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Wireless LAN (Wi-Fi)

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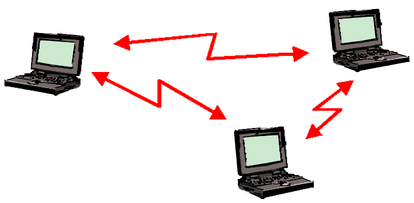
Wireless LAN Standards

- 802.11 (July 1997)
  - **IEEE specification for 1, 2 Mb/s running in 2.4GHz ISM band (Industrial Scientific and Medical)**
  - **common MAC layer (CSMA/CA)**
  - **different PH layers (FHSS, DSSS)**
- 802.11b (Sept. 1999)
  - **IEEE specification for 11 Mbit/s running at 2.4 GHz (CCK 2.4GHz)**
  - **actually you only get 5.5-8 Mb/s**
  - **Widely adopted**
- 802.11a
  - **IEEE specification for 54 Mbit/s running at 5 GHz (OFDM)**
  - **Not (yet) widely adopted**
- 802.11g
  - **Emerging IEEE specification for up to 54 Mbit/s running in 2.4 GHz**

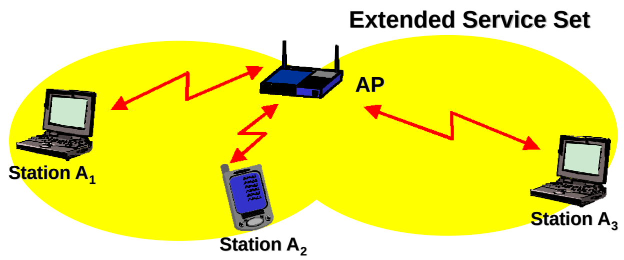
Had-hoc mode

- Ad-hoc network is formed by the group of stations that are all under the same covered area (a cell), that is defined as Independent Basic Service Set (IBSS)
  In a Ad-hoc network, stations communicate directly with other stations within the same IBSS
  - **If a client in an ad-hoc network wishes to communicate outside of the cell, a member of the cell MUST operate as a gateway (router) and perform routing**

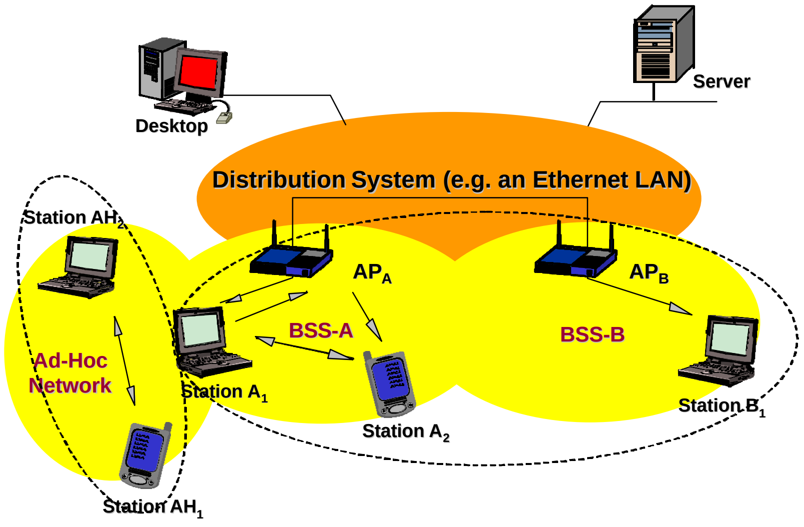


Infrastructure mode

- Infrastructure mode
  - **each client sends all of it's communications to a central station AP (Access Point)**
  - **the access point acts as an Ethernet Bridge/Switch**
    - forwards the communications (the layer-2 PDU) onto the appropriate network, either wired or wireless



Ad-hoc and Infrastructure modes



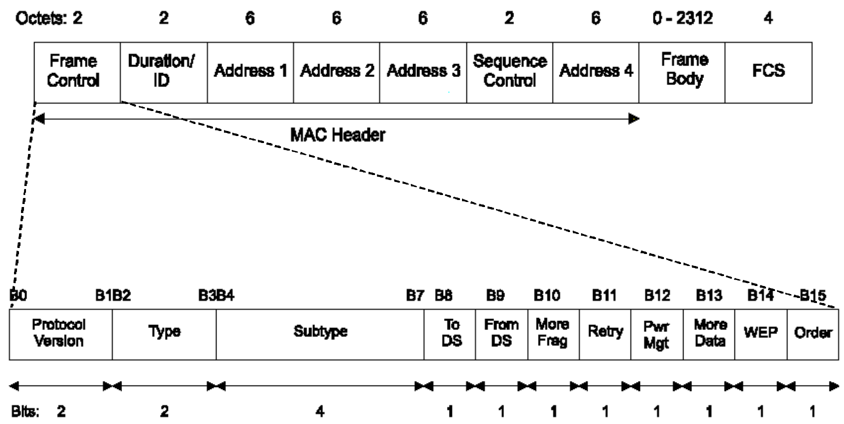
802.11 MAC Layer

- Medium Access Control (MAC) sublayer is responsible for
  - **channel allocation procedures,**
  - **MAC-PDU addressing,**
  - **frame formatting,**
  - **error checking**
  - **fragmentation and reassembly**
- 802.11 MAC can operate in two different modes:
  - **Distributed Coordination Function (DCF)**
    - applied in both ad-hoc (IBSS) and infrastructure mode (with AP)
  - **Point Coordination Function (PCF)**
    - the medium access is controlled by the AP (applied only with AP)
- 802.11 MAC is based upon CSMA/CA (Carrier Sense Medium Access with Collision Avoidance)
- Three types of frames
  - **management, control, data**

