Wireless High Performance

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Wi4Net - Totalconn

- Mikrotik Italian distributor
- Training and Consulting
- Building Certified Devices for EU market
- Wireless distribution
- E-commerce Web site www.wi4net.it

Andrea Grittini

- Graduated in Computer Science
- Working with wireless since 2003
- Startup of one of the first Italian WISP
- Mikrotik distributor since 2005
- Mikrotik Certified in MTCNA, MTCRE, MTCWE, MTCTCE

- More 10 trainings a year, with more than 60 graduates

Goal

Wireless New possibilities

Wireless Plan tools

Topics

- MIMO & 802.11ac
- Our tests on 802.11ac

- Optimizing wireless projects:
  – Channel planning for indoor coverage
  – Indoor wireless levels
  – Outdoor link planning

Mimo 802.11n

- MIMO is an abbreviation for **Multiple-Input Multiple-Output**, which refers to the ability of equipment to handle multiple data input and multiple data output operation.

- Wi-Fi 802.11n devices make use of multiple antennas to send and receive more than one communication signal **simultaneously**

- **2x2, 3x3 up to 4x4 streams**

RFC 2597 and RFC 2598

Wireless High Performance
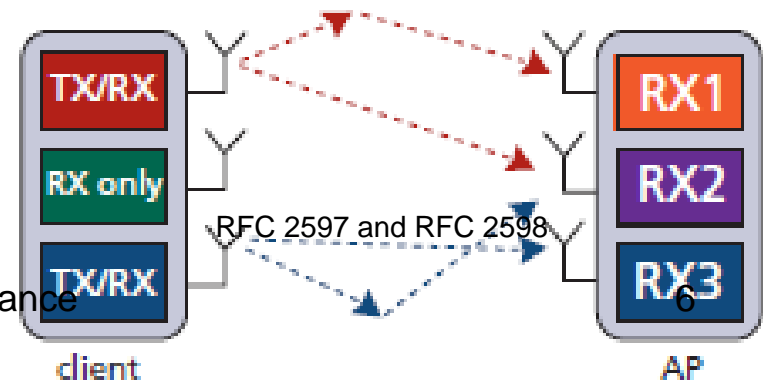
802.11ac is the future

- Broadcom chipsets supports 80Mhz 802.11ac

- Qualcomm/**Atheros** supports 80Mhz 802.11ac

- Openwrt implements the 20/40/80Mhz driver

- Mikrotik ? NV2, routeros and routerboards
     will be a very strong «plus».
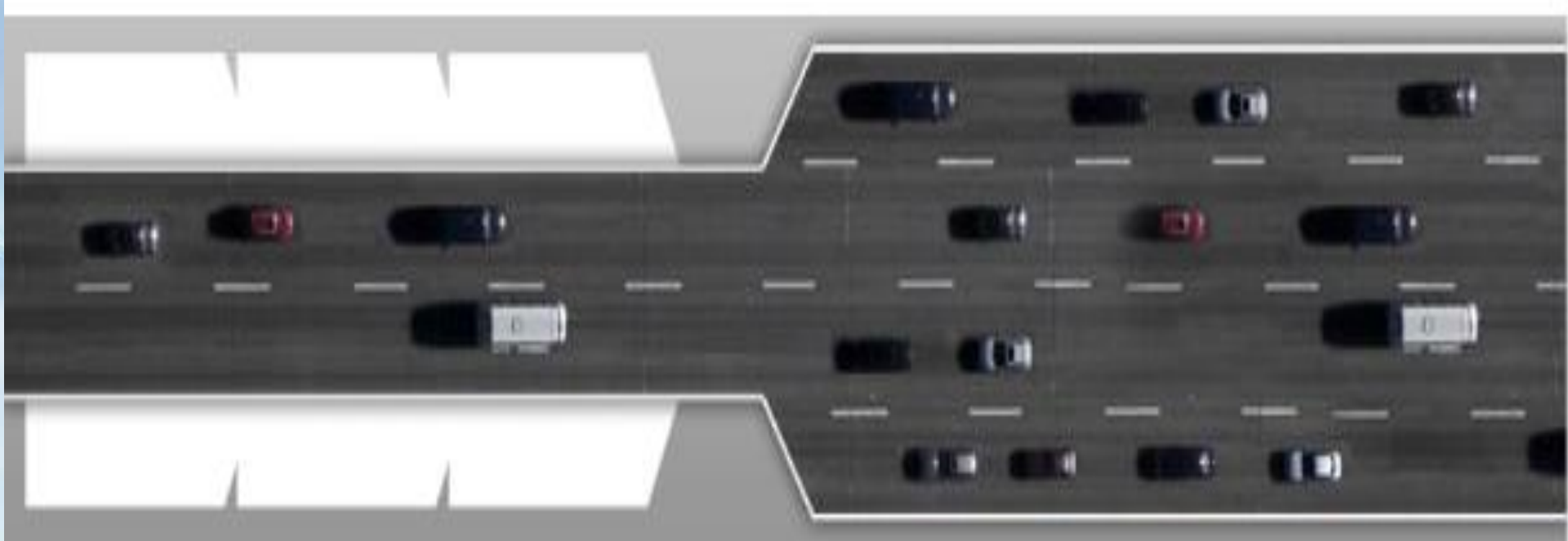
802.11n support 40MHz

