# 14. **Wireless LAN**

14.1 **Electromagnetic waves**

An alternative current with a frequency f higher than 30kHz will tend to produce an electromagnetic wave which has the property to propagate through space. Compared to acoustic waves electromagnetic wave don't need a medium to propagate, which means that they can also travel through vacuum. The propagation speed of electromagnetic waves is equal to the speed of light (~300 000 000 m/s = 3E8 m/s).

Electromagnetic waves cannot only be transmitted but also received by the means of antennas. Therefore electromagnetic waves are amongst other applications used to transmit data wirelessly.

Definition:

The wave length λ (said: lambda) is the length an electromagnetic wave travels within one cycle duration T.

$$\lambda = \frac{c}{f}$$

$$T = \frac{1}{f}$$
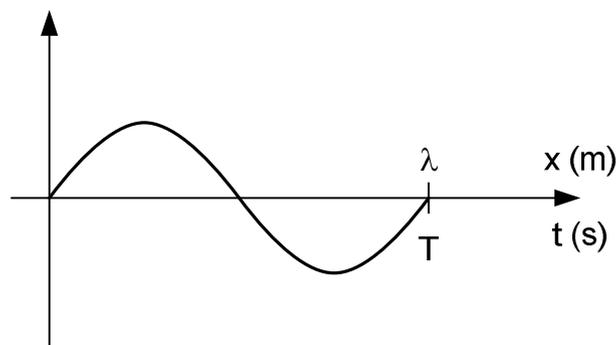
λ is the wavelength in meters (m)
c is the speed of light in meters per second (m/s)
f is the frequency in hertz (Hz)

T is the cycle duration in seconds (s)
f is the frequency in hertz (Hz)

Revision:

1 THz	=	10^{12} Hz	=	1000 GHz
1 GHz	=	10^{9} Hz	=	1000 MHz
1 MHz	=	10^{6} Hz	=	1000 kHz
1 kHz	=	10^{3} Hz	=	1000 Hz
1 mm	=	10^{-3} m	=	0,001 m
1 μm	=	10^{-6} m	=	0,001 mm
1 nm	=	10^{-9} m	=	0,001 μm
1pm	=	10^{-12} m	=	0,001 nm

$$9,27 \cdot 10^{7}\,\text{Hz}$$
$$= 9,27 \cdot 10^{1} \cdot 10^{6}\,\text{Hz}$$
$$= 92,7 \cdot 10^{6}\,\text{Hz}$$
$$= 92,7\,\text{MHz}$$

$$123 \cdot 10^{-8}\,\text{m}$$
$$= 123 \cdot 10^{-2} \cdot 10^{-6}\,\text{m}$$
$$= 123 \cdot 0,01 \cdot 10^{-6}\,\text{m}$$
$$= 1,23 \cdot 10^{-6}\,\text{m}$$
$$= 1,23\,\mu\text{m}$$

Exercise 1:

a) Calculate the wavelength of the electromagnetic wave signal of an 2,4GHz access point.

b) Calculate the approximate frequency in the "3m-band".

c) Explain why an audio signal cannot produce an electromagnetic wave.

According to their wavelength the electromagnetic waves have been split into the following ranges:

| type	range of wave length
radio waves	10 km till 1 m
micro waves	1 m till 1 mm
infrared radiation	1 mm till 780 nm
light	780 nm till 380 nm
ultra violet radiation	380 nm till 1 nm
X radiation	1 nm till 1 pm
gamma radiation	1 pm till 1 fm

http://de.wikipedia.org/wiki/Elektromagnetisches_Spektrum

The simplest antenna to transmit or receive an electromagnetic wave is a dipole antenna:

$$\frac{\lambda}{2}$$
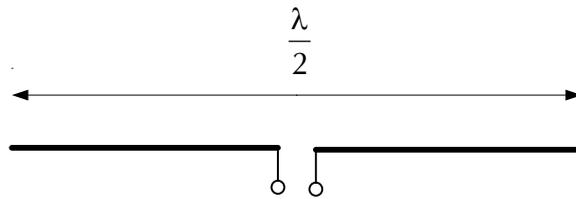
The optimal length of the dipole antenna is half the wavelength of the electromagnetic wave you want to transmit or receive. That's why we talk about a half-wave dipole.

