MAC in 802.11

2/20/06

MAC

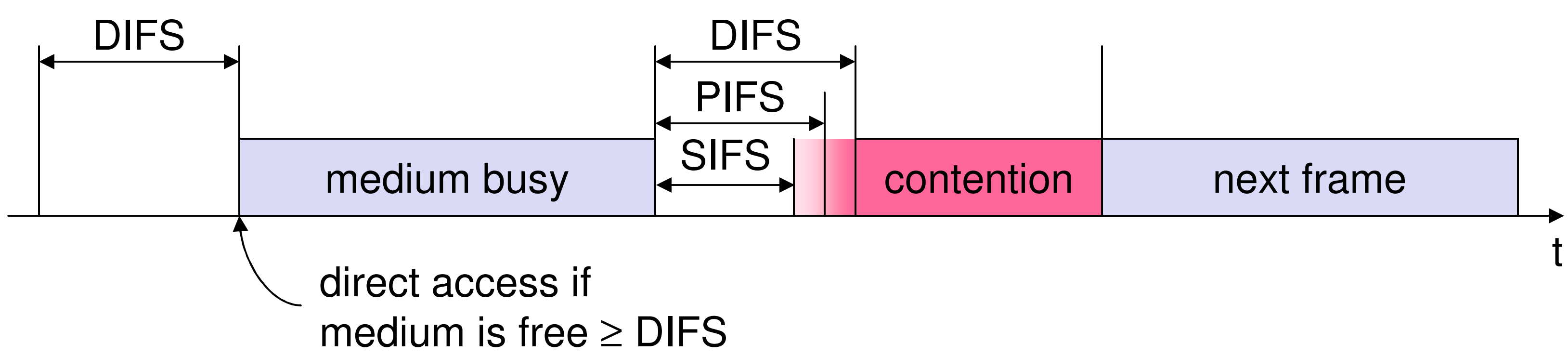
- Multiple users share common medium.
- Important issues:
  - Collision detection
  - Delay
  - Fairness
  - Hidden terminals
  - Synchronization
  - Power management
  - Roaming
- Use 802.11 as an example to see how these issues are handled.

802.11 - MAC layer I - DFWMAC

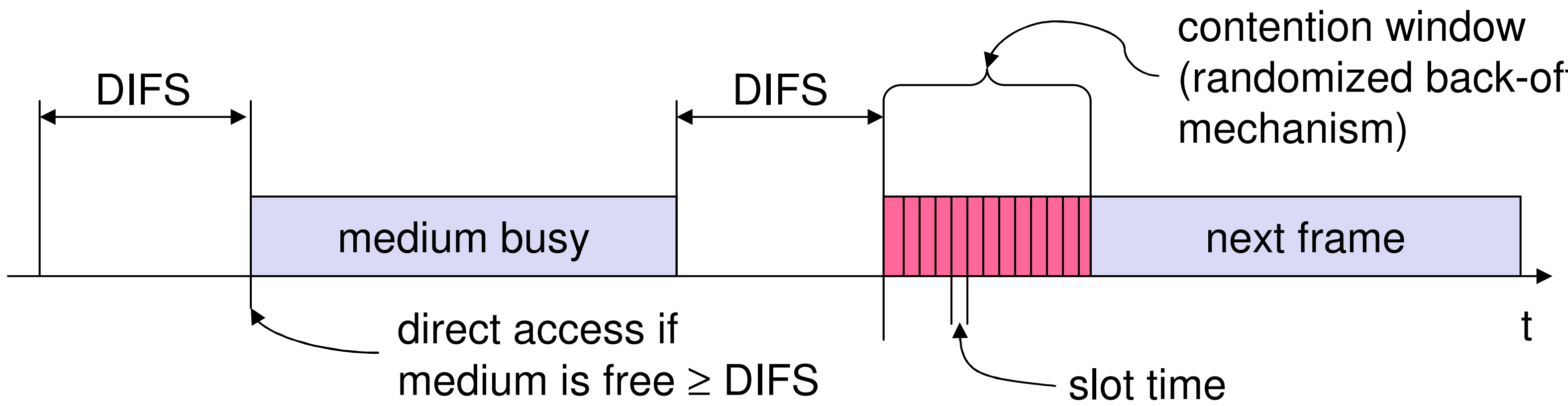
- Traffic services
  - Asynchronous Data Service (mandatory)
    - exchange of data packets based on “best-effort”
    - support of broadcast and multicast
  - Time-Bounded Service (optional)
    - implemented using PCF (Point Coordination Function)
- Access methods
  - DFWMAC-DCF CSMA/CA (mandatory)
    - collision avoidance via randomized „back-off“ mechanism
    - minimum distance between consecutive packets
    - ACK packet for acknowledgements (not for broadcasts)
  - DFWMAC-DCF w/ RTS/CTS (optional)
    - Distributed Foundation Wireless MAC
    - avoids hidden terminal problem
  - DFWMAC- PCF (optional)
    - access point polls terminals according to a list

802.11 - MAC layer II

- Priorities
  - defined through different inter frame spaces
  - no guaranteed, hard priorities
  - SIFS (Short Inter Frame Spacing)
    - highest priority, for ACK, CTS, polling response
  - PIFS (PCF IFS)
    - medium priority, for time-bounded service using PCF
  - DIFS (DCF, Distributed Coordination Function IFS)
    - lowest priority, for asynchronous data service

