EC 553
Communication Networks

Mohamed Essam Khedr

Department of Electronics and Communications

IEEE 802.11 WLAN

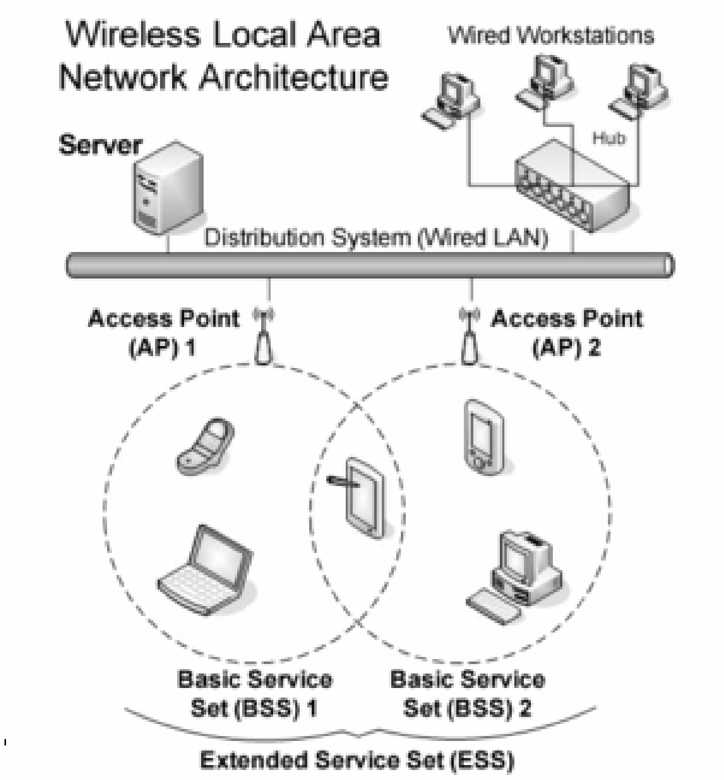
Syllabus

- Tentatively

Week 1	Overview
Week 2	Packet Switching
Week 3	Multiple Access I
Week 4	Multiple Access II
Week 5	Routing
Week 6	IP Networking
Week 7	IP Networking II
Week 8	ARP, ICMP
Week 9	Cellular Networks
Week 10	**Wlan MAC**
Week 11	**Wlan Mac evaluation**
Week 12	TCP, Congestion Control
Week 13	QoS I
Week 14	Qos II
Week 15	Application Layer

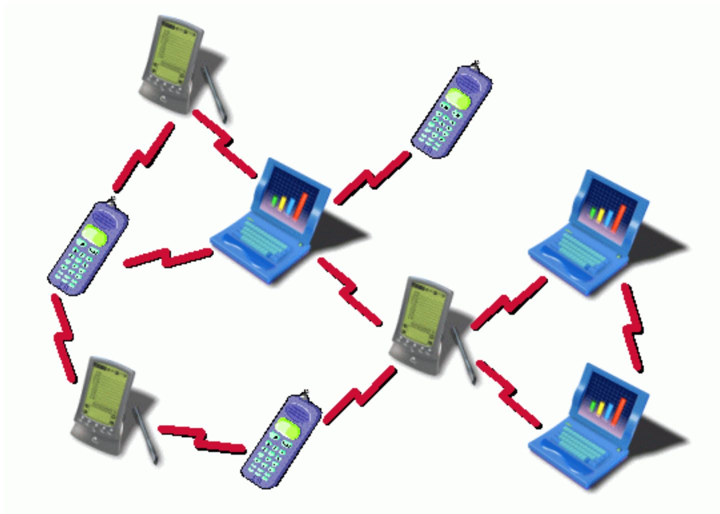
Wireless LANs

- Infrastructure based
  - Access points
  - Mobile hosts
- Connected to Internet
- Industrial standard
  - IEEE 802.11 protocols
    - De facto industrial standard
  - HiperLAN
    - European standard. Obsolete.



Ad Hoc Networks

- Formed by wireless hosts which may be mobile
- Without (necessarily) using a pre-existing infrastructure
- Routes between nodes may potentially contain multiple hops
- No standards yet, many possible solutions



