Low Power High Speed Wireless

Sometimes less is more

MikroTik SA

Course Objective

- Provide an outline of the challenges involved in wireless networking and insight into achieving the best performance of wireless networks.

About MikroTikSA

- Independent Wireless Training company
- Official training and support partner for MikroTik
- Specialist in all forms of wireless and wired networking technologies
- Next Training Course: MikroTik Certified Traffic Control Engineer (Firewall, Bandwidth Management and QOS)
  - **29-31 July, Emperors Palace**

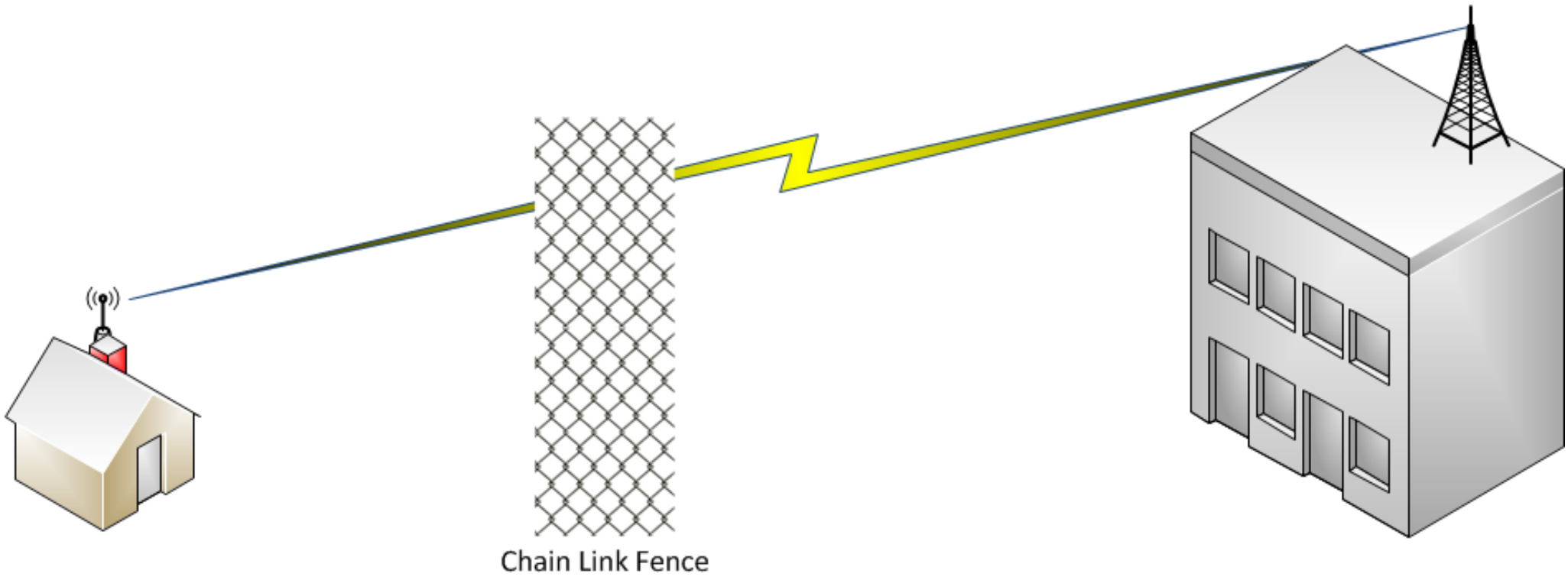
The enemies!

- Reflection
- Refraction
- Absorption
- Diffraction
- Scattering
- Multipath
- Fading
- Free Space Path Loss

Reflections

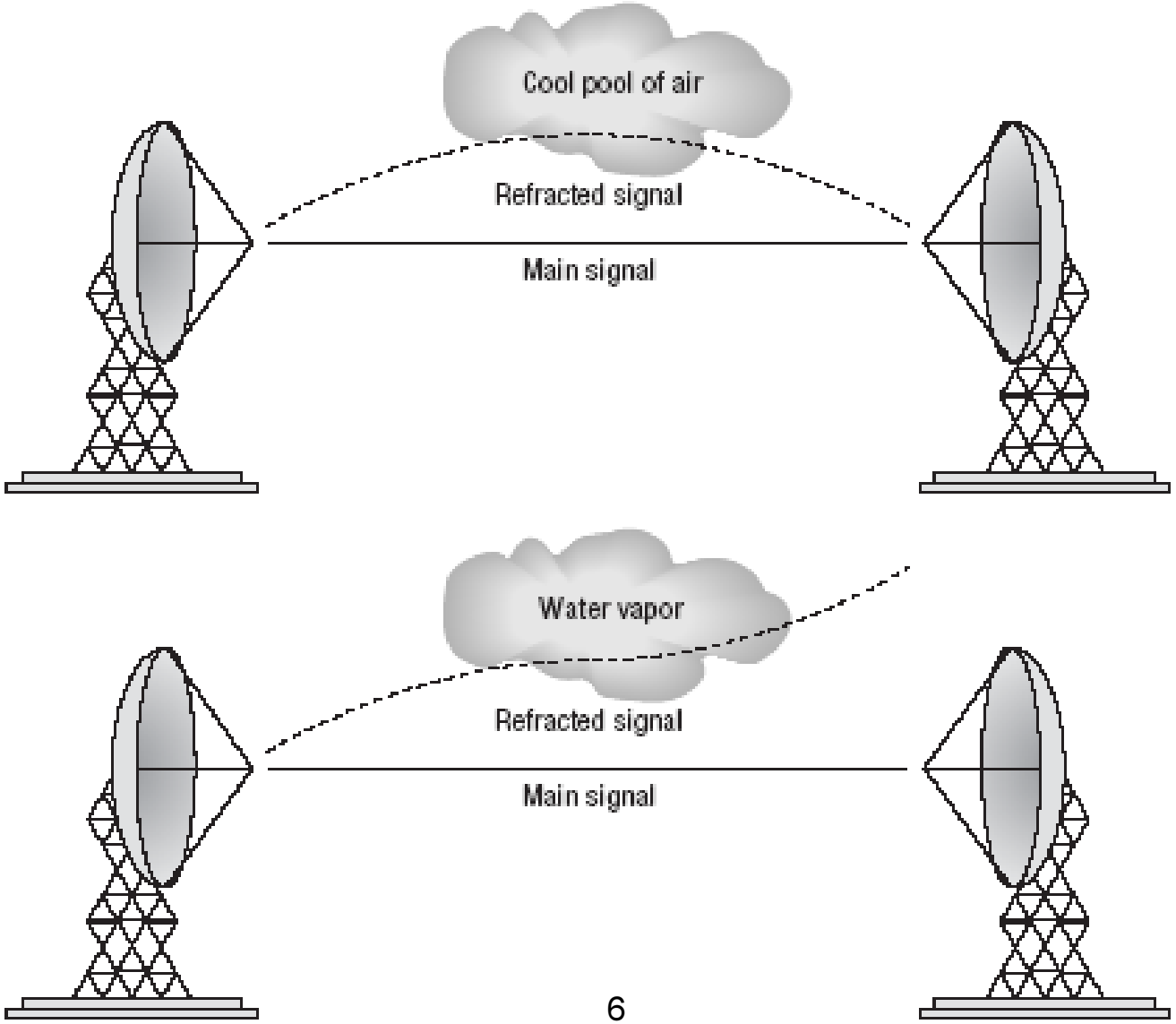
- RF signals are reflected just as with light
- Water surfaces move
  - This provides an unreliable reflection
- Glass lined with Gold (or any metal) on multi-storey buildings reflects well
  - Can be used for non-LOS links
  - Also look for billboards or other large flat expanses of metal
- Does visual line of sight always guarantee a useable link?

