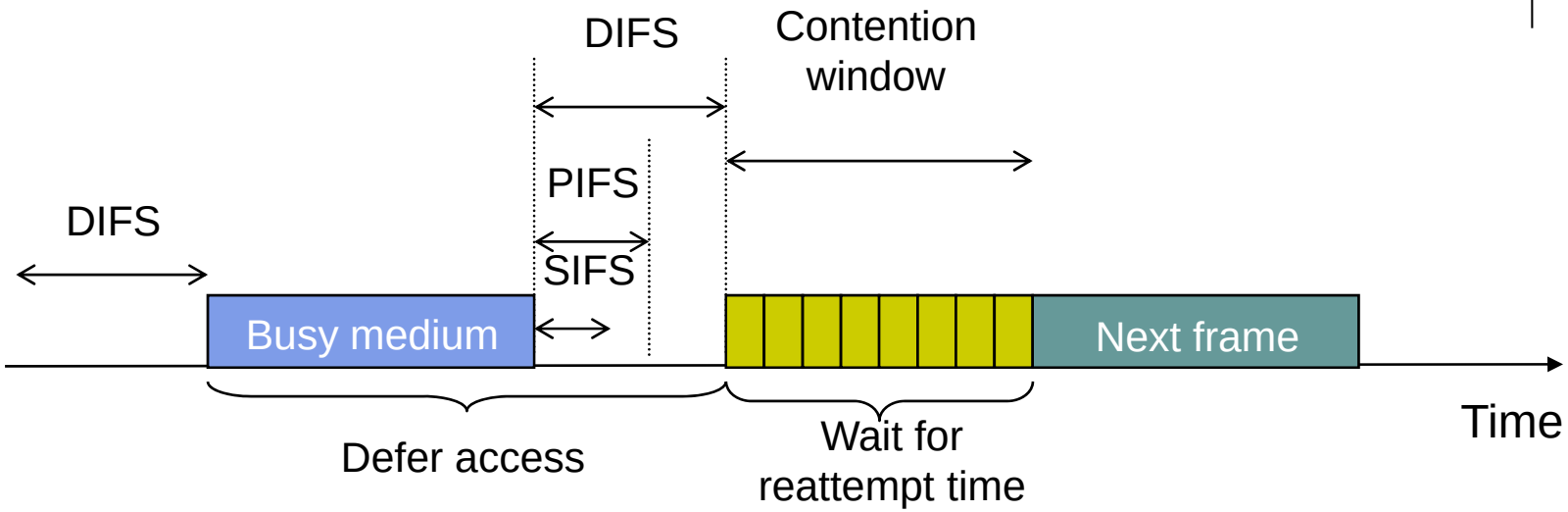


Distributed Coordination Function (DCF)



- DCF provides basic access service
  - Asynchronous best-effort data transfer
  - All stations contend for access to medium
- CSMA-CA
  - Ready stations wait for completion of transmission
  - All stations must wait *Interframe Space (IFS)*