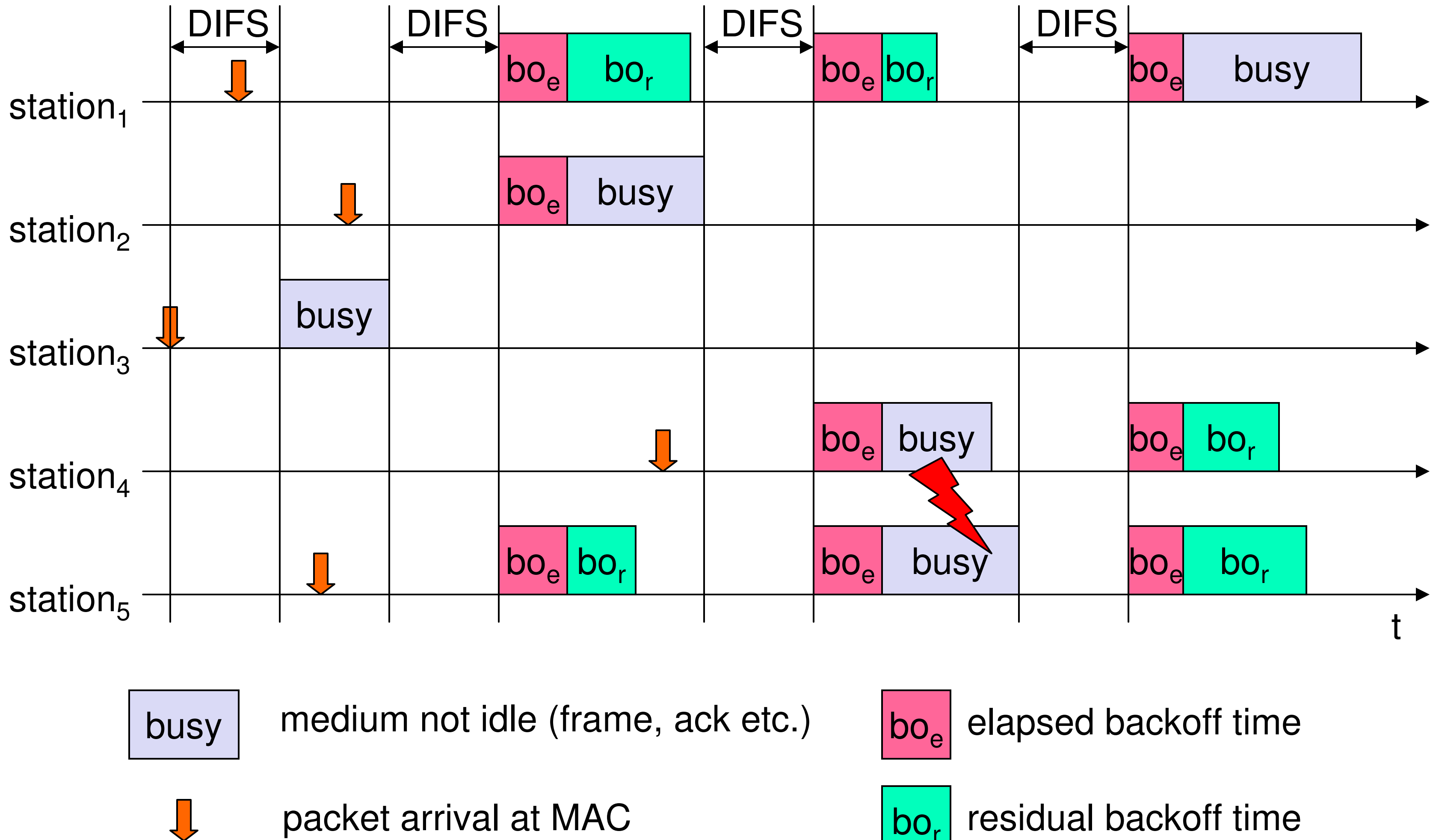


802.11 - CSMA/CA access method I



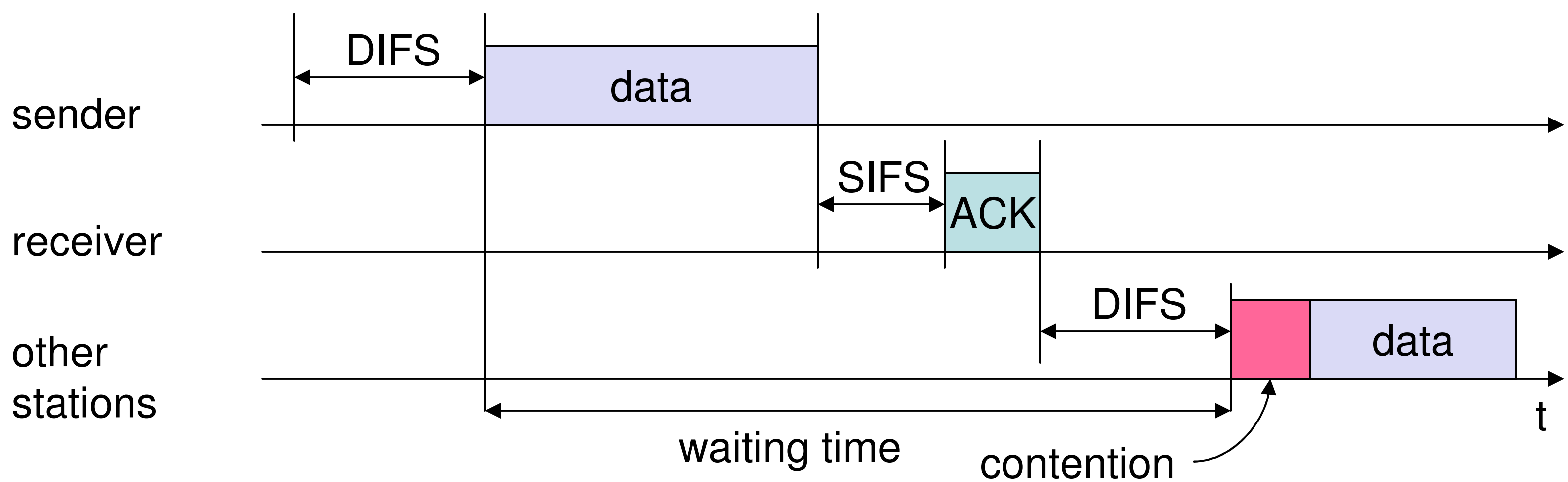
- station ready to send starts sensing the medium (Carrier Sense based on CCA, Clear Channel Assessment)
- if the medium is free for the duration of an Inter-Frame Space (IFS), the station can start sending (IFS depends on service type)
- if the medium is busy, the station has to wait for a free IFS, then the station must additionally wait a random back-off time (collision avoidance, multiple of slot-time)
- if another station occupies the medium during the back-off time of the station, the back-off timer stops (fairness)

