

Communication in Distributed Systems

Kommunikation in verteilten Systemen

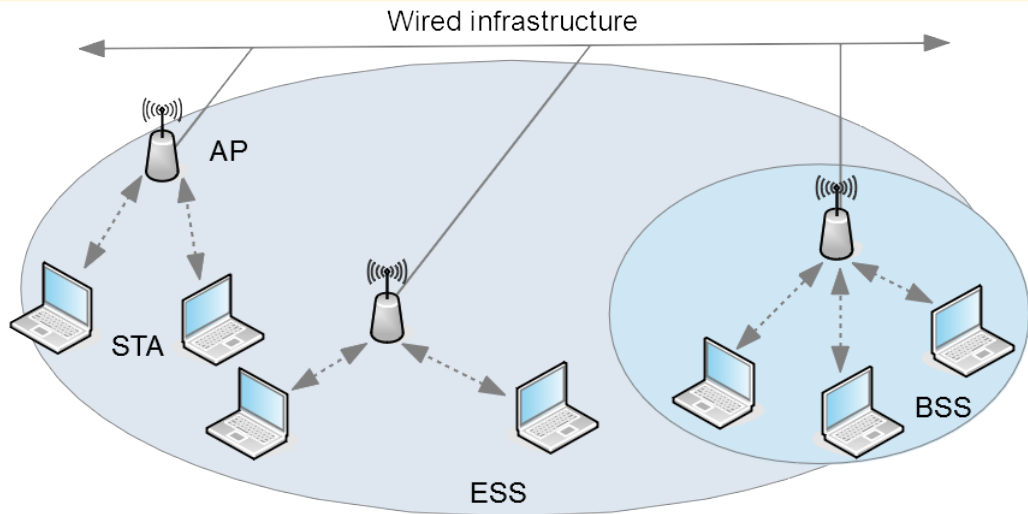
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Summer Term 2021



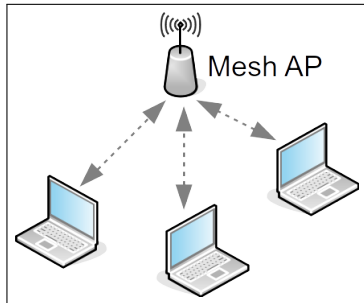
Classical IEEE 802.11 Network



WiFi Modes

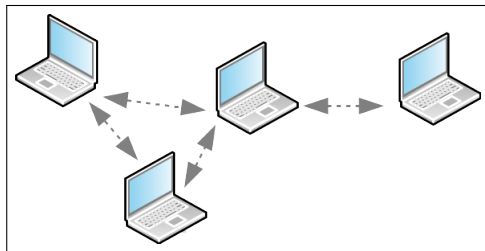
Infrastructure Mode

- wireless nodes connected to AP



Ad-Hoc mode

- wireless nodes connected to each other



Wireless Link Characteristics

Important differences from wired links...

- radio signal attenuates with distance (free space path loss)
- interference from other sources
- multipath propagation, reflection

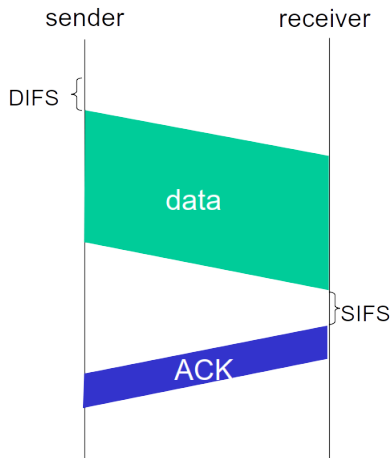
... makes wireless communication challenging.

Wireless Channels

- 2.4 GHz spectrum (2.4 - 2.485 GHz) divided in 11 channels
- AP defines channel (infrastructure mode)
- passive scanning: STA waits for beacon from AP
- active scanning: STA sends `Probe Request`, AP answers with `Probe Reply`
- shared spectrum requires channel access algorithm to avoid collision
- 802.11 uses CSMA/CA

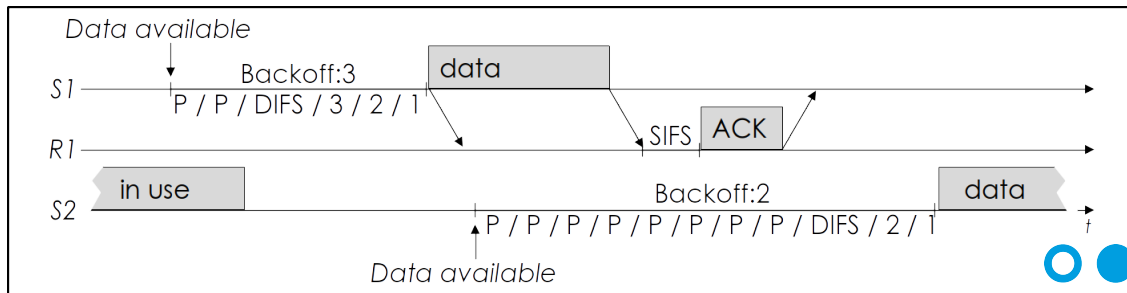
CSMA/CA

- CSMA: Carrier Sensing:
Channel free?
- CA:
 - if free: wait for DIFS
 - else if busy:
 - ...
 - send data (no CD)
- receiver: wait for SIFS, then
send ACK



