IEEE 802.11 MAC

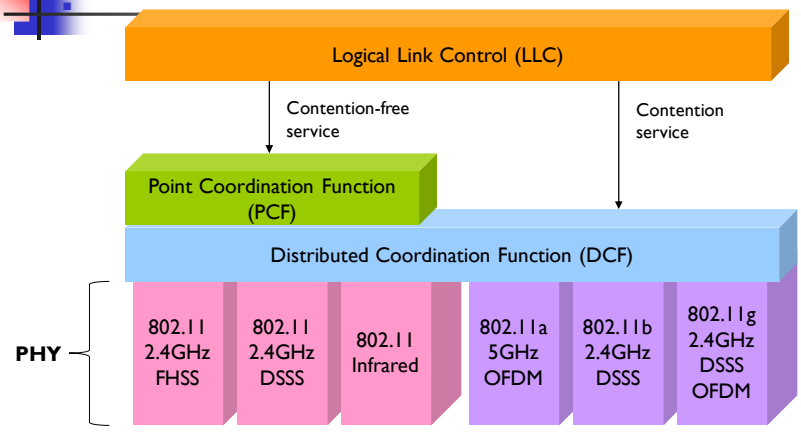
Instructor: Dr. Sunho Lim (Ph.D., Assistant Professor)

Lecture 06

sunho.lim@ttu.edu

Adapted partially from Mobile Communications, Jochen Schiller, Energy-Efficient Medium Access Control, K. Langendoen and G. Halkes, and AVAYA communication

IEEE 802.11 MAC Protocol Architecture



Frequency Hopping Signal Spectrum (FHSS): a method of transmitting radio signal
Direct Sequence Spread Spectrum (DSSS): a modulation technique
Orthogonal Frequency-Division Multiplexing: encoding digital signal on multiple carrier frequencies

IEEE 802.11 MAC

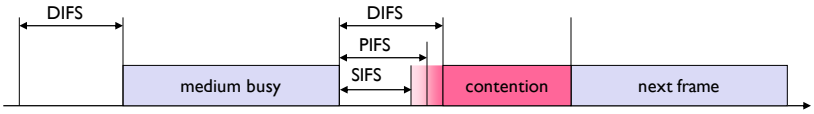
- Contention-based protocol:
  - Node can start a transmission at any random moment
  - Must contend for the channel
  - CSMA/CA
- Traffic services
  - Asynchronous Data Service (mandatory):
    - exchange of data packets based on "best-effort"
    - support of broadcast and multicast
  - Time-Bounded Service (optional):
    - implemented using PCF (Point Coordination Function)

IEEE 802.11 MAC (cont.)

- Access methods:
  - DCF CSMA/CA (mandatory)
    - collision avoidance via randomized back-off mechanism
    - minimum distance between consecutive packets
    - ACK packet for acknowledgements (not for broadcasts)
      - Unicast only
  - DCF w/ RTS/CTS (optional)
    - Also called Distributed Foundation Wireless MAC
    - avoids hidden terminal problem
  - PCF (optional)
    - access point polls terminals according to a list

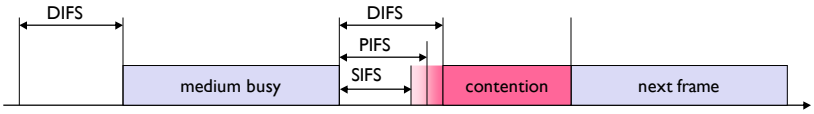
IEEE 802.11 MAC (cont.)

- Controlling the waiting time before medium access,
  - Value of parameters depend on the PHY
  - Slot time,
    - e.g. 50 micro second for FHSS, and 20 micro second for DSSS
  - Short inter-frame spacing (SIFS):
    - DSSS SIFS, 10 micro second
    - FHSS SIFS, 28 micro second
  - PCF inter-frame spacing (PIFS):
    - SIFS + *one* slot time
  - DCF inter-frame spacing (DIFS):
    - SIFS + *two* slot times



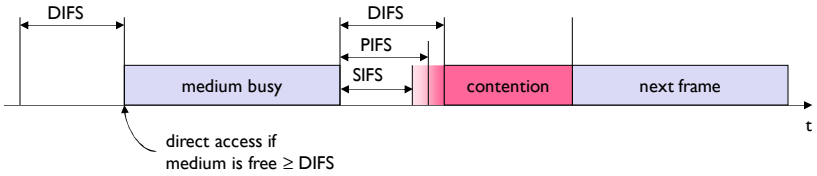
IEEE 802.11 MAC (cont.)

