„WiFi Power vs Sensitivity and EM wave propagation complexity "

Peter Zalar, Advant d.o.o., Slovenia

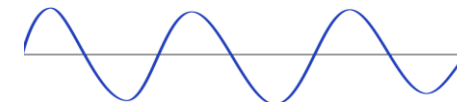Enterprise design&troubleshoot engineer, ECSE design, WLA member

Pre – Basics ☺ way of perception

CLI perception

■ DIGITAL focused

Design perception
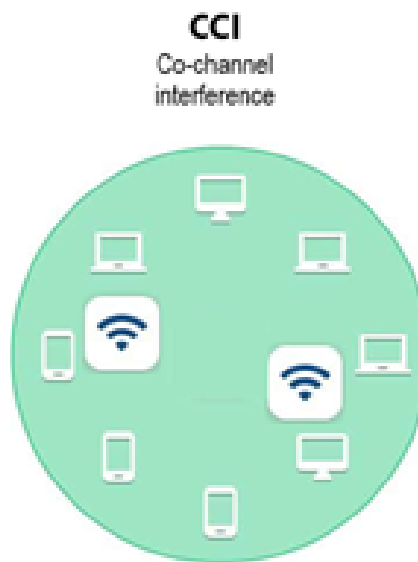

■ ANALOG focused

Basics

Airtime vs. Data rate → → →   Airtime utilization – affects „Free time" by:
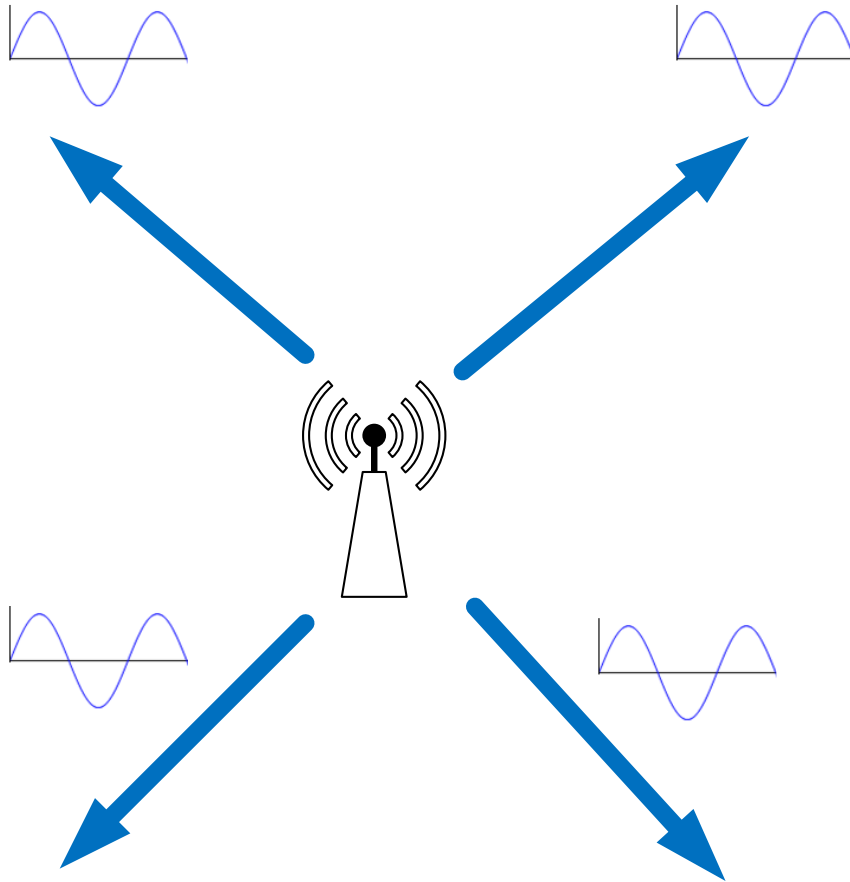

802.11b(11Mb)
802.11n(150Mb)
802.11b(11Mb)
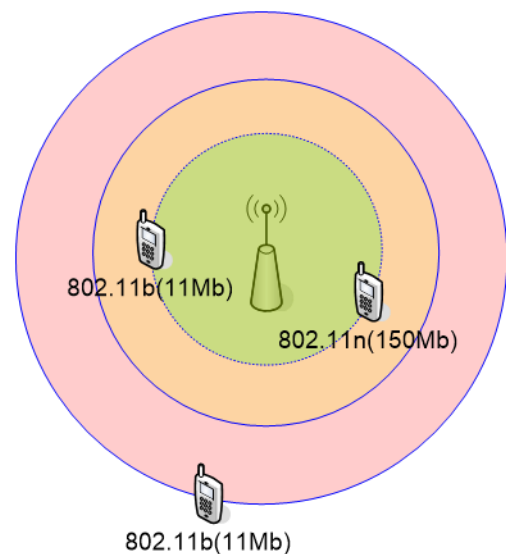
Airtime – „Free time":
- Half Duplex communication
- Speed – not fixed
- DataRate – combined user speeds during „Free time"

