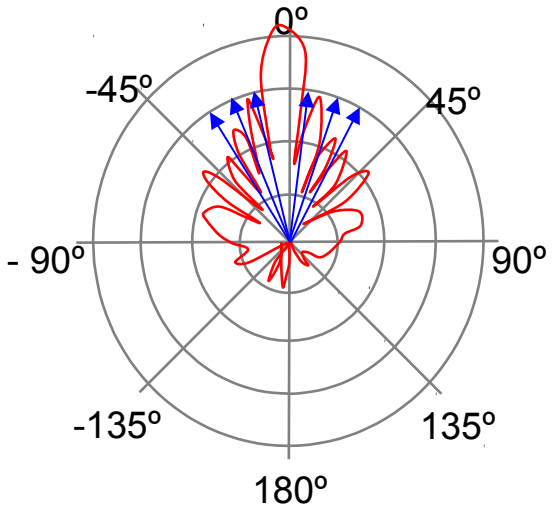
CMP4204
Wireless Technologies

Lecture 5

Microwave Radio



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Microwave Spectrum

- The microwave spectrum is defined as electromagnetic energy ranging from approximately 300 MHz to 300 GHz in frequency.
- Most common applications are within the 1 to 40 GHz range.
- The characteristics of radio waves in this band are Point to Point.
- Relatively low output power directed with highly directional antenna is the norm.

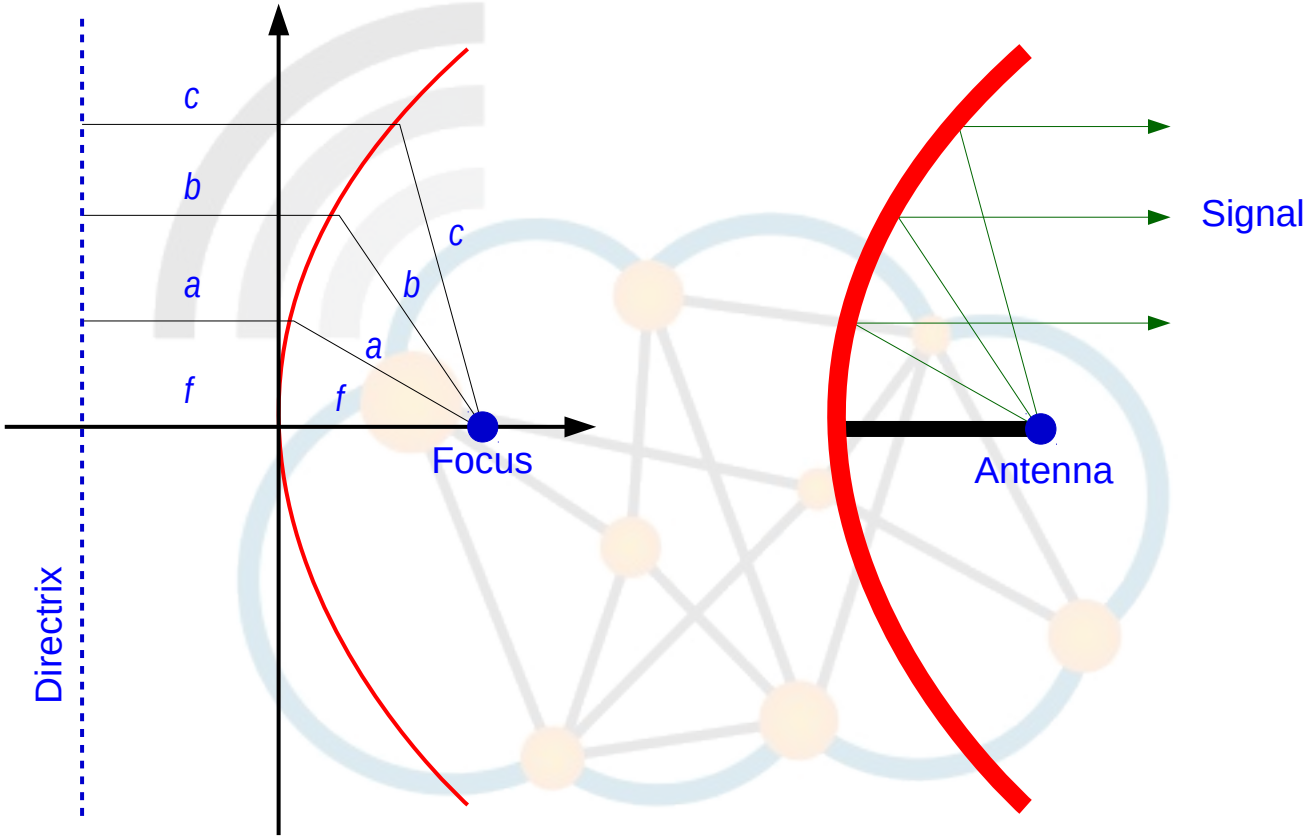
Antennas

- Electrical conductor (or array of..) used to radiate electromagnetic energy or collect electromagnetic energy
- Transmission
  - Radio frequency energy from transmitter
  - Converted to electromagnetic energy
  - By antenna
  - Radiated into surrounding environment.
- Reception
  - Electromagnetic energy impinging on antenna
  - Converted to radio frequency electrical energy
  - Fed to receiver.
- Same antenna often used for both.

Parabolic Reflective Antenna

- Used for terrestrial and satellite microwave.
- Parabola is locus of point equidistant from a line and a point not on that line.
- A radio source signal placed at focus will produce waves reflected from parabola in parallel to axis.
  - Creates (theoretical) parallel radio beam.
- On reception, signal is concentrated at focus, where detector is placed.

Parabolic Reflective Antenna



Antenna Parameters

- Frequency
- Gain (main Lobe)
- Half Power Beam Width
- Side Lobe
- Front to Back Ratio
- Polarisation
- Nulls
- Environmental Conditions
- . . .

Microwave Frequency Spectrum

- The microwave spectrum is usually defined as electromagnetic energy ranging from approximately 1 GHz to 300 GHz in frequency.
- Most common applications are within the 1 to 40 GHz range.
  - FWALA 3.5 - 3.7 GHz
  - FWALA 10.5 GHz
  - FWALA 26 GHz
  - SRD 2.4 and 5 GHz (WiFi)
  - SRD 17 and 24 GHz

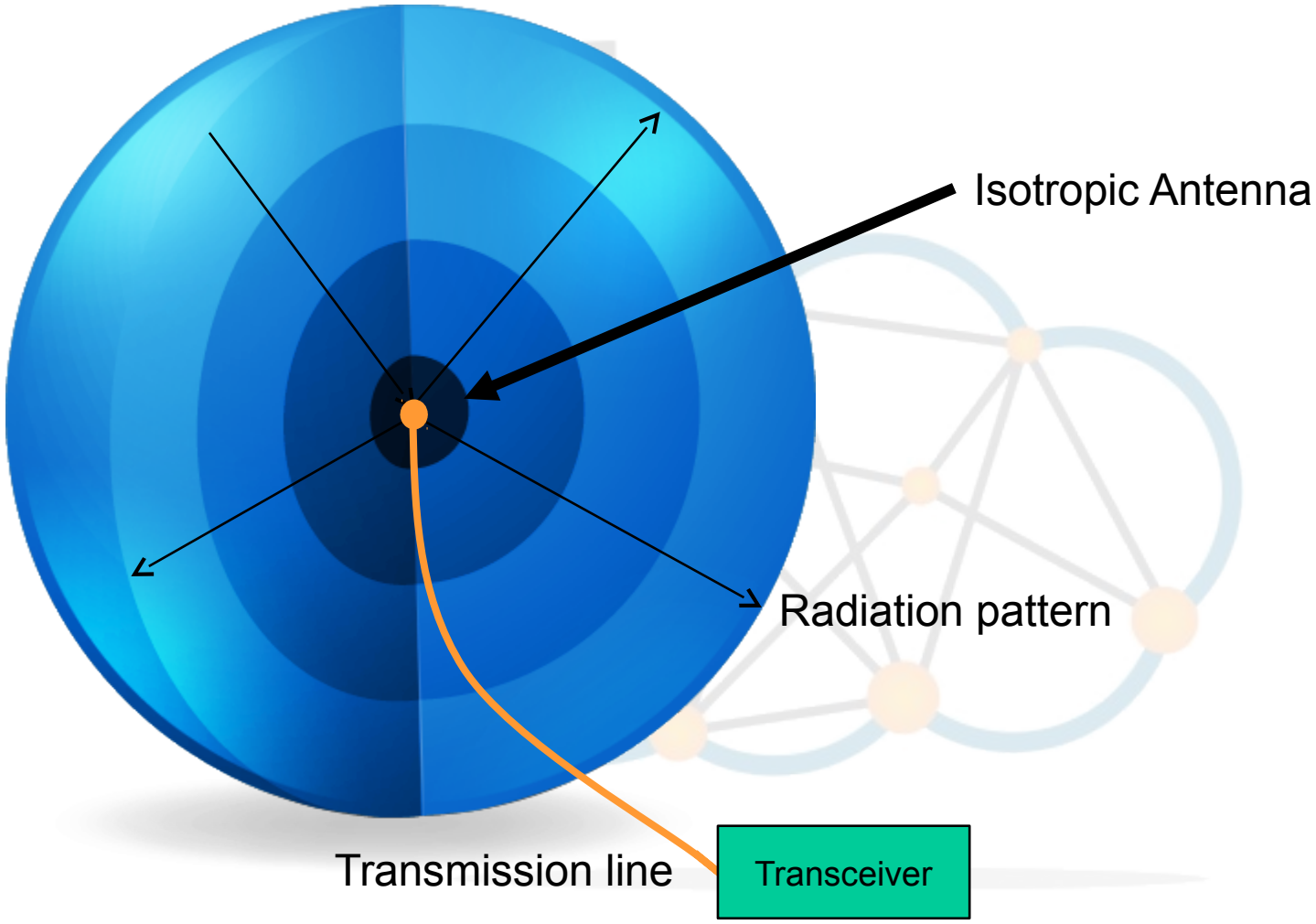
Microwave frequency bands

Letter Designation	Frequency range
L band	1 to 2 GHz
S band	2 to 4 GHz
C band	4 to 8 GHz
X band	8 to 12 GHz
$K_{u\ band}$	12 to 18 GHz
K band	18 to 26.5 GHz
$K_{a\ band}$	26.5 to 40 GHz

Antenna Gain

- Gain: The amplification of the transmitted / received power where power output in particular direction compared with that produced by isotropic antenna measured in decibels (dB).
- The higher the gain, the longer the possible distance between the user and the base station for effective link.
- That allows larger cell size and requires less base stations.

Hypothetical Isotropic Antenna

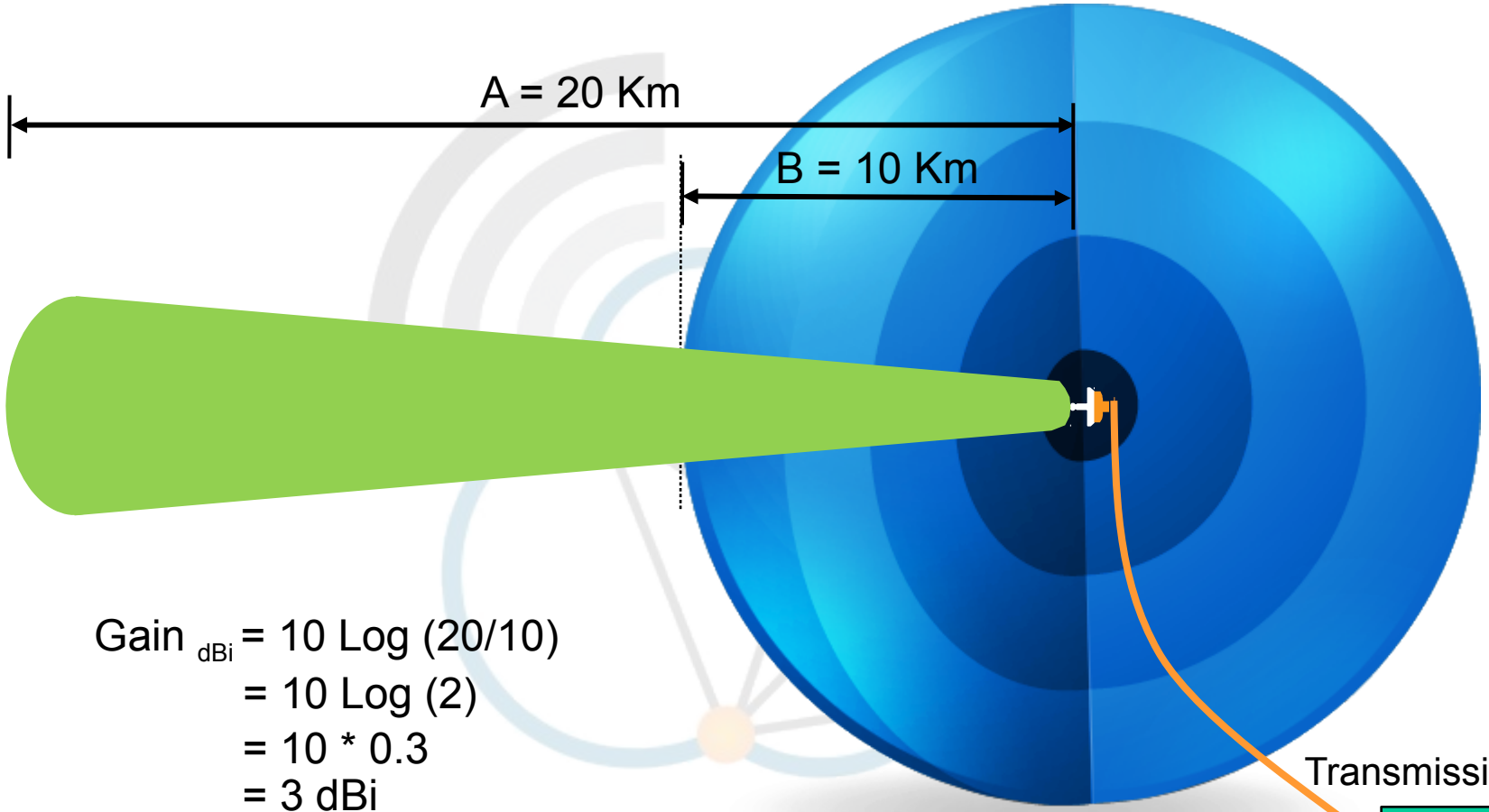


decibel (dB)

