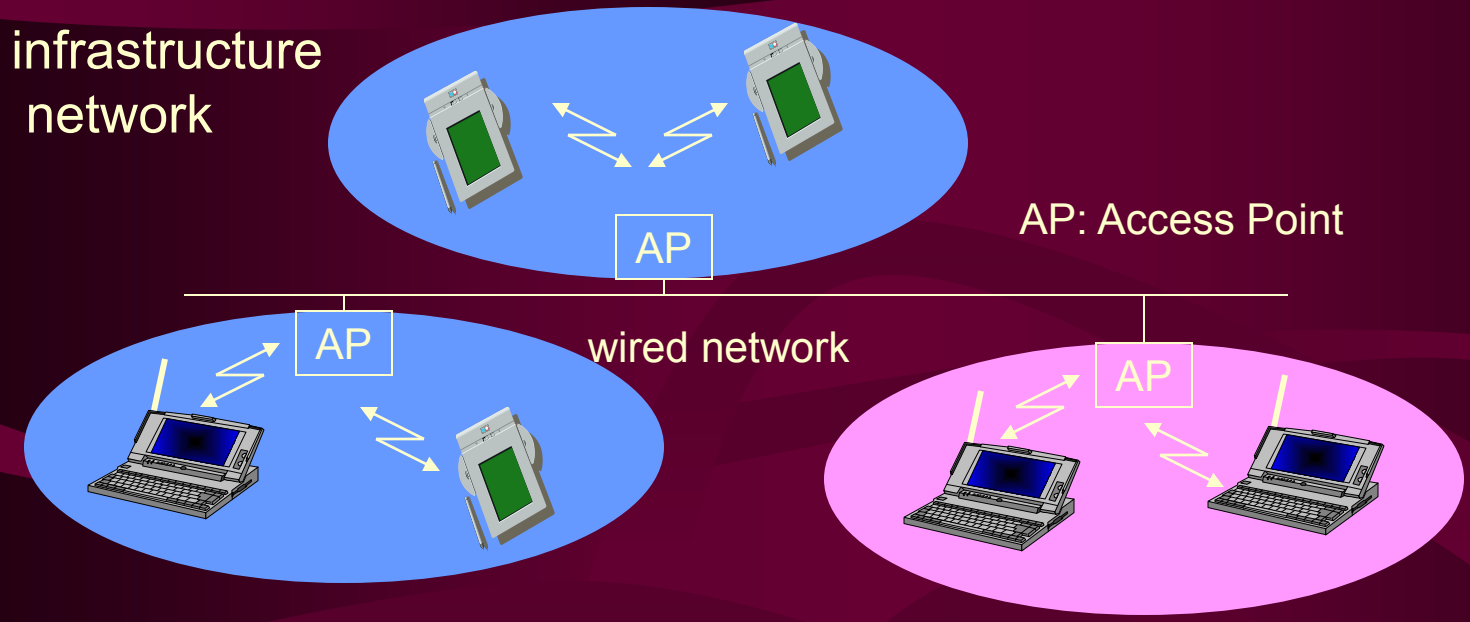
IEEE 802.11
Wireless LAN

Wireless LANs: Characteristics

- **Types**
  - **Infrastructure based**
  - **Ad-hoc**
- **Advantages**
  - **Flexible deployment**
  - **Minimal wiring difficulties**
  - **More robust against disasters (earthquake etc)**
  - **Historic buildings, conferences, trade shows,…**
- **Disadvantages**
  - **Low bandwidth compared to wired networks (1-10 Mbit/s)**
  - **Proprietary solutions**
  - **Need to follow wireless spectrum regulations**

