Mobilný prenos dát v podnikových sieťach - prehľad technológií, návrh a implementácia

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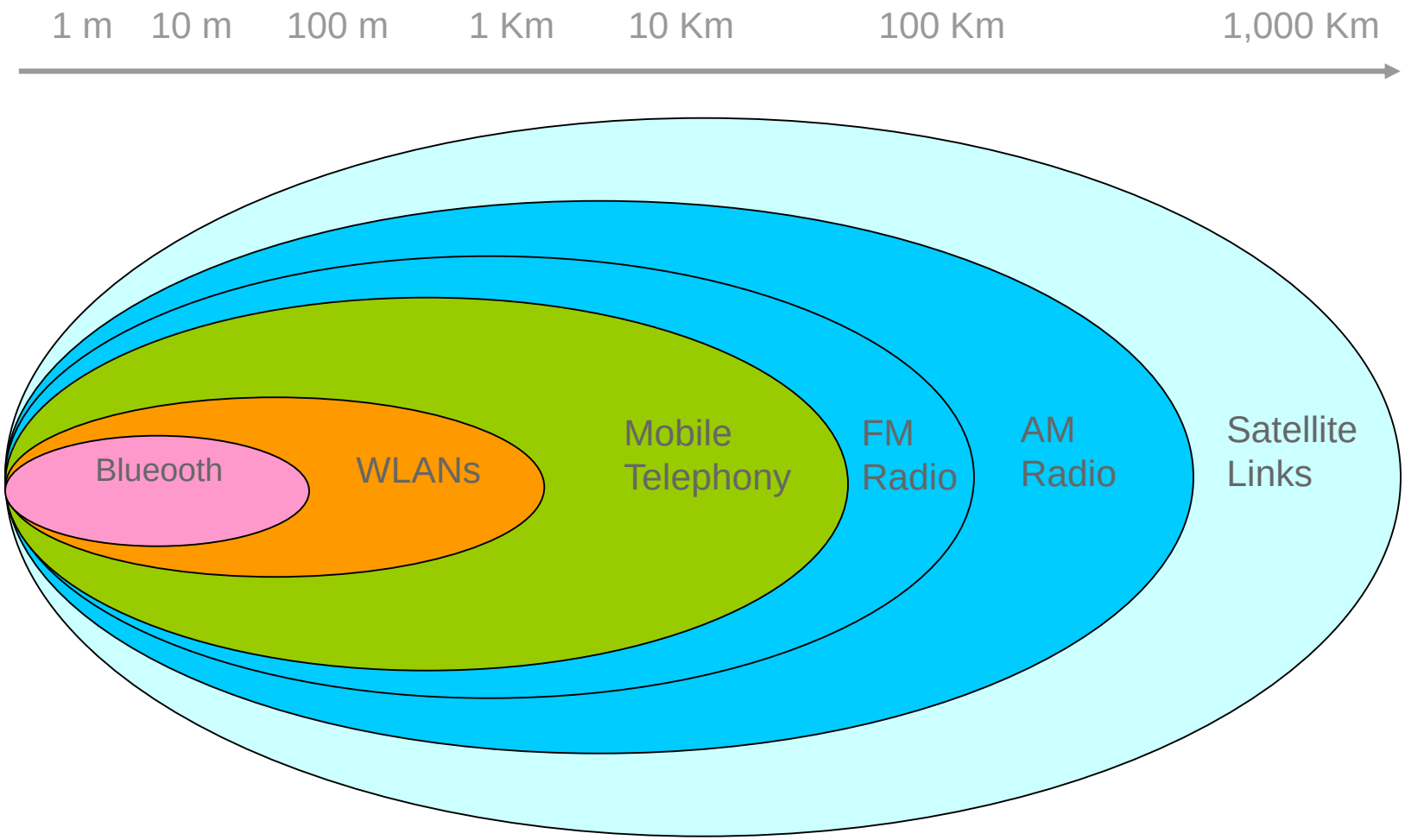
Wireless Systems: Range Comparison

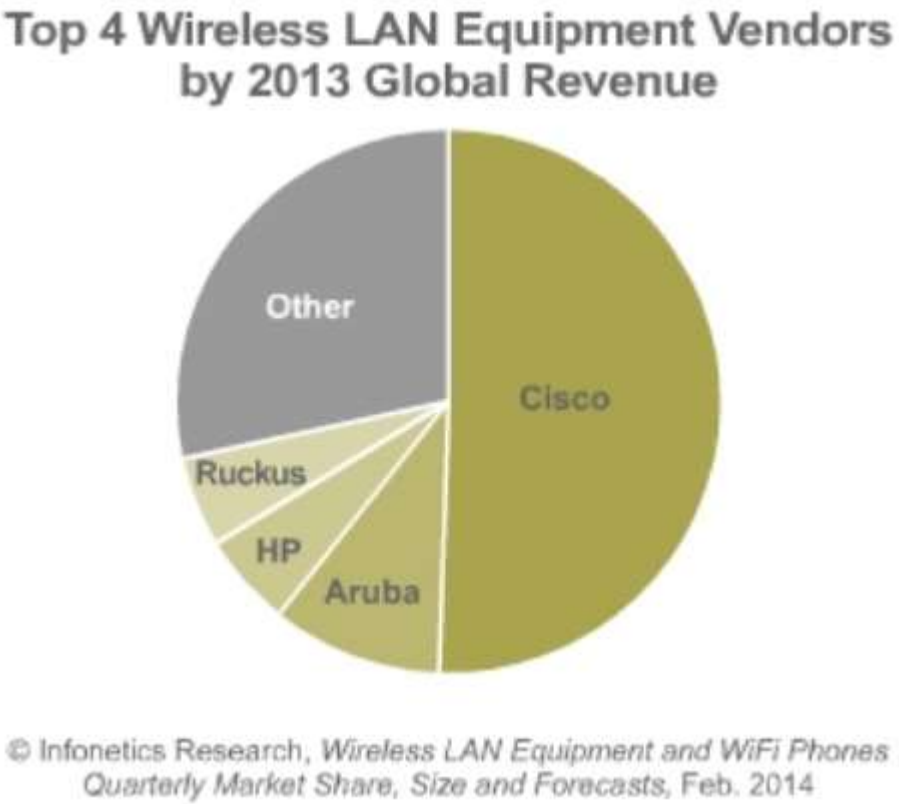


WiFi Alliance

Formed in 1999

Founding Companies:

- 3Com
- Aironet
- Harris Semi Conductor
- Lucent
- Symbol Technologies
- Nokia



802.11 Is Evolving to Meet the Challenge

Standard	Year Ratified	Frequency Band	Modulation	Channel Bandwidth	Max. Data Rate
802.11b	1999	2.4 GHz	DSSS	22MHz	11 Mbps
802.11a	1999	5 GHz	OFDM	20 MHz	54 Mbps
802.11g	2003	2.4 GHz	OFDM	20 MHz	54 Mbps
802.11n	2009	2.4/5 GHz	MIMO-OFDM	20,40 MHz	600 Mbps
802.11ac	2013	5 GHz	MIMO-OFDM	20, 40, 80, 160 MHz	6.93 Gbps

The main concept of introducing 802.11ac is to improve the data rates and reduce the latency.

HOW IS THIS ACHIEVED ??

Mandatory 5GHz operation

Wider channels (up to 160 MHz)

More spatial streams (up to 8)

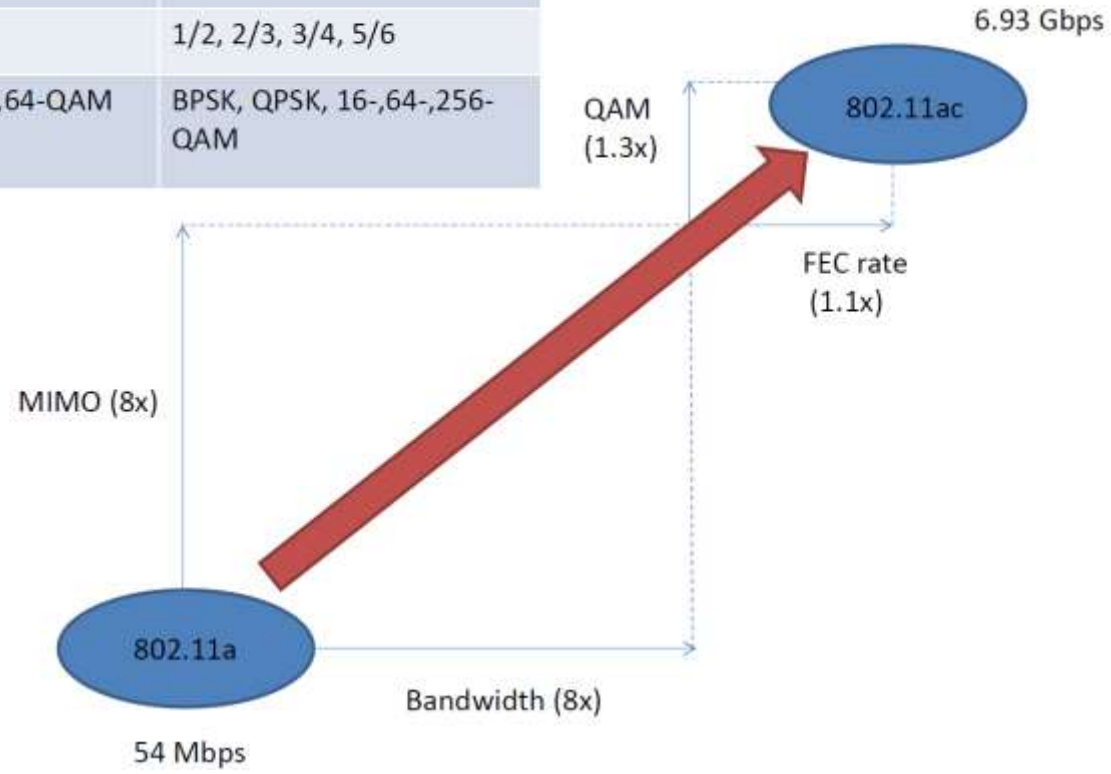
256-QAM modulation

MU-MIMO (Transmit Beamforming)

Backwards Compatibility

802.11 Is Evolving to Meet the Challenge

	802.11a	802.11ac
Modulation	OFDM	MIMO-OFDM
Subcarrier spacing	312.5 KHz	312.5 KHz
Symbol Duration	4 us (800 ns guard interval)	3.6 us (400 ns guard interval)
FFT size	64	64(20 MHz)/512 (160 MHz)
FEC	BCC	BCC or LDPC
Coding rates	1/2, 2/3, 3/4	1/2, 2/3, 3/4, 5/6
QAM	BPSK, QPSK, 16-,64-QAM	BPSK, QPSK, 16-,64-,256-QAM



