

教育部資通訊科技人才培育先導型計畫

無線區域網路媒體存取控制層協定

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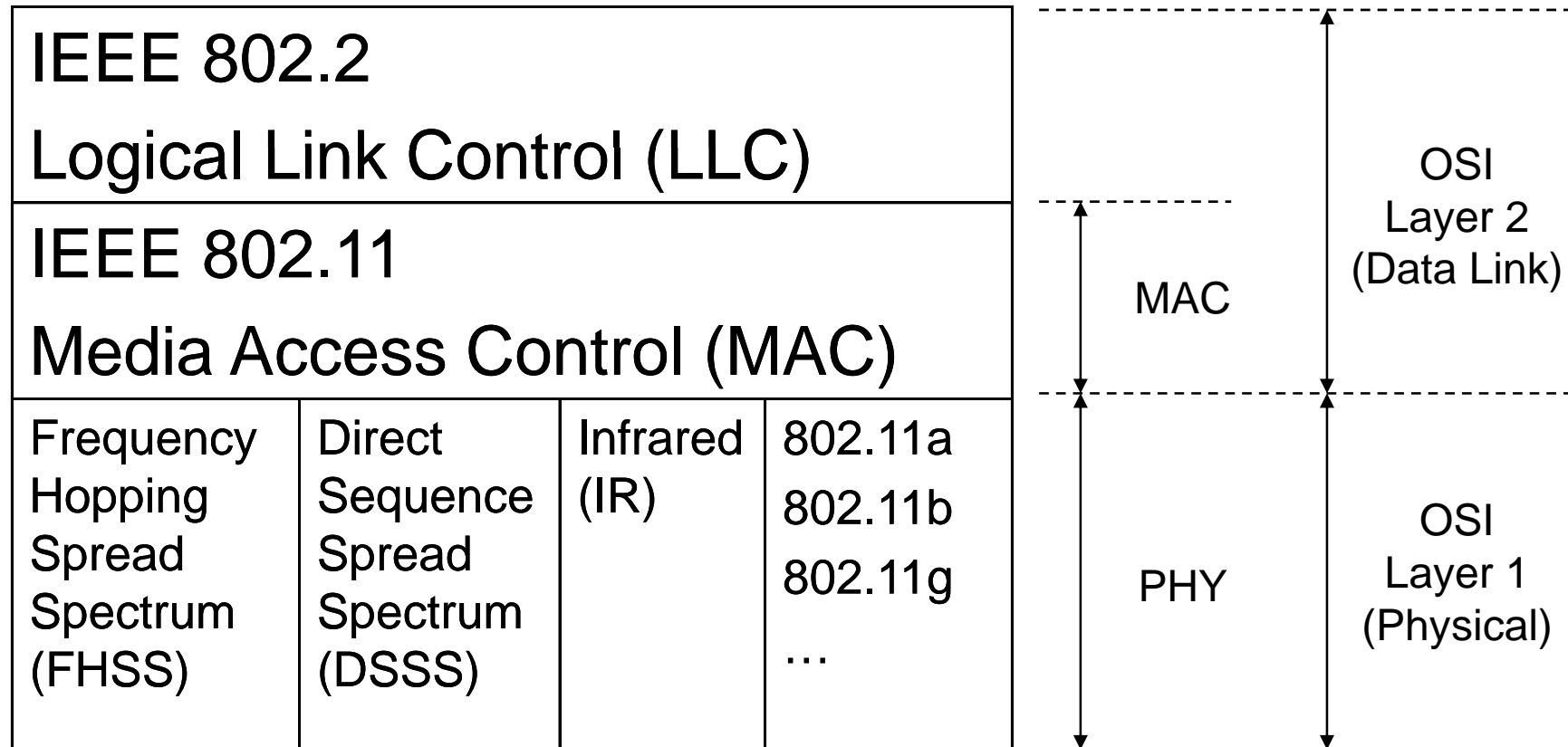
Outline

- Introduction to IEEE 802.11
- Frame Format
- Medium Access Control Protocol
- MAC Access Modes
- Carrier Sense Multiple Access / Collision Avoidance
- Distributed Coordination Function
- Point Coordination Function
- IEEE 802.11e

Introduction to IEEE 802.11

- Wireless networks get rid of tangling and restriction of wired networks.
- Wireless channels are inherently unreliable and of limited bandwidth → Dedicated MAC/PHY protocols are required.
- IEEE 802.11 standardizes and boosts the deployment of WLAN.

IEEE 802.11 vs. OSI Model



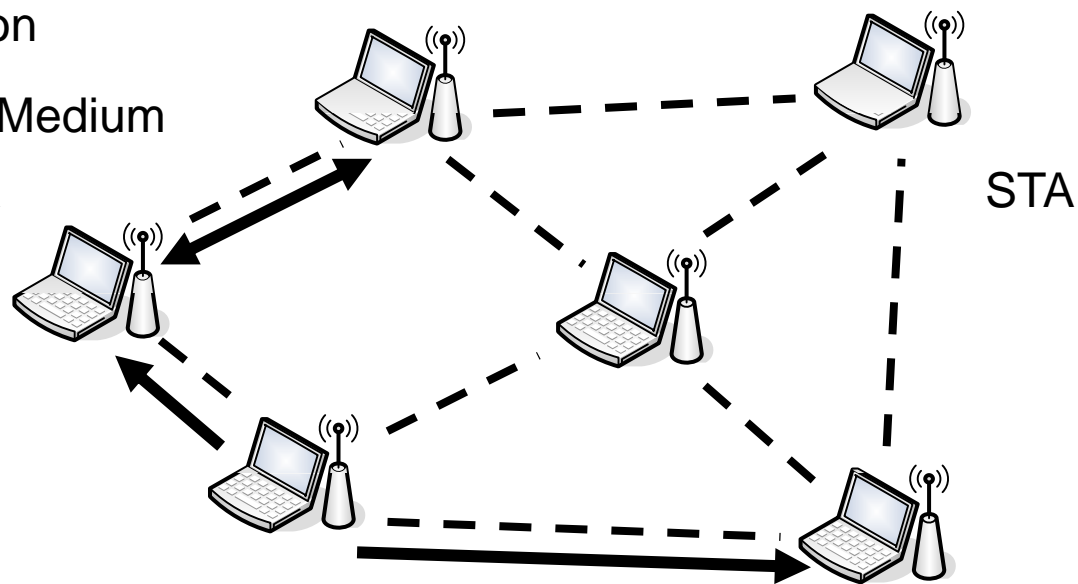
IEEE 802.11 Topologies

- Independent Basic Service Set (also called Ad-Hoc Network)