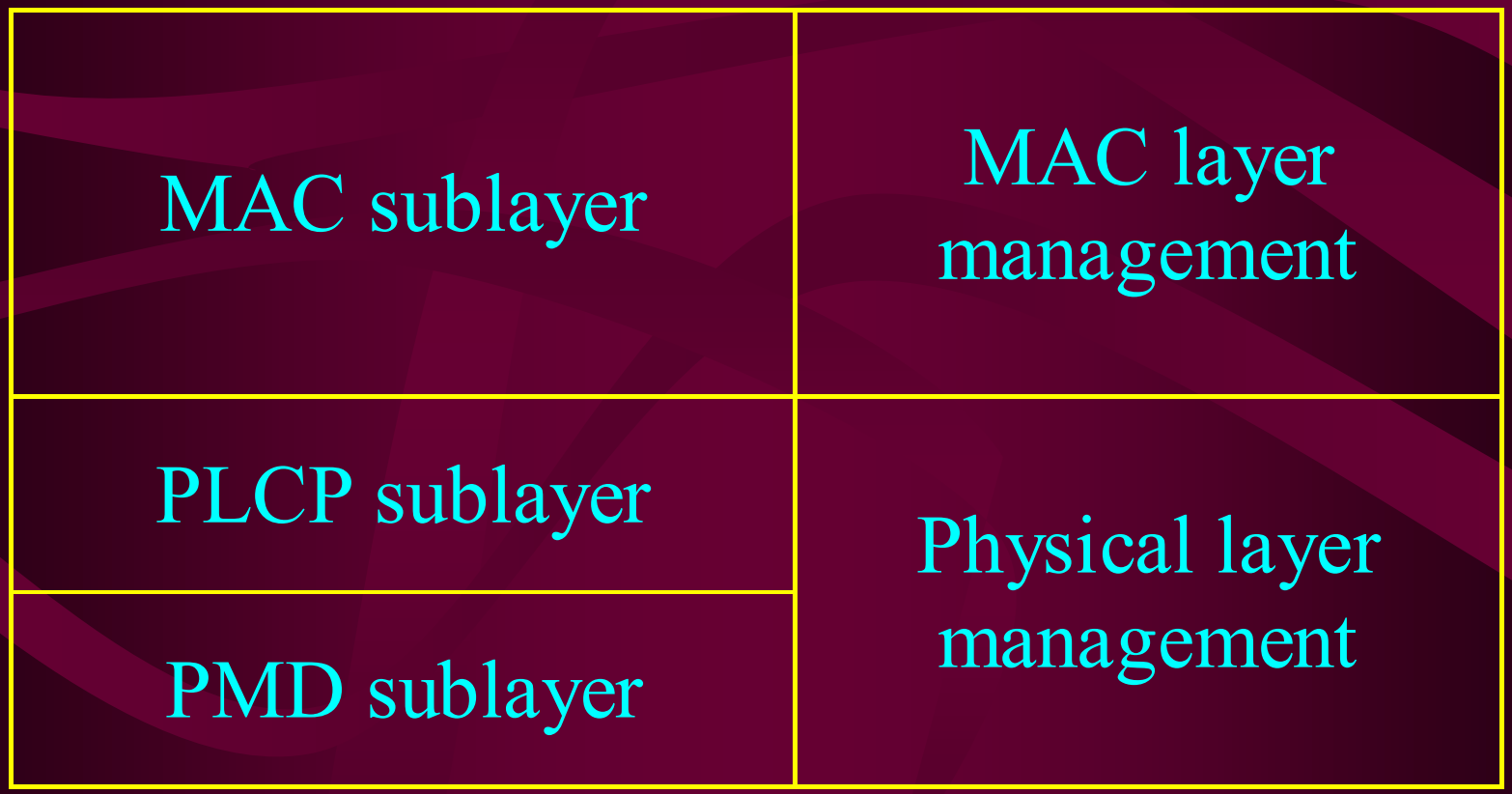
Components/Architecture

- Station (STA) - **Mobile node**
- Access Point (AP) - **Stations are connected to access points.**
- Basic Service Set (BSS) - **Stations and the AP with in the same radio coverage form a BSS.**
- Extended Service Set (ESS) - **Several BSSs connected through APs form an ESS.**