- 40MHz = 2 aggregated 20MHz channels
- takes advantage of the reserved channel space through bonding to gain more than double the data rate of 2 20MHz channels
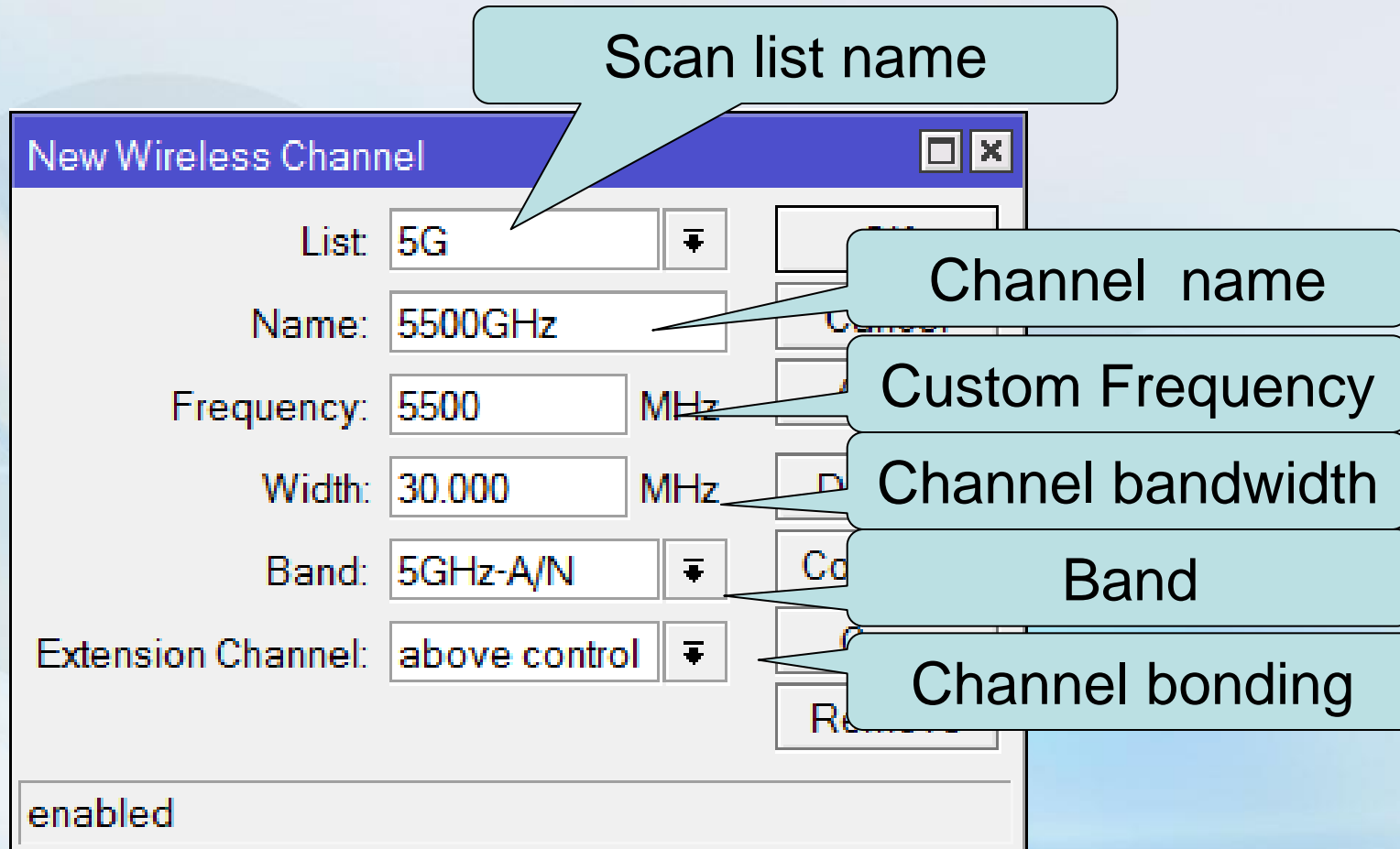
RouterOs 802.11n up to 60MHz