- The decibel symbol is often qualified with a suffix.
- dBi dB(isotropic) – the forward gain of an antenna compared with the hypothetical isotropic antenna, which uniformly distributes energy in all directions.

$$\text{Gain}_{\text{dBi}} = 10 \text{ Log } (A / B)$$

Directional Antenna



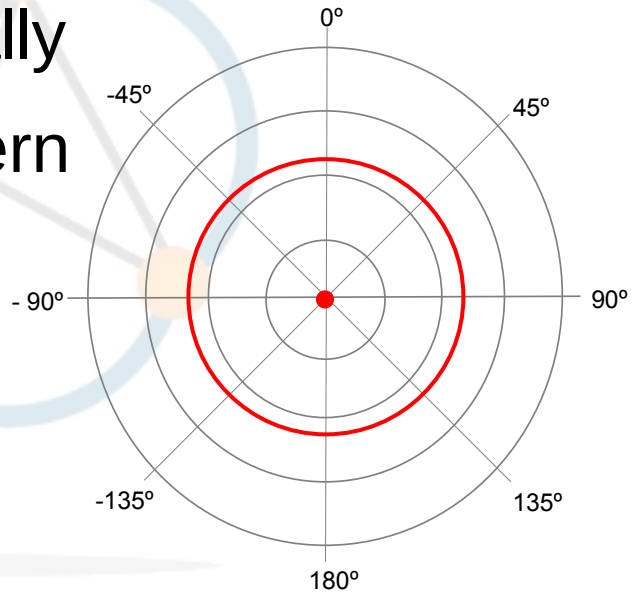
Gain $_{dBi}$ = 10 Log (20/10)
= 10 Log (2)
= 10 * 0.3
= 3 dBi

decibel (dB)

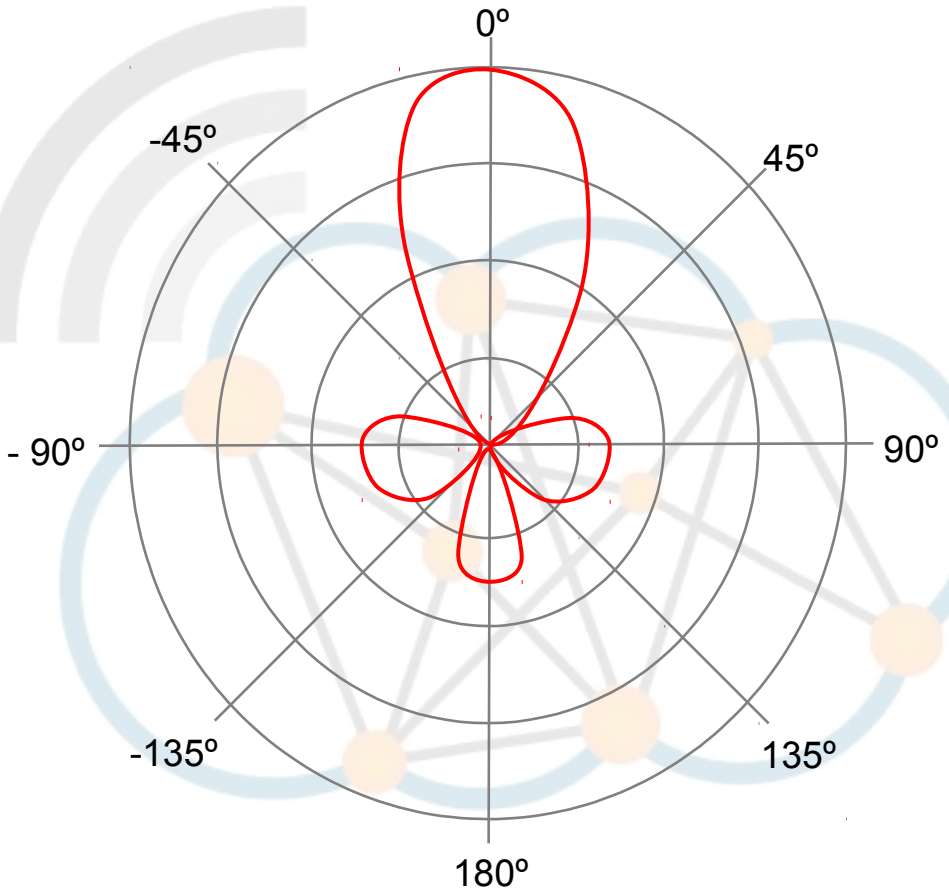
- The decibel symbol is often qualified with a suffix.
- dBi dB(isotropic) – the forward gain of an antenna compared with the hypothetical isotropic antenna, which uniformly distributes energy in all directions.
- dBm dBm (milliwatt) – is an abbreviation for the power ratio in decibels (dB) of the measured power referenced to one milliwatt (mW).

Radiation Pattern

- Power radiated in all directions
- Not same performance in all directions
- Isotropic antenna is (theoretical) point in space
  - Radiates in all directions equally
  - Gives spherical radiation pattern

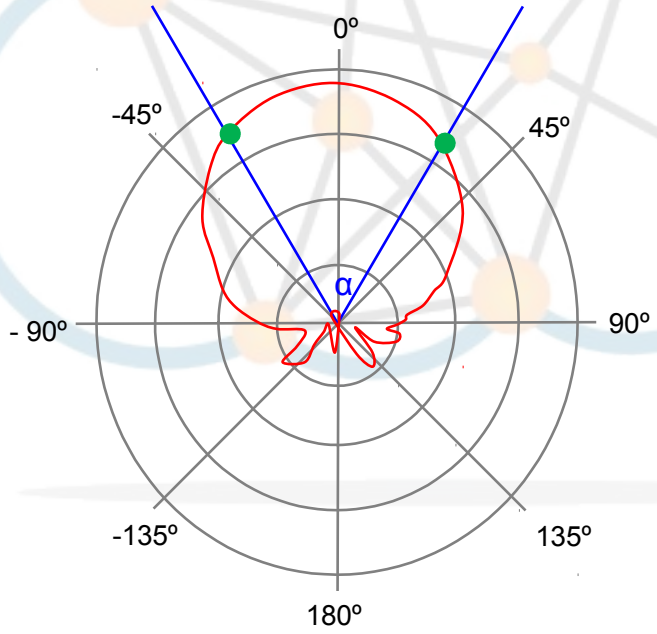


Radiation pattern



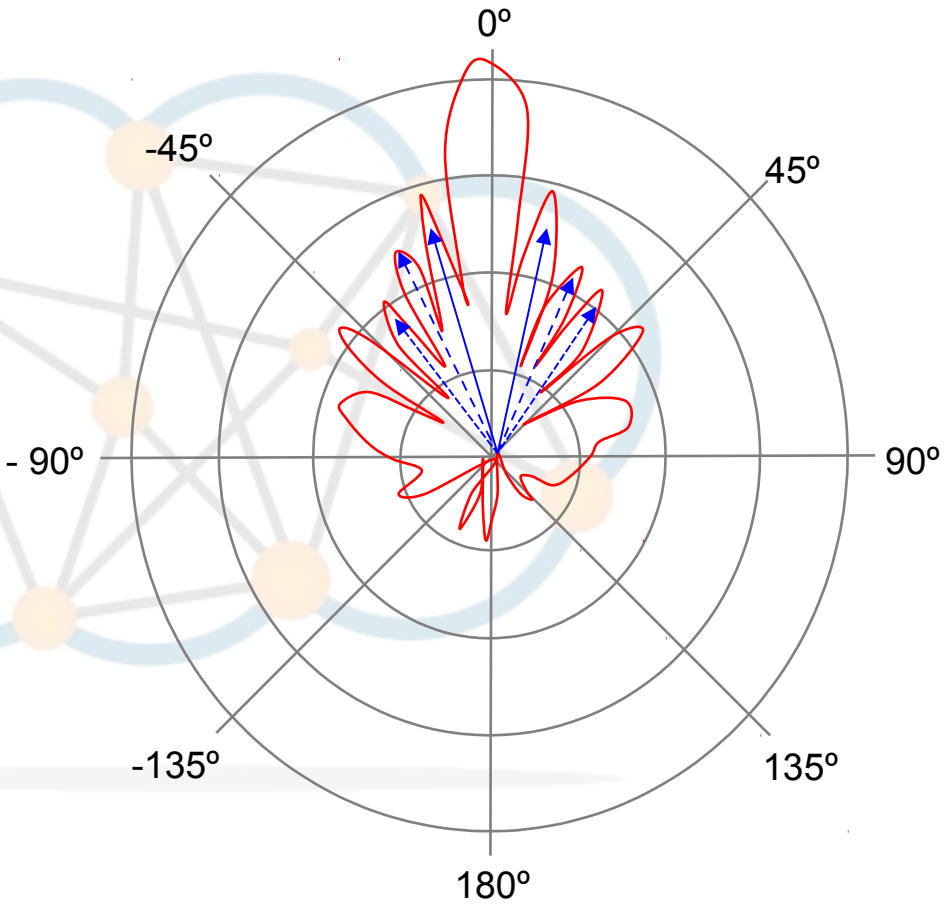
Beam Width

- Defined at - 3 dB or Half Power.
- The angle of which the main lobe gain is higher then half of the maximum power.



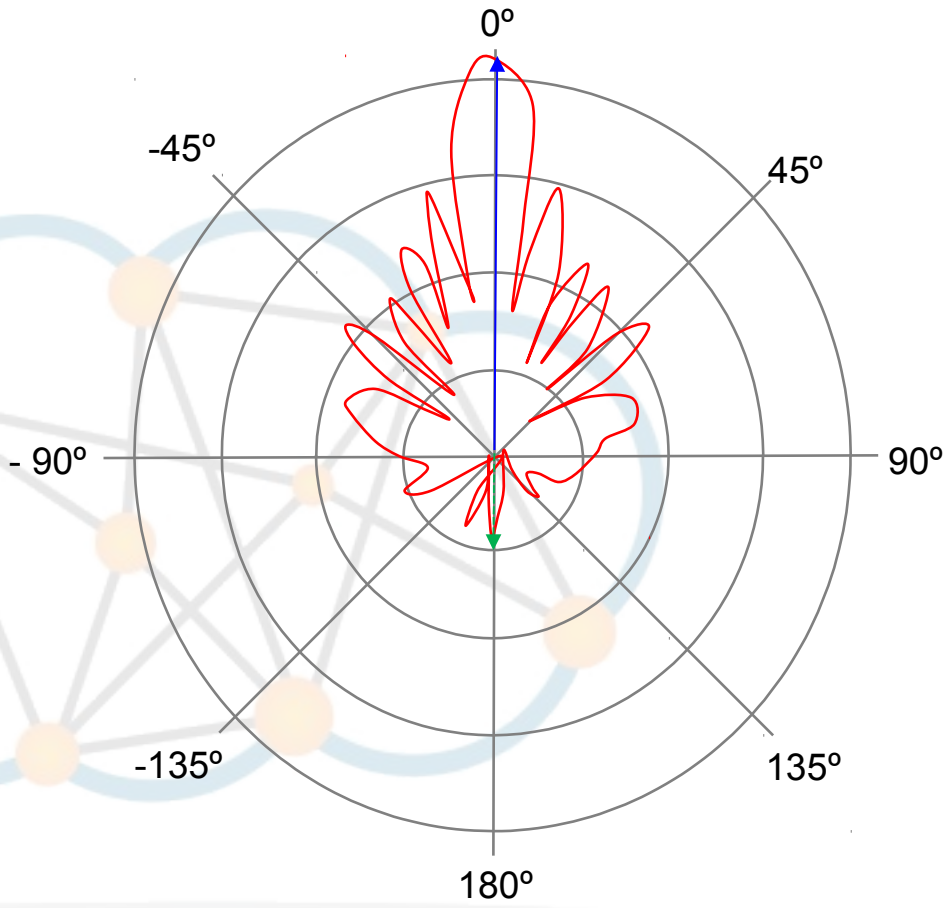
Side Lobe

- Side Lobes are the gain of transmitted/received signal in unwanted directions.
  - Side Lobe 1
  - Side Lobe 2
  - Side Lobe 3



