IEEE 802.11 Medium Access Control

EECS3214

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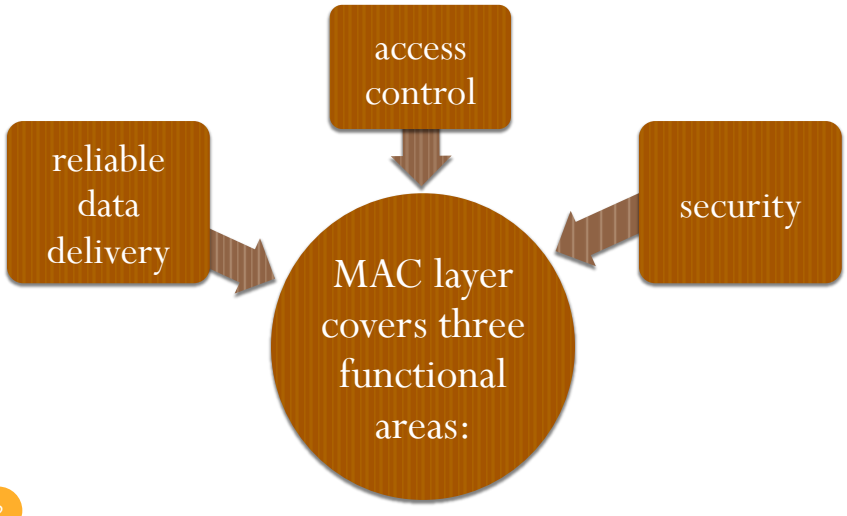
Medium Access Control



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MAC Requirements

- To avoid interference among simultaneous transmissions
  - But enable as many non-interfering transmission as possible
  - Maintain fairness among transmissions
- No centralized coordinators: fully distributed operations
- No clock synchronization: asynchronous operations

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CSMA/CA

- No collision detection since on wireless network, so use collision avoidance (backoff and RTS/CTS)
- Includes delays that act as a priority scheme
  - DIFS: DCF inter-frame space
  - SIFS: short inter-frame space (SIFS < DIFS)

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CSMA/CA Algorithm

- If station has frame to send, it listens to medium

1. if medium idle for DIFS, station may transmit
2. else waits until current transmission completes then
   a. if medium idle for DIFS
      - start (or resume) random backoff time
      - timer counts down while channel is idle (see *Note*)
      - transmit when timer expires
   b. else go back to 2

- *Note*: if channel becomes busy during the count down period, go back to 2.

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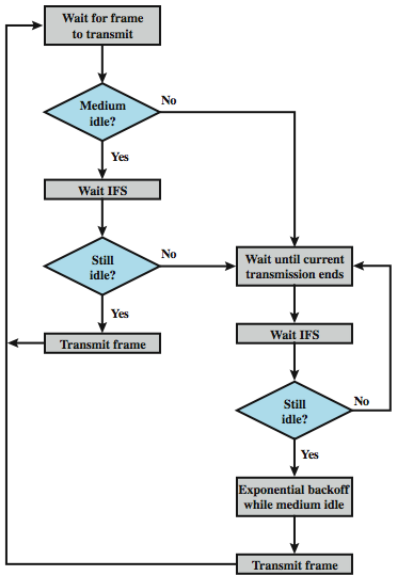
IEEE 802.11 Medium Access Control Logic



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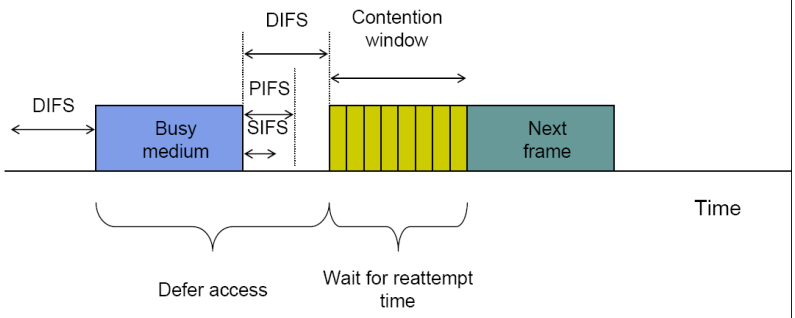

Basic CSMA/CA operations

Fig. 6.69 (Leon-Garcia)

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Carrier Sense in 802.11

- Physical carrier sense
- Virtual carrier sense using Network Allocation Vector (NAV)
  - Header of data frame specifies duration of data transmission
  - "Neighboring" nodes stay silent during this period, then "wake up" to continue sensing the medium.

