Unit 4 – Wireless LAN

Introduction

Infrared vs radio transmissions

Architecture of an infrastructure based IEEE 802.11 and Ad-hoc networks

Protocol architecture

Physical Layer Format of an IEEE 802.11 frame using DSSS.

Medium access control layer

MAC management- synchronization, power management, Roaming.

Bluetooth Architecture - simple Bluetooth piconet.

Characteristics of wireless LANs

- Advantages
  1. Flexibility
  2. Planning
  3. Design
  4. Robust
  5. Cost
- Disadvantages
  1. Quality of Service
  2. Proprietary Solutions
  3. Restrictions
  4. Safety and Security

Design goals for wireless LANs

- Global operation
- Low power for battery use
- License Free Operation
- Robust transmission technology
- Simplified and Spontaneous Cooperation
- Easy to use for everyone
- Protection of investment in wired networks
- Security, privacy, safety
- Transparency for applications

Comparison: infrared vs. radio transmission

- Infrared
  - uses LEDs, diffuse light, multiple reflections (walls, furniture etc.)
- Advantages
  - simple, cheap, available in many mobile devices
  - no licenses needed
  - simple shielding possible.

- Radio
  - typically using the license free ISM band at 2.4 GHz
- Advantages
  - experience from wireless WAN and mobile phones can be used
  - coverage of larger areas possible (radio can penetrate walls, furniture etc.)

Comparison: infrared vs. radio transmission

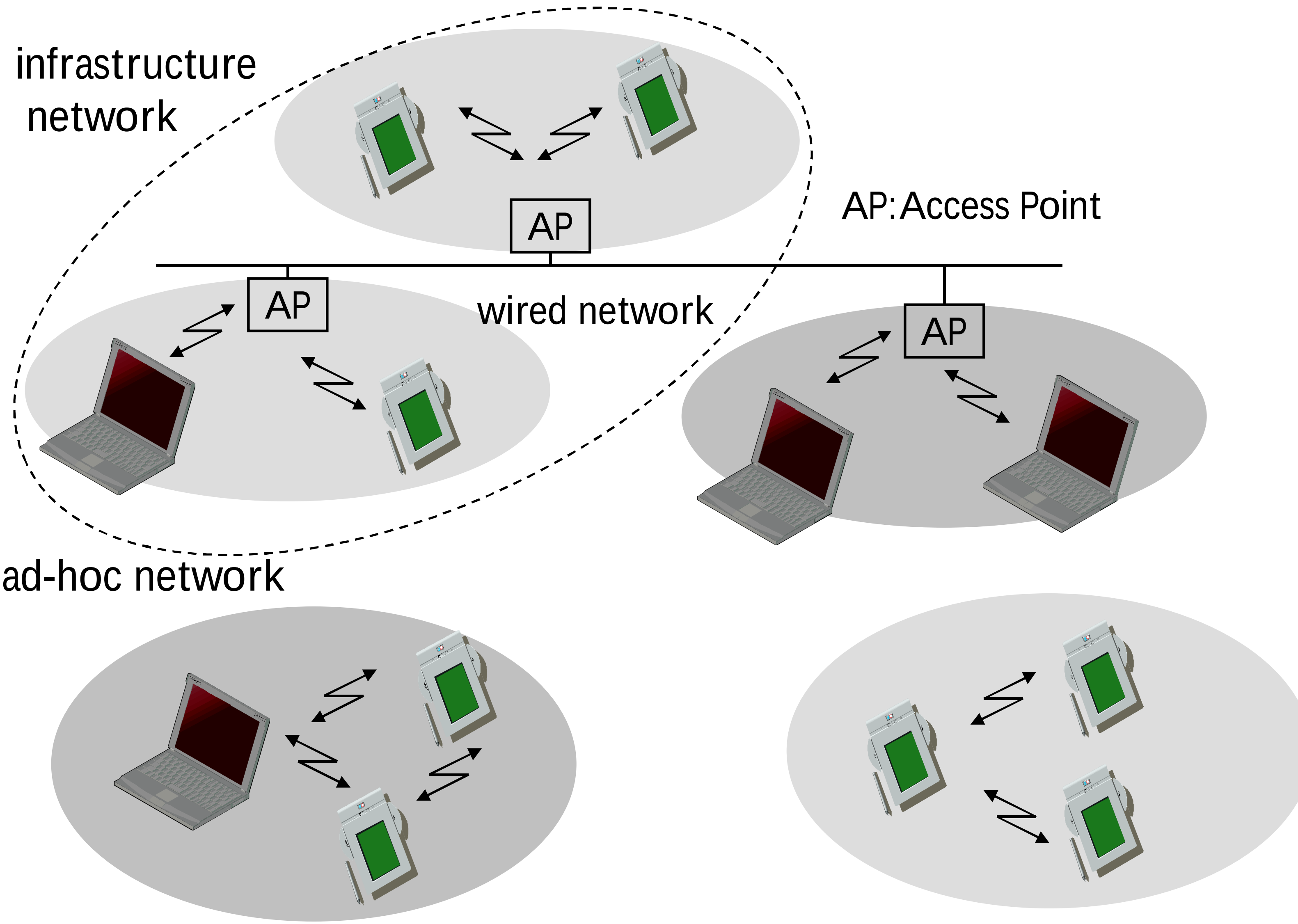
Infrared

- Disadvantages
  - interference by sunlight, heat sources etc.
  - many things shield or absorb IR light
  - low bandwidth
- Example
  - IrDA (Infrared Data Association) interface available everywhere

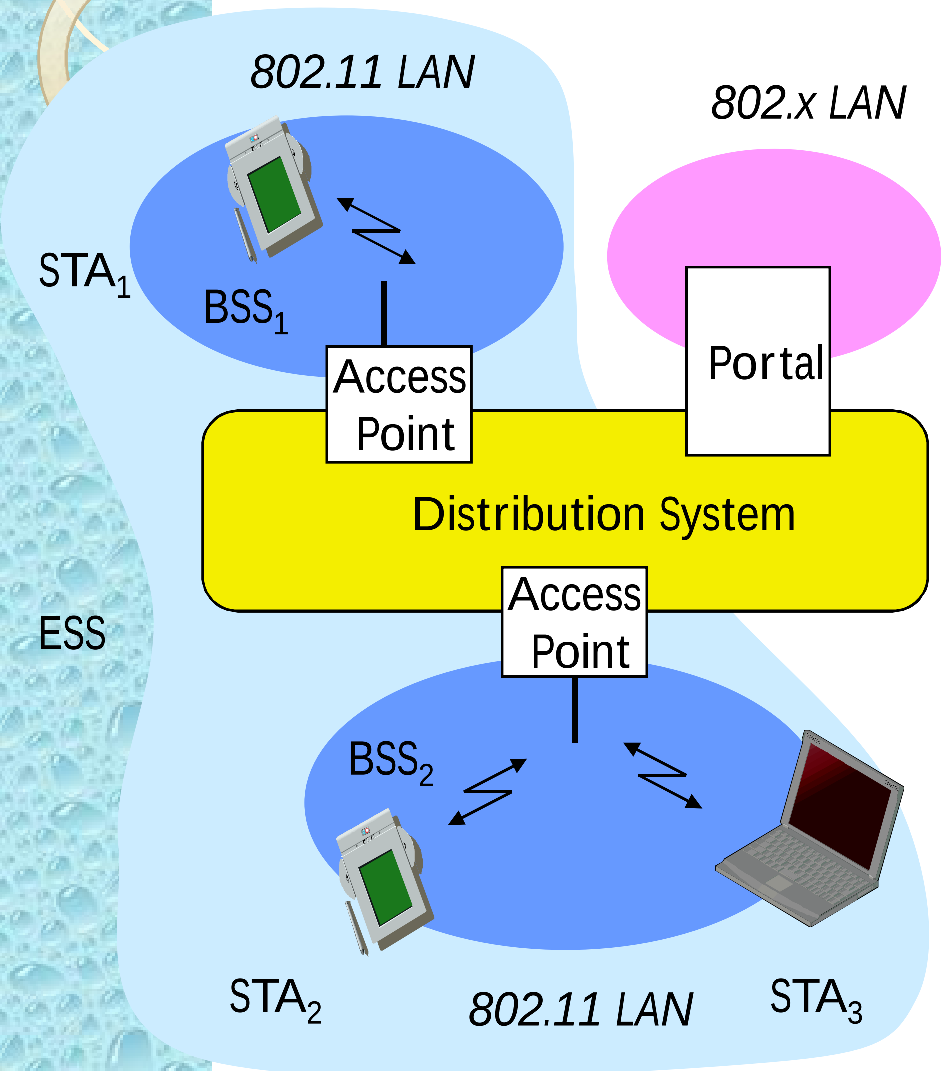
Radio

- Disadvantages
  - very limited license free frequency bands
  - shielding more difficult, interference with other electrical devices
- Example
  - WaveLAN, HIPERLAN, Bluetooth