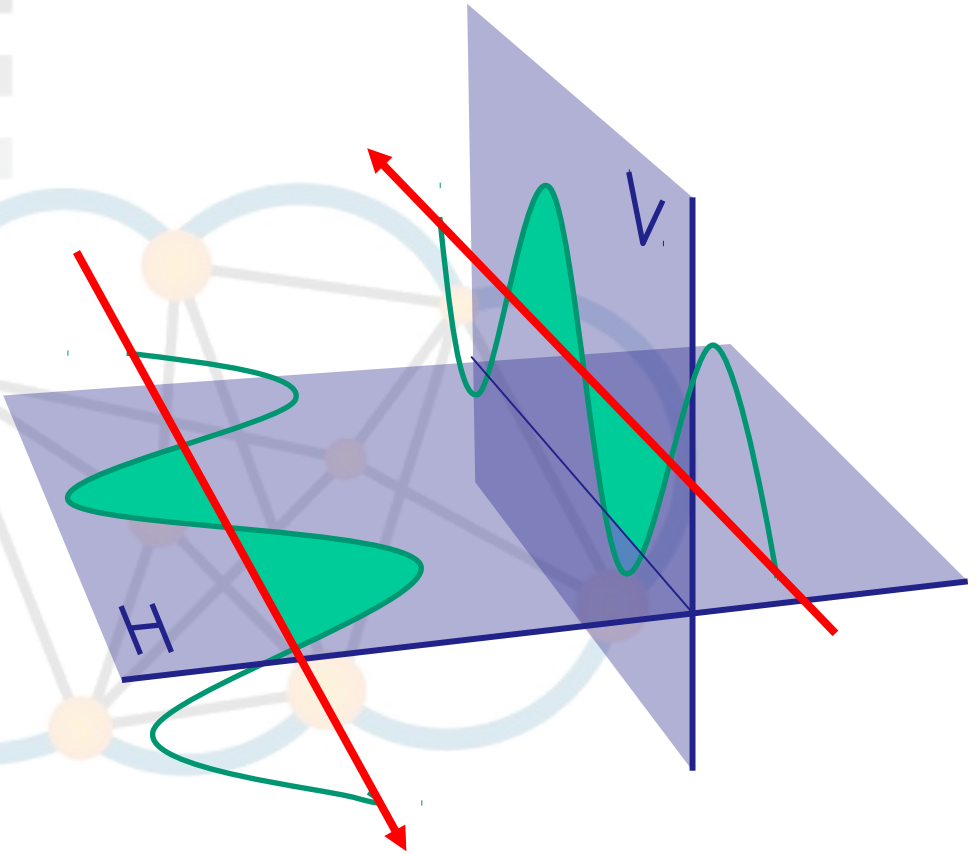
Front to Back Ratio

- Front
- Back

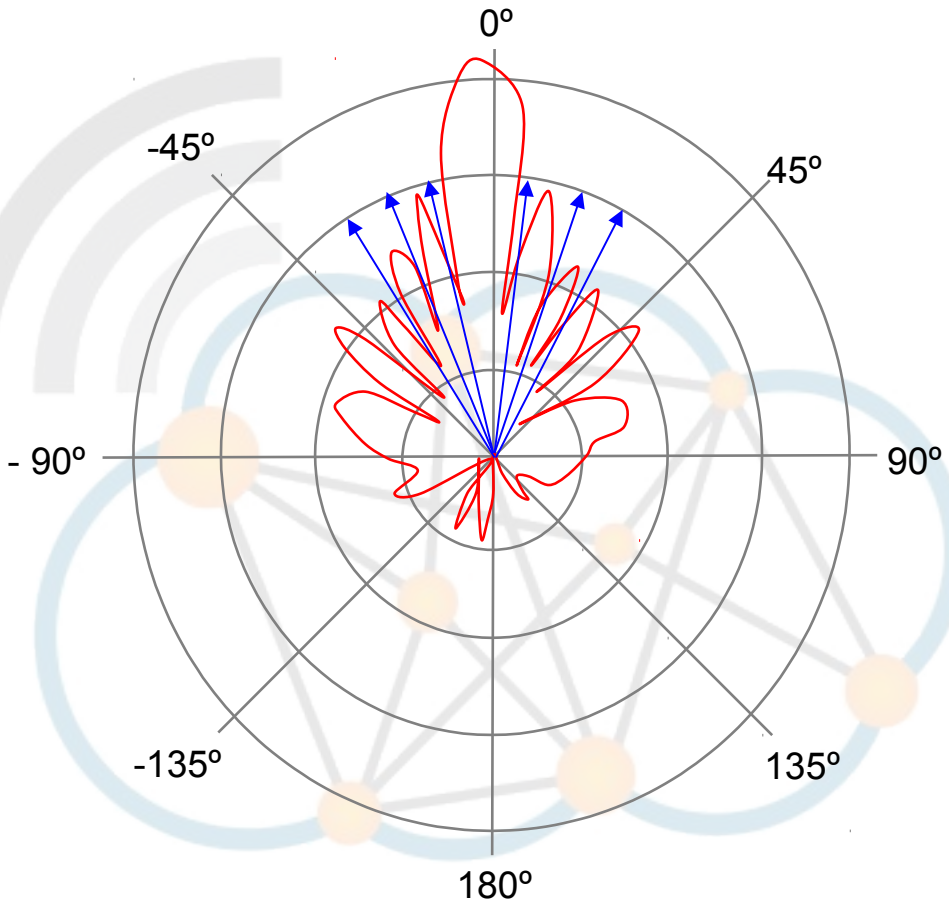


Polarisation

- Vertical
- Horizontal



Nulls



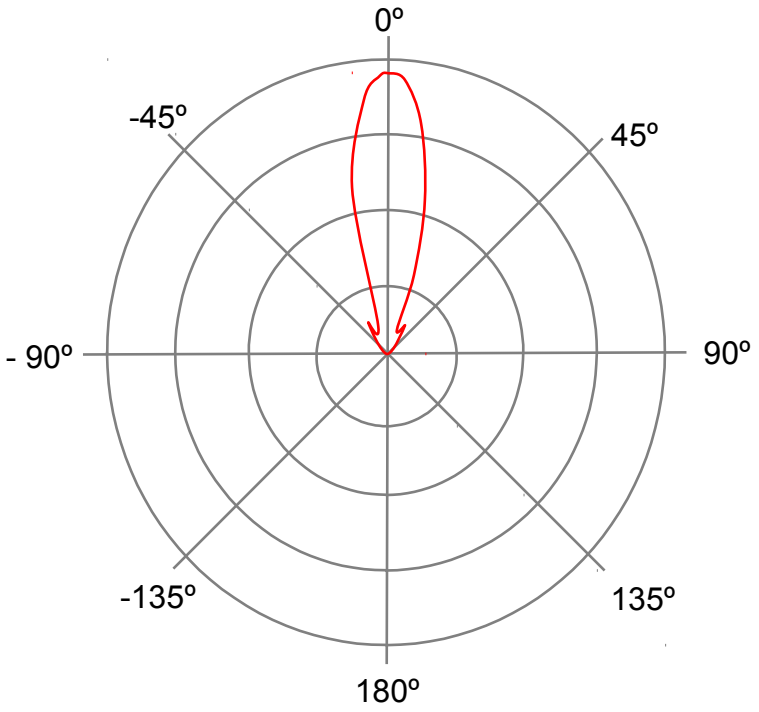
Voltage Standing Wave Ratio (VSWR)

- Transmission line (cable) is terminated by an impedance (Antenna) that do not match characteristic impedance.
- Part of the power is reflected back down the transmission line to the radio.
- A VSWR of 1:1 means that there is no power being reflected back to the source.
- Real world, a VSWR of 1.2 is considered excellent in most cases. At a VSWR of 2.0, approximately 10% of the power is reflected back to the radio.

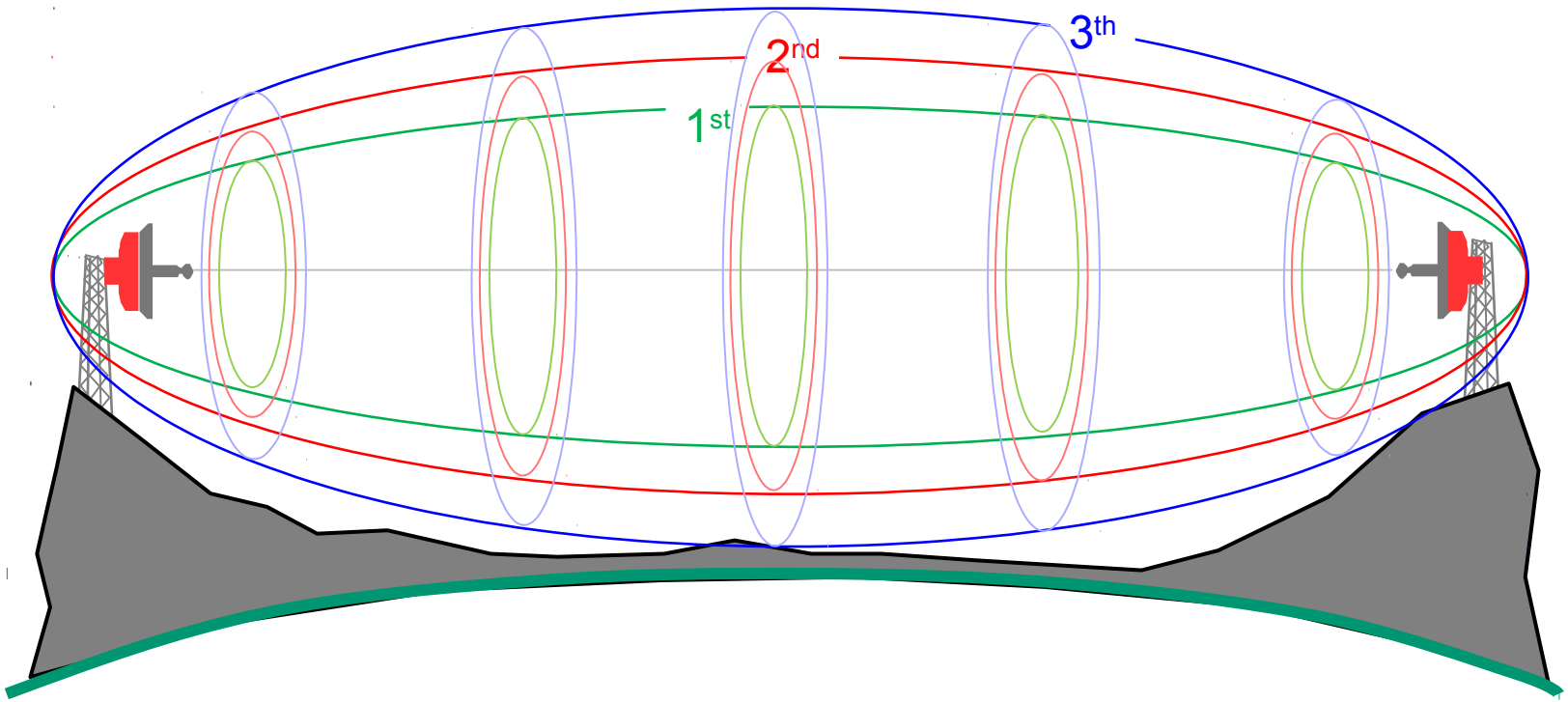
Grid Antenna

- 27 dBi Parabolic Grid Antenna for 5GHz

Jirous Antenna

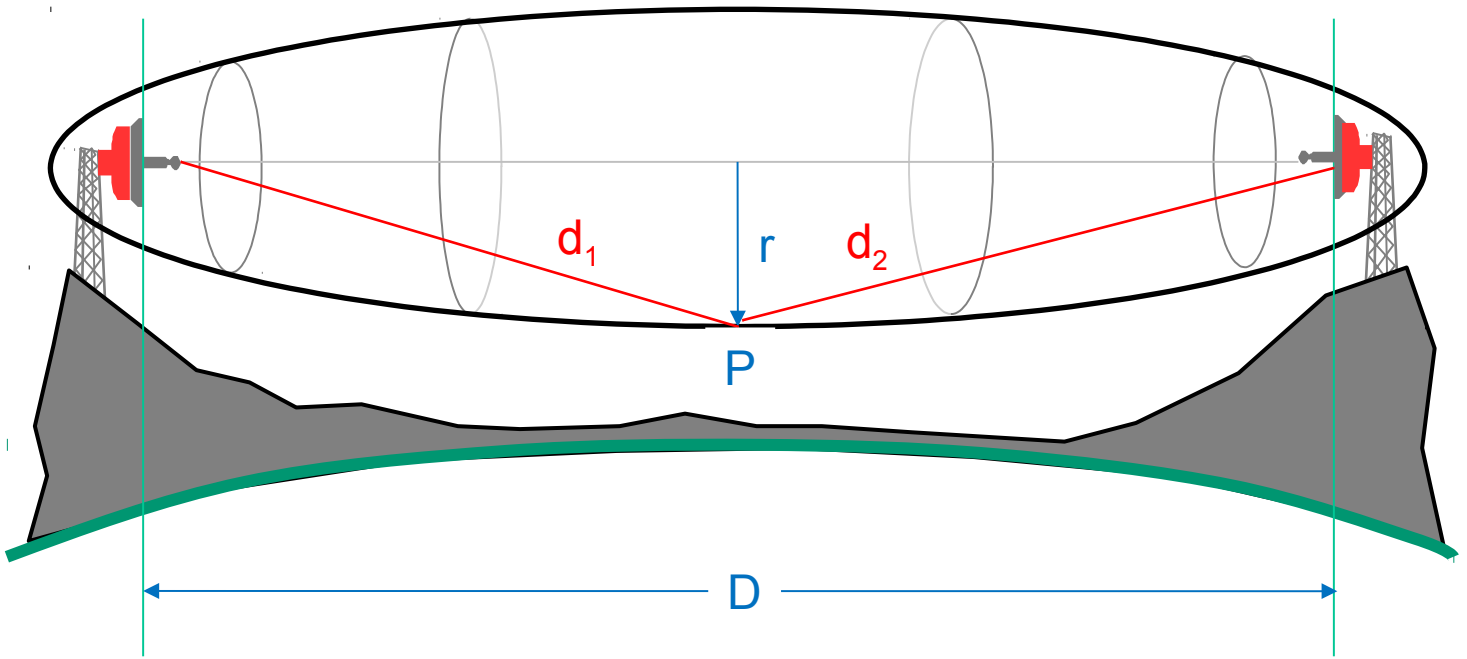


Freznel Zones



- Fresnel zone clearance may be used to analyse interference by obstacles near the path of a radio beam.
- The first zone must be kept largely free from obstructions to avoid interfering with the radio reception.
- Some obstruction of the Fresnel zones can often be tolerated, as a rule of thumb the maximum obstruction allowable is 40%, but the recommended obstruction is 20% or less.