- Priorities:
  - Defined through different Inter Frame Spaces (IFS)
  - NO guaranteed, hard priorities
  - SIFS (Short Inter Frame Spacing)
    - Highest priority, for ACK, CTS, polling response
  - PIFS (PCF, Point Coordination Function IFS)
    - Medium priority, for time-bounded service using PCF
  - DIFS (DCF, Distributed Coordination Function IFS)
    - Lowest priority, for asynchronous data service



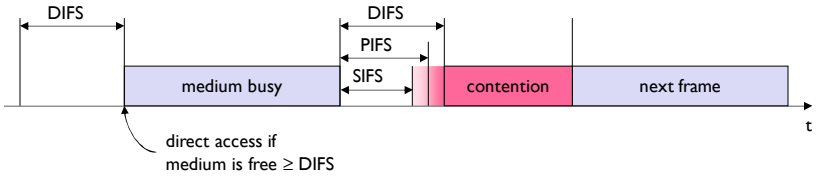
IEEE 802.11 MAC: CSMA/CA

- IEEE 802.11 based on CSMA/CA:
  - Random access scheme with
    - Carrier sense
    - Collision avoidance
  - Random backoff,
    - Clear Channel Access (CCA) signal of the PHY



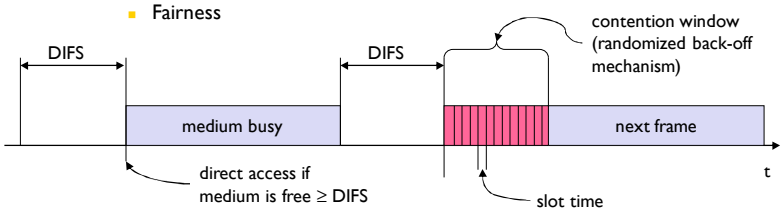
IEEE 802.11 MAC: CSMA/CA (cont.)

- If the medium is idle for at least the duration of DIFS or more,
  - Access the medium at once
  - Work fine under *light* load
- Under heavy load?
  - More nodes try to access the medium
  - Need additional mechanism



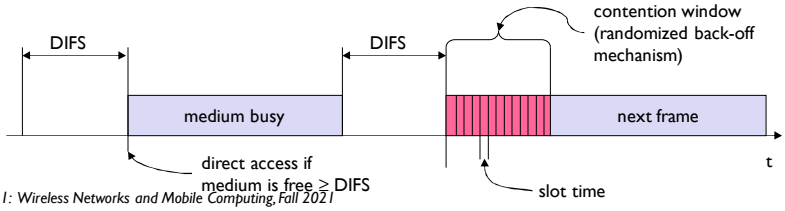
IEEE 802.11 MAC: Contention Window

- Node ready to send starts sensing the medium
  - Carrier Sense based on CCA, Clear Channel Assessment
- If the channel is busy?
  - The node has to wait for a free DIFS
  - Then the node must additionally wait a random back-off time
    - Collision avoidance and multiple of slot-time
  - If another station occupies the channel during the back-off time of the node?
    - The back-off timer **stops**
      - Fairness

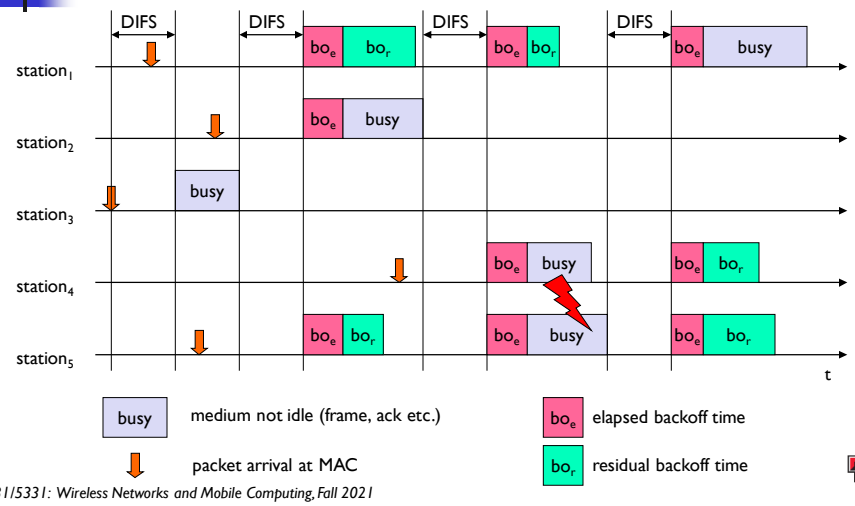


IEEE 802.11 MAC: Contention Window (cont.)