Source: Schiller

Protocol Architecture

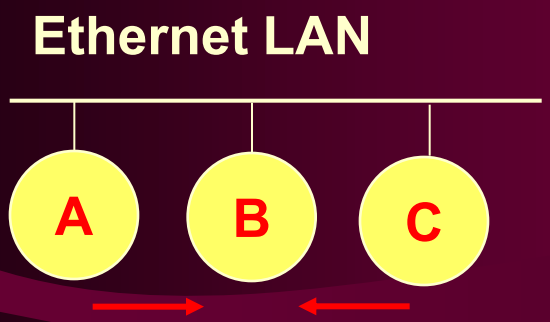


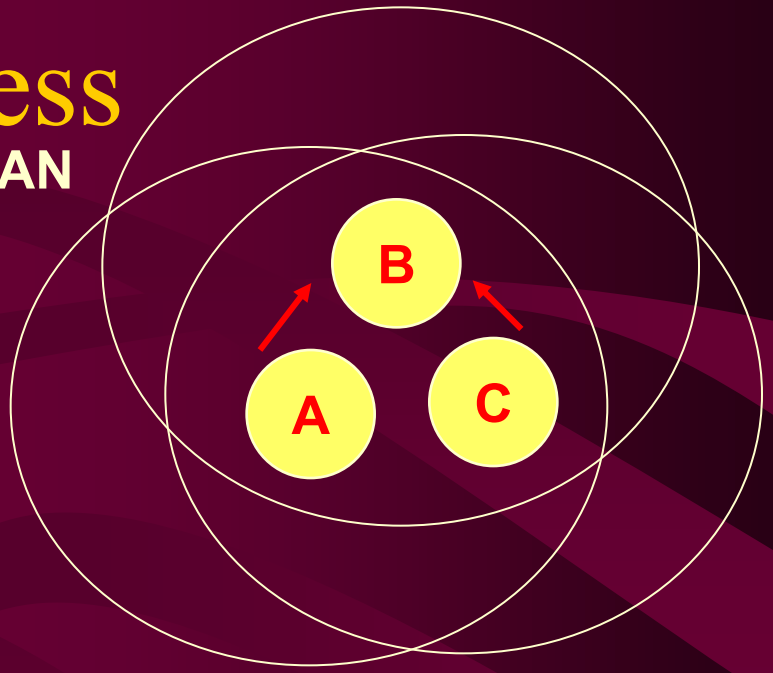
Wireless LAN: Motivation

- Can we apply media access methods from fixed networks?
- Example CSMA/CD
  - **C**arrier **S**ense **M**ultiple **A**ccess with **C**ollision **D**etection
  - send as soon as the medium is free, listen into the medium if a collision occurs (original method in IEEE 802.3)

- Medium access problems in wireless networks
  - signal strength decreases proportional to the square of the distance
  - sender would apply CS and CD, but the collisions happen at the receiver
  - sender may not “hear” the collision, i.e., CD does not work
  - CS might not work, e.g. if a terminal is “hidden”

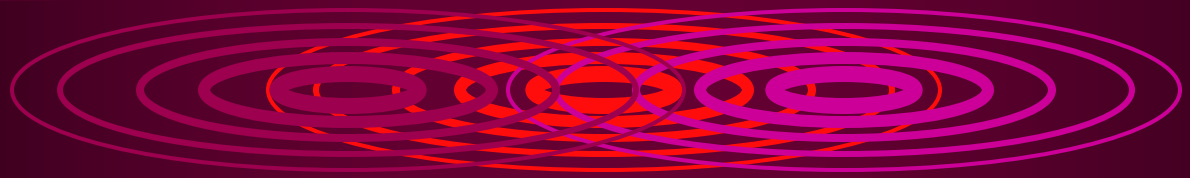
Difference Between Wired and Wireless





- If both A and C sense the channel to be idle at the same time, they send at the same time.
- Collision can be detected at sender in Ethernet.
- Half-duplex radios in wireless cannot detect collision at sender.