Comparison: infrastructure vs. ad-hoc networks



802.11 - Architecture Infrastructure network



Station (STA)
access mechanisms to wireless medium and radio contact to the access point

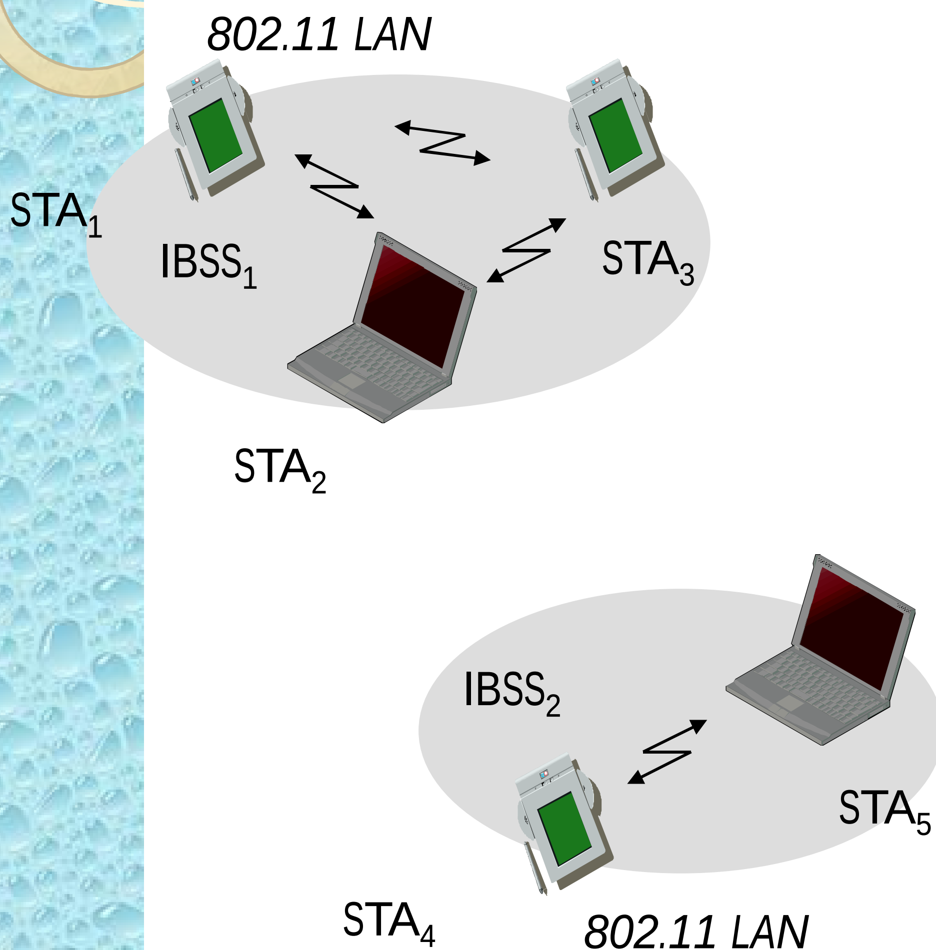
Basic Service Set (BSS)
group of stations using same radio freq.

Access Point
station integrated into wireless LAN and the distribution system.

Portal
bridge to other (wired) networks.

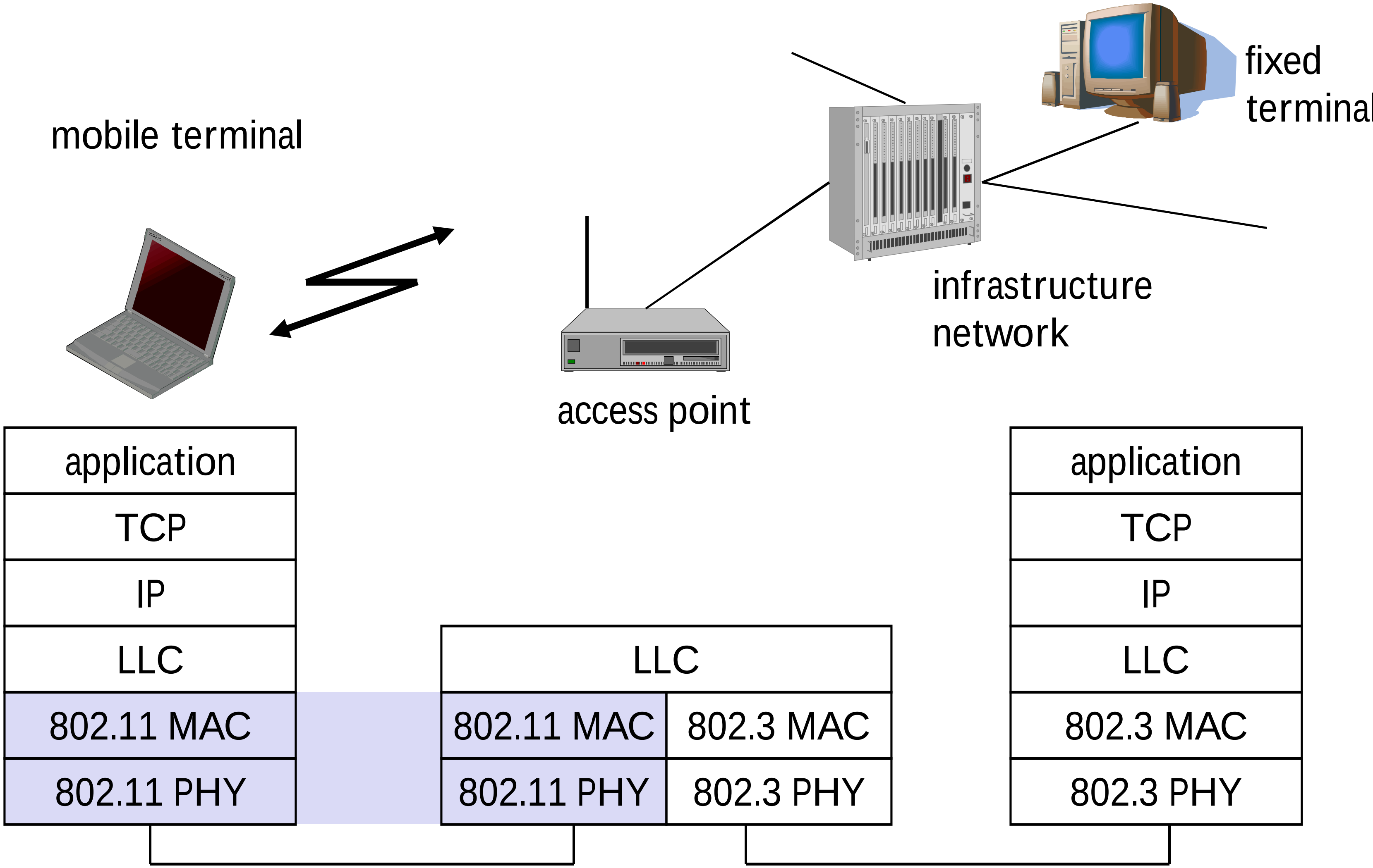
Distribution System
interconnection network to form one logical network (EES: Extended Service Set) based on several BSS.

802.11 - Architecture of an ad-hoc network



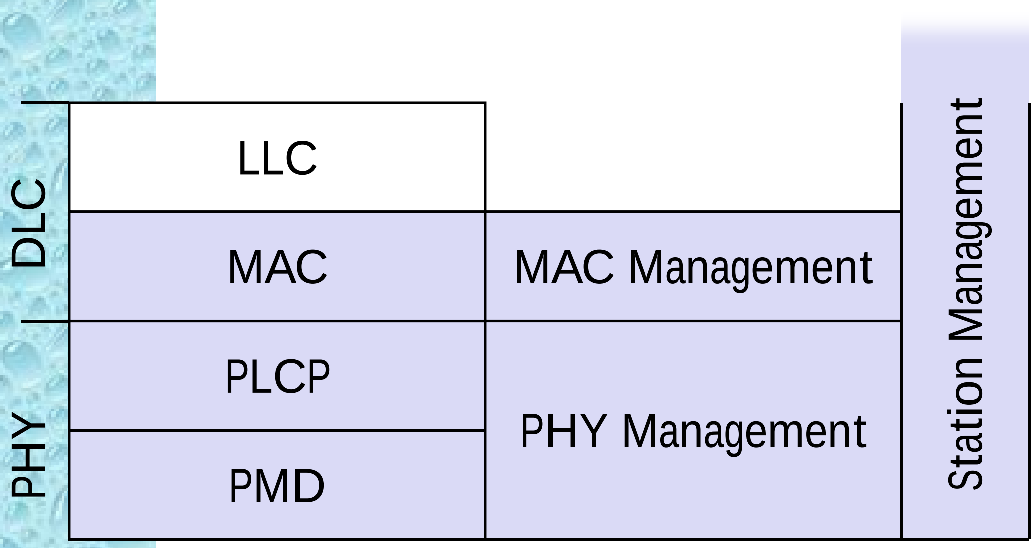
- Direct communication within a limited range
  - **Station (STA):** terminal with access mechanisms to the wireless medium
  - **Independent Basic Service Set (IBSS):** group of stations using the same radio frequency

IEEE standard 802.11 Protocols



802.11 - Layers and functions

- MAC
  - access mechanisms, fragmentation, encryption
- MAC Management
  - synchronization, roaming, power management



- PLCP Physical Layer Convergence Protocol
  - clear channel assessment signal (carrier sense)
- PMD Physical Medium Dependent
  - modulation, coding
- PHY Management
  - channel selection, MIB
- Station Management
  - coordination of all management functions

DSSS PHY packet format

- Synchronization
  - synch., gain setting, energy detection, frequency offset compensation
- SFD (Start Frame Delimiter) : 1111001110100000
- Signal : data rate of the signal
- Service : future use
- Length : length of the payload
- HEC (Header Error Check)
  - protection of signal by using checksum.