- 50MHz = 2 aggregated 25MHz channels
- More than 300Mbps aggregated throughput

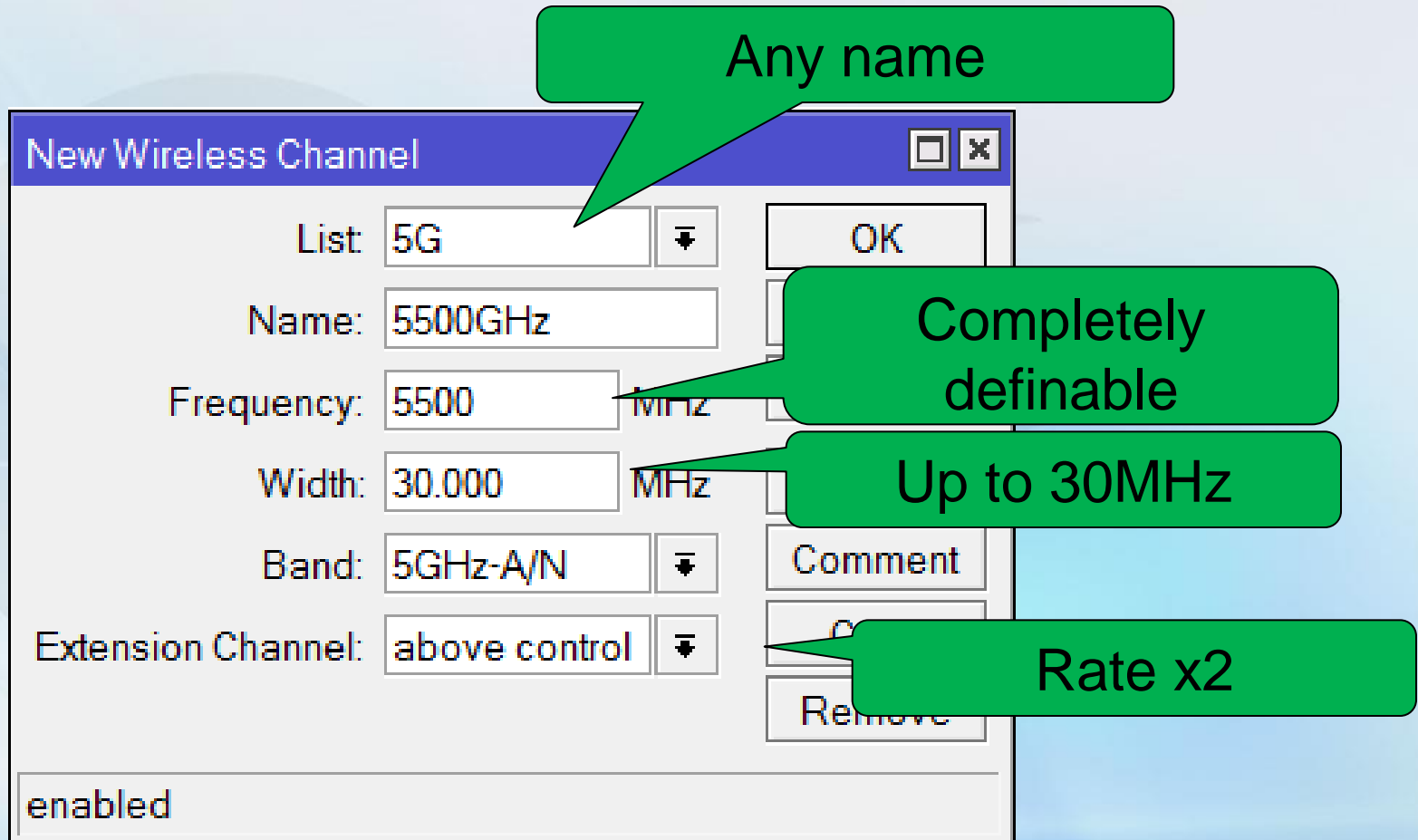# With Custom Channel

Scan list name

Channel name

Custom Frequency

Channel bandwidth

Band

Channel bonding

New Wireless Channel

List: 5G

Name: 5500GHz

Frequency: 5500 MHz

Width: 30.000 MHz

Band: 5GHz-A/N

Extension Channel: above control

Custom Channel

New Wireless Channel

List:	5G	⏷	OK
Name:	5500GHz		
Frequency:	5500	MHz	
Width:	30.000	MHz	
Band:	5GHz-A/N	⏷	Comment
Extension Channel:	above control	⏷	
			Remove

enabled

Any name

Completely definable

Up to 30MHz

Rate x2

802.11ac 80MHz

802.11ac

Bandwidth	20 MHz	40 MHz	80 MHz	160 MHz
# of Spatial Streams				
1	86.7 Mbps	200 Mbps	433.3 Mbps	866.7 Mbps
2	173.3 Mbps	400 Mbps	866.7 Mbps	1733 Mbps
3	288.9 Mbps	600 Mbps	1300 Mbps	2340 Mbps
4	346.7 Mbps	800 Mbps	1733 Mbps	3466 Mbps
5	433.3 Mbps	1000 Mbps	2166 Mbps	4333 Mbps
6	577.8 Mbps	1200 Mbps	2340 Mbps	5200 Mbps
7	606.7 Mbps	1400 Mbps	3033 Mbps	6066.7 Mbps
8	693.3 Mbps	1600 Mbps	3466 Mbps	6933 Mbps

MIMO and 802.11ac

	MIMO	802.11ac
2x2 40MHz	300Mbps	400Mbps
3x3 40Mhz	450Mbps	600Mbps
2x2 50Mhz ROs	375Mbps	??

+33%

- In the same condition

802.11ac channels
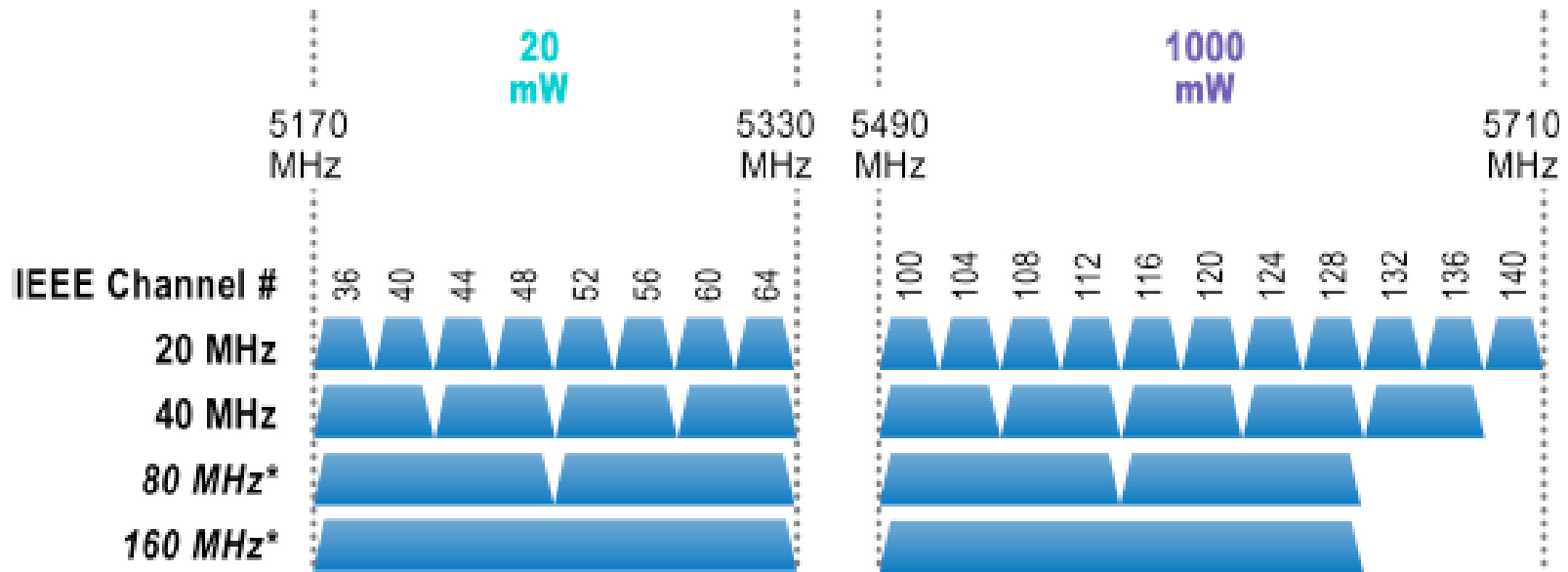

FIGURE • European channel allocations for 20/40/80/160 MHz

• Problem: channels are often already busy !