Hidden Terminal Problem

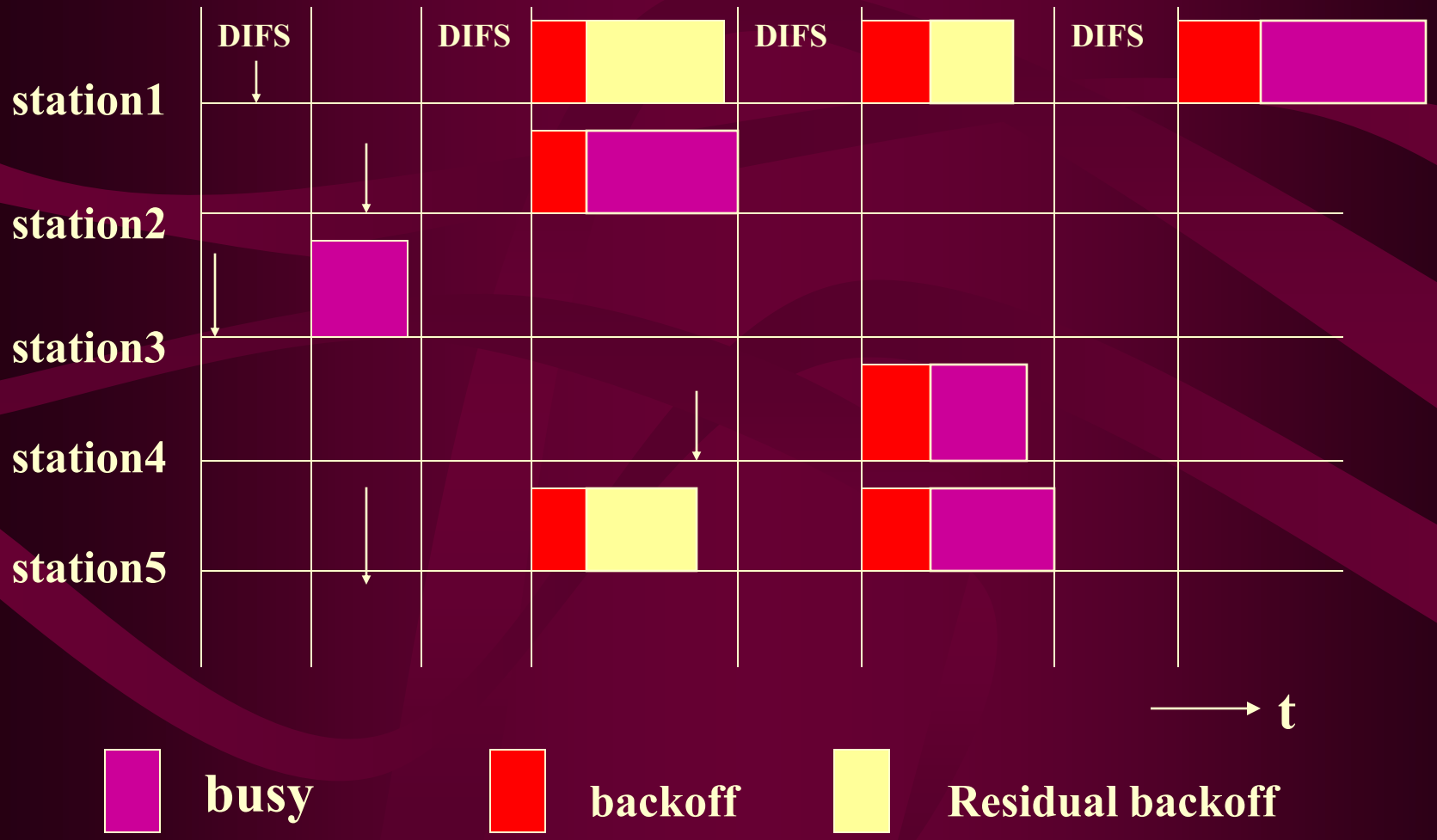


- **Hidden terminals**
  - **A and C cannot hear each other.**
  - **A sends to B, C cannot receive A.**
  - **C wants to send to B, C senses a "free" medium (CS fails)**
  - **Collision occurs at B.**
  - **A cannot receive the collision (CD fails).**
  - **A is "hidden" for C.**
- **Solution?**
  - **Hidden terminal is peculiar to wireless (not found in wired)**
  - **Need to sense carrier at receiver, not sender!**
  - **"virtual carrier sensing": Sender "asks" receiver whether it can hear something. If so, behave as if channel busy.**

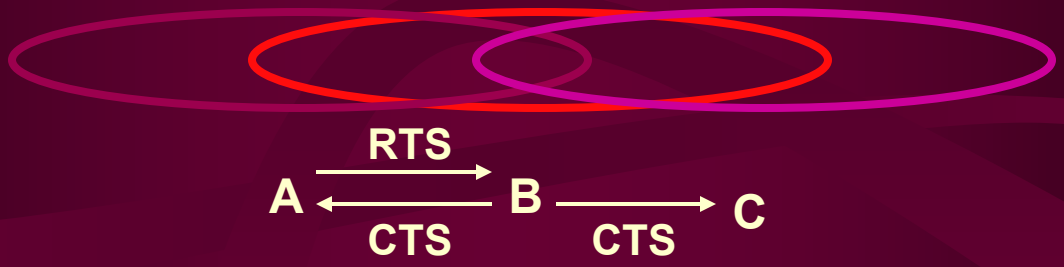
Medium access control layer

- Asynchronous data service (DCF)
  - **CSMA/CA**
  - **RTS/CTS**
- Time bounded service (PCF)
  - **Polling**
- Inter-frame spacing (IFS)
  - **DIFS**
  - **PIFS**
  - **SIFS**