128	16	8	8	16	16	variable	bits
synchronization	SFD	signal	service	length	HEC	payload	
PLCP preamble		PLCP header					

OLD

802.11 - MAC layer : Services

- Basic Services:

1. Asynchronous Data Service

    - Available in both modes
    - mandatory service
    - supports multicast and broadcast.
    - uses Distributed Co-ordinated Function (DCF)

2. Time Bounded Service

    - Not available in ad-hoc mode.
    - optional service
    - used for polling
    - uses Point Co-ordinated Function (PCF).

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802.11 - MAC layer : Access Methods

DFWMAC (Distributed Foundation Wireless MAC)

- 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

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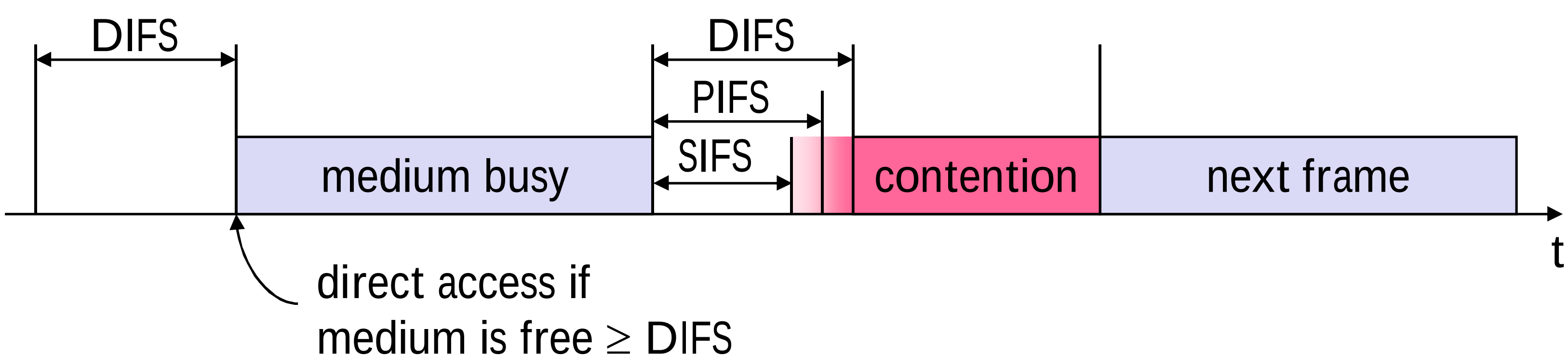
802.11 - MAC layer

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 IFS)-
  - lowest priority, for asynchronous data service



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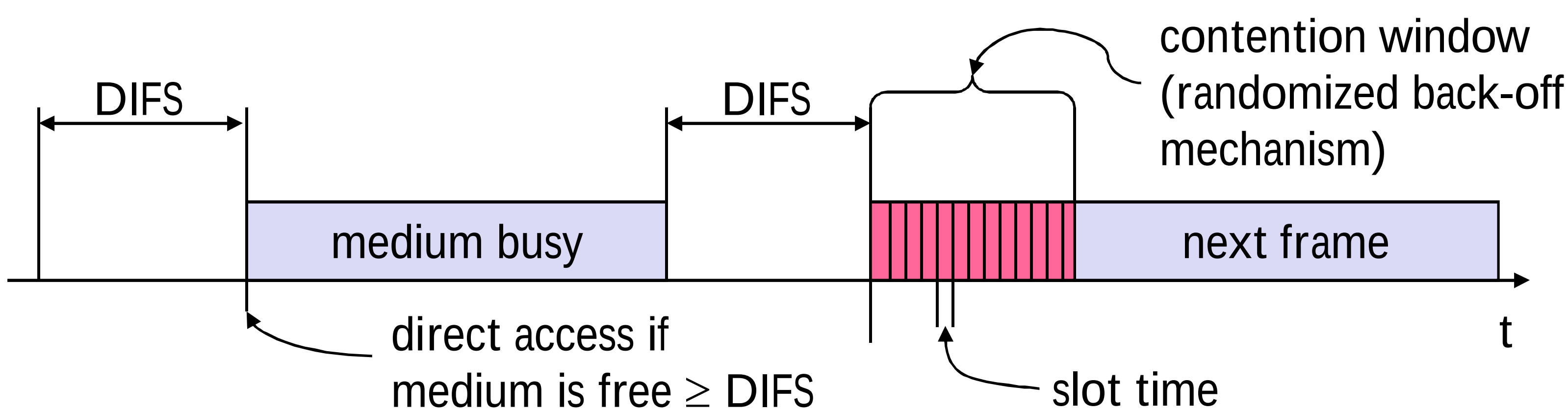
Basic DFWMAC-DCF using CSMA/CA

- station ready to send starts sensing the medium (CCA)
- 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)



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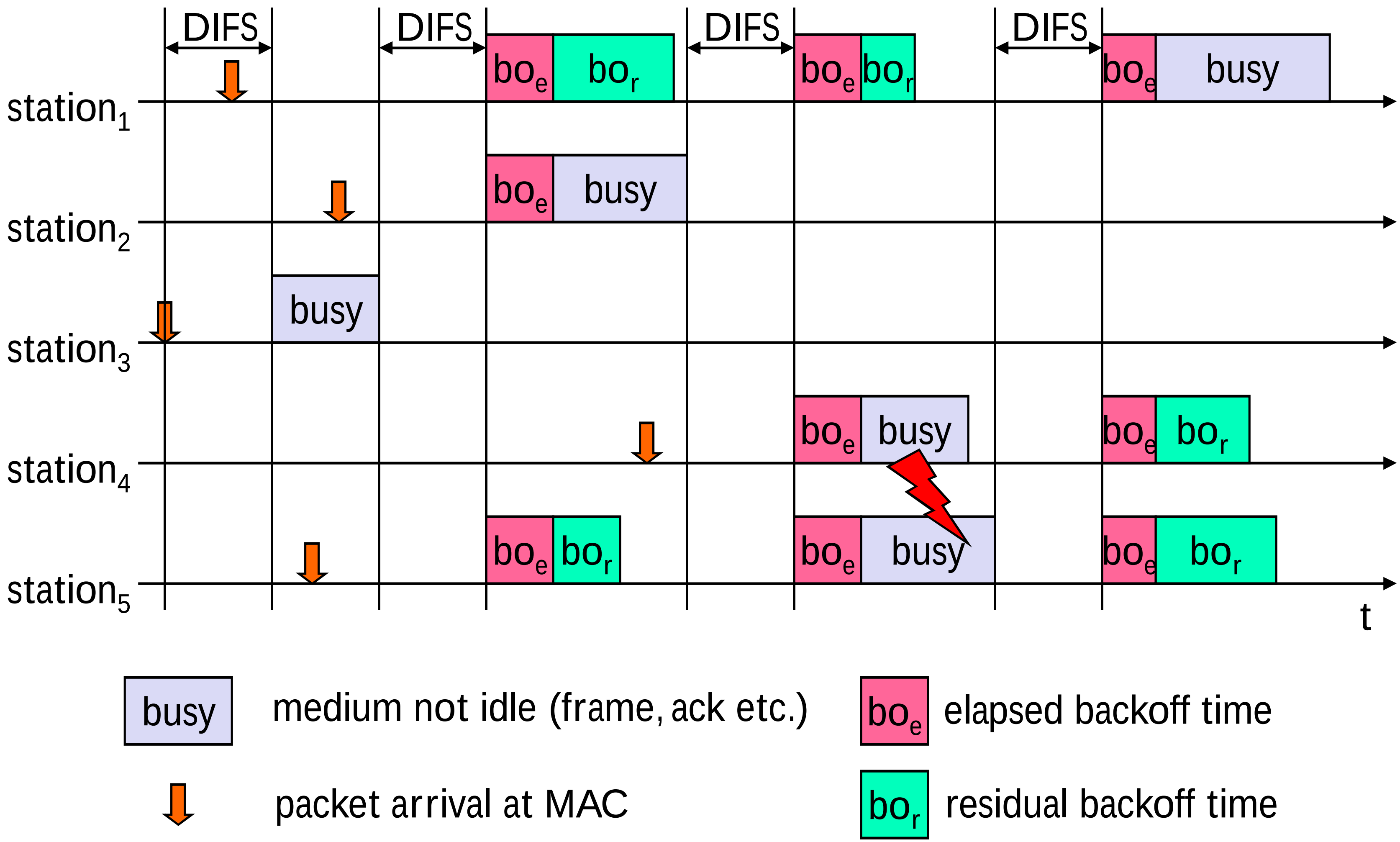