One of the two elements of a dipole antenna can be eliminated if the other element is mounted towards a conductive surface as the ground or the roof of a car. This antenna is called a quarter-wave monopole.

$$\frac{\lambda}{4}$$
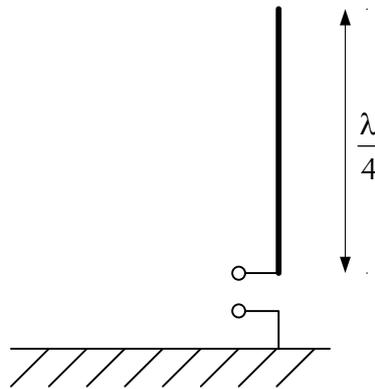
Exercise 2:

Calculate the optimal length L of a quarter-wave monopole at 2,4GHz.

14.2 The IEEE 802.11 standard family

The Wireless LAN is a layer 1 technique to connect several hosts to a network by electromagnetic waves. The WLAN is described in a series of standards (deut.: Normen) all starting with the number 802.11 of the IEEE (Institute of Electrical and Electronics Engineers).

14.2.1 Frequencies used

WLAN uses so called ISM bands to transmit. An ISM band is a range of radio frequencies that can be used without forcing every individual to have a license.
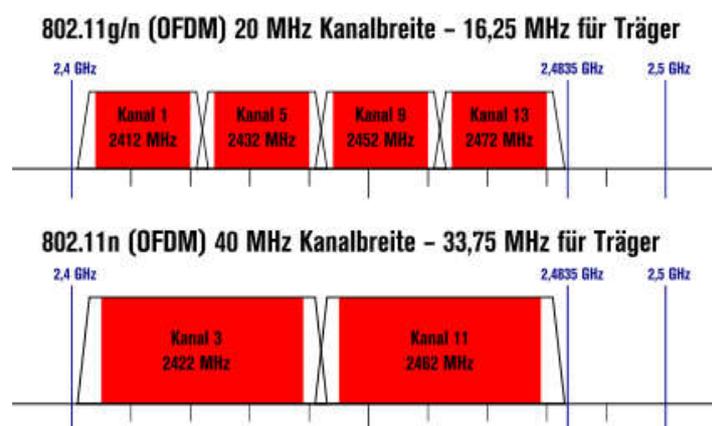
standard	year	frequencies
IEEE 802.11a	1999	5,15 - 5,725 GHz (5 GHz band)
IEEE 802.11b	1999	2,4 - 2,4835 GHz (2,4 GHz band)
IEEE 802.11n	2009	2,4 GHz and 5GHz band
IEEE 802.11ac	2013	5 GHz band
IEEE 802.11ad	2014	57,0 - 66,0 GHz (60 GHz band)

(Source: https://de.wikipedia.org/wiki/Wireless_Local_Area_Network)

14.2.2 Channel width and maximum transmission speed

Every frequency band is divided into several channels. The channel width and the number of channels depend on the WLAN standard. One channel is needed to connect two hosts.

Example:

Exercise 3:

By analysing the following table find the relation between the channel width and the max. transmission speed. By the way MIMO (Multiple Input Multiple Output) is a technique using the same channel at the same time by several antennas. For example a 2x2 MIMO uses a channel twice while having 2 antennas at the sender and 2 at the receiver.

standard	band	MIMO	channel width	max. transmission speed
IEEE 802.11a	5,0 GHz	–	20 MHz	54 Mbit/s
IEEE 802.11n	2,4 GHz or 5,0 GHz	–	20 MHz	65 Mbit/s
		2×2	20 MHz	130 Mbit/s
		–	40 MHz	150 Mbit/s
		2×2	40 MHz	300 Mbit/s
		3×3	40 MHz	450 Mbit/s
		4×4	40 MHz	600 Mbit/s
IEEE 802.11ac	5,0 GHz	3×3	80 MHz	1,3 Gbit/s
			160 MHz	2,6 Gbit/s
		8×8	160 MHz	6,9 Gbit/s
IEEE 802.11ad	60,0 GHz	–	2 GHz	6,7 Gbit/s

(Source: https://de.wikipedia.org/wiki/Wireless_Local_Area_Network)

Conclusion:

14.3 <u>SSID</u>

The SSID (service set identifier) is a string of maximum 32 characters displayed on the hosts when they are scanning for WLAN access points.

The SSID can be set hidden in the configuration of the access point, so that is must be entered manually on the host. The idea of this feature was to create a kind of security but network scanners can still detected the hidden access points.

Most access points can have several SSIDs. This can be useful to provide for example a Guest-WLAN in addition to a private WLAN. This avoids that guests can scan the whole LAN via their wireless device.

14.4 <u>Security</u>

Most communication on LANs isn't encrypted. Sniffing traffic on a wired LAN still requires physical access to the wires. Access to WLANs doesn't need a wired connection so it is much easier to sniff them. Therefore the data sent over a WLAN should always be encrypted.

