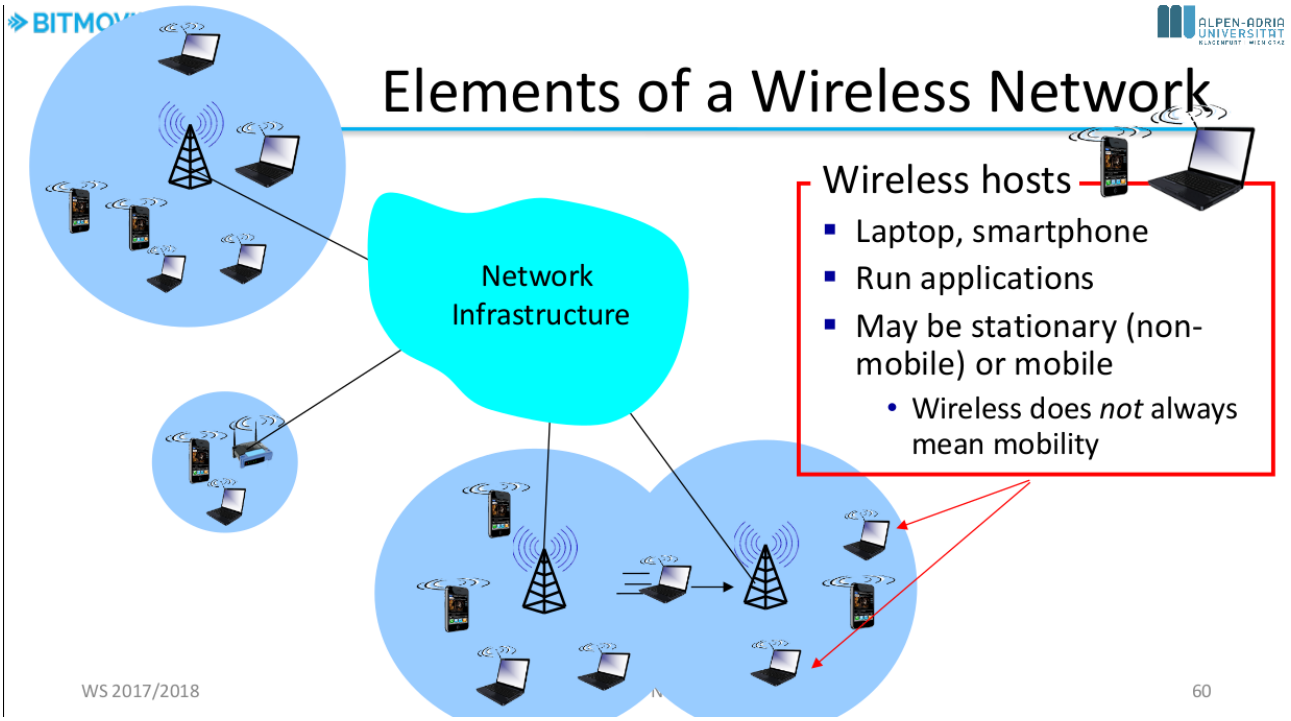
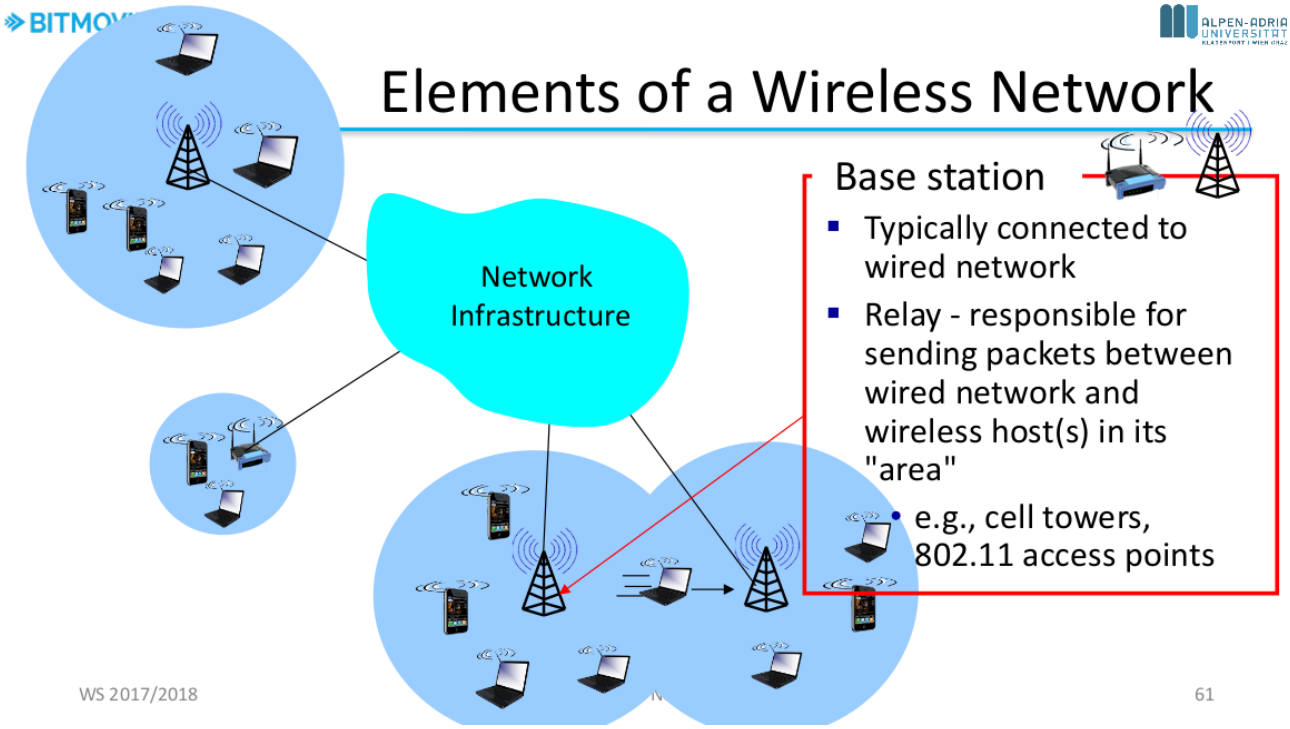
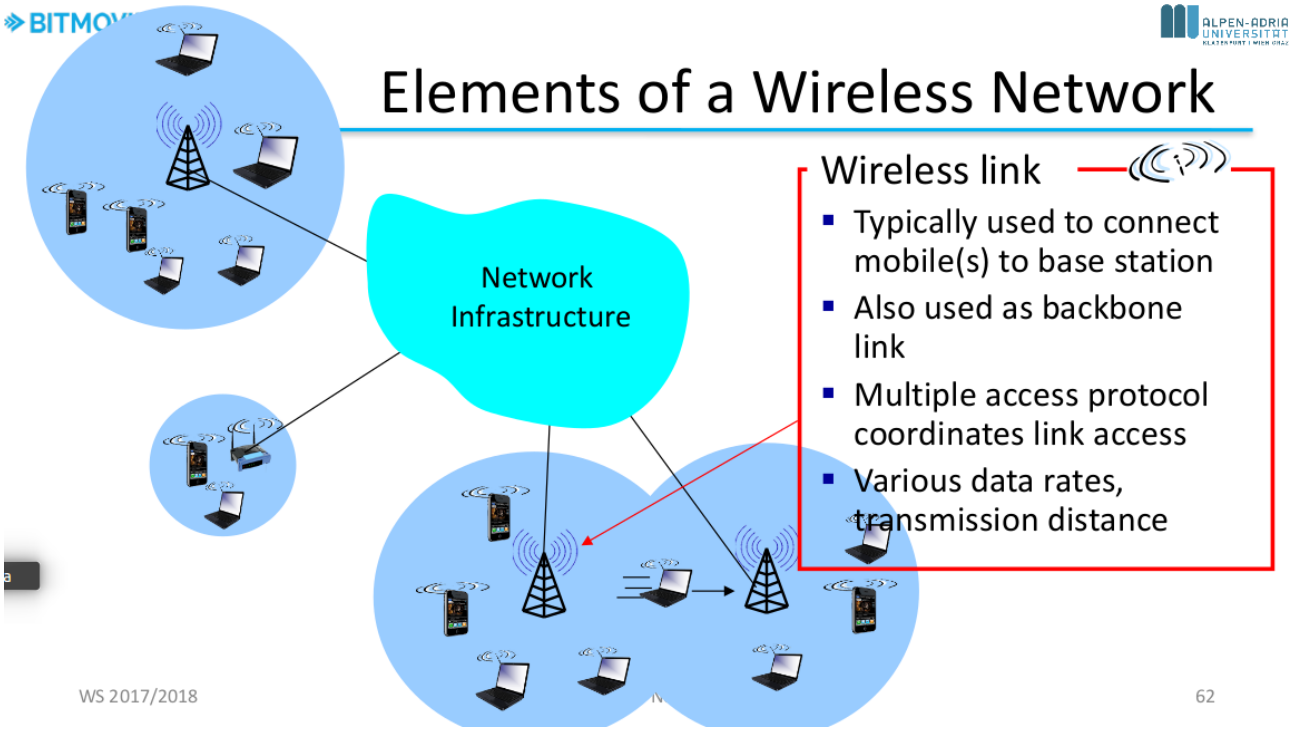
- REP: ATSC 3.0
-