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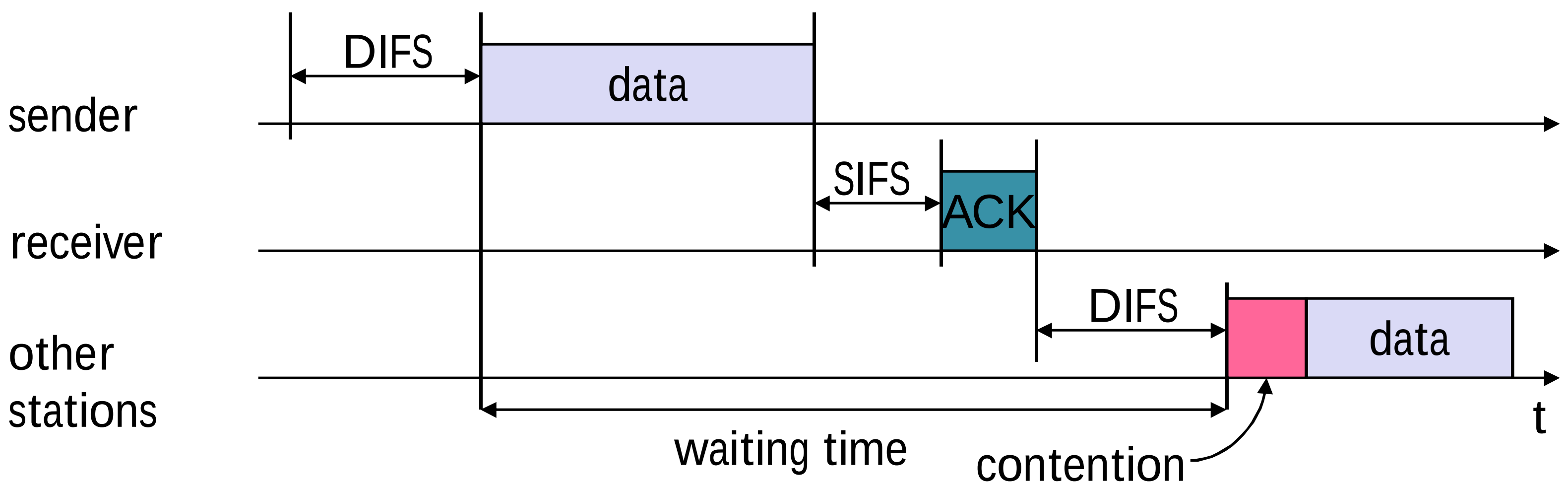
Basic DFWMAC-DCF using CSMA/CA

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



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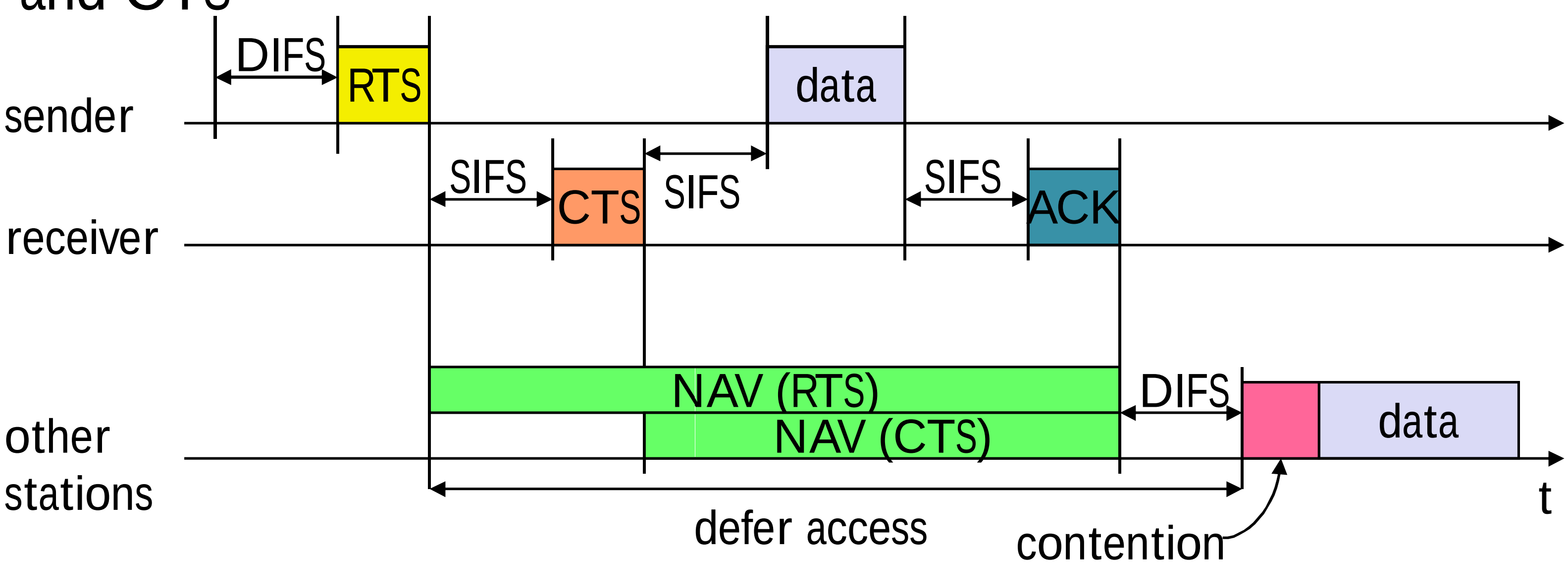
DFWMAC-DCF with RTS/CTS Extension

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.
- sender can now send data at once, acknowledgement via ACK
- other stations store medium reservations distributed via RTS and CTS



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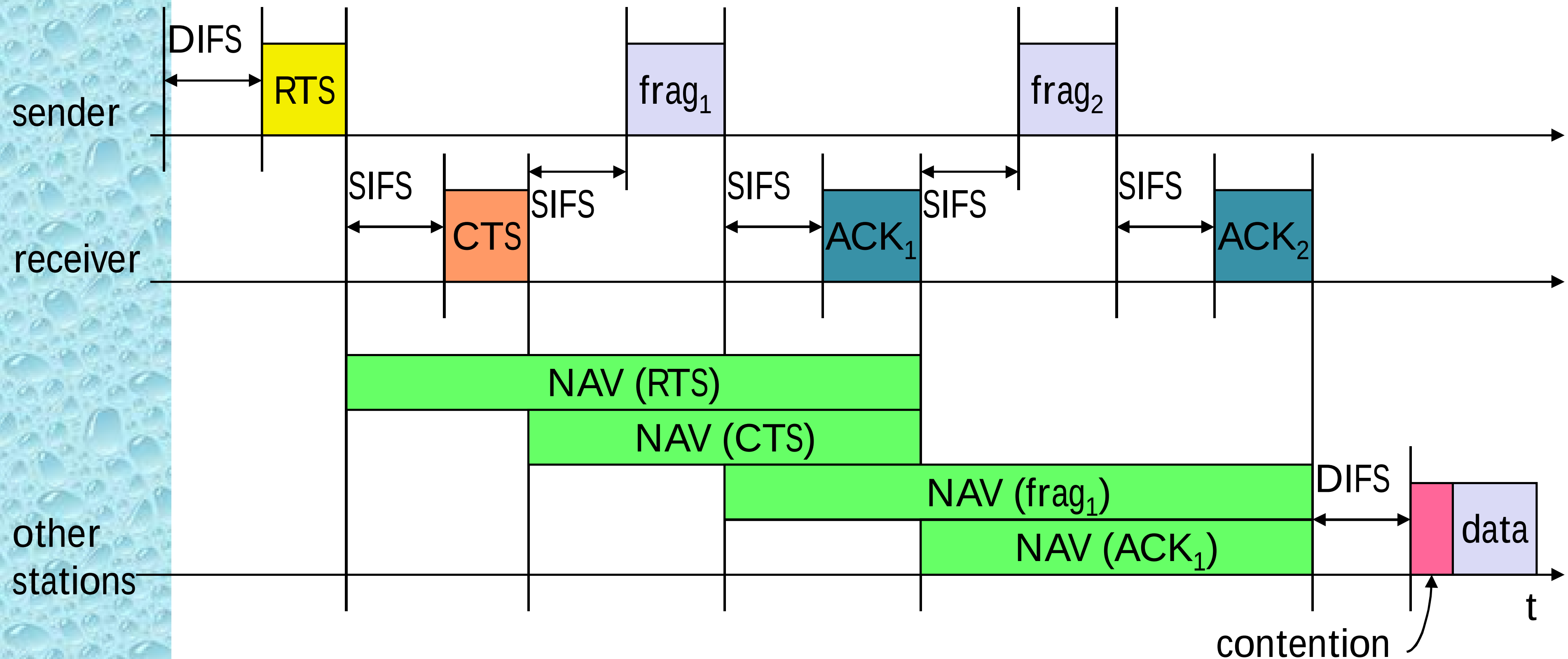
DFWMAC-DCF with RTS/CTS Extension