Freznel Zone



$$F_n = \sqrt{\frac{n \lambda d_1 d_2}{d_1 + d_2}}$$

F_n = The nth Fresnel Zone radius in metres

d_1 = The distance of P from one end in metres

d_2 = The distance of P from the other end in metres

λ = The wavelength of the transmitted signal in metres

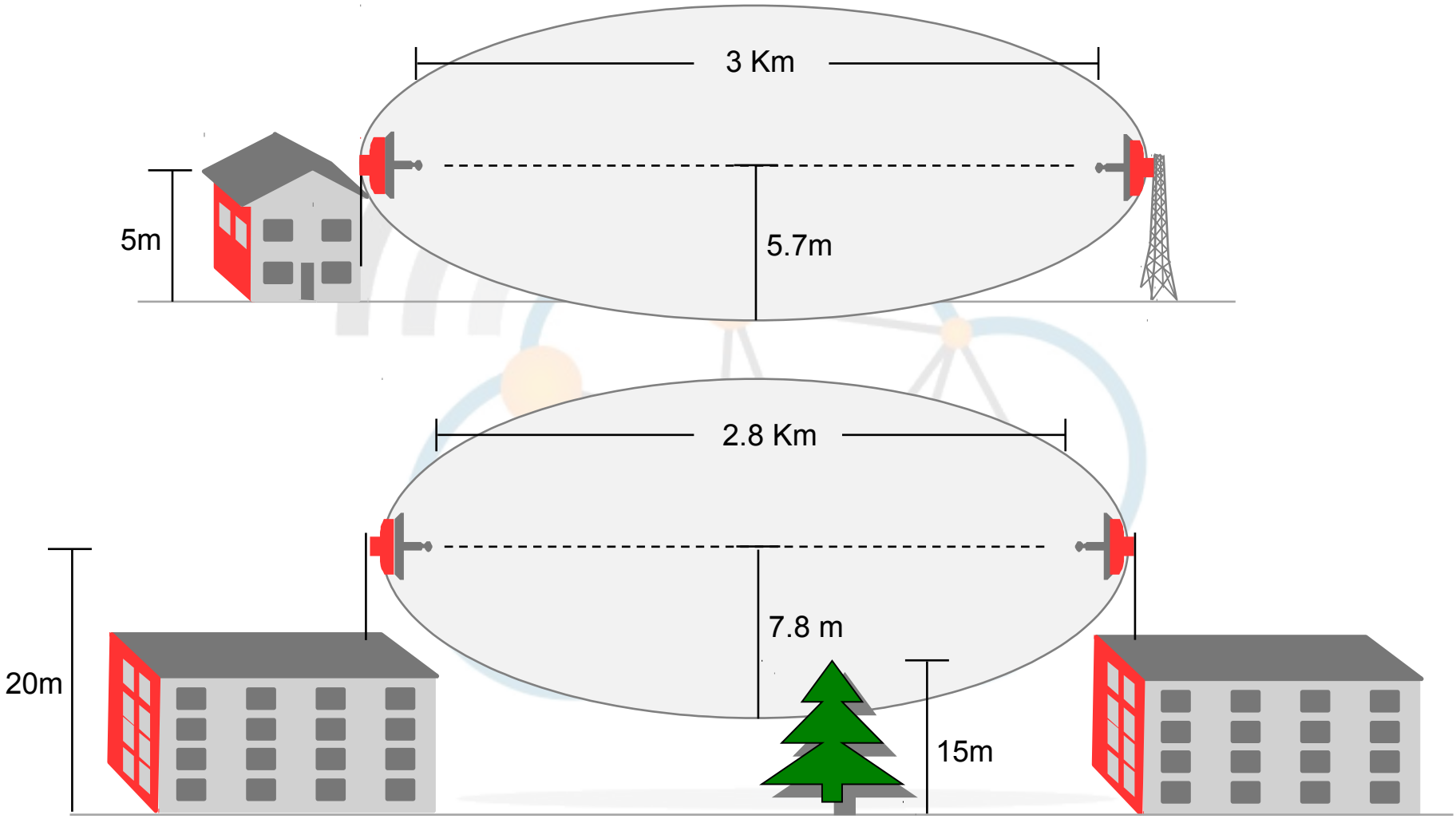
$$r = \sqrt{\frac{D}{f}}$$

r = radius in metres

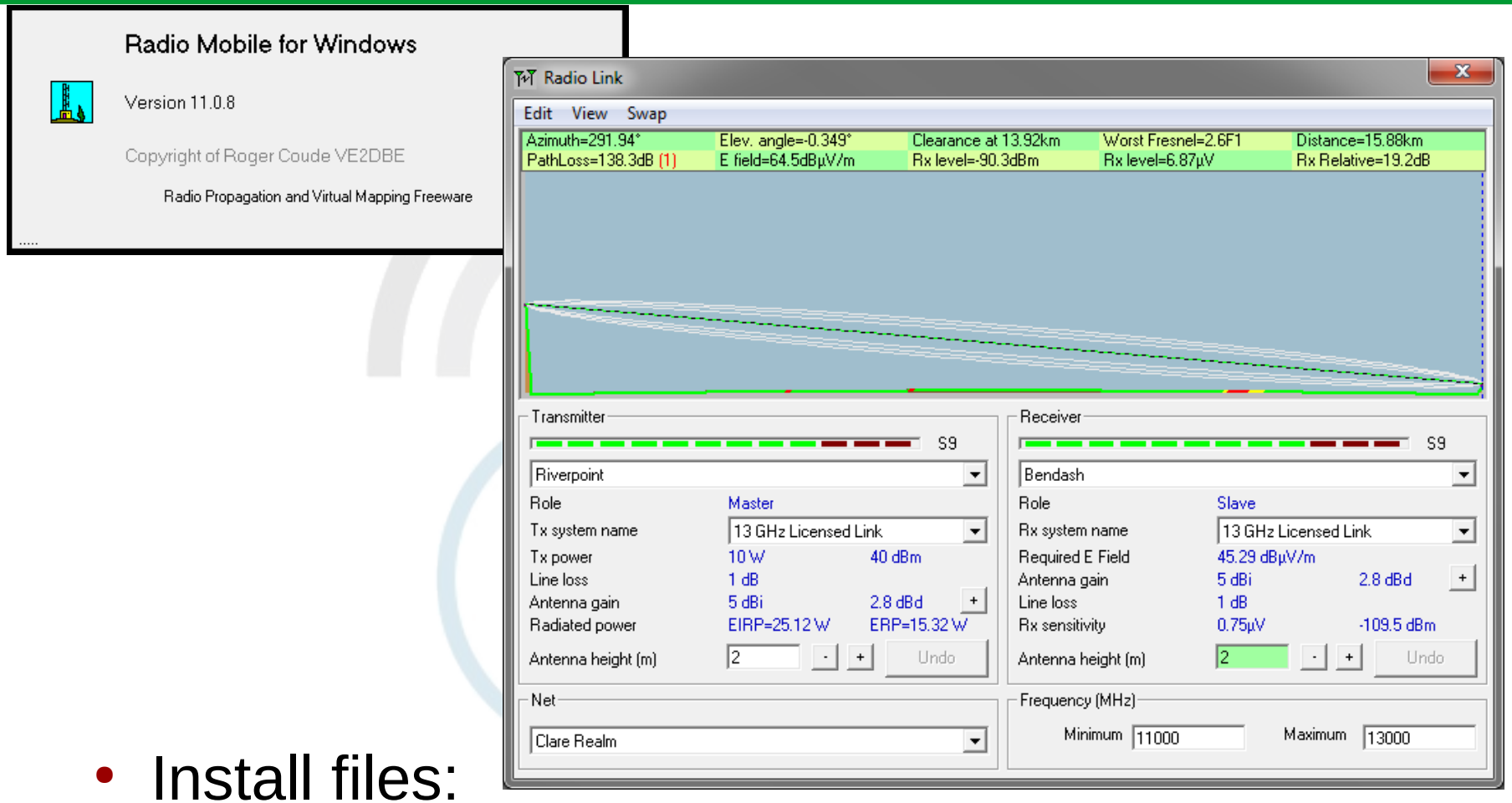
D = total distance in kilometres

f = frequency transmitted in gigahertz

Fresnel zone disruption



Radio Mobile



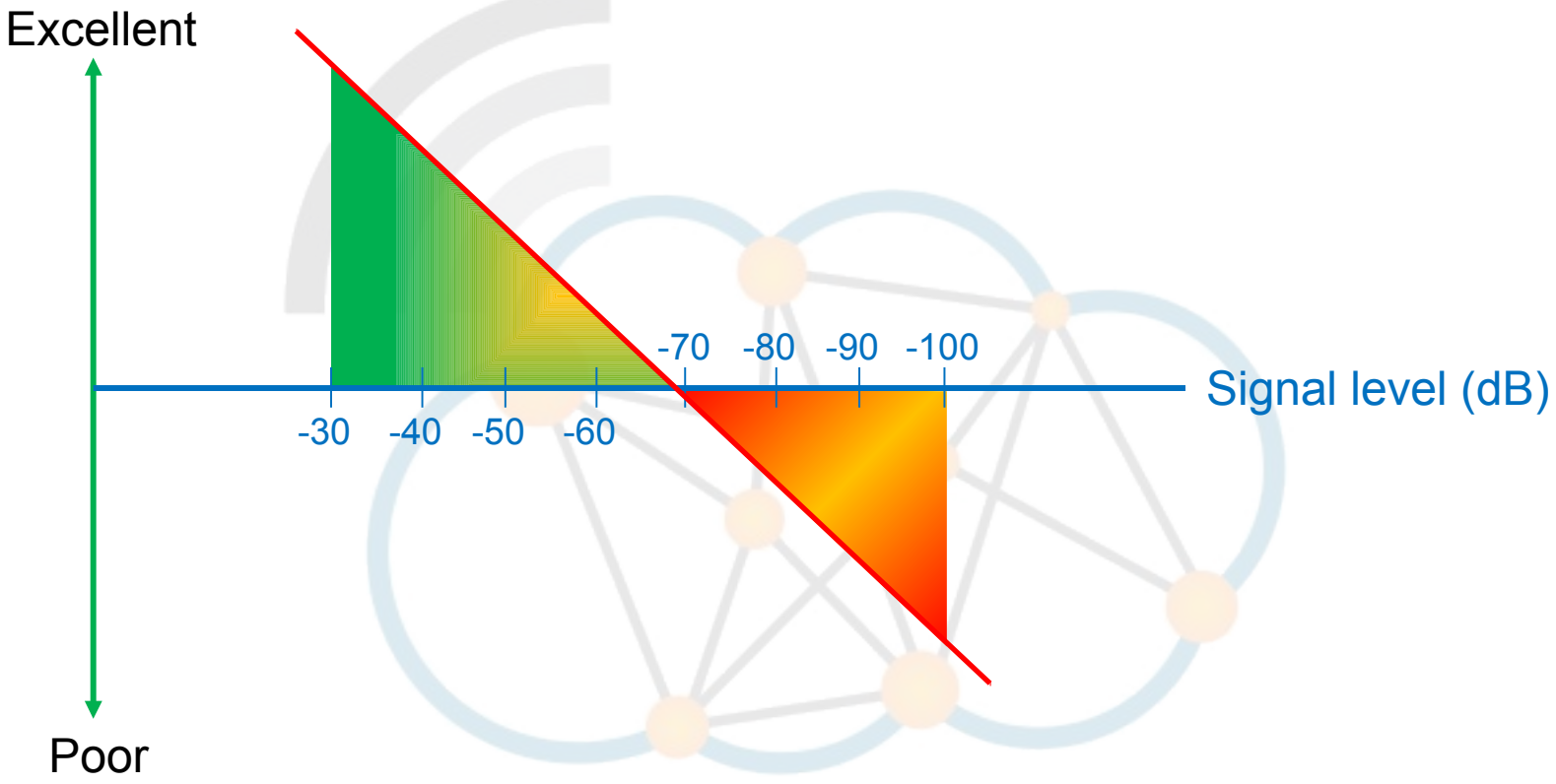
- Install files: http://www.cplus.org/rmw/english1.html
- Map Files: SRTM (Free Online)

Relative Signal Strength Indicator (RSSI)

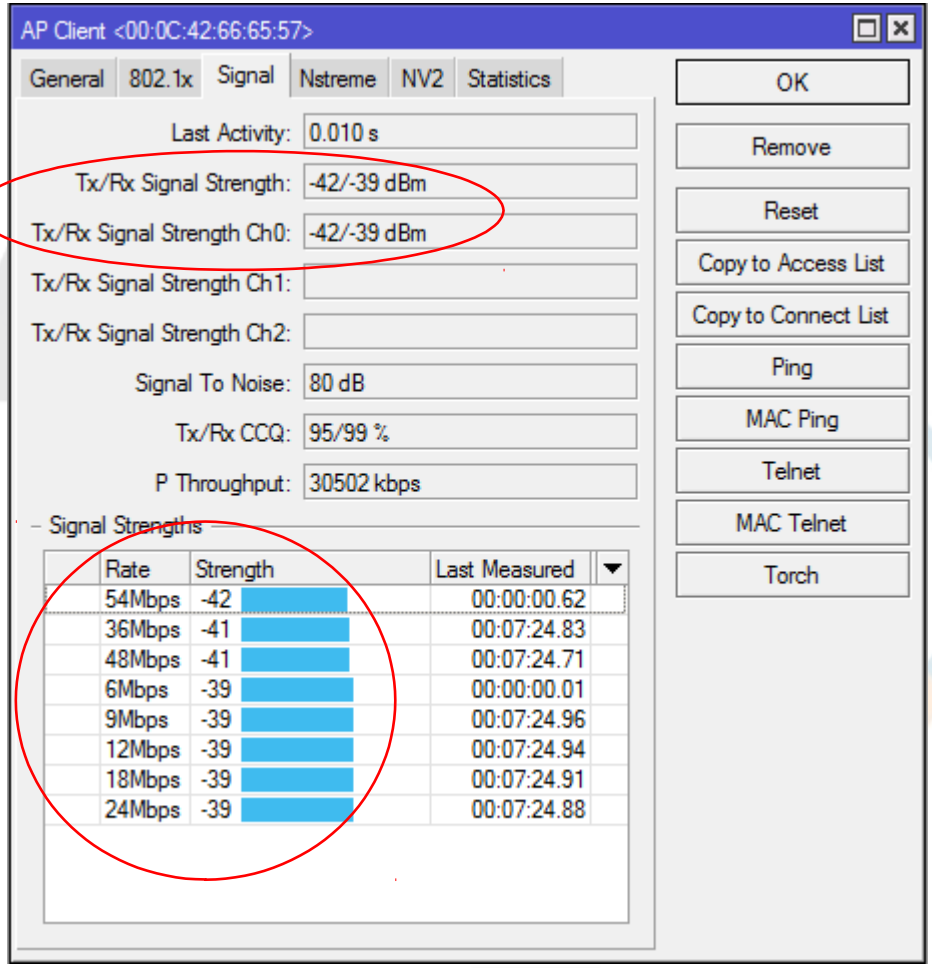
- RSSI is the relative received signal strength in a wireless environment, in arbitrary units.