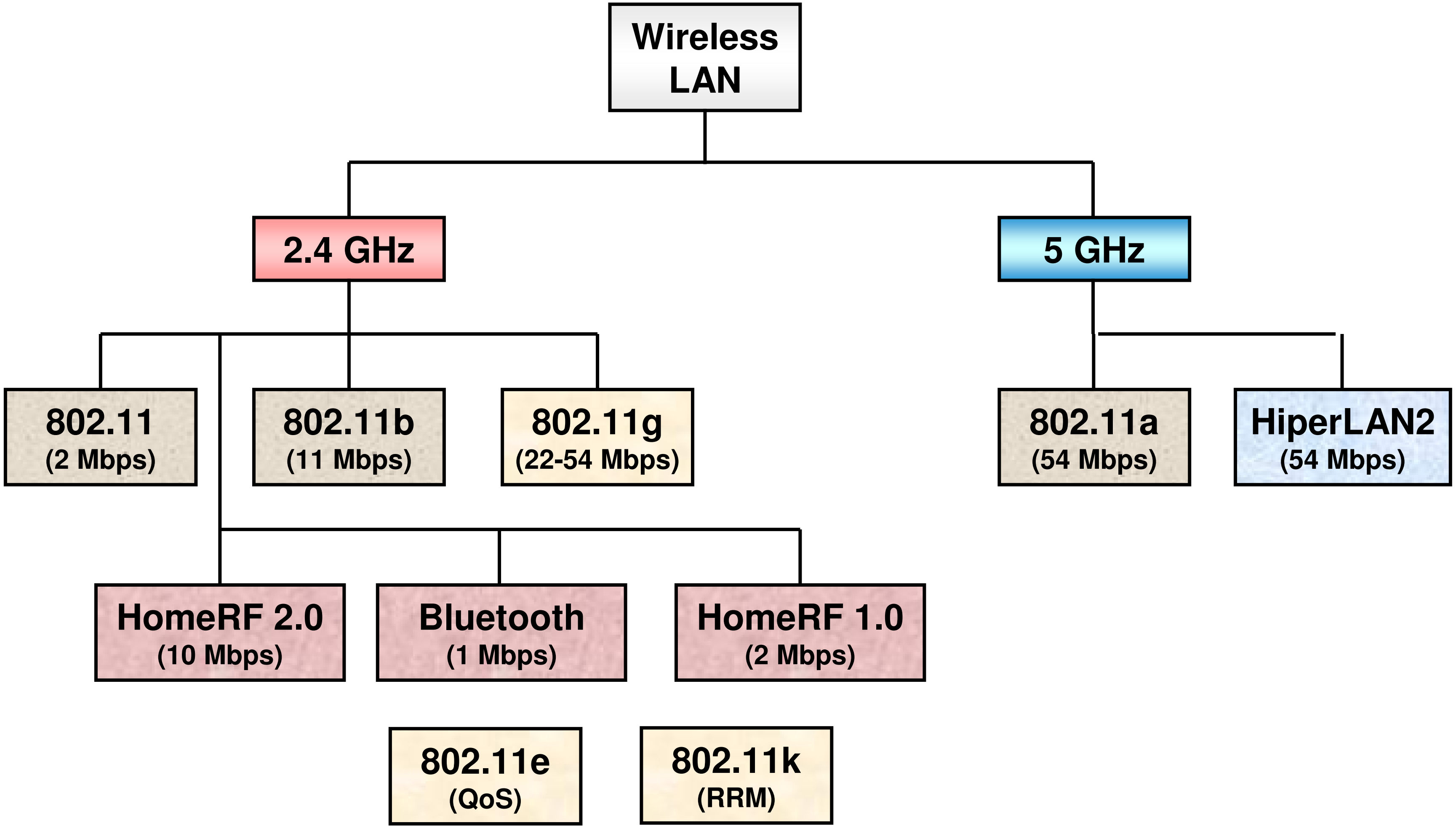
Ad hoc networks

- Collection of wireless mobile nodes dynamically forming a temporary network without the use of any existing network infrastructure or centralized administration.
- Hop-by-hop routing due to limited range of each node
- Nodes may enter and leave the network
- Very mobile – whole network may travel
- No pre-existing infrastructure. Do-it-yourself infrastructure
- Coverage may be very uneven
- Usage scenarios:
  - Military
  - Disaster relief
  - Temporary groups of participants (conferences)

Issues in ad hoc networks

- Routing performance
  - Routes change over time due to node mobility
  - Would like to avoid long delays when sending packets
  - But would like to avoid lots of route maintenance overhead
  - Want as many participating nodes as possible for greater aggregate throughput, shorter paths, and smaller chance of partition
- Medium Access Control
  - Admission control
  - Collision avoidance
  - Mobility
  - QoS