- Even though we have perfect “visual” line of site through the chain link fence, RF will be almost completely blocked



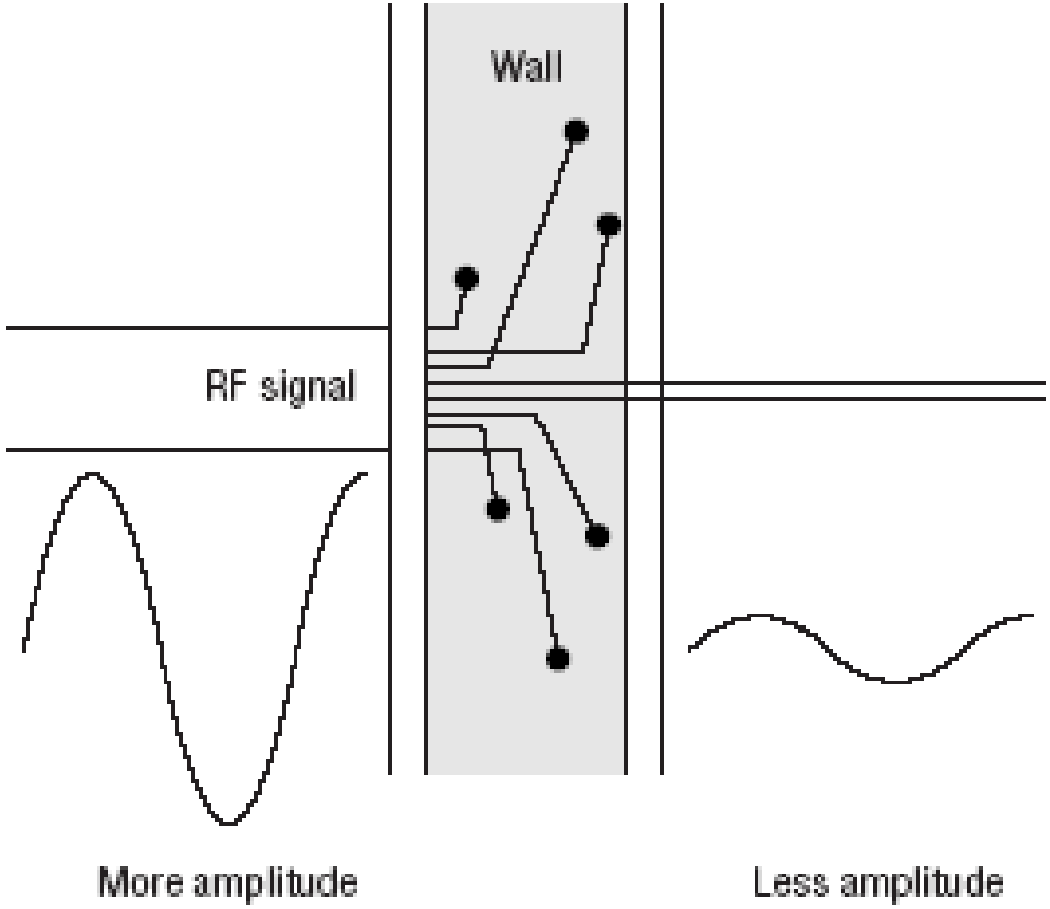
Refractions

RF signals are refracted through different densities of air

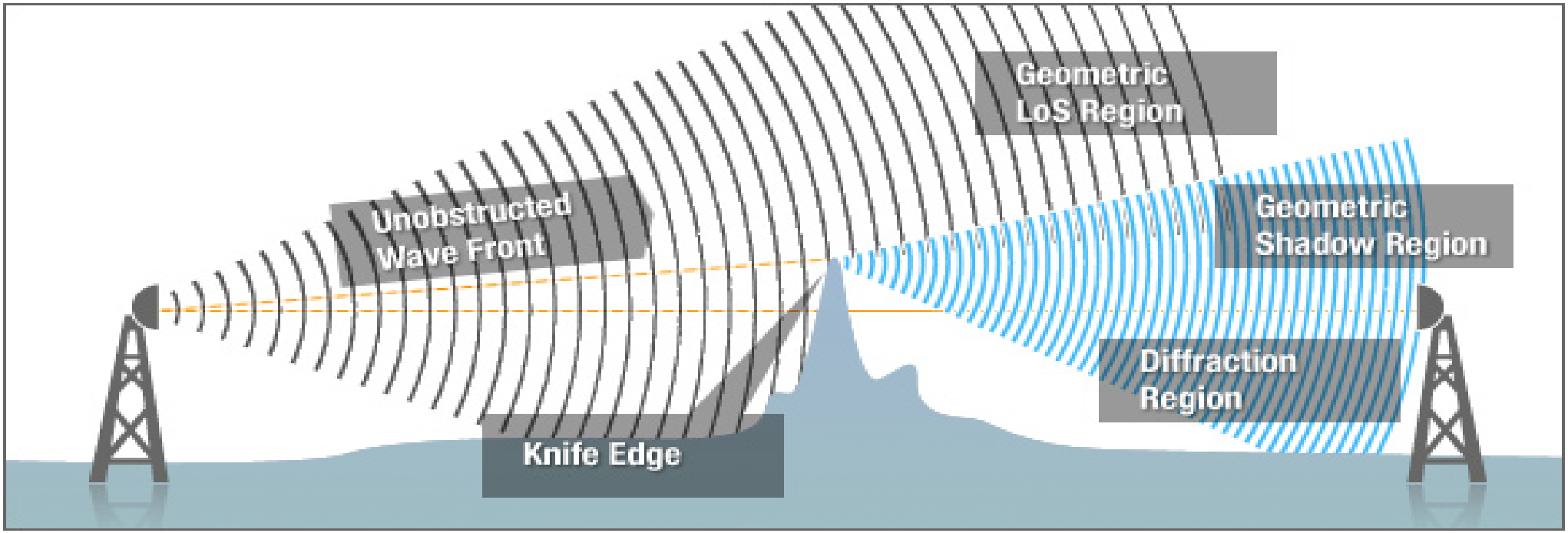


Absorption

- Dense materials block the RF from escaping
  - Brick walls -10dB
  - Plate glass -3dB
  - Metallized glass >-50dB

