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Wireless Local Area Networks

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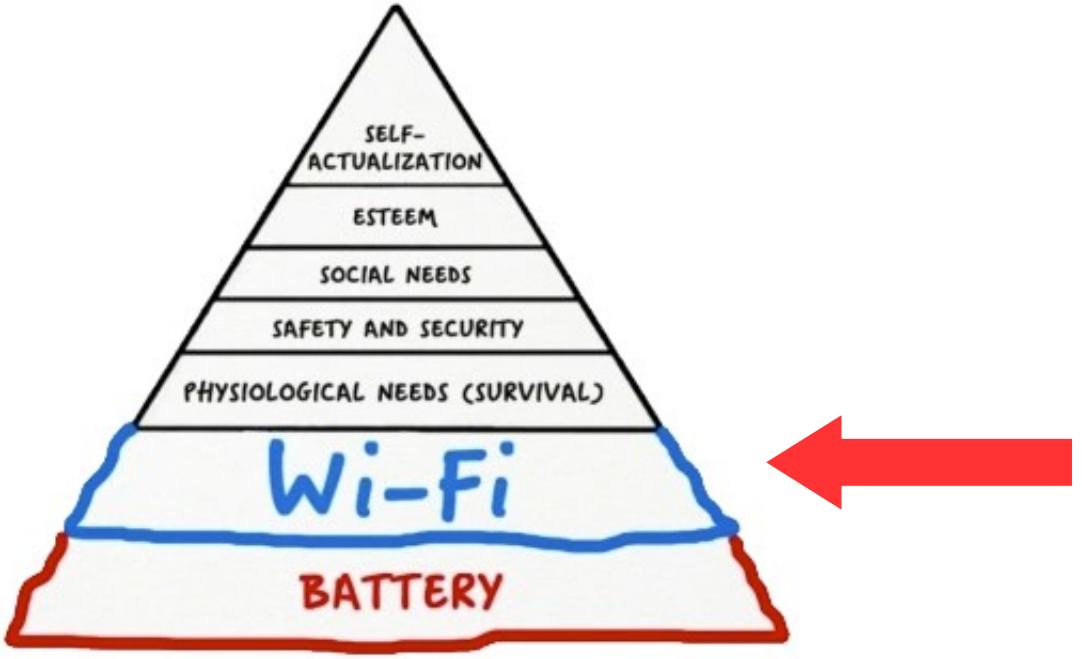
Network Engineering

upf. WN Wireless Networking Group
http://wnrg.upf.edu/

BASIC HUMAN NEEDS



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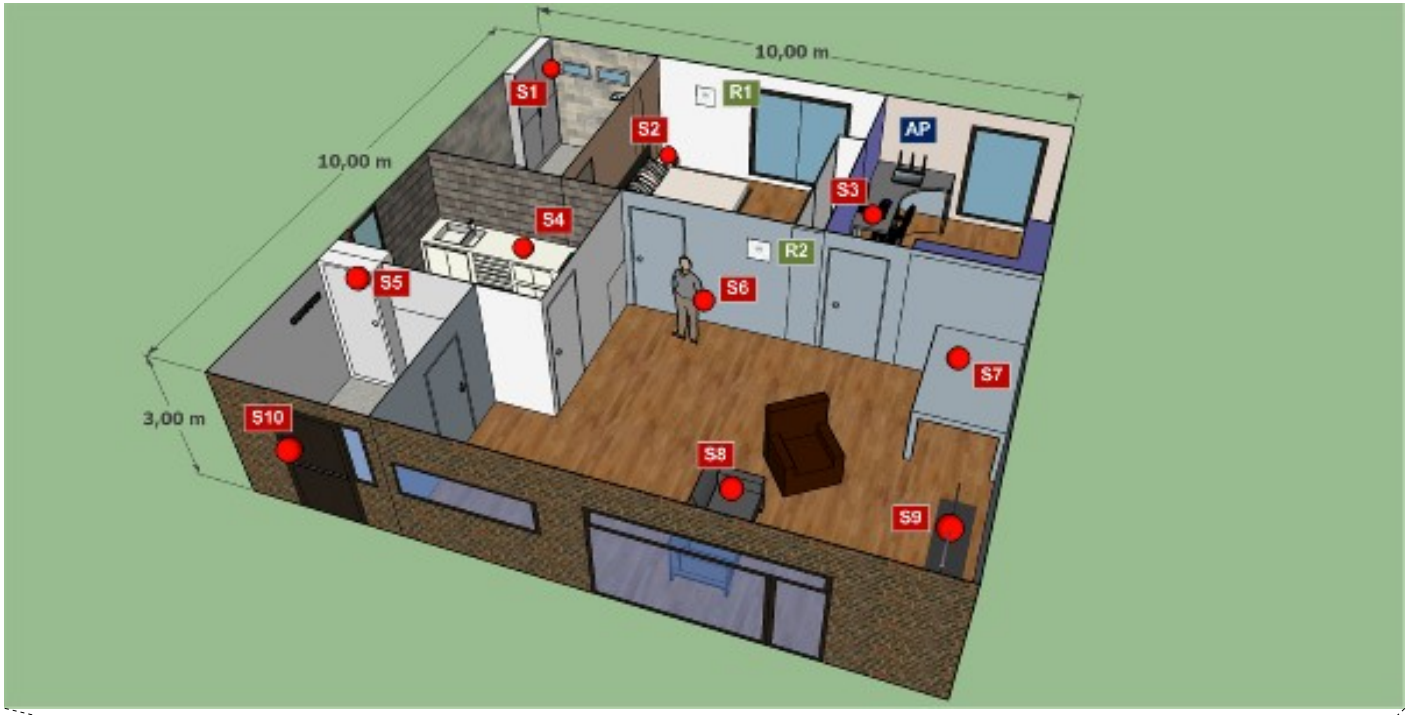
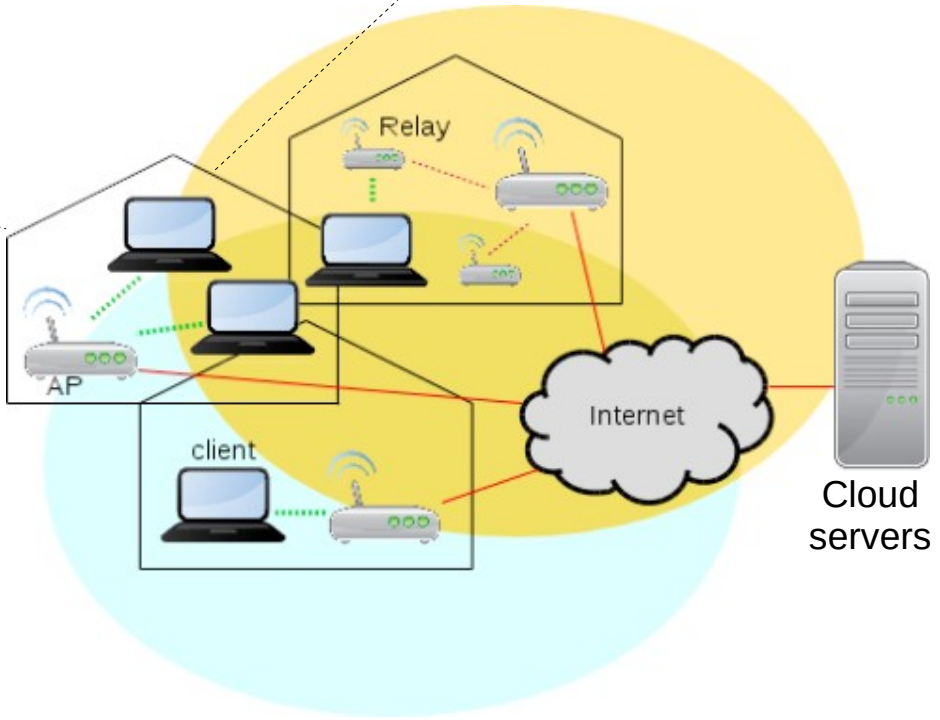
WIFI at home





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WIFI everywhere!