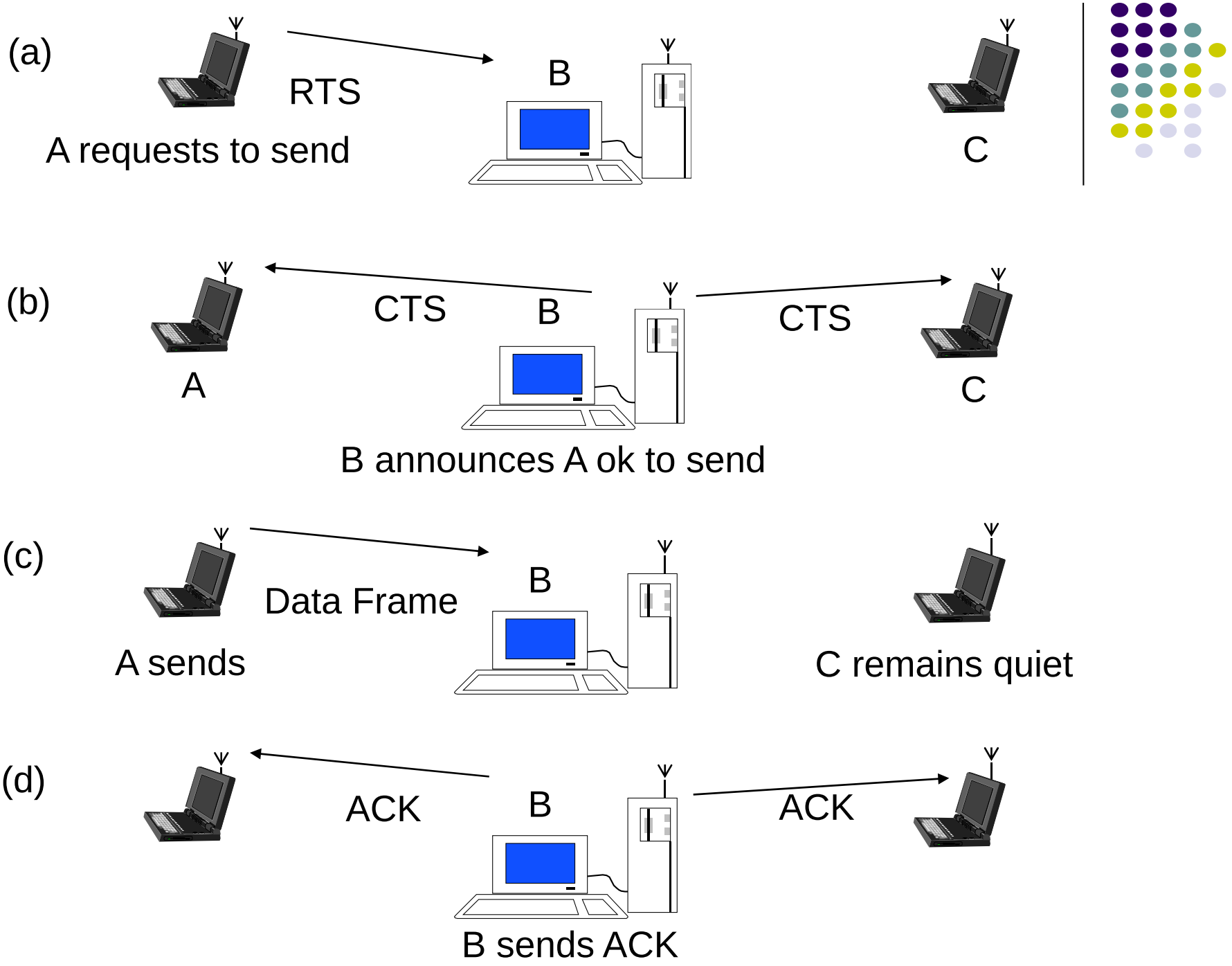
Priorities through Interframe Spacing



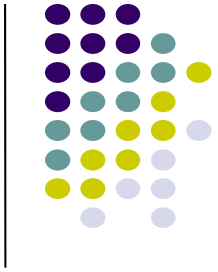
- High-Priority frames wait Short IFS (SIFS)
  - Typically to complete exchange in progress
  - ACKs, CTS, data frames of segmented MSDU, etc.
- PCF IFS (PIFS) to initiate Contention-Free Periods
- DCF IFS (DIFS) to transmit data & MPDUs

Contention & Backoff Behavior

- If channel is still idle after DIFS period, ready station can transmit an *initial* MPDU
- If channel becomes busy before DIFS, then station must schedule *backoff* time for reattempt
  - Backoff period is integer # of *idle contention time slots*
  - Waiting station monitors medium & decrements backoff timer each time an idle contention slot transpires
  - Station can contend when backoff timer expires
- A station that completes a frame transmission is not allowed to transmit immediately
  - Must first perform a backoff procedure