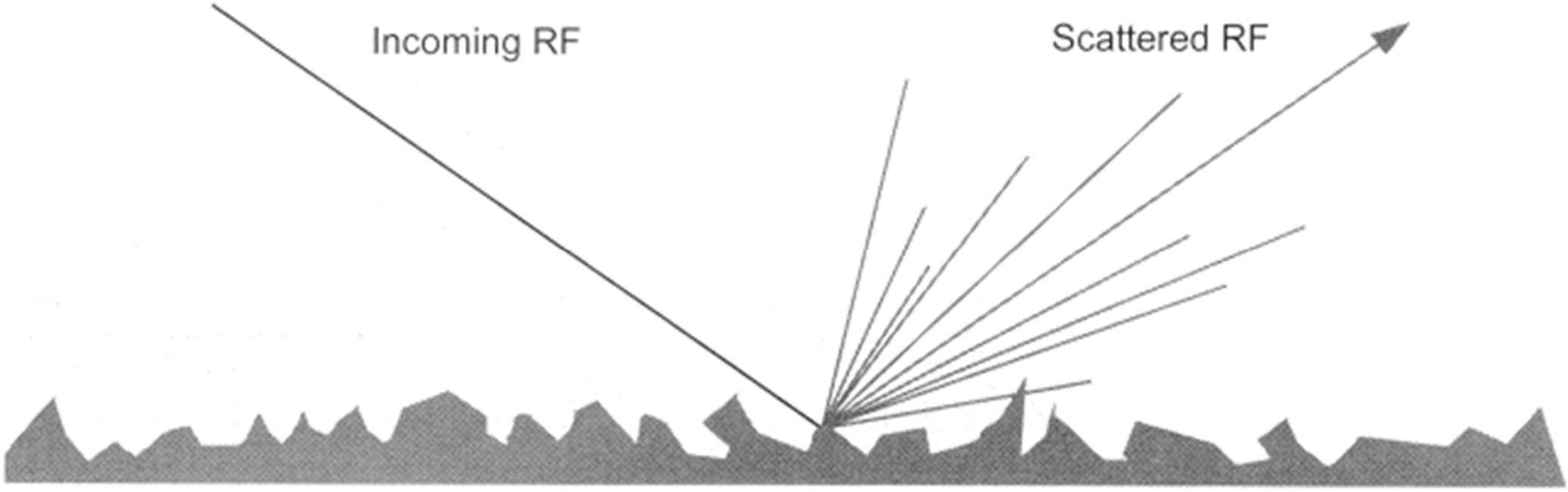


Diffraction



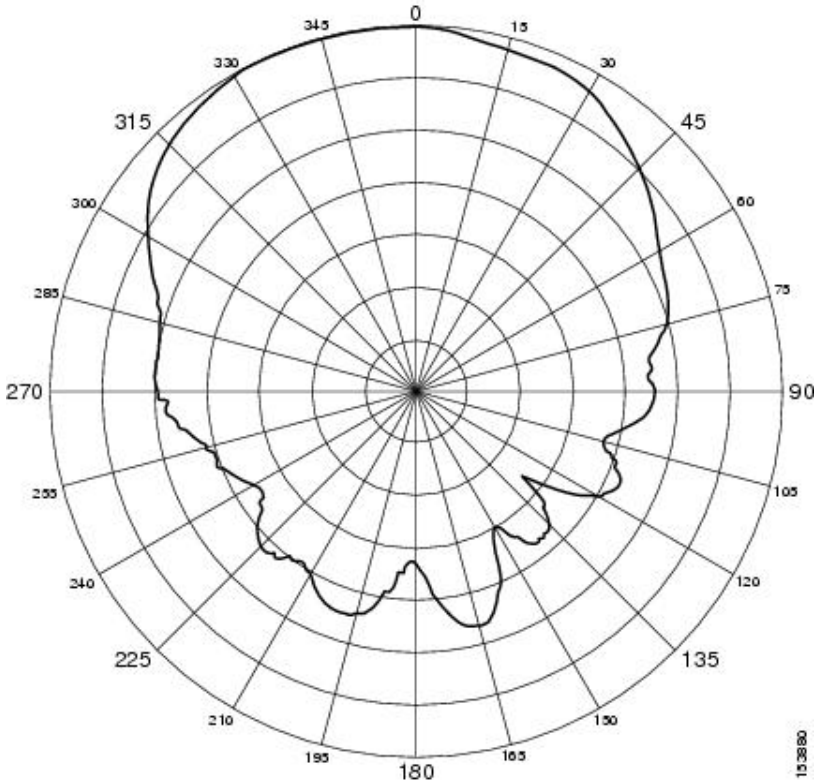
In the shadow region, you still get RF being received due to diffraction if far enough away from the knife edge obstruction

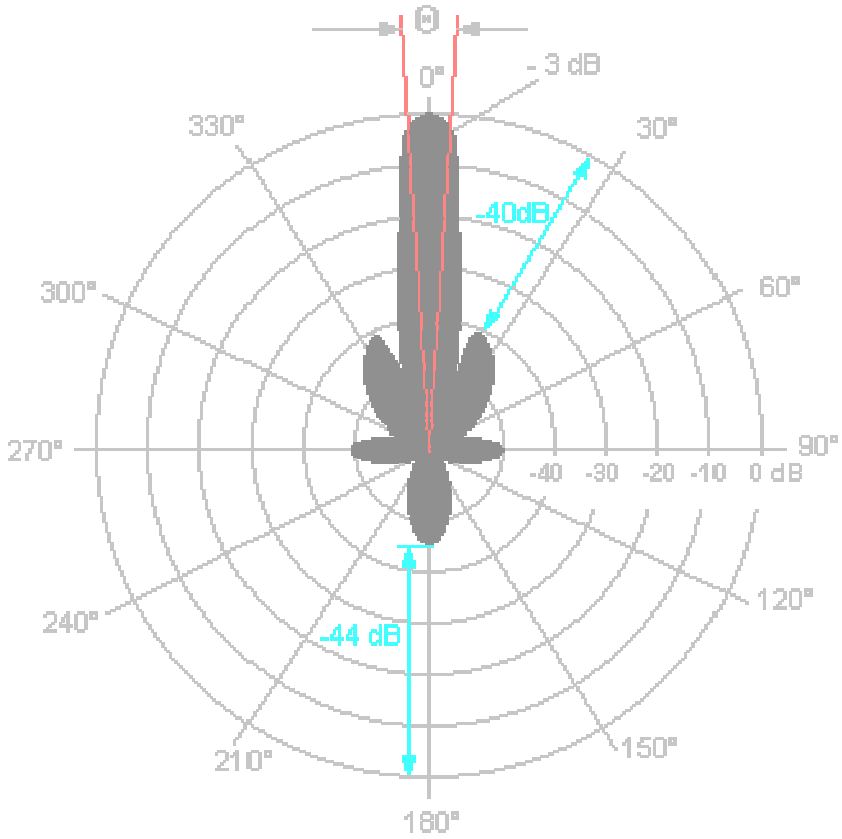
Scattering



Chain link fences, tree foliage, rocky terrain, random ground clutter

Side and rear lobes





- Antennae can have rear lobes as well as side lobes (especially dishes)
- Antennae with large or many side lobes create multipath problems