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Setting-up a WLAN

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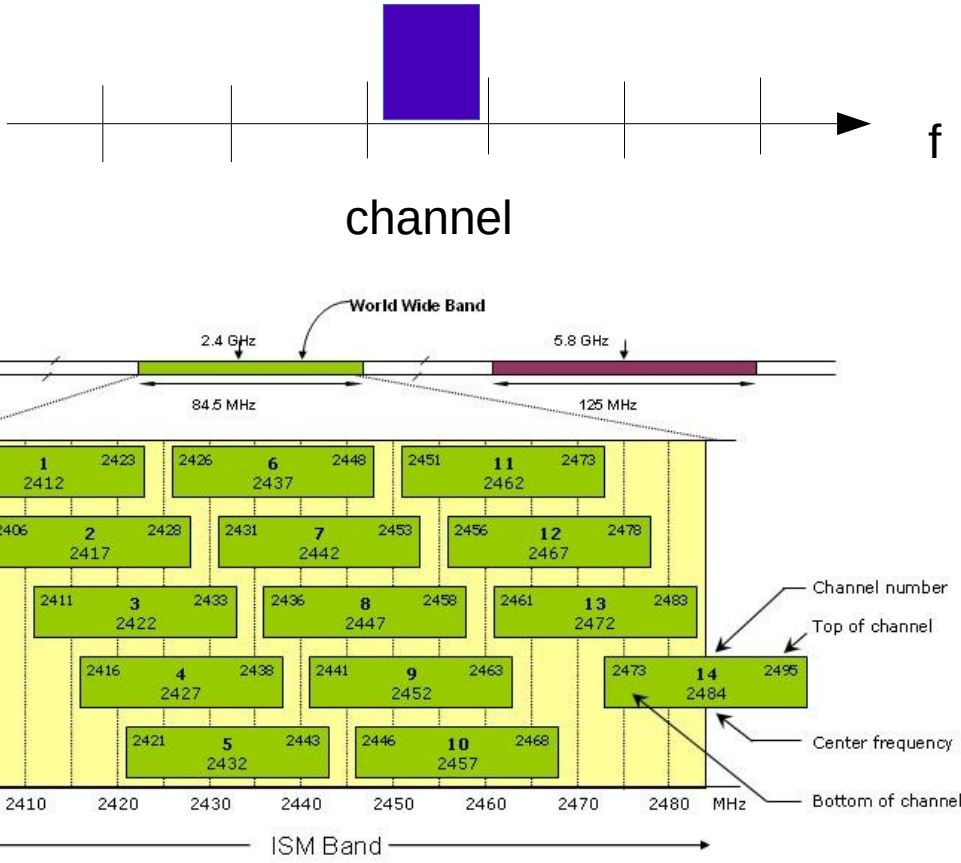
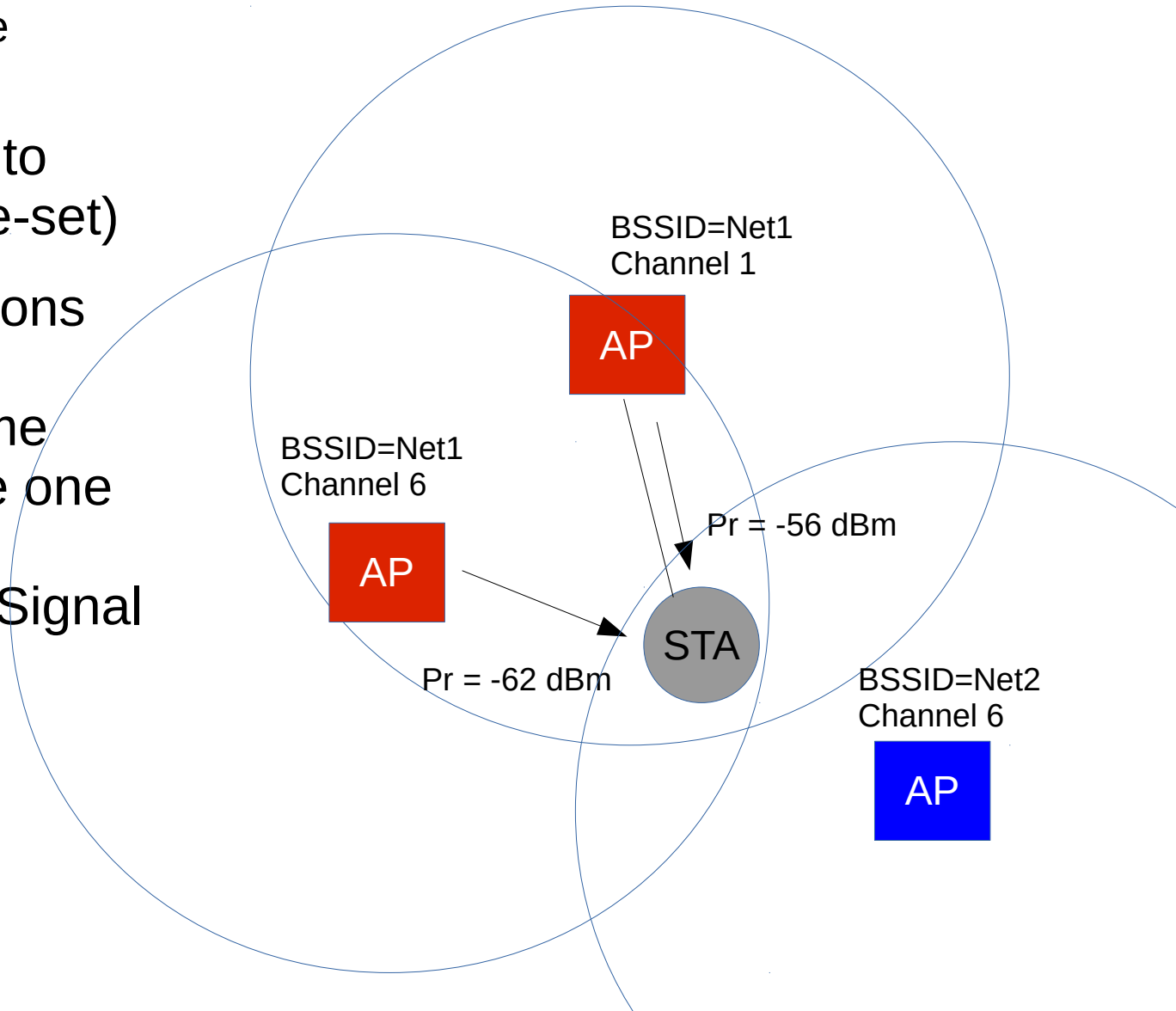
When the AP is turned ON

- Selects a channel to use.
- Starts transmitting beacons each T_{beacon} msecs (usually, 100 msecs).
- Each beacon contains information about the AP:
  - BSSID (name of the network)
  - Supported transmission rates
  - Other characteristics (antennas, channel widths, etc.)



