IEEE 802 and IEEE 802.11 © Dr. Ayman Abdel-Hamid, CS6504
Spring 2007

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 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

- **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 5/7

- **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
IEEE 802 Architecture

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

IEEE 802.11 Architecture

- 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 4/6

• 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 other)
  ➢ Disassociation (terminate an existing association by AP or station)

IEEE 802.11 Architecture 5/6

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

Centralized MAC algorithm to provide contention-free services

Uses a contention algorithm to provide access to all traffic

IEEE 802.11 MAC layer (DCF) 1/6

start

Set backoff to zero

Persistence strategy

Wait DIFS

Wait backoff time

No

Increment backoff

Abort

No

CTS received before timeout?

Yes

Wait SIFS

Wait SIFS

Send the frame

No

ACK received before timeout?

Yes

Send the frame

Set a timer

DIFS: Distributed interframe 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?

Source

Destination

Other stations

DIFS

RTS

SIFS

CTS

SIFS

Data

SIFS

ACK

SIFS

NAV

(no carrier sensing)

NAV: Network Allocation Vector (A timer to implement collision avoidance)
IEEE 802.11 MAC layer (DCF) 3/6

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
  
  • Backoff incremented when no CTS, or no ACK received

IEEE 802.11 MAC layer (DCF) 4/6

IEEE 802.11 MAC layer (DCF) 5/6

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
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)

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**

<table>
<thead>
<tr>
<th>No.</th>
<th>From DS</th>
<th>Addr3</th>
<th>Addr2</th>
<th>Addr1</th>
<th>Addr0</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>Addr</td>
<td>Addr</td>
<td>Addr</td>
<td>Addr</td>
<td>From one station in a BSS to another without passing through DS</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>Addr</td>
<td>Addr</td>
<td>Addr</td>
<td>Addr</td>
<td>From an AP to a station. Address 3 is original sender of frame in another BSS</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>Addr</td>
<td>Addr</td>
<td>Addr</td>
<td>Addr</td>
<td>From a station to an AP. Address 3 is the final destination of frame in another BSS</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>Addr</td>
<td>Addr</td>
<td>Addr</td>
<td>Addr</td>
<td>From AP to another in a wireless DS</td>
</tr>
</tbody>
</table>

IEEE 802.11 Addressing Mechanism 1/2

**Case 1**

- BSS-ID
- B SS
- A

IEEE 802.11 Addressing Mechanism 2/2

**Case 2**

- Distribution System
- B SS
- A

**Case 3**

- Wireless Distribution System
- B SS
- A

**Case 4**

- Distribution System
- B SS
- A