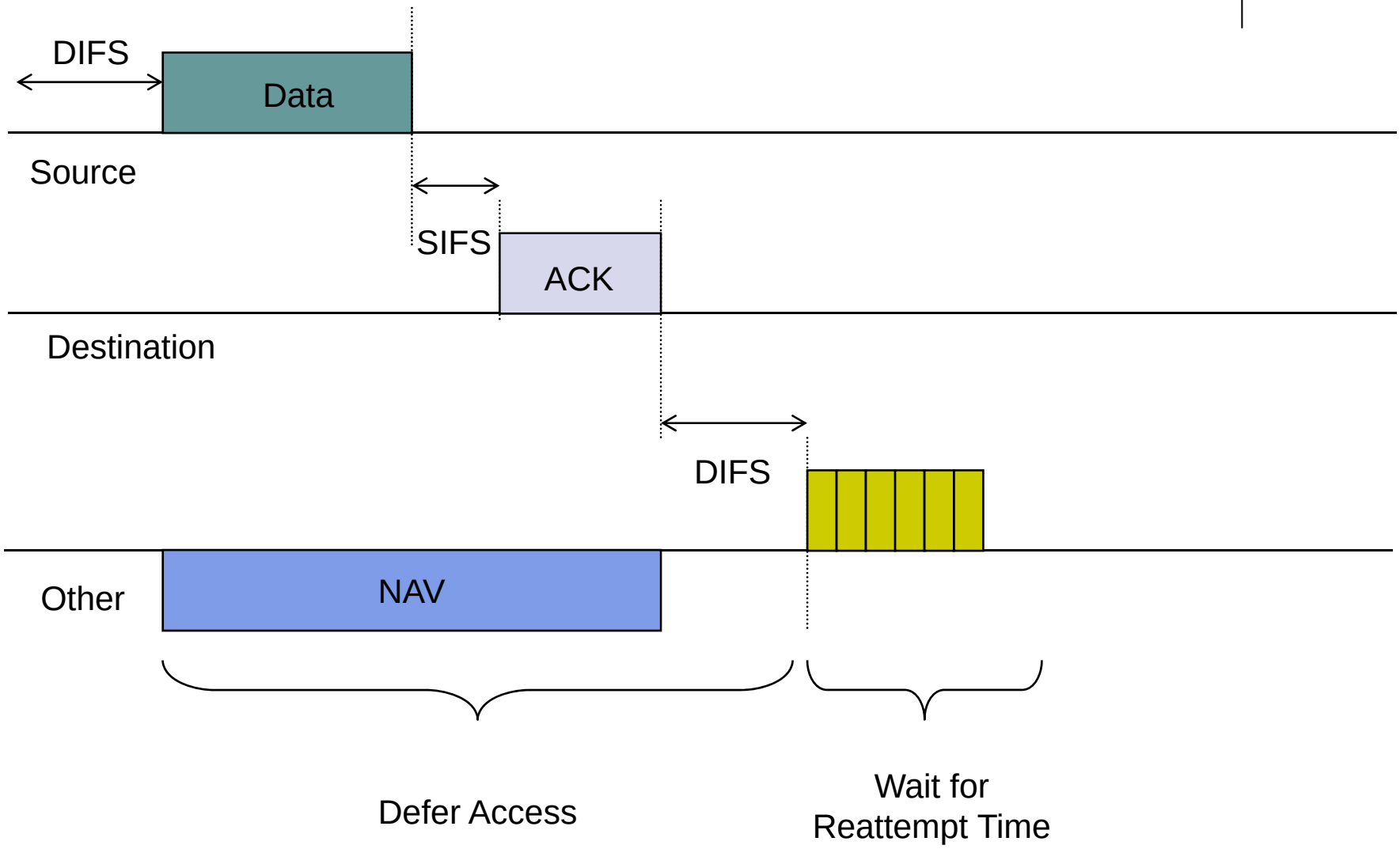

(a)
RTS
B
A requests to send
C
(b)
CTS
B
CTS
A
C
B announces A ok to send
(c)
Data Frame
B
A sends
C remains quiet
(d)
ACK
B
ACK
B sends ACK