802.11 - competing stations - simple version



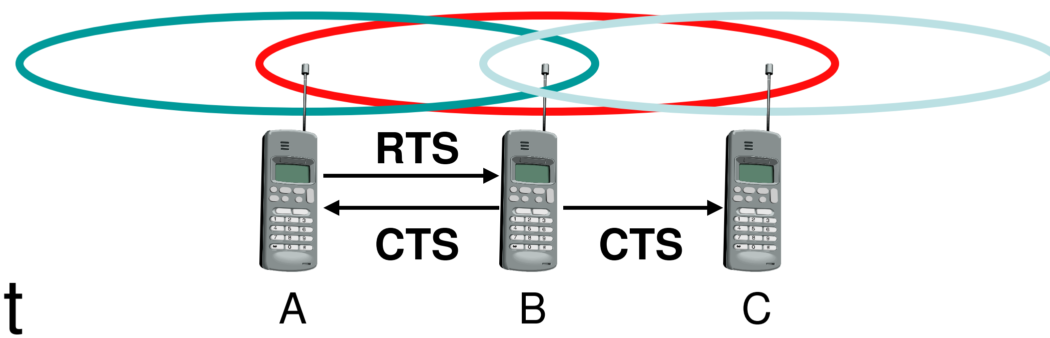
802.11 - CSMA/CA access method II

- Sending unicast packets
  - station has to wait for DIFS before sending data
  - receivers acknowledge at once (after waiting for SIFS) if the packet was received correctly (CRC)
  - automatic retransmission of data packets in case of transmission errors



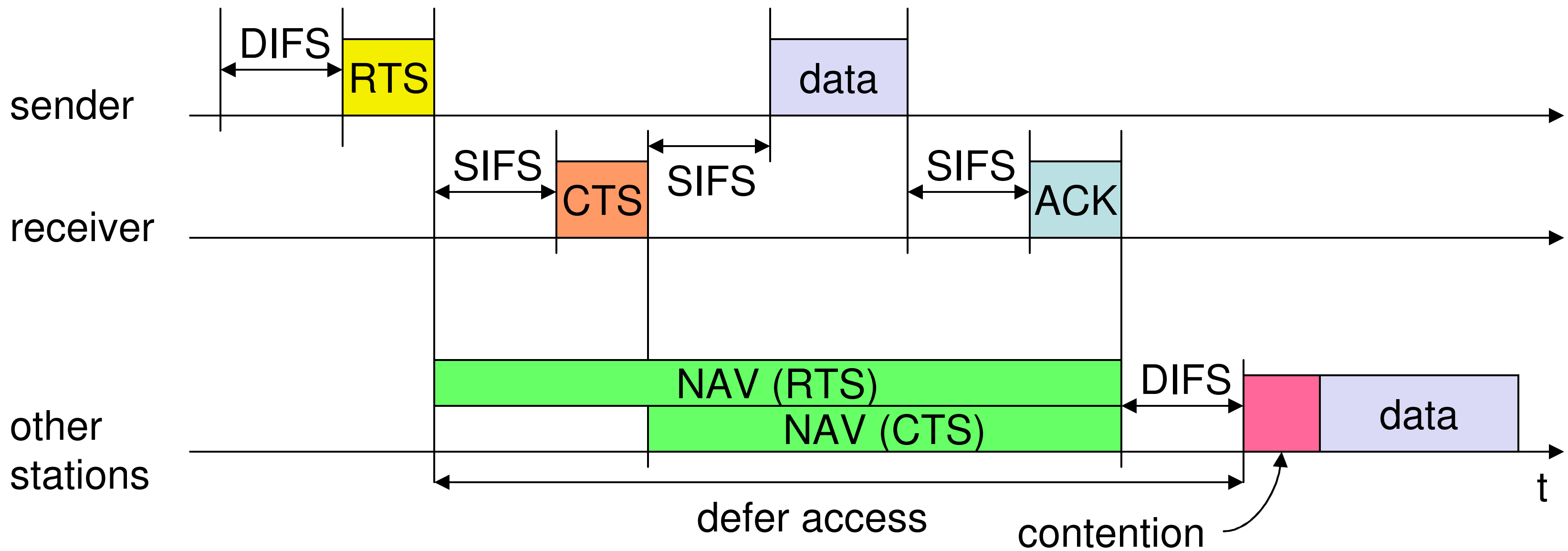
Hidden terminals

- MACA avoids the problem of hidden terminals
  - A and C want to send to B
  - A sends RTS first
  - C waits after receiving CTS from B