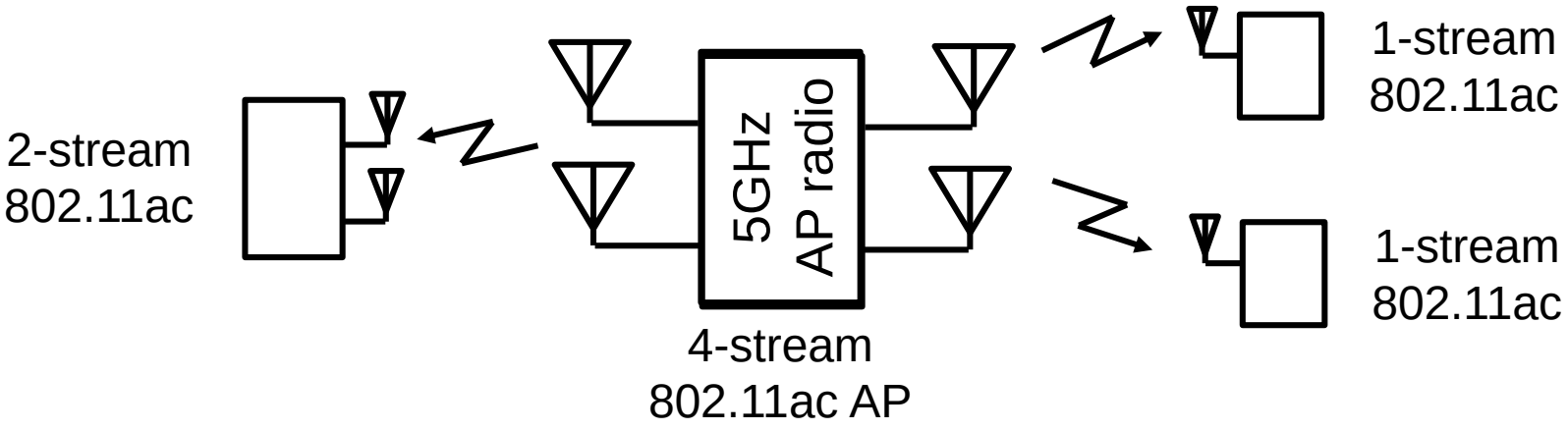
Phases of 802.11ac

Phase 1: Gigabit Speeds (’2013)

- 5GHz only
- Up to 80MHz channels in Phase 1 (160MHz in Phase 2)
- Up to 3 spatial streams in Phase 1 (8 in Phase 2)

Phase 2: Multi-User MIMO (’2014)

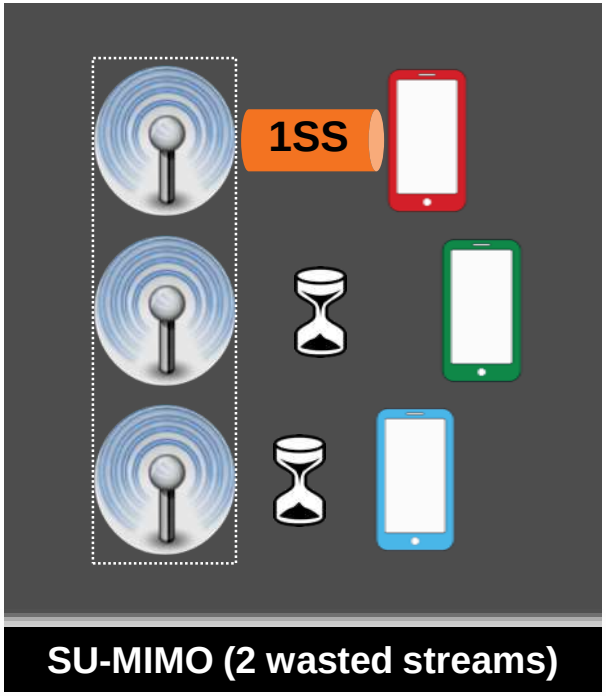
Increased Capacity with simultaneous transmit to multiple receivers



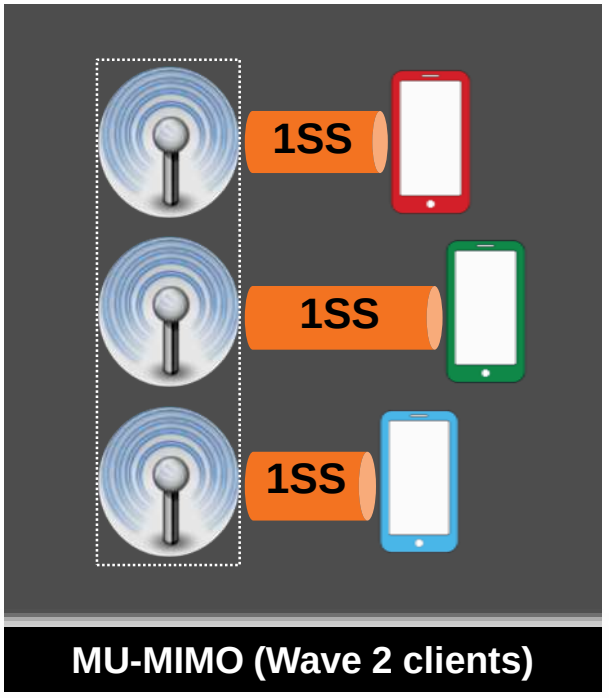
Multi-User MIMO

MU-MIMO is the defining feature for “Wave 2”

- Enables simultaneous transmissions of data from AP to multiple clients (downstream only), optimizing the use of AP resources



SU-MIMO (2 wasted streams)



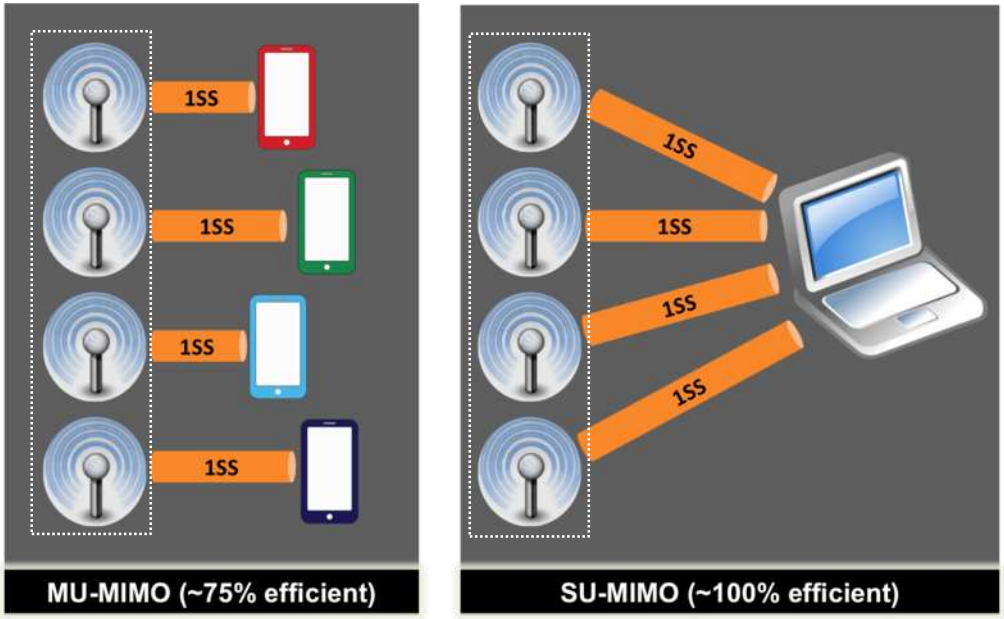
MU-MIMO (Wave 2 clients)

Important: *MU-MIMO needs to be supported by the client as well*

Requires new client hardware (chipset)

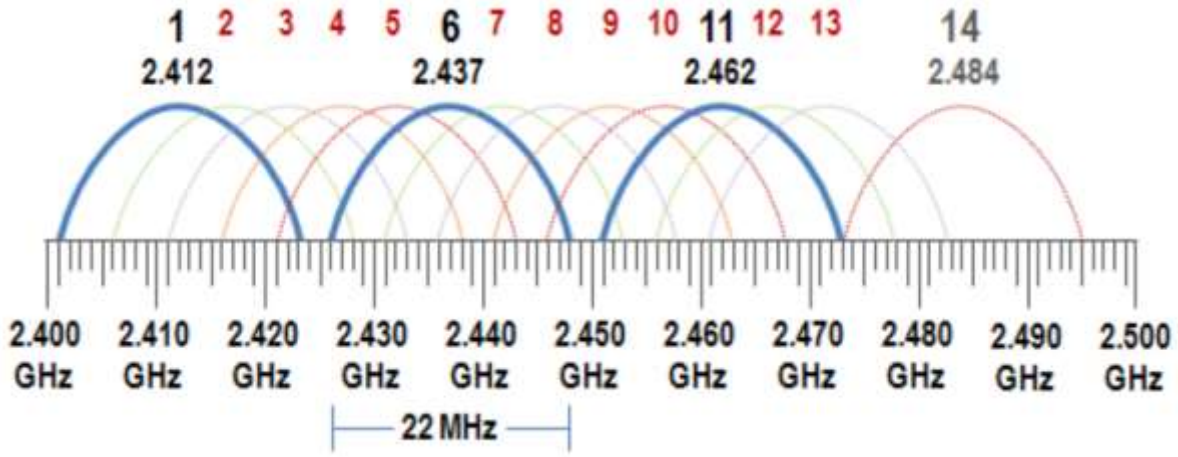
Not yet supported/enabled on most current client devices