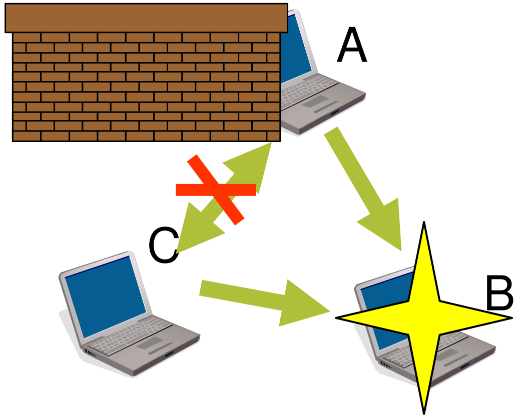
WLAN: Standards



Cotention-based Protocols

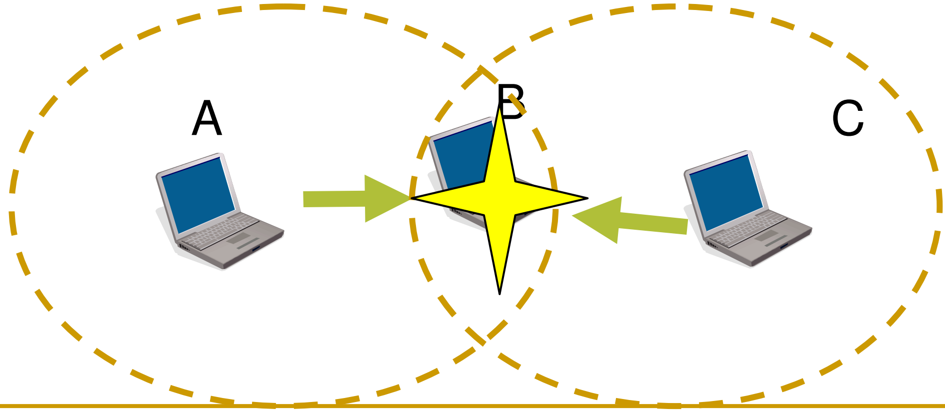
- Random assignment approaches
  - Dynamic number of transceivers contend for medium
  - Distributed (peer-to-peer) algorithms for contention
  - Great for dynamic / unplanned or distributed networks
  - Problem: Hidden and Exposed Terminal Problems

Hidden Terminal Problem

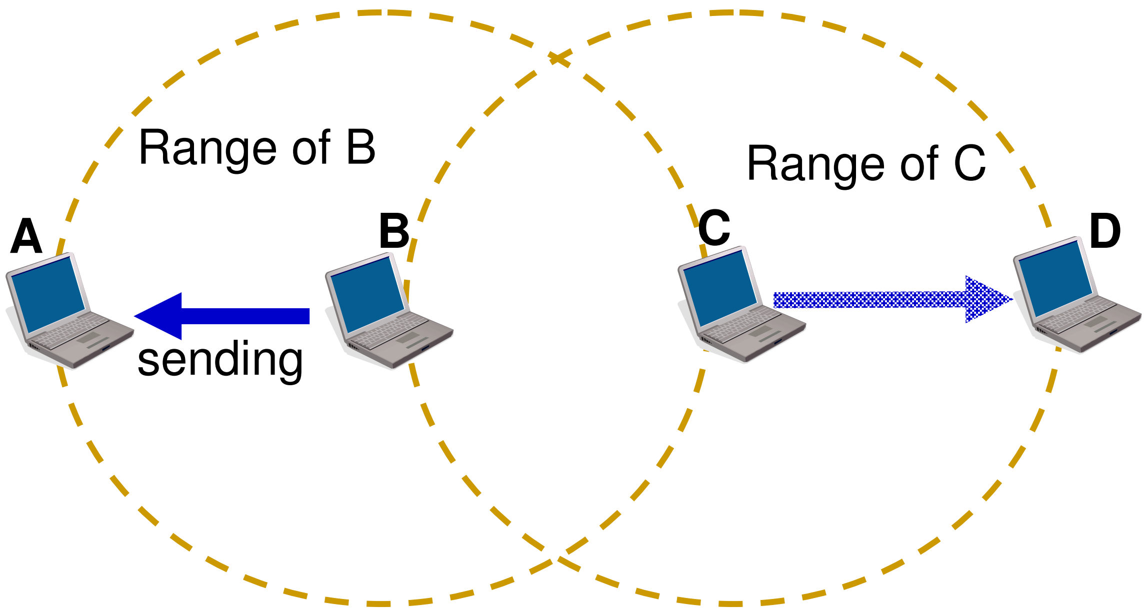


Senders A and C separated by obstacle. Each thinks the medium is free.

Senders A and C out of range of each other. Each thinks medium is free.

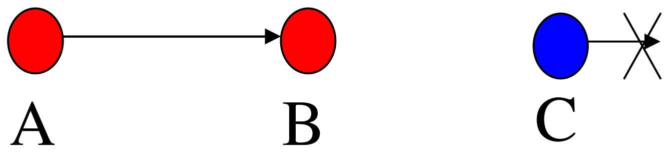


Exposed Terminal Problem



Contention-based Protocols -Examples

- CSMA — Carrier Sense Multiple Access
  - Ethernet
  - Not enough for wireless (collision at receiver)



Hidden terminal: A is hidden from C's CS

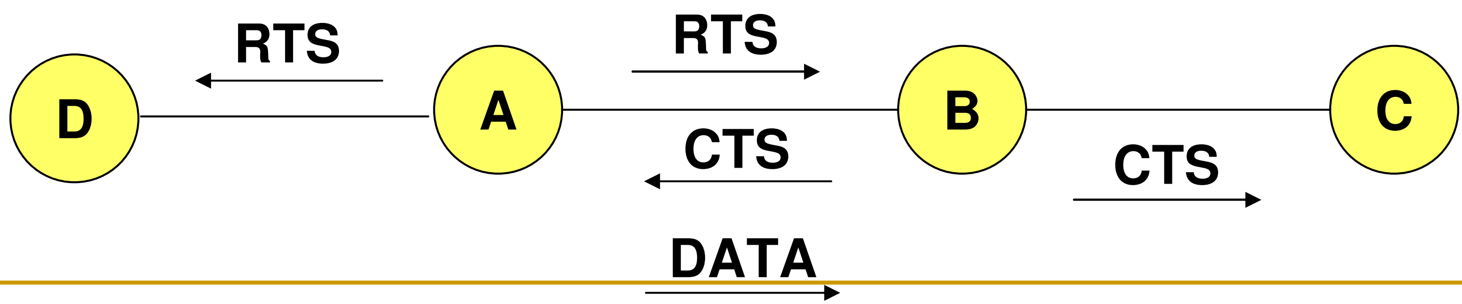
- MACA — Multiple Access w/ Collision Avoidance
  - RTS/CTS for hidden terminal problem
  - RTS/CTS/DATA

