# CS5984

# Mobile Computing

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IEEE 802 and IEEE 802.11



# Outline

- IEEE 802 Architecture
- IEEE 802.11 Wireless LANs

*Based on*

Chapter 14 in *Wireless Communications and Networks*, William Stallings, Prentice Hall, 2002



## IEEE 802 Architecture 1/7

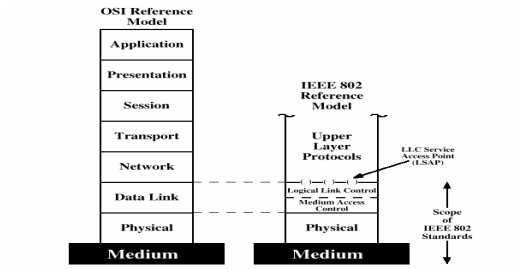



**Figure 14.1 IEEE 802 Protocol Layers Compared to OSI Model**

Chapter 14 in *Wireless Communications and Networks*, William Stallings, Prentice Hall, 2002



## IEEE 802 Architecture 2/7

- Physical layer
  - Encoding/decoding of signals
  - Preamble generation/removal (for synchronization)
  - Bit transmission/reception
  - *Specification of transmission medium and topology (considered below lowest layer of OSI model)*
- Medium Access Control layer (MAC)
  - On transmission, assemble data into a frame with address and error detection fields
  - On reception, disassemble frame, and perform address recognition and error detection
  - Govern access to the LAN transmission medium



## IEEE 802 Architecture 3/7

- Logical Link Control (LLC) layer
  - Provide an interface to higher layers and perform flow and error control
- Why the separation?
  - Logic required to manage access to a shared-access medium is not found in traditional layer 2 data link control
  - For the same LLC, several MAC options may be provided



## IEEE 802 Architecture 4/7

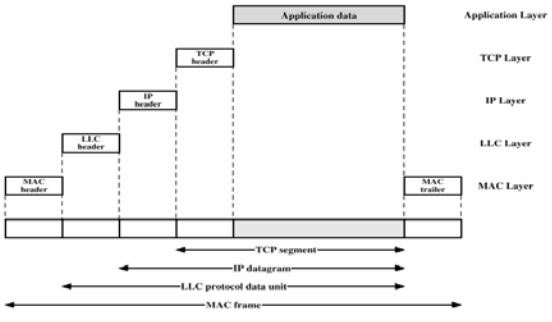



**Figure 14.2 IEEE 802 Protocols in Context**

## IEEE 802 Architecture 5/7

•MAC frame format

- ➢MAC control: protocol control information needed for functioning of MAC protocol
- ➢Destination MAC address: destination physical attachment point on LAN
- ➢Source MAC address: source physical attachment point on LAN
- ➢Data: body of MAC frame
- ➢CRC: cyclic redundancy check field (error detecting code)

•MAC layer is responsible for detecting errors and discarding any frames that are in error

•LLC layer *optionally* keeps track of which frames have been successfully received and retransmits unsuccessful frames

•Previous 2 tasks normally responsibility of data link protocol



## IEEE 802 Architecture 6/7

•LLC specifies mechanisms for addressing stations across the medium and for controlling the exchange of data between users

•LLC services

- ➢Unacknowledged connectionless service: datagram-style service. No flow or error control mechanisms (delivery of data not guaranteed). How is reliability ensured then, if needed?
- ➢Connection-mode service: logic connection set up between 2 users, providing flow-control and error control
- ➢Acknowledged connectionless service: datagrams to be acknowledged, but no prior logical connection is set up

•MAC layer is responsible for detecting errors and discarding any frames that are in error



## IEEE 802 Architecture 7/7

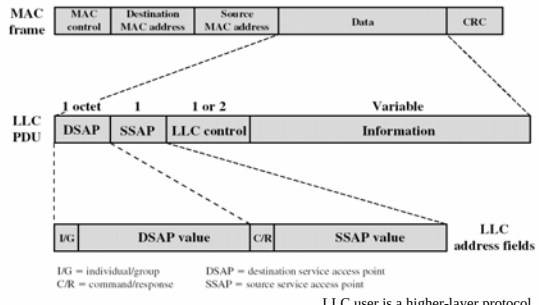



**Figure 14.3** LLC PDU in a Generic MAC Frame Format

LLC user is a higher-layer protocol or a network management function



## IEEE 802.11 Architecture 1/6

•Work on IEEE 802 began in 1987 within IEEE 802.4 group

•IEEE 802 Working groups

http://grouper.ieee.org/groups/802/dots.html

•In 1990, IEEE 802.11 was formed with a charter to develop a MAC protocol and physical medium specifications