A STA is turned on

- Scans all channels.
  - Lists all the available BSSIDs
- Selects the BSSIDs to which it belongs (pre-set)
- If a STA detect beacons from different APs belonging to the same BSSID, it selects the one with higher RSSI (Received Strength Signal Indicator)



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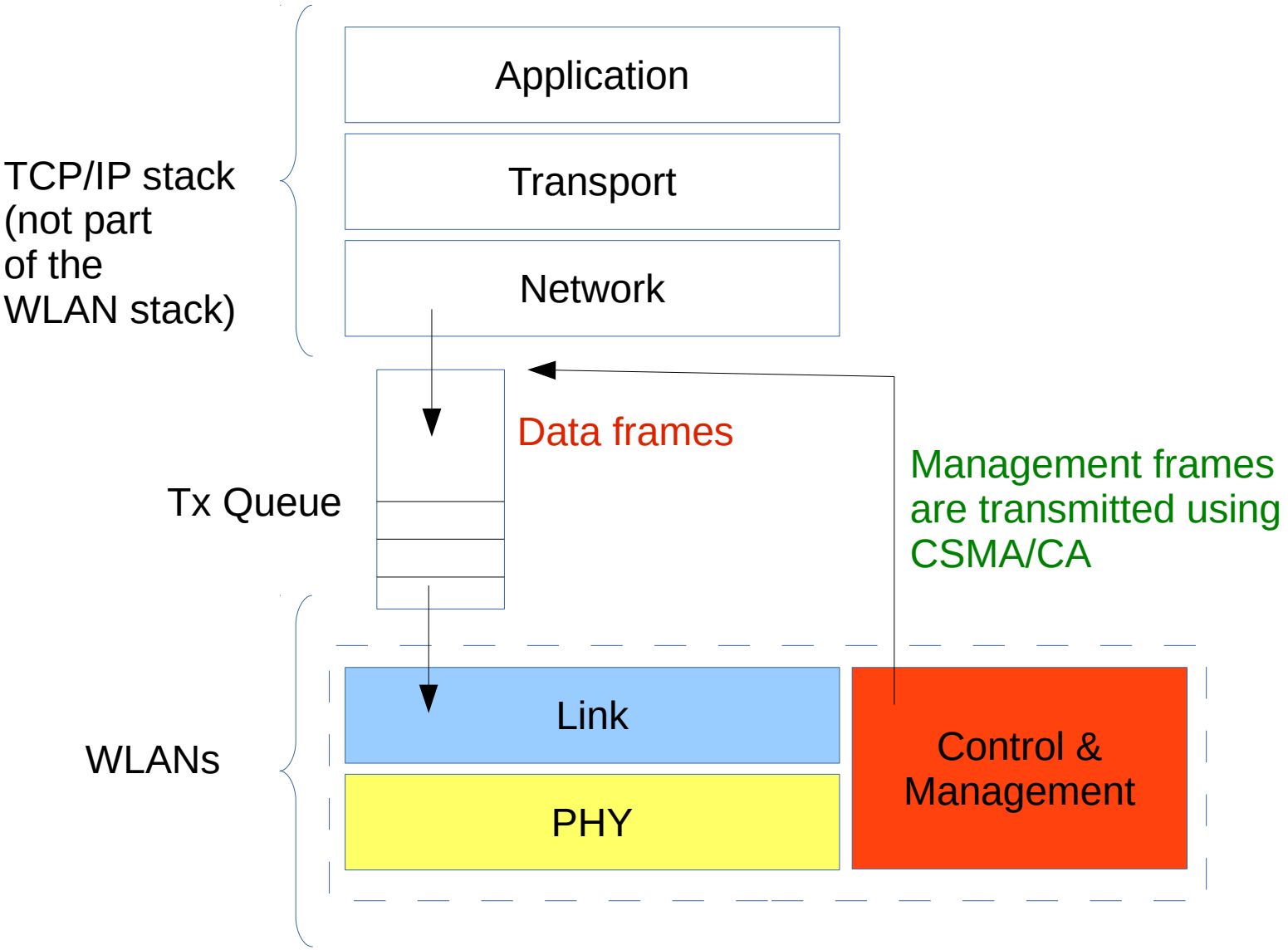
WLAN Device: Protocol Stack



Transmitted power, Path-loss, Received Power

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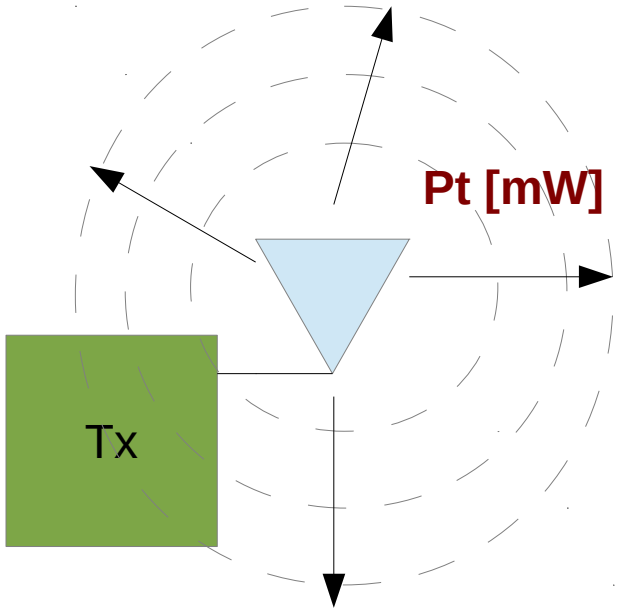
Transmit Power

Omnidirectional Pattern

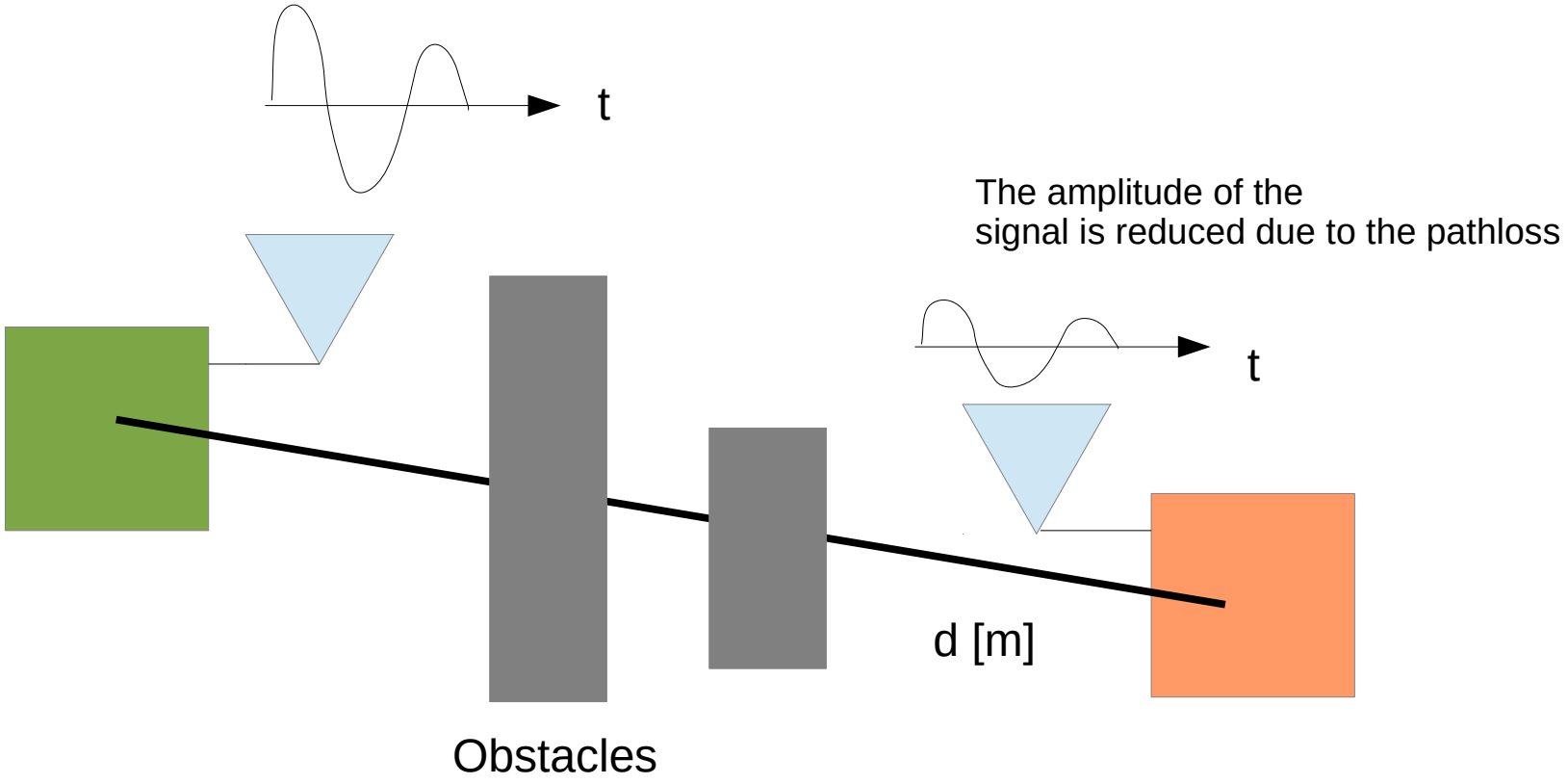


Pt(dBm)= 10 log10(Pt [mW])