STA: Wireless Station

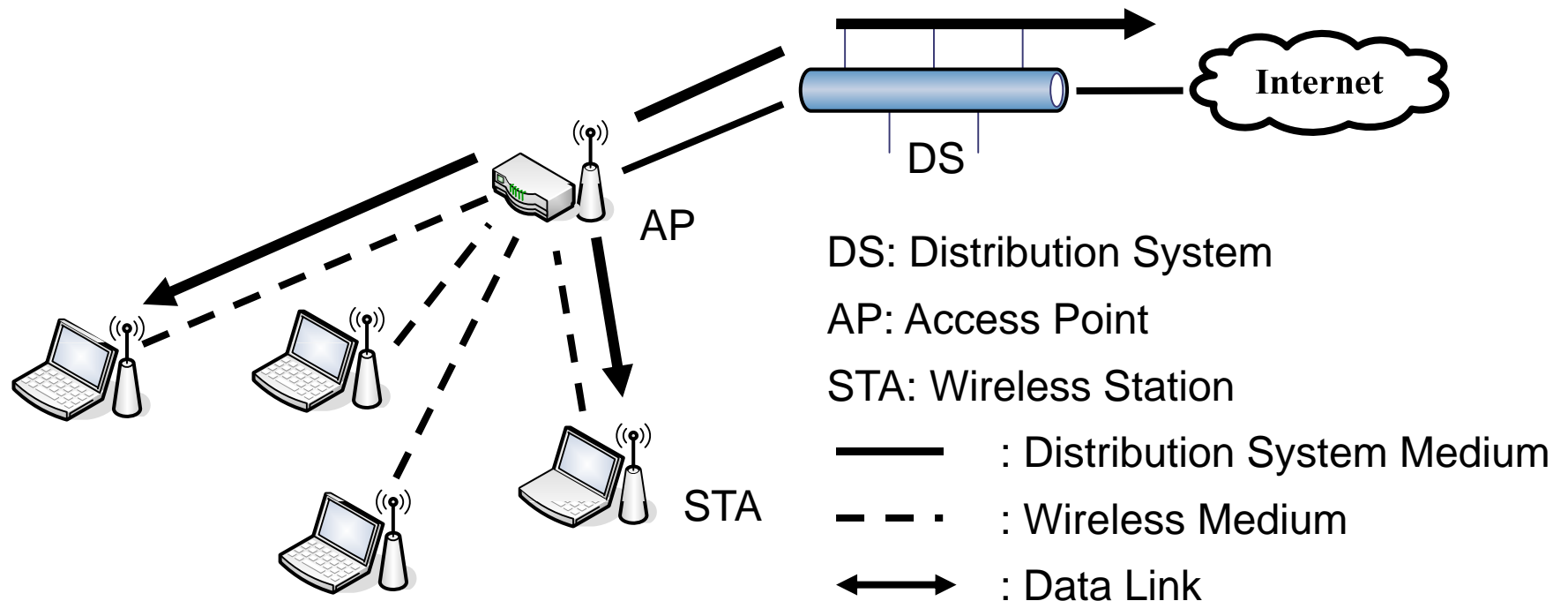
- - - : Wireless Medium

↔ : Data Link



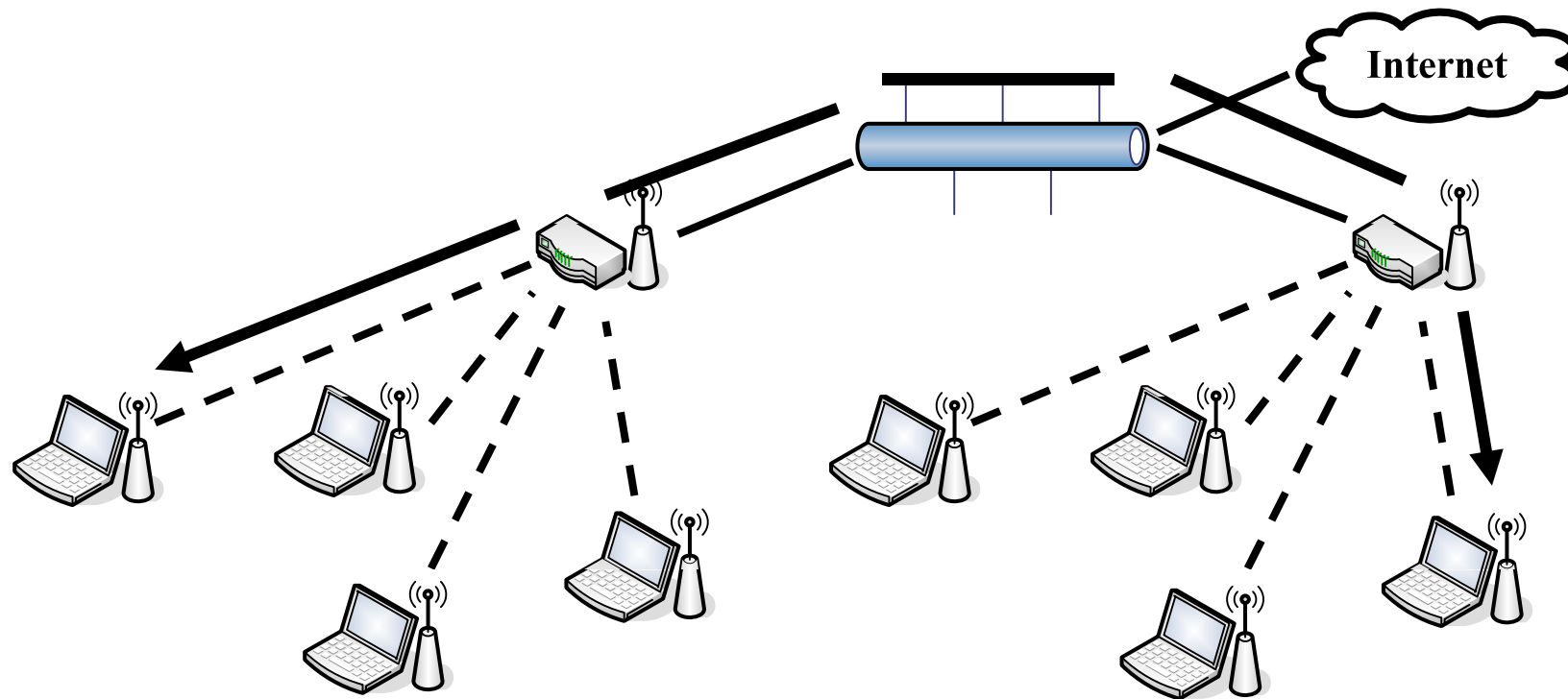
IEEE 802.11 Topologies (cont)