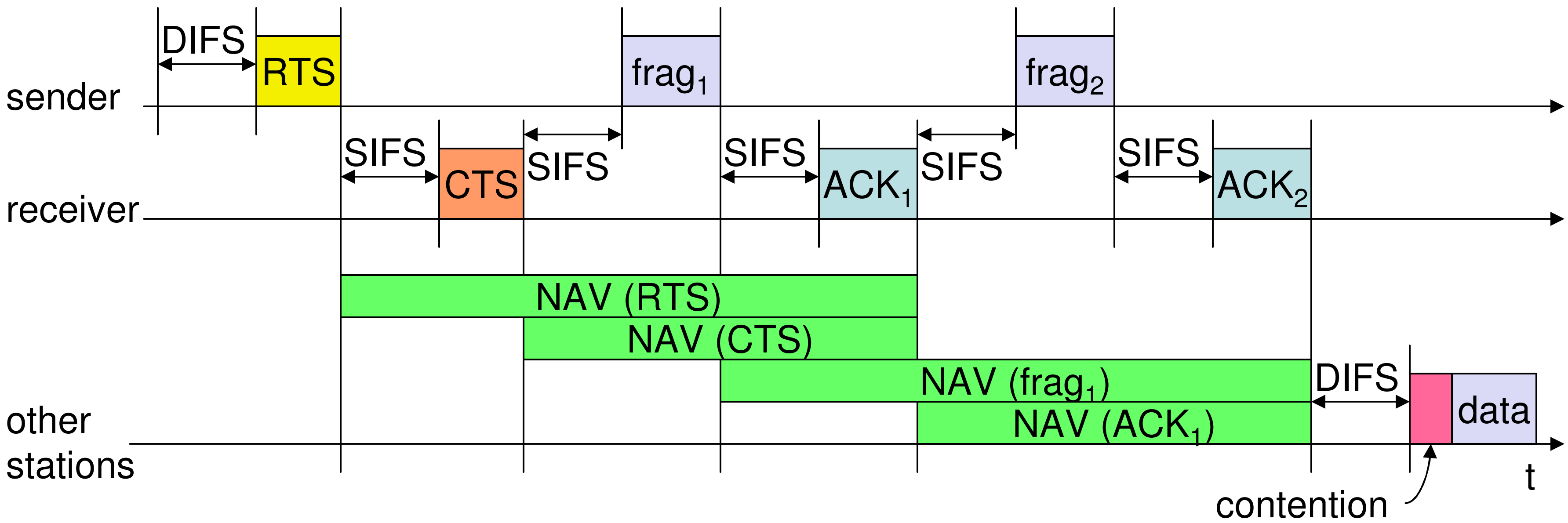


802.11 - DFWMAC

- Sending unicast packets
  - station can send RTS with reservation parameter after waiting for DIFS (reservation determines amount of time the data packet needs the medium)
  - 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



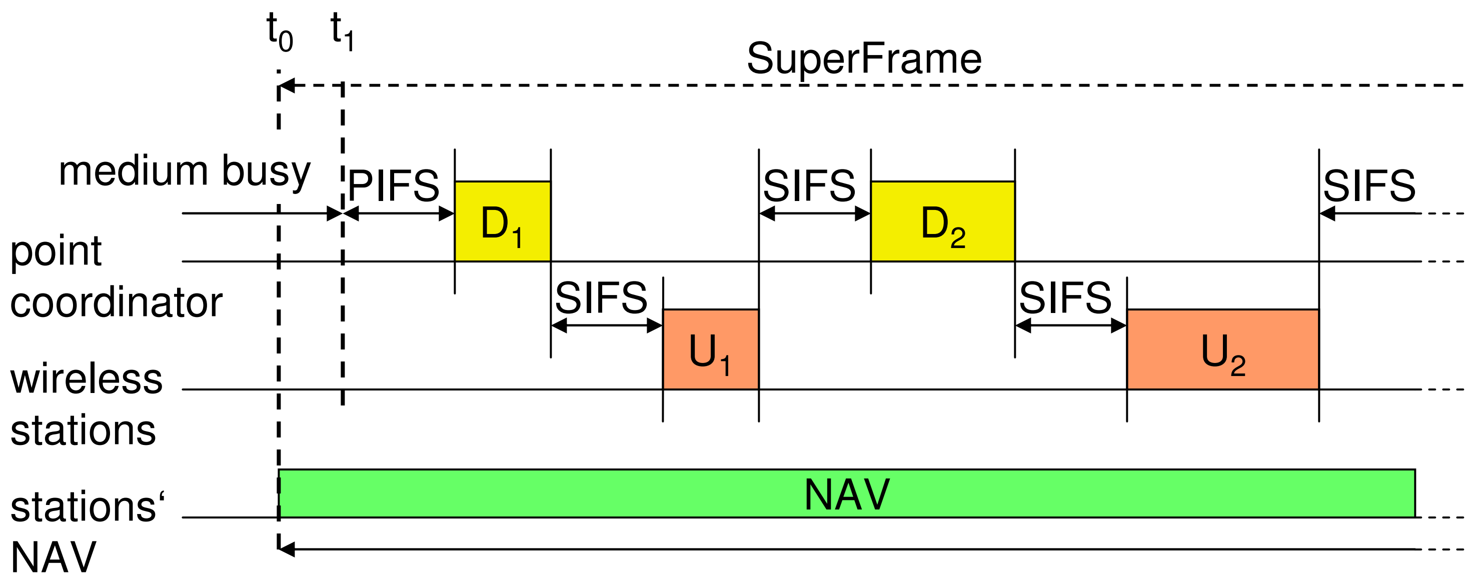
Fragmentation



Why segmentation?