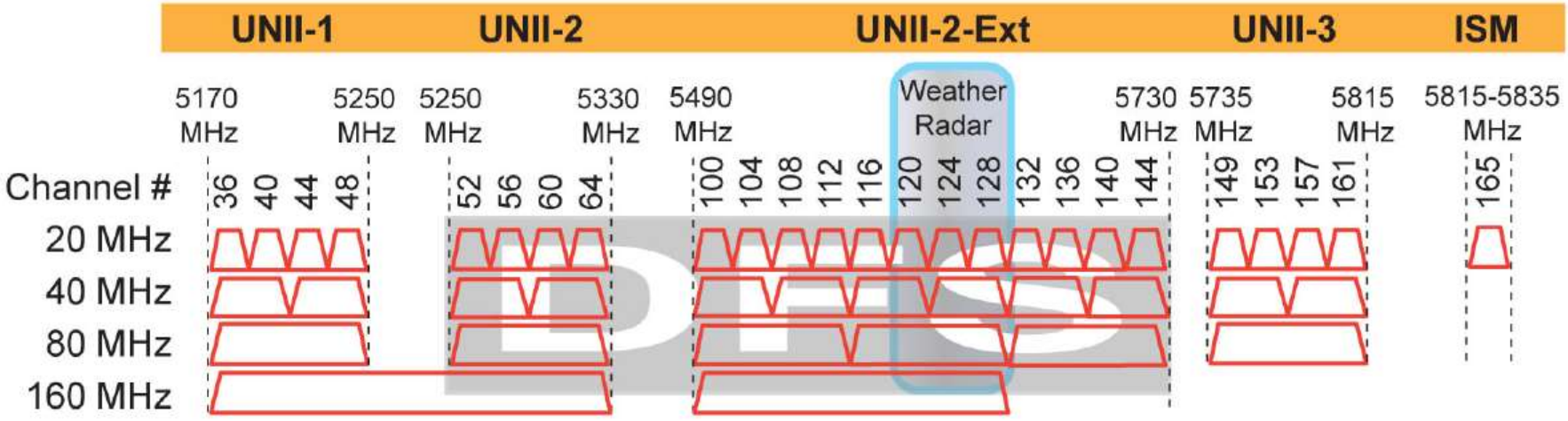
4 Spatial Streams



- Increases throughput by 33% for a single 4SS client with 3SS SU-MIMO
- Leverage with MU-MIMO to enable transmission up to four 1SS clients to maximize throughput
- Optional Wave 2 feature; some implementations

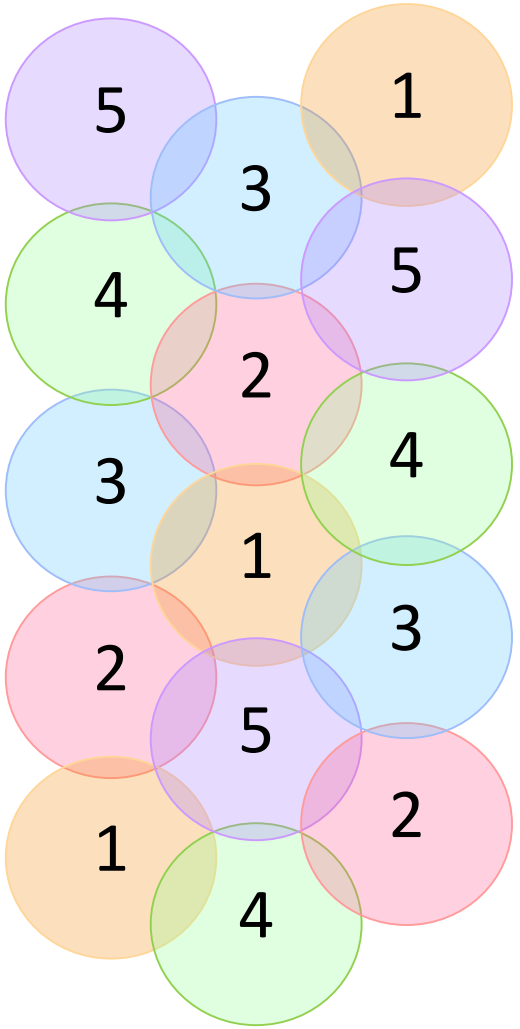
WiFi frekvencie



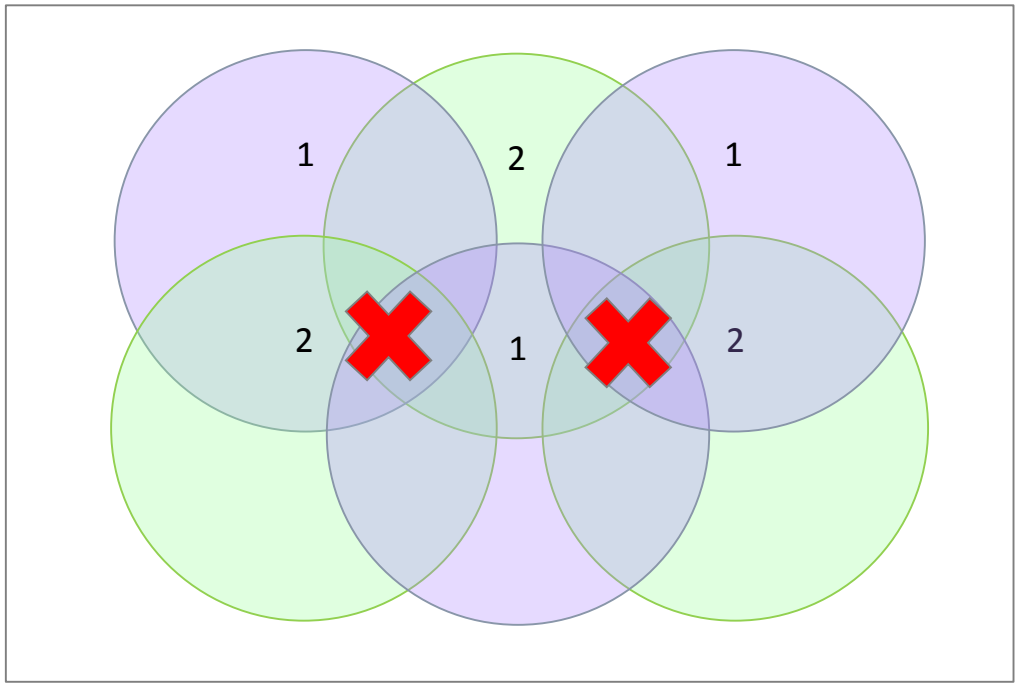


RF Planning Recommendations for Wave 2

- Utilize 80 MHz channels in a 5-channel plan
- Use of *160 MHz* channels for large deployments *not recommended* due to overlap



160 MHz…for the Enterprise or Home?



- There are only two 160 MHz channels available today, and both require DFS
- Vendors may sell you on 160 MHz performance but really can only be deployed for single AP

Lots of Devices Support 802.11ac Wave 1

Over 1.000 devices certified by WiFi Alliance

- Hundreds of phones
- Dozens of tablets

Examples:

- Microsoft Surface Pro 3 (2x2:2)
- MacBook Pro (3x3:3)
- iPhone 6 (1x1:1)
- Galaxy S5 (2x2:2)

802.11ac Data Rates

Theoretical throughput for single Spatial Stream (in Mbps)

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
0	BPSK	1/2	6.5	7.2	13.5	15	29.3	32.5	58.5	65
1	QPSK	1/2	13	14.4	27	30	58.5	65	117	130
2	QPSK	3/4	19	21.7	40.5	45	87.8	97.5	175.5	195
3	16-QAM	1/2	26	28.9	54	60	117	130	234	260
4	16-QAM	3/4	39	43.3	81	90	175.5	195	351	390
5	64-QAM	2/3	52	57.8	108	120	234	260	468	520
6	64-QAM	3/4	58.5	65	121.5	135	263.3	292.5	526.5	585
7	64-QAM	5/6	65	72.2	135	150	292.5	325	585	650
8	256-QAM	3/4	78	86.7	162	180	351	390	702	780
9	256-QAM	5/6	N/A	N/A	180	200	390	433.3	780	866.7

Up to 8 streams, MU-MIMO = 6.77G

The world today: Wi-Fi is a Right!!

Today . . .

Stadiums

Airports

Hotels

Restaurants

Stores

Hospitals

And tomorrow . . .