- Infrastructure Basic Service Set



IEEE 802.11 Topologies (cont)

- Extended Service Set



IEEE 802.11 Network Services

- IEEE 802.11 Network Services
 - MAC Service Data Unit (MSDU) delivery
 - Association
 - Disassociation
 - Authentication
 - De-authentication
 - Privacy (Wired Equivalent Privacy, WEP)
 - ...

IEEE 802.11 Network Services (cont)

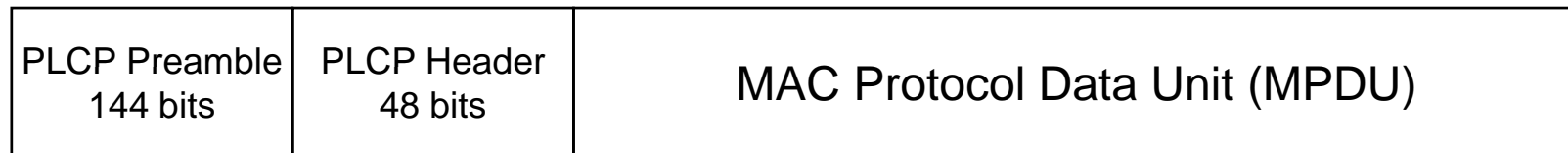
- Network services are implemented via the exchange of frames by following MAC protocol
 - Data Frame
 - Control Frame
 - Management Frame

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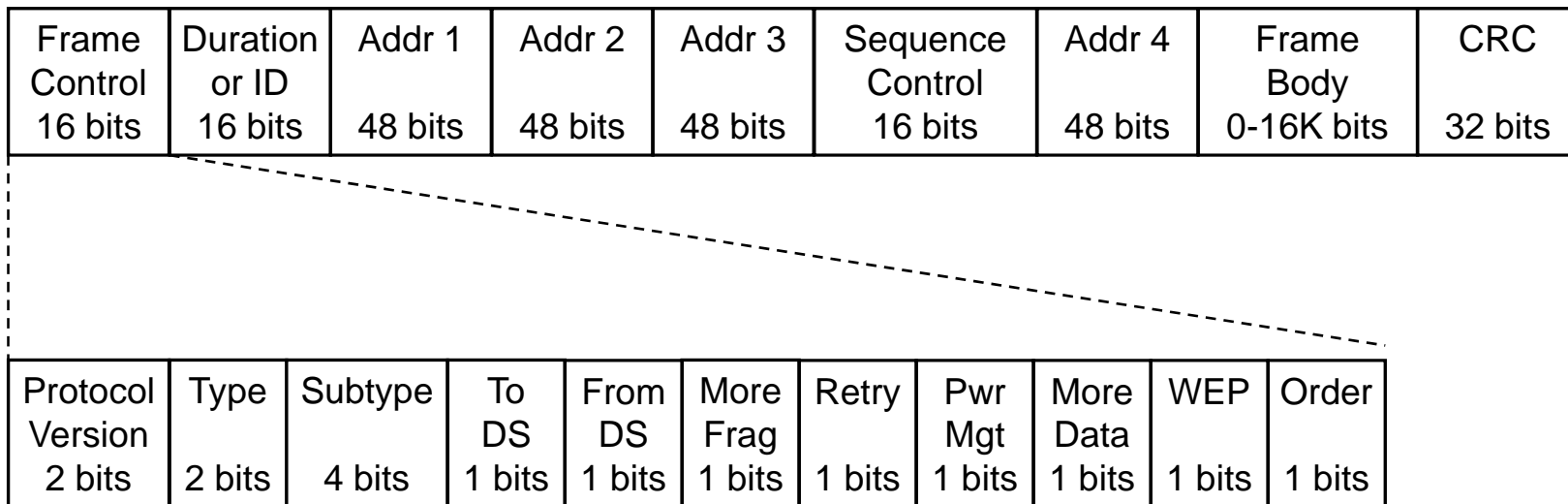
Frame Format

- PHY Layer Convergence Protocol (PLCP) Data Unit (PPDU)



Frame Format (cont)

- MAC Protocol Data Unit (MPDU)



Frame Format (cont)

■ Partial List of Type and Subtype

Type	Type Description	Subtype	Subtype Description
00	Management	0000	Association Request
		1000	Beacon
		1011	Authentication
01	Control	1011	Request To Send (RTS)
		1100	Clear To Send (CTS)
		1101	Acknowledgement (ACK)
10	Data	0000	Data
11	Reserved		Reserved