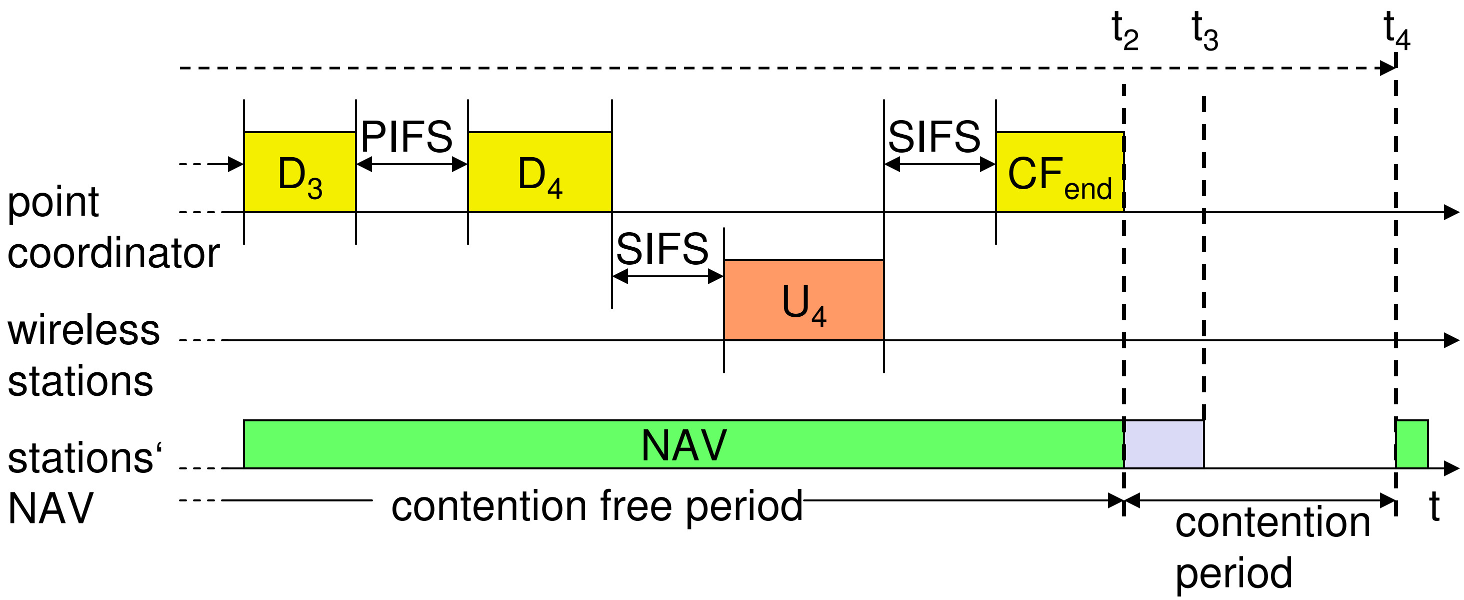
Better error correction.

DFWMAC-PCF I



t0
t1
SuperFrame
medium busy
PIFS
D1
SIFS
D2
SIFS
point
coordinator
SIFS
U1
SIFS
U2
wireless
stations
NAV
stations‘
NAV

DFWMAC-PCF II



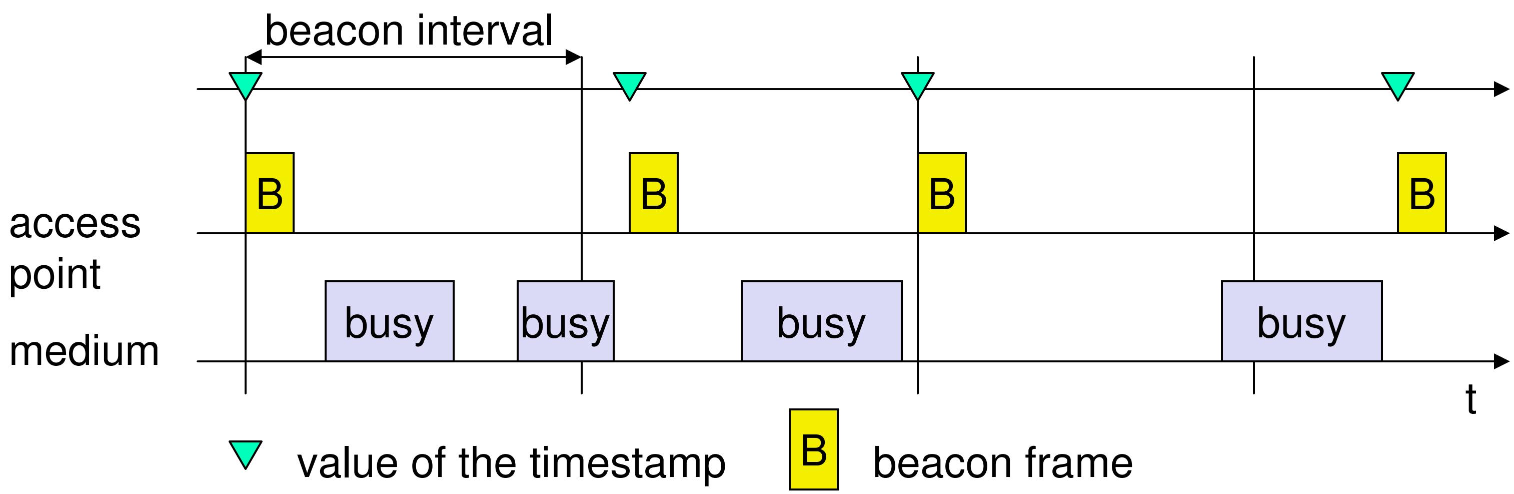
802.11 - MAC management

- Synchronization
  - try to find a LAN, try to stay within a LAN
  - timer etc.
- Power management
  - sleep-mode without missing a message
  - periodic sleep, frame buffering, traffic measurements
- Association/Reassociation
  - integration into a LAN
  - roaming, i.e. change networks by changing access points
  - scanning, i.e. active search for a network
- MIB - Management Information Base
  - managing, read, write