Carrier Sensing in 802.11

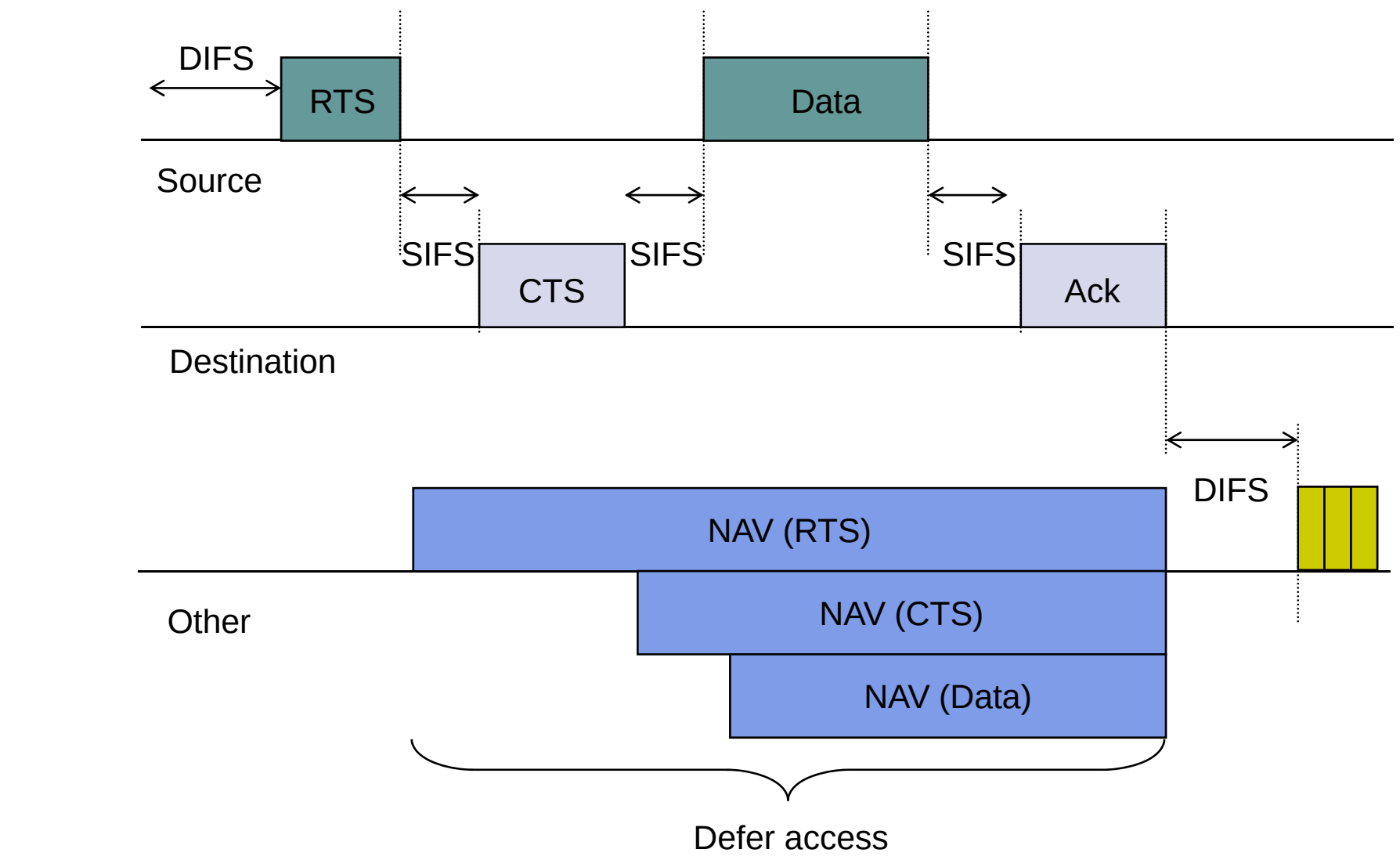


- *Physical Carrier Sensing*
  - Analyze all detected frames
  - Monitor relative signal strength from other sources
- *Virtual Carrier Sensing* at MAC sublayer
  - Source stations informs other stations of transmission time (in μsec) for an MPDU
  - Carried in *Duration* field of RTS & CTS
  - Stations adjust *Network Allocation Vector* to indicate when channel will become idle
- Channel busy if either sensing is busy