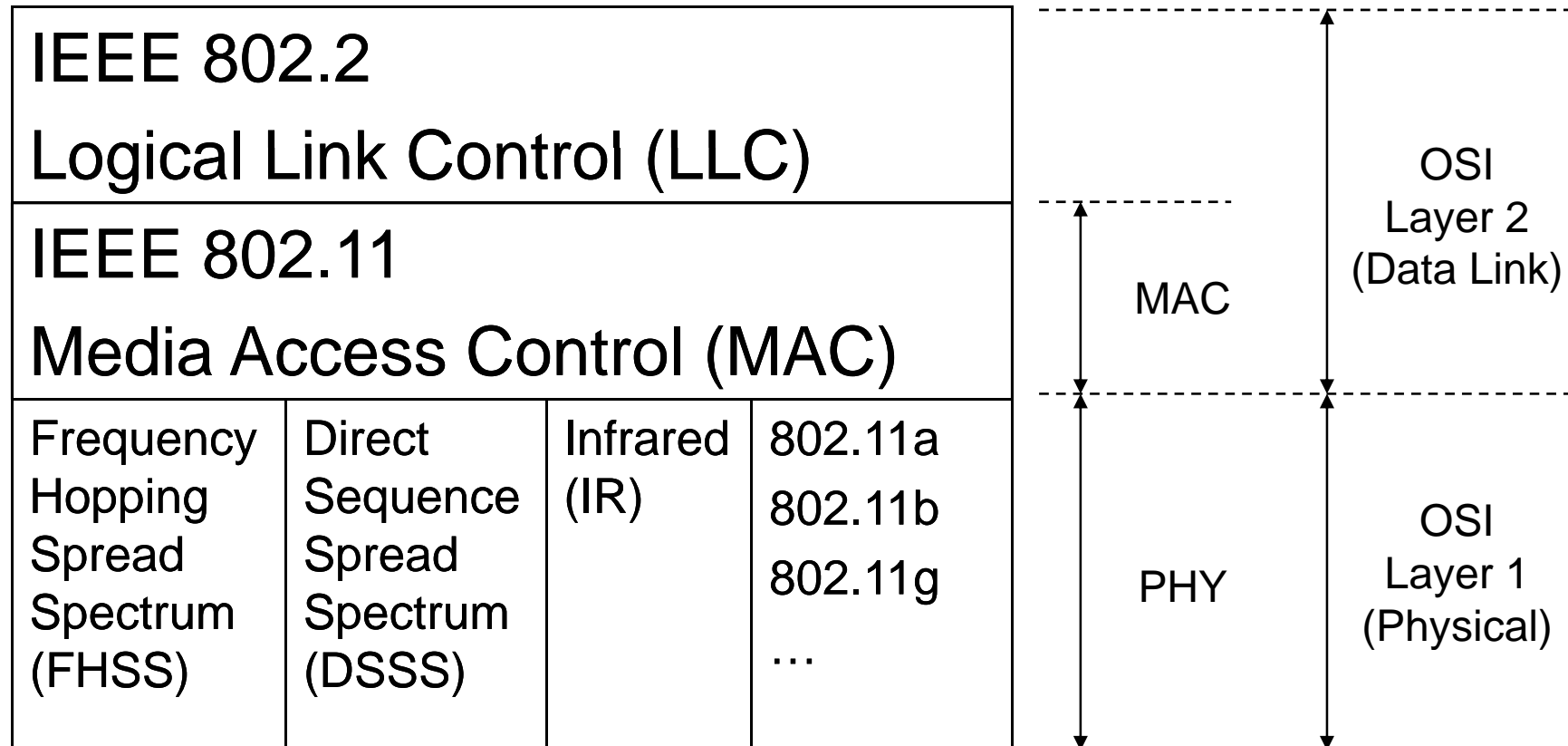
Frame Format (cont)

- Inter Frame Space
 - Short Inter Frame Space (SIFS)
 - Point Coordination Inter Frame Space (PIFS)
 - Distributed Inter Frame Space (DIFS)
 - ...
- IFSs provide guarding spaces between frames
- With different durations, IFSs differentiate frames/entities with different priority
 - Duration: DIFS>PIFS>SIFS
 - Frames follow shorter IFSs have higher priority

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IEEE 802.11 MAC Protocol



IEEE 802.11 MAC Protocol (cont)

- Functionalities
 - Reliable frame delivery over the wireless PHY media
 - Controlled multiple access to the shared wireless media
 - Protection of the security/privacy of frames being delivered
 - ...

IEEE 802.11 MAC Protocol (cont)

- Objectives
 - Reliable Delivery
 - Multiple Access
 - Security/Privacy
 - QoS (Quality of Service) Support
 - Fair Sharing
 - ...

IEEE 802.11 MAC Protocol (cont)

- Mechanisms
 - Carrier Sense Multiple Access / Collision Avoidance
 - Distributed Coordination Function
 - Point Coordination Function
 - IEEE 802.11e
 - ...

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MAC Access Modes

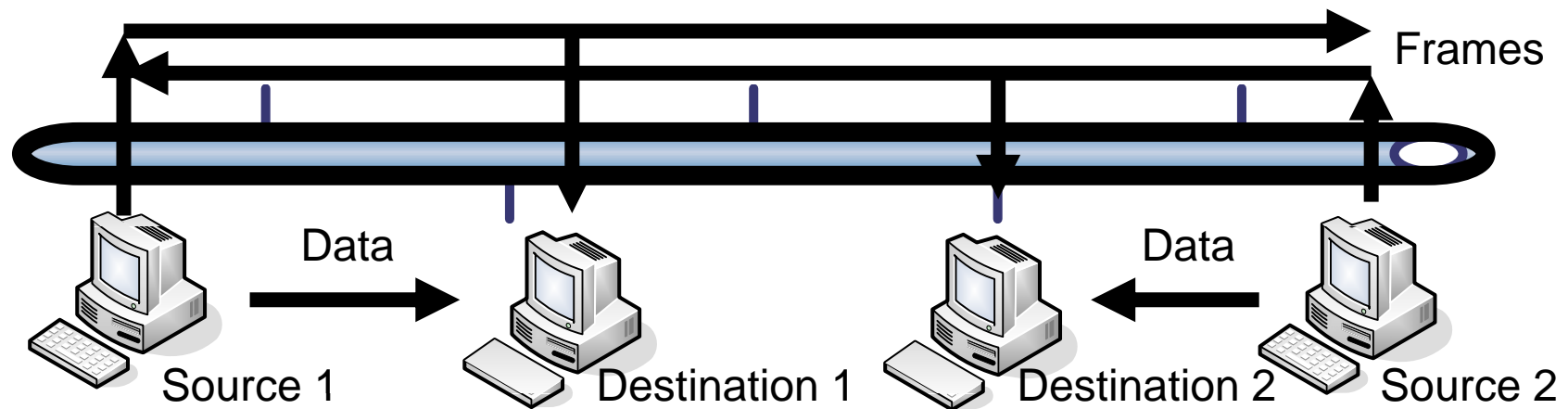
- Distributed Coordination Function (DCF)
 - Distributed, contention-based
 - Exponential backoff upon collision
 - Optional CSMA/CA
- Point Coordination Function (PCF)
 - Superframe = Content Free Period + Contention Period (DCF)
 - AP polls STAs in turn in Content Free Period (CFP)
 - CFP is centralized, polling-based, contention-free