Examples:
Pt=100 mW → Pt=20 dBm
Pt=1 mW → Pt = 0 dBm
Pt=1 microW → Pt = -30 dBm
Pt=1 nanoW → Pt = -60 dBm

Path-loss

To know more: https://arxiv.org/pdf/1812.00667.pdf



- Relation with the distance: PL [dB] = L1m [dB] + 10 γ(f,environment) log10(d) [dB]

Path-loss at 1 meter
(usually, 20-25 dBs)

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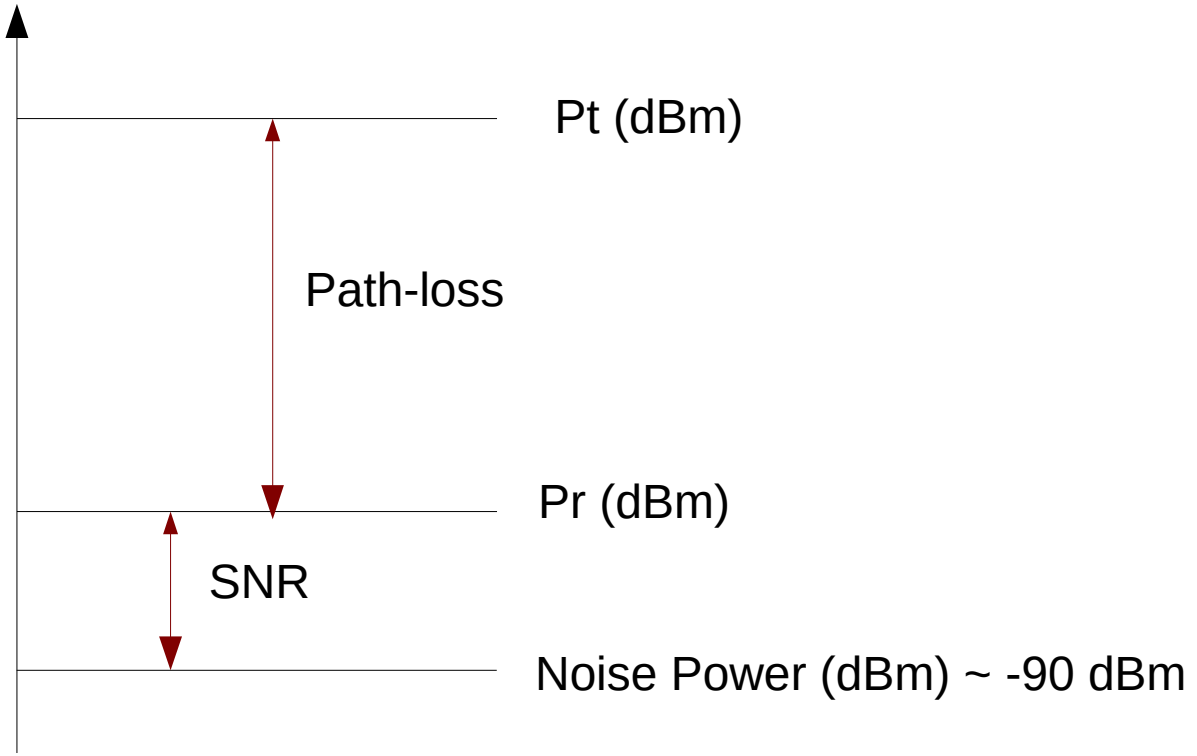
SNR

- Signal-to-Noise Ratio
  - SNR [dB] = Pr [dBm] – Noise Power [dBm]



WLANs

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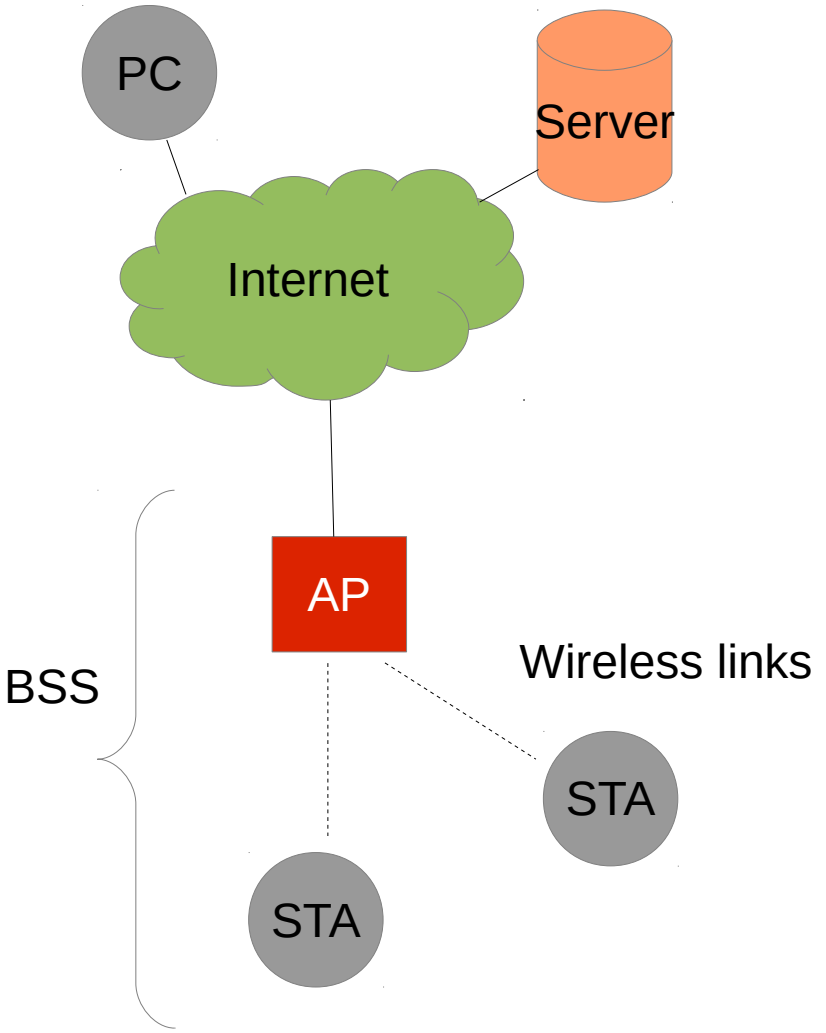
Infrastructure

- Stations (STAs) access to Internet and to talk to each other through an Access Point (AP)
- Single-hop communication
- Basic Service Set (BSS)
- STAs must associate to the BSS in order to be able to transmit and receive data
- Direct STA2STA communication is possible with WIFI Direct



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Operating Bands (Spectrum)

- License-exempt bands.
- Maximum Transmission Power (i.e. 100 mW = 20 dBm)
- Most common bands: 1 GHz, 2.4 GHz, 5 GHz, 60 GHz
  - 1 GHz: 'large' coverage, lower transmission rates
  - 60 GHz: 'low' coverage, higher transmission rates
- In 2.4 and 5 GHz WLANs use a minimum channel width of 20 MHz channels

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Operating Bands (Spectrum)