802.11ac with two streams

MCS index	Modulation type	Coding rate	20 MHz channels		40 MHz channels		80 MHz channels		160 MHz channels	
			800 ns GI	400 ns GI	800 ns GI	400 ns GI	800 ns GI	400 ns GI	800 ns GI	400 ns GI
Theoretical throughput for two Spatial Stream (in Mb/s)										
6	64-QAM	3/4	117	130	243	270	**526.6**	585	**1053**	1170
7	64-QAM	5/6	130	144.4	270	300	**585**	650	**1170**	1300
8	256-QAM	3/4	156	173.4	324	360	**702**	780	**1040**	1560
9	256-QAM	5/6	N/A	N/A	360	400	**780**	866.6	**1560**	1733,4

Constellation

Ideal 64 QAM Constellation → Ideal 256QAM Constellation
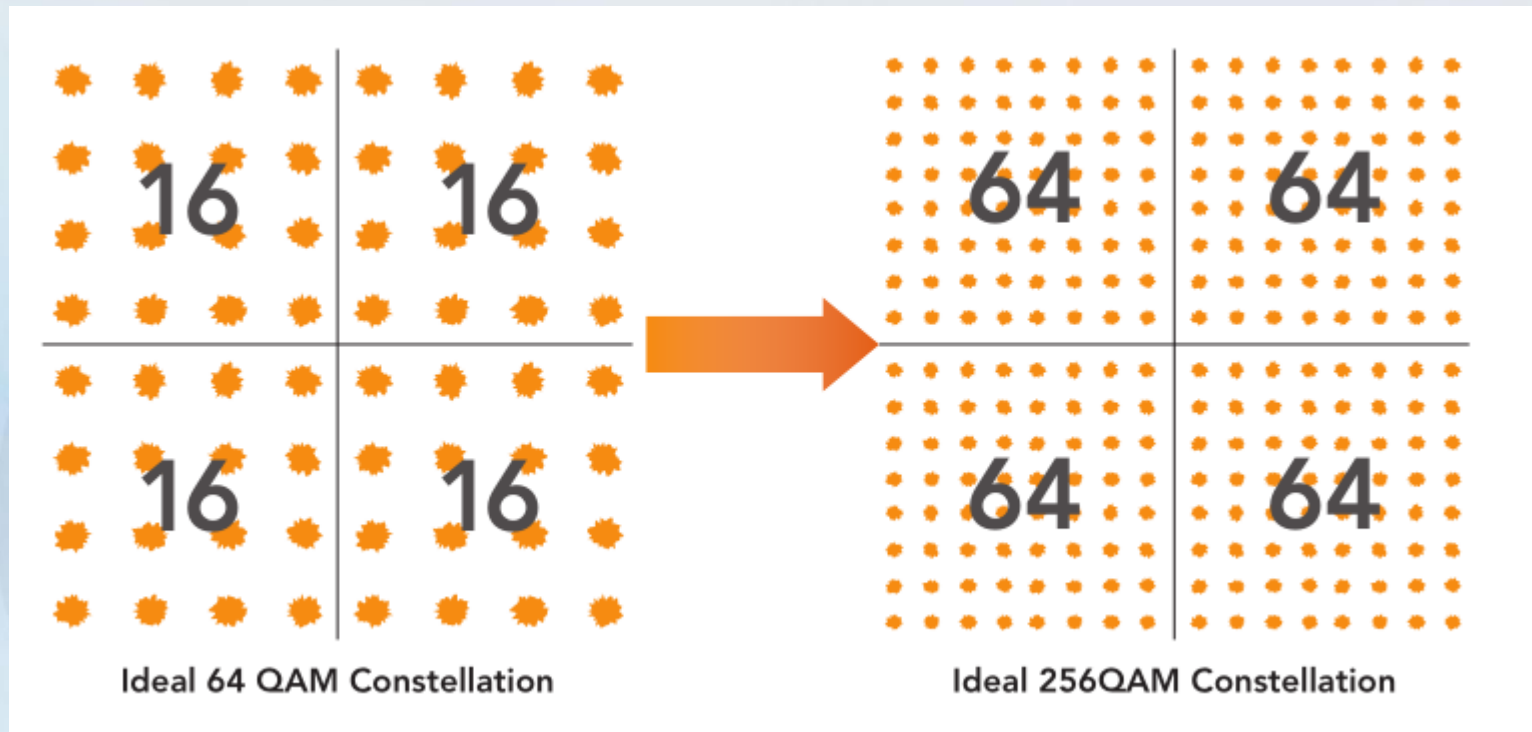
- 802.11ac protocol introduce the 256QAM modulation, in order to send more data at the same time
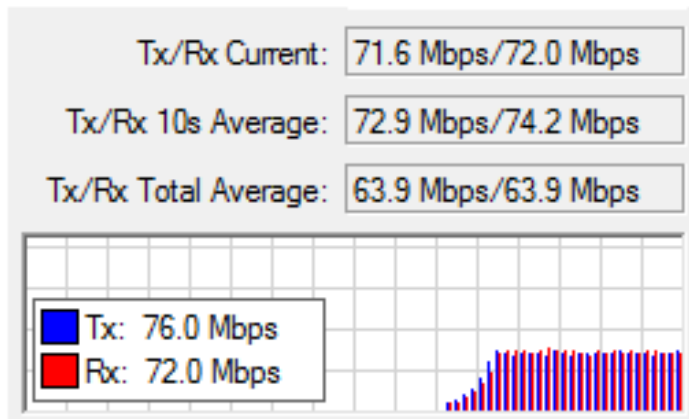
- Higher signal strength required !!

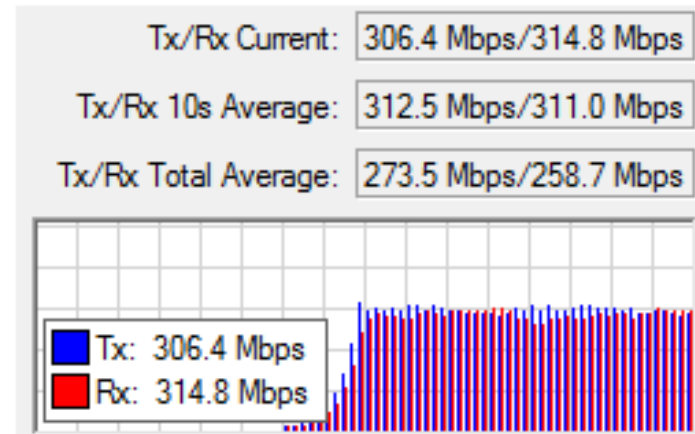# Our tests on 802.11ac radio

80Mhz channel

- 2 Compex WPJ433 board with 802.11ac mpcie 5 GHz radio
- 2 RB2011 to generate traffic on gbit port