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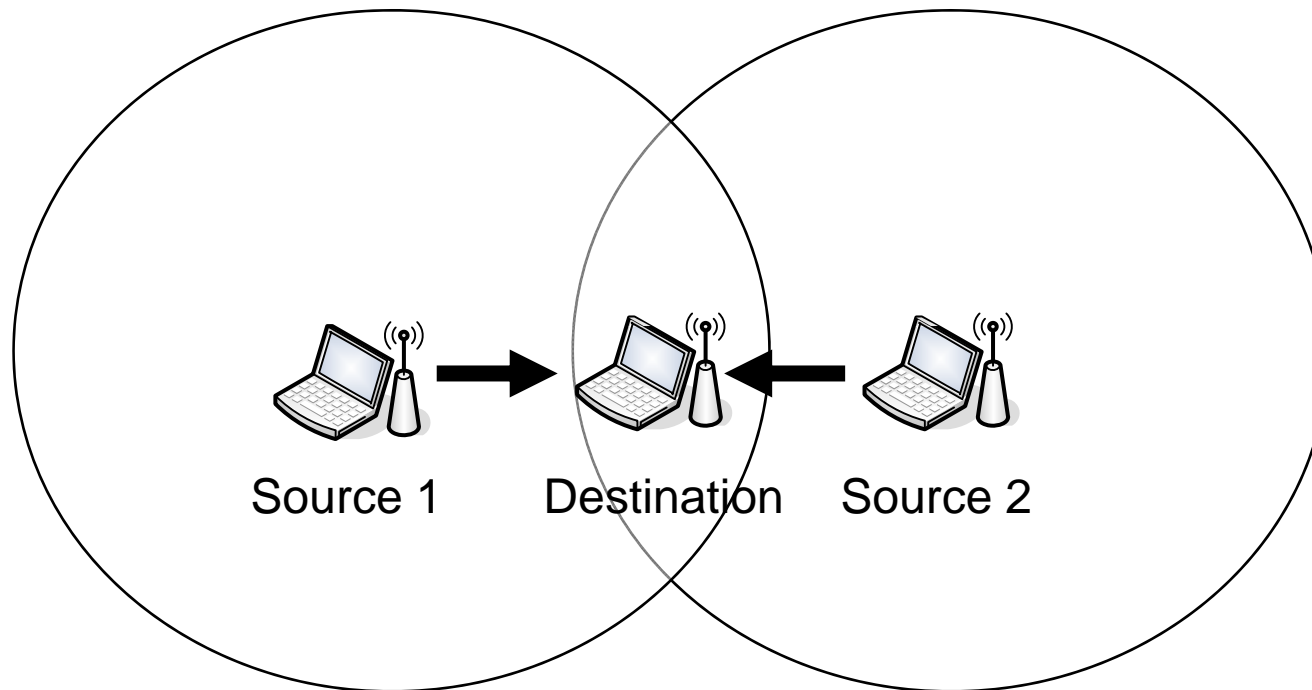
Carrier Sense Multiple Access / Collision Avoidance

- 802.3 (Ethernet) adopts Carrier Sense Multiple Access / Collision Detection (CSMA/CD) for medium access control
- Collision detection by sending and listening



Carrier Sense Multiple Access / Collision Avoidance (cont)

- Collision detection is infeasible in WLAN
 - Hidden Terminal Problem

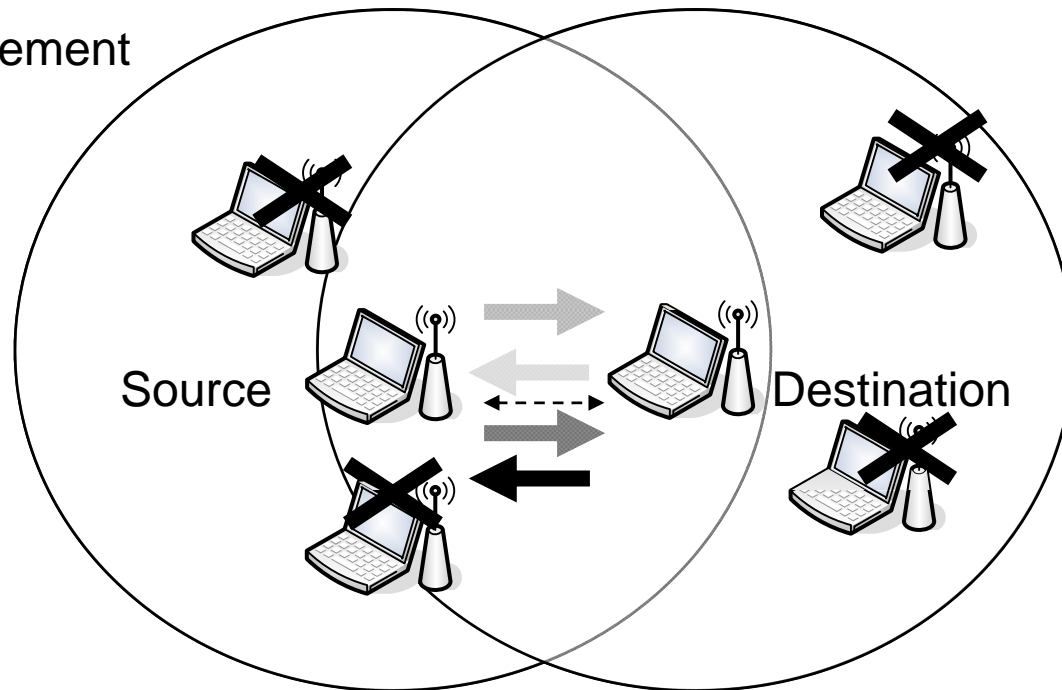


Carrier Sense Multiple Access / Collision Avoidance (cont)