CSMA/CA

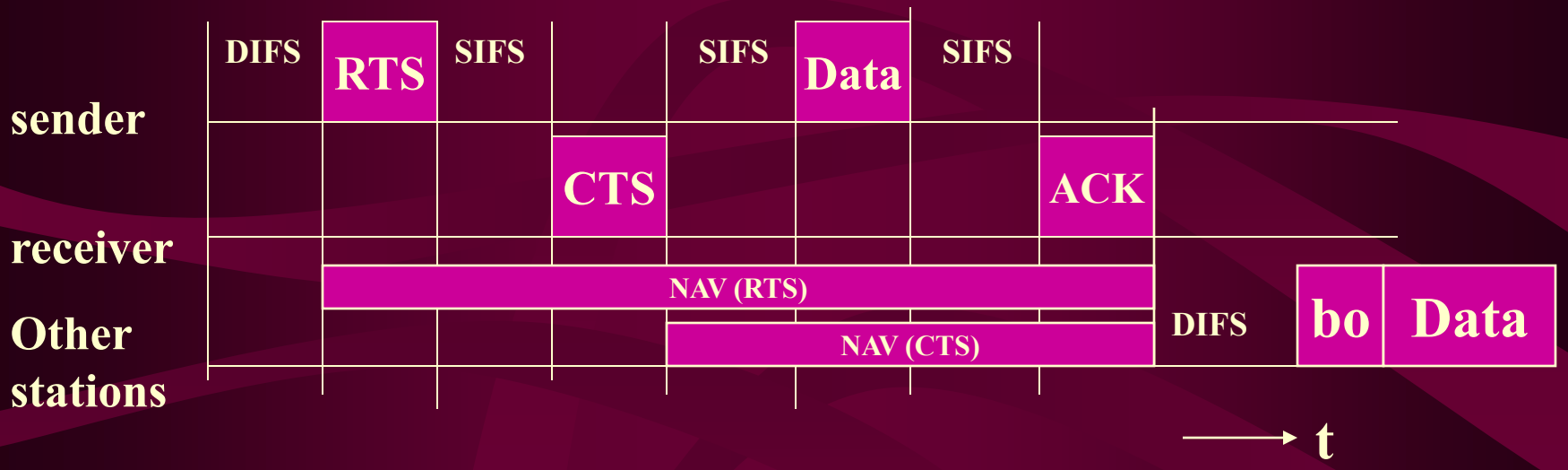

DIFS
DIFS
DIFS
DIFS
station1
station2
station3
station4
station5
t
busy
backoff
Residual backoff

RTS/CTS



- 802.11 avoids the problem of hidden terminals
  - A and C want to send to B
  - A sends RTS to B
  - B sends CTS to A
  - C "overhears" CTS from B
  - C waits for duration of A's transmission