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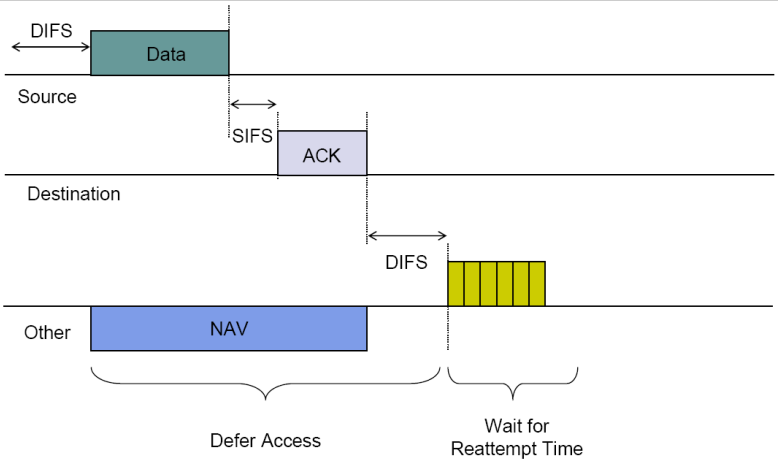

Transmission without RTS/CTS

Fig. 6.71 (Leon-Garcia)

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Backoff Interval

- When channel is busy, choose a backoff interval in the range [0, *cw*].
- Count down the backoff interval when medium is idle for DIFS.
- Count down is suspended if medium becomes busy again.
- When backoff interval reaches 0, transmit data.

- **Binary exponential backoff**
  - When a node fails to receive ACK, *cw* is doubled up (up to an upper bound).
  - When a data transfer completes successfully, *cw* is reset to cw_{min}.

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Carrier Sensing

- Transmission range
- Sensing range
- Sensing range > Transmission range
- Problems
  - Hidden terminal problem
  - Exposed terminal problem
- Note: contention matters only at the receiver's terminal

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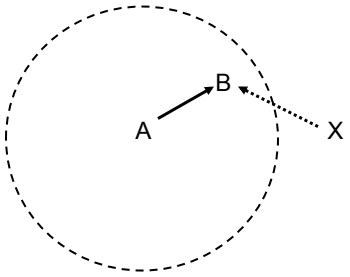
Hidden Terminal Problem



No carrier ≠ OK to transmit

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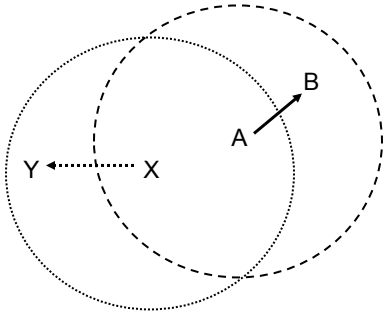
Exposed Terminal Problem



Presence of carrier ≠ holds off transmission

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Solutions to Hidden Terminal Problem

- MACA [Karn 1990]
  - Proposes to solve the hidden terminal problem by RTS/CTS dialog
- MACAW [Bharghanvan 1994]
  - Increasing reliability by RTS/CTS/DATA/ACK dialog
- IEEE 802.11
  - CSMA/CA
  - Also use RTS/CTS/DATA/ACK dialog

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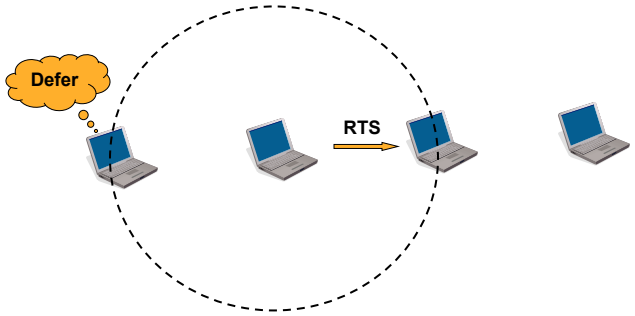
RTS/CTS dialog (1)



Any node hearing this RTS will defer medium access

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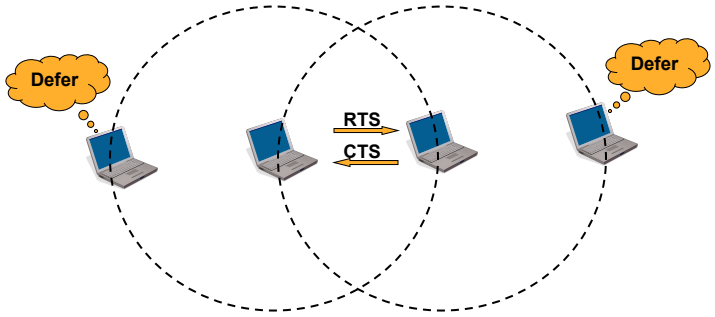
RTS/CTS dialog (2)