- 80 MHz channel
- 2x2 MIMO transmission

Our Test on 802.11ac

20Mhz channel, P2P

Tx/Rx Current:	71.6 Mbps/72.0 Mbps
Tx/Rx 10s Average:	72.9 Mbps/74.2 Mbps
Tx/Rx Total Average:	63.9 Mbps/63.9 Mbps

Tx: 76.0 Mbps
Rx: 72.0 Mbps

80Mhz channel, P2P

Tx/Rx Current:	306.4 Mbps/314.8 Mbps
Tx/Rx 10s Average:	312.5 Mbps/311.0 Mbps
Tx/Rx Total Average:	273.5 Mbps/258.7 Mbps

Tx: 306.4 Mbps
Rx: 314.8 Mbps

With 80Mhz channel: 620Mbps (310+310) of real traffic

Same performance in lab and in a short range «real» installation
We are actually testing long-range (some km)
Packet latency (802.11) reasonable but high

802.11ac

Advantages

- Introduce 80Mhz channel width (up to 866Mbps)
- +33% in same condition
- Uses QAM256 and better aggregation protocol

Disadvantages

- Only 5GHz frequency (not suported on 2.4)
- Crowded frequency
- Higher signal strength to use QAM256

Wireless Planning and Optimization tools

Optimization tools

Installers needs to grant to their clients that the **installation** they are proposing will be **successful**.

We developed algorythms useful for:

- **Channel planning** for 2.4G and 5G, mainly for indoor

- **Wireless coverage** planning at 2.4GHz and 5GHz

- Complete **link planning**, outdoor

Channel planning

- Assignment of different frequencies to cells is an usual problem of wireless planning
- Artificial Intelligence techniques are useful to plan bandwidth usage

Min-Max algorithm, with specialized heuristic function
- List of possible channels
- List of APS and their positions
- Rules: wider channels are better, nearest machines needs far channels

An online tool – sample map

PIANTA PIANO PRIMO
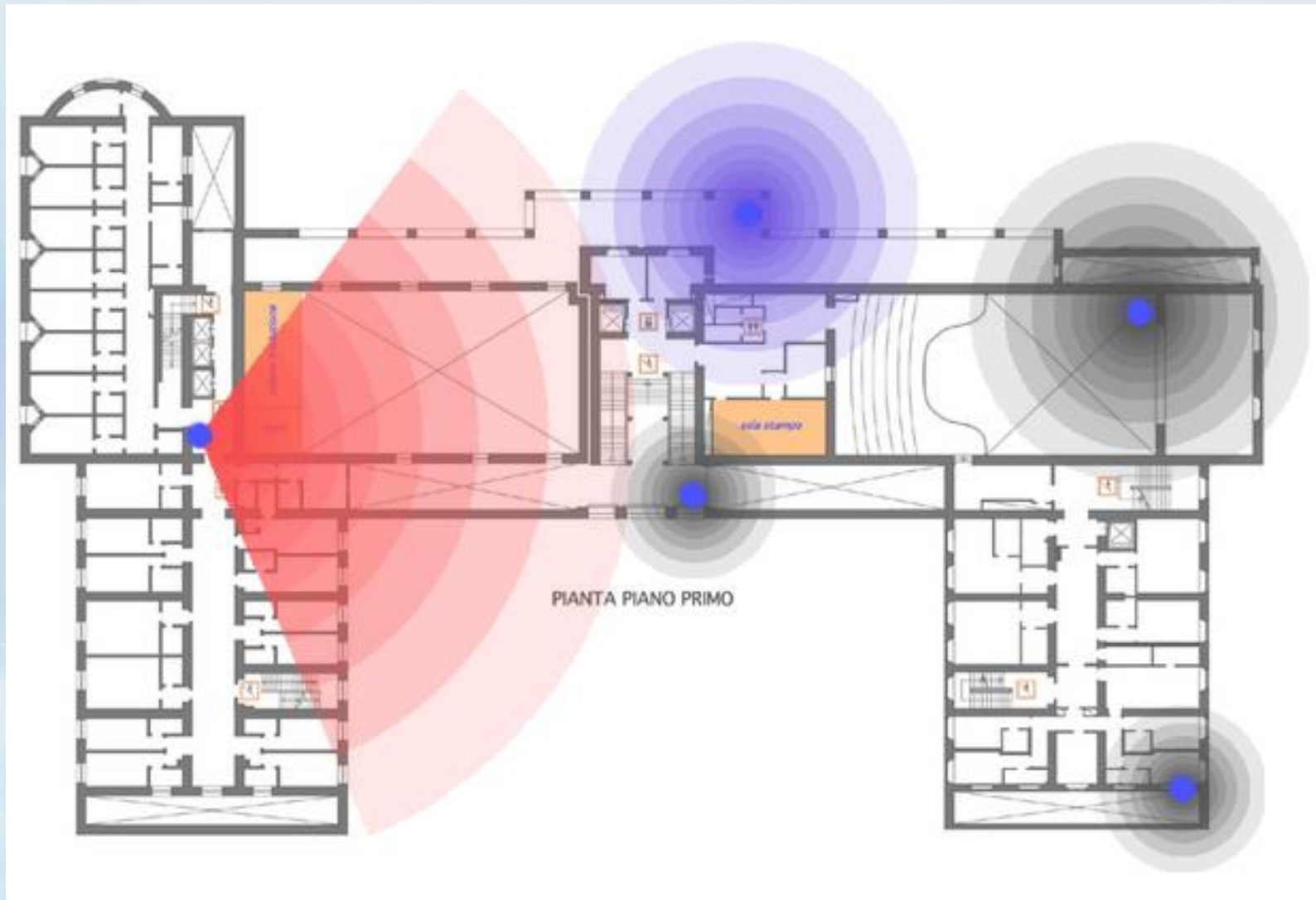
Some result: 2 + 5Ghz

Name ▼	Enabled	Channel
2ghz sector	Yes	2 - 2417/20Mhz
5ghz spot	Yes	44 - 5220/20Mhz
5ghz spot2	Yes	42 - 5210/40Mhz
5ghz spot3	Yes	44 - 5220/20Mhz
5ghz spot4	Yes	