2 Unterschiedliche Aspekte: Was bedeutet Mobilität ↔ Im gleichen IT-Netzwerk mit Bewegung?
-



Base Station: Turm vor der AAU z.B. ↔ Access Netzwerk abbilden.
-



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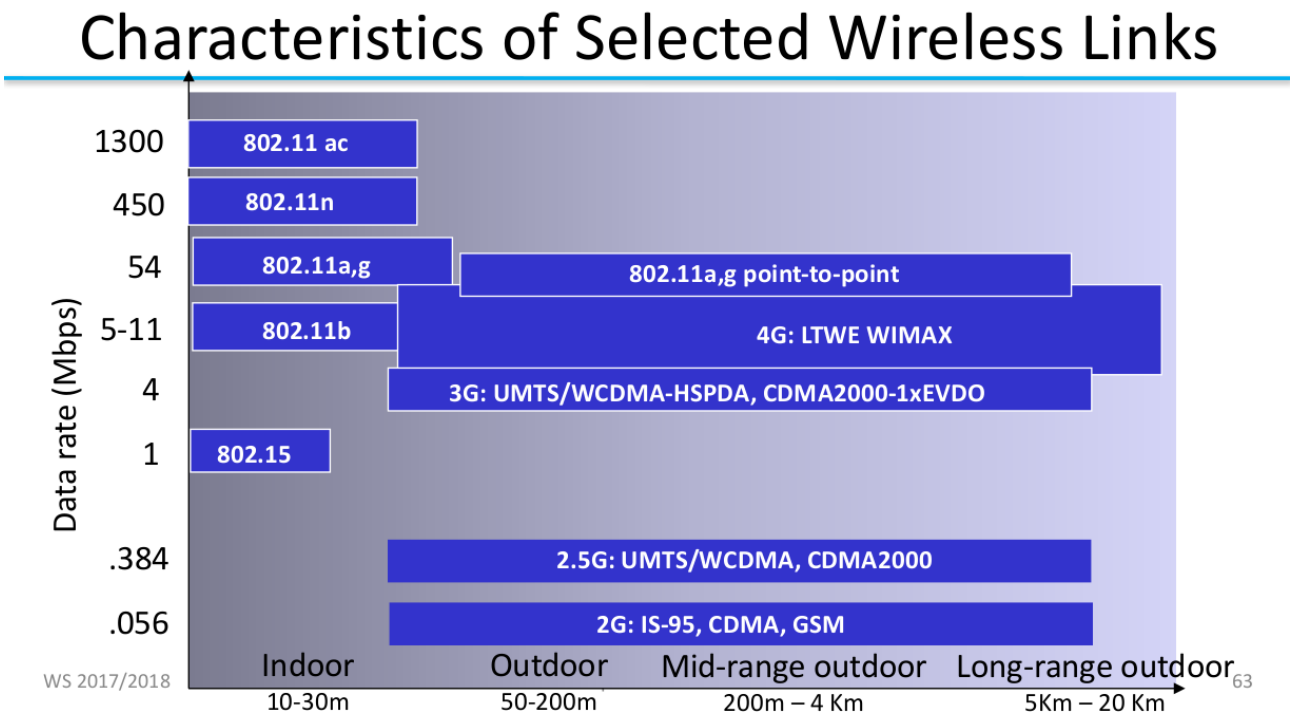
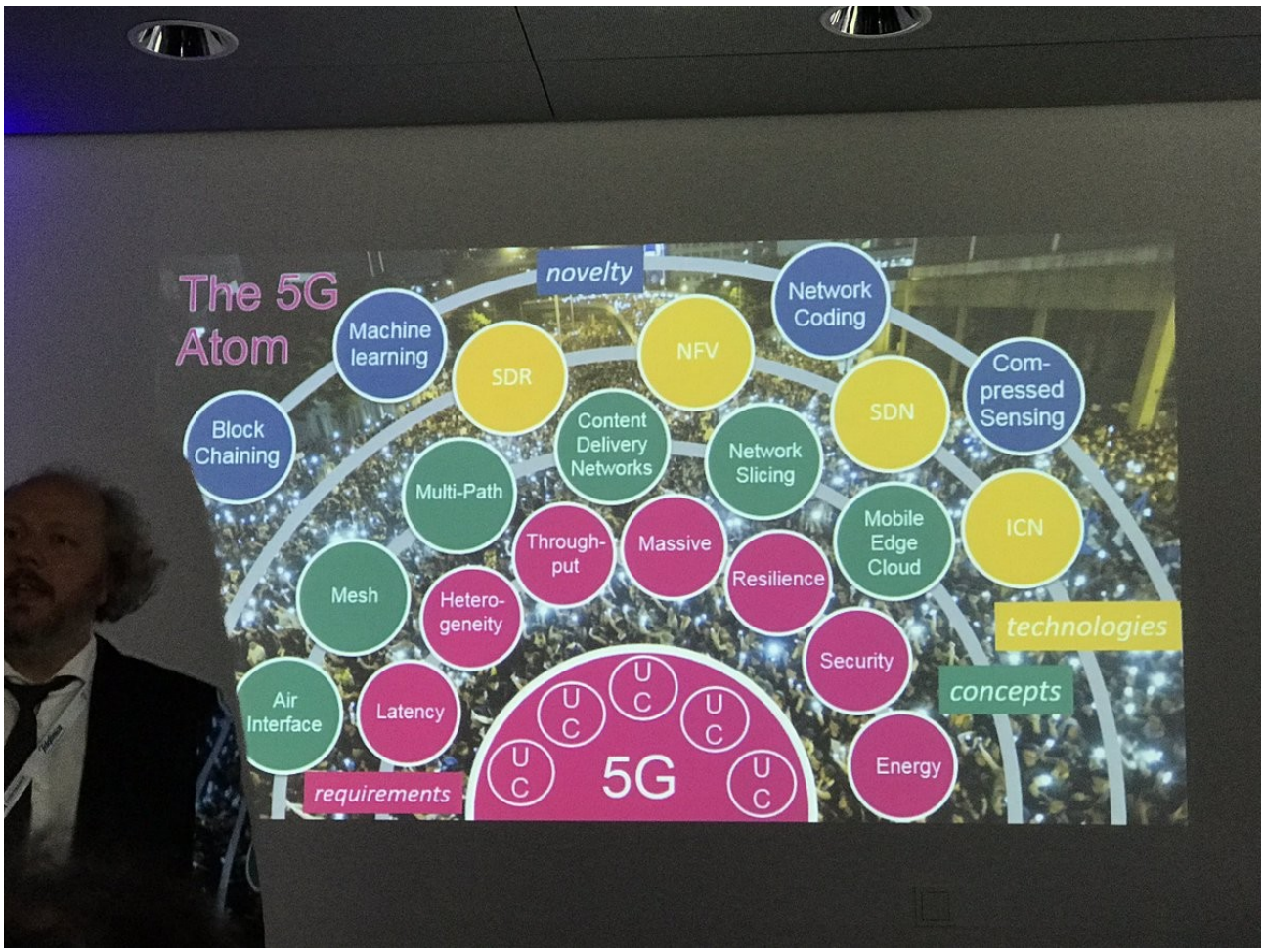