802.11 MAC Layer

- Management frames are used for
  - **association/disassociation with a AP**
  - **timing and synchronization**
  - **authentication**
- Control frames are used for
  - **request to send, clear to send (i.e. confirm to receive)**
  - **positive acknowledgment**
  - **polling stations, in a PCF**
  - **control the contention mode, in a PCF (e.g. to terminate a contention-free period)**
- Data frames are used for
  - **transmission of data during in both PCF and DCF,**
  - **and can be combined with polling and acknowledgment**

MAC-PDU format



Distributed Coordination Function (DCF)

- Fundamental access method used to support asynchronous data transfer (must be always supported)
- Is the only access method for Ad-hoc mode
- DCF is a contention access method based on Carrier Sense Multiple Access with collision Avoidance (CSMA/CA)
  - **collision detection (CSMA/CD) is not used due to the inability for a station to listen to the channel while transmitting**
  - **carrier sense is performed both at PH layer (*PH carrier sensing*) and at MAC layer (*virtual carrier sensing*)**
- Virtual carrier sensing is performed by sending MAC-PDU duration information in the header of request to send (RTS), clear to send (CTS), and data frames (see later)

Distributed Coordination Function (DCF)

- The MAC-PDU *duration* field indicates the amount of time (μs) that the channel will be utilized after the transmission of the current frame
- Stations use the information read in the *duration* field to adjust their "network allocation vector" (NAV) which indicates the amount of time that the channel must considered busy
  - **i.e. the time that must elapse before sampling again the medium for idle status**
- Priority access to the medium is controlled through the use of interframe space (IFS), i.e. the time interval between transmitted frames
- Three IFS are specified in growing order:
  - **short IDS (SIFS)**
  - **point coordination function IFS (PIFS)**
  - **distributed coordination function IFS (DIFS)**

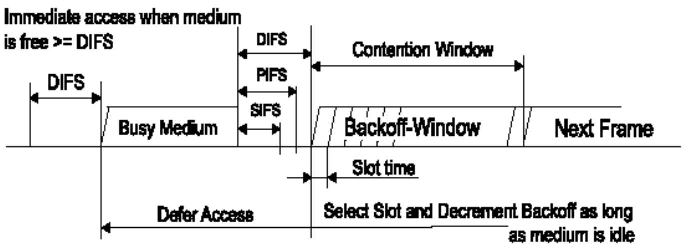
Distributed Coordination Function (DCF)

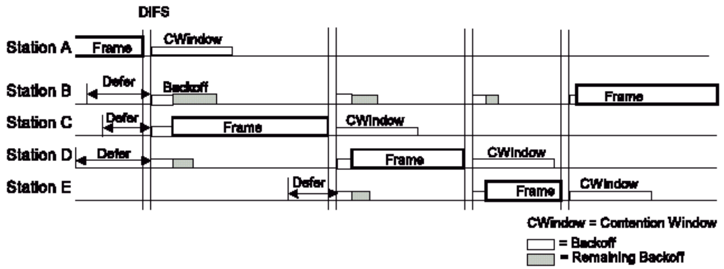
- Stations only required to wait a SIFS have priority access over those stations required to wait PIFS or DIFS
- For the basic access method, when a station sense (virtually and/or physically) the channel is idle, waits for a DIFS period before sampling the medium again
- if the channel is still idle the station can transmits a MAC-PDU
- The receiver station calculates the checksum and, if correct, waits a SIFS interval and transmit an ACK frame to the originator
- Each station calculate its NAV by reading the *duration* field in the MAC frames
  - **the *duration* field in Data frames includes the SIFS and the ACK duration**

Distributed Coordination Function (DCF)

- Since collisions can still occur, before sending a Data frame a station sends a Request To Send (RTS) control frame that should be confirmed by the receiver by a Clear To Send (CTS) control frame
- RTS and CTS are very short frames (20 and 14 respectively)
- If a collision occur (when sending a RTS) no CTS can be sent, and the originator station "detect" the collision and start the backoff
- Collisions can occur only on RTS frames
  - **each station receiving a RTS read the *duration* field, set its NAV, avoiding any successive collision (the medium becomes reserved)**
- Retransmission attempts use an exponential-backoff time
- The MAC algorithm is fair, however no bound exist for the maximum transmission delay

Distributed Coordination Function (DCF)





Point Coordination Function (PCF)

- PCF is an optional capability providing contention-free frame transfer (currently, rarely implemented)
- PCF relies on the point coordinator (the AP in each BSS), that polls the stations for enabling them to transmit (without contending for medium access)
- PCF must coexist with the DCF
- A station is not required to support PCF
- The time axes is slotted in contention-free intervals (CFPs) alternate with contention-based intervals (CPs)
- During a contention-free period, no RTS/CTS frames are used; it is the AP that polls the station for possible transmission

Point Coordination Function (PCF)

- At the nominal start of CFP the AP sense the medium and, if idle, wait a PIFS and then initiates the CFP with a “beacon” frame
- Successively, the following frames can be used:
  - **CF-Poll (no data): used by the AP to poll a station**
  - **Data: used to transmit a data frame**
  - **Data+CF-Poll: used by the AP to transmit a frame and poll a station**
  - **CF-ACK: used by a station to confirm to the AP the reception of a data frame (after a SIFS)**
  - **Data+CF-ACK: used by a station to send data after a CF-Poll**
  - **Data+CF-ACK+CF-Pool: used by the AP to confirm a received data (CF-ACK), plus a Data+CF-Poll**
  - **Null (no data): used by station as response to CF-Poll when no data has to be transmitted**
  - **CF-End: used by the AP to end the CFP**

Point Coordination Function (PCF)