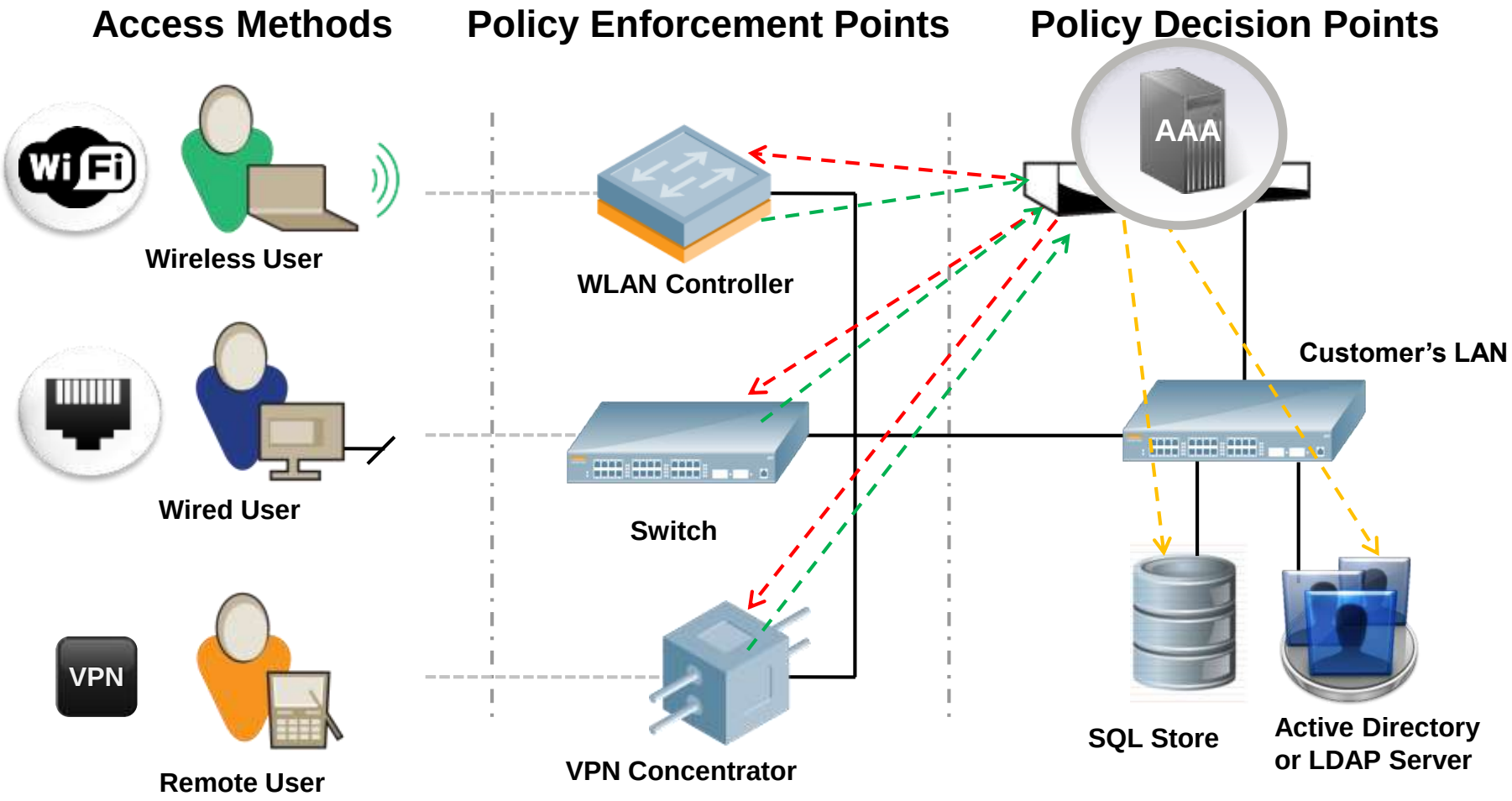
At 35,000 ft

While hitting the slopes

At the beach

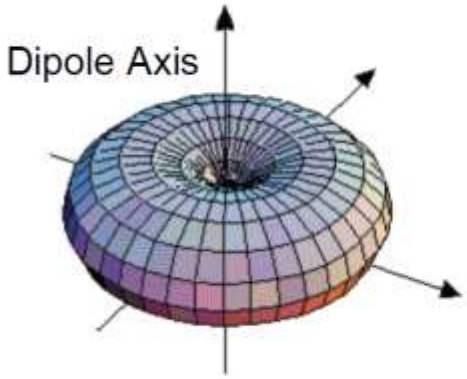
WiFi, controller a anténny

User Authentication

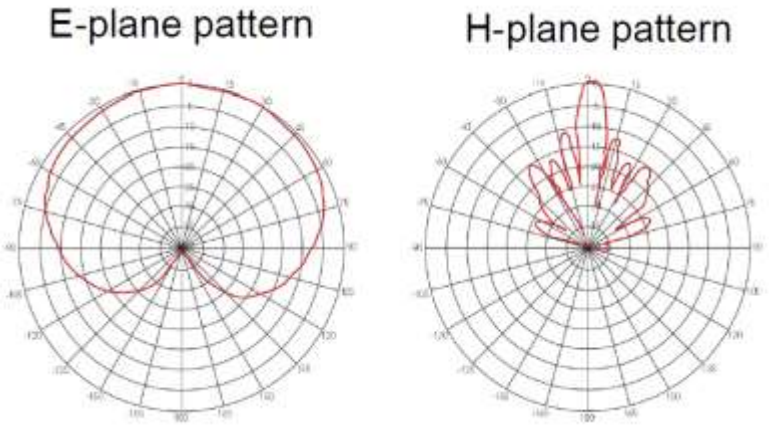


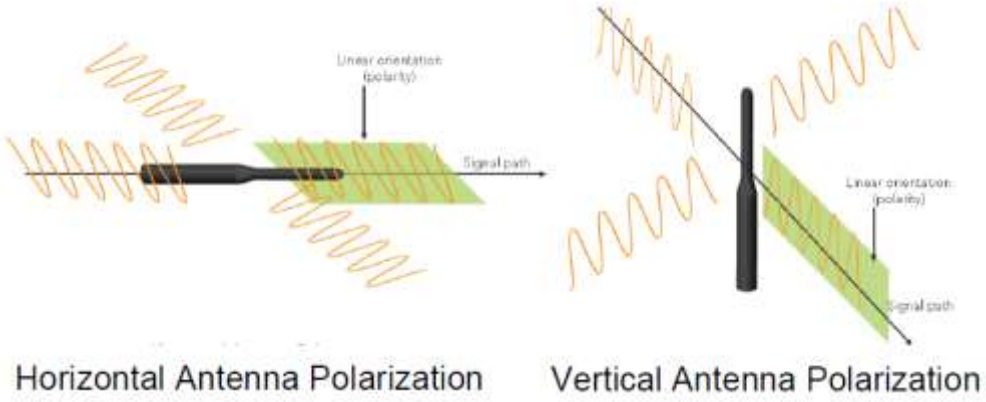
Antennas

Omnidirectional



Directional





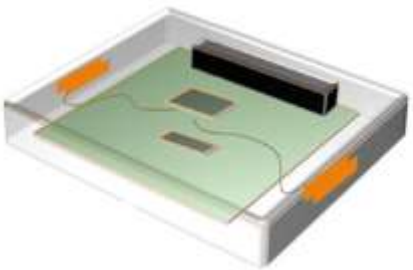
Horizontal Antenna Polarization

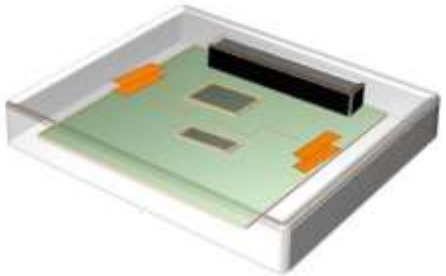
Vertical Antenna Polarization

Antennas

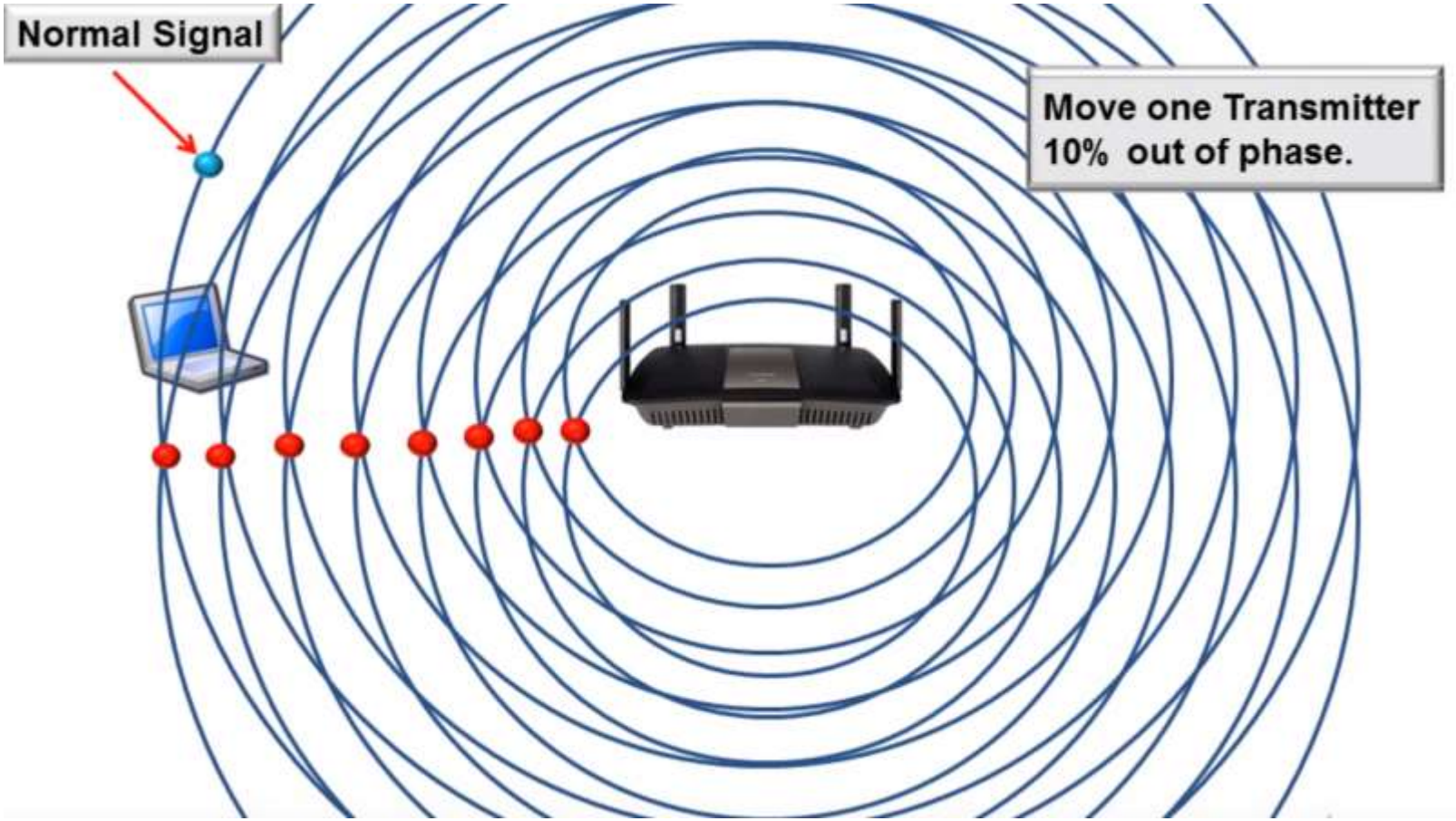
MIMO using external antennas

Integrated internal antennas

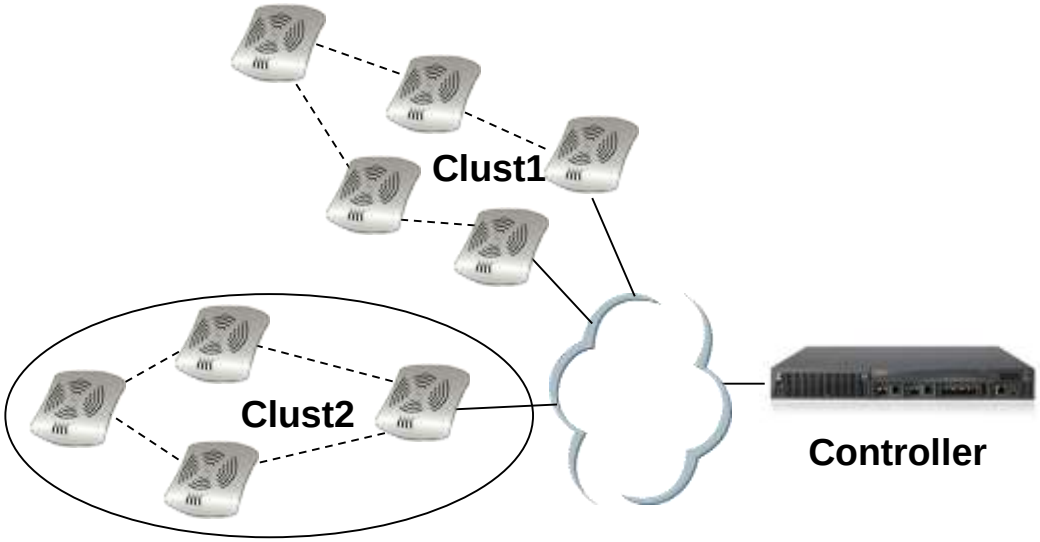