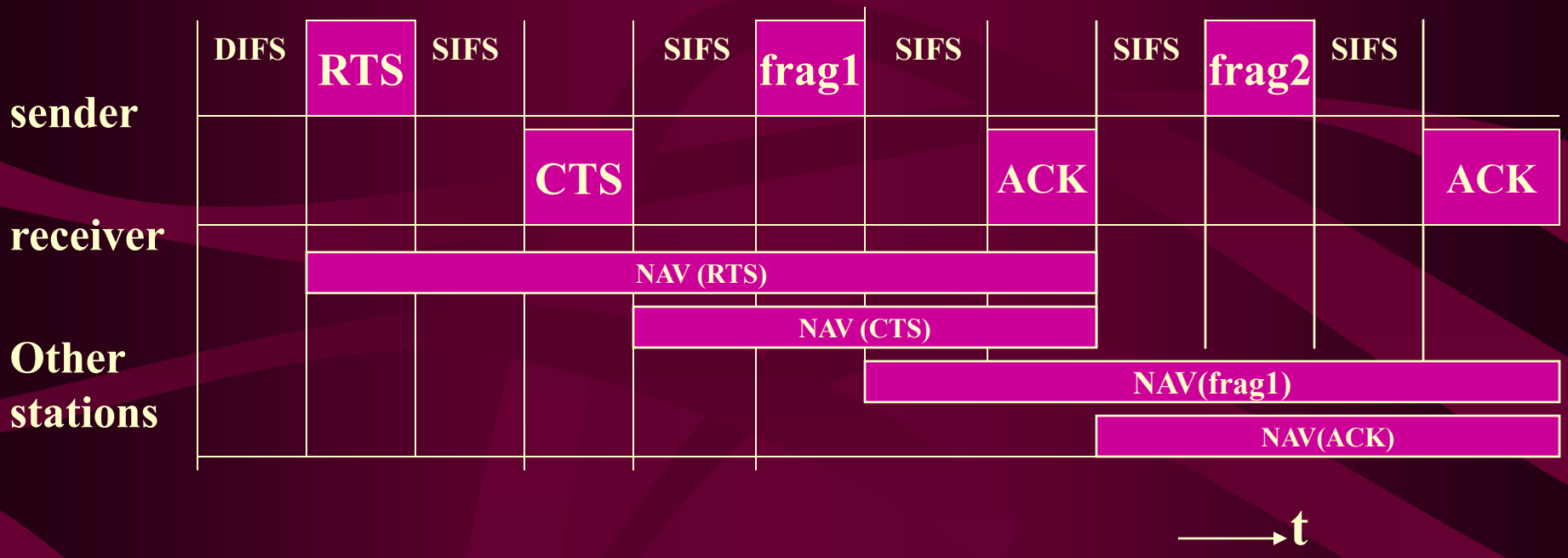
RTS/CTS


DIFS
RTS
SIFS
SIFS
Data
SIFS
sender
CTS
ACK
receiver
NAV (RTS)
Other stations
NAV (CTS)
DIFS
bo
Data
t

Fragmentation

- Wireless LANs have high bit error rates.
- The probability of erroneous frame is much higher for wireless links
- 802.11 uses fragmentation to reduce the frame error rate.

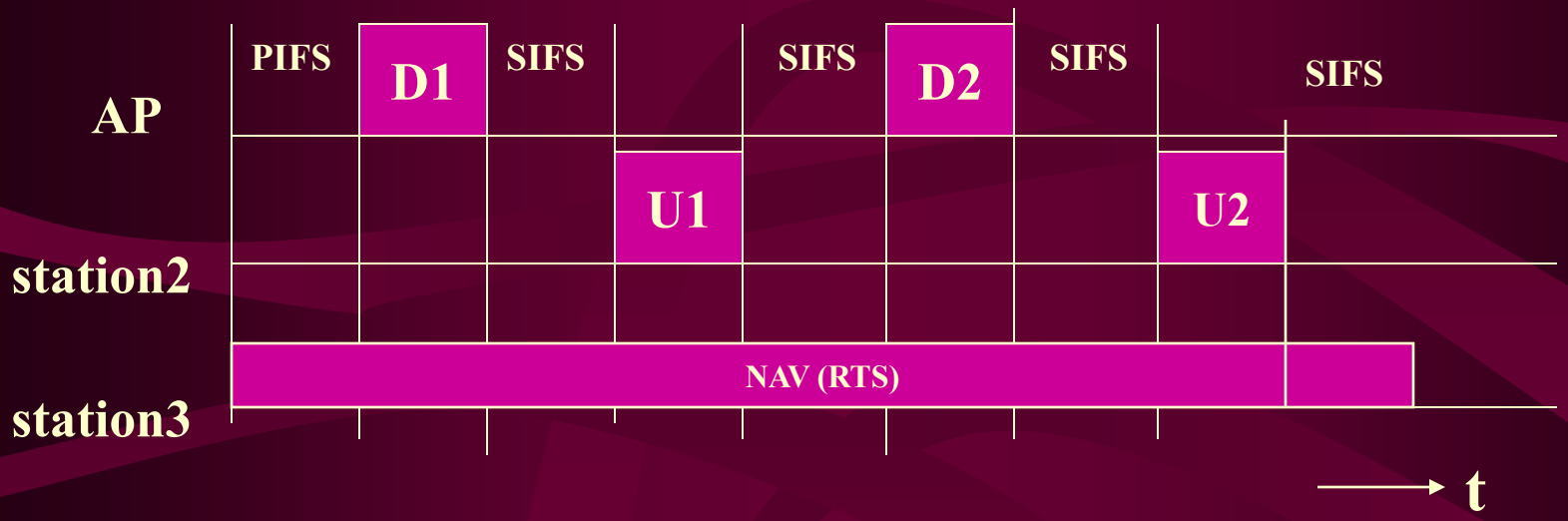
Fragmentation



PCF with Polling

- To provide time bounded service.
- Requires an access point.
- Access point polls each station during contention free period.
- Becomes an overhead during light load