→ Ausbreitungen der Datenraten

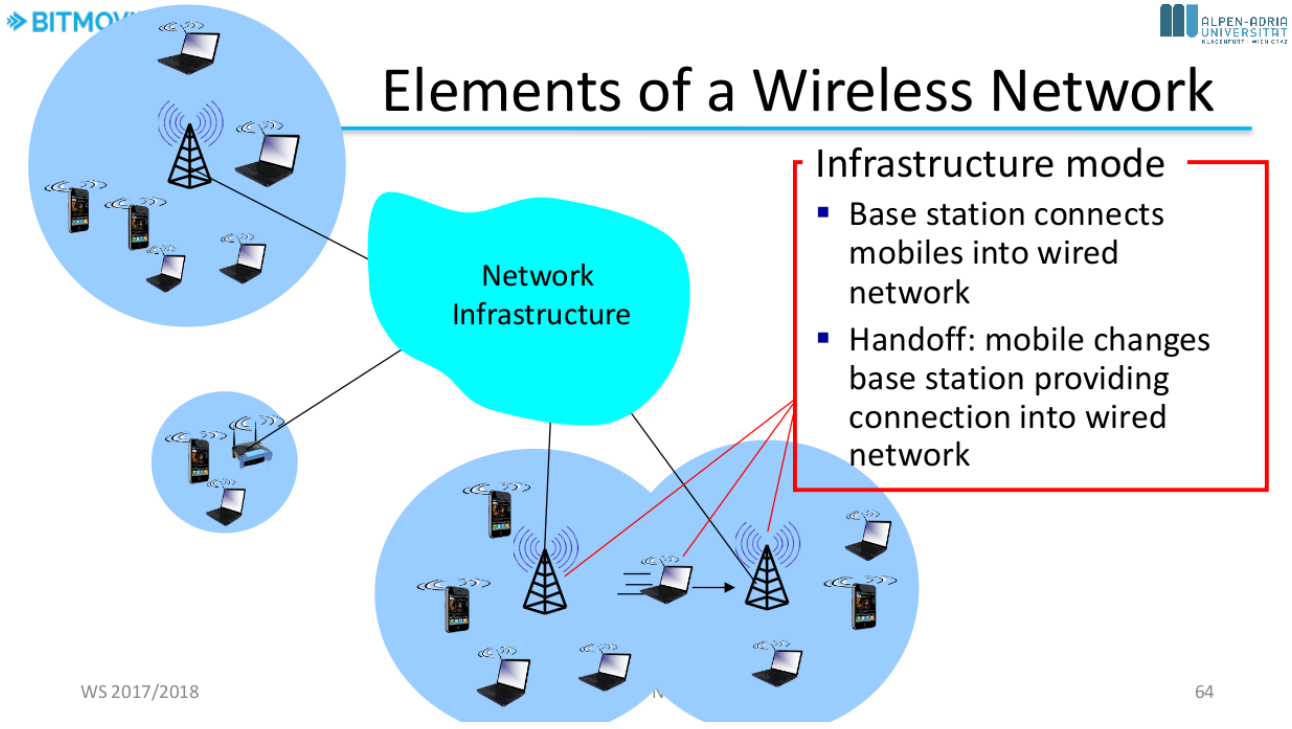
-

5G:

* Konzepte: Multipath, Air Interface, Mesh, Content delivery Networks, Mobile Edge cloud, …
* Requirements: Latency, Heterogenity, Throughput, Resilience, Security, …
* Technology: ICN, SDN, NFV, SDR
* Novelty: Block Chaining, machine learning Network Coding, Compressed Sensing



SDN – Dataplane(HW-Trennungen) & Control Plane-Trennung (SW-Installation)
– Serverzugriff via API bietet Businessmodelle par excellence. VGL.: Silicon Valley
ICN – Kontent selbst wird addressiert ↔ Das Web erfüllt die Angabe.
NFV – Caching von Data im Web
-



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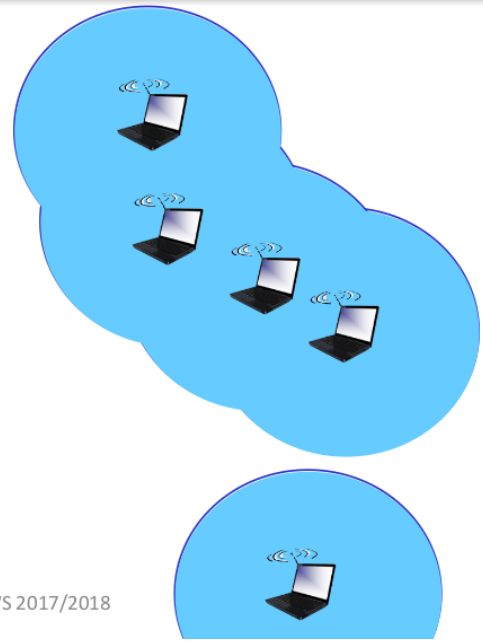
Elements of a Wireless Network



Ad hoc mode

- No base stations
- Nodes can only transmit to other nodes within link coverage
- Nodes organize themselves into a network: route among themselves

-

Wireless Link Characteristics (1)

Important differences from wired link ….