CCI
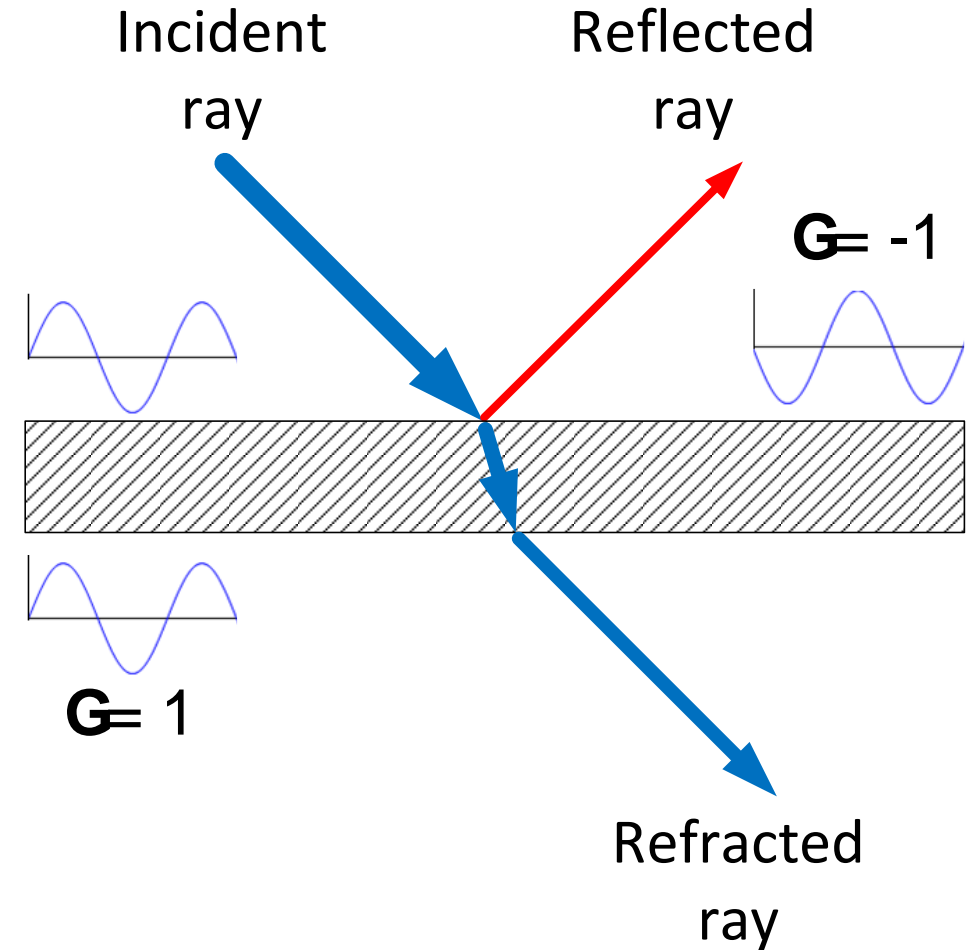Co-channel interference

ACI
Adjacent-channel interference

Non-WiFi
interference

Wireless Phone
Microwave
Analog Camera

EM propagation
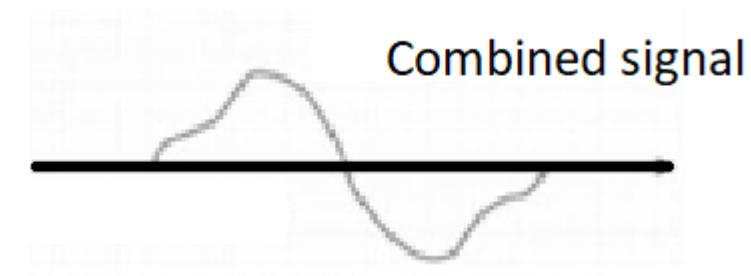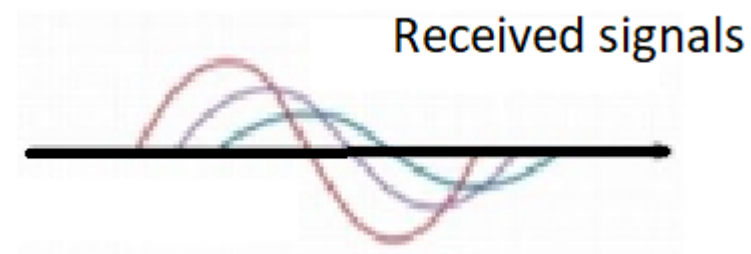
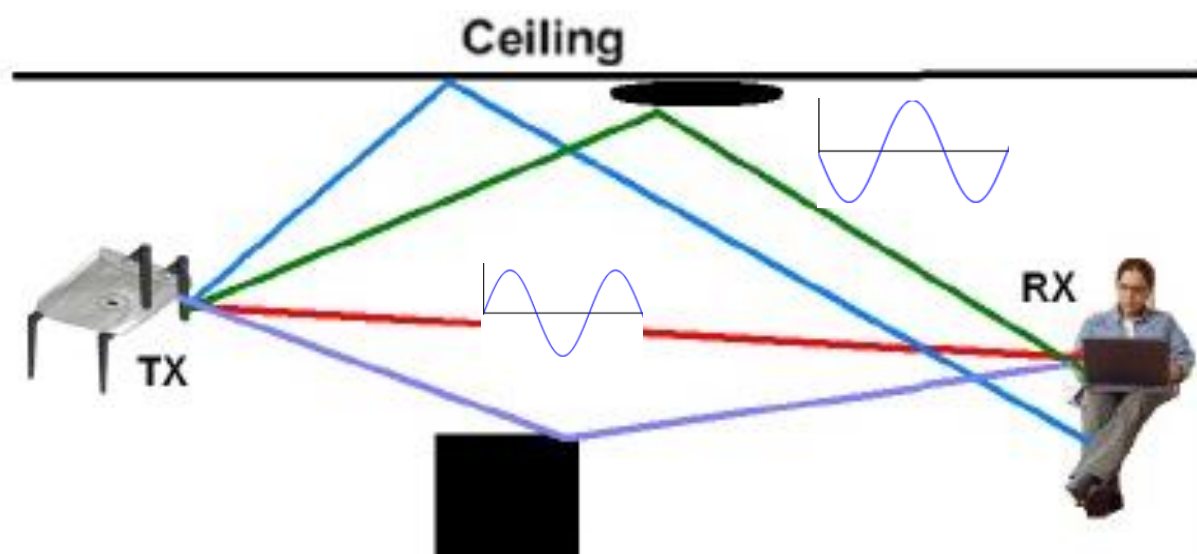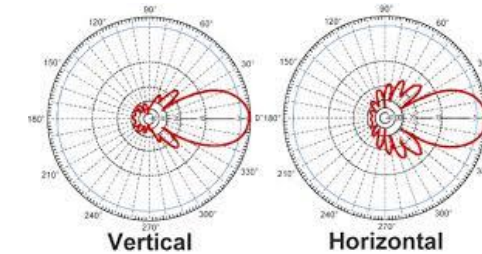## Direct EM wave – same phase