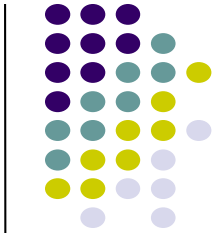
Transmission of MPDU without RTS/CTS



Transmission of MPDU with RTS/CTS



Collisions, Losses & Errors

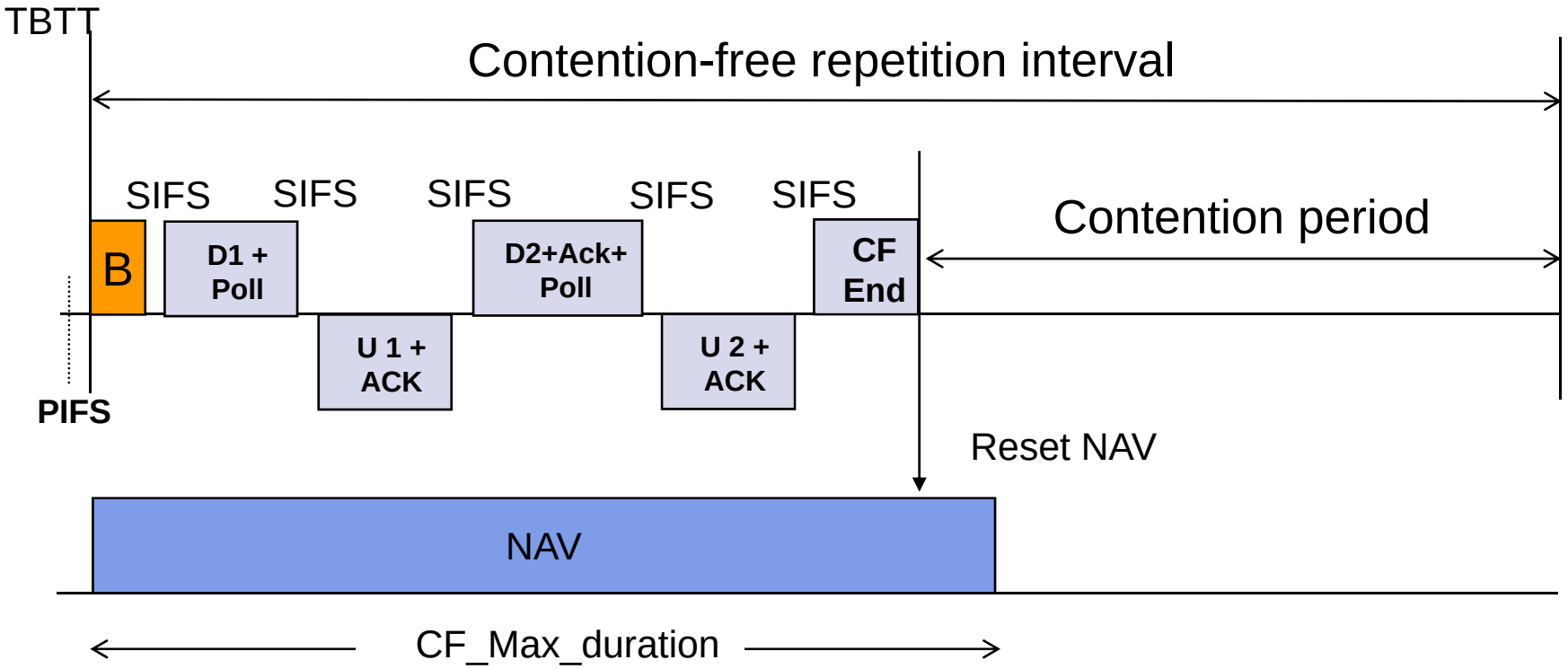


- Collision Avoidance
  - When station senses channel busy, it waits until channel becomes idle for DIFS period & then begins random backoff time (in units of idle slots)
  - Station transmits frame when backoff timer expires
  - If collision occurs, recompute backoff over interval that is twice as long
- Receiving stations of error-free frames send ACK
  - Sending station interprets non-arrival of ACK as loss
  - Executes backoff and then retransmits
  - Receiving stations use sequence numbers to identify duplicate frames

Point Coordination Function

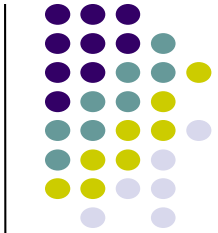
- PCF provides connection-oriented, contention-free service through *polling*
- *Point coordinator (PC)* in AP performs PCF
- Polling table up to implementor
- CFP repetition interval
  - Determines frequency with which CFP occurs
  - Initiated by *beacon frame* transmitted by PC in AP
  - Contains CFP and CP
  - During CFP stations may only transmit to respond to a poll from PC or to send ACK