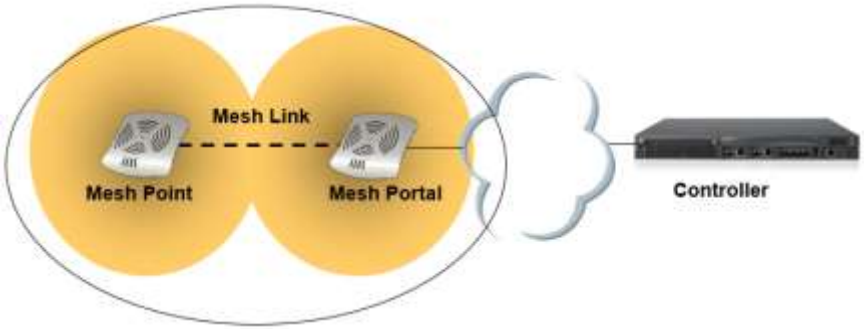


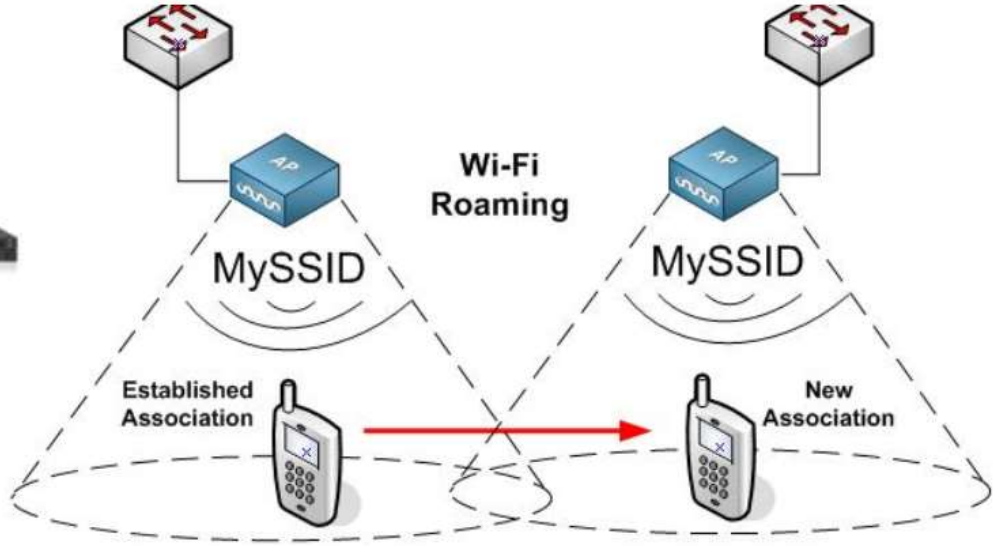
Beamforming



WiFi – Enterprise vs Home použitie

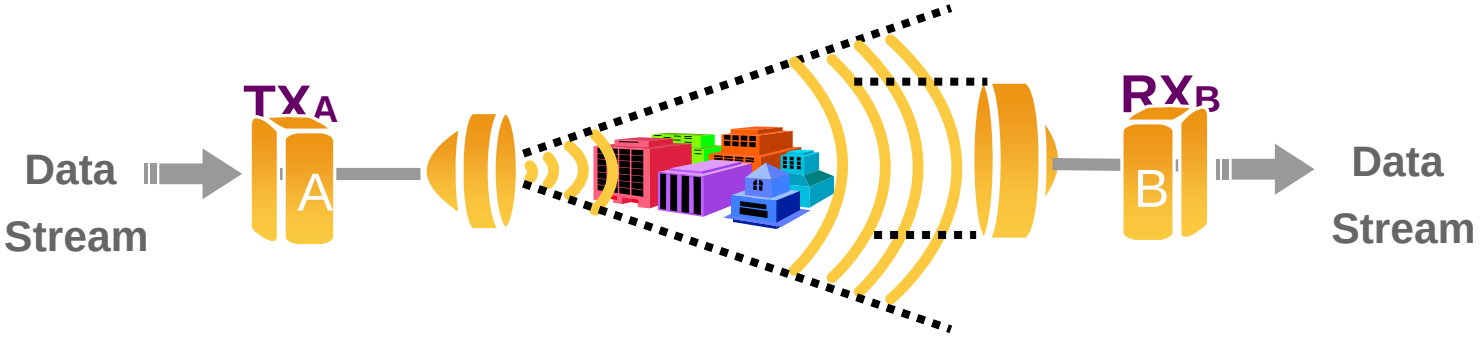




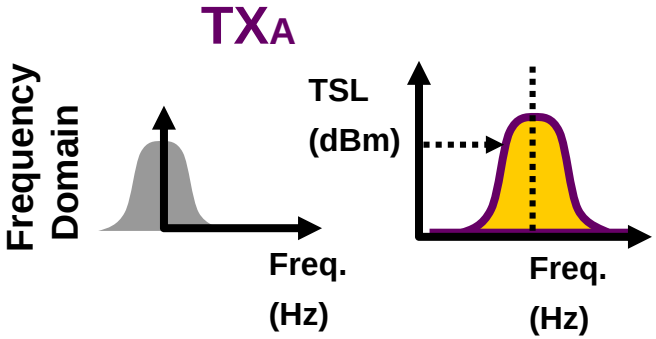


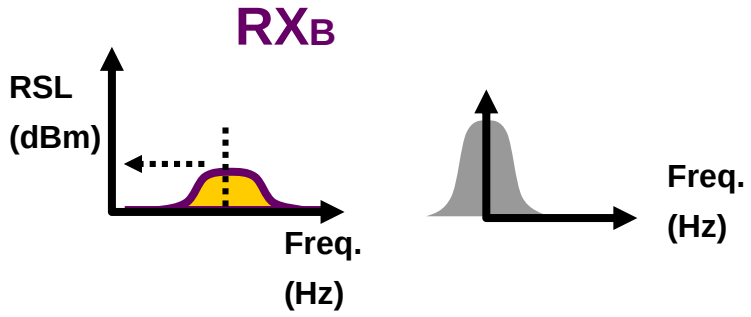
Mikrovlnné spoje

What is a Microwave Radio?

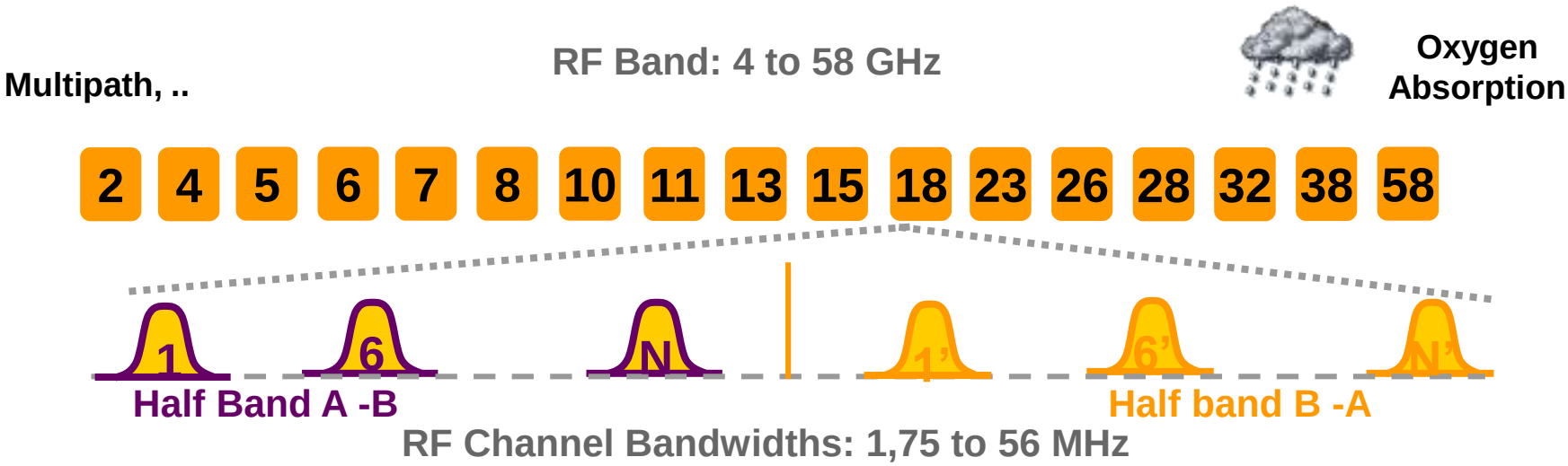


- A MW link establishes a digital radio bidirectional communication between two points (mainly in line of sight, except few applications)
- Each radio terminal is composed by a baseband/modem section (indoor unit), an RF section (typically placed in an outdoor unit) and the antenna system