Fading

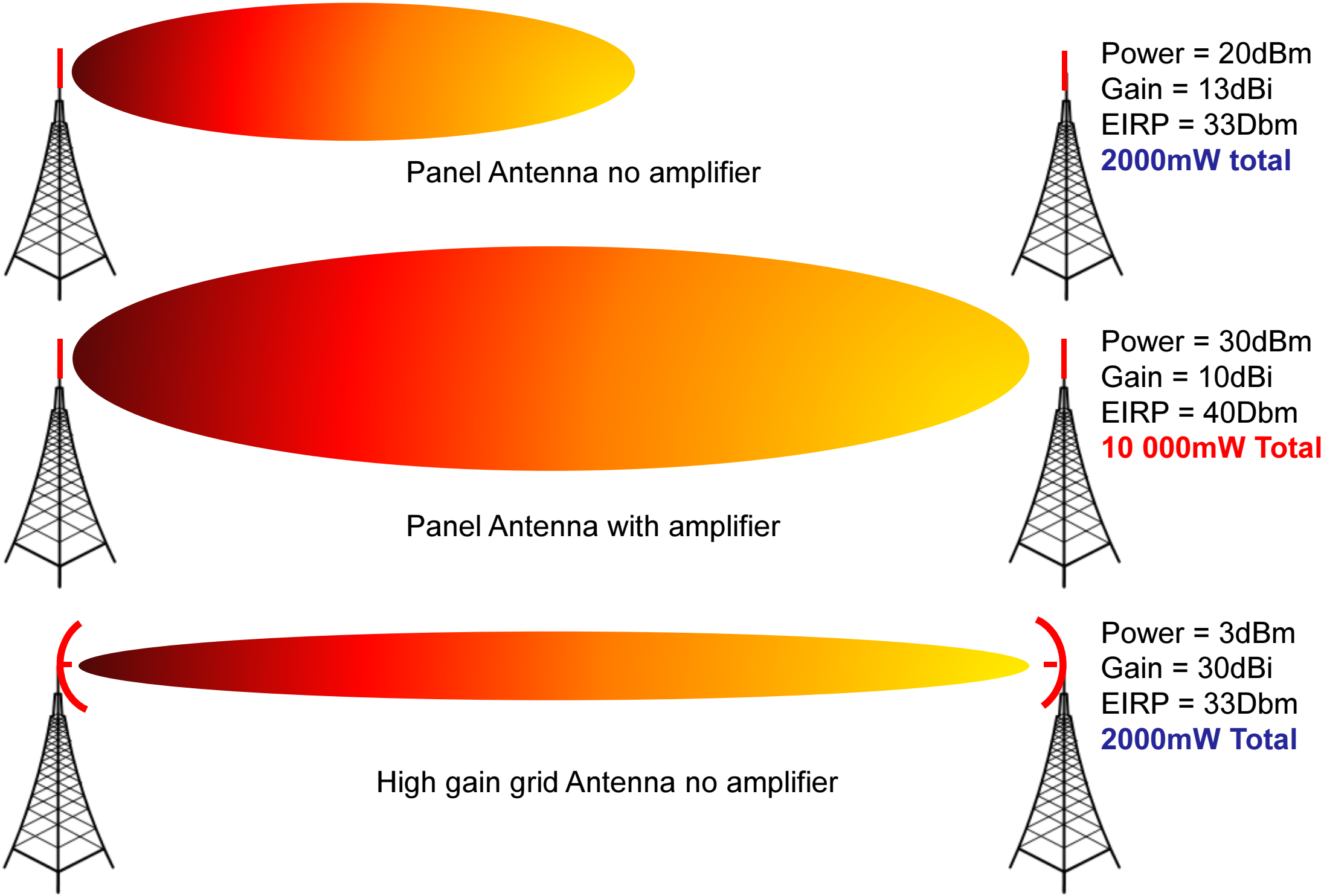
- Multipath effect
  - Bad LOS
  - Weather Conditions (density of air, rain/snow, mechanical movement from wind)
  - Birds / animals / snow or ice on Antenna radiator (no radome?)
- Answer:
  - Link Budget Calculations with high enough fade margin (>20dB)
  - Diversity antennae (spatial, multiple polarisation, MIMO)

Noise

- When waves interfere with each other, we call this noise
- The more radios are operating on the same or nearby frequencies, the more noise
- The maximum permissible power output on 2.4Ghz in most countries is 100mW
  - On 5Ghz it can range from 1000mW to 4000mW EIRP
  - Up to 200W for PTP links
- It might be tempting to amplify the signal to drown out other transmitters – DO NOT DO THIS!

Why not amplify?

- They are expensive
- You will need at least two
- They provide no additional directionality
- They create noise for other users of the band
- They are illegal in most cases
- Rather use more careful antenna choices and correct highsite planning.
  - High gain antenna's for PTP links allows lower power
  - Sector and dish shield can help limit sideband interference


Power = 20dBm
Gain = 13dBi
EIRP = 33Dbm
2000mW total
Panel Antenna no amplifier
Power = 30dBm
Gain = 10dBi
EIRP = 40Dbm
10 000mW Total
Panel Antenna with amplifier
Power = 3dBm
Gain = 30dBi
EIRP = 33Dbm
2000mW Total
High gain grid Antenna no amplifier

You Need to be More Sensitive

- Sensitivity defines how much signal a card needs to decode a packet at a certain data rate
- Modern 802.11N cards have a much better sensitivity than older generation devices
- **R52**

Data Rate / Power	Sensitivity
6mbps / 17dBm	-88
54mbps / 13dBm	-71

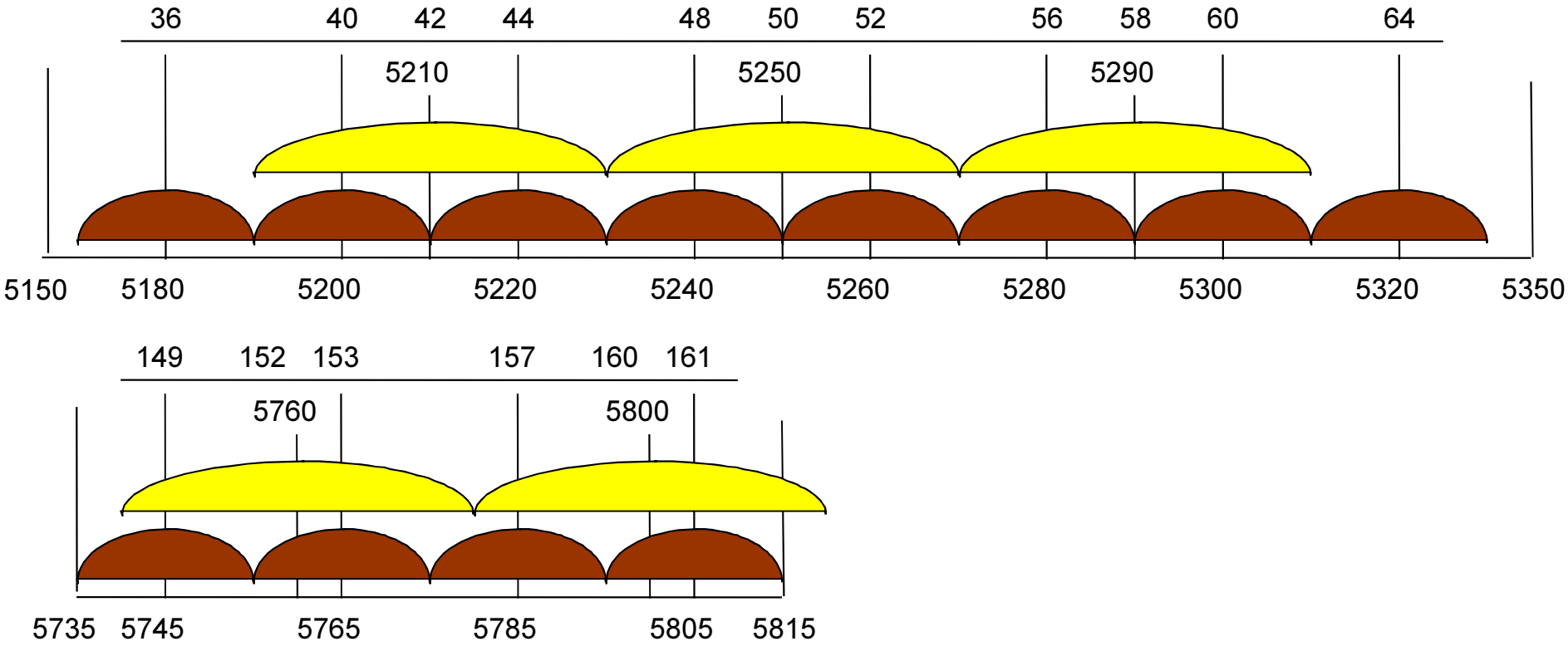
R52Hn MIMO

Data Rate / Power	Sensitivity
6mbps / 25dBm	-97
54mbps / 21dBm	-80
300mbps / 17dBm	-74

- With all else being equal you gain 9dB using the newer card!