Fragmentation



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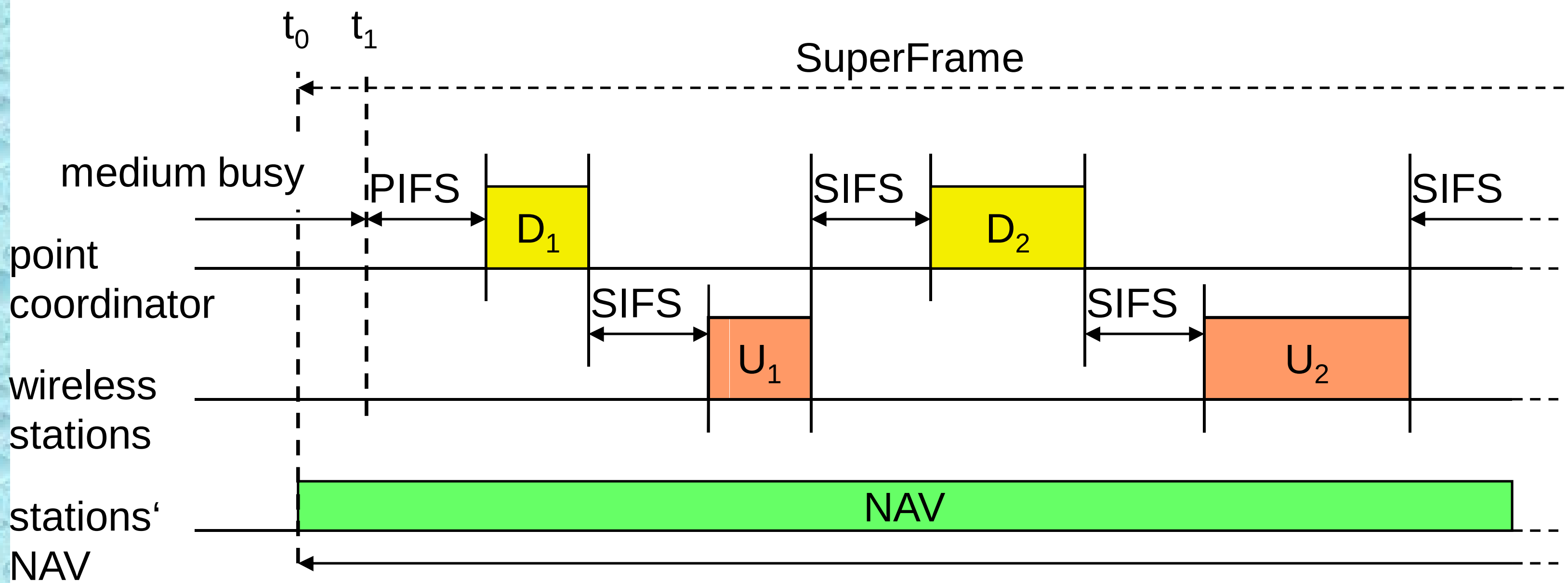
DFWMAC-PCF with Polling

- At t0 - contention period starts but medium is busy.
- After medium become idle at t1 point coordinator has to wait for PIFS time before accessing the medium.
- PIFS is smaller than DIFS, no other station can start sending earlier.
- Point coordinator now sends downstream for each station.
- Station can answer once after waiting for SIFS time.



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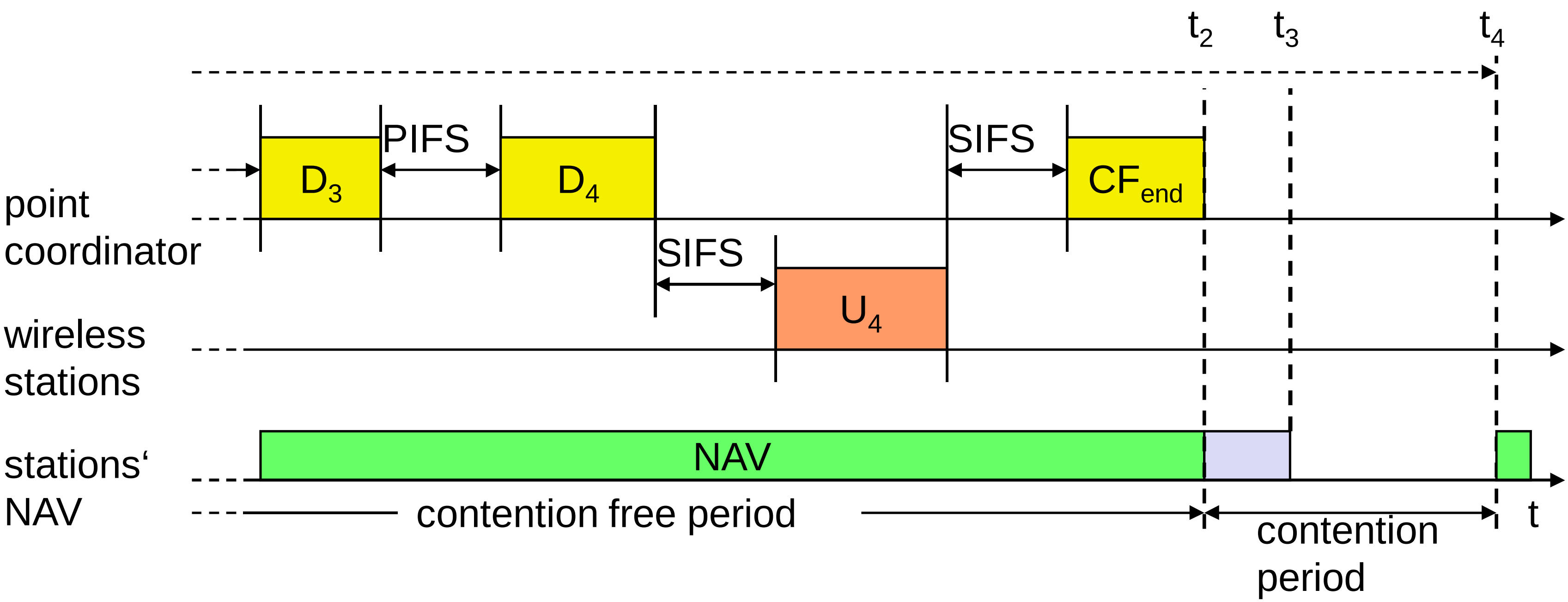
DFWMAC-PCF with Polling

- Polling continues with third node. This time node has nothing to answer. Thus point coordinator will not receive anything after SIFS time.
- After waiting for PIFS time point coordinator resumes polling the stations.
- Finally point coordinator will send CFend to indicate end of polling and then contention period will start again.



MAC Frames

bytes	2	2	6	6	6	2	6	0-2312	4
	Frame Control	Duration/ ID	Address 1	Address 2	Address 3	Sequence Control	Address 4	Data	CRC

bits	2	2	4	1	1	1	1	1	1	1	1
	Protocol version	Type	Subtype	To DS	From DS	More Frag	Retry	Power Mgmt	More Data	WEP	Order

- Frame Control
- Duration ID – The field value < 32768 indicates time for which medium is occupied in M--s. Other values are reserved
- Sequence Control - important against duplicated frames due to lost ACKs
- Data
- Checksum(CRC)

MAC Frames – Frame Control

- Protocol Version
- Current protocol version is fixed to 0.
- Further major revisions in protocol will increase the number.
- Type
- 00 : Management Frame
- 01 : Control Frame
- 10 : Data
- 11 : Reserved
- Sub Type
- 0000 : Association Request / User data
- 1000 : Beacon
- 1011 : RTS
- 1100 : CTS

MAC Frames – Frame Control

- More Fragments
- Set to 1 for frame that have another fragment of data
- Retry
- If current frame is retransmission of previous frame then it is set to 1
- Power Management
- 1 : Station goes in power saving mode
- 0 : Station is in active mode
- More Data
- Used to indicate to receiver that sender has more data to send than the current frame.

MAC Frames – Frame Control

- Wired Equivalent Privacy (WEP)

– indicates standard security mechanism.