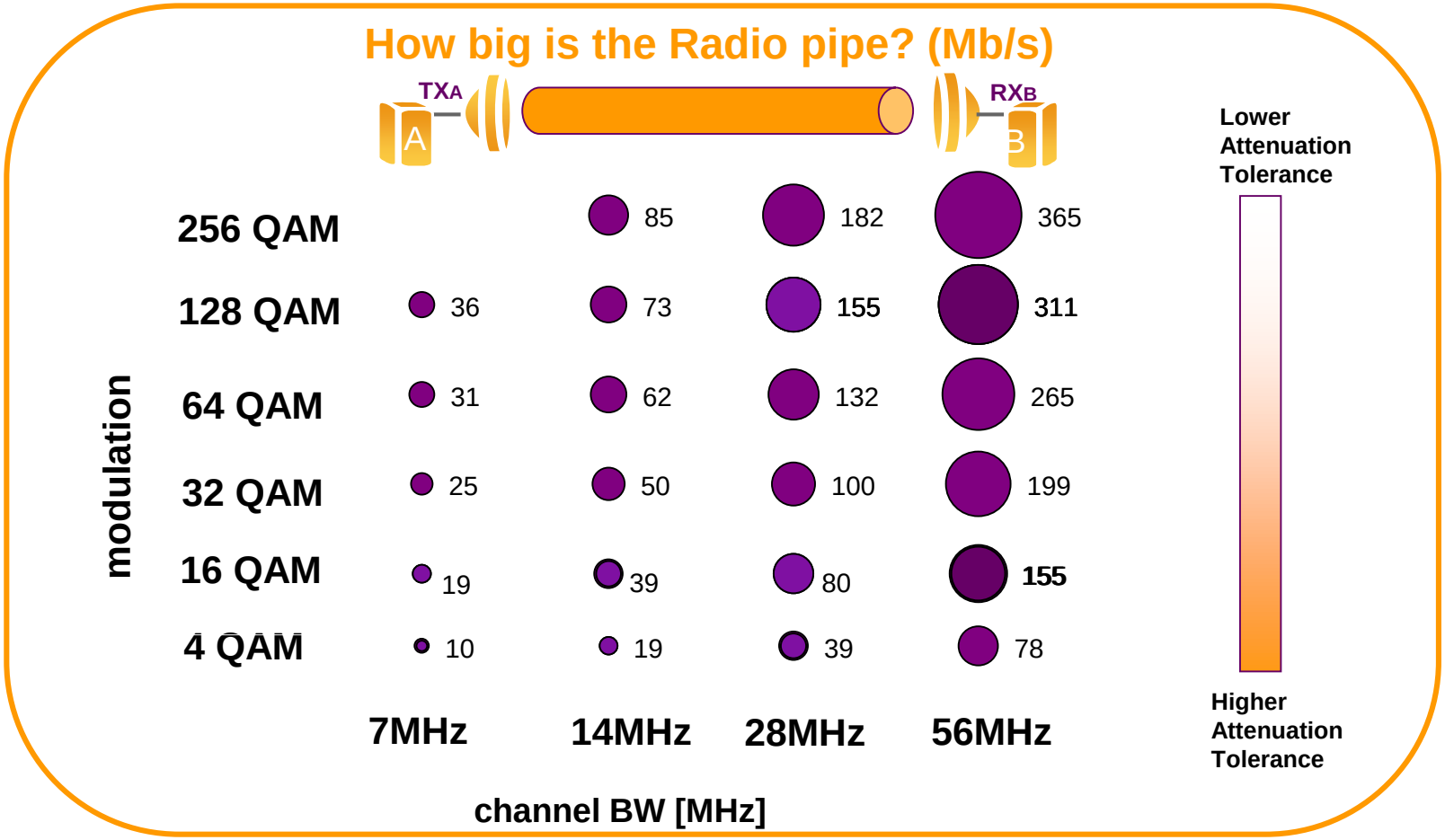


RF Bands and available RF Bandwidth



- The available range for the RF carriers is from 2GHz up to 58GHz (E-band 71-76 / 81-86 GHz). Proprietary protocols, equipment from different vendors not compatible with each other.
- One RF channel is needed for transmitting and another for receiving (half of the assigned band will be used for transmission and half for reception)
- Low frequencies (2GHz-13GHz) are affected by multipath (interference between main and reflected signals) phenomena, while at high frequencies (from 15GHz) the predominant phenomena is rain

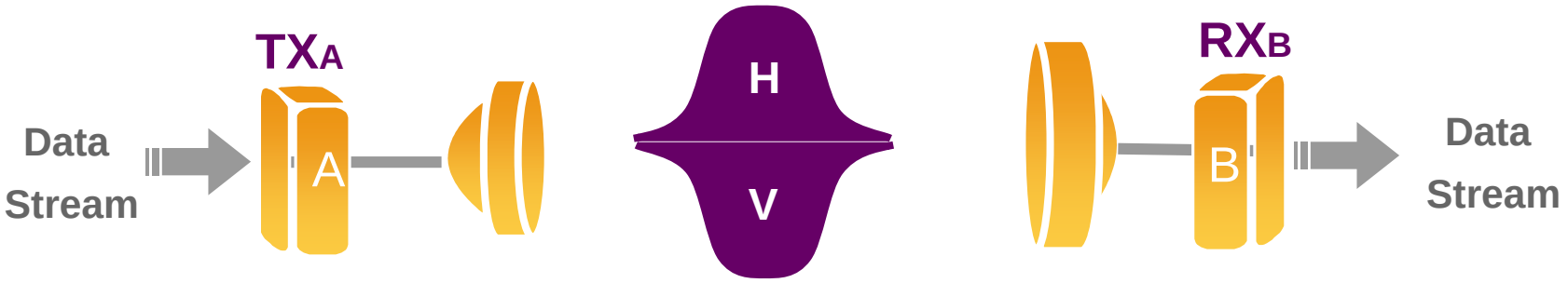
Spectral efficiency



- It's possible to send more capacity on the same RF bandwidth increasing Modulation complexity (i.e. increasing the spectral efficiency)
- The higher is the number of modulation states, the lower is the attenuation the link can tolerate

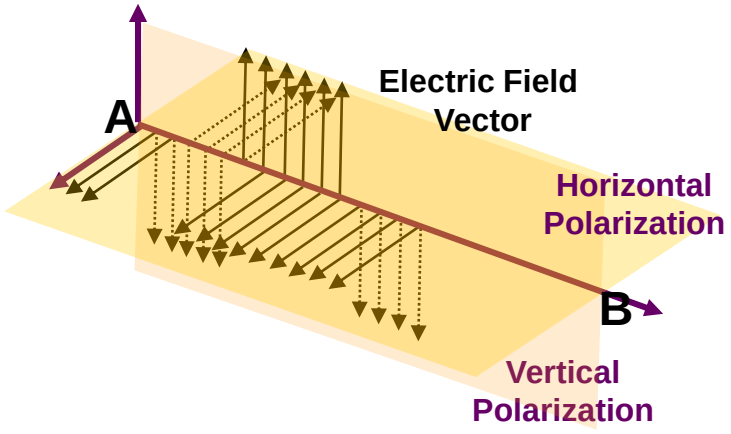
Co-channel system

Double capacity using the same bandwidth



- Another way to send more capacity on the same bandwidth is to use a Co-channel system: to transport two channels on the same RF carrier using two different polarizations of the transmitted electric signal

  E.g.: at 56 MHz with 16QAM the maximum capacity with Co-channel system is 300Mb/s (instead of 155Mb/s); the same capacity without Co-channel would require 128QAM



Typical Distances

Multipath, ..

RF Band: 2 to 58 GHz

Oxygen Absorption

2 4 5 6 7 8 10 11 13 15 18 23 26 28 32 38 58

Long Distances

Tens of kilometers

Short distances

Up few km

- The covered distance strongly depends on the selected RF band and on the performances of the system (level of modulation, system gain, protection vs propagation phenomena...etc)

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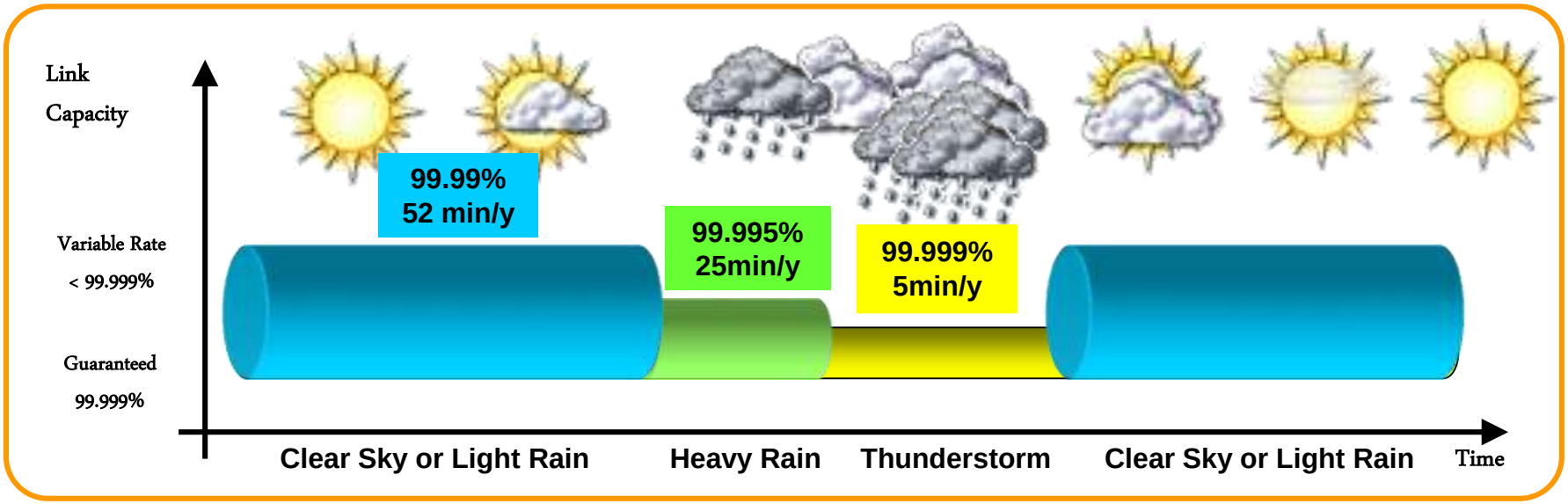
Adaptive Modulation MW in Time Domain

More Capacity, Same Antennas, Same RF Spectrum



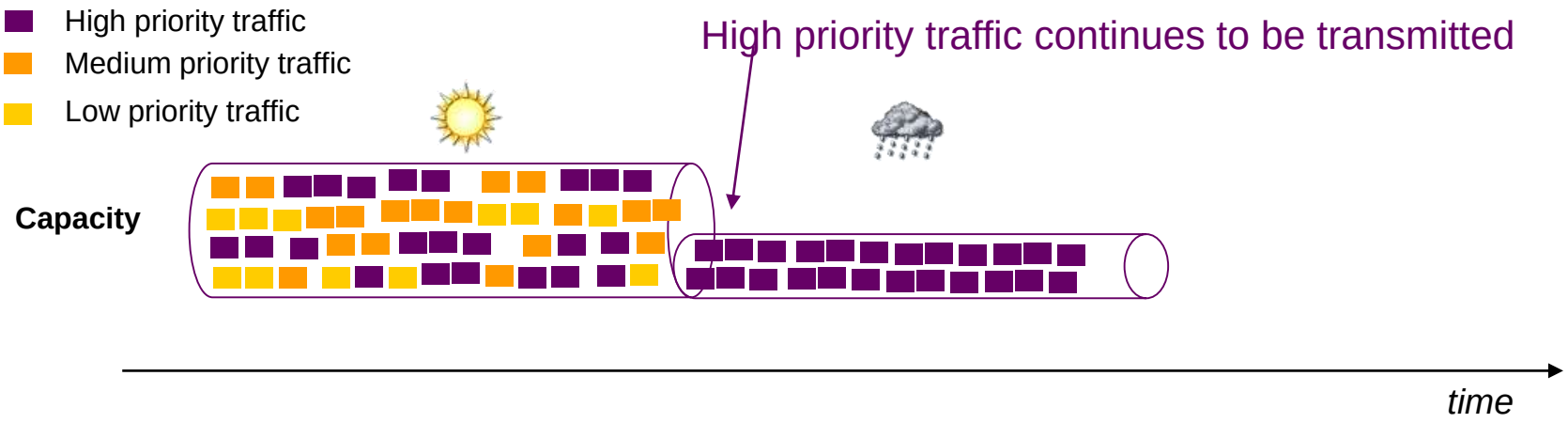
- The minimum required capacity is engineered to meet the Availability Objective, just as usual (e.g. 4xE1 @ 99.999%)
- Adapting the modulation to the weather, more traffic can be transmitted during good propagation conditions
- The minimum capacity is guaranteed, the additional traffic must tolerate differentiated QoS levels

QoS
Traffic priority management in Adaptive Modulation

- What happens when the radio capacity is reduced due to an adaptive modulation switching?