CSMA/CA

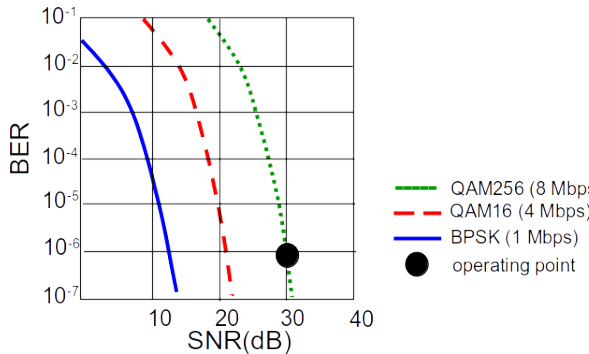
- if busy:
 - start random back-off
 - decrease back-off timer **while channel is free**
 - pause timer **while channel is busy**
- send data



Rate Adaptation

- modulation determines data rate
- high modulation \rightarrow high data rate
- *but:* \rightarrow low robustness, high BER
- STA and AP dynamically adapt modulation

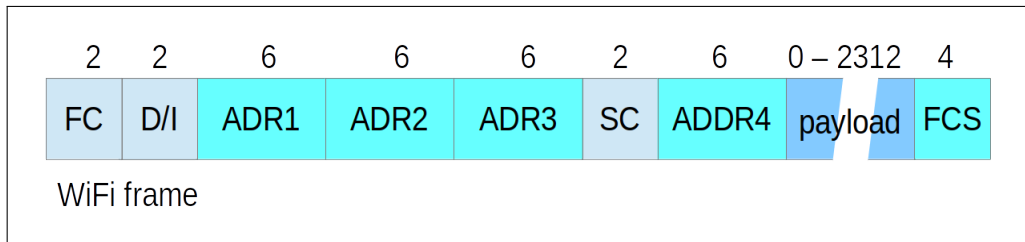
- if SNR decreases, BER increases (e.g. because STA moves away from AP)