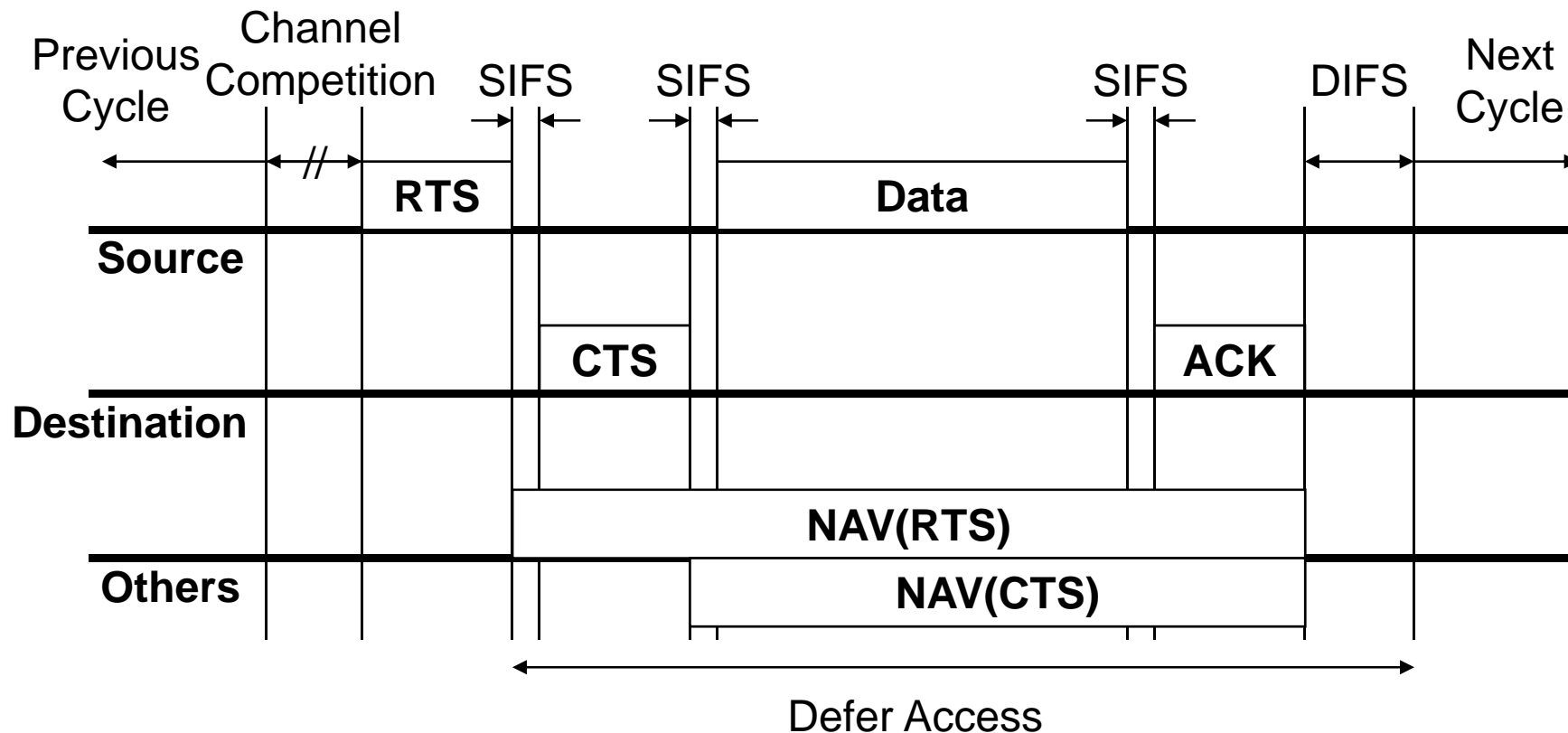
- 802.11 adopts Carrier Sense Multiple Access / Collision Avoidance (CSMA/CA) for medium access control
- RTS/CTS/Data/ACK 4-way handshaking and Virtual Carrier Sensing to reduce the chance of collision
- Network Allocation Vector (NAV), required duration for intended transmission, is carried in the Duration field of RTS and CTS

Carrier Sense Multiple Access / Collision Avoidance (cont)

- ➔ 1. RTS: Request To Send
- ➔ 2. CTS: Clear To Send
- ➔ 3. Data
- ➔ 4. ACK: Acknowledgement



Carrier Sense Multiple Access / Collision Avoidance (cont)



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Distributed Coordination Function

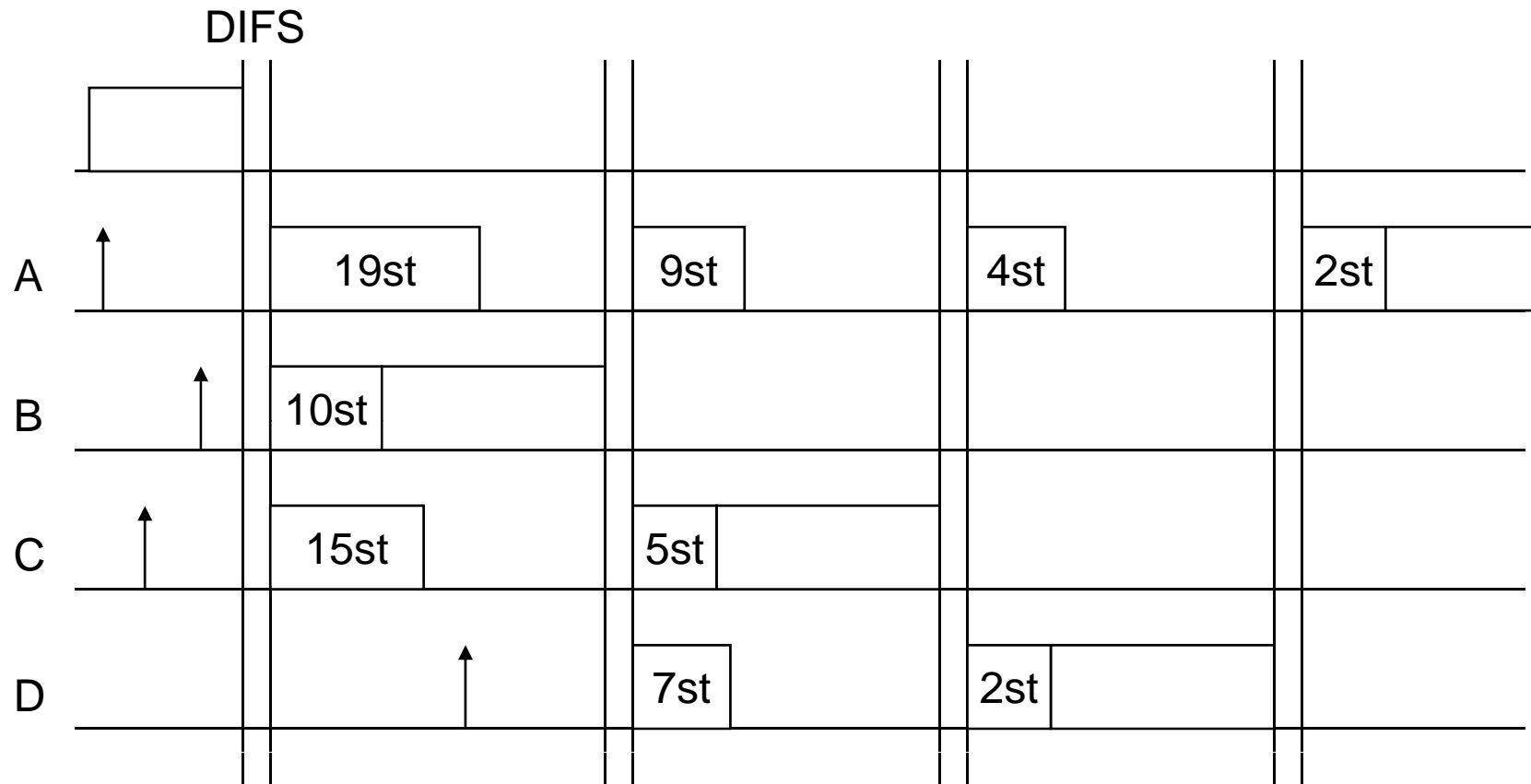
- Distributed Coordination Function
 - No coordinator
 - Contention-based
 - Exponential backoff upon collision
 - Optional CSMA/CA
 - For both infrastructure and ad-hoc topologies