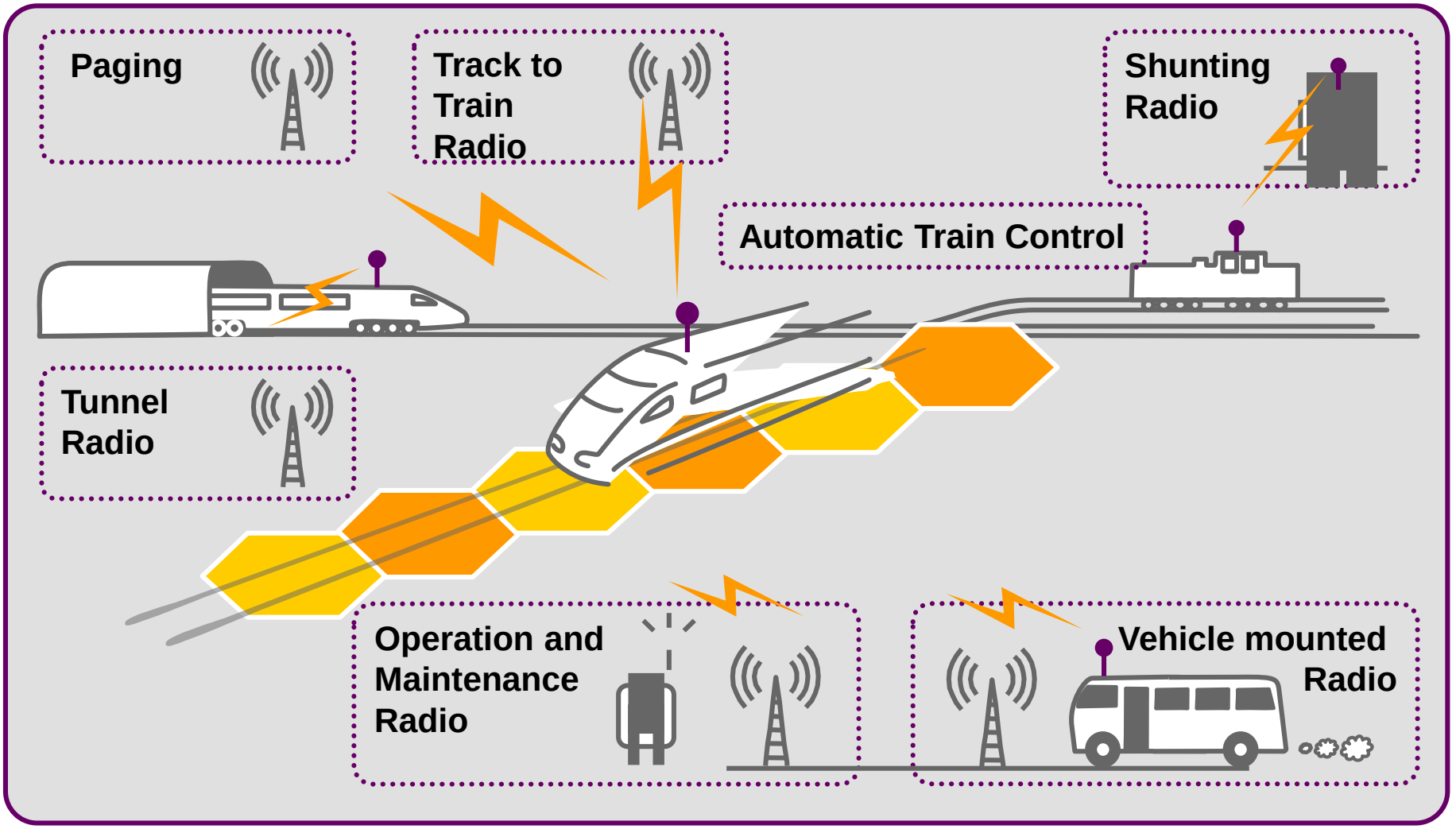
- The equipment has the intelligence to understand which packet to discard (i.e. low priority traffic)

QoS provides this intelligence



Železnice

Railways radios



GSM-R

Safety and future proof system

GSM + EIREN'E = GSM-R

GSM: Standardized and tested. Long history and over 120 mio users in 120 countries
EIRENE: Railway specific functionality
GSM-R: GSM for Railways

One system for railway communication

GSM-R integrates the different communication requirements into one System

The GSM-R System is suited for Railway operations and interoperable to ensure boarder crossing traffic

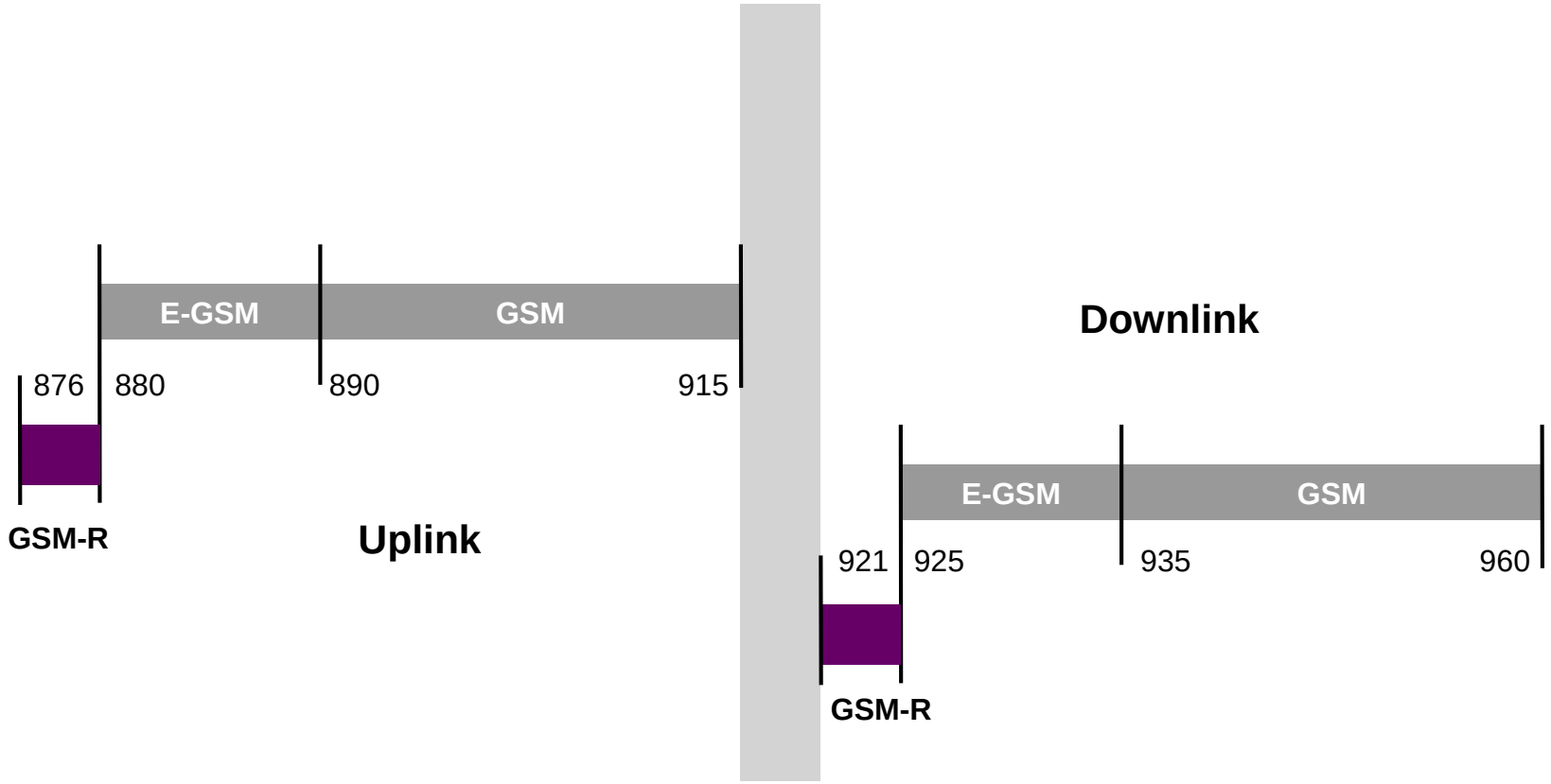
Expand the services for railway operations