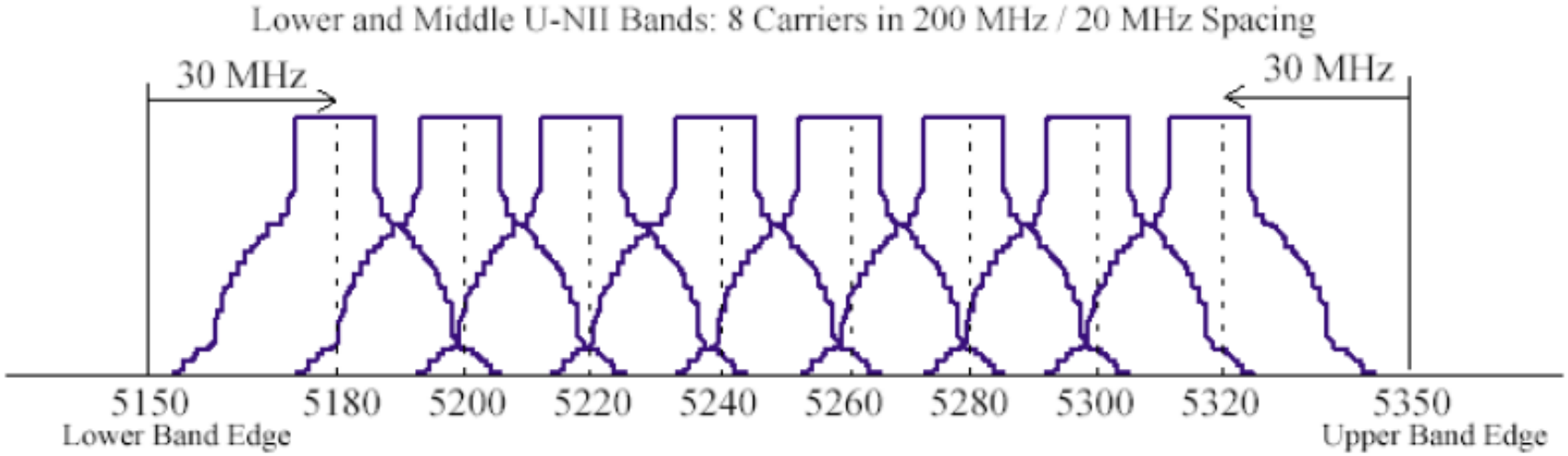
You need to filter Noise Better

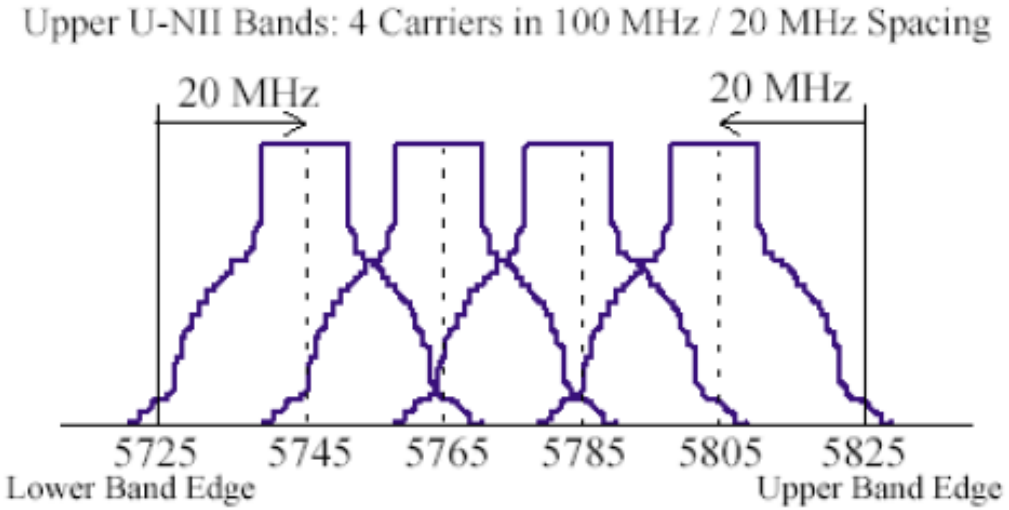
- Standard 802.11A channels are spaced 20Mhz apart and consume 20Mhz of bandwidth for maximum datarate
- Therefore we can use multiple wireless devices spaced 20Mhz apart for interference free operation?



Channel Consumption (actual)

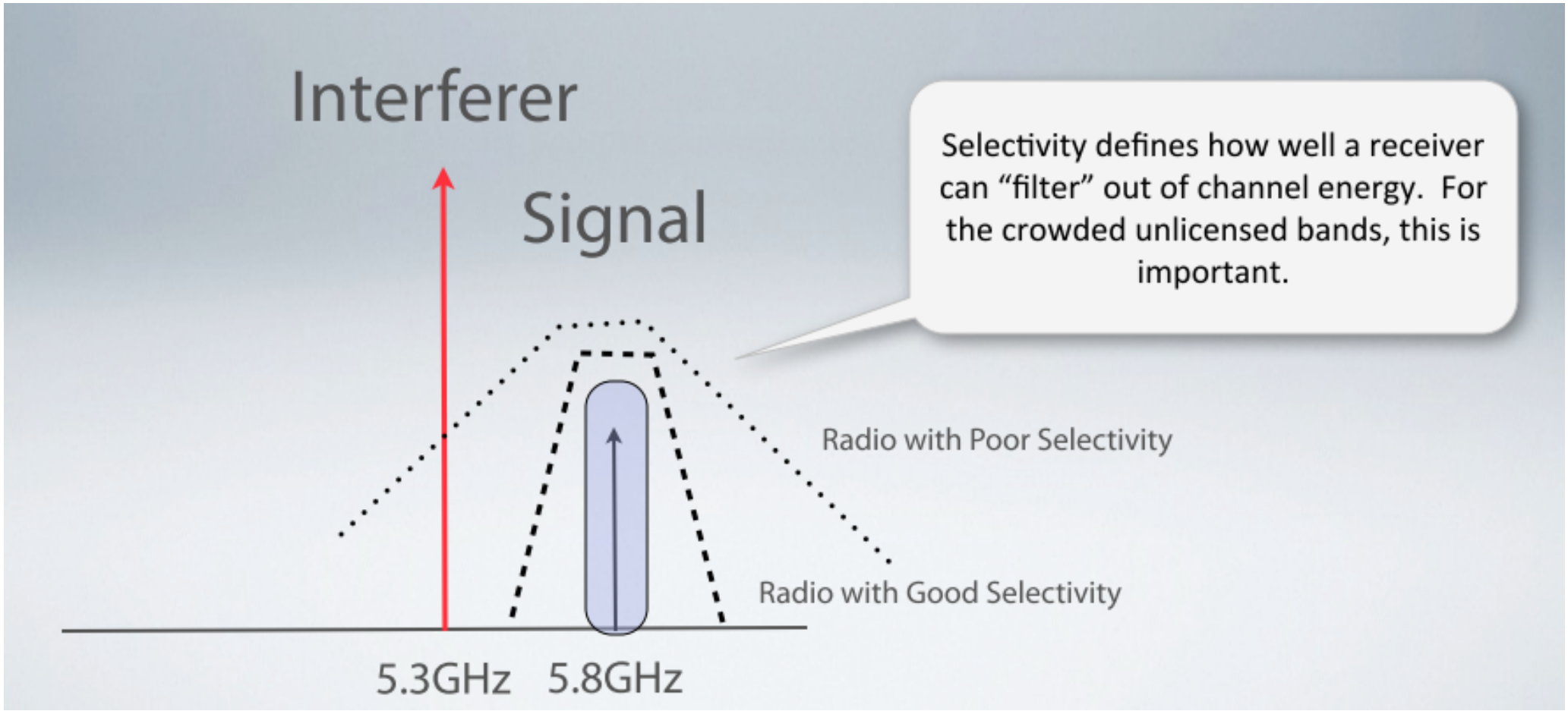
- Even at 40 MHz spacing there is still some overlap!