Distributed Coordination Function (cont)

- Backoff Algorithm
 - STA randomly picks up a *Backoff Time* (number of “Slot Time”) from $[0, CW]$
 - Backoff timer
 - Freeze when medium is busy
 - Decrease when free period $>$ DIFS
 - Transmission is commenced when timer reaches zero

Distributed Coordination Function (cont)

: Frame
 : Backoff
 ↑ : MSDU Arrival
 st: Slot Time



Distributed Coordination Function (cont)

- Exponential Backoff
 - Slot Time = transmitter turn-on delay + medium propagation delay + medium busy detect response time
 - On collision, CW is increased exponentially till CW_{max}
 - On success, CW is reset to CW_{min}
 - For IEEE 802.11b
 - A Slot Time is of 20us
 - CW is in $\{CW_{min}=31,63,127,255,511,CW_{max}=1023\}$

Outline

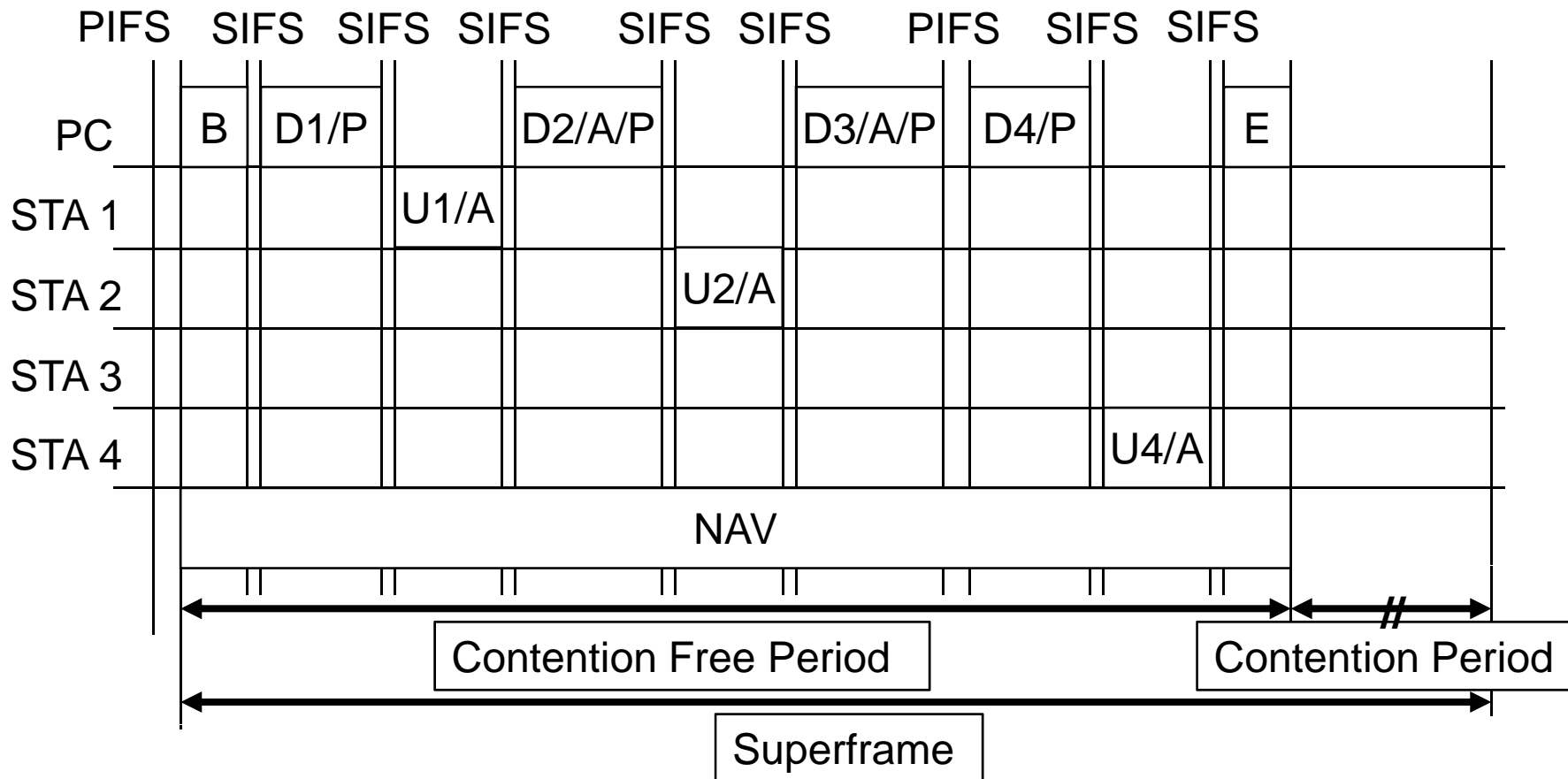
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Point Coordination Function