- Decreased signal strength: radio signal attenuates as it propagates through matter (path loss)
- Interference from other sources: standardized wireless network frequencies (e.g., 2.4 GHz) shared by other devices (e.g., phone); devices (motors) interfere as well
- Multipath propagation: radio signal reflects off objects ground, arriving ad destination at slightly different times

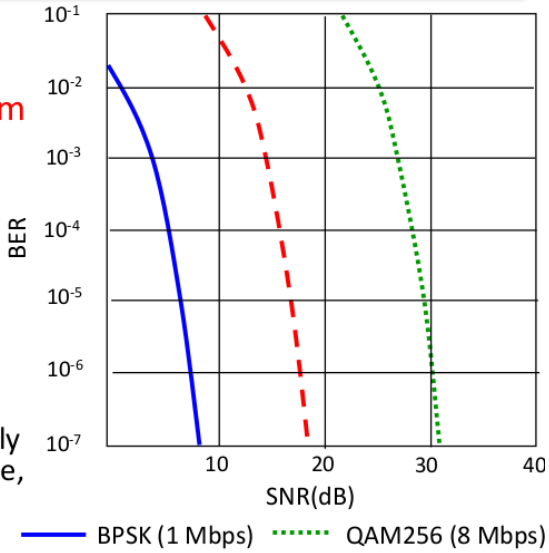
…. make communication across (even a point to point) wireless link much more "difficult"

1.) Datenratenstörung durch verschiedene Medien :: Luft & Kabel
3.) Mehrere Signale werden zeitlich unterschiedlich empfangen ↔ Sync!

-

Wireless Link Characteristics (2)

- SNR: signal-to-noise ratio
  - Larger SNR – easier to extract signal from noise (a "good thing")
- SNR versus BER tradeoffs
  - Given physical layer: increase power -> increase SNR -> decrease BER
  - Given SNR: choose physical layer that meets BER requirement, giving highest throughput
    - SNR may change with mobility: dynamically adapt physical layer (modulation technique, rate)

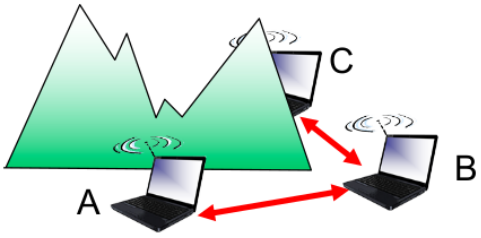


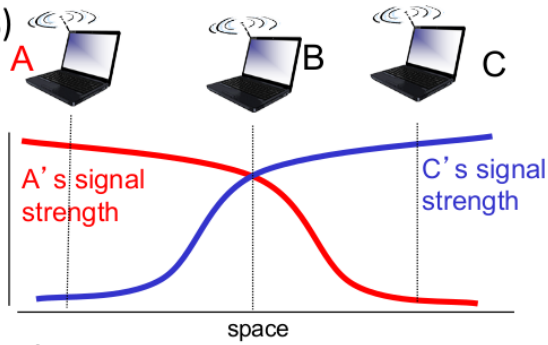
SNR = Metrik zur Performanz – Relative Maßzahl vom Signal und Geräusch via Medium
→ Je Höher: Desto leichter ist Signalextrahierung = desto besser.
Weiters verglichen mit Bit Error Rate

-

Wireless Network Characteristics

Multiple wireless senders and receivers create additional problems (beyond multiple access)





Hidden terminal problem

- B, A hear each other
- B, C hear each other
- A, C can not hear each other means A, C unaware of their interference at B

Signal attenuation

- B, A hear each other
- B, C hear each other
- A, C can not hear each other interfering at B

– Funkproblematik: Störung durch andere Signale oder phys. Hindernisse

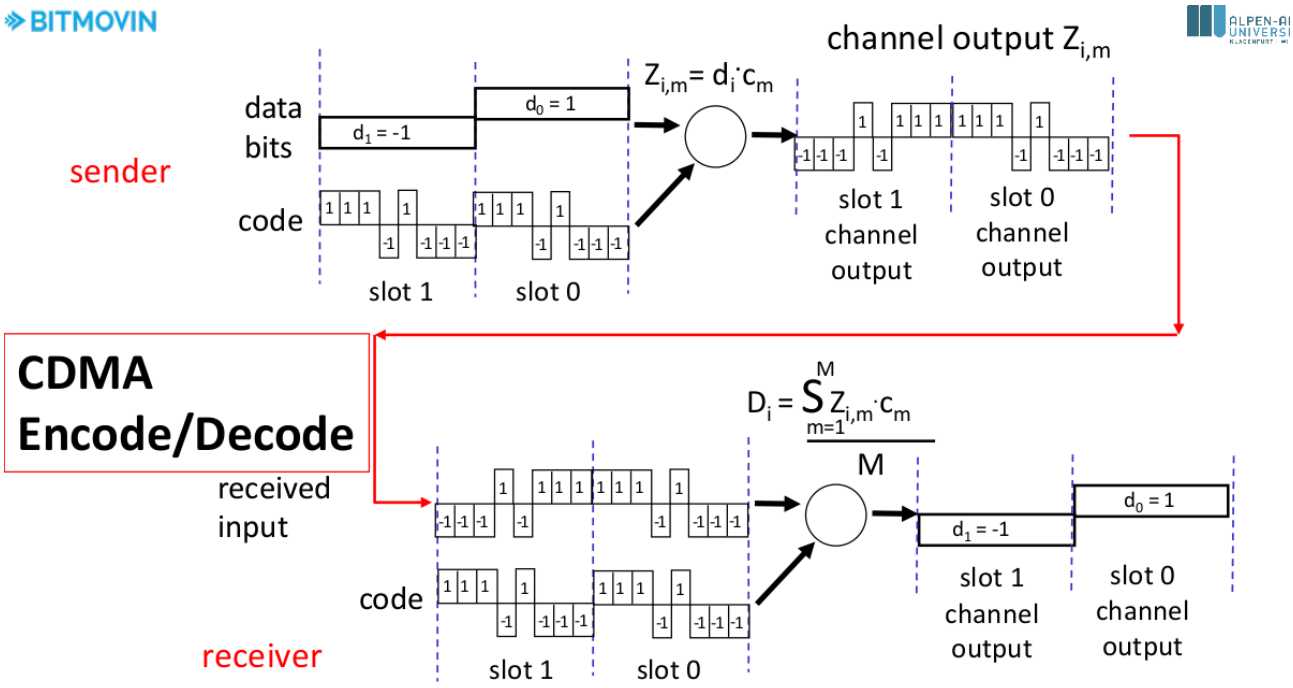
-

Code Division Multiple Access (CDMA)