- When BER becomes too high, switch to lower modulation

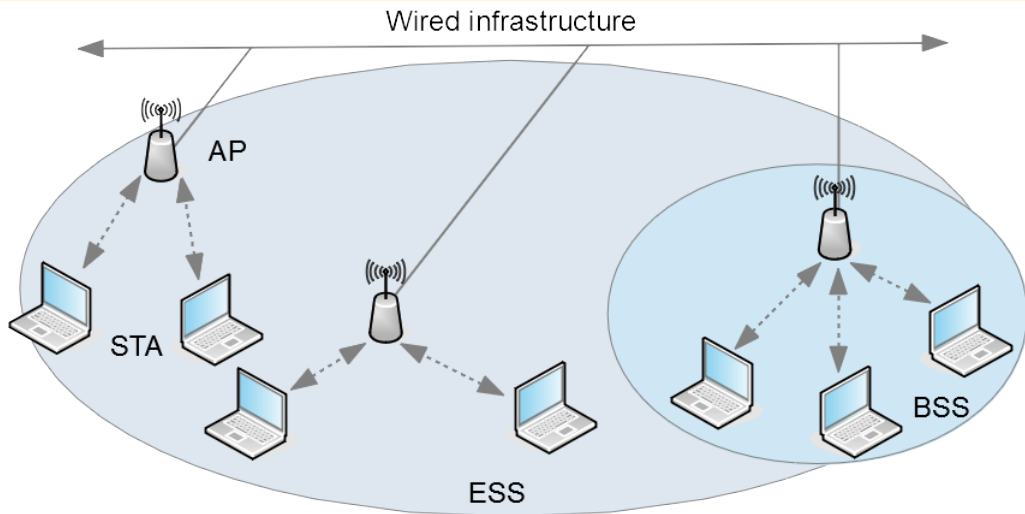


WiFi Frame revisited

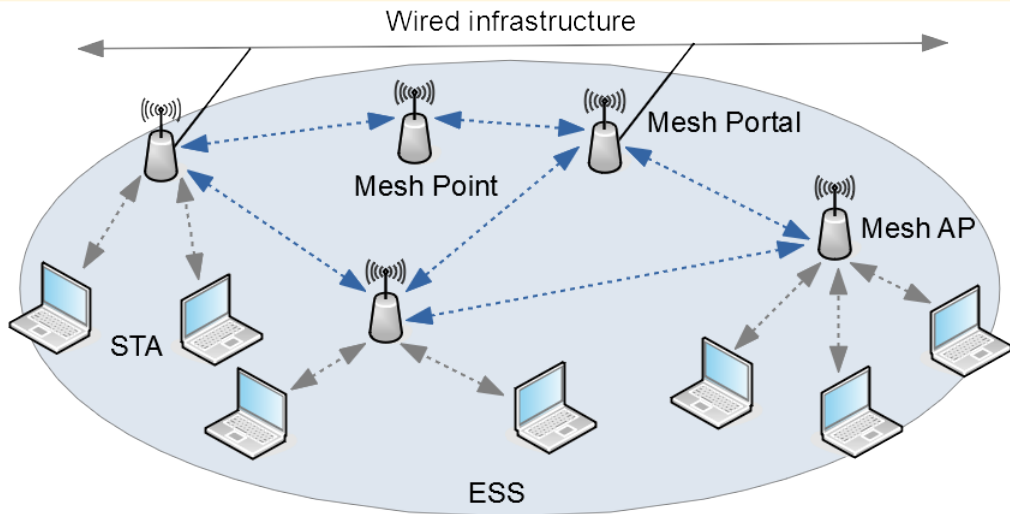


- **Frame Control:** Type of frame: control, management, or data;
- **Duration / Connection ID:** Airtime **or** connection identifier;
- **Address:** Number and meaning of addresses depend on context;
- **Sequence Control:** Fragment number and sequence number of a frame;
- **Payload** MTU is 2312 bytes;
- **Frame Check Sequence**

Classical IEEE 802.11 Network (revisited)



IEEE 802.11s Mesh Network



Hybrid Wireless Mesh Protocol

- Combination of **proactive** and **reactive** concepts
- Reactive (on-demand) mode is always available; allows peer-to-peer paths
- Optional pro-active tree-building mode based on root mesh station
 - Used concurrently with on-demand mode

Path Originator triggers a path discovery

Intermediate MP participates in path discovery without being originator or target

Path Target is the target of the discovery attempt

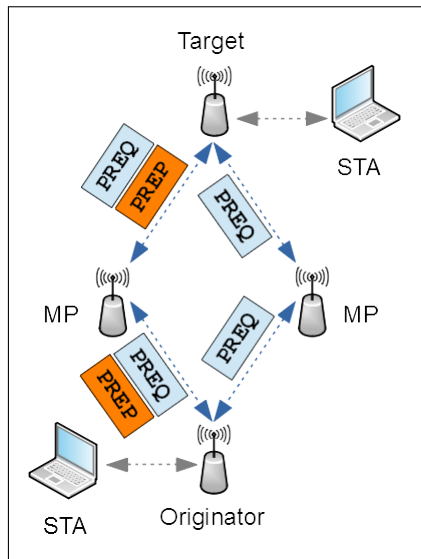
PREQ Path Request creates paths from mesh STA to root