PCF Frame Transfer



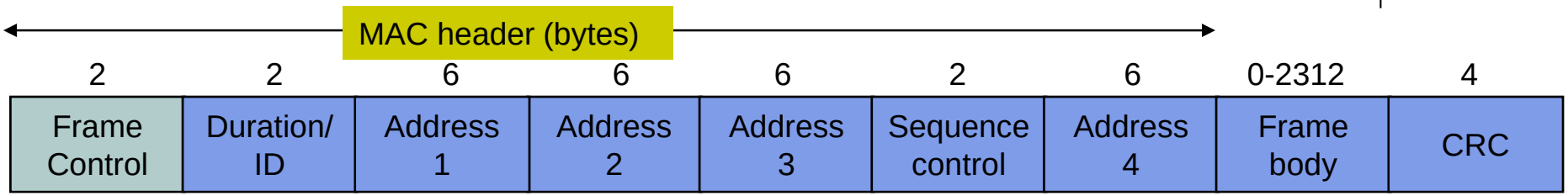
D1, D2 = frame sent by point coordinator
U1, U2 = frame sent by polled station
TBTT = target beacon transmission time
B = beacon frame

Frame Types



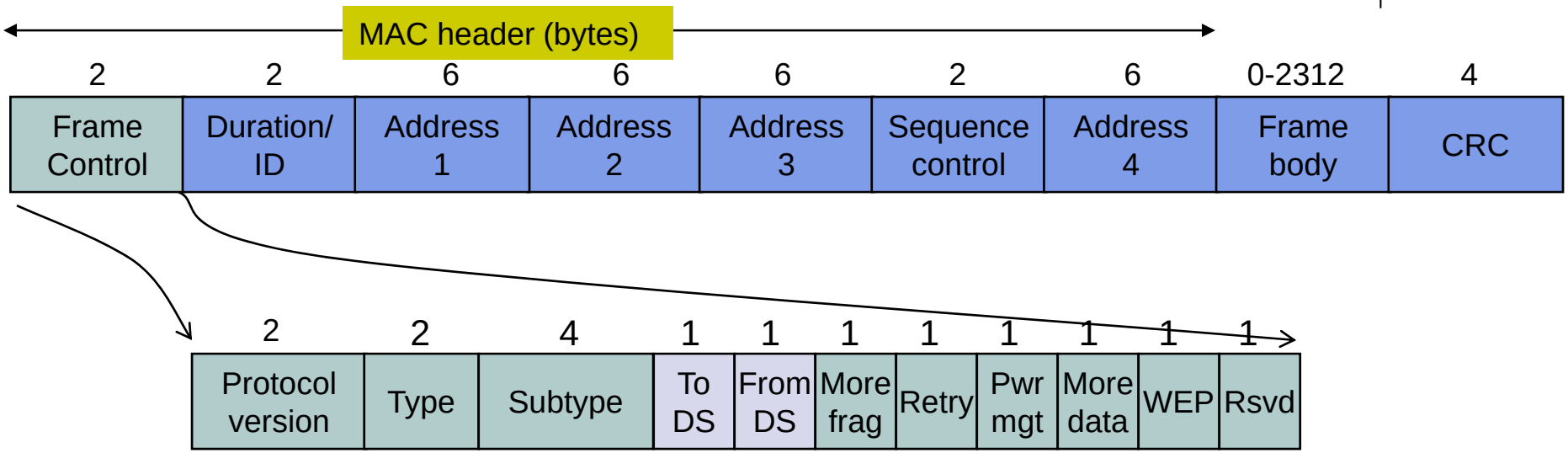
- Management frames
  - Station association & disassociation with AP
  - Timing & synchronization
  - Authentication & deauthentication
- Control frames
  - Handshaking
  - ACKs during data transfer
- Data frames
  - Data transfer

Frame Structure



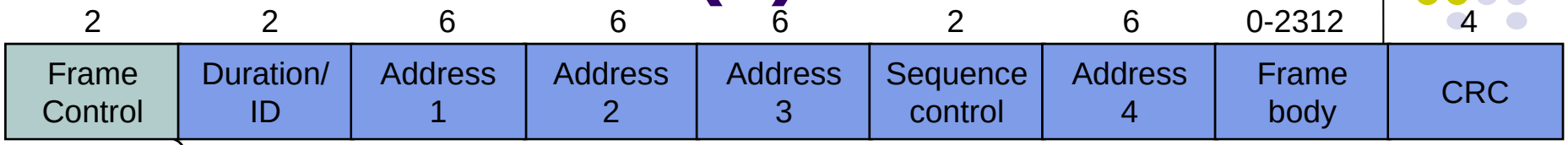
- MAC Header: 30 bytes
- Frame Body: 0-2312 bytes
- CRC: CCITT-32 4 bytes CRC over MAC header & frame body