- Unique "code" assigned to each user; i.e., code set partitioning
  - All users share same frequency, but each user has own "chipping" sequence (i.e., code) to encode data
  - Allows multiple users to "coexist" and transmit simultaneously with minimal interference (if codes are "orthogonal")
- Encoded signal = (original data) X (chipping sequence)
- Decoding: inner-product of encoded signal and chipping sequence

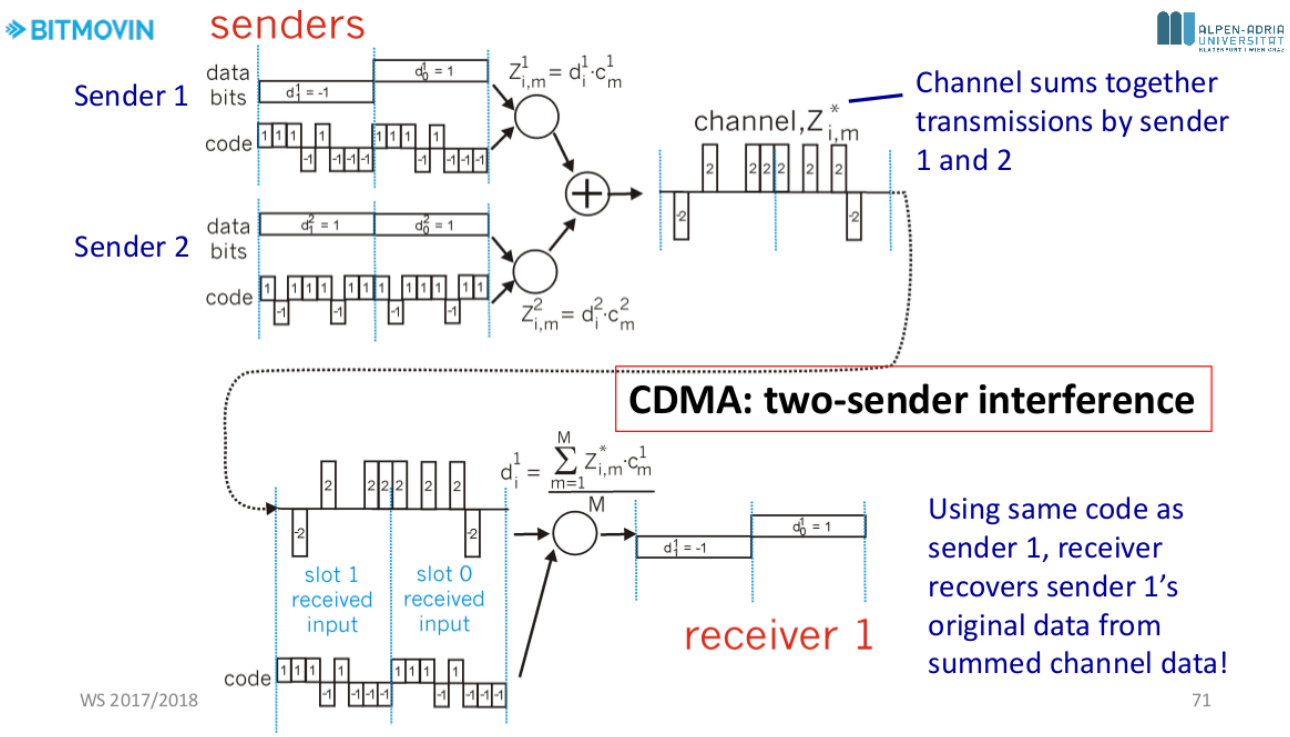
VGL.: FDMA(FREQUENCY dma) und TDMA(TIME division multiple access)
→ Unterschiedliche Frequenzbänder & unterschiedliche Sendeslots

-



Encoder:
Z_i,m = D_i*c_m → Datenbits.
d_1* Untere Bits → Erzeugt Sequenz.

Decode:
SUM
Upper Bit * Lower Bit → Sum / Anzahl Bits (M=8) → Databits.
-



– Encode: Selbes wie oben. Ergebnisse in Channel Z_im werden bitwise addiert.
– Decode: M = 8
→ CODE muss Oktagonal sein.
→ Schlüssel sind standardisiert.
-

IEEE 802.11 Wireless LAN

802.11b
- 2.4 GHz unlicensed spectrum
- Up to 11 Mbps
- Direct sequence spread spectrum (DSSS) in physical layer
- All hosts use same chipping code

802.11a
- 5-6 GHz range
- Up to 54 Mbps

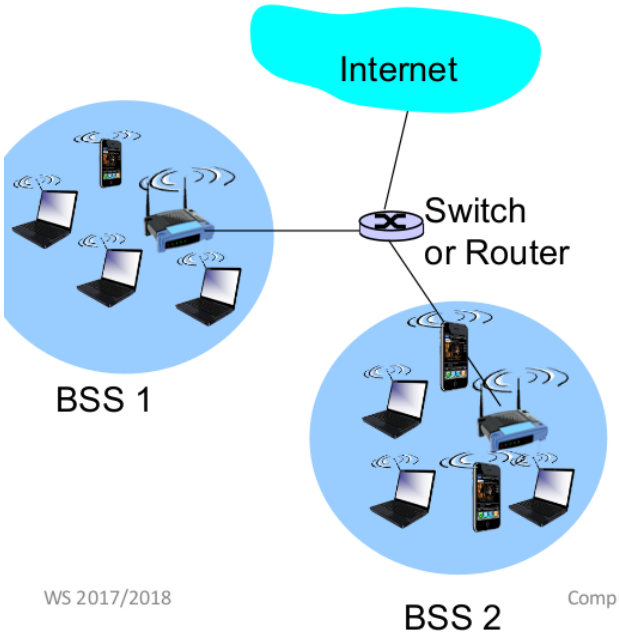
802.11g
- 2.4-5 GHz range
- Up to 54 Mbps

802.11n: multiple antennae
- 2.4-5 GHz range
- Up to 200 Mbps

All use CSMA/CA for multiple access
All have base-station and ad-hoc network versions

"Standards dauern zulange"
-

802.11 LAN Architecture



- Wireless host communicates with base station
  - Base station = access point (AP)
- Basic Service Set (BSS) (aka "cell") in infrastructure mode contains:
  - Wireless hosts
  - Access point (AP): base station
  - Ad hoc mode: hosts only