Reflection – opposite phase

Incident ray

Reflected ray

$G = -1$

$G = 1$

Refracted ray

Ceiling

TX

RX

Received signals

Combined signal

1st NO - **EM wave is self destructive by phase and delay – AWAY from walls**
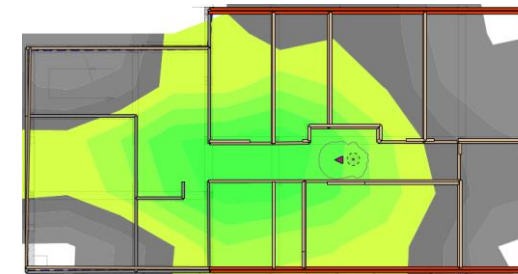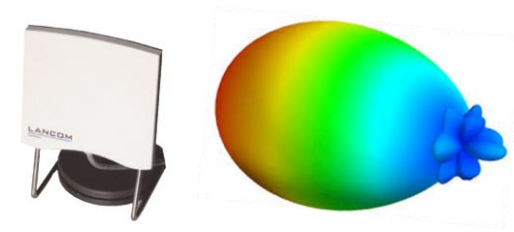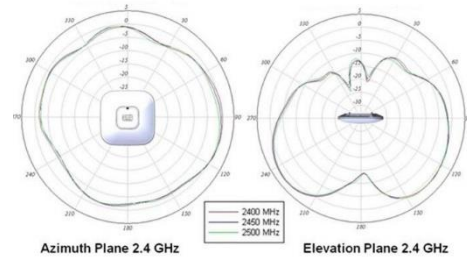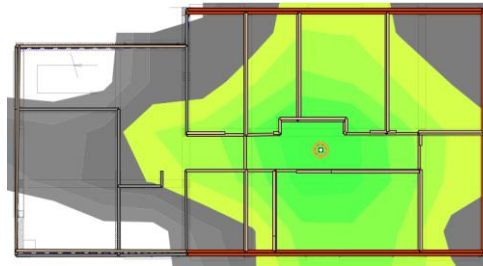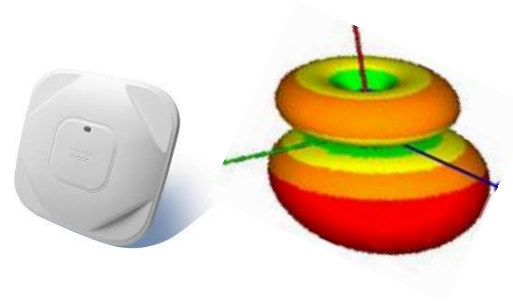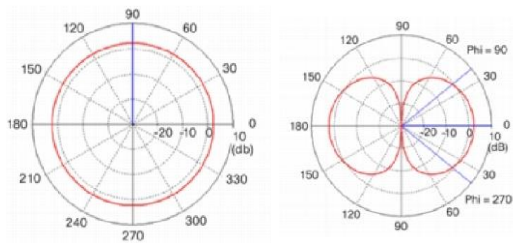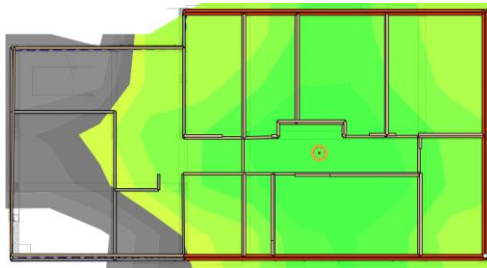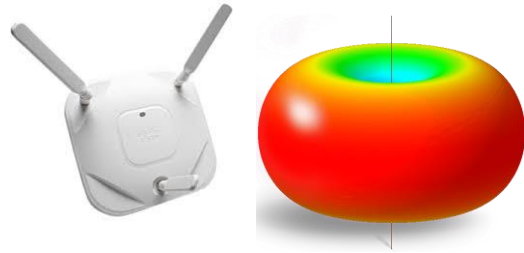
TX-shape = RX-Shape   (for certain frequency)

Spectrum case 1

Same outfit (internal ant) - different vendors

ADVANT
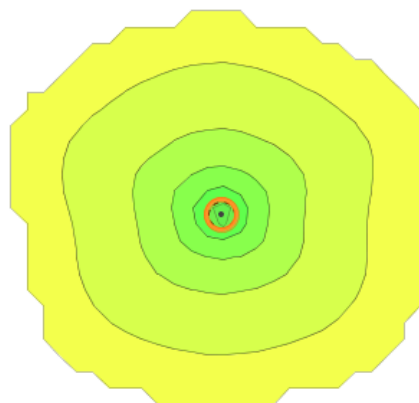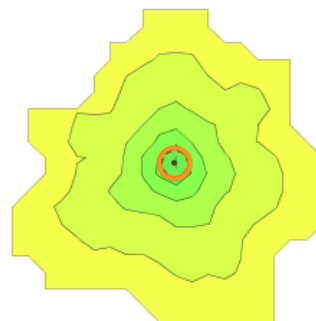
- **2,4 GHz**
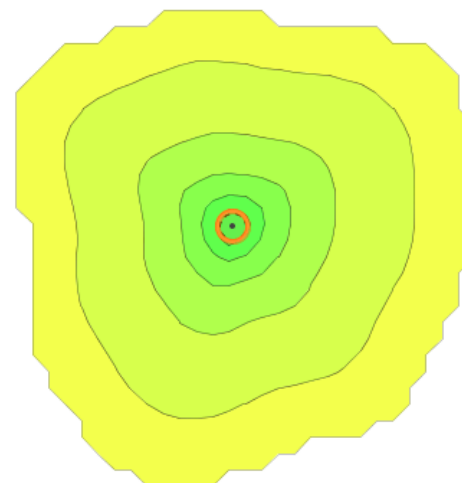
Vendor 1   Vendor 2   Vendor 3

- **5 GHz**
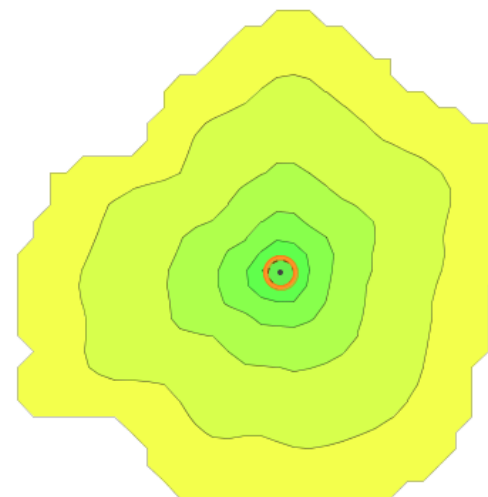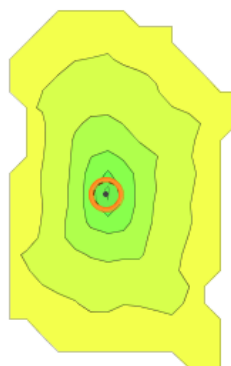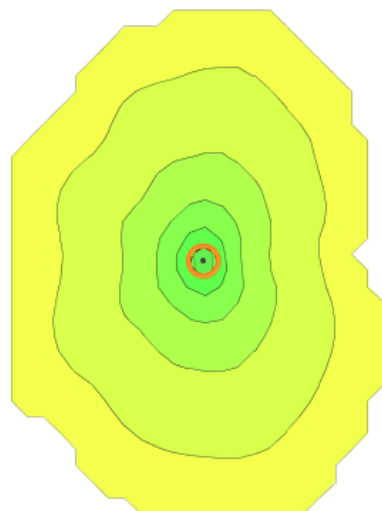
Input:

- Same output power (dBm)
- 2x2 SU-MIMO
- Dual radio

Spectrum case 2 – 2nd NO

Same vendor, same outfit - different product range

- **2,4 GHz**
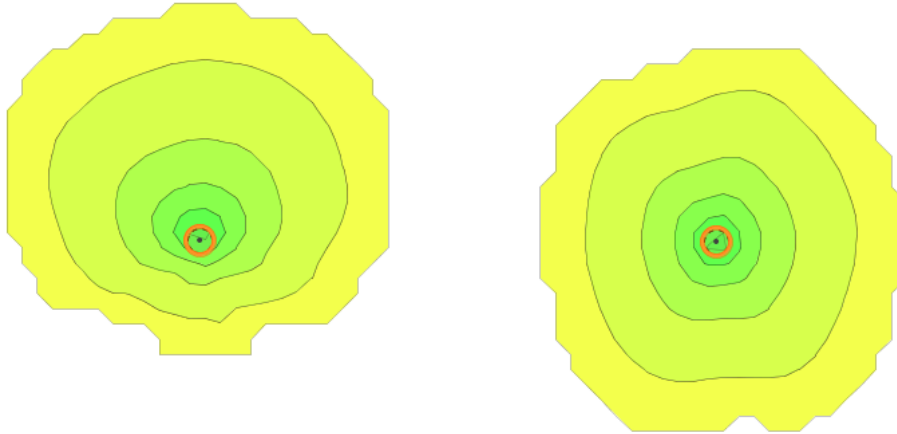
- **5 GHz**
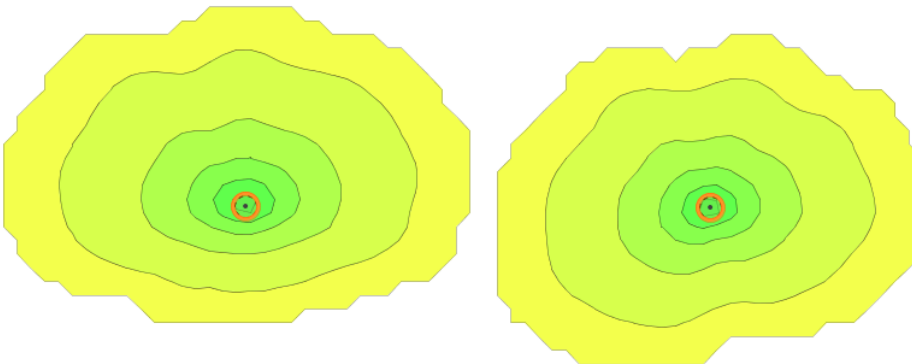
Input:
- Same output power (dBm)
- 2x2 SU-MIMO
- Dual radio

2nd NO - **Design for one PRODUCT can NOT be same for other PRODUCT or VENDOR**

Strength vs Sensitivity – AP to AP – same channel
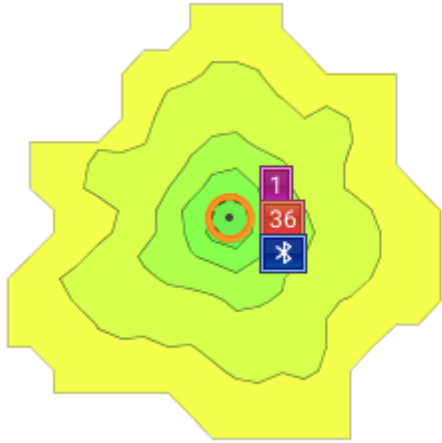
Access Point 1
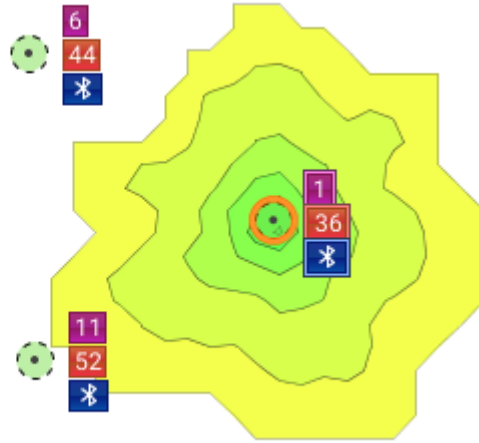
Access point 2

- 2 AP's are on same channel 1 – others are using different channel (6 and 11)

Question: Is it OK?

Strength vs Sensitivity – AP to AP – same channel

Access Point 1   **Access point 2**
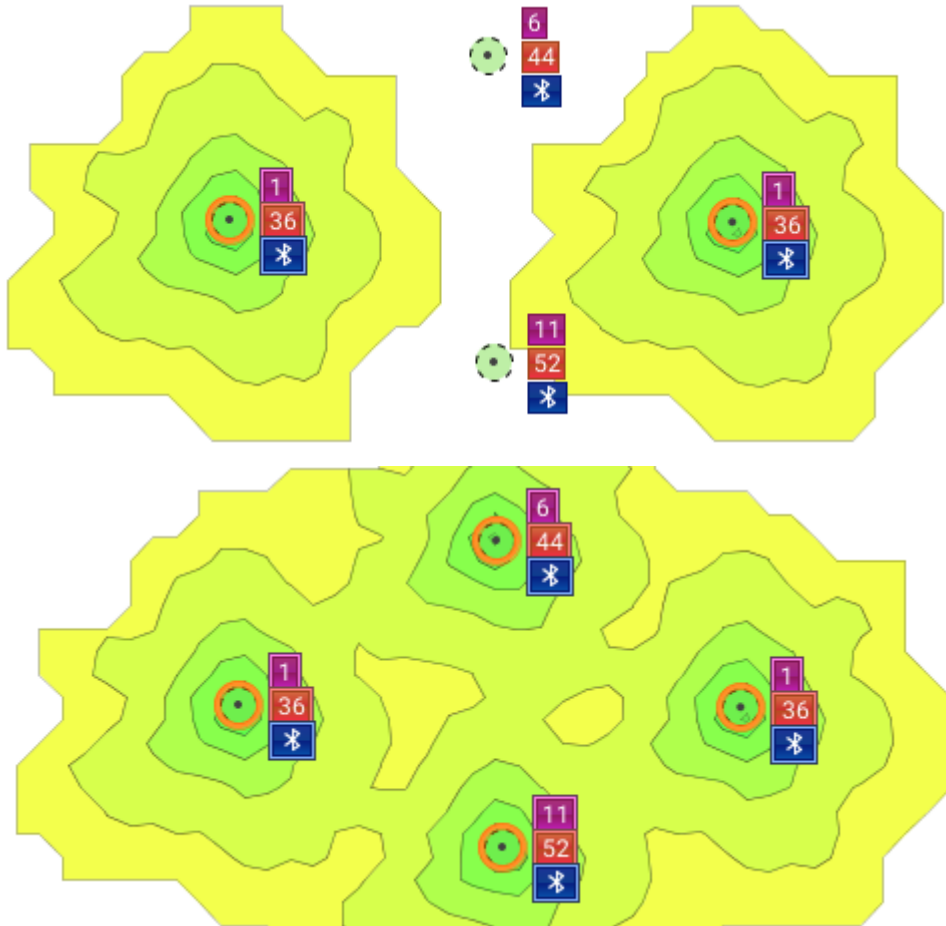
- 2 AP's are on same channel 1 – others are using different channel (6 and 11)

Question: Is it OK?

It is OK for users and capacity BUT……

Strength vs Sensitivity – AP to AP ……..