•Two kinds of services

- ➢Basic service set (BSS)
- ➢Extended service set (ESS)



## IEEE 802.11 Architecture 2/6

•Basic service set (BSS)

- ➢Made of stationary or mobile wireless stations and possible central base stations (Access Point AP)
- ➢Without an AP, a stand-alone network, cannot send data to the other BSSs (ad hoc architecture)
  - ✓Stations can form a network without the need of an AP (locate each other be part of a BSS)

•Extended service set (ESS)

- ➢Two or more BSSs with APs
- ➢BSSs connected through a distribution system (usually a wired LAN)
- ➢Similar to a cellular network ( a BSS is a cell and each AP a base station)
- ➢MH can belong to more than one BSS at the same time
- ➢ESS appears as a single LAN to LLC level



## IEEE 802.11 Architecture 3/6

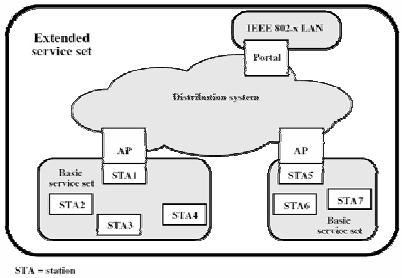
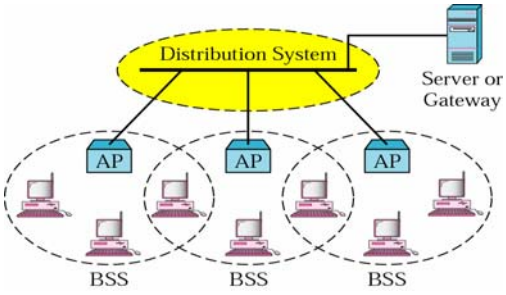



**Figure 14.4** IEEE 802.11 Architecture

## IEEE 802.11 Architecture 4/6






## IEEE 802.11 Architecture 5/6

- Station types (based on mobility in a wireless LAN)
  - ➢No-transition mobility
    - ✓either stationary or moving only inside a BSS
  - ➢BSS-transition mobility
    - ✓move from one BSS to another, but confined within one ESS
  - ➢ESS-transition mobility
    - ✓move from one ESS to another
- Message Delivery within DS
  - ➢Association (between a station and an AP)
    - ✓AP communicates to other APs
  - ➢Re-association (transfer from one AP to the another)
  - ➢Disassociation (terminate an existing association by AP or station)



## IEEE 802.11 Architecture 6/6

Table 14.1 IEEE 802.11 Terminology

| | |
|---|---|
| Access point (AP) | Any entity that has station functionality and provides access to the distribution system via the wireless medium for associated stations |
| Basic service set (BSS) | A set of stations controlled by a single coordination function. |
| Coordination function | The logical function that determines when a station operating within a BSS is permitted to transmit and may be able to receive PDUs. |
| Distribution System (DS) | A system used to interconnect a set of BSSs and integrated LANs to create an ESS. |
| Extended service set (ESS) | A set of one or more interconnected BSSs and integrated LANs that appear as a single BSS to the LLC layer at any station associated with one of these BSSs. |
| MAC protocol data unit (MPDU) | The unit of data exchanged between two peer MAC entities using the services of the physical layer. |
| MAC service data unit (MSDU) | Information that is delivered as a unit between MAC users. |
| Station | Any device that contains an IEEE 802.11 conformant MAC and physical layer. |



## IEEE 802.11 MAC layer 1/5

- Covers 3 functional areas: reliable data delivery, access control, and security

Reliable data delivery

- More efficient to deal with errors at the MAC level
  - ➢Timers used for higher layers are typically on the order of seconds
- Frame exchange protocol
  - ➢2 frame exchange: A frame is acknowledged (data/ACK)
  - ➢4 frame exchange: RTS/CTS then data/ACK (A required function but may be disabled)



## IEEE 802.11 MAC layer 2/5

Access Control

A distributed access control mechanism (using a carrier-sense mechanism) with an optional centralized control (centralized decision maker) built on top of that

- Distributed access protocol
  - ➢makes sense for an ad hoc network of peer workstations
- Centralized access protocol
  - ➢suitable for configurations in which a number of wireless stations are interconnected with each other and some sort of base station that attaches to a backboned wired LAN (infrastructure network)
  - ➢Useful if some of the data is time sensitive or high priority



