

# More MAC Protocol Analysis

# CSMA/CD

- If a collision is detected, abort after  $\beta$
- Maximum throughput ( $g(n) = \lambda\beta + nq_r$ ):

$$\lambda < \frac{g(n)e^{-g(n)}}{\beta + g(n)e^{-g(n)} + \beta[1 - e^{-g(n)} - g(n)e^{-g(n)}]}$$

# IEEE 802.11 MAC Protocol

- Specifies standards for both physical and MAC layers of wireless networks
- Physical layer can have the following modes:
  - Direct sequence spread spectrum
  - Frequency hopping spread spectrum
  - Infrared pulse modulation
- Channel data rate can either be 1Mbps or 2Mbps

# IEEE 802.11 MAC Protocol

- MAC layer is responsible for a structured channel access scheme
- Carrier Sense Medium Access with Collision Avoidance (CSMA/CA)
- Access control coordinated through:
  - Point Coordination Function (PCF)
  - Distributed Coordination Function (DCF)

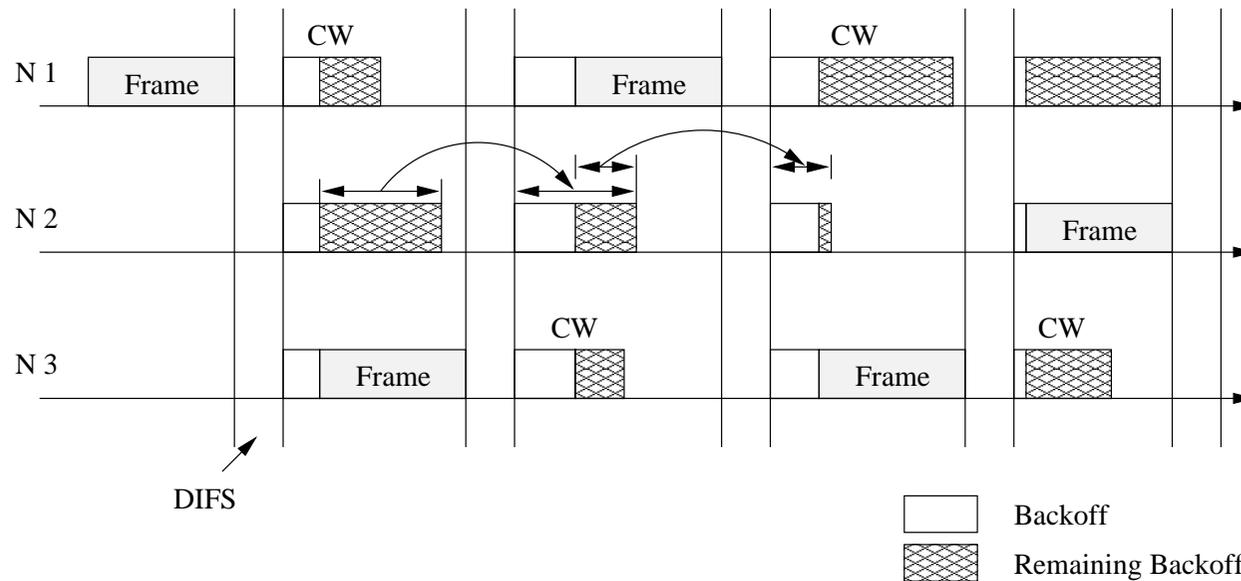
# CSMA/CA Details

- Nodes with a packet to transmit first sense the channel to ascertain whether it is in use
- It proceeds with the transmission if channel is sensed idle for DIFS seconds
- If channel is sensed busy, transmission is deferred till the end of the ongoing transmission
- The node now initializes its *backoff timer* with a randomly selected *backoff interval*

# CSMA/CA Details (Cont.)

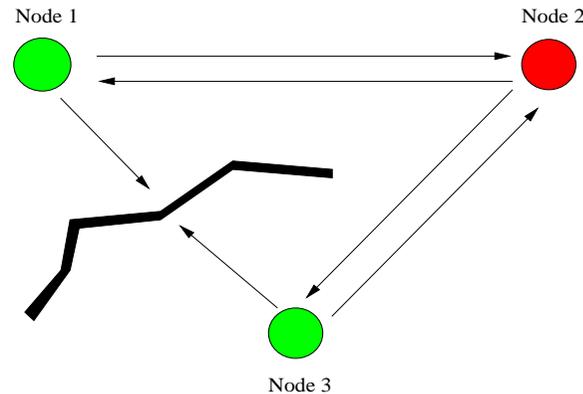
- The timer has the granularity of a *backoff slot* and is decremented everytime the channel is sensed idle
- In case the channel becomes busy while the timer is being decremented, the timer is stopped
- The timer is restarted again when the channel becomes idle for more than a DIFS
- The node is allowed to transmit when the timer reaches 0