Name ▼	Enabled	Channel
2ghz sector	Yes	1 - 2412/20Mhz
5ghz spot	Yes	152 - 5760/40Mhz
5ghz spot2	Yes	50 - 5250/40Mhz
5ghz spot3	Yes	42 - 5210/40Mhz
5ghz spot4	Yes	58 - 5290/40Mhz

- First image: starting situation
- Second image: AI engine proposes a (good)solution
- No channel overlaps

More complex: 2Ghz + overlap

Name	Enabled	Channel
2ghz sector	Yes	1 - 2412/20Mhz
2ghz spot	Yes	3 - 2422/20Mhz
2ghz spot2	Yes	4 - 2427/20Mhz
2ghz spot3	Yes	7 - 2442/20Mhz
2ghz spot4	Yes	8 - 2447/20Mhz

Name	Enabled	Channel
2ghz sector	Yes	1 - 2412/20Mhz
2ghz spot	Yes	13 - 2484/20Mhz
2ghz spot2	Yes	9 - 2452/20Mhz
2ghz spot3	Yes	12 - 2467/20Mhz
2ghz spot4	Yes	5 - 2432/20Mhz

Wireless High Performance

Extimated band

- We cannot avoid channels overlap
- Overlaps are limited as more as possible, and only between «far» routers
- % of real bandwidth usable can be computed

(«layer» is referred to different floors for palaces)

Channels - AP band overlaps

Overlap	AccessPoint	Freq. from	To	Band %	AccessPoint	Freq. from	To	Band %
Same layer	5ghz spot3	2467	2487	92.5	5ghz spot	2484	2504	92.5
Same layer	5ghz spot2	2452	2472	87.5	5ghz spot3	2467	2487	87.5

Back

Indoor Wireless Coverage

Ray tracing algorythms:

- Purpose: plan rough indoor coverage in complex environments (walls/reflections)

- Map is threated as bitmap: computation proceed with interlaced raster (like image on a TV screen).

- Walls and AP's are defined using vector graphics.

Simulation

- Model: «ray tracing for lights» similar to CAD rendering

- Access Points are «sources»