- Order

- 1 : received frames must be processed in strict order.

scenario	to DS	from DS	address 1	address 2	address 3	address 4
ad-hoc network	0	0	DA	SA	BSSID	-
infrastructure network, from AP	0	1	DA	BSSID	SA	-
infrastructure network, to AP	1	0	BSSID	SA	DA	-
infrastructure network, within DS	1	1	RA	TA	DA	SA

DS: Distribution System

AP: Access Point

DA: Destination Address

SA: Source Address

BSSID: Basic Service Set Identifier

RA: Receiver Address

TA: Transmitter Address

MAC Frames - Special Frames

- Acknowledgement

bytes	2	2	6	4
ACK	Frame Control	Duration	Receiver Address	CRC

- Request To Send

bytes	2	2	6	6	4
RTS	Frame Control	Duration	Receiver Address	Transmitter Address	CRC

- Clear To Send

bytes	2	2	6	4
CTS	Frame Control	Duration	Receiver Address	CRC

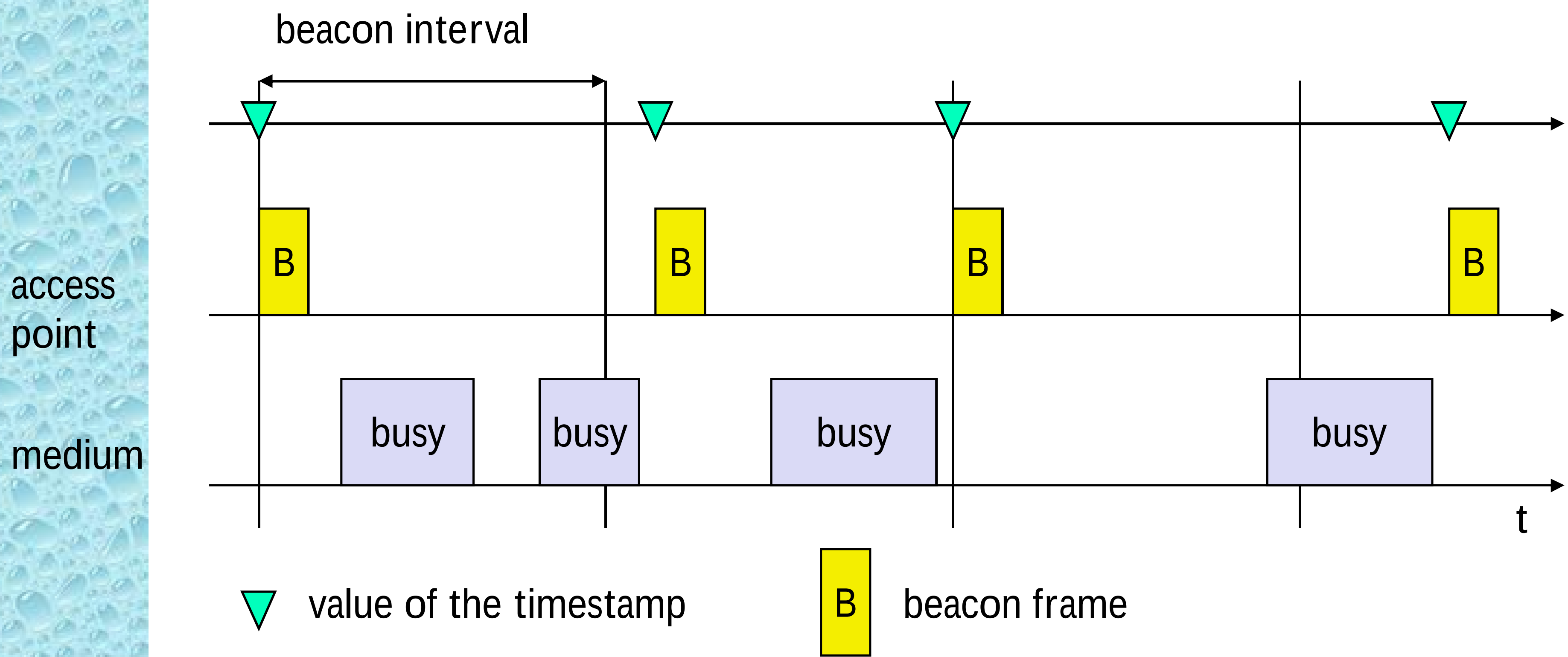
Synchronization – Infrastructure Mode

- Uses TSF (Timing Synchronization Function)
- Achieved by sending beacon frame periodically from Access point to other connected nodes in BSS.
- Beacon contains –

timestamp and other necessary info for power management and roaming.

- According to beacon signal, other wireless nodes adjust their local timers according to the timestamp.
- "Access point is not always able to send beacon frame periodically if medium is busy but tries to schedule transmission according to expected Beacon interval."

Synchronization (Infrastructure Mode)



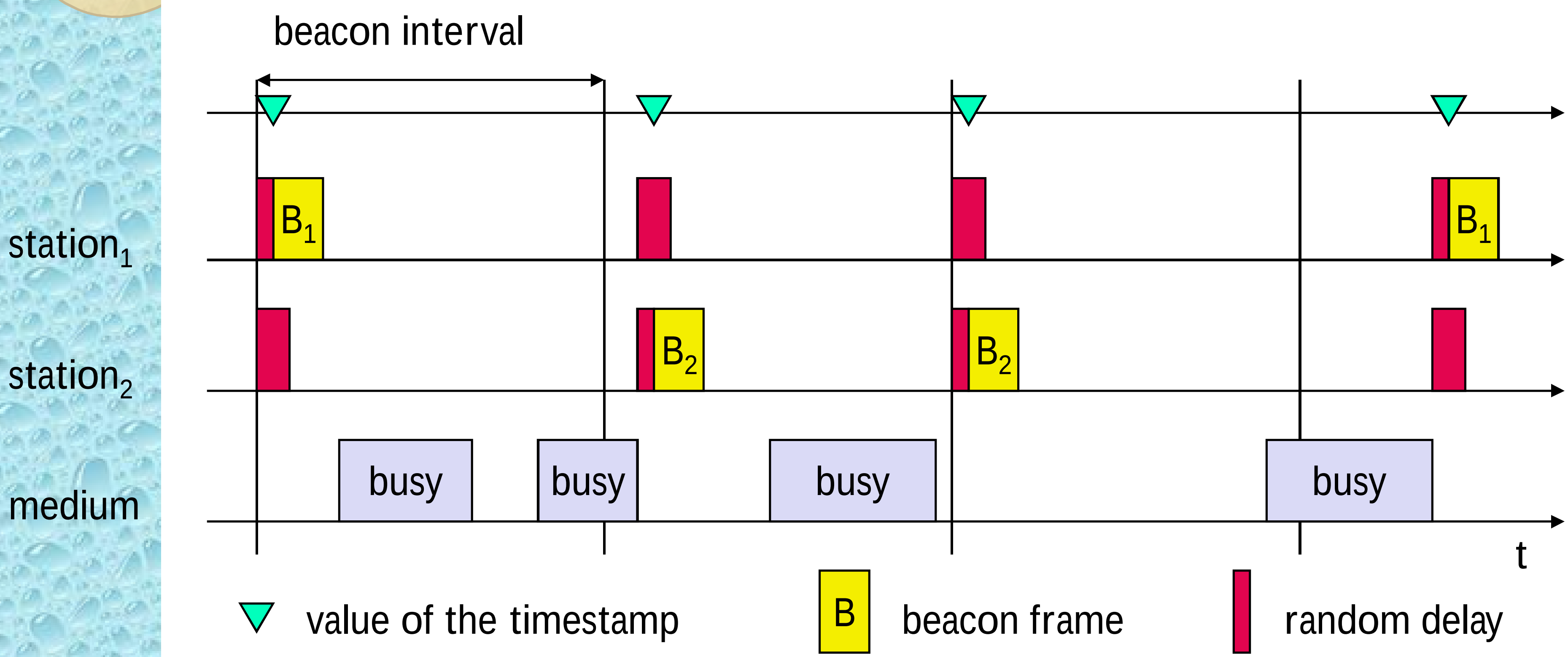
Synchronization – Ad hoc mode

- Each node maintains it's own synchronization times and starts transmission of Beacon frame after Beacon interval.
- The standard back off algorithm is also applied to Beacon frames, so only one frame wins.

All other stations adjust their intervals according to it.

- If collision occurs then Beacon frame will lost, then Beacon intervals shifted slightly.

Synchronization (Ad hoc Mode)



Power Management

- Basic Idea : Switch of transceiver whenever it is not needed.
- Two states for station

1. Sleep
2. Awake

- For power management TSF (Timing Synchronization) function is used.