ADVANT
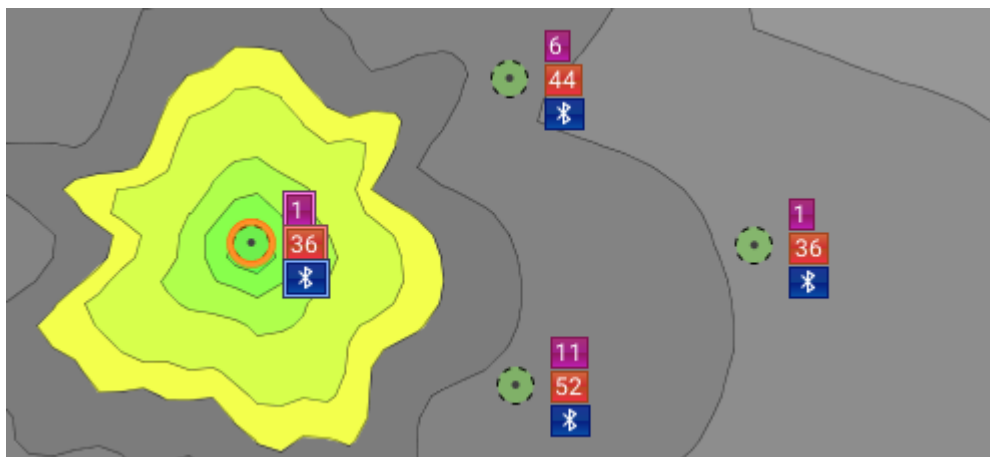
- Other AP is in range of BPSK (lowest Auth basic speed rate) – for BSS/BSSID basic service set identifier
- Every SSID is advertised 10x per second
- **SOLUTION – LOWER STRENGTH**

BSS=1Mb, SSID=5, CCI=1-3
Airtime LOSS - Overhead- EXAMPLE

Number of APs on Channel*	Number of SSIDs									
	1	2	3	4	5	6	7	8	9	10
1	3,38%	6,76%	10,14%	13,52%	16,90%	20,29%	23,67%	27,05%	30,43%	33,81%
2	6,76%	13,52%	20,29%	27,05%	33,81%	40,57%	47,33%	54,09%	60,86%	67,62%
3	10,14%	20,29%	30,43%	40,57%	50,71%	60,86%	71,00%	81,14%	91,28%	100,00%

BSS=2Mb, SSID=5, CCI=1-3
Airtime LOSS - Overhead- EXAMPLE

| Number of APs on Channel*	Number of SSIDs									
	1	2	3	4	5	6	7	8	9	10
1	0,58%	1,16%	1,74%	2,32%	2,90%	3,47%	4,05%	4,63%	5,21%	5,79%
2	1,16%	2,32%	3,47%	4,63%	5,79%	6,95%	8,11%	9,27%	10,42%	11,58%
3	1,74%	3,47%	5,21%	6,95%	8,69%	10,42%	12,16%	13,90%	15,64%	17,37%

- Comment:

2xAP with 5 SSID's make „noise"/Airtime loss to each other 10 times

*Source:
Andrew von Nagy*

Strength vs Sensitivity – AP to User
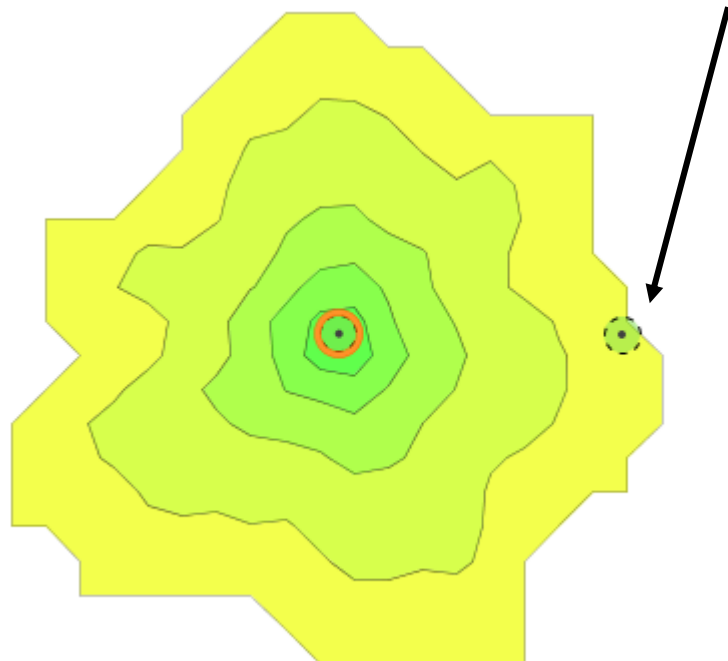
Access Point

User

- User is in a range of AP's for good connection speed

Question: Is it OK?

Strength vs Sensitivity – AP to User
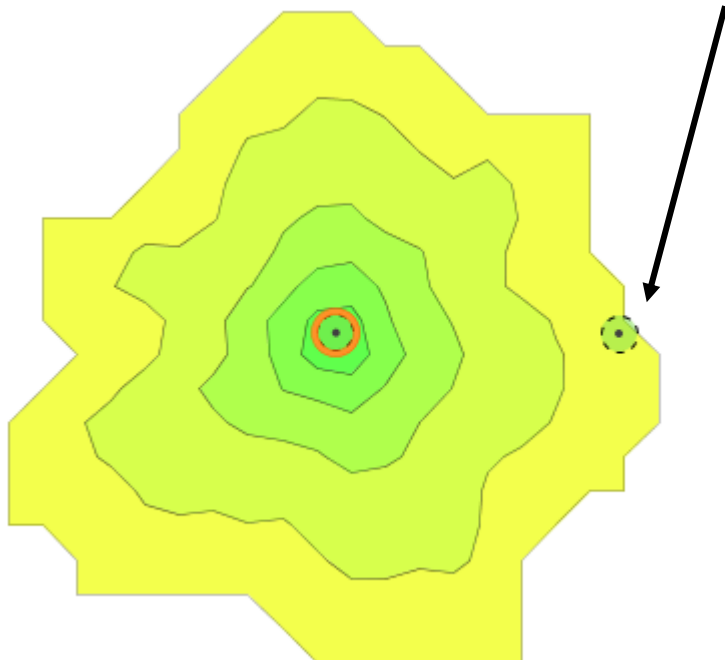
Access Point

User

- ■ User is in a range of AP's for good connection speed
Question: Is it OK?

- ■ YES, but they are in a range to authenticate only.

- ■ **Good enough?**

Strength vs Sensitivity – AP to User
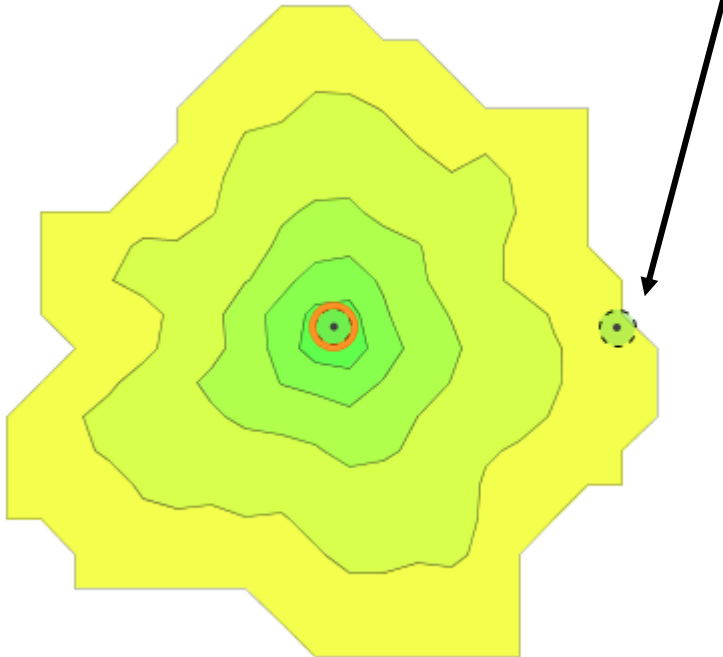
Access Point   User