Selectivity

- Newer technology cards have far better immunity to noise from surrounding channels



Online Link Planner

http://www.mikrotik.com/test_link.php

- Allows you to enter all information and automatically calculate results
- All you need are the specifications of the wireless card, cable length and distance of the link

Parametrs	SITE 1	SITE 2
Wireless cards		
Power	400 mW	26 dBm
RX Sensitivity	-80 dBm	-80 dBm
Antennas		
Gain	27 dBi	27 dBi
Cables		
Length	4 m	4 m
Type:	LMR400	LMR400
Link		
Distance	15 km	
Frequency	5180 MHz	

Calculate

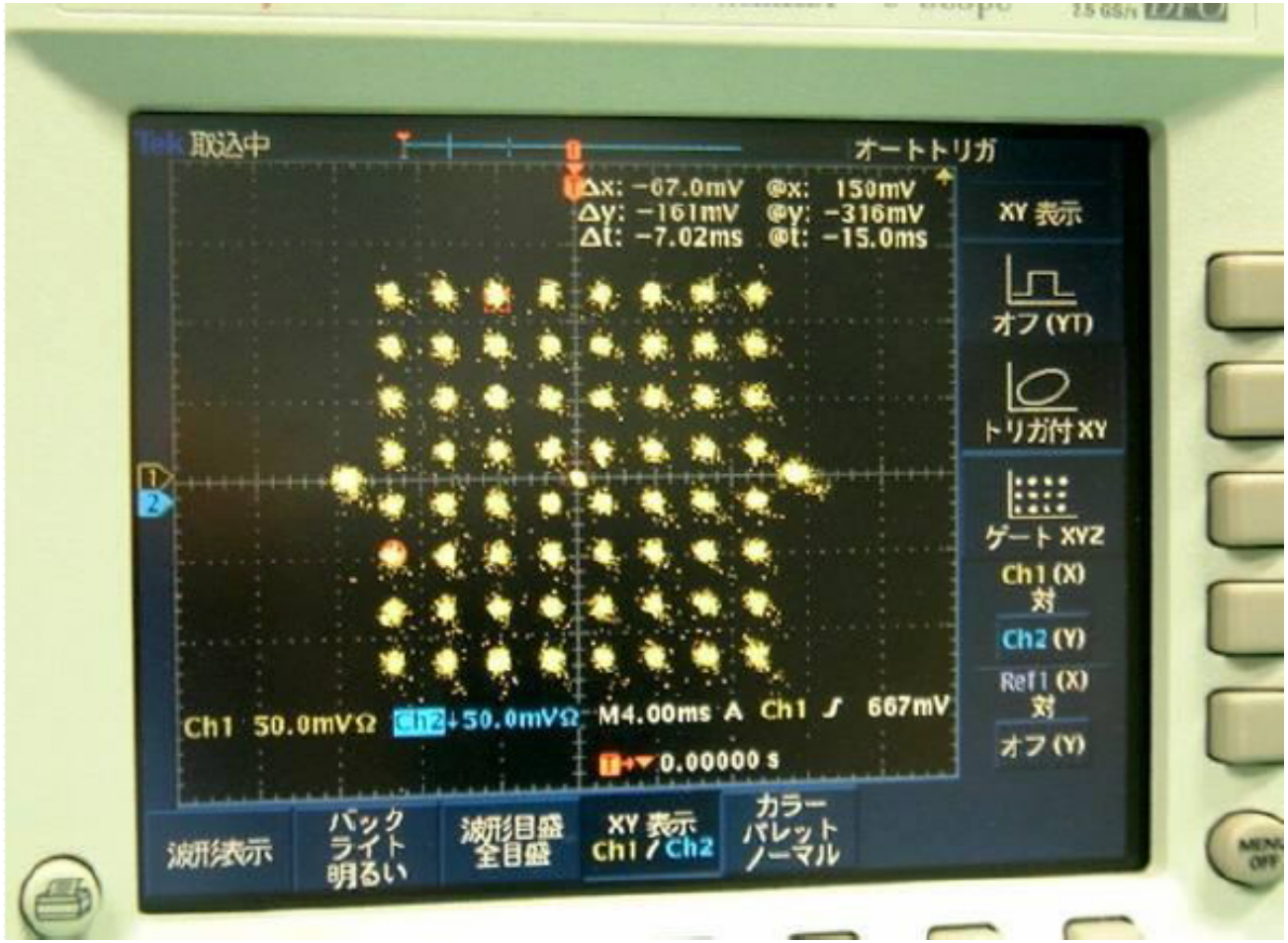
Link theoretical status	reliable
Theoretical signal level at site 1	-54/required -80
Theoretical signal level at site 2	-54/required -80

More Signal is Better?

- You want enough signal to ensure a good fade margin for maximum data rate without overloading the wireless card
- 20 dB is considered a good industry standard for fade margin
- So why not have even bigger fade margin?
  - At higher than optimal signal levels the FEC (Forwarding Error Correction) will be bumped up
  - This essentially means lower potential transfer speeds
- A general “rule of thumb” is a signal of between -50 and -60

High RX Levels

- This illustrates an RX signal of -35



Optimal RX Level

- This illustrates an RX signal of -65

Production Link

- The following slides illustrate a current production link using off the shelf MikroTik and Ubiquiti hardware
- The ink is on a building in relatively close proximity to 5 other high speed links