- 20 MHz channels
  - 2.4 GHz: ~3 non-overlapping channels (1~4 channels, 5 MHz spaced)

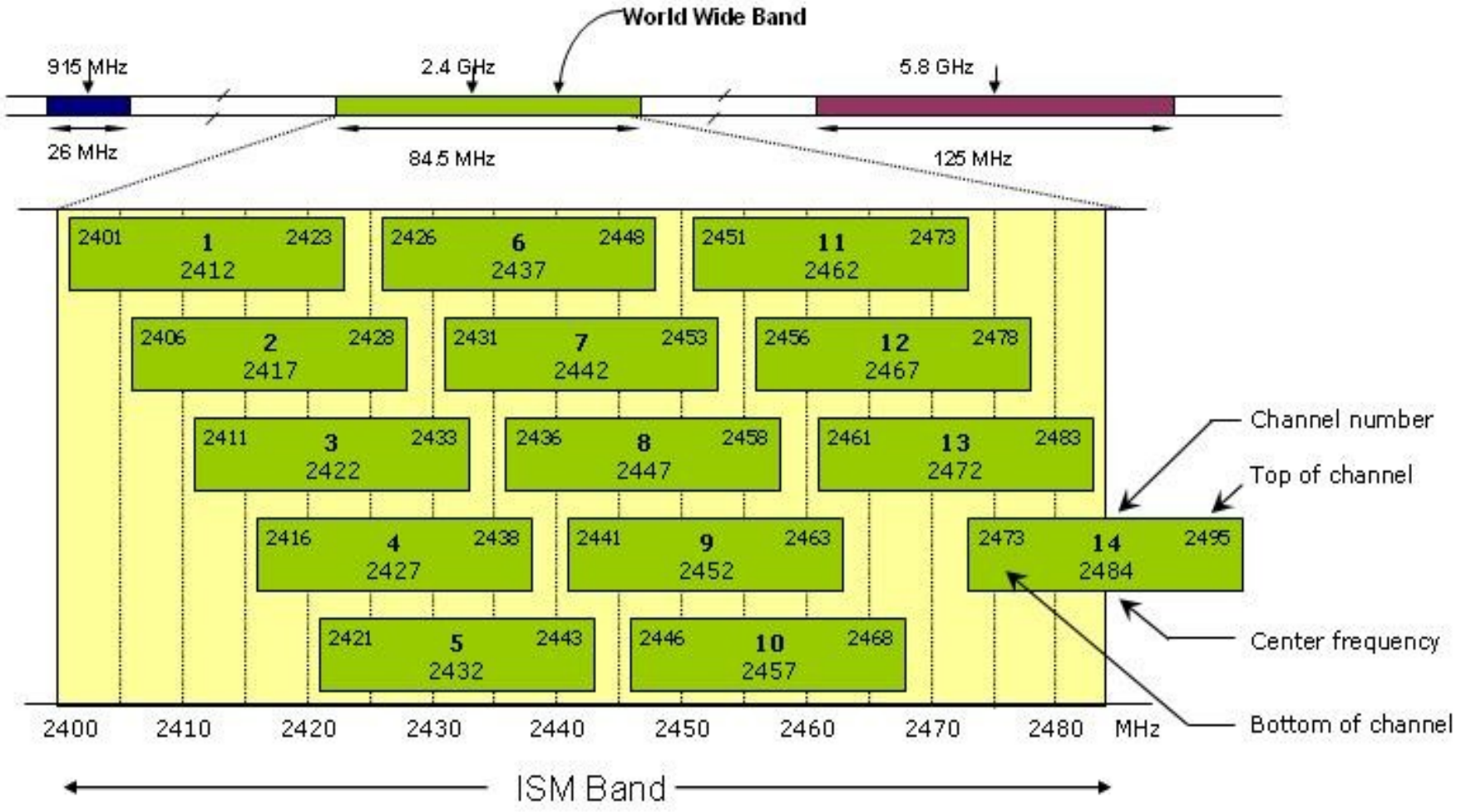


Image from:http://www.moonblinkwifi.com/2point4freq.cfm

Operating Bands (Spectrum)

- 20 MHz channels
  - 5 GHz: ~20 non-overlapping channels (20 MHz spaced)

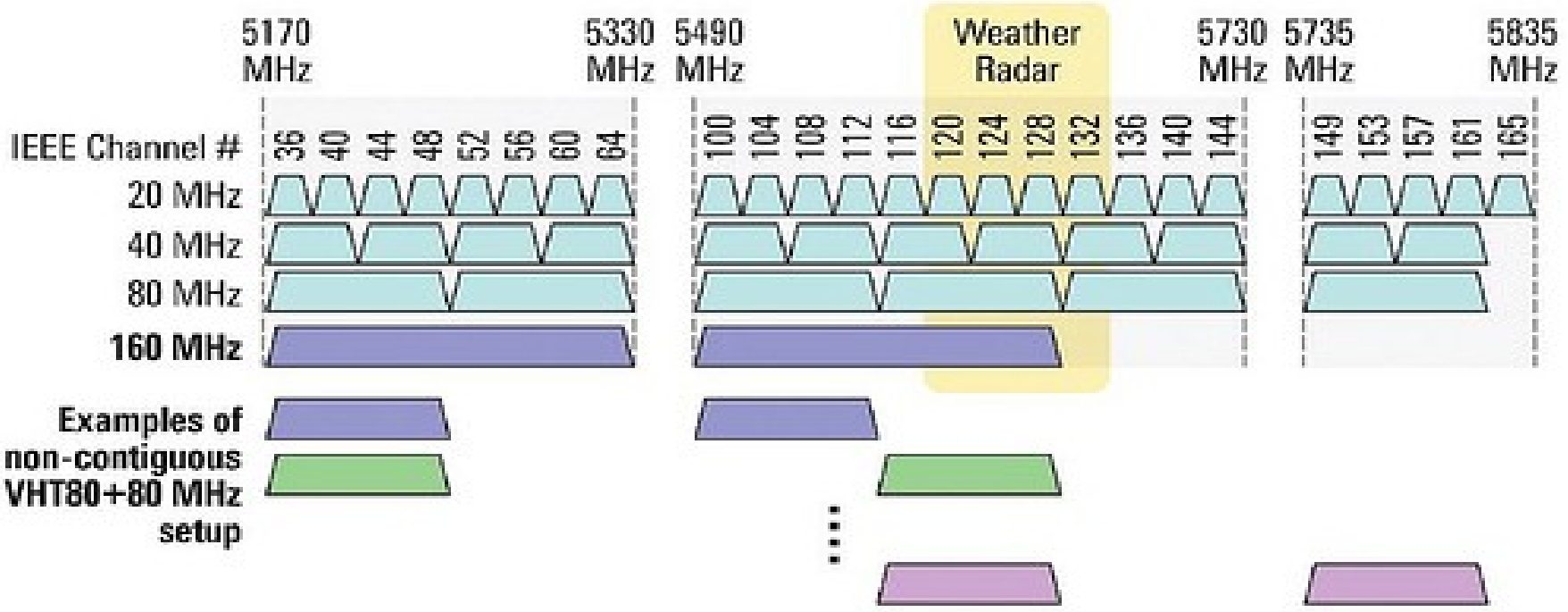
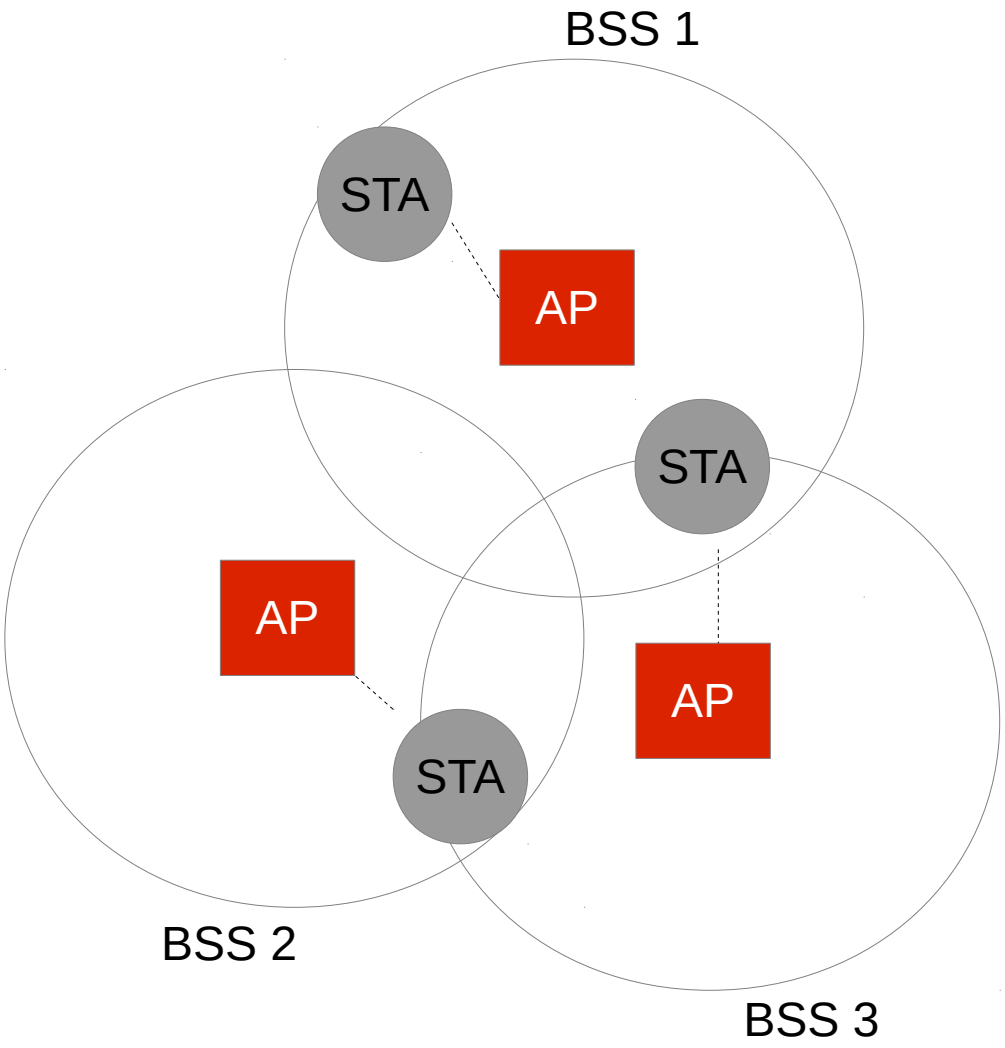