Synchronization

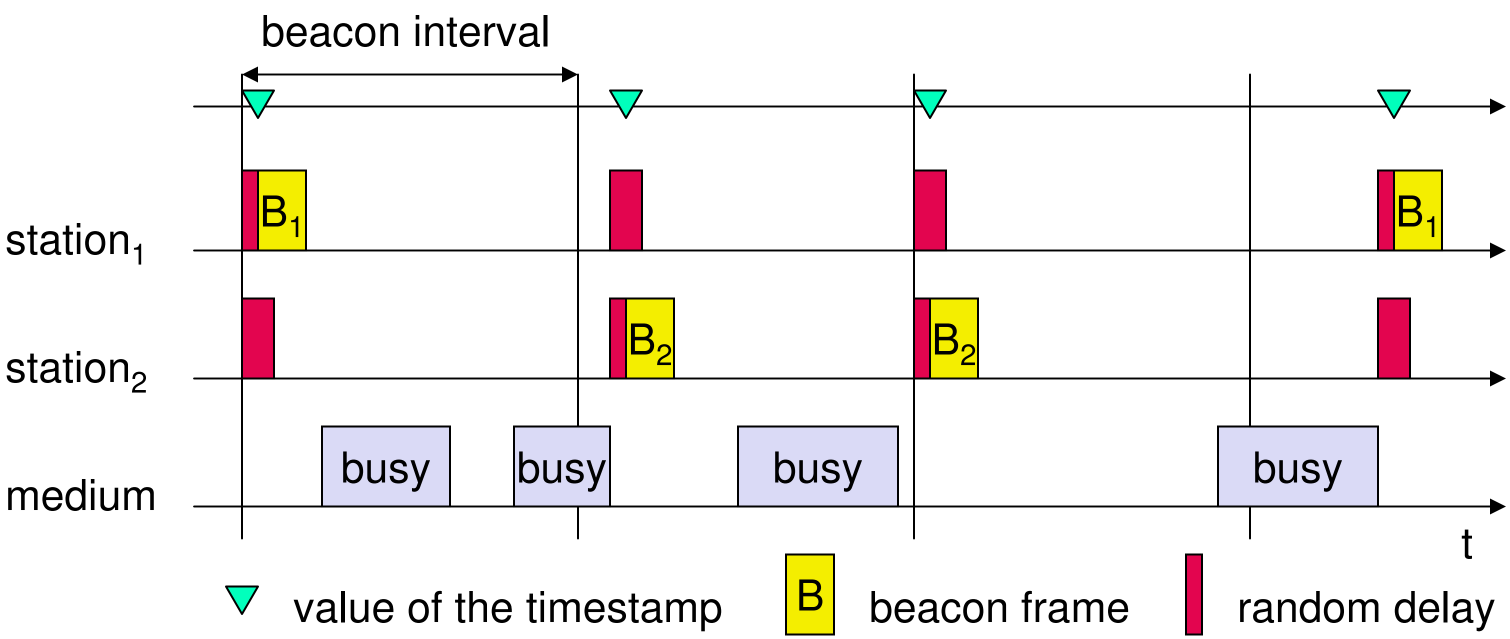
- Each node maintains an internal clock.
- Timing synchronization function (TSF)
  - Power management
  - Hopping sequence in FHSS system
- How to implement synchronization
  - Beacon
  - Infrastructure-based network
  - Ad hoc network (harder).

Synchronization using a Beacon (infrastructure)



Access point send out beacons to synchronize with stations.
Try to respect to the beacon interval
The timestamp refers to the transmit time.

Synchronization using a Beacon (ad-hoc)