- RSSI is an indication of the power level being received by the antenna. Therefore, the higher the RSSI number (or less negative in some devices), the stronger the signal.

Signal Strength



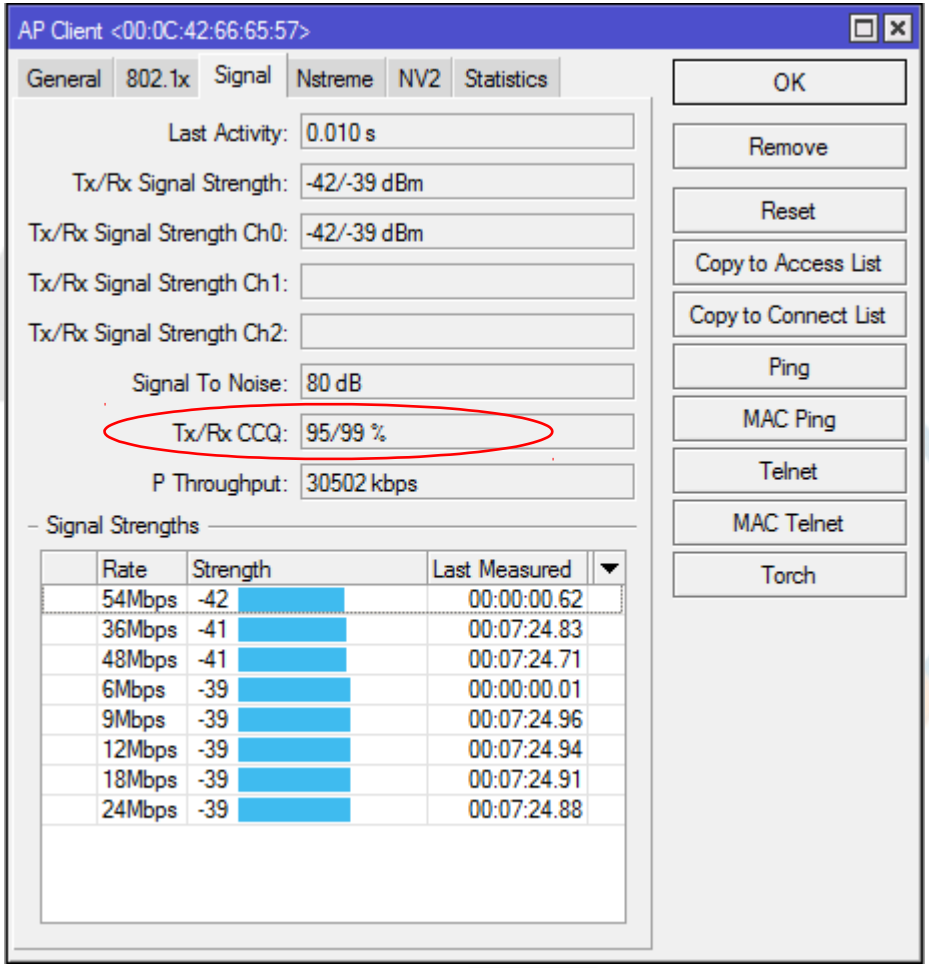
Relative Signal Strength Indicator (RSSI)



Client Connection Quality (CCQ)

- CCQ is a value in percentage that shows how effective the bandwidth is used regarding the theoretically maximum available bandwidth.
- CCQ is weighted average of values T_{min}/T_{real}, that get calculated for every transmitted frame:
  - T_{min} is time it would take to transmit given frame at highest rate with no retries.
  - T_{real} is time it took to transmit frame in real life.
- CCQ to be accurate needs traffic over the link, this is because it is calculated as a rolling average.

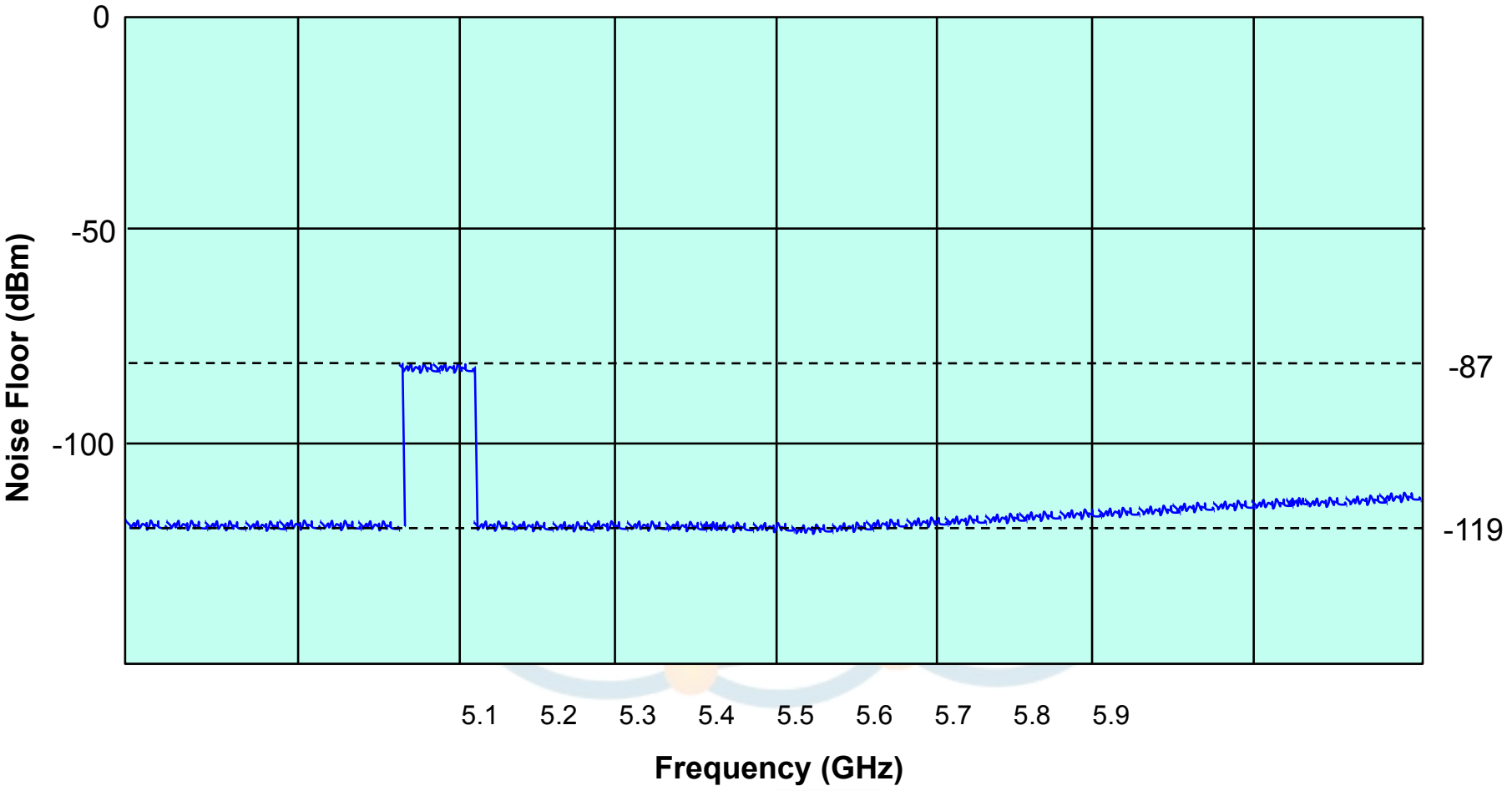
Client Connection Quality (CCQ)



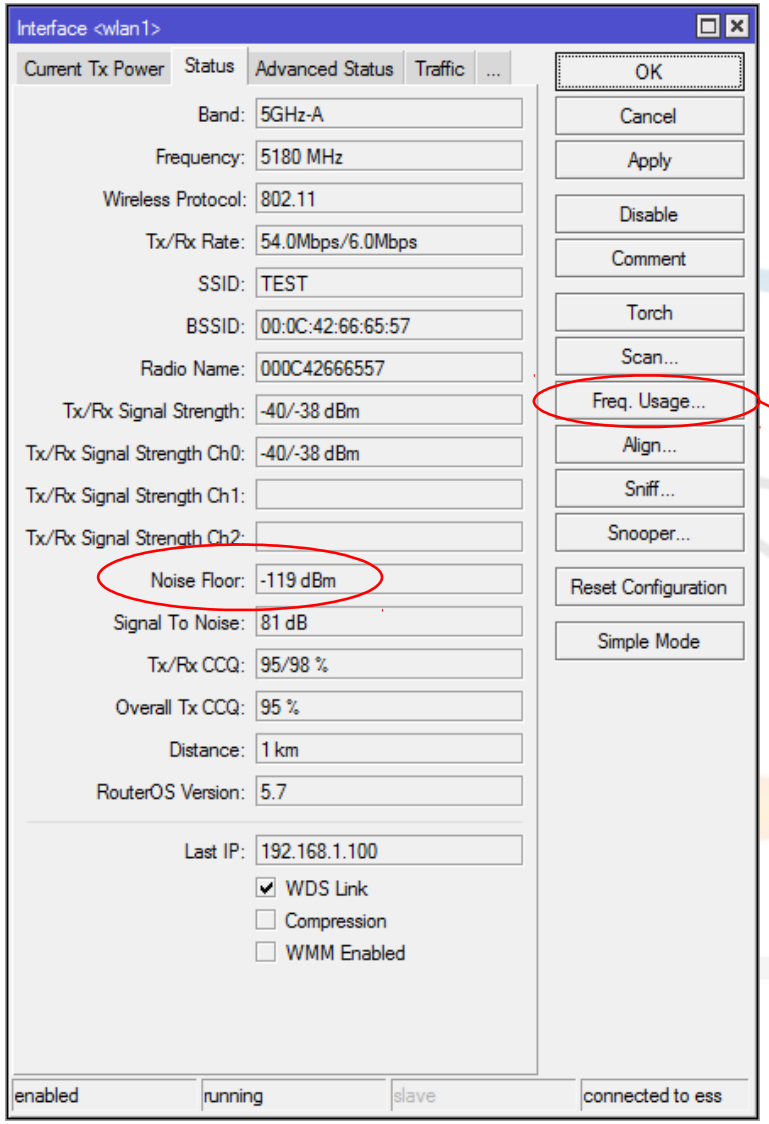
Noise floor

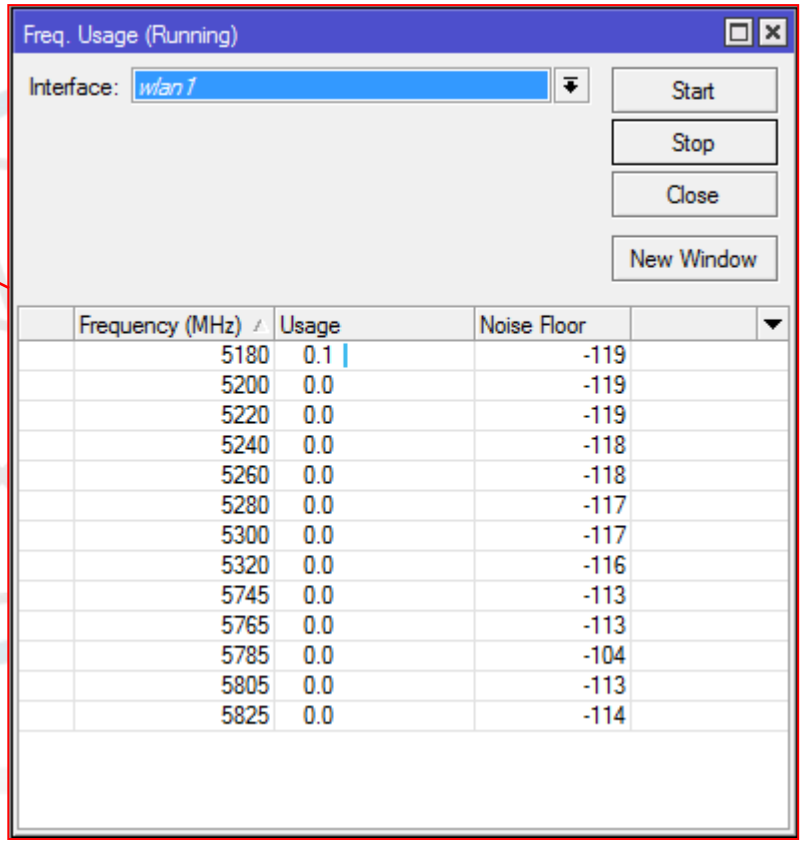
- Noise floor is the measure of the signal created from the sum of all the noise sources and unwanted signals within the radio, where the noise is defined any signal other than channel being monitored.