- If the channel is busy? (cont.)
  - A binary exponential backoff procedure:
    - At each re-transmission attempt, the length of the Collision Window (CW) is doubled
    - Contending nodes randomly select a time from their CW
  - To bound access latency,
    - CW is not doubled once a certain maximum (*CW_max*) has been reached
- If the sender does not receive the ACK?
  - Assume, the data was lost due to a collision at the receiver



IEEE 802.11 MAC: Contention Window (cont.)

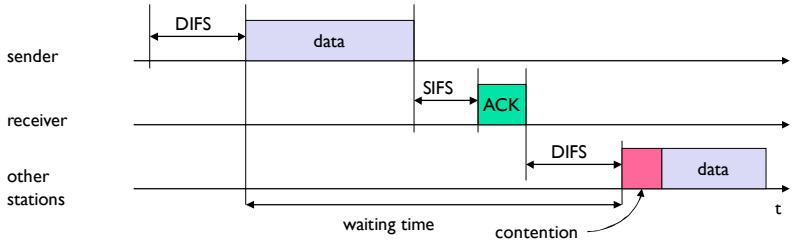


IEEE 802.11 MAC: Broadcast

- Broadcast Vs. Unicast:
  - ACK
- Sending Unicast packet:
  - A node wanting to transmit a packet,
    - Must first test the radio channel to check if it is free during a specified time
    - Distributed Inter Frame Space (DIFS)
  - If the channel is free,
    - Transmit a DATA packet
  - The receiver waits a Short Inter Frame Space (SIFS)
    - Check the received packet (e.g., CRC)
    - Acknowledging the reception of the data by sending an ACK packet
  - Automatic retransmission of data packets in case of transmission errors, e.g. no ACK is returned

IEEE 802.11 MAC: Broadcast (cont.)

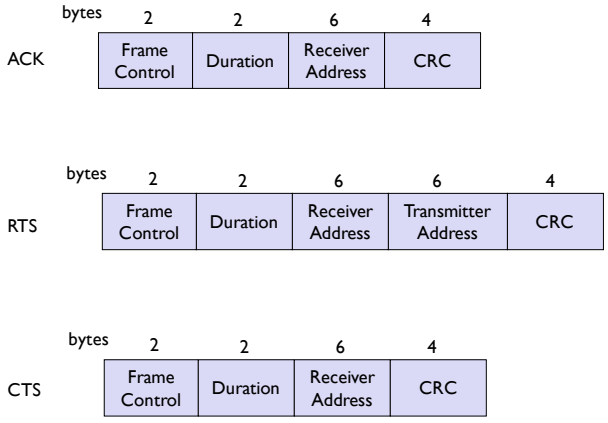
- Sending unicast packet: (cont.)



IEEE 802.11 MAC: RTS/CTS

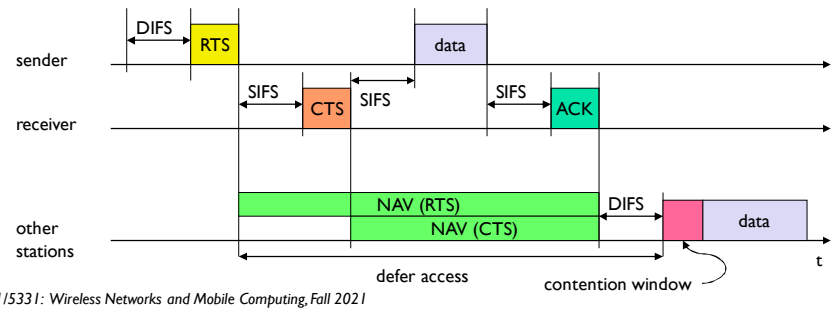
- Hidden terminal problem
- Sending unicast packet
- Virtual carrier sense mechanism:
  - Ad hoc mode
  - The RTS/CTS control packets include a time field in their header
    - Specify the duration of the upcoming DATA/ACK sequence
  - Neighbor nodes overhearing the control packets to set their Network Allocation Vector (NAV)
    - Defer transmission until it expires
    - Or, switch off the radio during of the NAV for energy saving

Special Frames: ACK, RTS, CTS



IEEE 802.11 MAC: RTS/CTS (cont.)

- Virtual carrier sense mechanism:
  - Node can send RTS with reservation parameter after waiting for DIFS
  - Acknowledgement via CTS after SIFS by receiver (if ready to receive)
  - Sender can now send data at once, acknowledgement via ACK
  - Other stations store medium reservations distributed via RTS **and** CTS



IEEE 802.11 MAC: RTS/CTS (cont.)

- Possible collision:
  - Two or more nodes may start sending the RTS at the same time
  - Overhead
    - Waste bandwidth and higher delay