→ Hotspot ↔ Wlan-Access Point

-

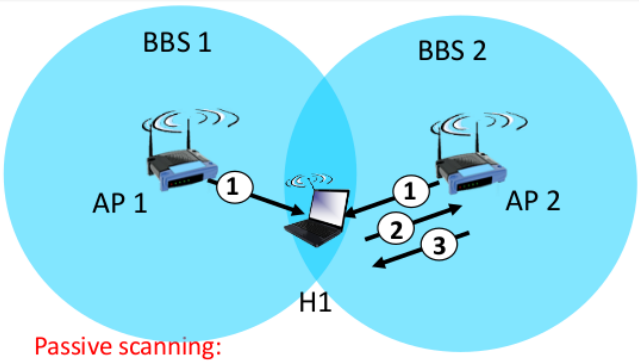
802.11: Channels, Association

- 802.11b: 2.4GHz-2.485GHz spectrum divided into 11 channels at different frequencies
  - AP admin chooses frequency for AP
  - Interference possible: channel can be same as that chosen by neighboring AP!
- Host: must associate with an AP
  - Scans channels, listening for beacon frames containing AP's name (SSID) and MAC address
  - Selects AP to associate with
  - May perform authentication
  - Will typically run DHCP to get IP address in AP's subnet

11b relevant ↔ Als Admin wählt man die Channel um Signale zu fixieren.
Es darf bei mehreren Access Points keine Überlappungen geben.
→ Heute:Plug and Play.
=> Scanning

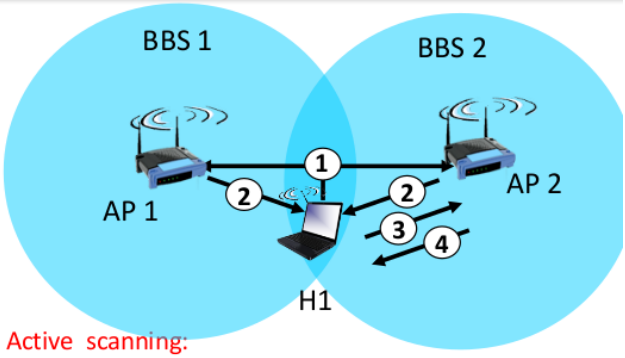
-

802.11: Passive/Active Scanning



Passive scanning:

① Beacon frames sent from APs
② Association Request frame sent: H1 to selected AP
③ Association Response frame sent from selected AP to H1



Active scanning:

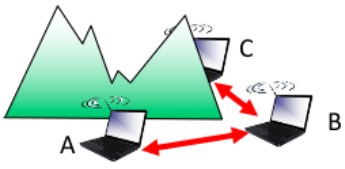
① Probe Request frame broadcast from H1
② Probe Response frames sent from APs
③ Association Request frame sent: H1 to selected AP
④ Association Response frame sent from selected AP to H1

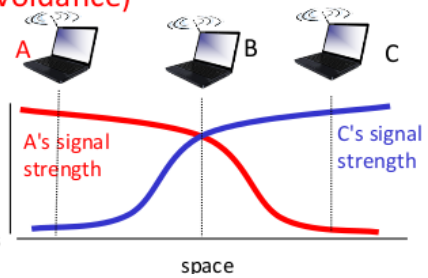
Passiv: Rechner wartet bis Access Point meldet. Rechner sendet dann Anfrage.
Aktiv: Rechner scannt und wählt AP.

-

IEEE 802.11: Multiple Access

- Avoid collisions: 2+ nodes transmitting at same time
- 802.11: CSMA - sense before transmitting
  - Don't collide with ongoing transmission by other node
- 802.11: no collision detection!
  - Difficult to receive (sense collisions) when transmitting due to weak received signals (fading)
  - Can't sense all collisions in any case: hidden terminal, fading
  - Goal: avoid collisions: CSMA/C(ollision)A(voidance)





CSMA: Kanal hört und sendet erst wenn bereit ↔ Carrier sense zur Kollisionsvermeidung.

-

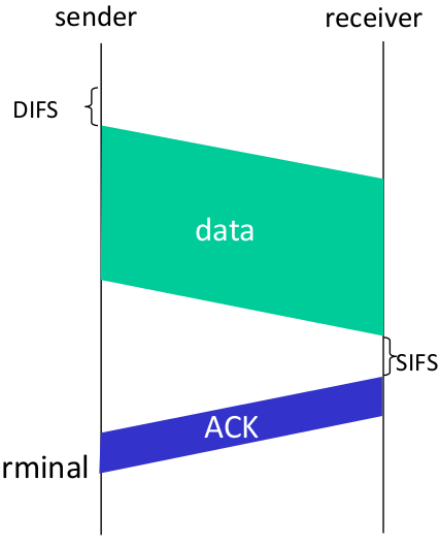
IEEE 802.11 MAC Protocol: CSMA/CA

802.11 sender

- If sense channel idle for DIFS then
  - Transmit entire frame (no CD)
- If sense channel busy then
  - Start random backoff time
  - Timer counts down while channel idle
  - Transmit when timer expires
  - If no ACK, increase random backoff interval, repeat

802.11 receiver

- If frame received OK
  - Return ACK after SIFS (ACK needed due to hidden terminal problem)



Unterschiede CSMA/CD und CSMA/CA!
CD: Sense & Send
CA: Request to Send! ↔ Dann wird geschickt. Es gibt keine Collission Detection und man erwartet eine ACK. ↔ Omnettpp ÜB12

Gemäß Timer DIFS sendet man Daten. Wenn ACK nicht kommt, so erhöht man DIFS und sendet erneut.