Any node hearing this CTS will defer medium access

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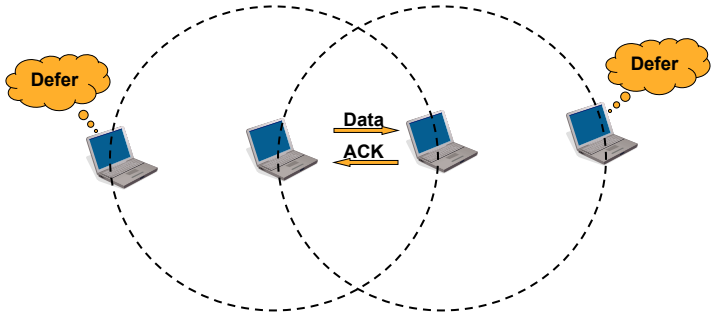
RTS/CTS/DATA/ACK dialog



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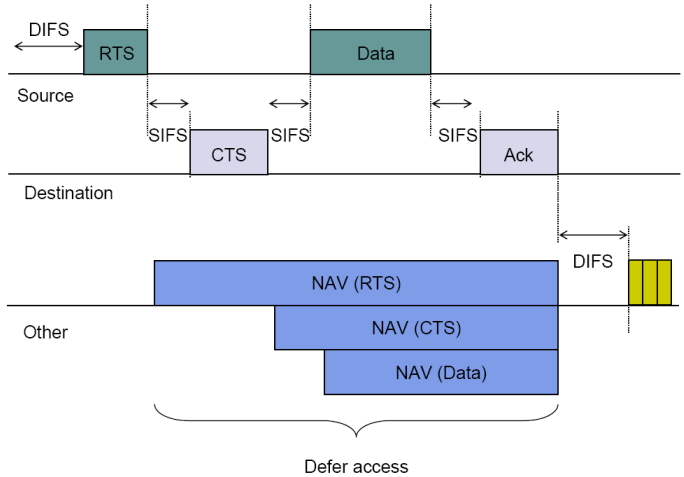

Transmission with RTS/CTS

Fig. 6.72 (Leon-Garcia)

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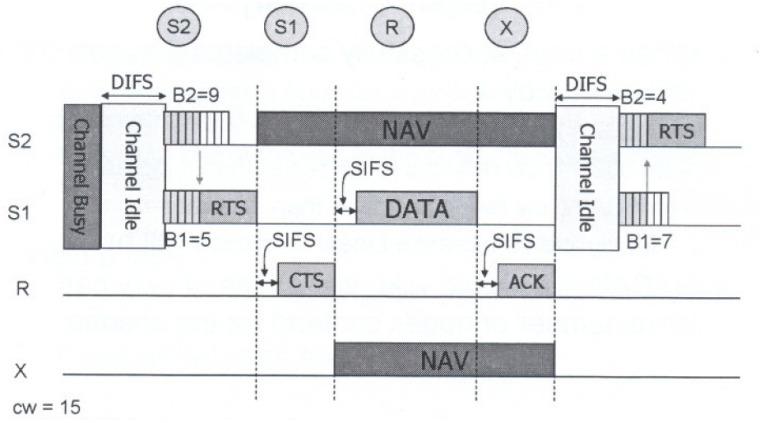
IEEE 802.11 CSMA/CA – Example



DIFS: DCF inter-frame space SISF: short inter-frame space

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IEEE 802.11 MAC (1)

- CSMA/CA
  - Contention-based random access
  - Collision detection not possible while transmitting
- Uses RTS/CTS exchange to avoid hidden terminal problem
  - Any node overhearing a CTS cannot transmit for the duration of the transfer.
  - Any node overhearing an RTS cannot transmit for the duration of the transfer (to avoid collision with ACK)
- Uses ACK to achieve reliability

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IEEE 802.11 MAC (2)

- Carrier sense in 802.11
  - Physical carrier sense
  - Virtual carrier sense using Network Allocation Vector (NAV)
    - RTS/CTS specify duration of subsequent DATA/ACK
    - NAV is updated based on overheard RTS/CTS /DATA
- Collision avoidance
  - Nodes stay silent when carrier sensed busy (physical/virtual)
  - Backoff intervals are used to reduce collision probability

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Backoff Interval

- When channel is busy, choose a backoff interval in the range [0, *cw*].
- Count down the backoff interval when medium is idle for DIFS.
- Count down is suspended if medium becomes busy again.
- When backoff interval reaches 0, transmit **RTS**.