## IEEE 802.11 MAC layer 3/5

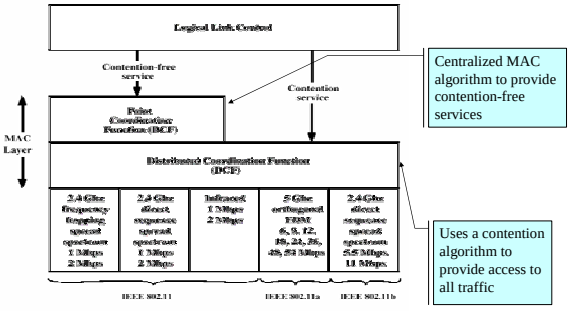


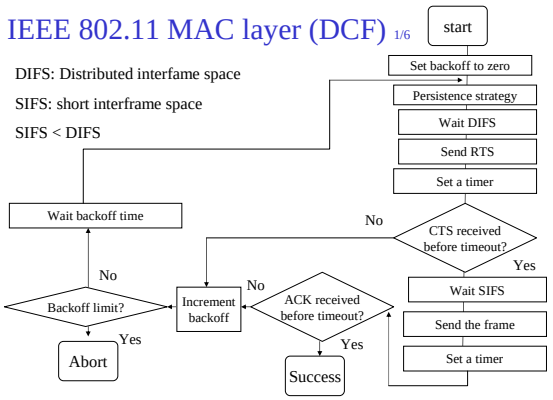

Figure 14.5 IEEE 802.11 Protocol Architecture

## IEEE 802.11 MAC layer (DCF) 1/6

DIFS: Distributed interfame space

SIFS: short interframe space

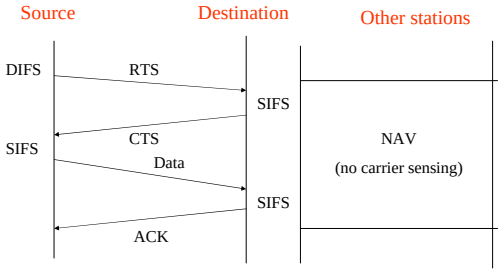
SIFS < DIFS






## IEEE 802.11 MAC layer (DCF) 2/6

**How do other stations defer sending their data if one station acquires access?**




NAV: Network Allocation Vector (A timer to implement collision avoidance)



## IEEE 802.11 MAC layer (DCF) 3/6

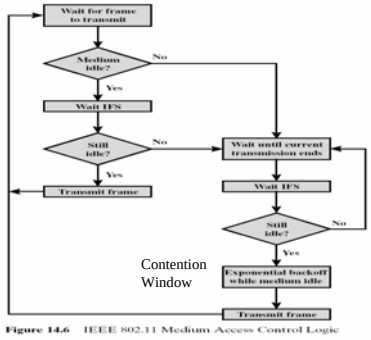



Figure 14.6 IEEE 802.11 Medium Access Control Logic

CSMA access rules

- Countdown backoff interval when medium is idle
- Countdown suspended, if medium becomes busy
- When backoff interval is 0, transmit RTS
- When a node successfully completes a data transfer, it restores cw to $Cw_{min}$
- Backoff incremented when no CTS, or no ACK received



## IEEE 802.11 MAC layer (DCF) 4/6

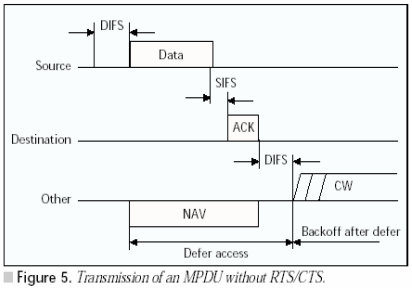



Figure 5. *Transmission of an MPDU without RTS/CTS.*



## IEEE 802.11 MAC layer (DCF) 5/6

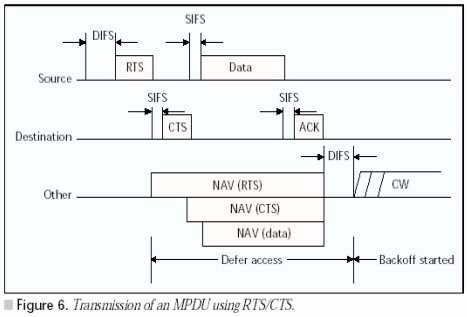



Figure 6. *Transmission of an MPDU using RTS/CTS.*



## IEEE 802.11 MAC layer (DCF) 6/6

- Large MSDUs from LLC to MAC may require fragmentation
- Once a station has contended for the channel, it will maintain control of the channel until all fragments are sent