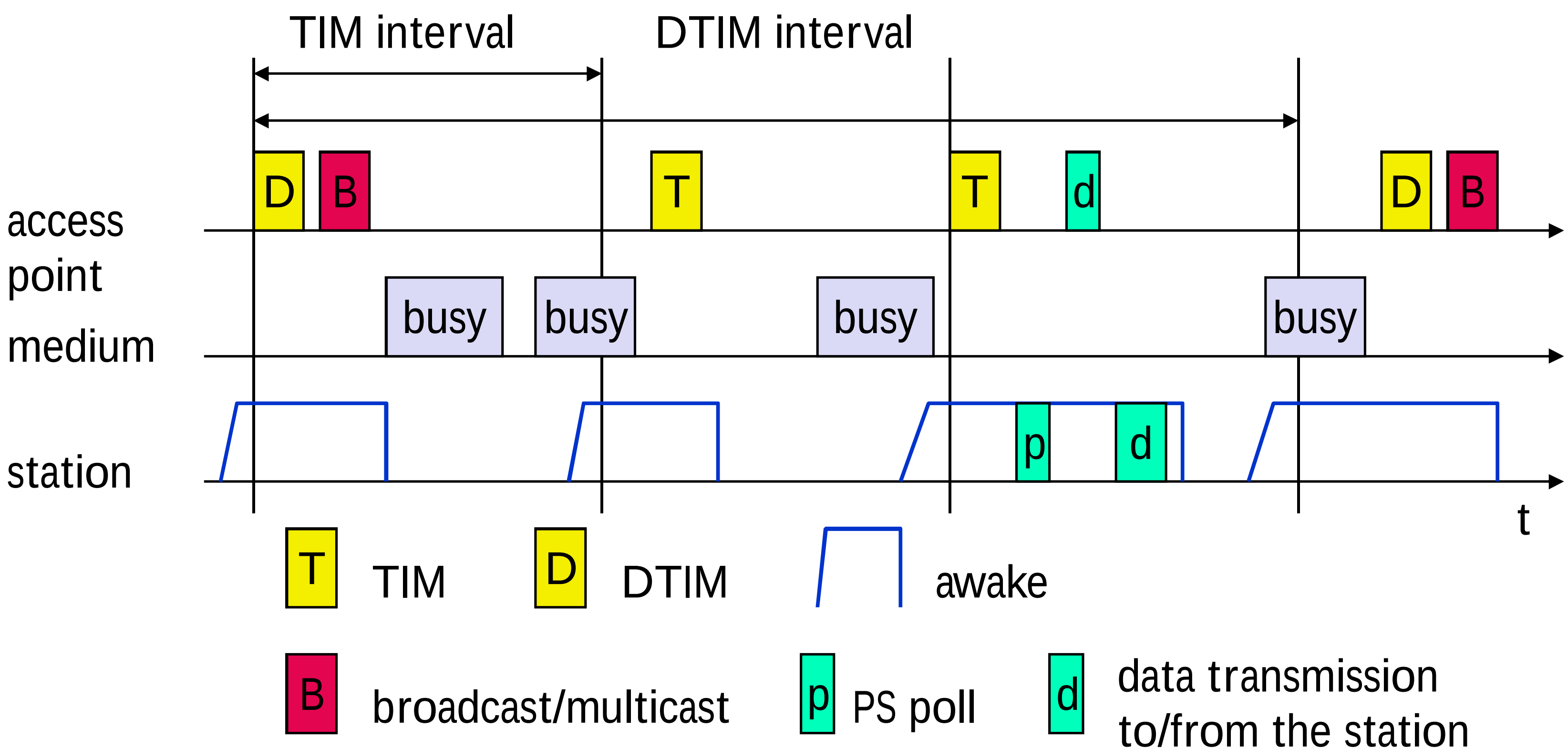
Power Management – Infrastructure Mode

- Access Point maintains two types of lists

1. TIM (Traffic Indication Map) : List of Unicast Receivers for message transmitted by Access Point,
2. DTIM (Delivery Traffic Indication Map) : Broadcast / multicast receivers.

- Access Point buffers all frames to be transmitted for TIM.
- Access Point sends TIM and DTIM after TIM interval and DTIM interval respectively.
- DTIM interval is multiple of TIM interval.

Power Saving (Infrastructure Mode)



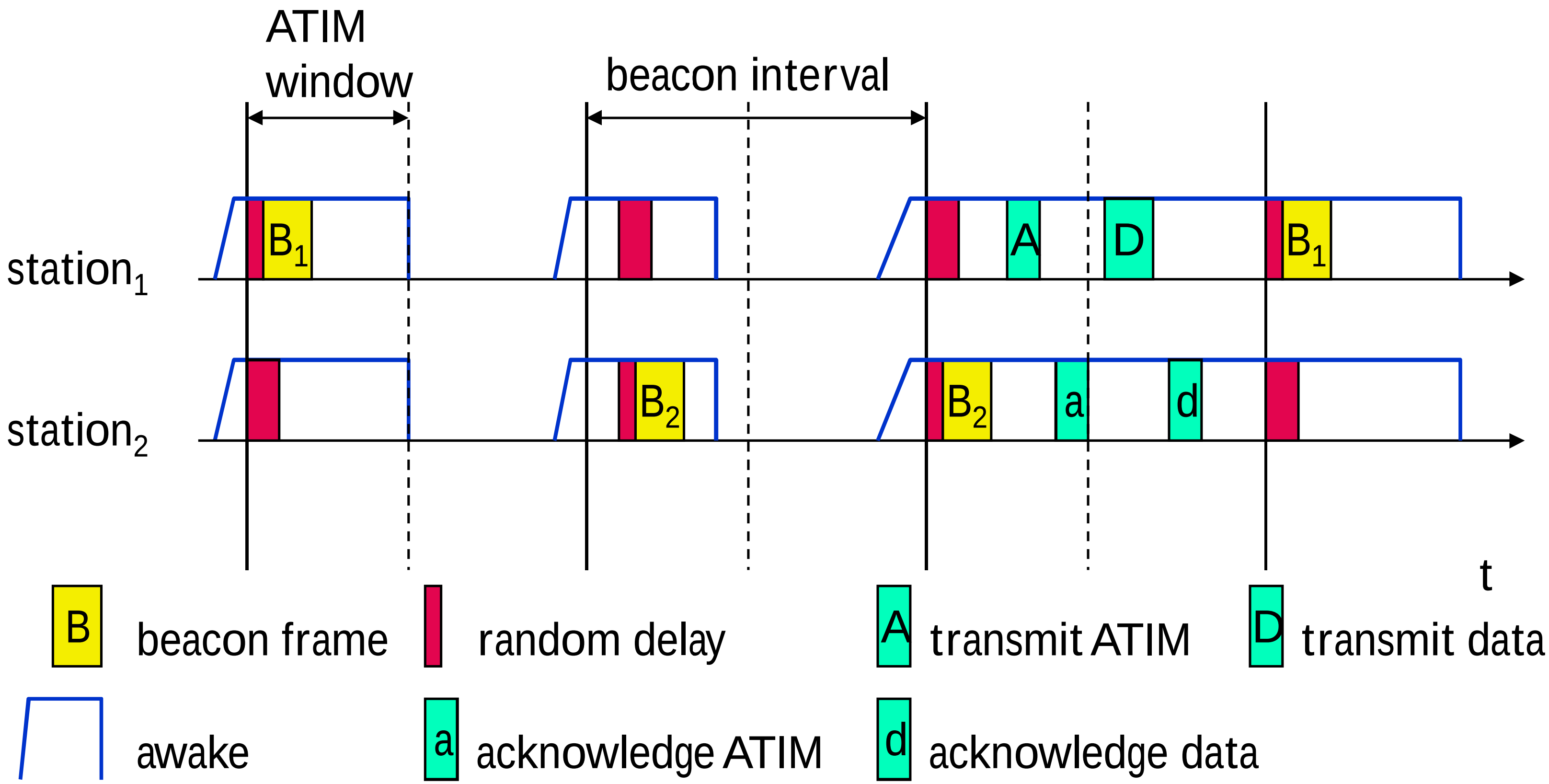
Power Management – Ad hoc mode

- Each station maintains ATIM (Ad-hoc TIM).
- ATIM is announcement of receivers by sender.
- All stations wake up before ATIM.
- If no frame is buffered for the station then that station goes in sleep mode.
- Synchronization (Beacon) is necessary in this scenario.