- **Binary exponential backoff** in 802.11 DCF:
  - When a node fails to receive **CTS**, *cw* is doubled up (up to an upper bound).
  - When a data transfer completes successfully, *cw* is reset to cw_{min}.

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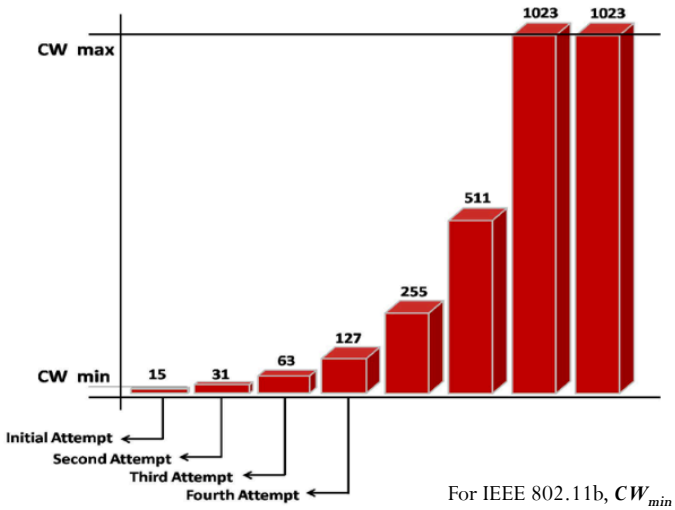
CW_{min} and CW_{max}



For IEEE 802.11b, $CW_{min} = 31$

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Disadvantages of IEEE 802.11 DCF

- High power consumption
- Hidden terminal problem not totally solved (e.g., collision of RTS)
- Exposed terminal problem not solved
- Fairness problem among different transmitting nodes
- Only providing best-effort service

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Priority IFS Values

- SIFS (short IFS)
  - for all immediate response actions (see later)
- DIFS (DCF IFS)
  - used as minimum delay for asynchronous frames contending for access

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SIFS Use

- SIFS gives highest priority
  - over stations waiting PIFS or DIFS time
- SIFS used in following circumstances:
  - Acknowledgment (ACK)
    - station responds with ACK after waiting SIFS gap
    - for efficient collision recovery (there is no collision detection) and multi-frame transmission
  - Clear to Send (CTS)
    - station ensures data frame gets through by issuing RTS
    - and waits for CTS response from destination

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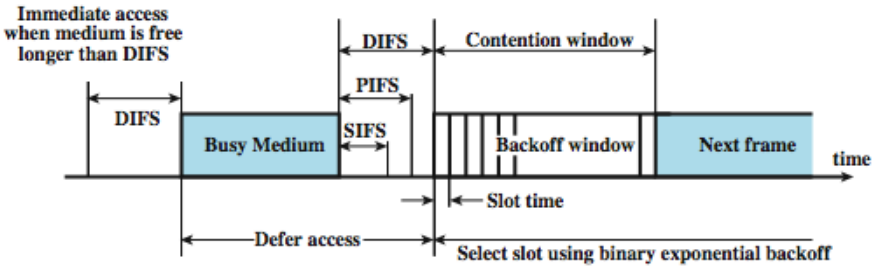
IEEE 802.11 MAC Timing
Basic Access Method



(a) Basic Access Method

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IFS and Slot Time Values

PHY	SIFS*	Slot Time*	PIFS	DIFS
HR/DSSS (802.11b)	10 µs	20 µs	30 µs	50 µs
ERP (802.11g)	10 µs	Long = 20 µs Short = 9 µs	Long = 30 µs Short = 19 µs	Long = 50 µs Short = 28 µs
OFDM (802.11a)	16 µs	9 µs	25 µs	34 µs
HT (802.11n)	10 µs – 2.4 GHz 16 µs – 5 GHz	Long = 20 µs – 2.4 GHz Short = 9 µs – 2.4 GHz 9 µs – 5 GHz	Long = 20 µs – 2.4 GHz Short = 9 µs – 2.4 GHz 25 µs – 5 GHz	Long =50 µs – 2.4 GHz Short = 28 µs – 2.4 GHz 34 µs – 5 GHz

* Both the SIFS and Slot Time values are provided in each PHY amendment/clause.
--Note: 802.11n specifies a RIFS interval = 2 µs

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Reference

- Chapter 17, William Stallings

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