- User is in a range of AP's for good connection speed

Question: Is it OK?
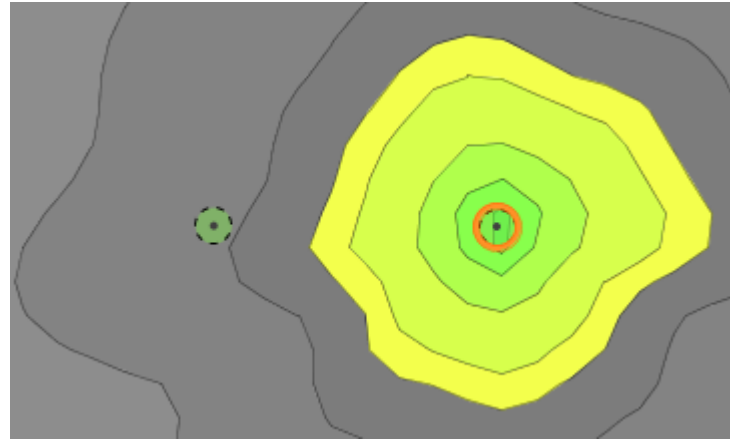
- YES, but they are in a range to authenticate only.

- **Good enough?**
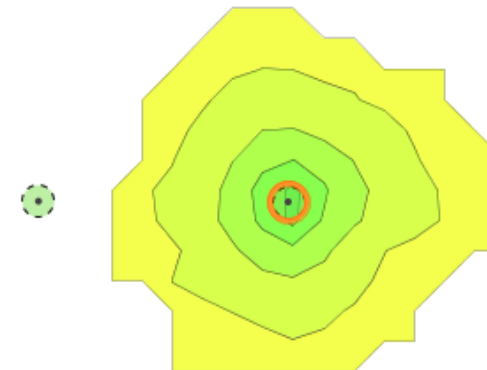
- No, it is not,
- There will be slow connection speed

User should come closer

Strength vs Sensitivity – AP to User **RSSI**

ADVANT

Access Point   User

- YES, but they are in a range to authenticate only.

- **Good enough?**

- No, it is not,
- There will be slow connection speed
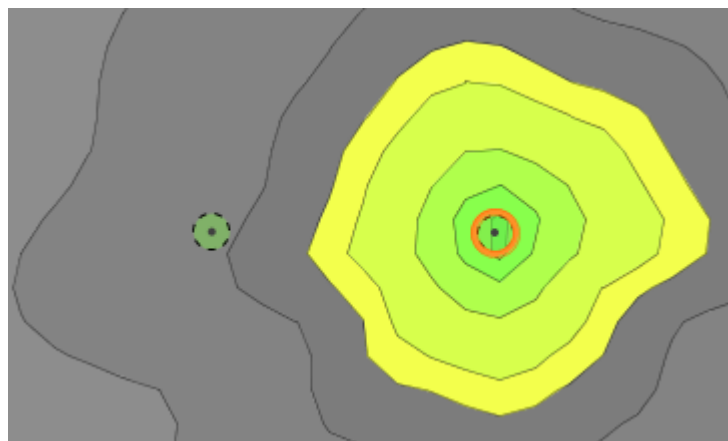
- User is in a range of AP's for good connection speed
Question: Is it OK?
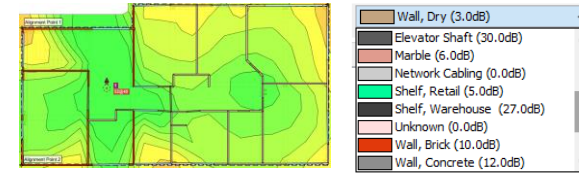
User should come closer

RSSI received signal strength indicator is a measurement of the power present in a received radio signal – CONNECTION SPEED ESTABLISHES ACCORDING TO LOWER RSSI

Design - types

A. Predictive SiteSurvey Design with SW standard walls and oobstacles – SIMULATION + „AP on a Stick"

B. Predictive SiteSurvey - MEASURED walls and obstacles – SIMULATION calls 95%
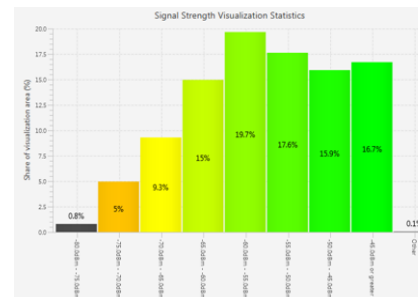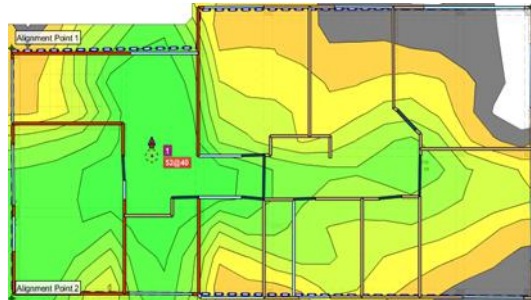
	Klet	Pritličje	1N	2N	Povprečje pokritosti
> −40 dBm	3,1 %	0,0 %	0,1 %	3,0 %	1,55 %
−45 dBm	14,4 %	44,6 %	16,6 %	17,7 %	23,33 %
−50 dBm	10,8 %	10,8 %	15,9 %	11,0 %	12,13 %
−55 dBm	15,4 %	19,1 %	17,6 %	8,9 %	15,25 %
−60 dBm	30,1 %	8,4 %	19,7 %	10,6 %	17,20 %
−65 dBm	15,3 %	8,2 %	15,0 %	11,8 %	12,58 %
−70 dBm	2,6 %	7,2 %	9,3 %	15,9 %	8,75 %
−75 dBm	4,2 %	1,7 %	5,0 %	12,3 %	5,80 %
<−80 dBm	4,1 %	0,0 %	0,8 %	8,8 %	3,43 %
Seštevek	100,0 %	100,0 %	100,0 %	100,0 %	100,0 %

- Enables design of non existing buildings – future design

C. Real SiteSurvey

- Design combined with „AP on a Stick" or
- Final check of implemented WiFi
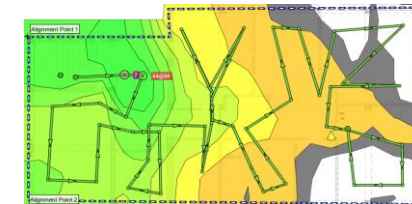
Case 1 – Connection speed (MCS Index)

- AP – 5 GHz, 3x3 SU-MIMO, max 1300Mbps@80MHz (SGI), SNR min 37dB, RSSI min -51dB