Contention-based Protocols -Examples

- MACAW — improved over MACA
  - RTS/CTS/DATA/ACK
  - Fast error recovery at link layer
- IEEE 802.11 Distributed Coordination Function (DCF)
  - Largely based on MACAW

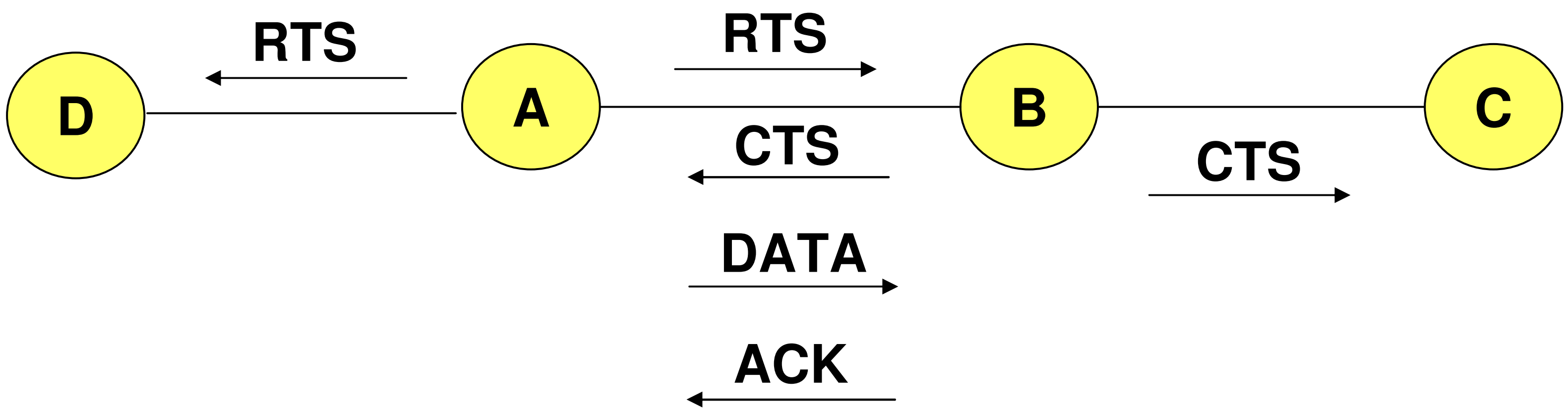
Solution for Hidden Terminals

- A first sends a *Request-to-Send (RTS)* to B
- On receiving RTS, B responds *Clear-to-Send (CTS)*
- Hidden node C overhears CTS and keeps quiet
  - Transfer duration is included in both RTS and CTS
- Exposed node overhears a RTS but not the CTS
  - D's transmission cannot interfere at B



802.11 – Reliability: ACKs

- When B receives DATA from A, B sends an ACK
- If A fails to receive an ACK, A retransmits the DATA
- Both C and D remain quiet until ACK (to prevent collision of ACK)
- Expected duration of transmission+ACK is included in RTS/CTS packets