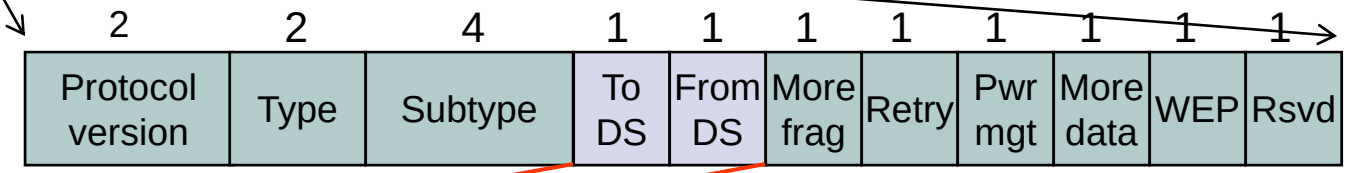
Frame Control (1)



- Protocol version = 0
- Type: Management (00), Control (01), Data (10)
- Subtype within frame type
- Type=00, subtype=association; Type=01, subtype=ACK
- MoreFrag=1 if another fragment of MSDU to follow

Frame Control (2)

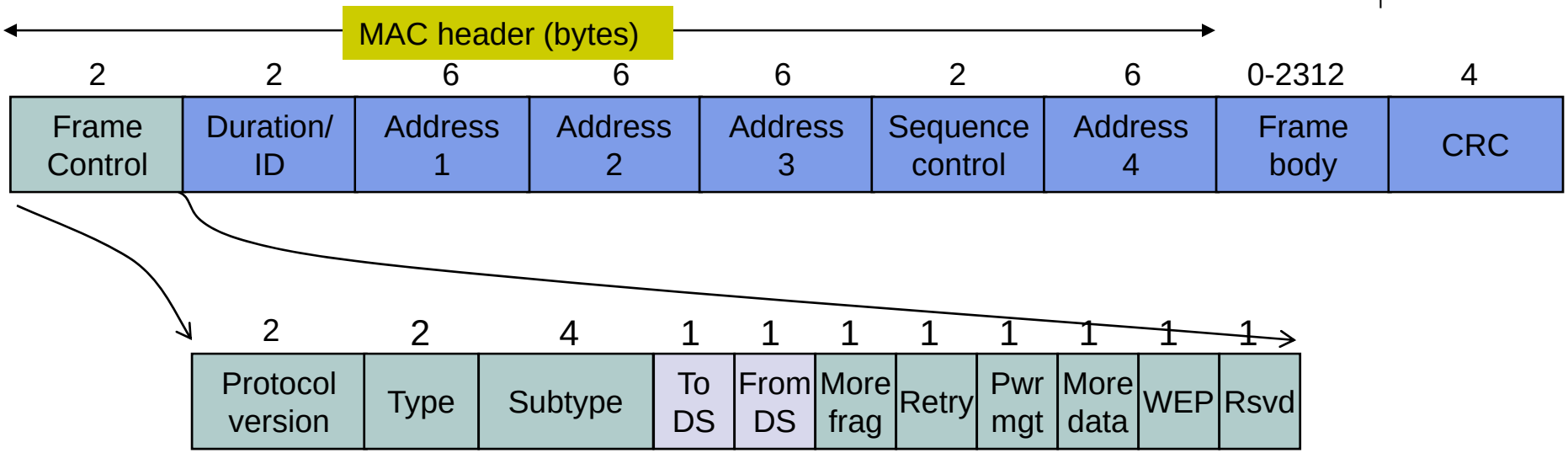




To DS	From DS	Address 1	Address 2	Address 3	Address 4	Meaning
0	0	Destination address	Source address	BSSID	N/A	Data frame from station to station within a BSS
0	1	Destination address	BSSID	Source address	N/A	Data frame exiting the DS
1	0	BSSID	Source address	Destination address	N/A	Data frame destined for the DS
1	1	Receiver address	Transmitter address	Destination address	Source address	WDS frame being distributed from AP to AP