Noise floor

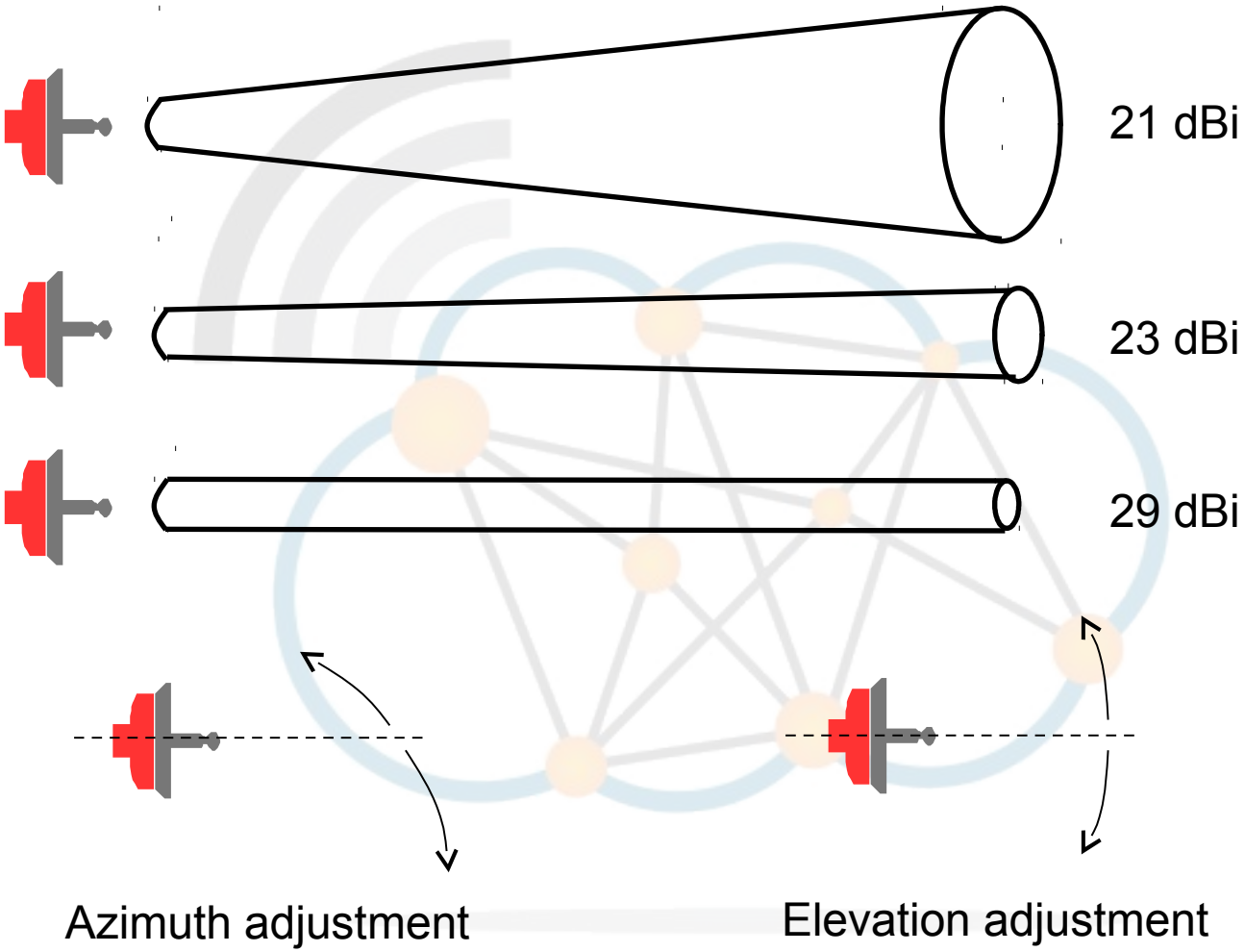

0
-50
-100
Noise Floor (dBm)
-87
-119
5.1
5.2
5.3
5.4
5.5
5.6
5.7
5.8
5.9
Frequency (GHz)

Noise Floor


Interface <wlan1>
Current Tx Power
Status
Advanced Status
Traffic
...
OK
Cancel
Apply
Disable
Comment
Torch
Scan...
Freq. Usage...
Align...
Sniff...
Snooper...
Reset Configuration
Simple Mode
Band: 5GHz-A
Frequency: 5180 MHz
Wireless Protocol: 802.11
Tx/Rx Rate: 54.0Mbps/6.0Mbps
SSID: TEST
BSSID: 00:0C:42:66:65:57
Radio Name: 000C42666557
Tx/Rx Signal Strength: -40/-38 dBm
Tx/Rx Signal Strength Ch0: -40/-38 dBm
Tx/Rx Signal Strength Ch1:
Tx/Rx Signal Strength Ch2:
Noise Floor: -119 dBm
Signal To Noise: 81 dB
Tx/Rx CCQ: 95/98 %
Overall Tx CCQ: 95 %
Distance: 1 km
RouterOS Version: 5.7
Last IP: 192.168.1.100
WDS Link
Compression
WMM Enabled
enabled
running
slave
connected to ess

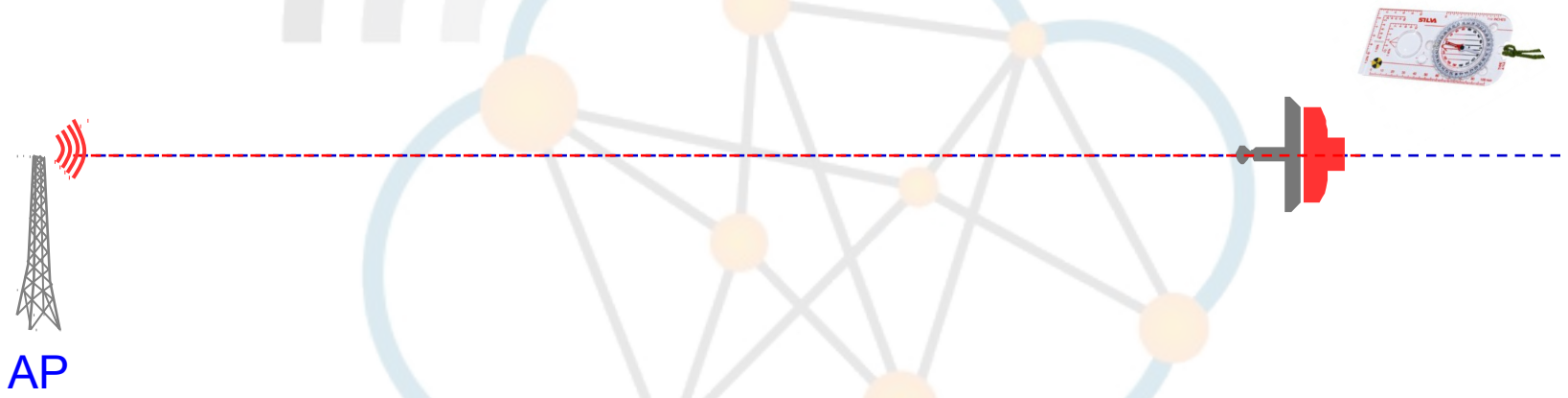

Freq. Usage (Running)
Interface: wlan1
Start
Stop
Close
New Window
Frequency (MHz)
Usage
Noise Floor
5180 0.1 -119
5200 0.0 -119
5220 0.0 -119
5240 0.0 -118
5260 0.0 -118
5280 0.0 -117
5300 0.0 -117
5320 0.0 -116
5745 0.0 -113
5765 0.0 -113
5785 0.0 -104
5805 0.0 -113
5825 0.0 -114

Antenna Adjustment



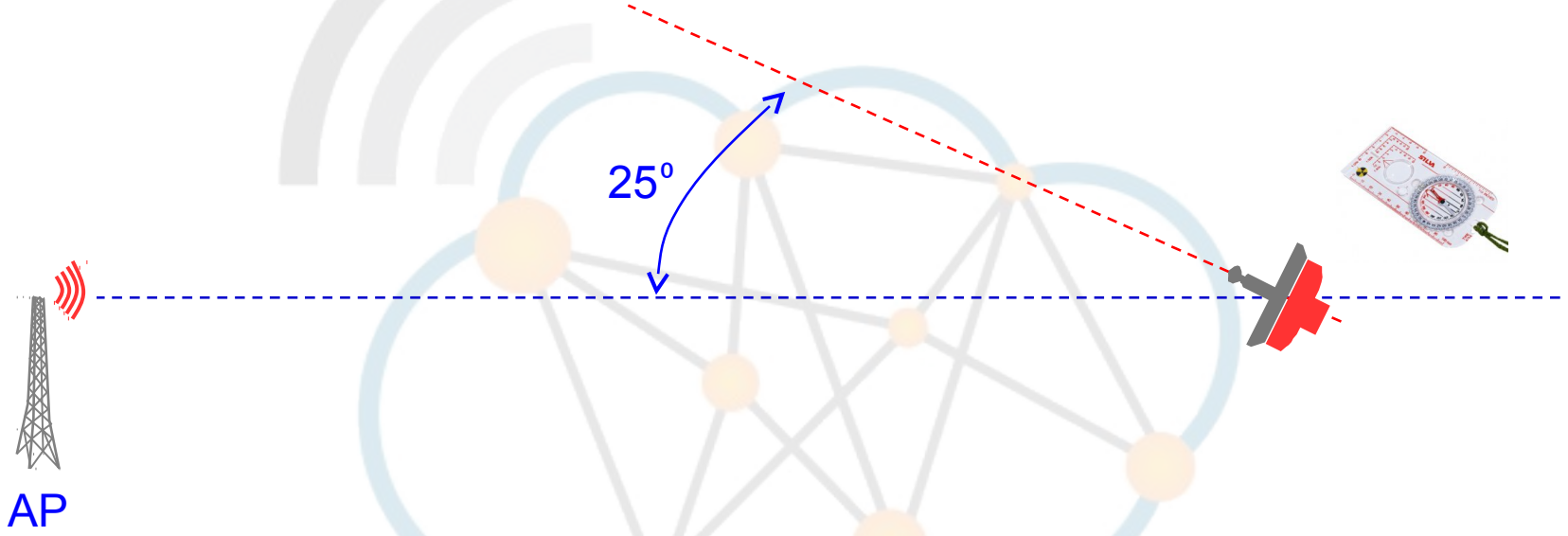
Alignment process

- Use a compass to determine the azimuth (angle to the Access Point).



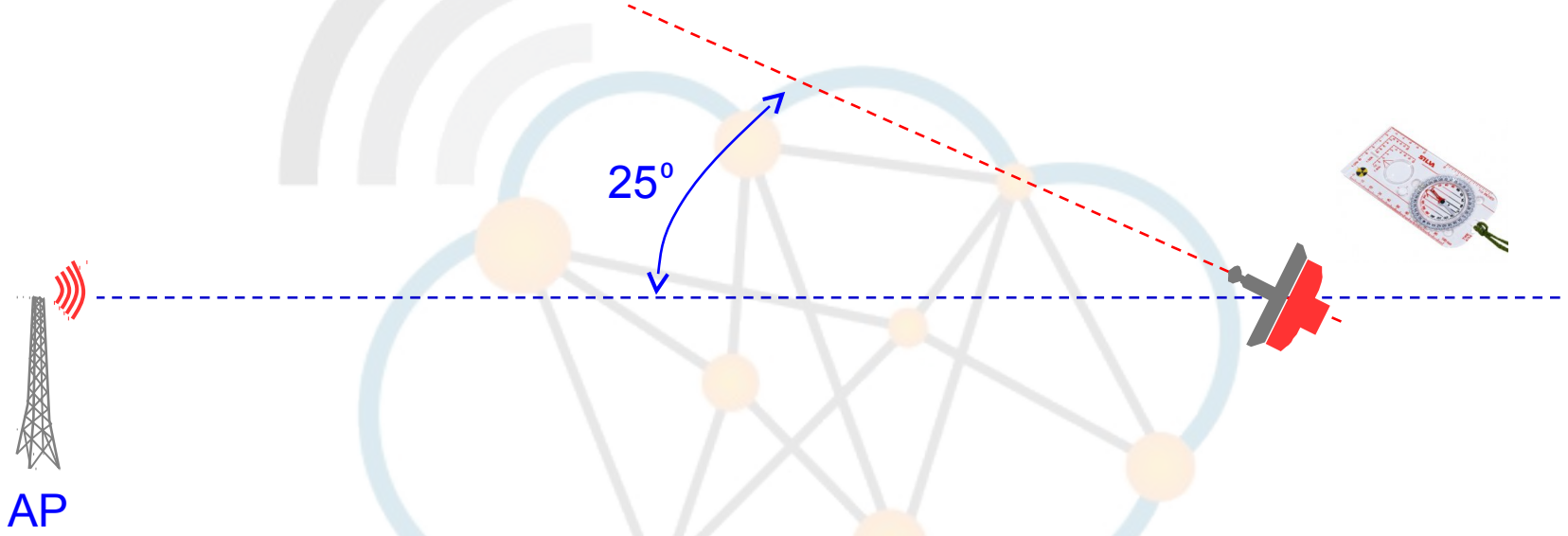
Alignment - Azimuth

- Rotate the panel 25^{0} off the azimuth bearing line.



