Universität
Paderborn
Computer networks
group

Winter term 2017/2018

Mobile communications

Homework assignment 10: Wireless LANs

Due date: 2018-01-17

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1. Compare the IEEE 802.11 infrastructure and ad hoc mode according to their architecture, services, and Medium Access Control (MAC) functions.

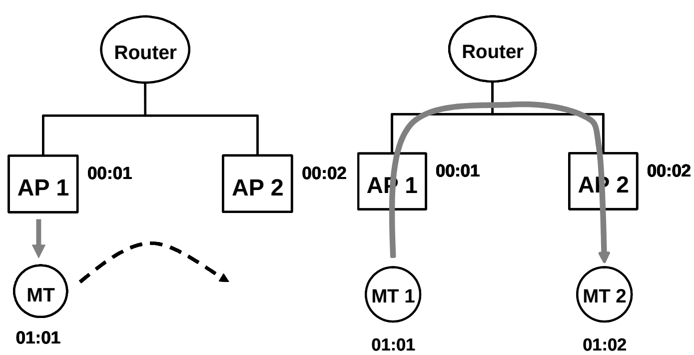
   Solution:

Modus	Architecture	Services	MAC
infrastructure	AP as coordinator; BSS or ESS	best-effort and time-bounded (in old versions)	PCF (in old versions), DCF
Ad hoc	no coordinator, IBSS	best-effort	only DCF

   BSS: Basic Service Set, ESS: Extended Service Set, PCF: Point Coordination Function, DCF: Distributed Coordination Function, IBSS: Independent BSS

2. **Further IEEE 802.11 MAC and PHY control functions**

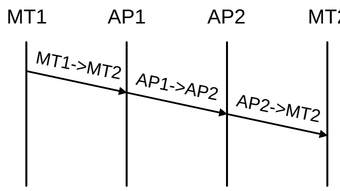
   Assume the following IEEE 802.11-based scenarios: The left scenario shows a Mobile Terminal (MT) roaming from Access Point (AP) 1 to AP 2 *while* receiving data from AP 1. In the right scenario, MT 1 transmits data to MT 2. Each number stands for the MAC address of the respective AP.



Provide for each scenario an Message Sequence Chart (MSC) and the entries of the Distribution System (DS) and address fields.

Solution:

Right scenario:

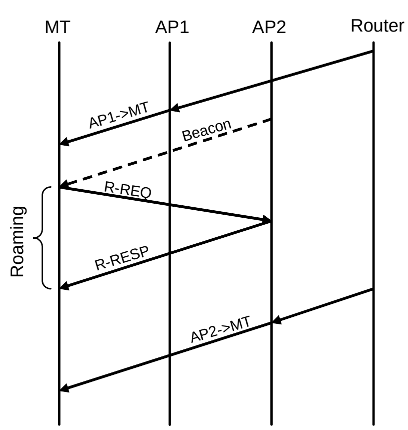


MT1 → AP1:
DS-Bits: 10
Addr 1: AP1
Addr 2: MT1
Addr 3: MT2

AP1 → AP2:
DS-Bits: 11
Addr 1: AP2
Addr 2: AP1
Addr 3: MT2
Addr 4: MT1

AP2 → MT2:
DS-Bits: 01
Addr 1: MT2
Addr 2: AP2
Addr 3: MT1

Left scenario:



R-REQ: Reassociation Request
R-RESP: Reassociation Response

AP1 $\rightarrow$ MT:
DS-Bits: 01
Addr 1: MT
Addr 2: AP1 (BSSID)
Addr 3: Router
MT $\rightarrow$ AP2 (R-REQ):
DS-Bits: 10
Addr 1: AP2
Addr 2: MT
Addr 3: AP2

AP2 $\rightarrow$ MT (R-RESP):
DS-Bits: 01
Addr 1: MT
Addr 2: AP2
Addr 3: AP2
AP2 $\rightarrow$ MT:
DS-Bits: 01
Addr 1: MT
Addr 2: AP2
Addr 3: Router

In order for data to be transmitted correctly after roaming, AP2 has to update the MAC address-to-AP address database of the distribution system.

3. **Phy-Layer data rate of IEEE 802.11n and 11ac**

Use the following parameters to calculate the maximum data rate achievable at the PHY layer of 11n and 11ac. You might have to do some background checks.

- Number of data subcarriers
- Number of spatial streams
- Data bits per OFDM symbol, including code rate
- Duration of an OFDM symbol

Is it plausible to assume that this improvement of PHY data rate from 11n to 11ac is completely visible to and useful by an end-user device? Is that the improvement you expect to see as application-level data rate?

Solution:

	11n	11ac
Maximum bandwidth	40 MHz	160 MHz
Spectrum per subcarrier	312.5 kHz	312.5 kHz
Number of data subcarriers	108	468
Number of spatial streams	4	8
Data bits per OFDM symbol, including code rate	5	6.67
Duration of an OFDM symbol	3.6 μs	3.6 μs
Nominal PHY rate	600 Mbit/s	6.936 Mbit/s

Note: Number of subcarriers differs depending on concrete amount of spectrum as different number of pilots/nulls are used.

Of course not visible. These numbers are "standard max", achievable perhaps in ideal conditions on the PHY. Then, MAC overhead etc. kicks in.

Good survey: `https://arxiv.org/pdf/1702.03257.pdf`