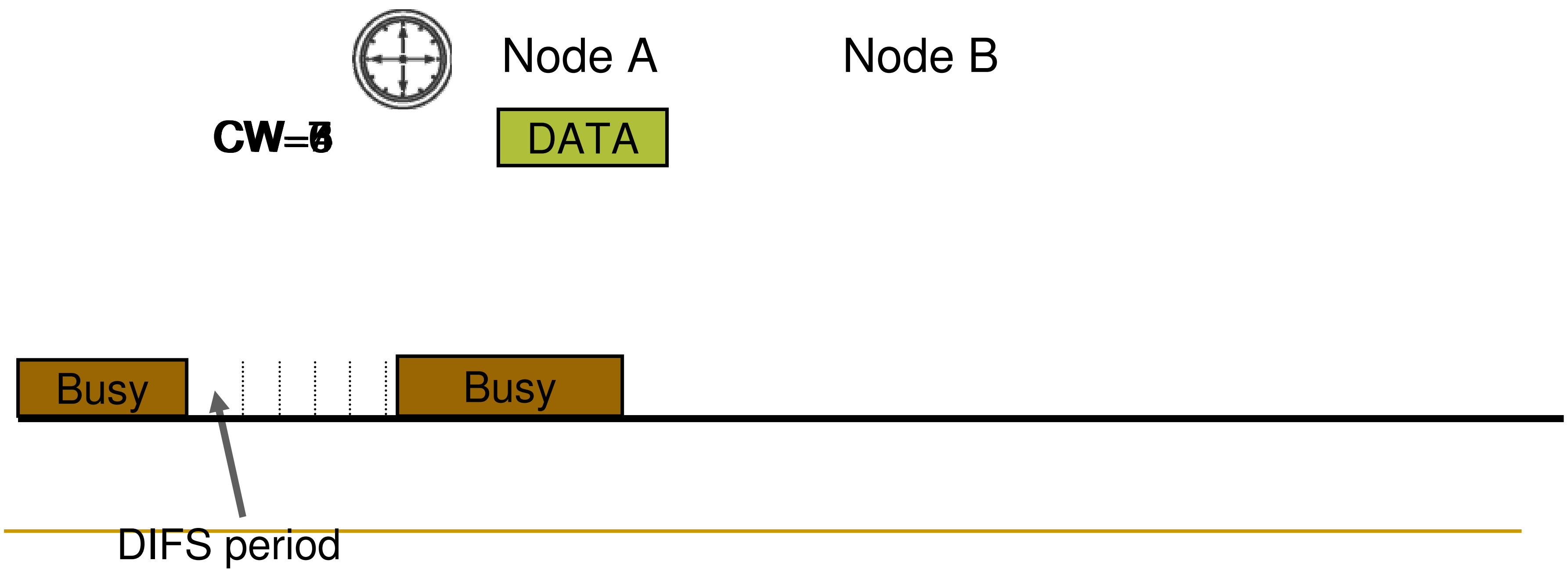


IEEE 802.11 DCF

- Distributed coordinate function: ad hoc mode
  - Virtual and physical carrier sense (CS)
    - Network allocation vector (NAV), duration field
  - Binary exponential backoff
  - RTS/CTS/DATA/ACK or DATA/ACK for unicast packets
  - Broadcast packets are directly sent after CS
  - Fragmentation support
    - RTS/CTS reserve time for first (frag + ACK)
    - First (frag + ACK) reserve time for second…
    - Give up tx when error happens

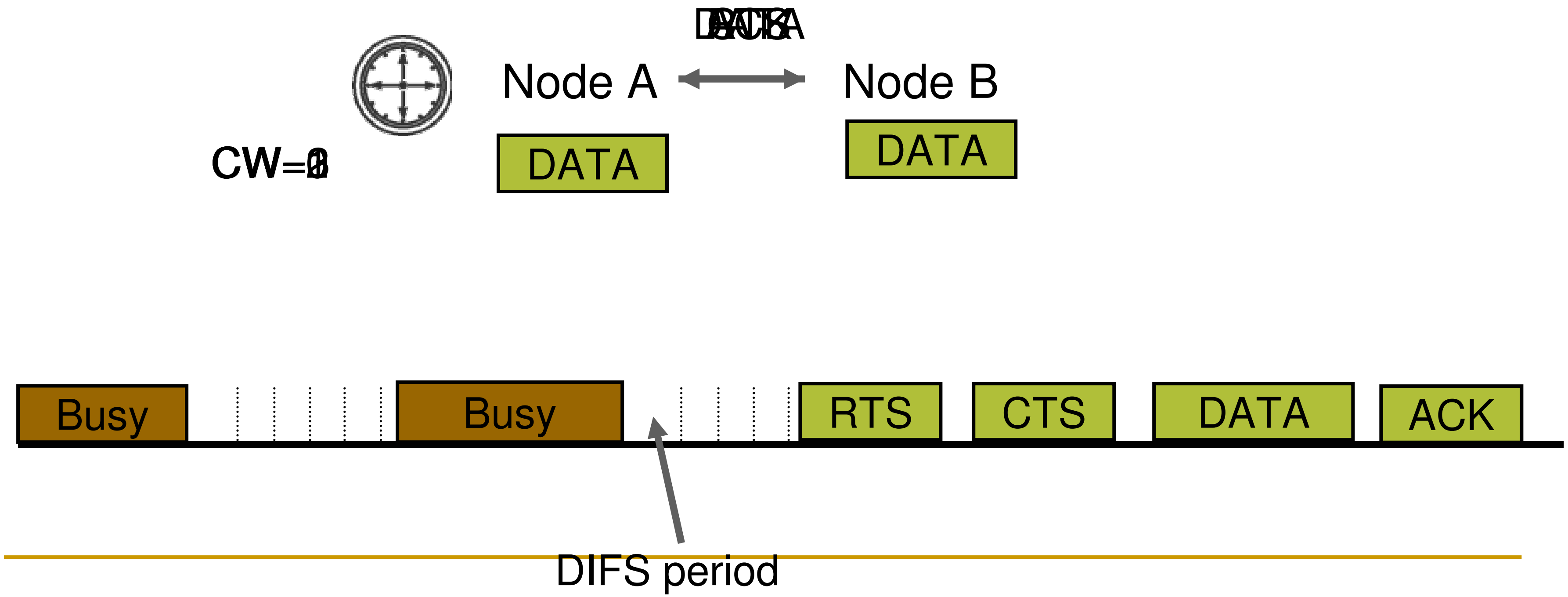
IEEE 802.11 DCF (2)

- Carrier-sensing until channel idle for DIFS period
- If channel not idle, random backoff based on contention window
- If channel idle, RTS-CTS-DATA-ACK or DATA-ACK handshake
- If transmission unsuccessful, double contention window size