Image from:http://www.dailywireless.org/2011/12/13/1-gbps-wifi-next-year/

Coexistence Problem in ISM bands

- Everyone can deploy a Wireless Network
  - IEEE 802.11 IEEE 802.15.4, Microwaves, etc.
- No planning is required
- Mutual Interference
- Potential low performance



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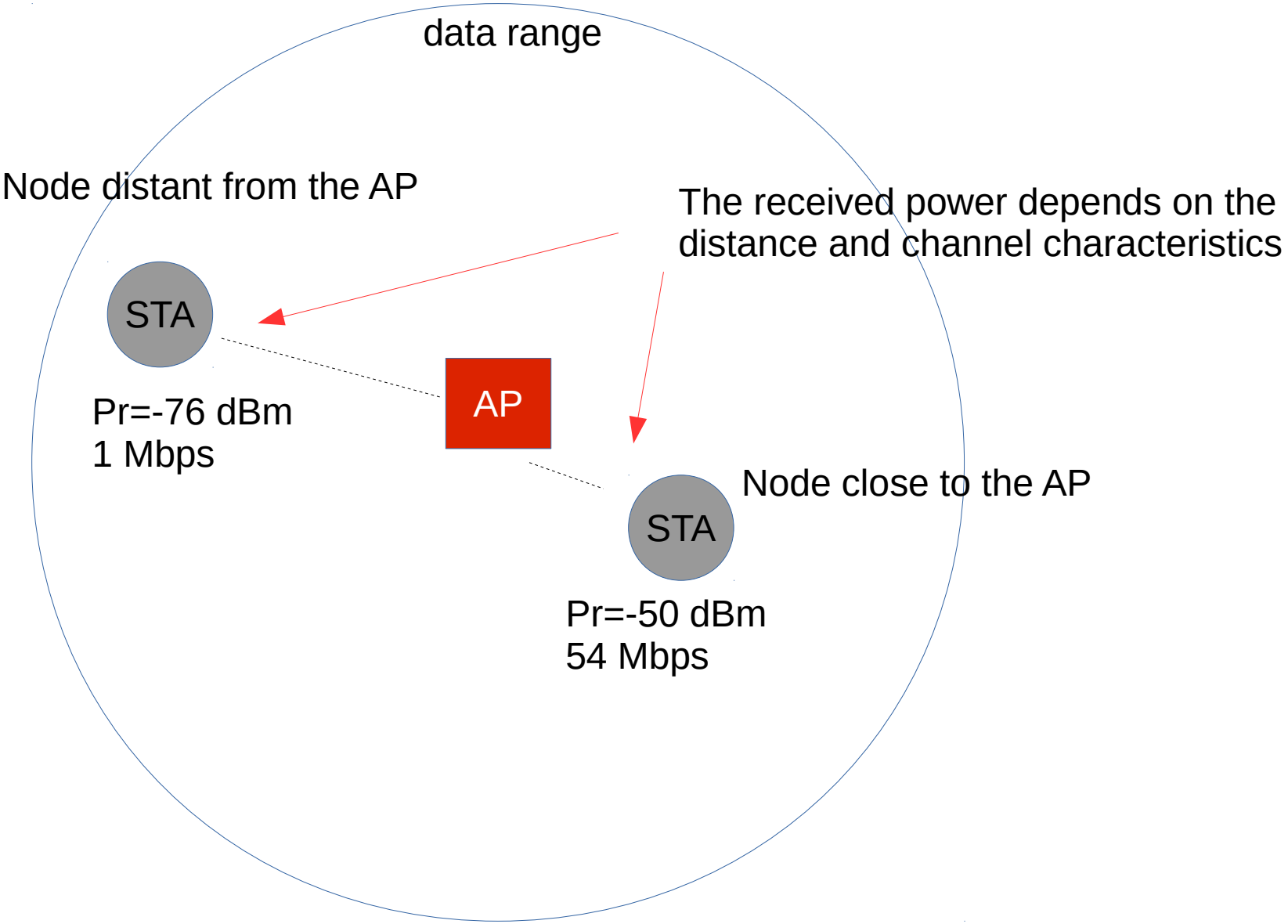
Transmission Rates



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802.11ac

Transmission Rates

MCS	Modulation	Rate	Minimum Sensitivity [dBm]			
			20 MHz	40 MHz	80 MHz	160 MHz
0	BPSK	1/2	-82	-79	-76	-73
1	QPSK	1/2	-79	-76	-73	-70
2	QPSK	3/4	-77	-74	-71	-68
3	16-QAM	1/2	-74	-71	-68	-65
4	16-QAM	3/4	-70	-67	-64	-61
5	64-QAM	2/3	-66	-63	-60	-57
6	64-QAM	3/4	-65	-62	-59	-56
7	64-QAM	5/6	-64	-61	-58	-55
8	256-QAM	3/4	-59	-56	-53	-50
9	256-QAM	5/6	-57	-54	-51	-48

MCS	Sensitivity (dBm)-20 MHz	Rate (Mbps)
0	-82	6.5
1	-79	13
2	-77	19.5
3	-74	26
4	-70	39
5	-66	52
6	-65	58.5
7	-64	65
8	-59	78
9	-57	86.67

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Link-layer

- Multiple nodes, and a single (half-duplex) shared channel.
- If two or more nodes transmit at the same time, we have a collision.
- The channel access arbitration is done using the **Distributed Coordination Function (DCF)**, which consists of:
  - CSMA protocol.
  - Backoff (BEB).
  - Stop & Wait ARQ protocol, for packet retransmissions.
- Other relevant features:
  - The Backoff countdown is paused if channel activity is detected.
  - After any transmission, all nodes are synchronized.