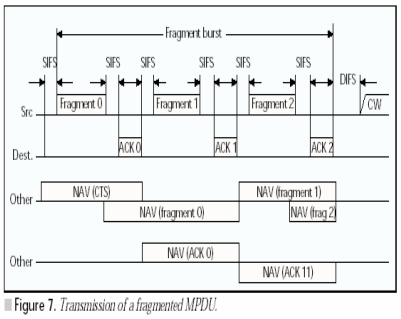



Figure 7. *Transmission of a fragmented MPDU.*

# IEEE 802.11 MAC layer (PCF)

Point Coordination Function (optional)

•Polling by the point coordinator (the AP in BSS) (some of the stations will be configured for polling)

•Point coordinator uses PIFS (point coordination function IFS) when issuing polls

•SIFS < PIFS < DIFS ( a priority scheme)

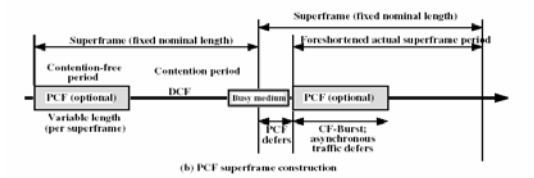



**Figure 14.7** IEEE 802.11 MAC Timing



# IEEE 802.11 MAC Frame 1/5

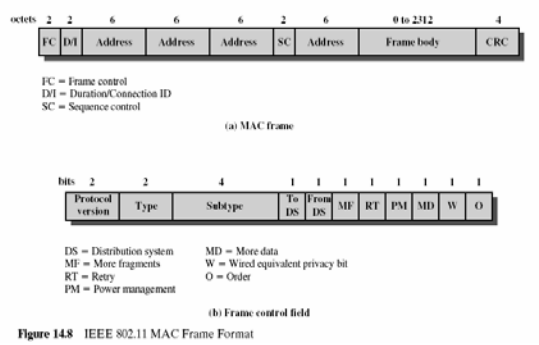



**Figure 14.8** IEEE 802.11 MAC Frame Format



# IEEE 802.11 MAC Frame 2/5

MAC Frame

- *Frame Control*: type of frame and provides control information
- *Duration/Connection ID*: time (in microseconds) the channel will be allocated for a transmission of a MAC frame
- *Addresses*: source/destination/transmitting station/receiving station
- *Sequence Control*: 4-bit fragment number subfield and a 12-bit sequence number used to number frames
- *Frame body*: a MSDU or a fragment of an MSDU
- *Frame check sequence*: 32-bit CRC



# IEEE 802.11 MAC Frame 3/5

MAC Frame – Frame Control Field

- *Protocol Version*: type of frame and provides control information
- *Type*: identifies the frame as control, management, or data
- *To DS*: set to 1 in a frame destined to distribution system
- *From DS*: set to 1 in a frame leaving the distribution system
- *More fragments*: 1 if more fragments follow this one
- *Retry*: 1 if a retransmission of a previous frame
- WEP: 1 if optional wired equivalent privacy is implemented. Used in exchange of encryption keys
- *Order*: 1 if any frame is sent using the strictly ordered service (frames must be processed in order)



# IEEE 802.11 MAC FRAME 4/5

MAC Frames

- *Management*: used for initial communication between stations and access points
- *Control*: channel access and acknowledgment
- *Data*: data and control information
- See [STA02] pp 468-471 for more information

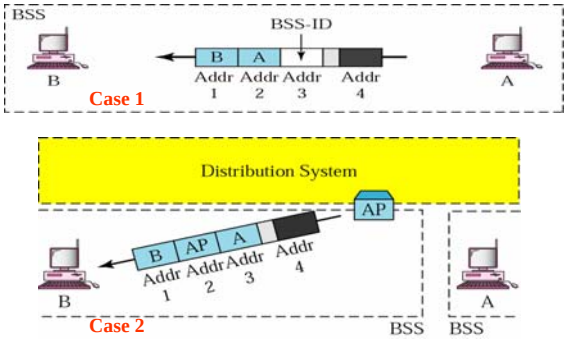


# IEEE 802.11 MAC Frame 5/5

Addressing Mechanism

| *To DS* | *From DS* | *Addr1* | *Addr2* | *Addr3* | *Addr4* | *Explanation* |
|---|---|---|---|---|---|---|
| 0 | 0 | Destination station | Source station | BSS ID | N/A | From one station in a BSS to another without passing through DS |
| 0 | 1 | Destination station | Sending AP | Source station | N/A | From an AP to a station. Address 3 is original sender of frame in another BSS |
| 1 | 0 | Receiving AP | Source station | Destination station | N/A | From a station to an AP. Address 3 is the final destination of frame in another BSS |
| 1 | 1 | Receiving AP | Sending AP | Destination station | Source station | From AP to another in a wireless DS |

## IEEE 802.11 Addressing Mechanism 1/2






## IEEE 802.11 Addressing Mechanism 2/2