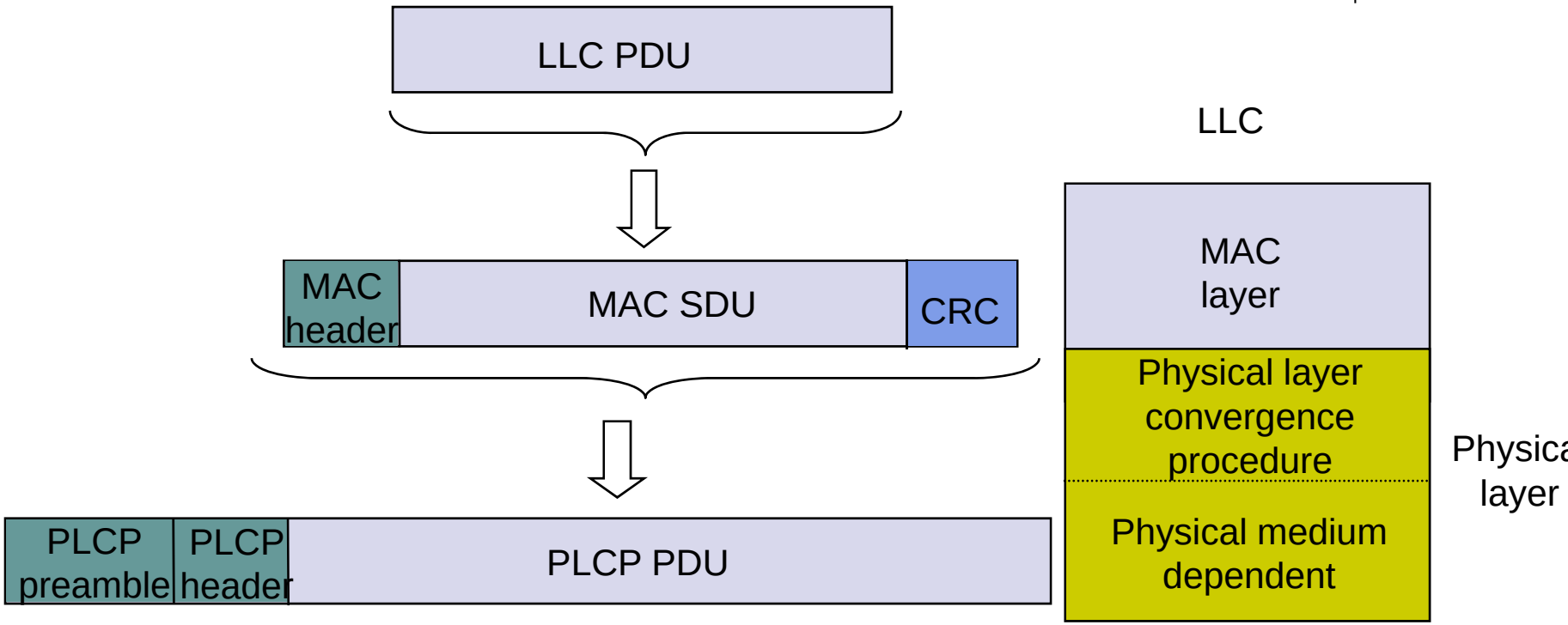
To DS = 1 if frame goes to DS; From DS = 1 if frame exiting DS

Frame Control (3)



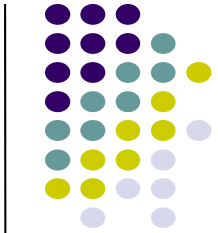
- Retry=1 if mgmt/control frame is a retransmission
- Power Management used to put station in/out of sleep mode
- More Data =1 to tell station in power-save mode more data buffered for it at AP
- WEP=1 if frame body encrypted

Physical Layers



- 802.11 designed to
  - Support LLC
  - Operate over many physical layers

IEEE 802.11 Physical Layer Options



	Frequency Band	Bit Rate	Modulation Scheme
802.11	2.4 GHz	1-2 Mbps	Frequency-Hopping Spread Spectrum, Direct Sequence Spread Spectrum
802.11b	2.4 GHz	11 Mbps	Complementary Code Keying & QPSK
802.11g	2.4 GHz	54 Mbps	Orthogonal Frequency Division Multiplexing & CCK for backward compatibility with 802.11b
802.11a	5-6 GHz	54 Mbps	Orthogonal Frequency Division Multiplexing