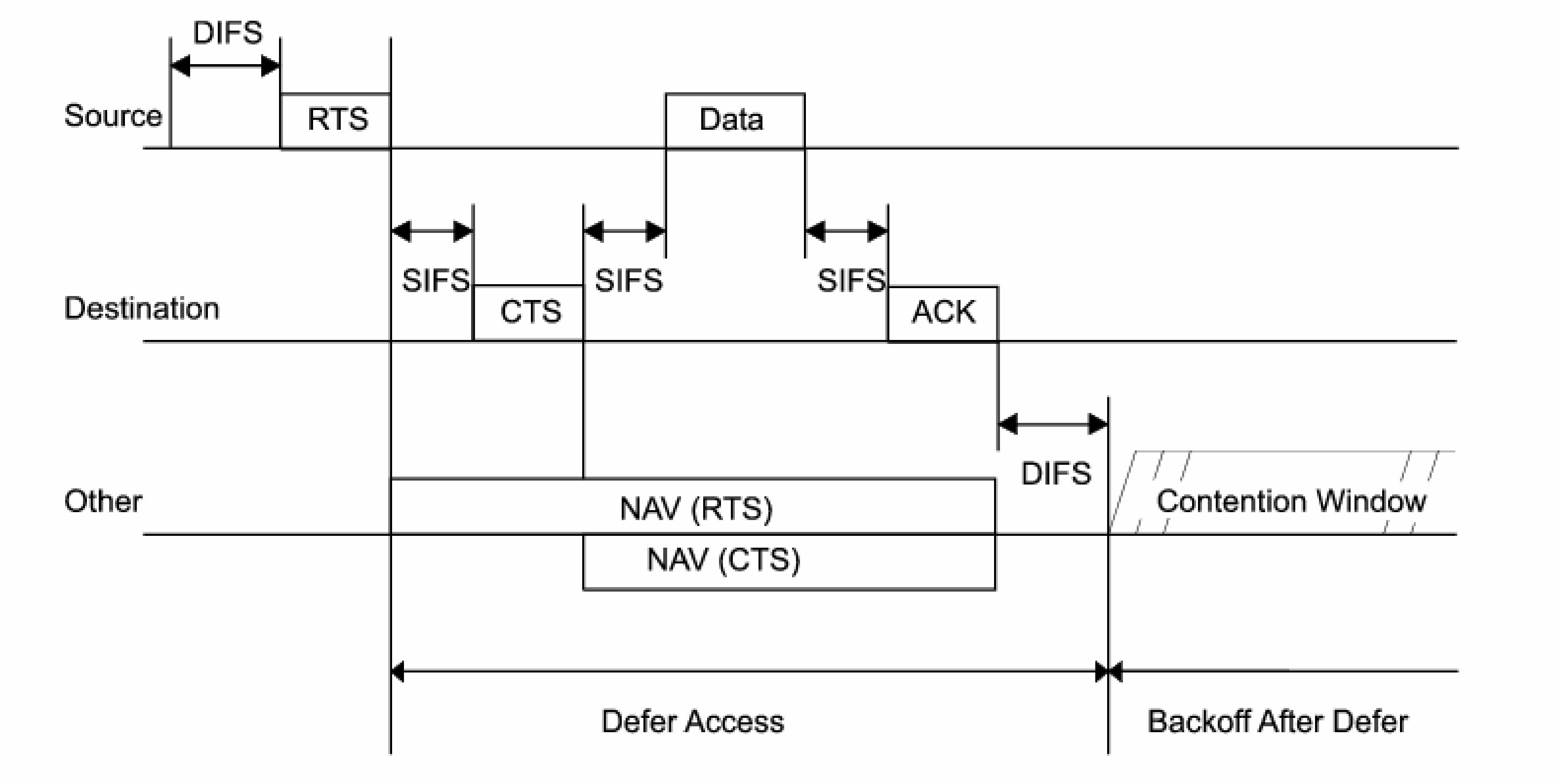
IEEE 802.11 DCF (2)

- Carrier-sensing until channel idle for DIFS period
- If channel not idle, random backoff based on contention window
- If channel idle, RTS-CTS-DATA-ACK or DATA-ACK handshake
- If transmission unsuccessful, double contention window size