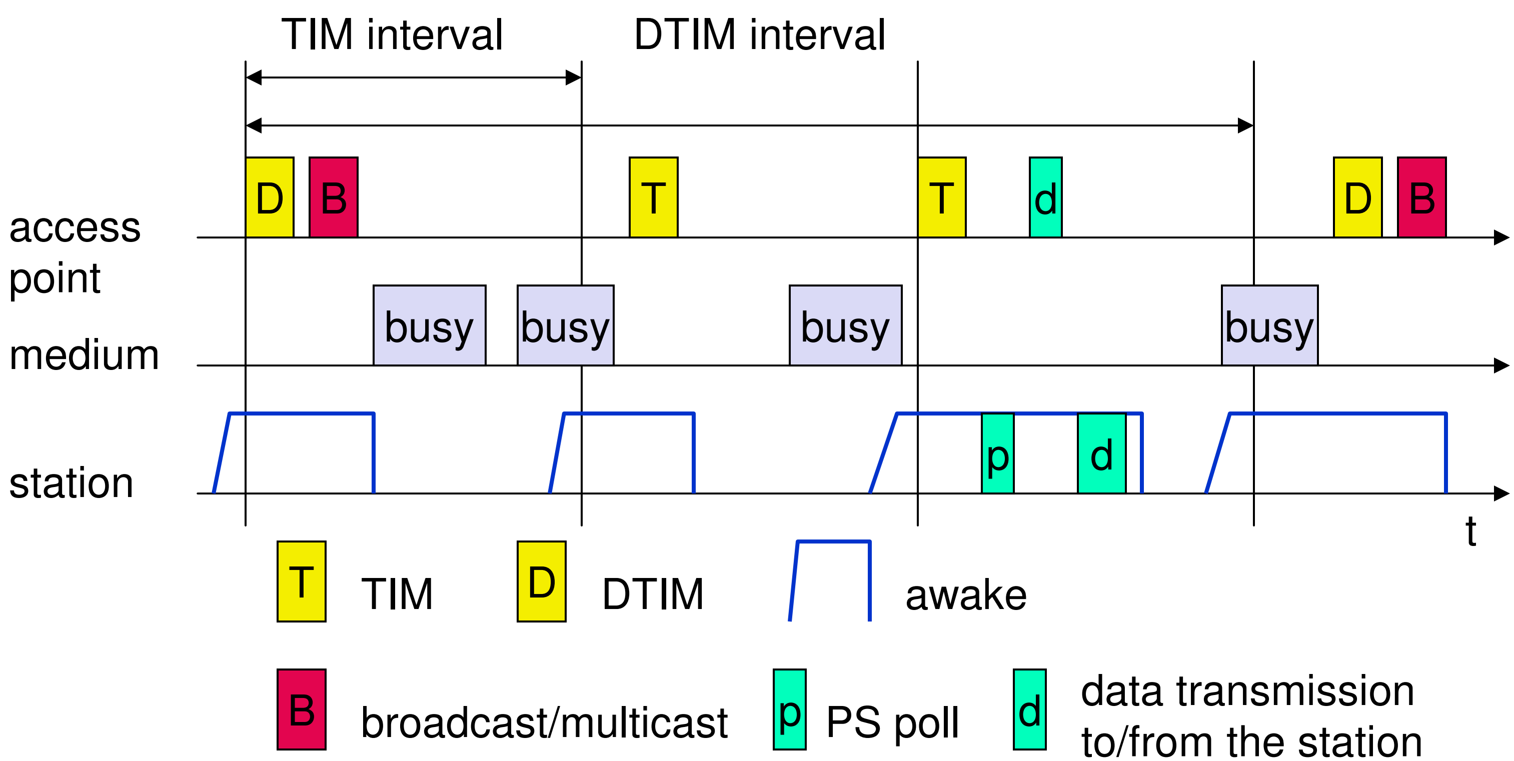


This assumes that all the nodes hear each other.
What if we have a multi-hop network?
Does the system converge?

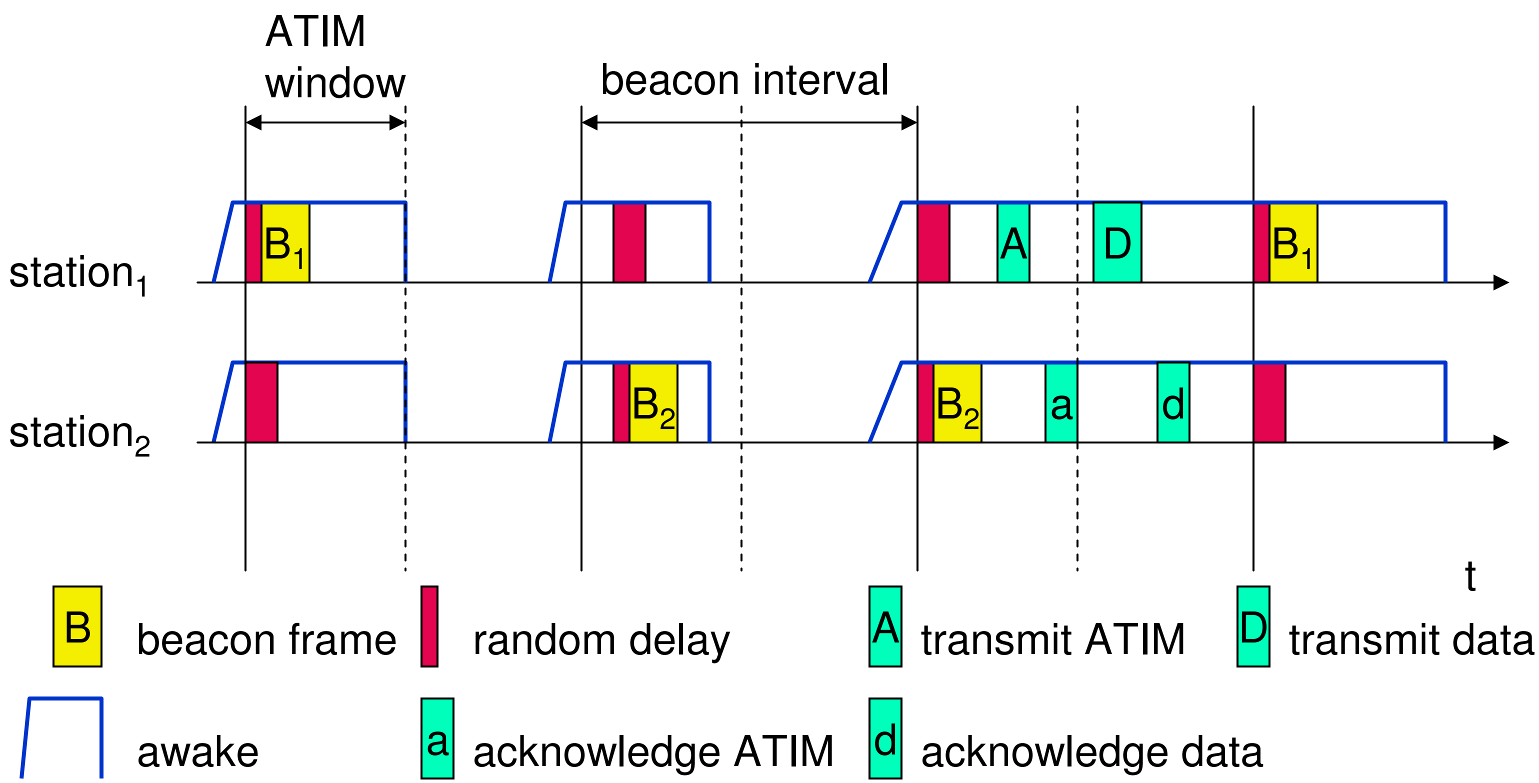
Power management

- Idea: switch the transceiver off if not needed
- States of a station: sleep and awake
- Timing Synchronization Function (TSF)
  - stations wake up at the same time
- Infrastructure
  - Traffic Indication Map (TIM)
    - list of unicast receivers transmitted by AP
  - Delivery Traffic Indication Map (DTIM)
    - list of broadcast/multicast receivers transmitted by AP
- Ad-hoc
  - Ad-hoc Traffic Indication Map (ATIM)
    - announcement of receivers by stations buffering frames
    - more complicated - no central AP
    - collision of ATIMs possible (scalability?)