- SP – 5GHz, 2x2 SU-MIMO, max 400Mbps@40MHz (SGI), SNR min 34dB, RSSI min -54dB

60 Mbps, -73 dB   **162 Mbps, -68 dB**   **270 Mbps, -57 dB**   **400 Mbps, -42 dB**
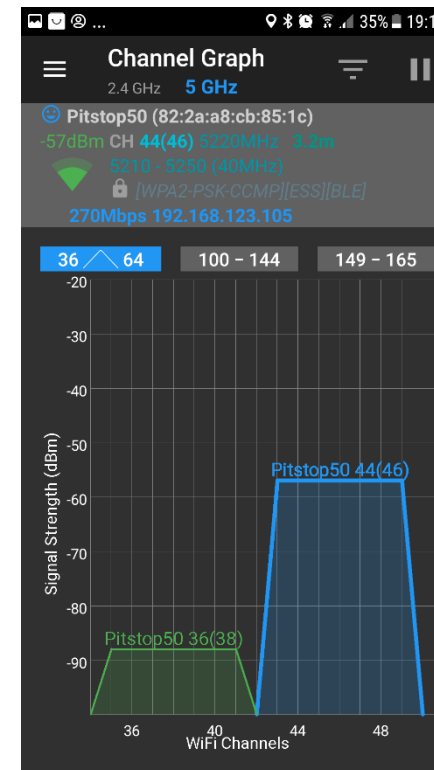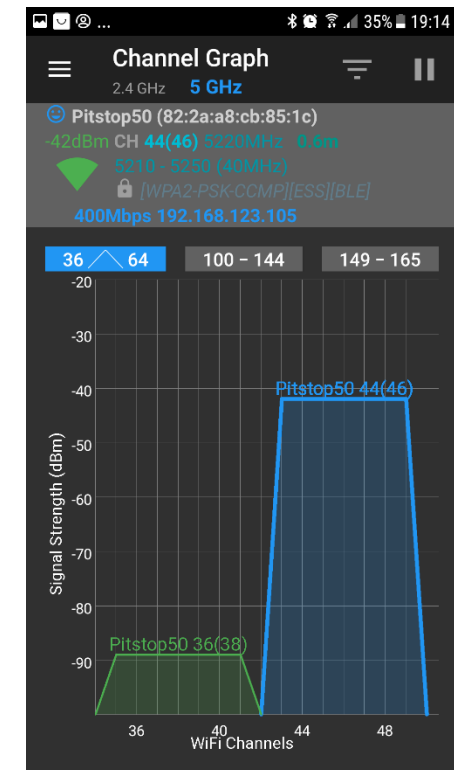
Case 2: Library – new building – PSS+RSS – NO USEFUL SIGNAL OUTSIDE OF THE BUILDING

4. RSS proved design up to 95%

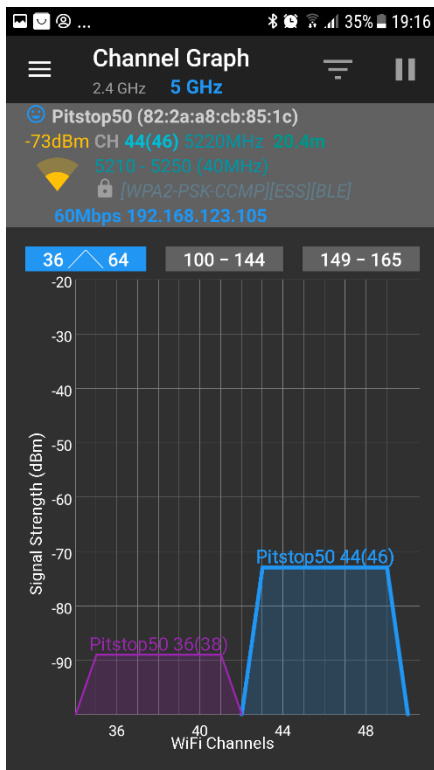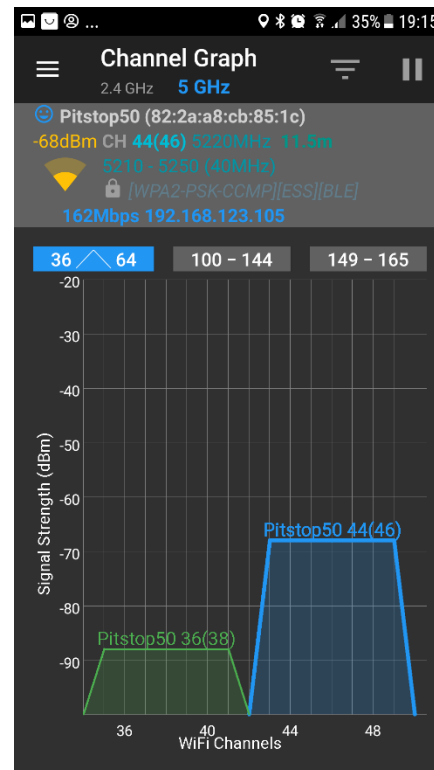Signal Strength Visualization Statistics
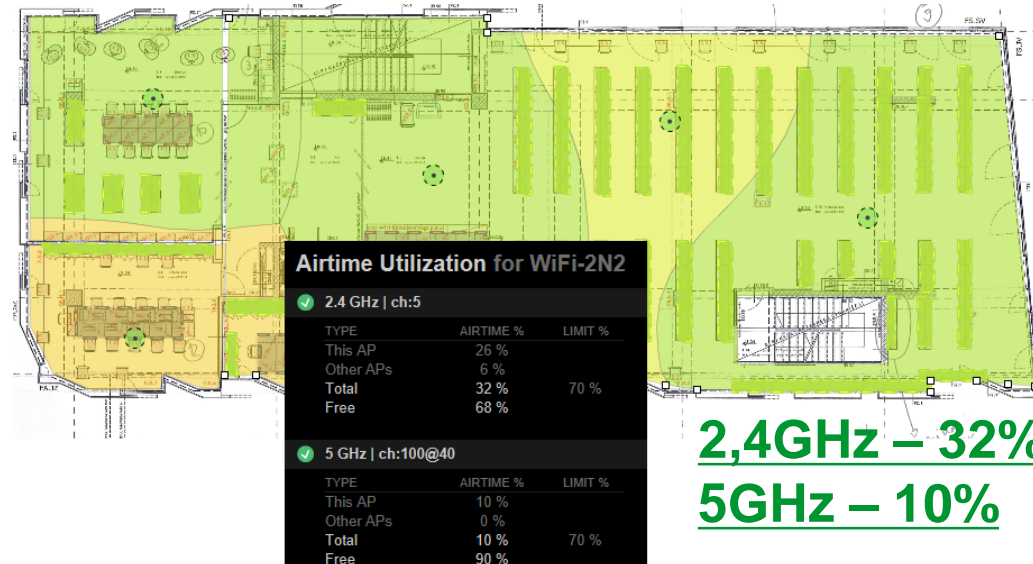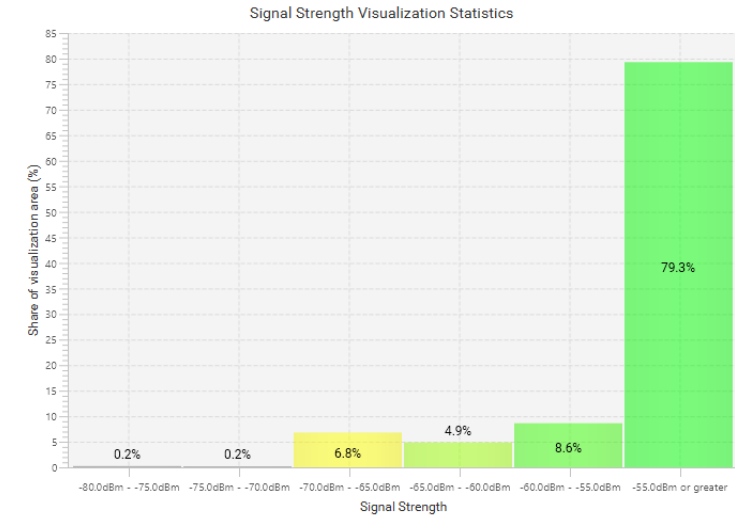
Capacity? Est. 120 devices