- Signal level for each point is computed considering all walls and Aps

- Attenuation and reflection model is different than the ones used for light

- **Slow**: simulation can require from few seconds to some minutes

- **Accurate**: wireless level is accurate and precise

Example: a single wall
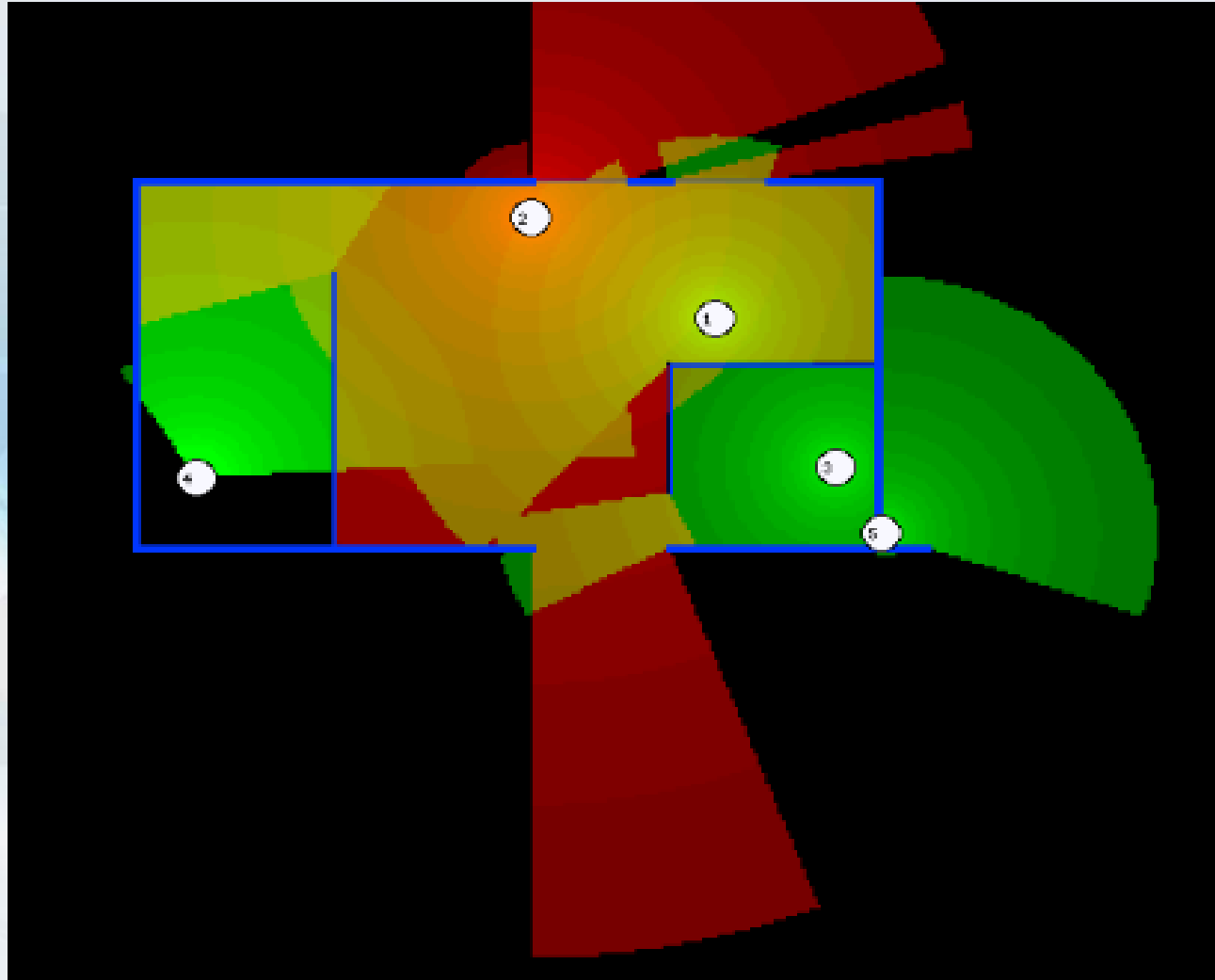

4 APs: 1: prova   2: 5gant   3: prova   4: prova
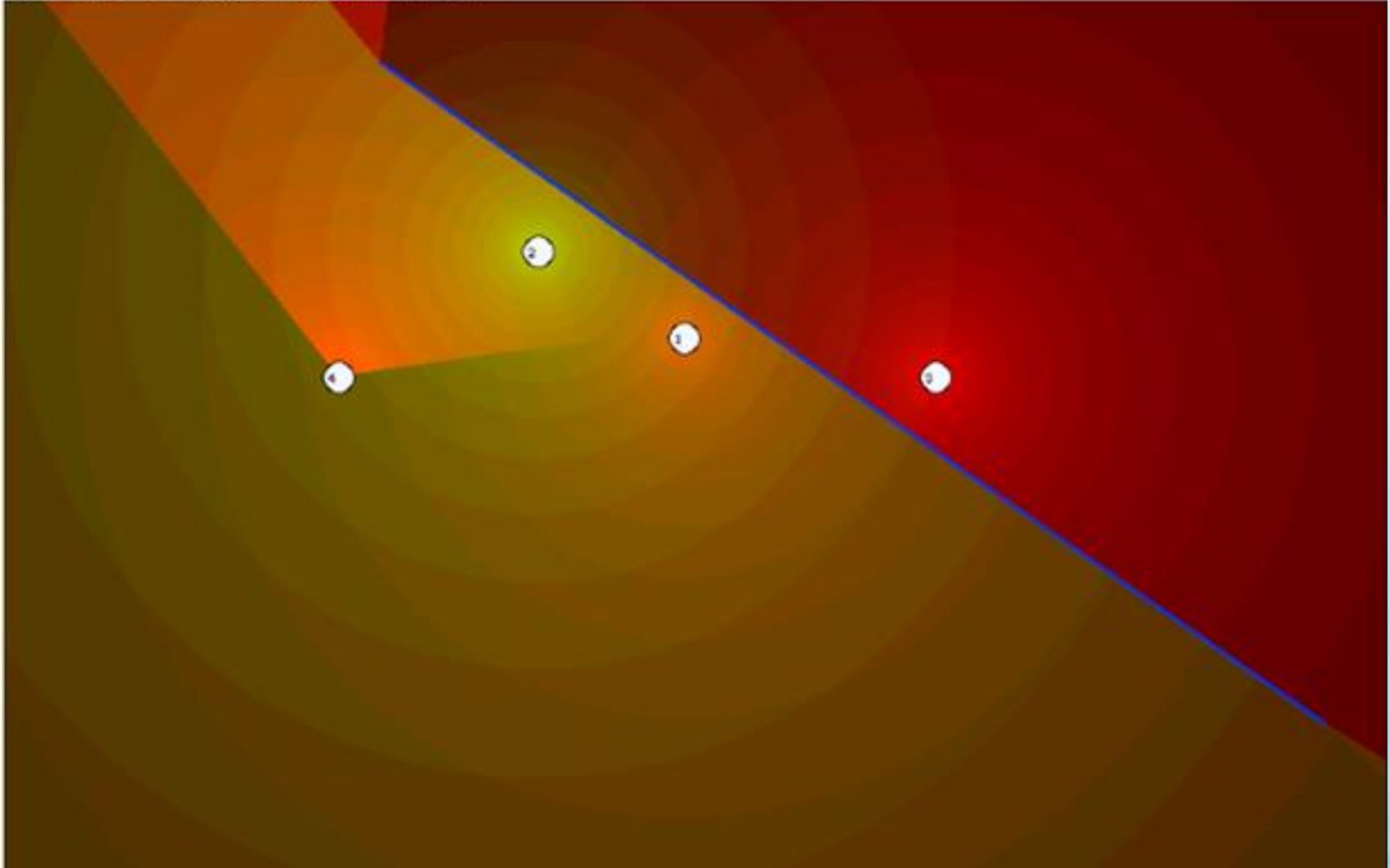
Example: a building

Minimum signal level is set to -94dBm

Simulation includes walls and windows

Punctual 2G/5G levels can be read on Mousemove

Color change Level set to 5Db

A look outside the building

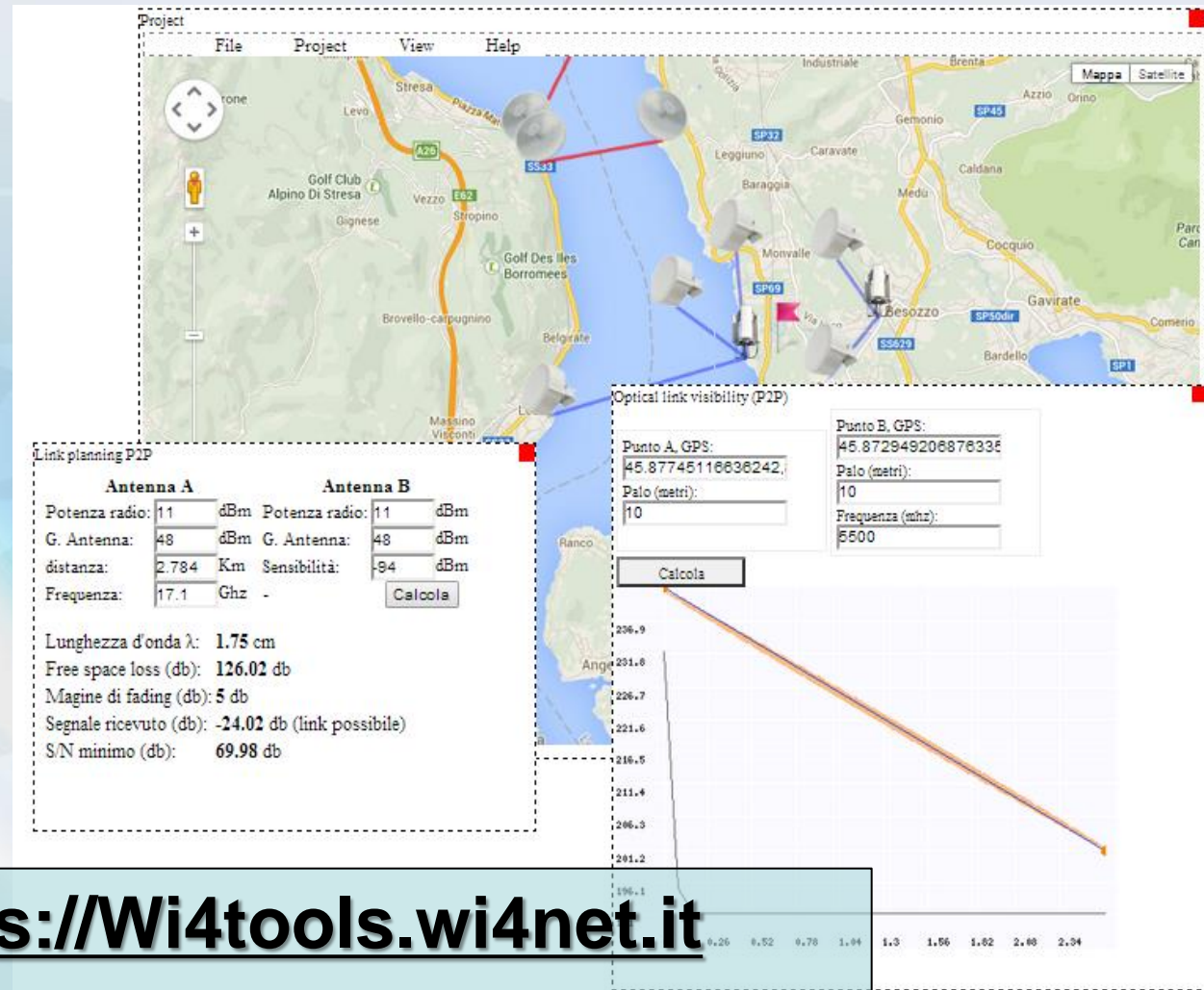## Minimum level raised to -120Dbm, reversed colors