PREP Path Reply, PERR Path Error

RANN Root Announcement creates paths between root and each MP

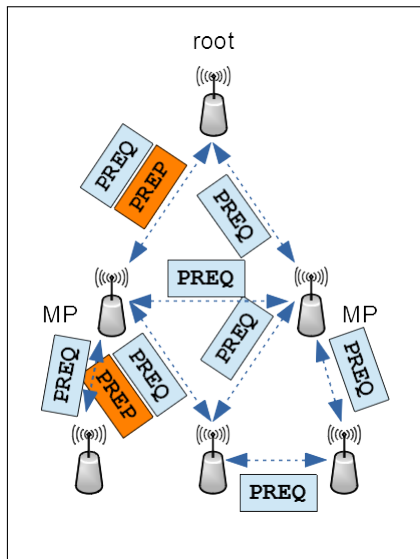


On-Demand (re-active) Path Selection



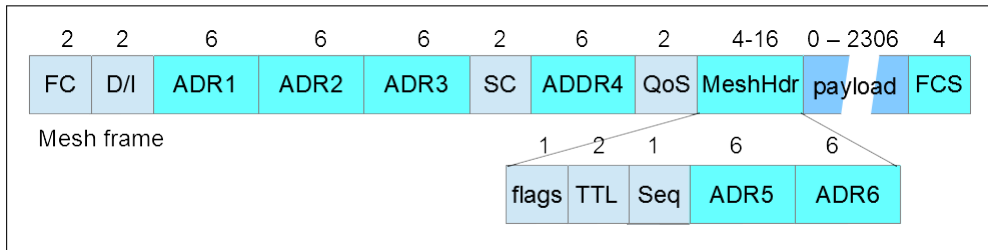
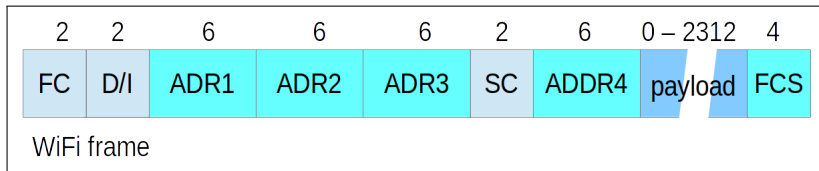
- Derived from AODV
- Originator broadcasts PREQ towards target (create reverse path from T to O)
- MP receives new PREQ, updates own path information to the originator
- MP updates metric and propagates PREQ to its neighbours
- Target replies to a PREQ with a PREP towards the originator (creates forward path from O to T)

Pro-Active Path Selection

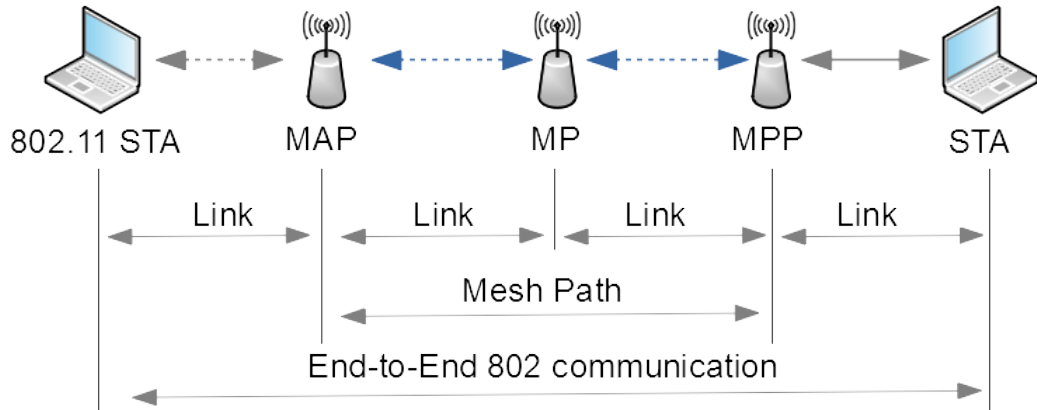


- *If present*, root node generates proactive PREQ or RANN periodically
- PREQ target address set to all 1s (broadcast) and TO subfield set to 1
- Receiving STA updates hopcount and metric towards root STA
- STA may reply with PREP
- STA forwards PREQ to neighbors
- PREQ (with PREP) creates paths between all mesh STAs and root

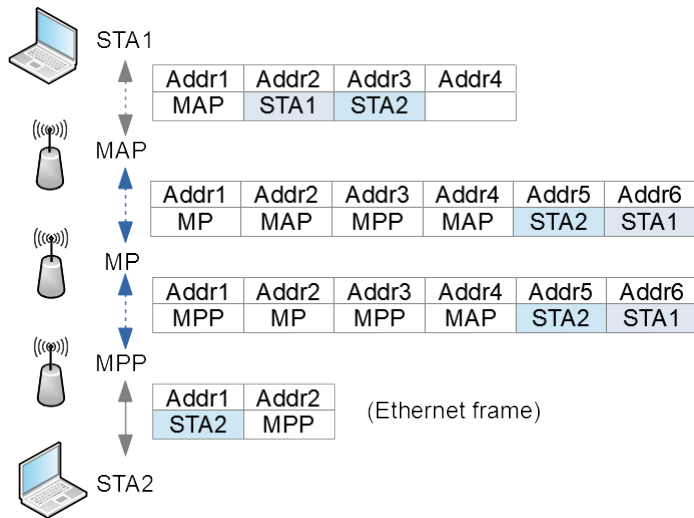
Frame Format



6-Address-Mode



6-Address-Mode



- **Addr1 and Addr2:**
link RX, TX
- **Addr3 and Addr4:**
Endpoints of a mesh path
(incl. MPPs and MAPs)
- **Addr5 and Addr6:**
802 Communication
endpoints (STA inside or
outside the mesh)

Wireless Mesh Networks: Summary

- Targeting multihop wireless networks with limited (no) mobility
- Typically multipath, dynamic routing
- Fairness problem
- AODV, OLSR, B.A.T.M.A.N, IEEE 802.11s
- 6-Address-Mode

Reading

Hiertz et al.: IEEE 802.11s: The WLAN Mesh Standard
IEEE Wireless Communications (Volume: 17 , Issue: 1 , February 2010)