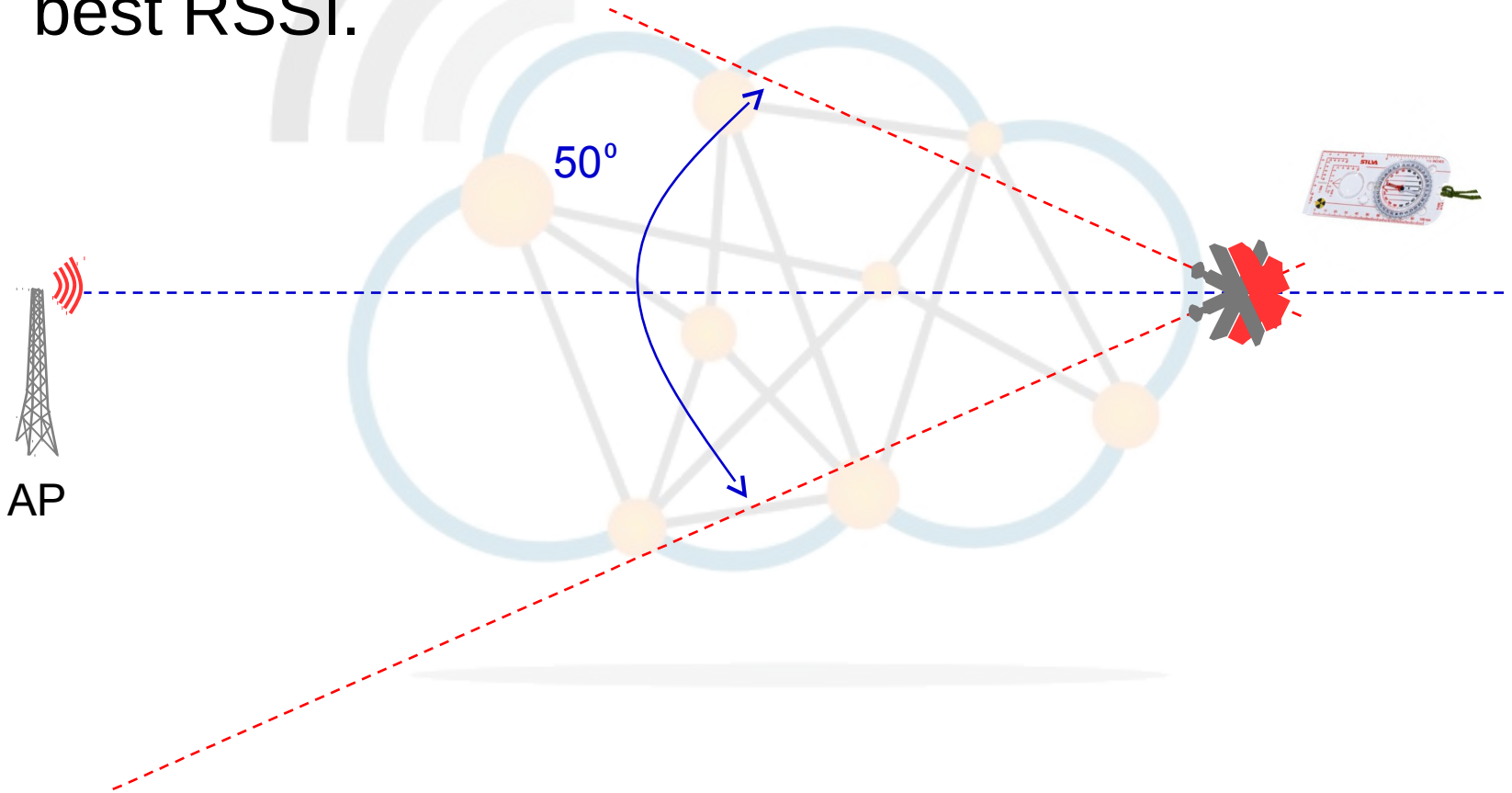
Alignment - Azimuth

- Rotate the panel 25^{0} off the azimuth bearing line.

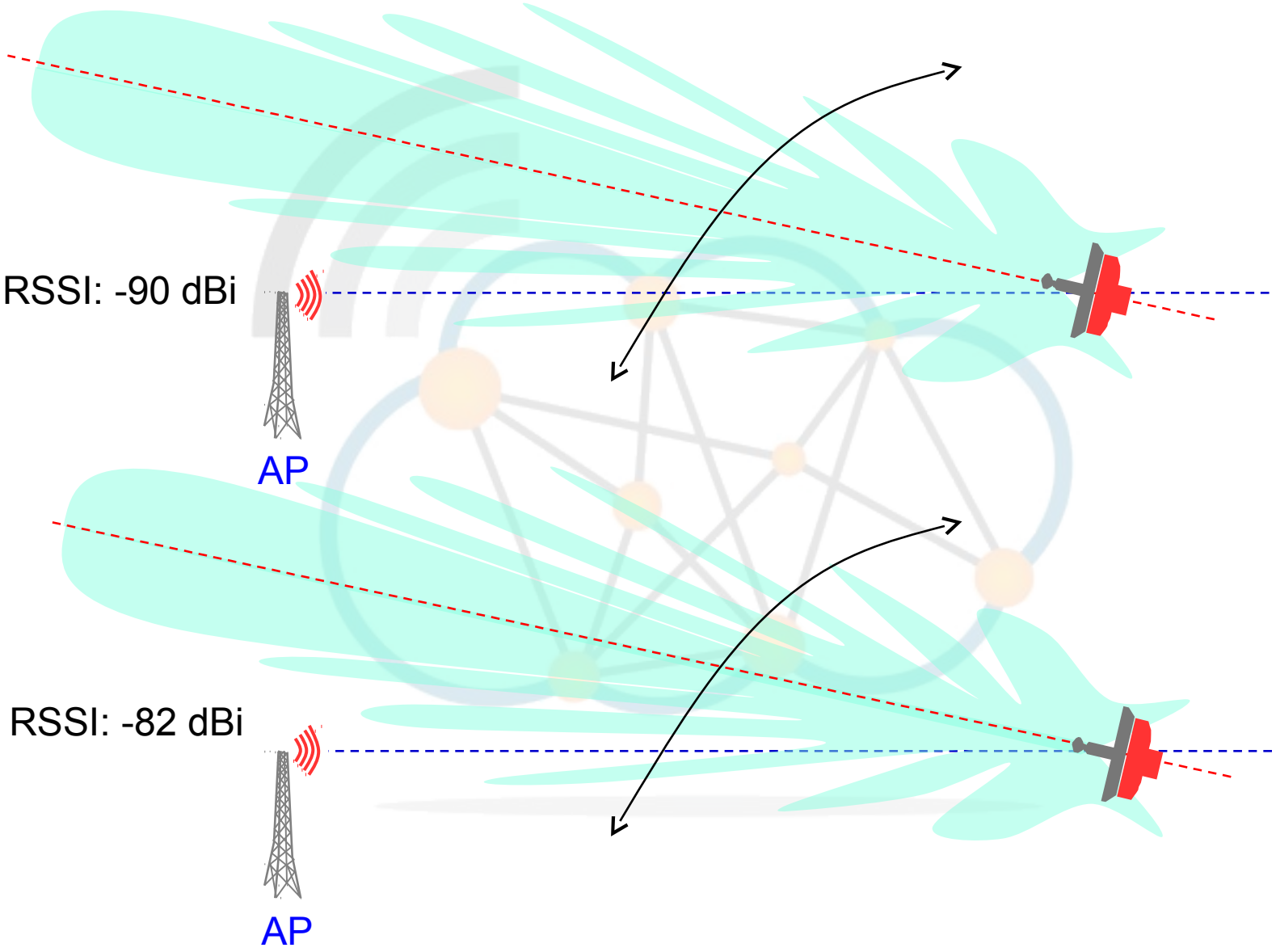


Alignment - Azimuth

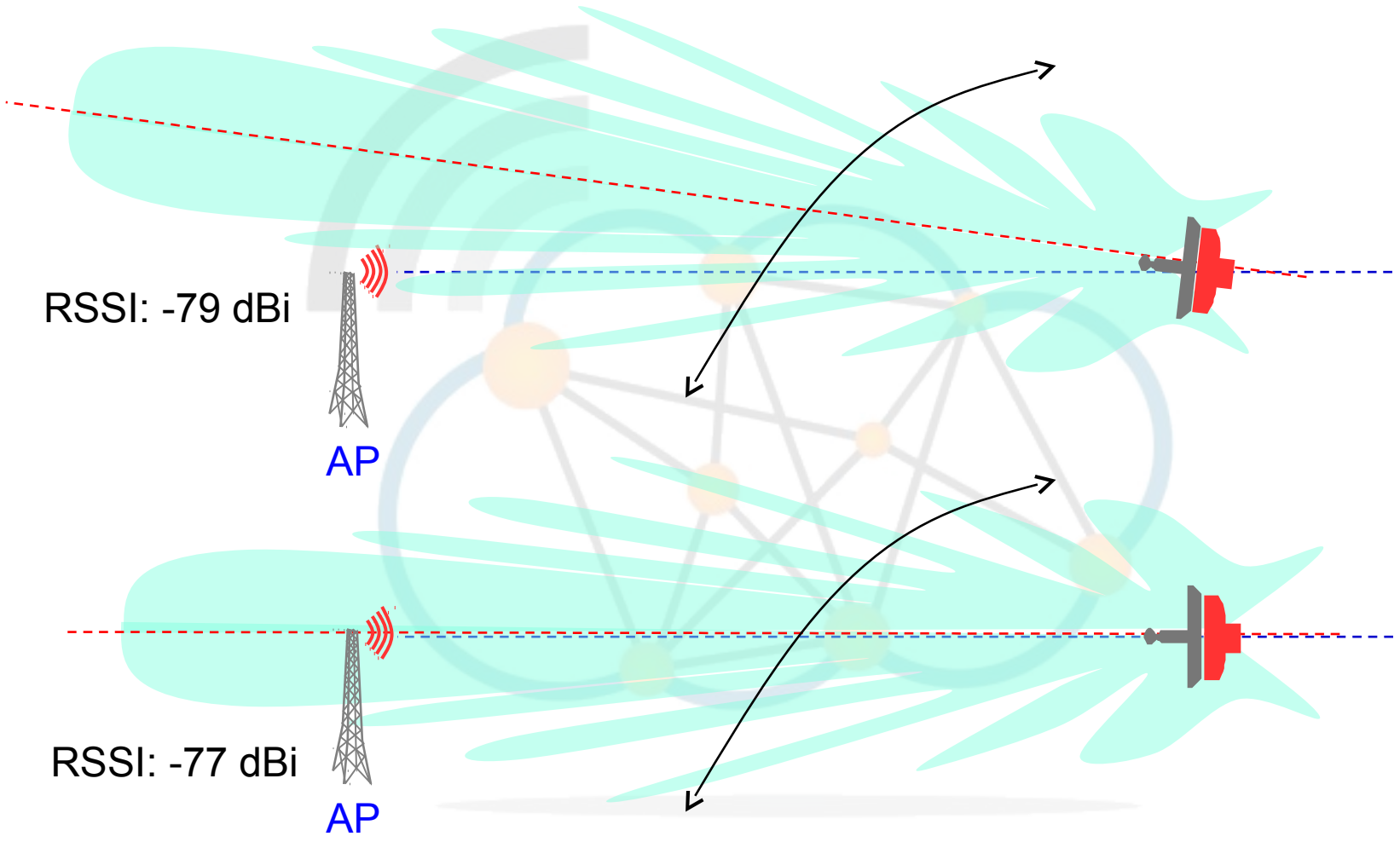
- Rotate through and angle for 50^{o} to determine the angle of best RSSI. Note the bearing for the best RSSI.