PCF with polling



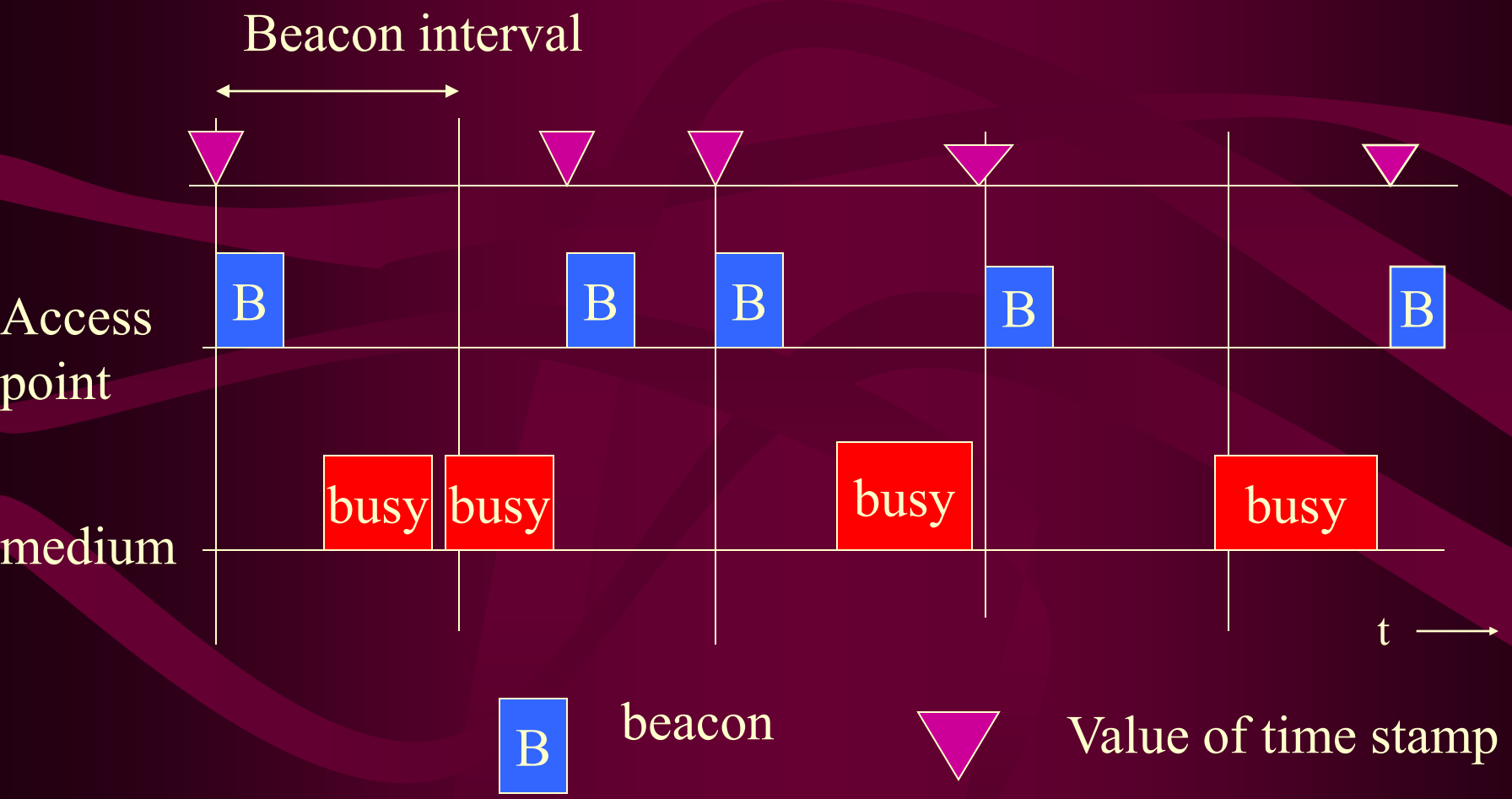
MAC management

- **Synchronization**
  - **finding and staying with a WLAN**
  - **synchronization functions**
- **Power Management**
  - **sleeping without missing any messages**
  - **power management functions**
- **Roaming**
  - **functions for joining a network**
  - **changing access points**
  - **scanning for access points**
- **Management information base**

Synchronization

- Timing synchronization function (TSF)
- Used for power management
  - beacons sent at well known intervals
  - all station timers in BSS are synchronized