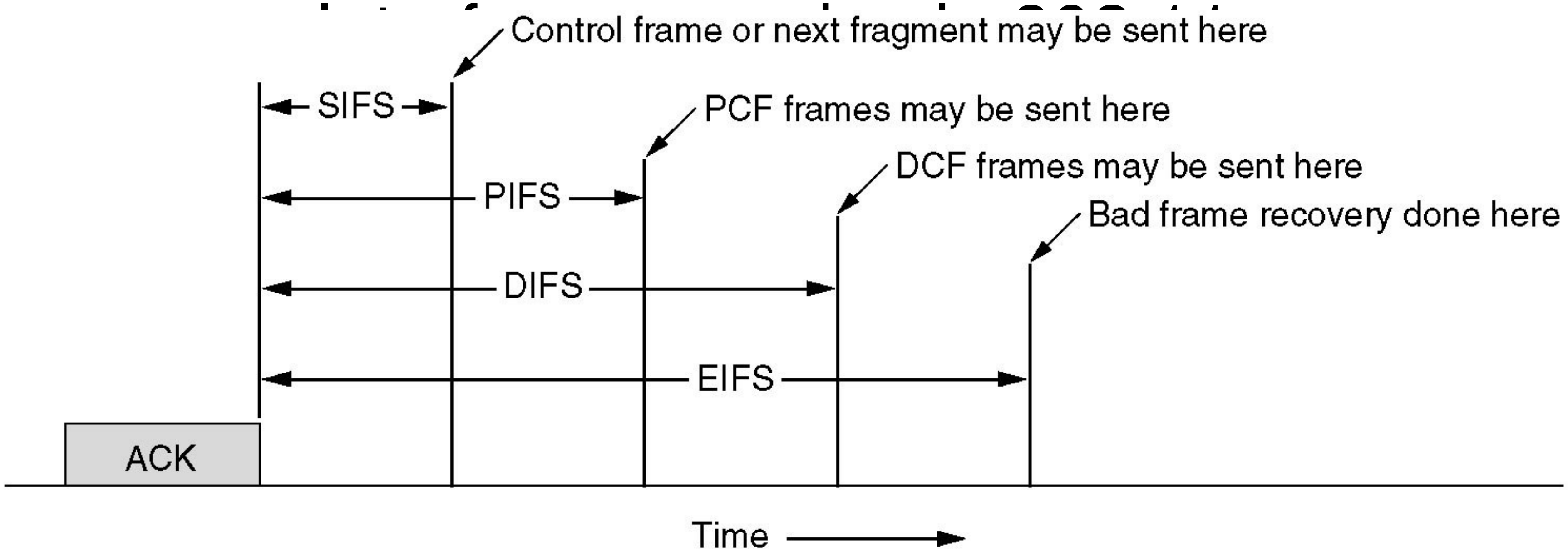


IEEE 802.11 DCF (3)