Parts List

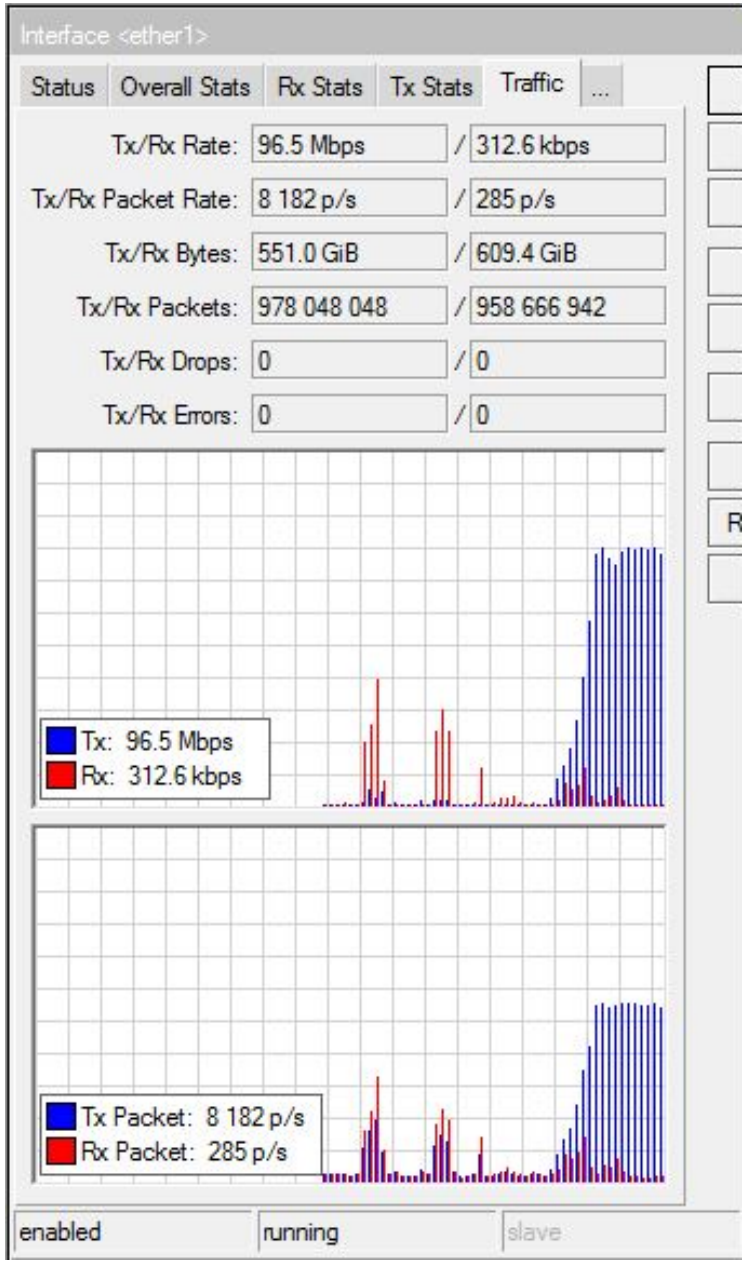
RouterBoard RB711G

Aluminium enclosure

30dBi Dual Polarised Dish antenna

Dish shield

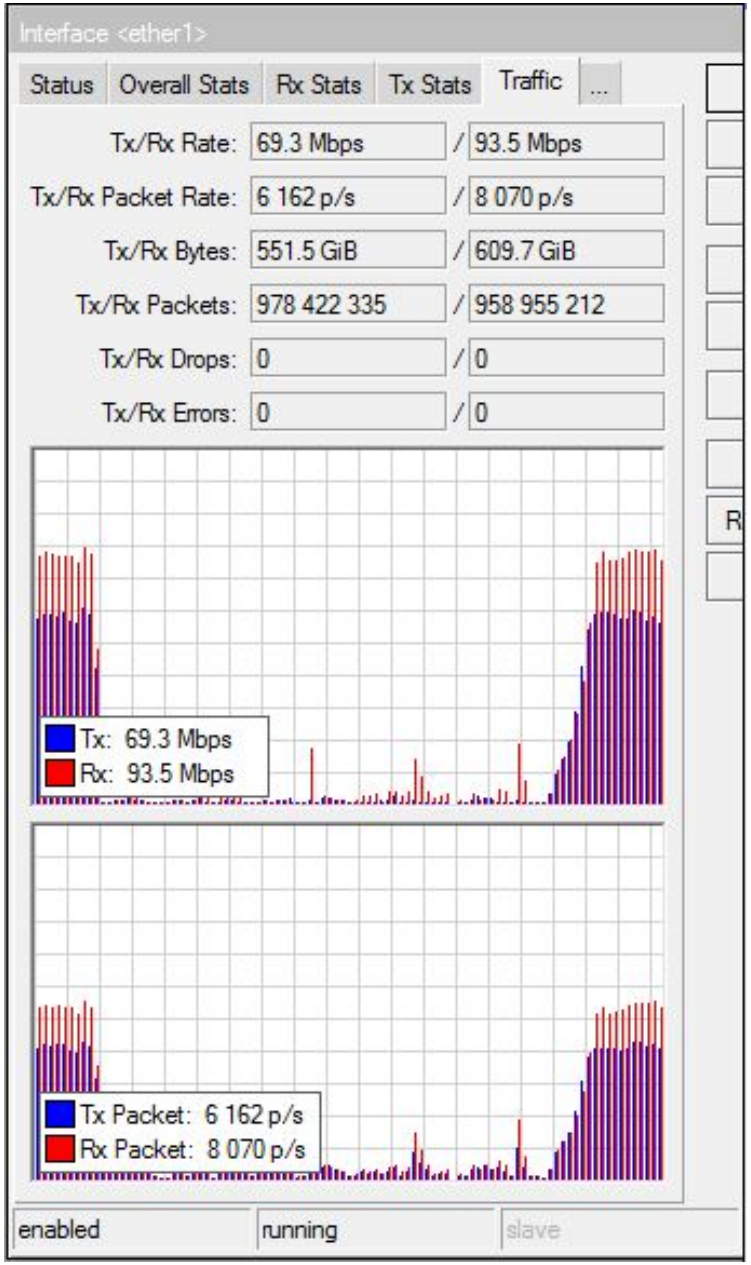
Bandwidth Tests - UDP



96 Mbps one way

69/93 Mbps Full Duplex

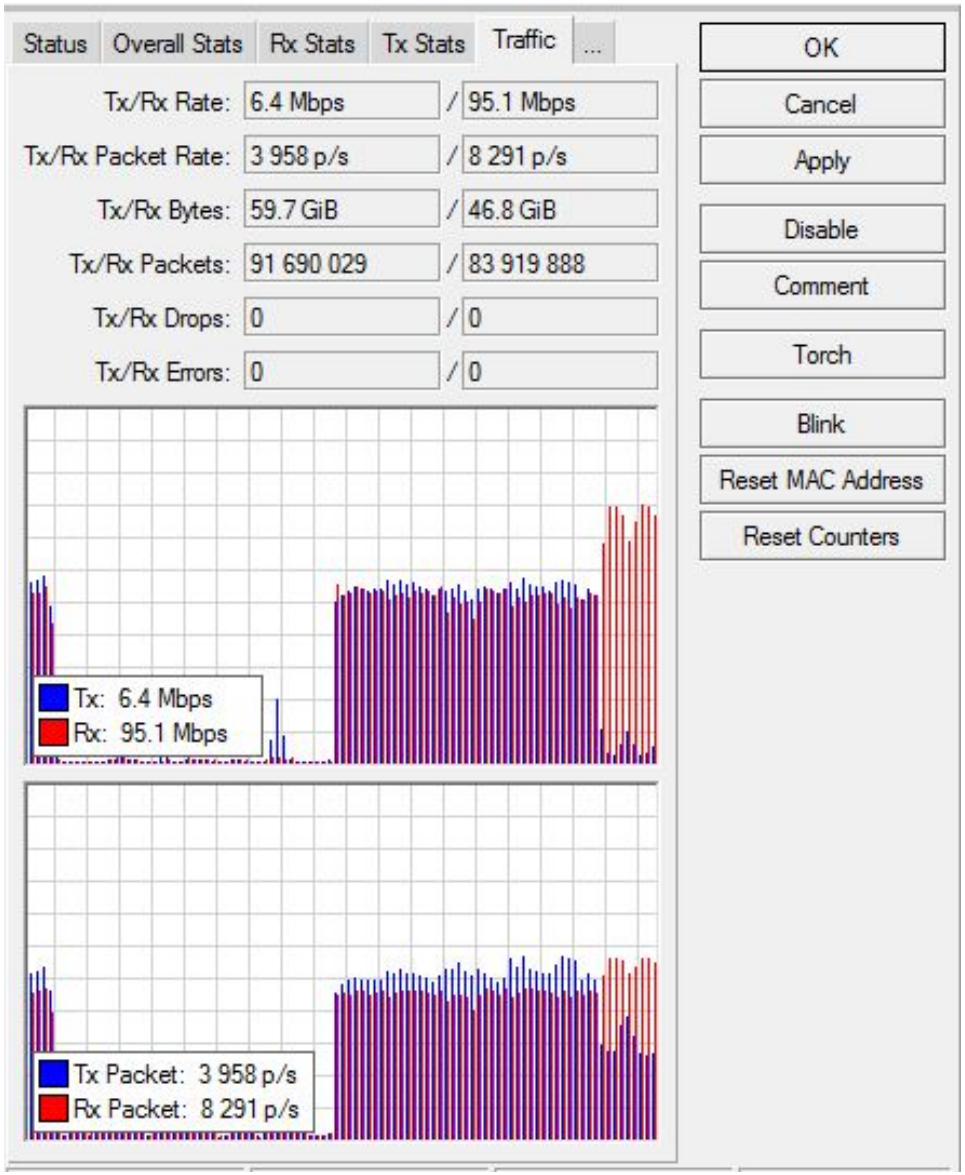
In both cases absolute throughput is limited by the 10/100 Ethernet port on the testing device