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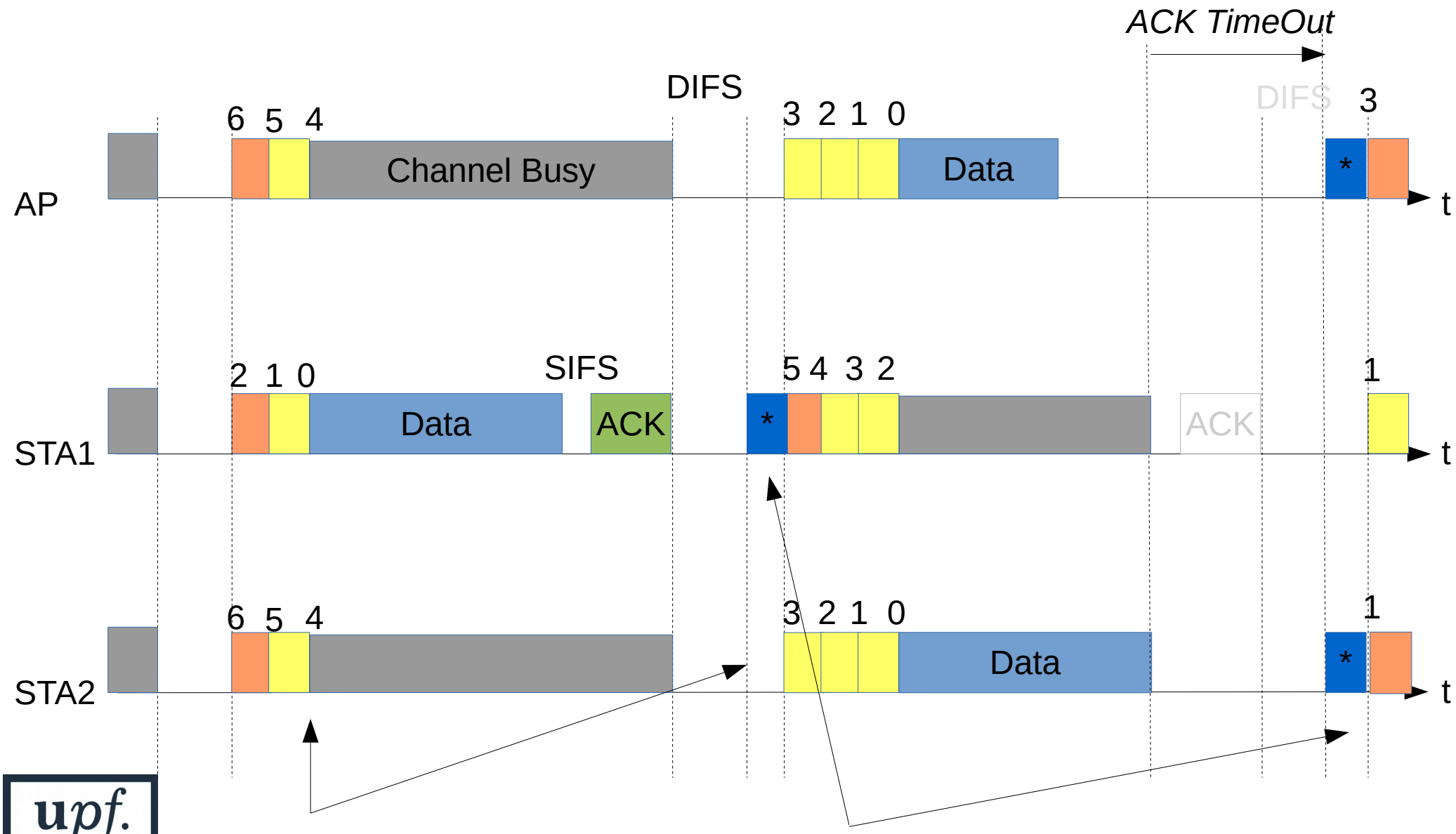
New Random selected backoff value (orange slots)