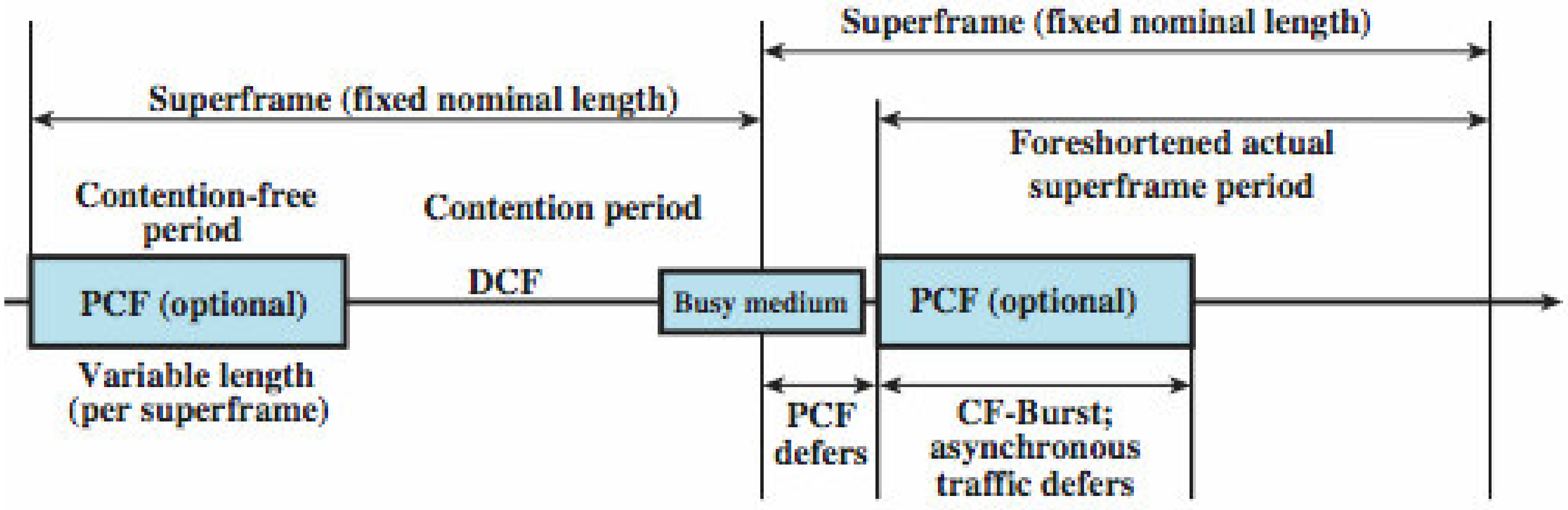
- Timing relationship



The 802.11 MAC Sublayer Protocol

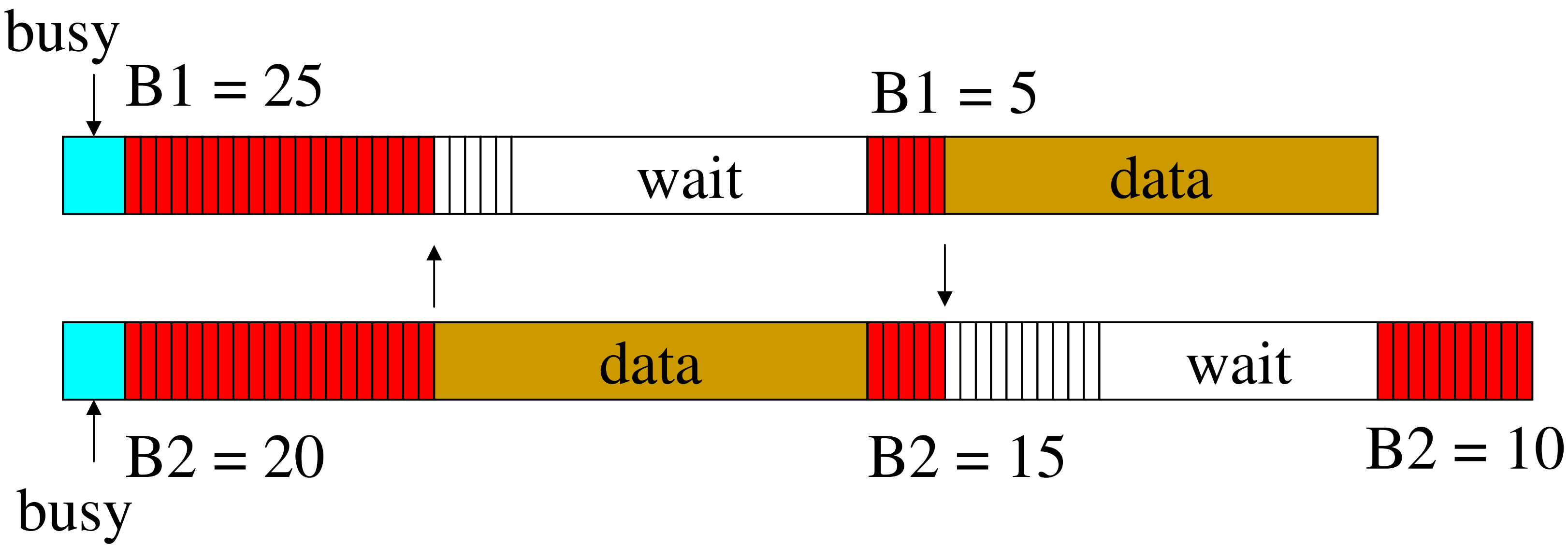


PCF Superframe Timing



(b) PCF Superframe Construction

Congestion Avoidance: Example



cw = 31

B1 and B2 are backoff intervals at nodes 1 and 2

Backoff Interval

- The time spent counting down backoff intervals is a part of MAC overhead
  - large CW ➔ large overhead
  - however, small CW ➔ may lead to many collisions (when two nodes count down to 0 simultaneously)

- Since the number of nodes attempting to transmit simultaneously may change with time, we need some mechanism to manage contention

- IEEE 802.11: contention window CW is adapted dynamically depending on collision occurrence
  - after each collision, CW is doubled

Overview of IEEE 802.11 DCF

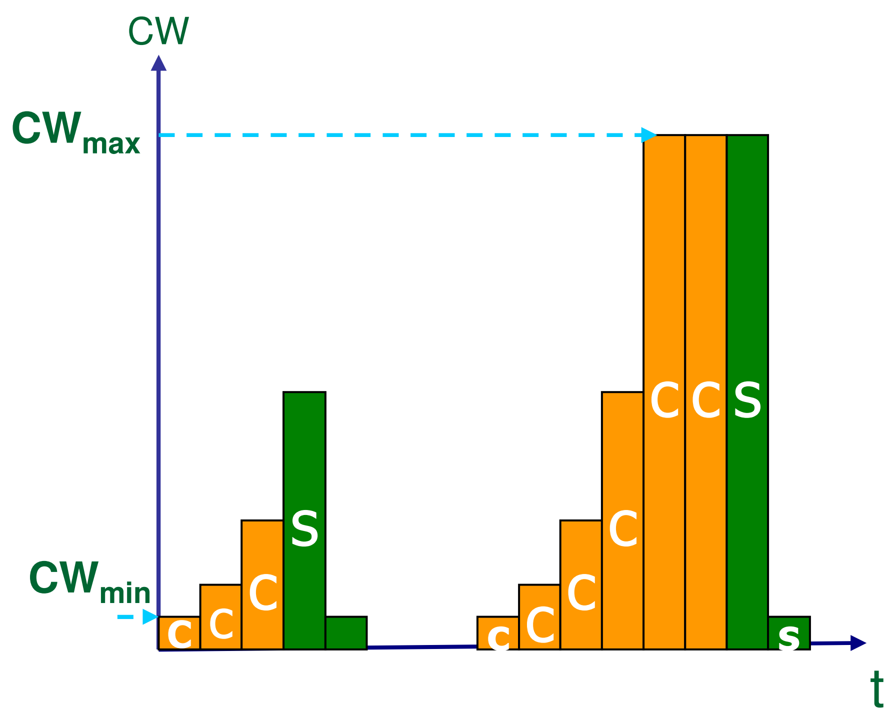
Backoff procedure—BEB algorithm

Backoff counter:

·Initial: uni~[0,CW-1]

·Non zero: decremented for each idle slot

·Zero: transmit



Discrete Time Model

- Discrete and integer time scale
- At beginning of a slot time, backoff time counter decrements or regenerated
- [t, t+1], interval between 2 consecutive slot time, can be variable length