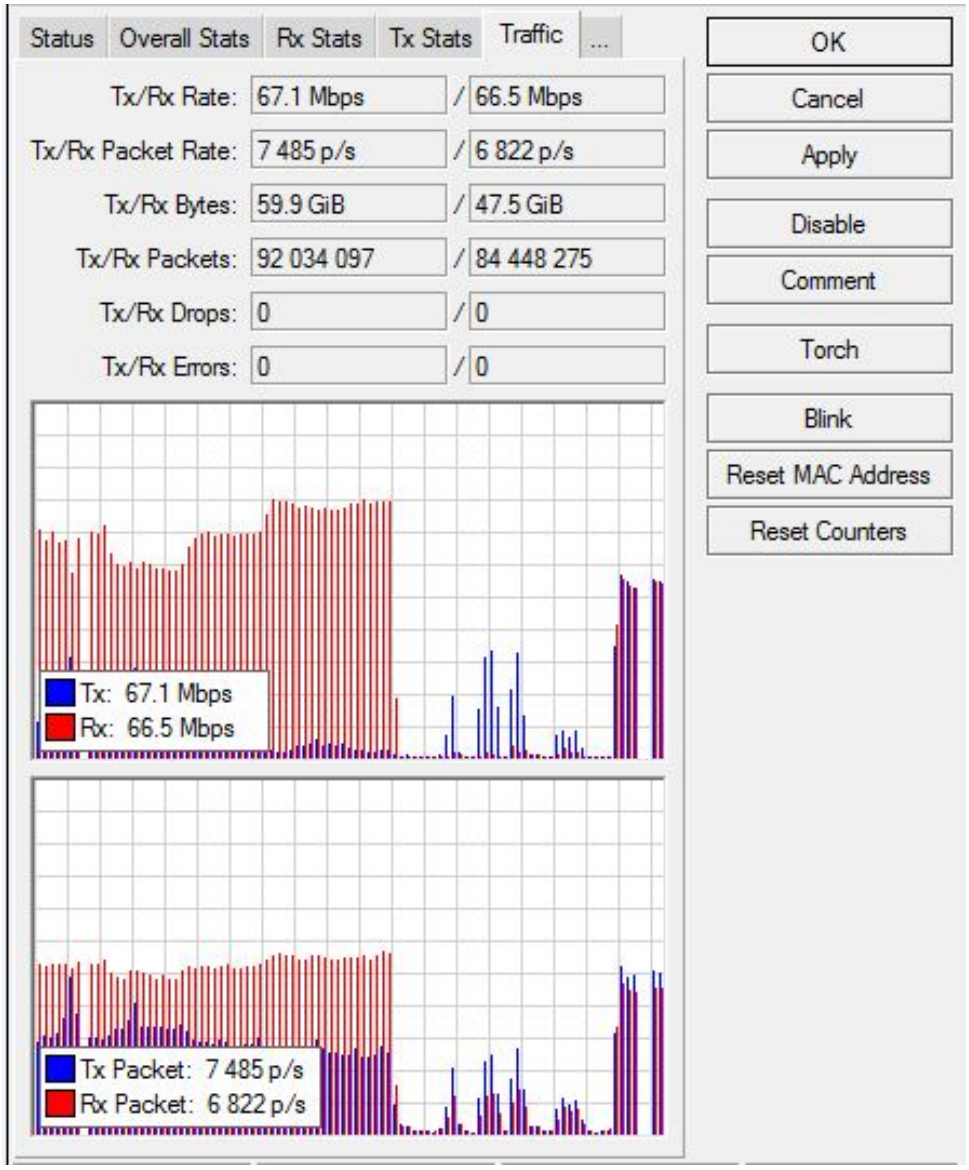


Bandwidth Tests - TCP

96 Mbps one way 67/67 Mbps Full Duplex (130Mbps aggregate)

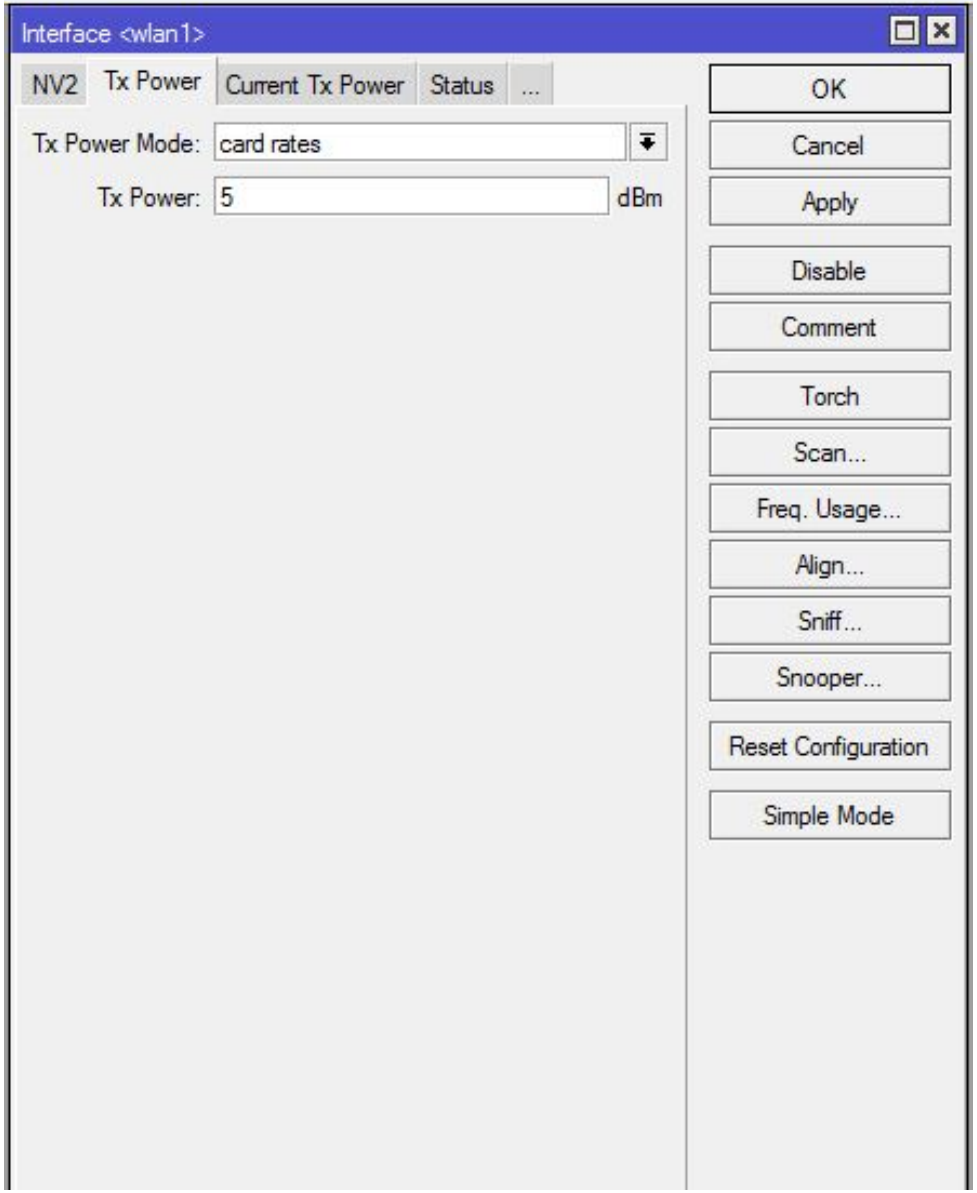
Again absolute throughput is limited by the 10/100 port





Transmit Power Settings

- Transmit power is turned right down to bring signal to within the target level (around -59dB signal)
- 5dBm Tx Power (3.5mW)



Contact me?

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