Drawbacks:

1. No QoS guarantee under heavy load.
2. Collision of ATIMs is possible.

Power Saving (Ad hoc Mode)



Bluetooth Characteristics

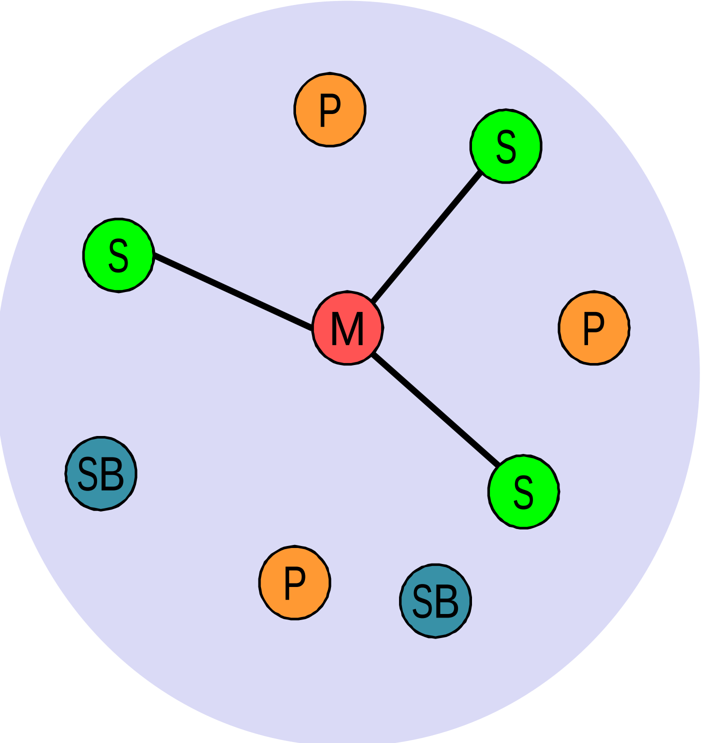
- 2.4 GHz ISM band, 79 RF channels, 1 MHz carrier spacing
  - Channel 0: 2402 MHz … channel 78: 2480 MHz
  - FSK modulation, 1-100 mW transmit power
- FHSS and TDD
  - Frequency hopping with 1600 hops/s
  - Hopping sequence in a pseudo random fashion, determined by a master
  - Time division duplex for send/receive separation

Bluetooth Characteristics

- Voice link – SCO (Synchronous Connection Oriented)
  - FEC (forward error correction), no retransmission, 64 kbit/s duplex, point-to-point, circuit switched
- Data link – ACL (Asynchronous ConnectionLess)
  - Asynchronous, fast acknowledge, point-to-multipoint, up to 433.9 kbit/s symmetric or 723.2/57.6 kbit/s asymmetric, packet switched
- Topology
  - Overlapping piconets (stars) forming a scatternet

Piconet -Architecture

- One unit acts as master and the others as slaves for the lifetime of the piconet
- Master determines hopping pattern, slaves have to synchronize
- Each piconet has a unique hopping pattern
- Participation in a piconet = synchronization to hopping sequence
- Each piconet has one master and up to 7 simultaneous slaves (> 200 could be parked)

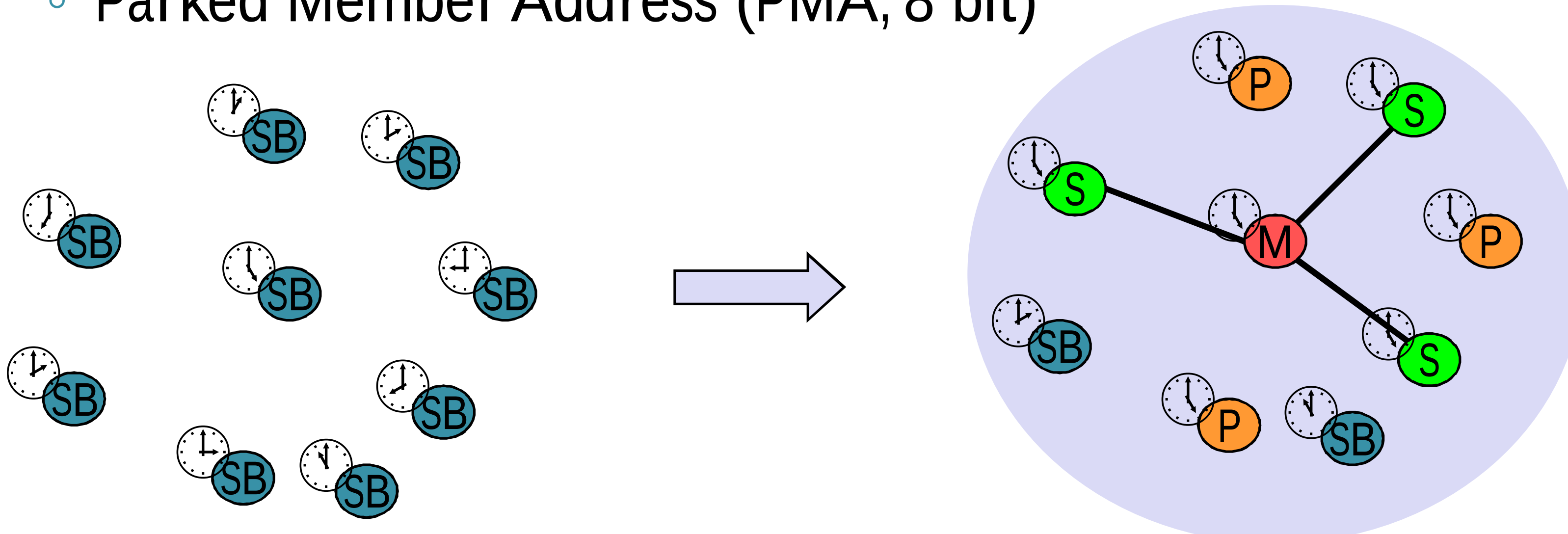


M=Master
S=Slave

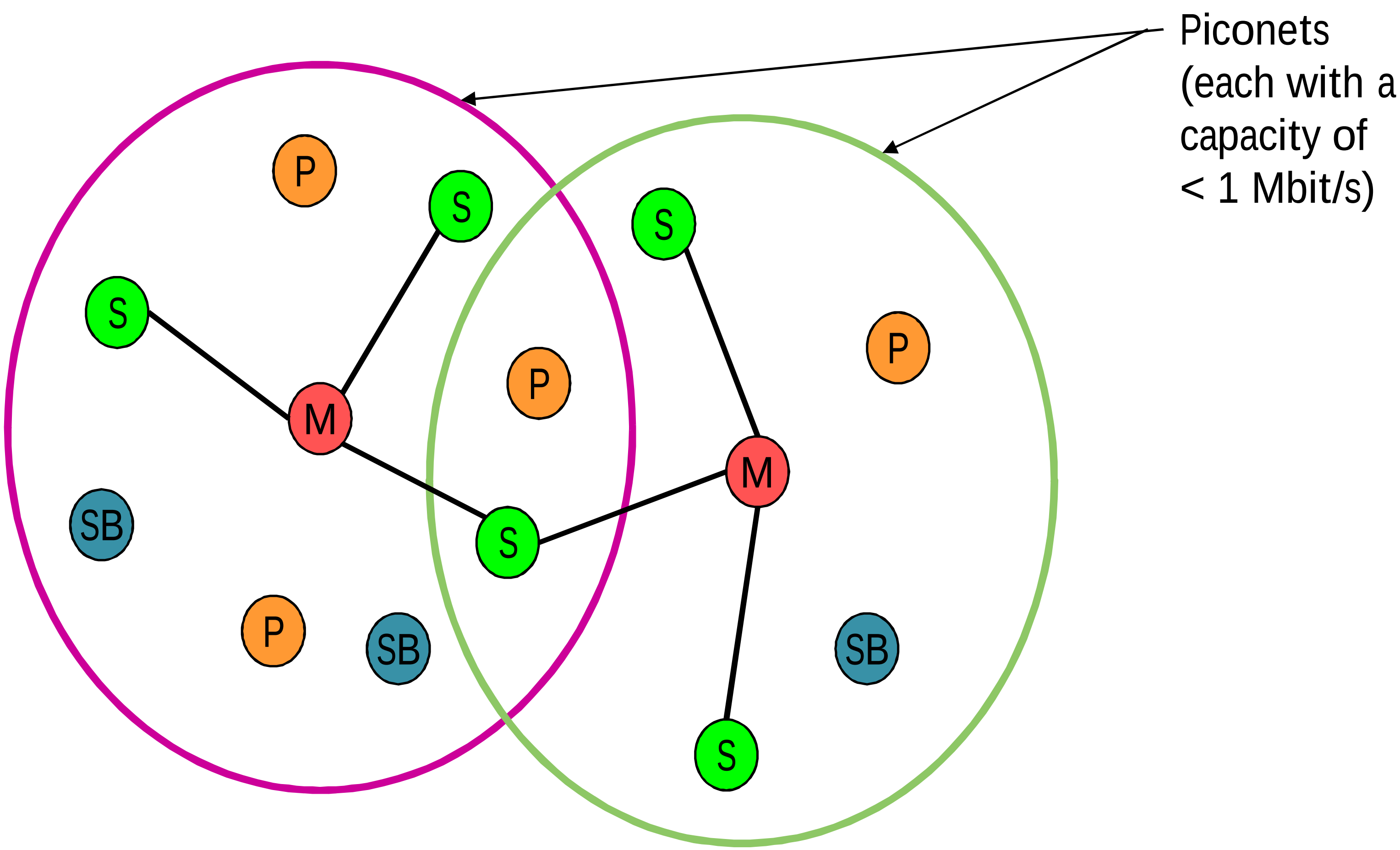
P=Parked
SB=Standby

Forming a Simple Bluetooth Piconet

- All devices in a piconet hop together
  - Master gives slaves its clock and device ID
    - Hopping pattern: determined by device ID (48 bit, unique worldwide)
    - Phase in hopping pattern determined by clock
- Addressing
  - Active Member Address (AMA, 3 bit)
  - Parked Member Address (PMA, 8 bit)



Scatternet



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