- Point Coordination Function
 - Superframe = Content Free Period + Contention Period (DCF)
 - In Content Free Period (CFP), Point Coordinator (AP in general) polls STAs in turn
 - CFP is centralized, polling-based, contention-free
 - Adequate for time-bounded applications
 - Only for infrastructure topologies
 - Not widely implemented

Point Coordination Function (cont)

B: Beacon, Dx: Downlink, Ux: Uplink, P: CF-Poll, A: CF-Ack, E: CF-End



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IEEE 802.11e

- Limitation of 802.11 PCF
 - Simple round-robin algorithm
 - Limited QoS support
 - Transmission time of the polled stations is not under control
- IEEE 802.11e
 - Enhanced QoS supports for service differentiation
 - Different Arbitration Inter Frame Space (AIFS) and CW_{\min}/CW_{\max} for different Access Categories (ACs)
 - Controlled Transmission Opportunity (TXOP)

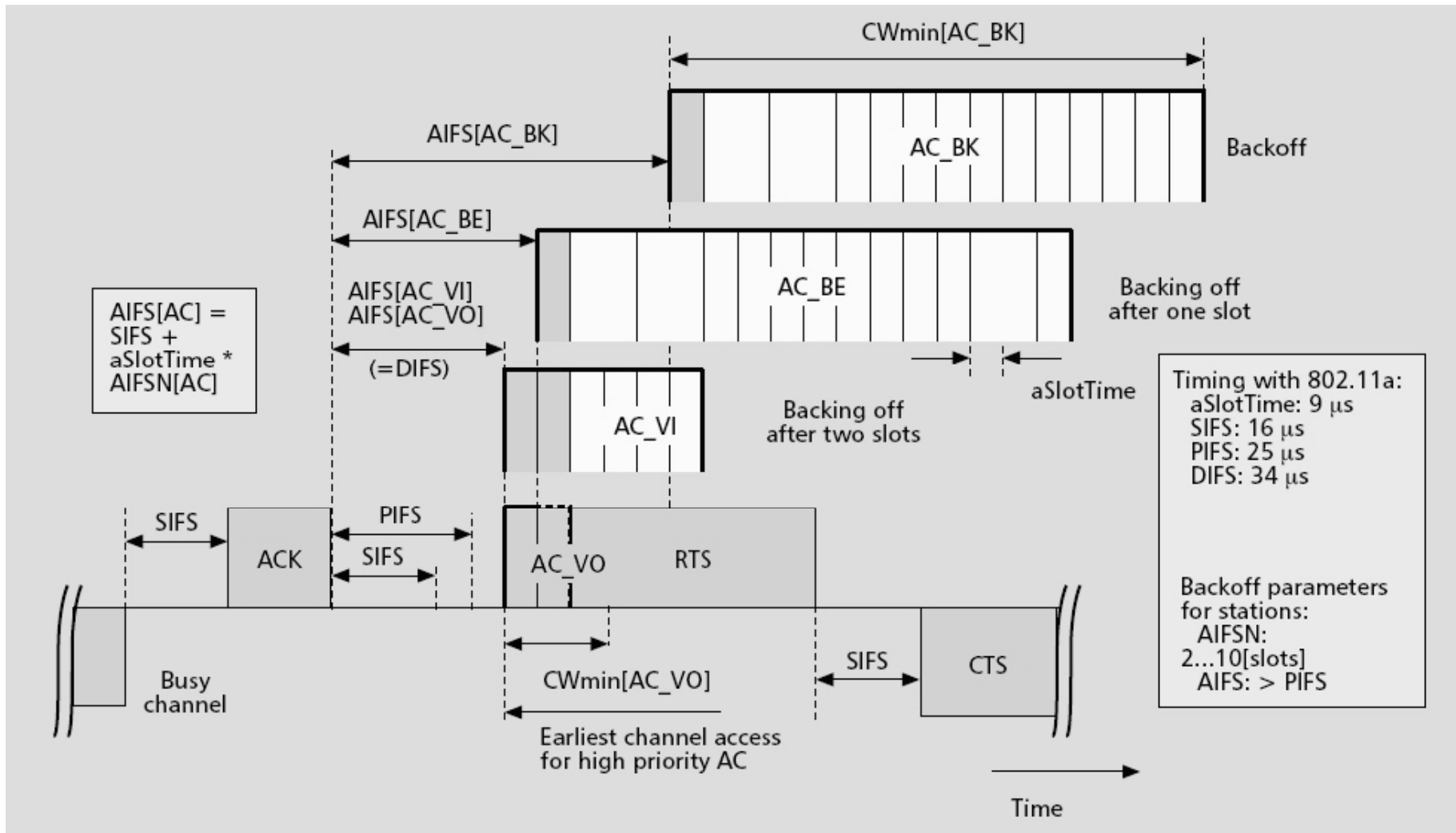
IEEE 802.11e (cont)

- IEEE 802.11e Superframe =
(Optional) Point Coordination Function (PCF) +
Hybrid Coordination Function (HCF)
- HCF = Mixture of
 - Enhanced DCF channel access (EDCA)
 - HCF controlled channel access (HCCA)
- Hybrid Coordinator (HC) has total control
over the mixture of EDCA/HCCA

IEEE 802.11e (cont)

- Enhanced DCF Channel Access (EDCA)
 - Prioritized QoS support
 - 4 Access Categories
 - AC_VO (voice), AC_VI (video), AC_BE (best effort), AC_BG (background)
 - Different AIFS and CW_{\min}/CW_{\max} for different ACs
 - ACs with higher priorities have better chance to gain access right

IEEE 802.11e (cont)



IEEE 802.11e (cont)

- HCF controlled channel access (HCCA)
 - Parameterized QoS support
 - HC polls and assigns TXOP to Traffic Stream (TS) according to its Traffic Specification (TSPEC)
 - HC can gain control of medium after PIFS