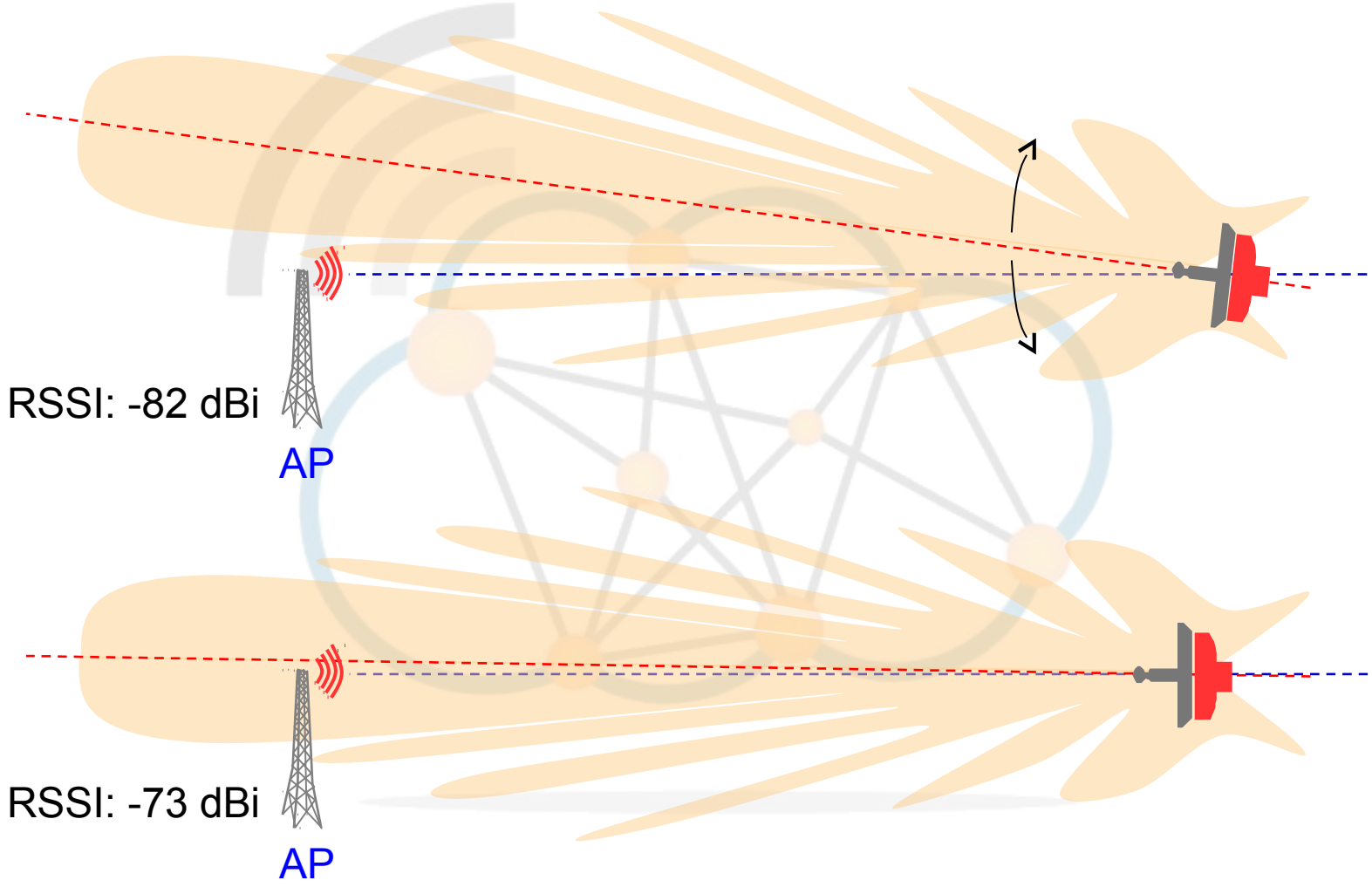
Alignment - Azimuth



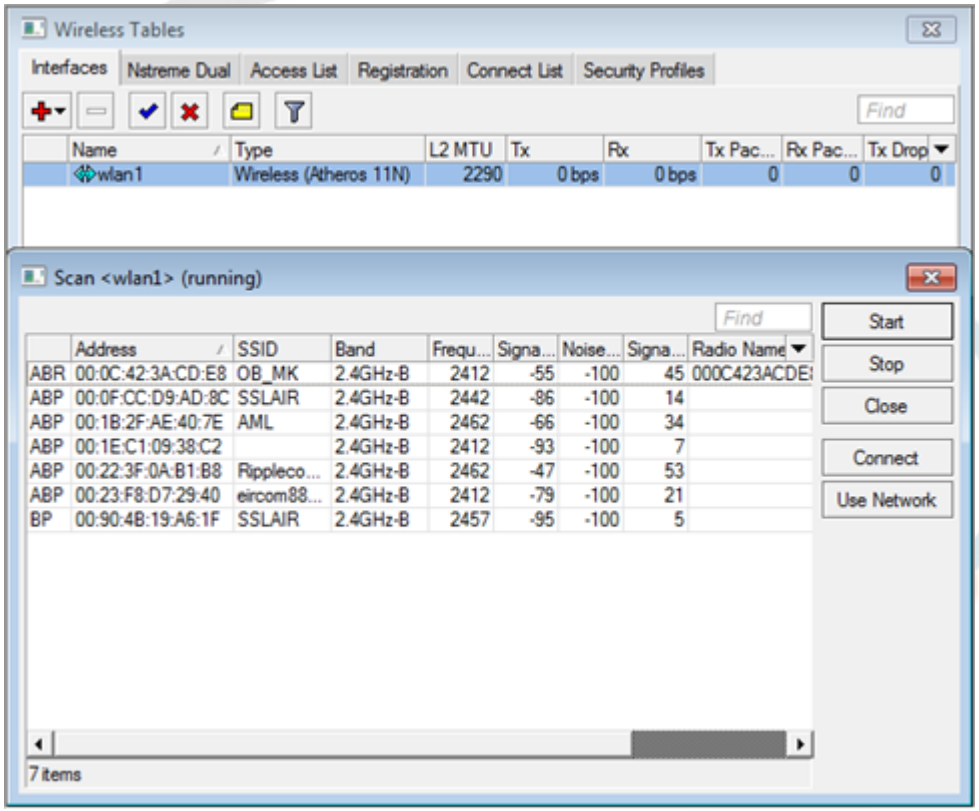
Alignment - Azimuth



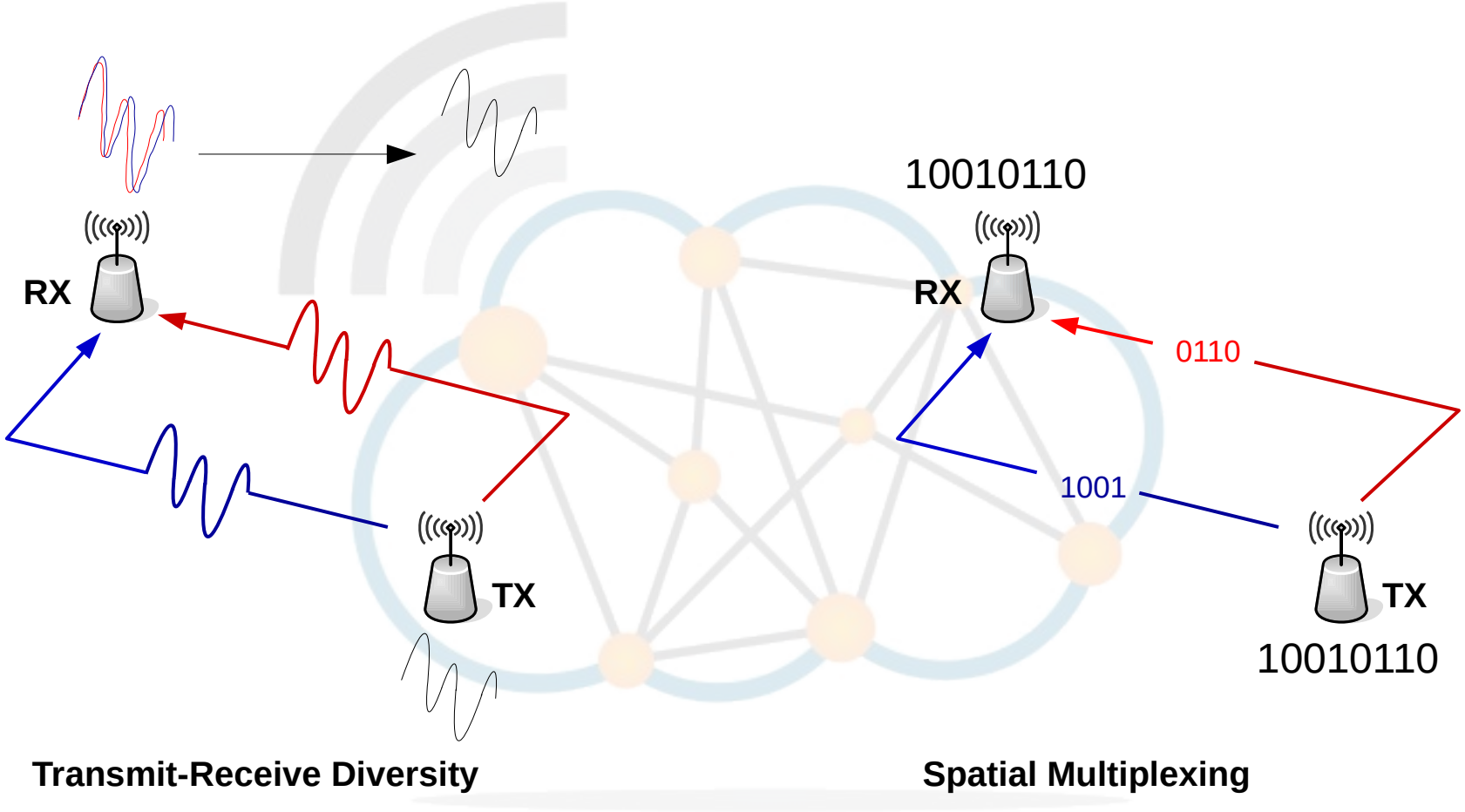
Alignment - Elevation



Signal Strength

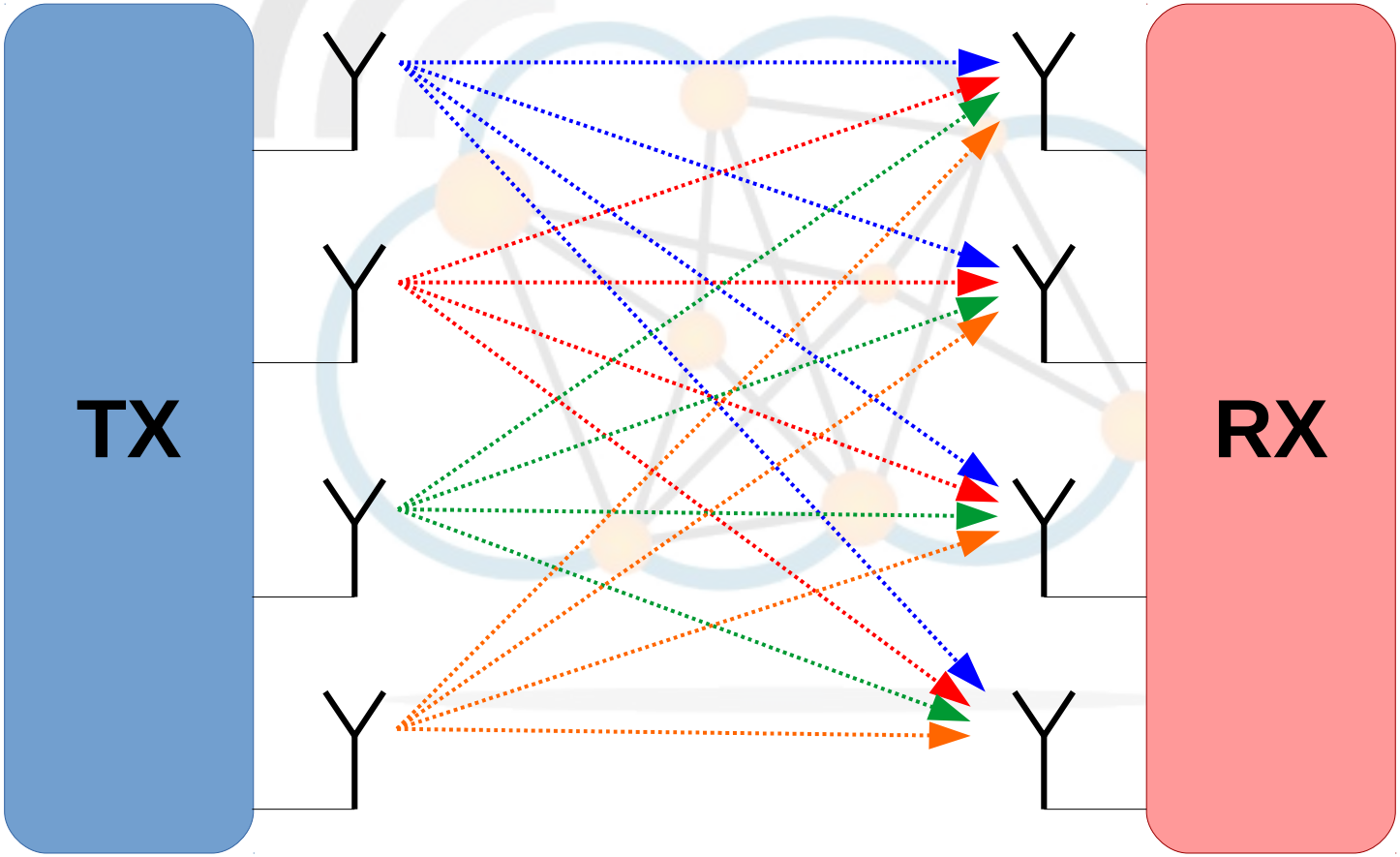


Multiple In, Multiple Out (MIMO)



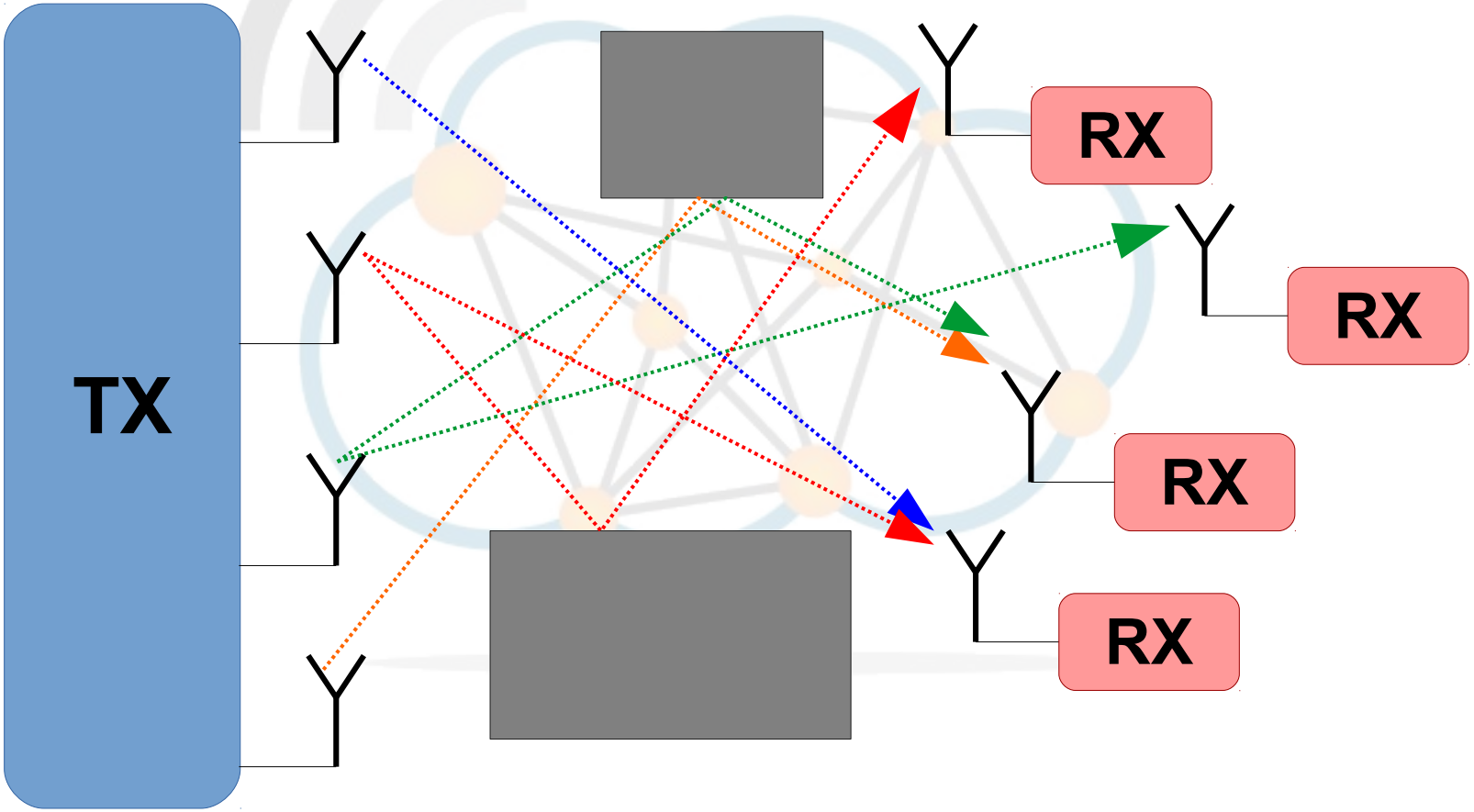
Multiple In, Multiple Out (MIMO)

- 4X4 MIMO
  - Four transmit antennas, Four receive antennas.



Beamforming

- Identifies the most efficient data-delivery route to each user, and it reduces interference for nearby users using a signal-processing algorithm.



Thank You

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