Synchronization



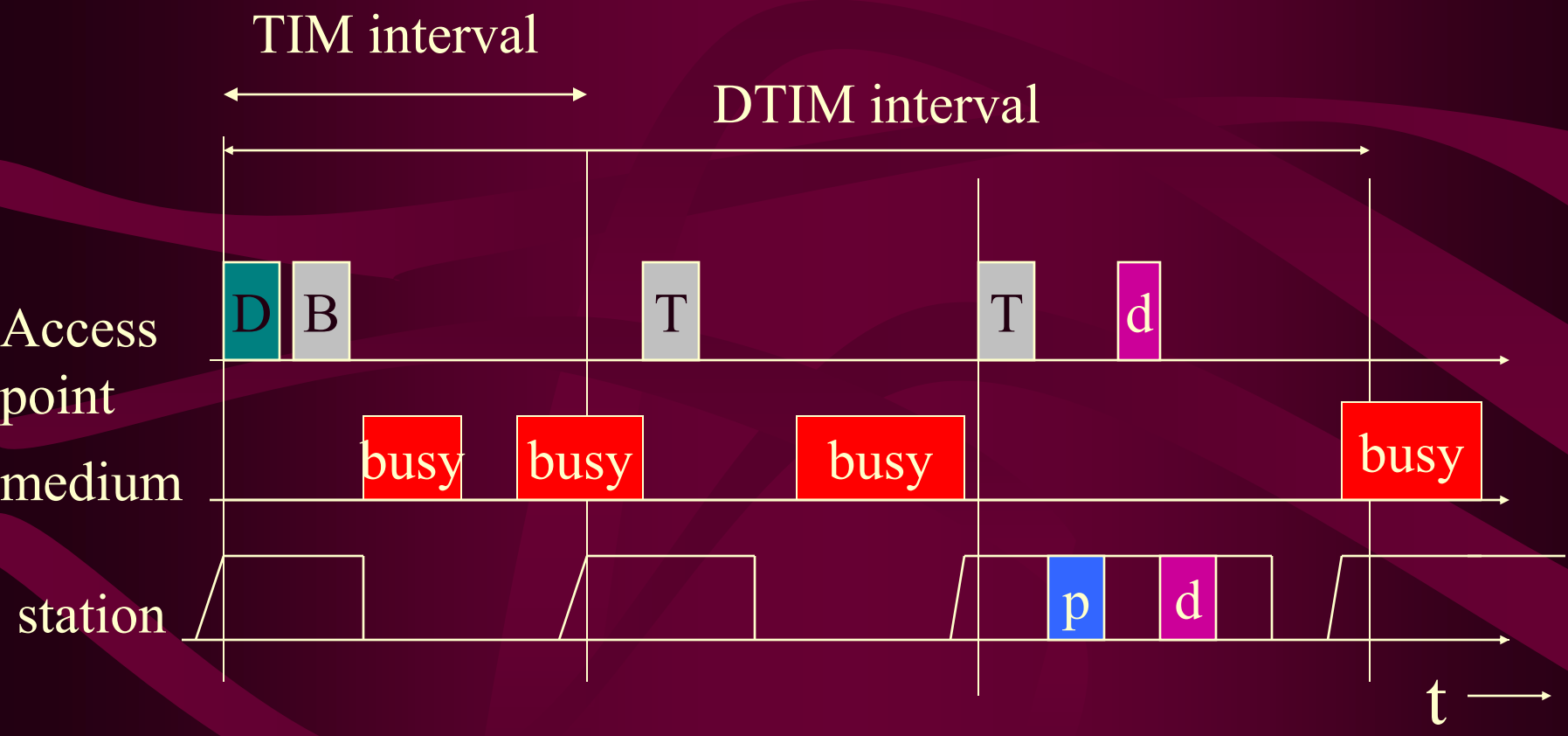
Power Management

- Mobile devices are battery powered
  - power management is important for mobility
- 802.11 power management protocol
  - allows transceiver to be off as much as possible
  - is transparent to existing protocols

Power management approach

- Allow idle stations to go to sleep
  - station's power save mode stored in AP
- APs buffer packets for sleeping stations
  - AP announces which stations have frames buffered
  - traffic indication map (TIM) sent with every beacon
- Power saving stations wake up periodically

Power management



B Broadcast/ multicast

p PS poll

d Data transmission to/from the station

Roaming

- Mobile stations may move
  - beyond the coverage area of their AP
  - but within range of another AP
- Re association allows station to continue operation.

Roaming approach

- Station decides that link to its current AP is poor.
- Station uses scanning function to find another AP
- Station sends Re-association Request to new AP
- If Re-association Response is successful
  - then station has roamed to the new AP
  - else station scans for another AP
- If AP accepts Re-association Request
  - AP indicates Re-association to the distributed system
  - Distributed system information is updated

Scanning

- **Scanning is required for many functions**
  - **finding and joining a network**
  - **finding a new access point during roaming**
- **Passive scanning**
  - **find networks simply by listening for beacons**
- **Active scanning**
  - **on each channel send a probe and wait for probe response**

References

- Brian P Crow, Indra Widjaja, J G Kim, Prescott T Sakai. IEEE 802.11 Wireless Local Area Networks. IEEE Communications Magazine
- www.breezecom.com
- Jochen H. Schiller, Mobile Communications