DCF

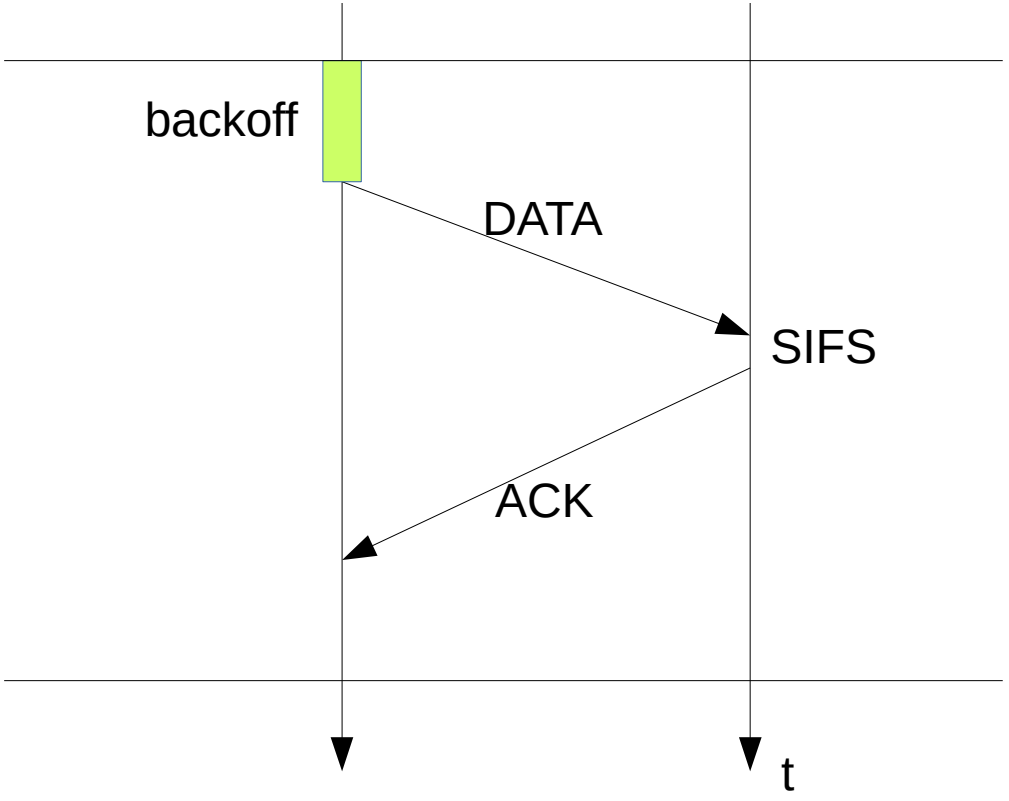


The backoff is frozen,
and continues later with the same value

Extra slot time for those nodes
that have transmitted

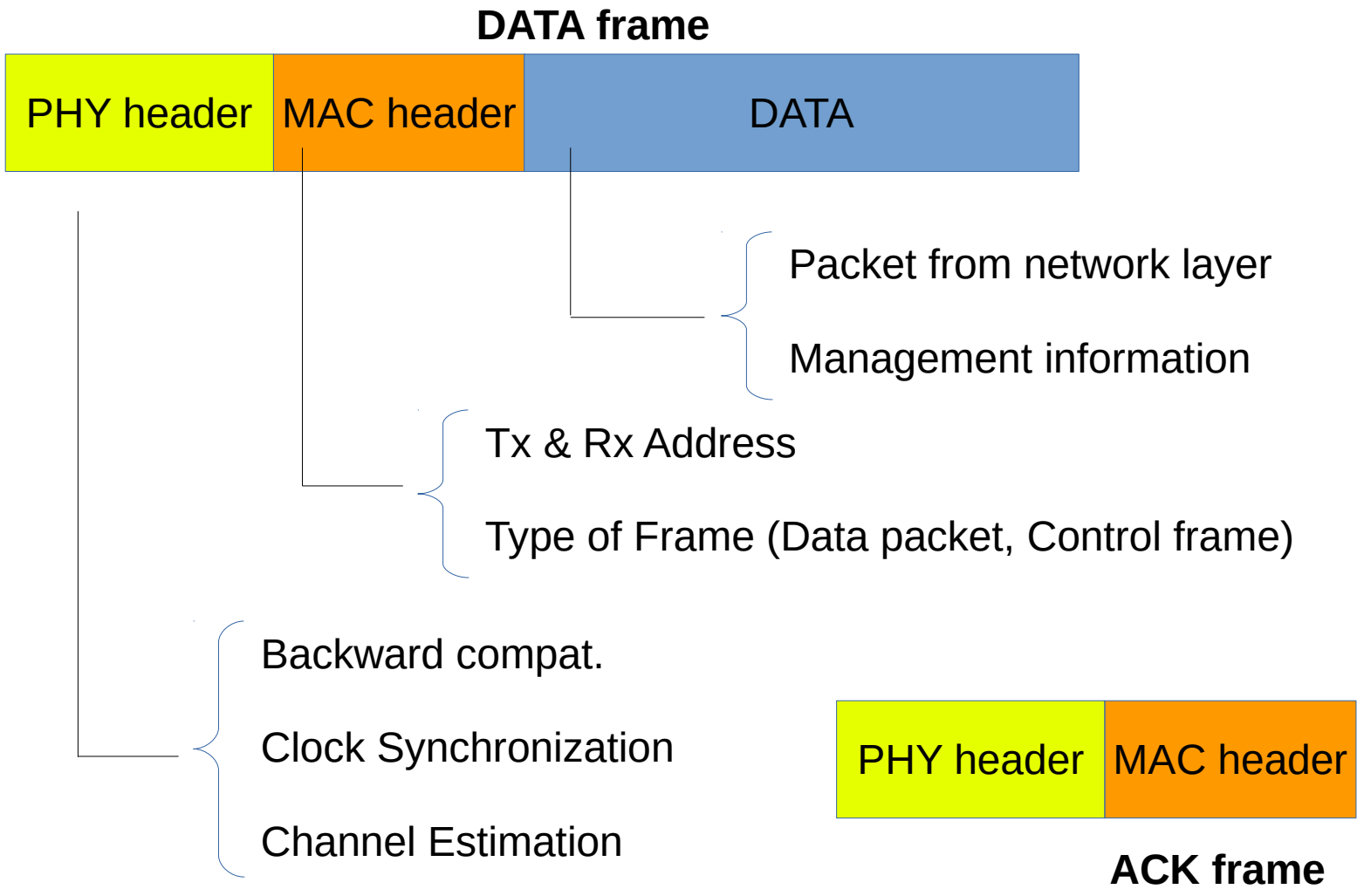
Automatic ReQuest prtocol (Stop & Wait)

- Unconfirmed Packets are retransmitted until they are acknowledged or discarded.
- There is a maximum number of retransmissions: R_{max}
- Stop & Wait ARQ protocol.



Frame Structure

- A single and common structure



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Packet Transmission Time

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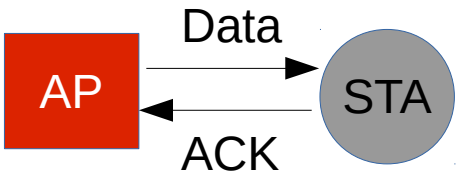
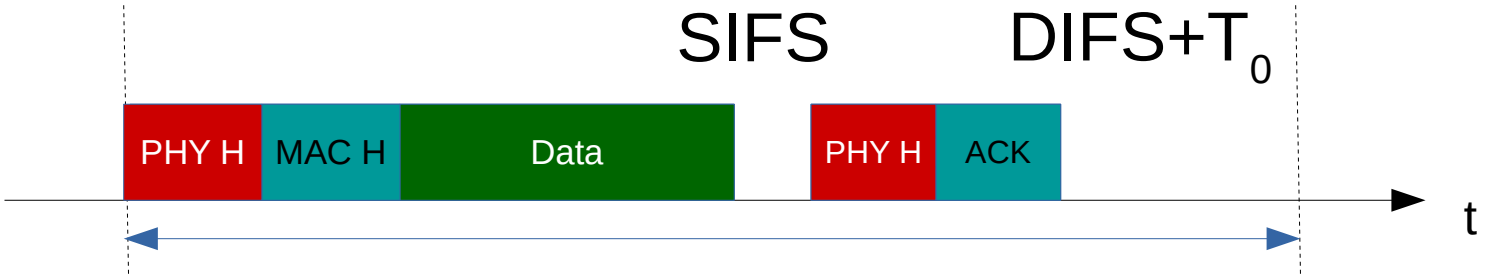
Packet Transmission time



$T_{DATA}=T_{PHY}+(L_{MAC}+L)/R$

Values:
T_{PHY}=40 micro seconds
L_{ACK}=112 bits
L_{MAC}=240 bits
SIFS = 16 micro seconds
DIFS = 34 micro seconds
T_0 = 9 micro seconds

$T_{ACK}=T_{PHY}+(L_{ACK})/R$



$T=T_{DATA}+SIFS+T_{ACK}+DIFS+T_0$

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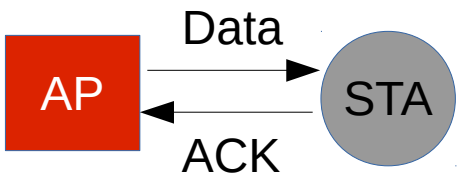

Example

- Pt=20 dBm, PL(dB)=95 dB, Pr=Pt-PL(dB)=20-92 =-72 dBm
- Rate: MCS = 3 → R= 26 Mbps
- L=12000 bits
- $T_{DATA}=T_{PHY}+(L_{MAC}+L)/R$ = 40E-6 + (240+12000)/26E6 = 0.51 ms
- $T_{ACK}=T_{PHY}+(L_{ACK})/R$ = 40E6 +112 / 26E6 = 0.044 ms
- T = 0.51E-3+16E-6+0.044E-3+34E-6+9E-6=0.613 ms

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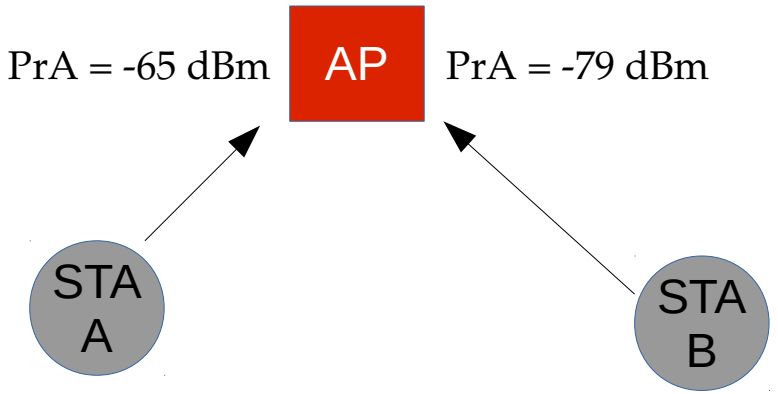
Exercise

- Calculate the transmission time for STA A and STA B in the following WLAN if STA A transmits packets of size LA=1000 bits and LB=12000 bits.



- Considering they alternate transmissions, which station will transmit more packets to the AP? How many?

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