-

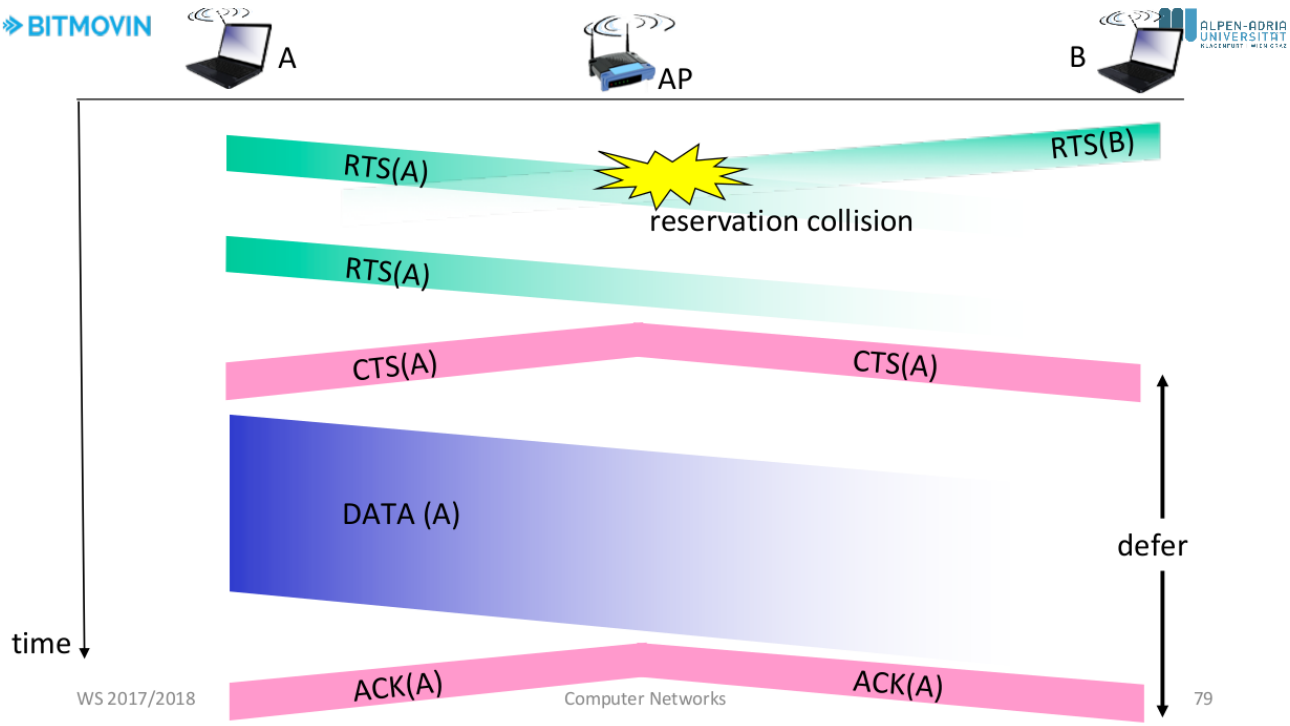
Avoiding Collisions (more)

Idea: allow sender to "reserve" channel rather than random access of data frames: avoid collisions of long data frames

- Sender first transmits small request-to-send (RTS) packets to BS using CSMA
  - RTSs may still collide with each other (but they're short)
- BS broadcasts clear-to-send CTS in response to RTS
- CTS heard by all nodes
  - Sender transmits data frame
  - Other stations defer transmissions

Avoid data frame collisions completely using small reservation packets!

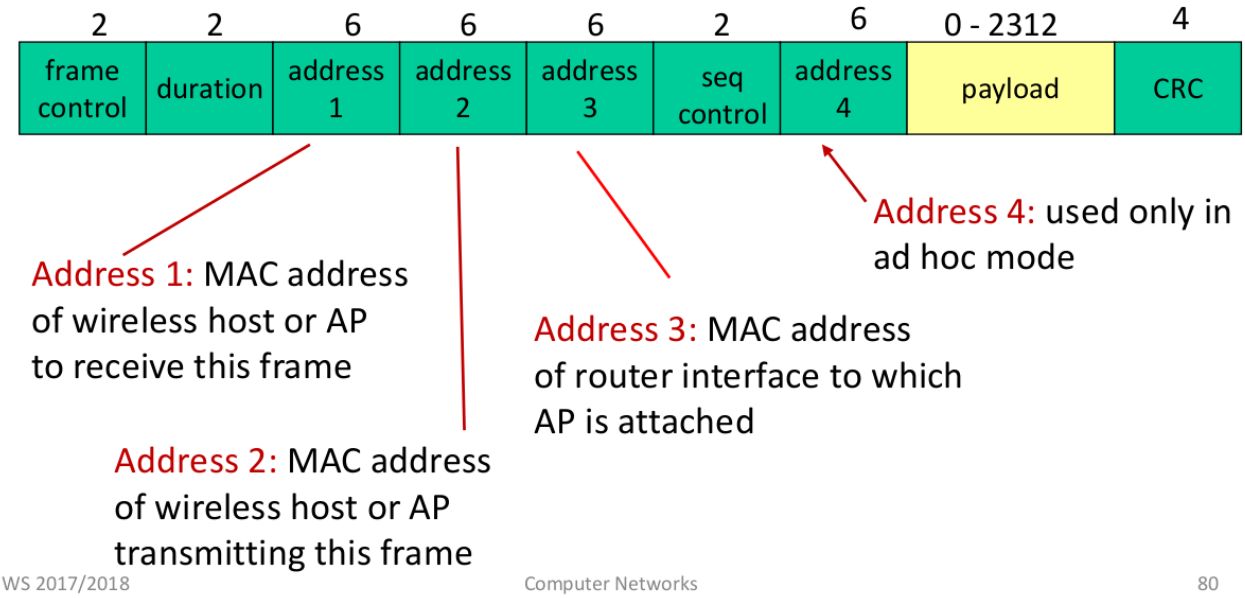
-



→ A kommt an AP an
→ AP sendet an ALLE dass A besetzt.
→ Datensendung
→ Nach Übertragung: AP sendet ACK an alle.
→ Repeat with RTS.
=> Keiner muss auf Kollissionen scannen.