Three encryption techniques are used today on WLAN:

1. WEP
2. WPA
3. WPA2

WEP shouldn't be used anymore as there is a series of tools to hack the key.

Be aware that only the traffic over the WLAN will be encrypted. The connection of the access point to the wired network will only be encrypted if the application encrypts the data. For example browser traffic via HTTP is not encrypted whereas HTTPS will encrypt.

14.5 WLAN-Networks

Things start to get more complex if the area that should be provided with WLAN is bigger than the coverage of a single access point. There is several solutions:

14.5.1 Wired backbone

The classic and still the best way to do this is to setup several access points all configured with the same SSID and password but using a different channel for every access point. The access points are connected together via a wired LAN called backbone.

Example:
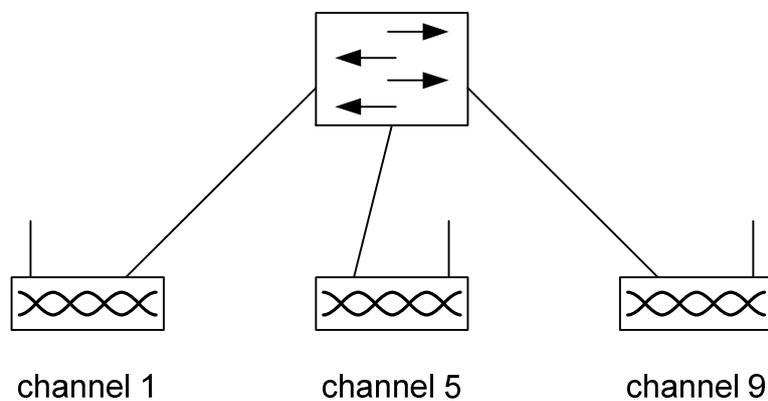
advantage:

- Highest possible transmission speed on every access point
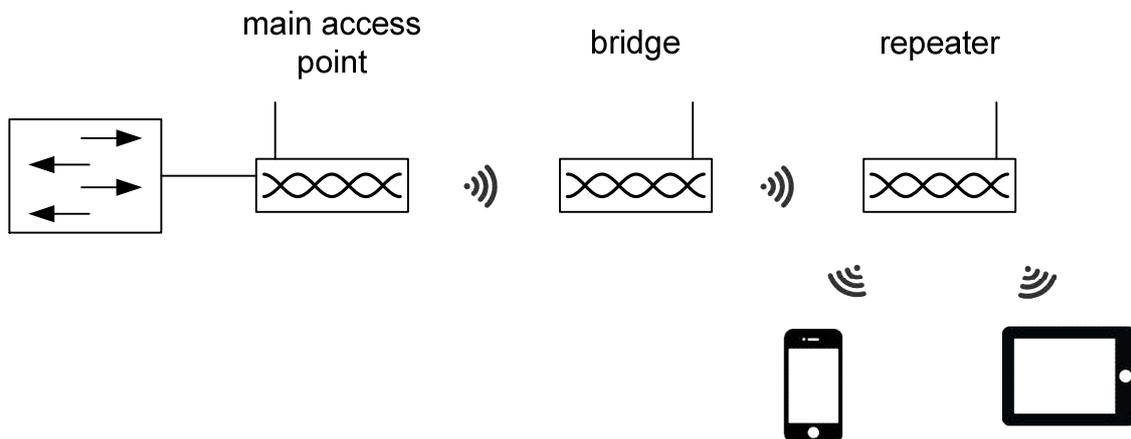
disadvantage:

- need of a wired LAN

14.5.2 WDS (wireless distribution system)

With WDS you can expand your WLAN using multiple access points without a wired backbone. The access points are communicating wirelessly between each other. WDS defines three operating modes for the access points.

1. Main access point: The access point is connected to the wired LAN.

2. Repeater mode: The access point communicates with all other access points and wireless hosts.

3. Bridge mode: The access point communicates only with other access points.

Example:

advantage:

- No need of a wired LAN.

disadvantage:

- All access points work on the same channel, thus with every transmission at least two devices will use the same frequency simultaneously. *This will half the effective transmission speed*.

- The further a bridge or repeater is away from its neighbour the slower the transmission speed gets in the overall network.

14.5.3 <u>WLAN controller</u>

In professional environments WLAN controllers are used in order to be able to administer all access points from one central interface. As no standard exists for such controllers, the whole equipment needs to be from the same supplier.

14.5.4 <u>Switching of access points</u>

Opposite to the GSM network most WLAN hosts will only change from one access point to another when they lose the signal from their current access point. Only very recent hosts will change as soon as a stronger WLAN access point is captured.