Airtime Utilization for WiFi-2N2

2.4 GHz | ch:5

TYPE	AIRTIME %	LIMIT %
This AP	26 %	
Other APs	6 %	
Total	32 %	70 %
Free	68 %	

5 GHz | ch:100@40

TYPE	AIRTIME %	LIMIT %
This AP	10 %	
Other APs	0 %	
Total	10 %	70 %
Free	90 %	

2,4GHz – 32%
5GHz – 10%

NOTE: SW predicted (AUTO) 31xAP,
Realized with 24xAP – WiFi office

Case – Library – new building – PSS+RSS

After

3. **PSS** - **MEASURED** obstacles like cupboards, book shelves...

MEASURED book shelf
(in old library ☺)

NEW challenge
AP's are visibly densed
(Airtime utilization - CCI)

Case 3: "HOSTILE ENVIROMENT"

Case – Hotel class Superior – existing building - RSS

Neigbouring

AP's 116x

1. **Existing Ruckus WiFi coverage influenced by Power Mng, user experience bad because of CCI/ACI and re-channel . No PSS.**
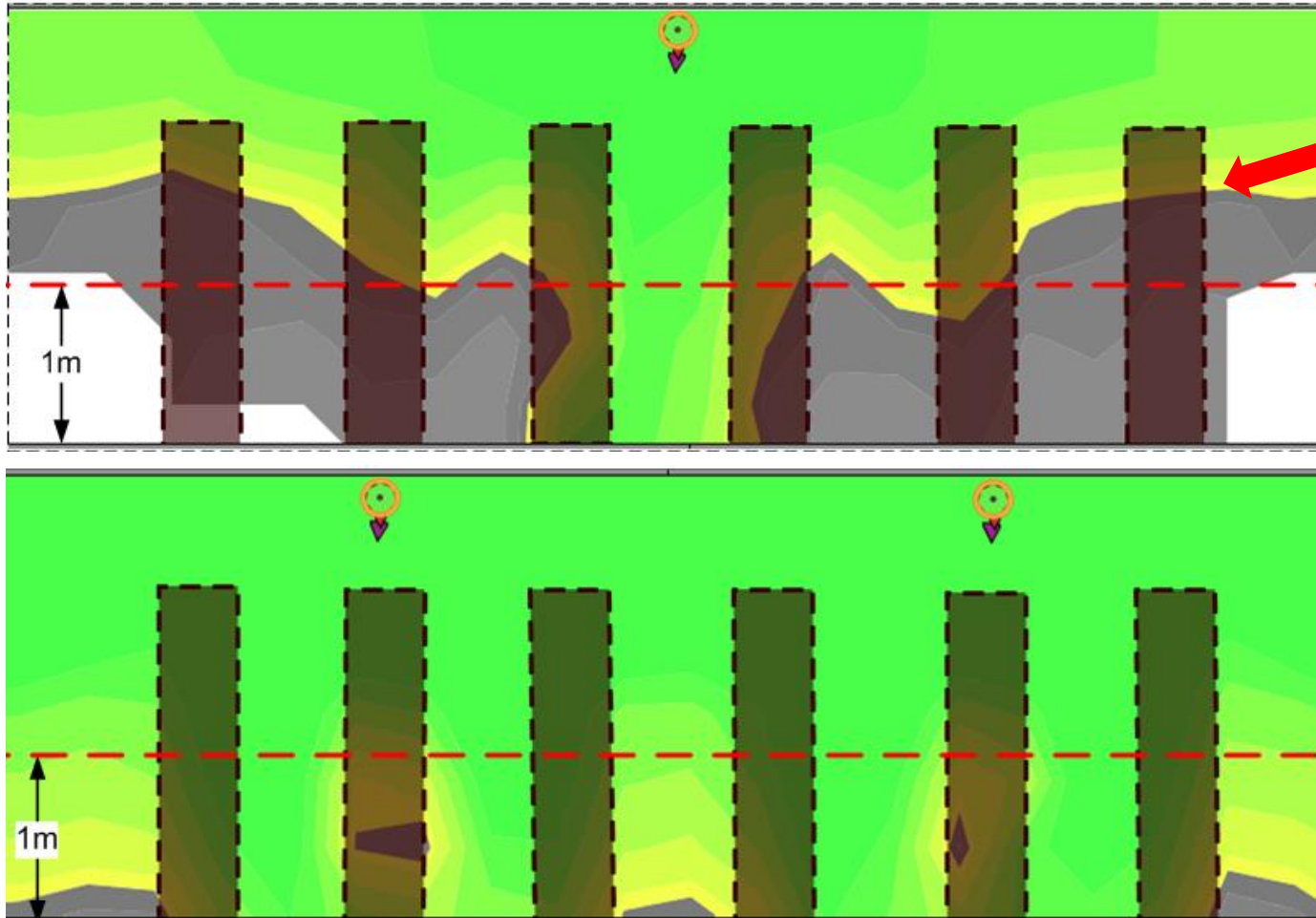
2. **Started to be replaced by Ubiquity. No PSS. „AP on a stick" & 20m**

3. **Optimized by design – some AP's off . Optimized by CLI – full power and no auto re-channel (picture)**

4. **Future plan – MEASURED design**
   - **old AP's kept in sauna, cellar, kitchen**
   - **new AC added**

Airtime utilization (coverage, capacity, Co-Channel interference....)

Before

After

Before

	Ruckus ZoneFlex	Ubiquiti UniFi
Basement	0	1
Groundfloor	1	0
1N	3	4
2N	3	2
3N	2	1
4N	2	5
5N	2	2
6N	3	0
Sum	**16**	**15**

After

	Ruckus ZoneFlex	Ubiquiti UniFi
Basement	0	1
Groundfloor	1	0
1N	2	3
2N	3	1
3N	2	0
4N	2	2
5N	2	2
6N	3	0
Sum	**15**	**9**

More is NOT neccessary better!

Questions

Peter Zalar

E-mail: **peter.zalar@advant.si**

THANK YOU
(and thanks to my co-workers)