2G: -110, 5G:-95

5 APs: 1: 5ghz spot 2: 2ghz spot 3: 5ghz spot3 4: 5ghz sector 5: 5ghz spot2
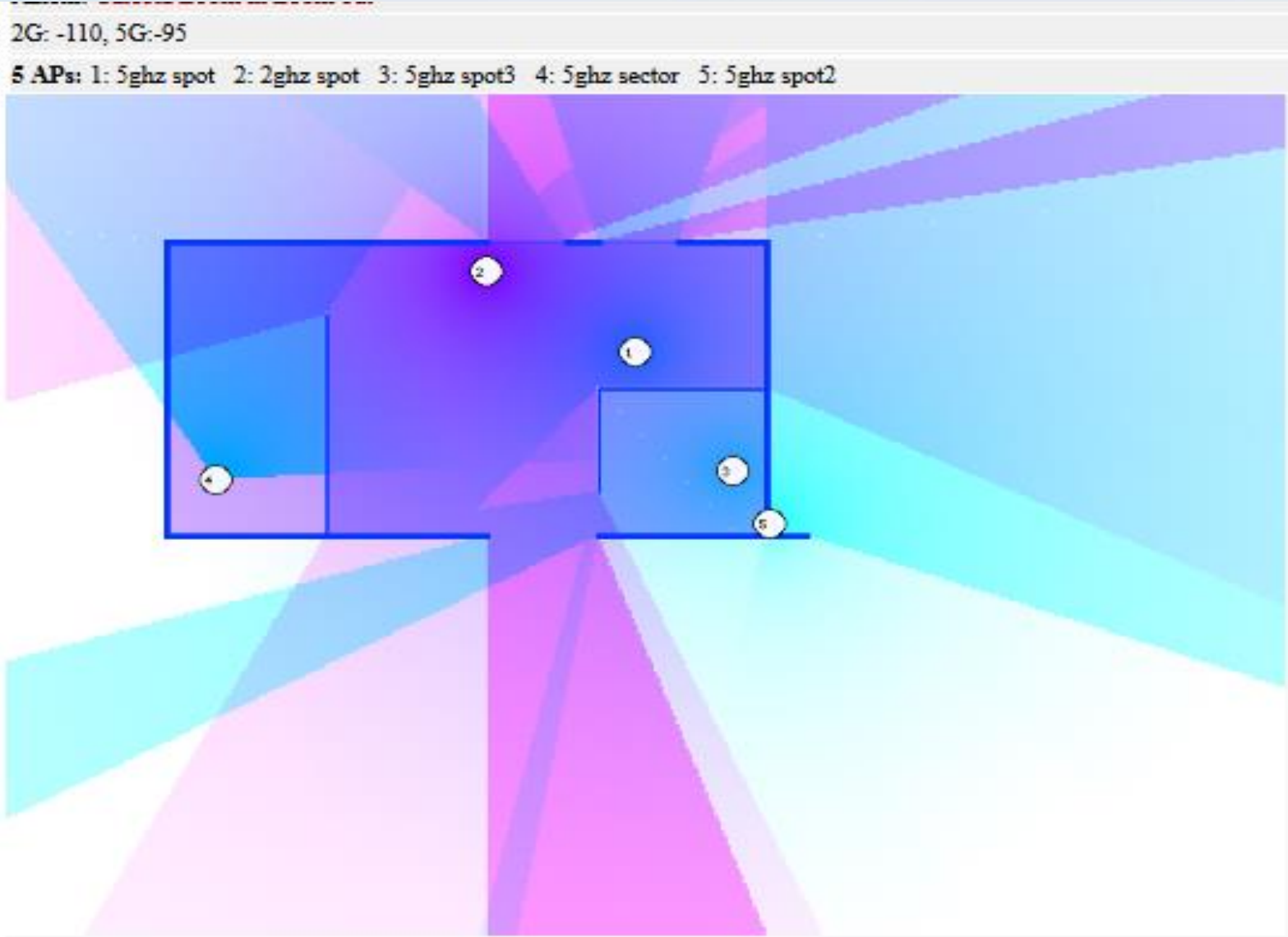
Outdoor link planning

For outdoor planning you need:

- Optical visibility check

- Link signal planning

- Editable maps to dinamically test sites for antennas

Try online our **free** planning tools.

https://Wi4tools.wi4net.it

Thanks for your attention !

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