Power saving with wake-up patterns (infrastructure)



Power saving with wake-up patterns (ad-hoc)



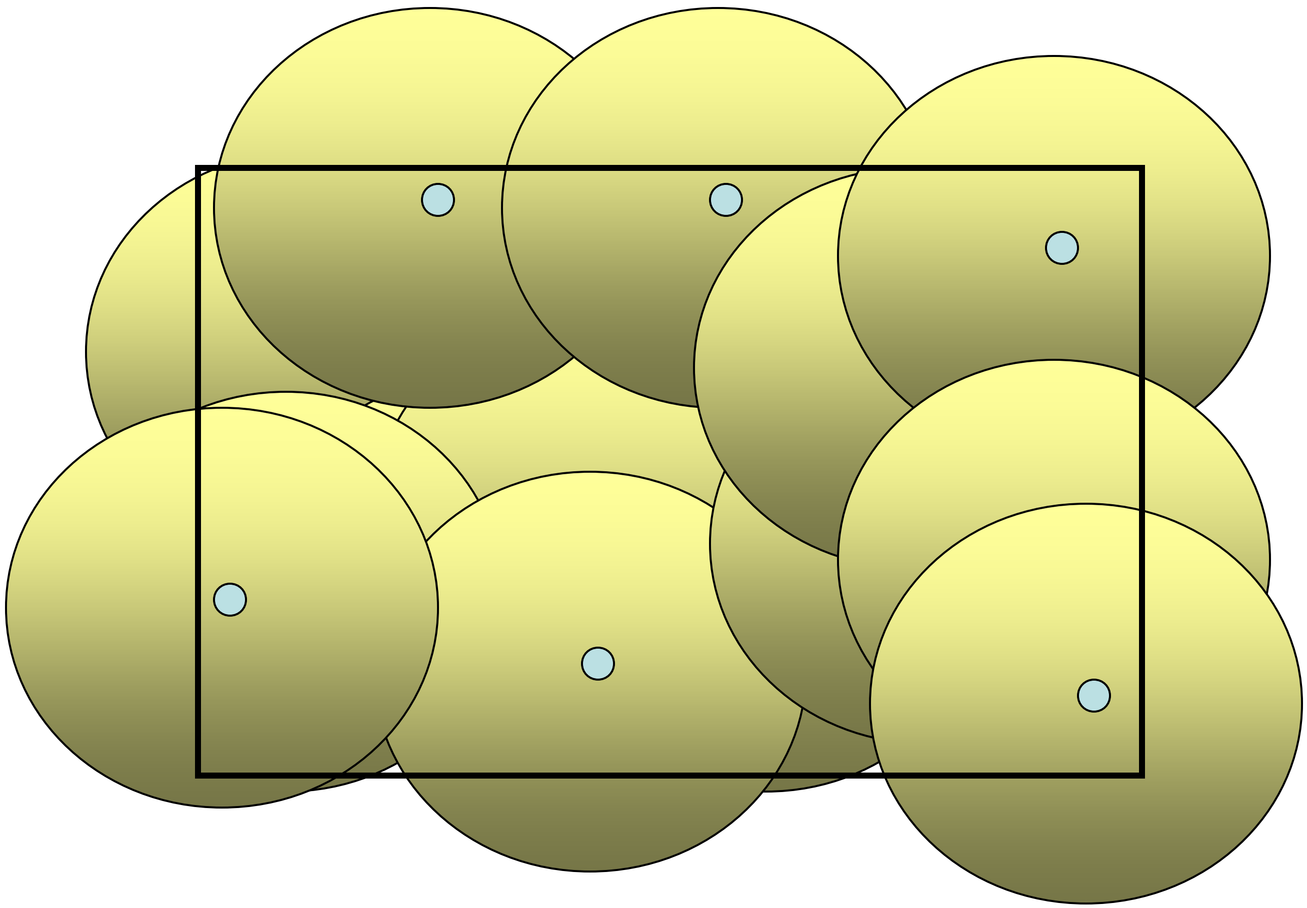
Synchronization makes power management easy.
But increases the chance of collision!

802.11 - Roaming

- No or bad connection? Then perform:
- Scanning
  - scan the environment, i.e., listen into the medium for beacon signals or send probes into the medium and wait for an answer
- Reassociation Request
  - station sends a request to one or several AP(s)
- Reassociation Response
  - success: AP has answered, station can now participate
  - failure: continue scanning
- AP accepts Reassociation Request
  - signal the new station to the distribution system
  - the distribution system updates its data base (i.e., location information)
  - typically, the distribution system now informs the old AP so it can release resources

One project idea

- Power management for sensor networks



One project idea

- Find schedules of sensors so that each point in the region is covered by at least one sensor at a time.
  - Synchronize all the sensors. Design global schedule for the sensors.
    - Synchronization & localization are necessary.
    - In a distributed environment how to compute the global schedule efficient?
  - Random access.
    - Each sensor wakes up, check how many neighbors alive, decide on how long it will stay awake.
    - How to guarantee good coverage (with high prob)?

One project idea

- Design a power management algorithm.
- Implement it with ns-2.
- Analyze its performance.
- Write a report.

- You are welcome to discuss with me about your idea.