# CSMA/CA Details (Cont.)



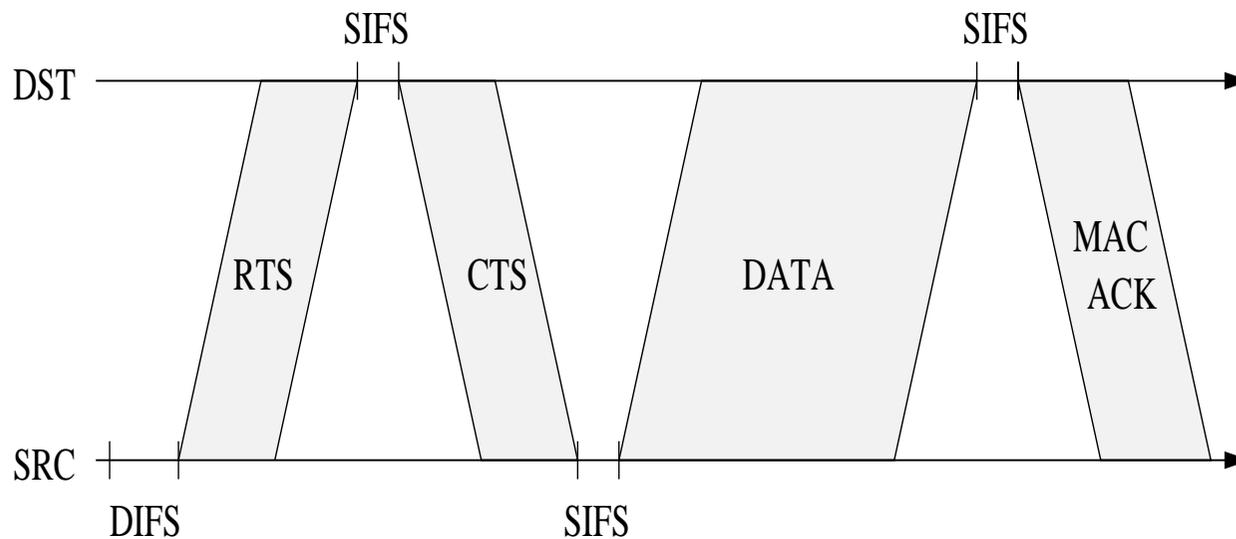
The backoff mechanism of 802.11 MAC. The frame transmission time includes the RTS/CTS exchange and the MAC layer ACK. CW = Contention Window.

# CSMA/CA Details (Cont.)



- Wireless networks have the “hidden node” problem
- Solved in 802.11 using a reservation based scheme
- Transmitter requests channel use with a RTS packet
- Receiver responds with a CTS packet

# CSMA/CA Details (Cont.)



Exchange of packets during a transfer using the CSMA/CA protocol

# Capacity Analysis

- Probability of collision

$$p = 1 - \left( 1 - \frac{2(1-2p)}{1-p-p(2p)^m} \frac{1}{W} \right)^{n-1}$$

$$r_{succ} = \frac{2(1-p)}{2-p} \frac{1}{T_{cycle}}$$

$$r_{xmit} = \frac{2}{2-p} \frac{1}{T_{cycle}}$$

$$r_{coll} = \frac{p}{2-p} \frac{1}{T_{cycle}}$$

$$T_{cycle} = T_{phy} + T_{DIFS} + T_{SIFS} + T_{ACK} + \frac{W}{n-1} T_{slot}$$

# Capacity Analysis (Cont.)

- Utilization and throughput

$$u_{total} = r_{succ}(T_{phy} + T_{ACK}) + r_{coll}T_{payload}$$

$$\begin{aligned} S &= r_{succ}T_{payload} \\ &= \frac{2(1-p)}{2-p} \frac{T_{payload}}{T_{phy} + T_{SIFS} + T_{DIFS} + T_{ACK} + \frac{W}{n+1}T_{slot}} \end{aligned}$$