-

802.11 Frame: Addressing



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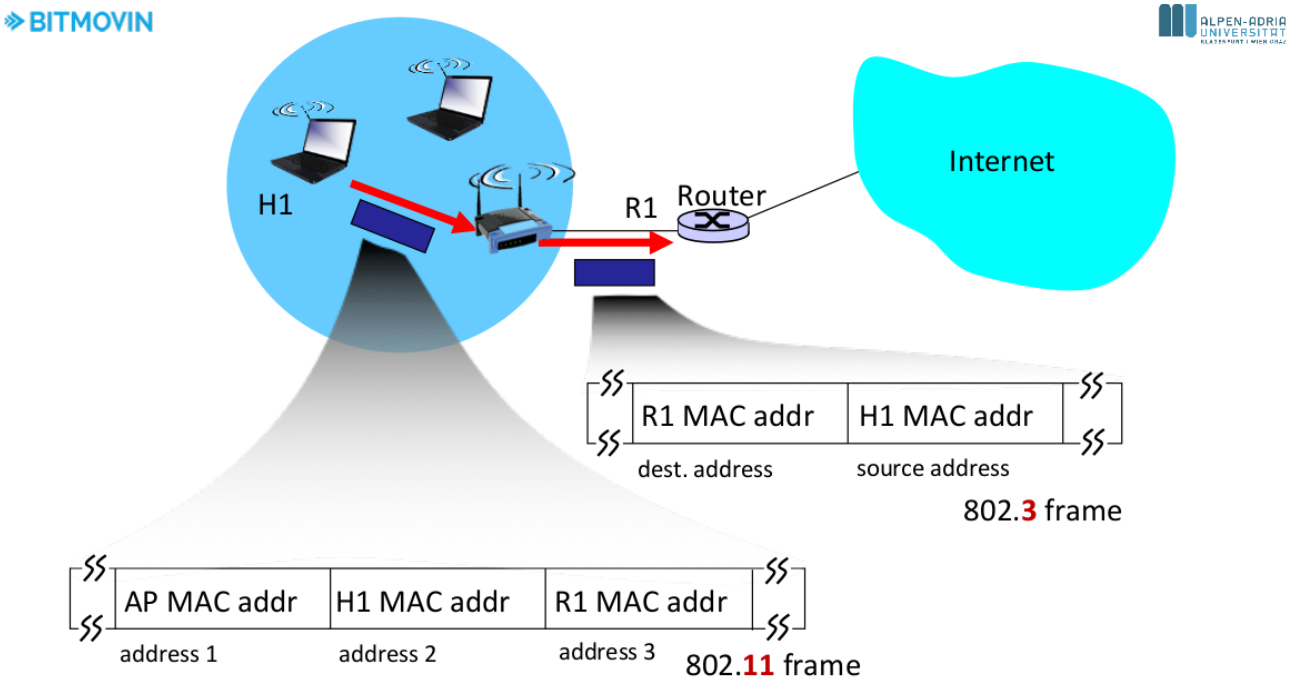
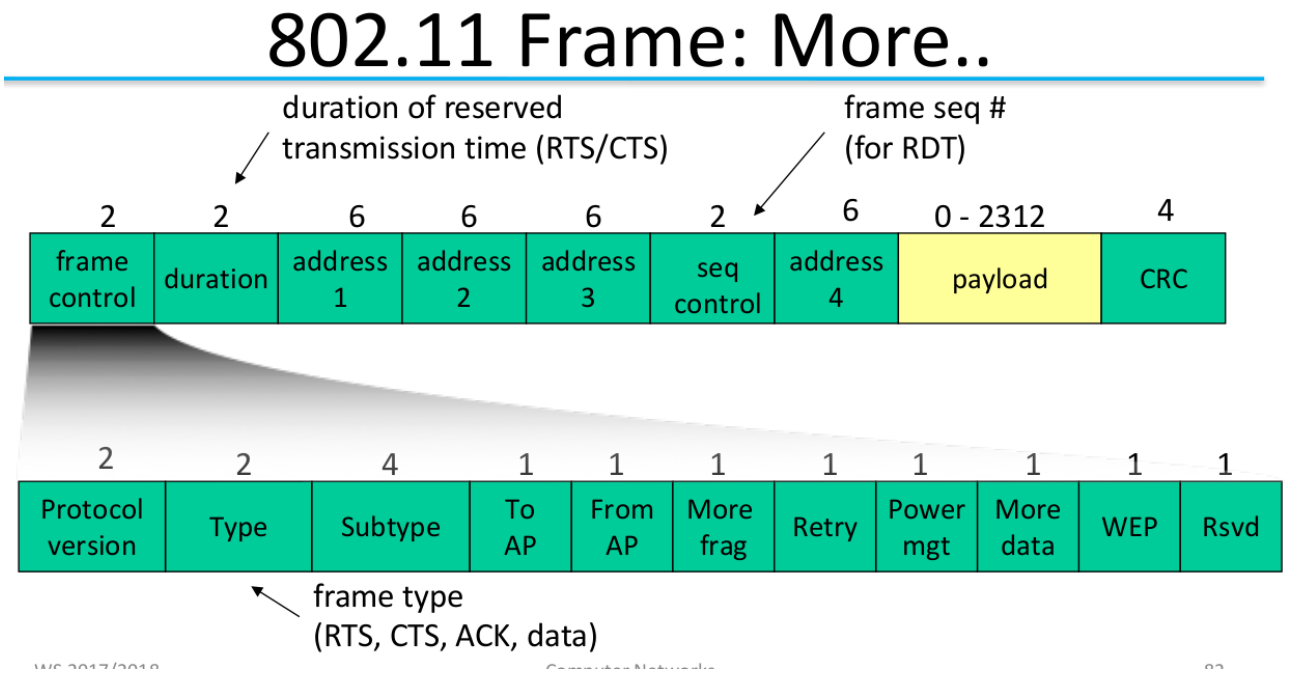


H1 extrahiert → R1 gebildet

-



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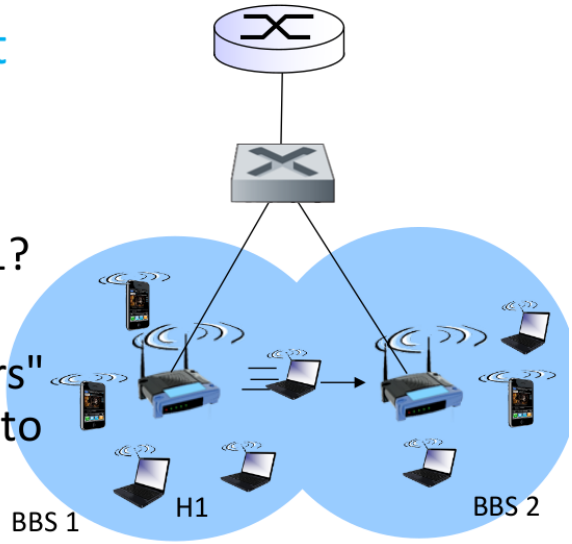
802.11: Mobility Within Same Subnet

- H1 remains in same IP subnet
  - IP address can remain same
- Switch
  - Which AP is associated with H1?
  - Self-learning: switch will see frame from H1 and "remembers" which switch port can be used to reach H1

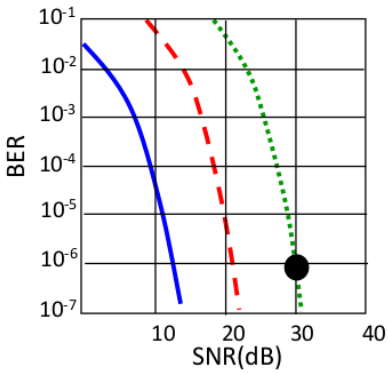


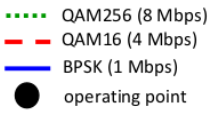
→ Switch reguliert Bewegung von Geräten zwischen AP.
(Switch lernt und passt an)
-

802.11: Advanced Capabilities

Rate adaptation

- Base station, mobile dynamically change transmission rate (physical layer modulation technique) as mobile moves, SNR varies





1. SNR decreases, BER increase as node moves away from base station

2. When BER becomes too high, switch to lower transmission rate but with lower BER

→ Man wechselt zwischen Datenraten zur optimierten Übertragung.
(Grün->Rot)
-

802.11: Advanced Capabilities

Power management

- Node-to-AP: “I am going to sleep until next beacon frame”
  - AP knows not to transmit frames to this node
  - node wakes up before next beacon frame
- Beacon frame: contains list of mobiles with AP-to-mobile frames waiting to be sent
  - Node will stay awake if AP-to-mobile frames to be sent; otherwise sleep again until next beacon frame

→ Wake requires only 250 Mikrosekunden.
→ Knoten buffert, wenn wieder aufgewacht: Übertragung.
-

– Ende der VO
→ Acknowledgment: Kurose/Rose, Computer Networking
“Synthesis: A day in the life of a web request” – Animated