Bearer for signalling systems (ETCS) and other applications

Technical solution
GSM-R frequencies

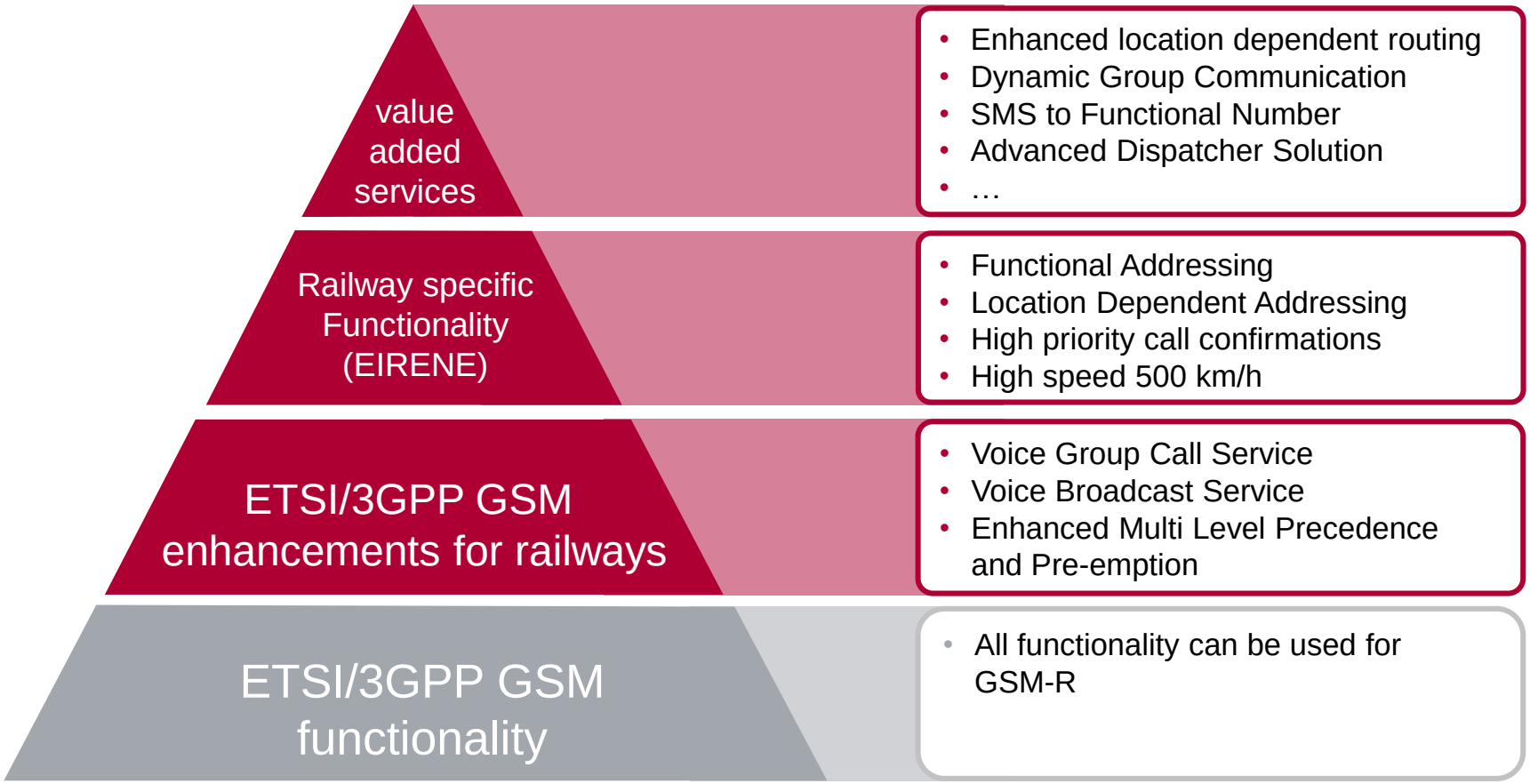
European/EIRENE frequency allocation



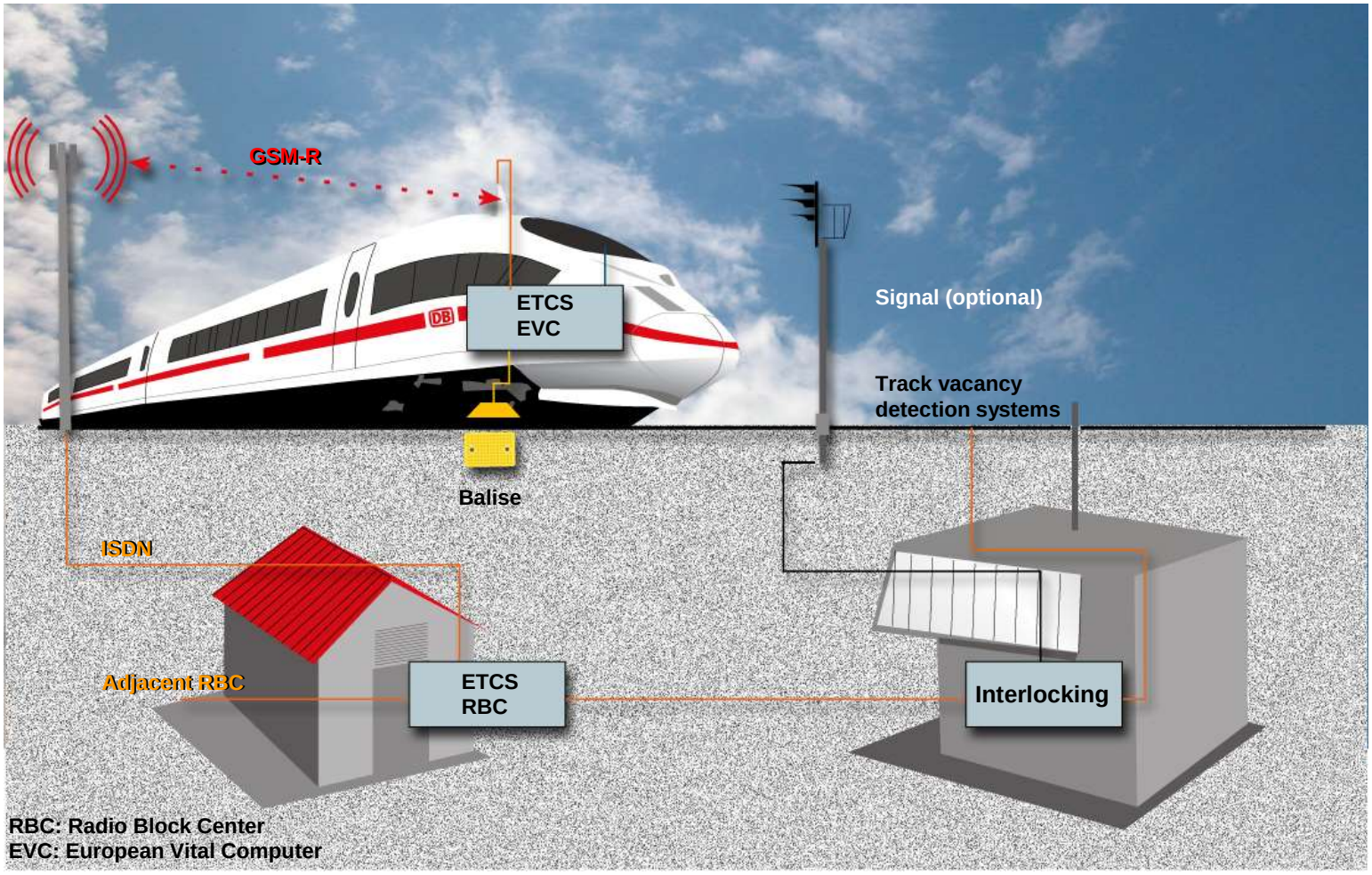
* All frequencies in MHz

GSM-R Functionality Overview

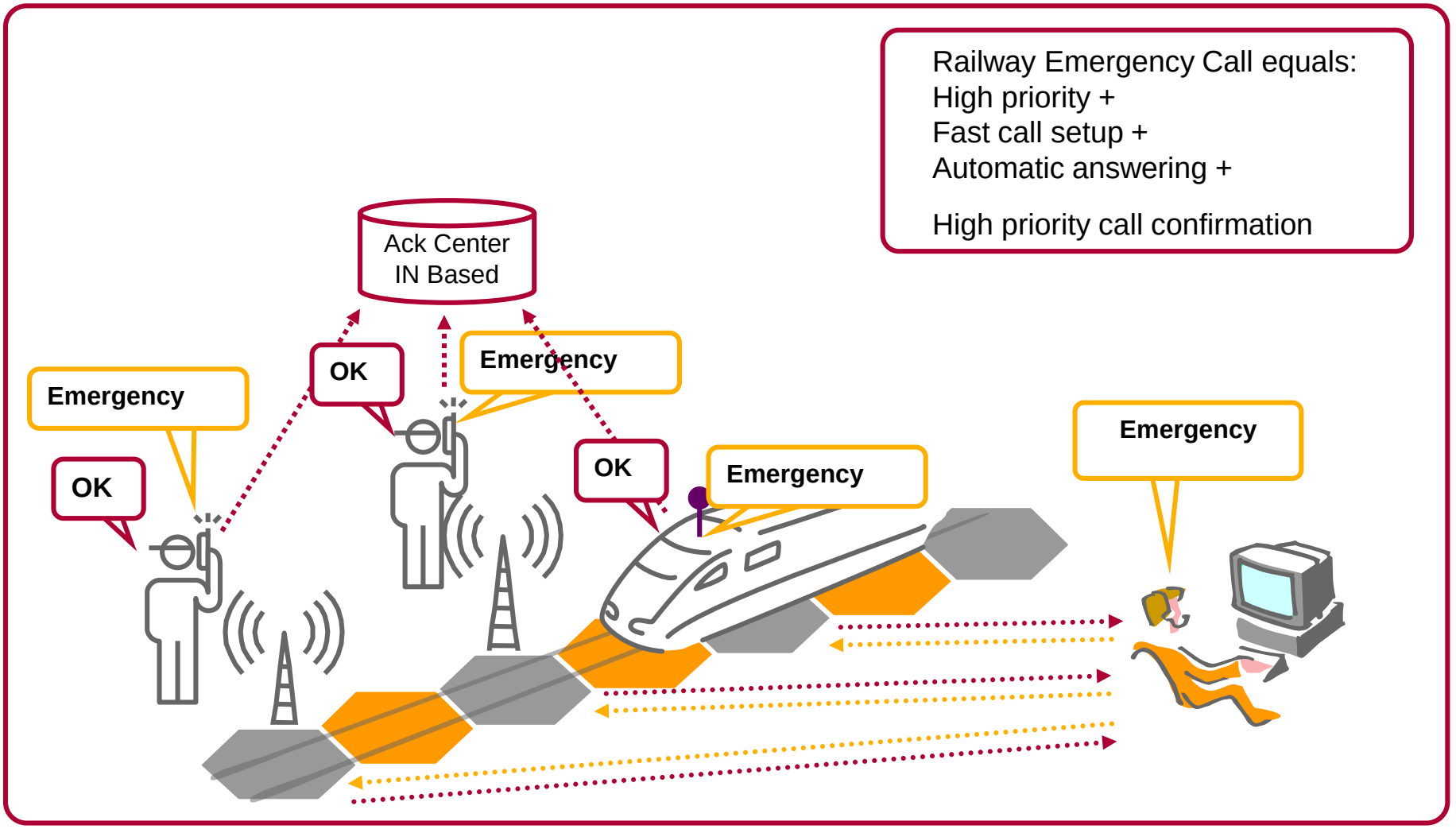
Examples of additional functionality



Application using GSM-R Networks :
ETCS Level 2 (Automatic Train Protection system on top of GSM-R)



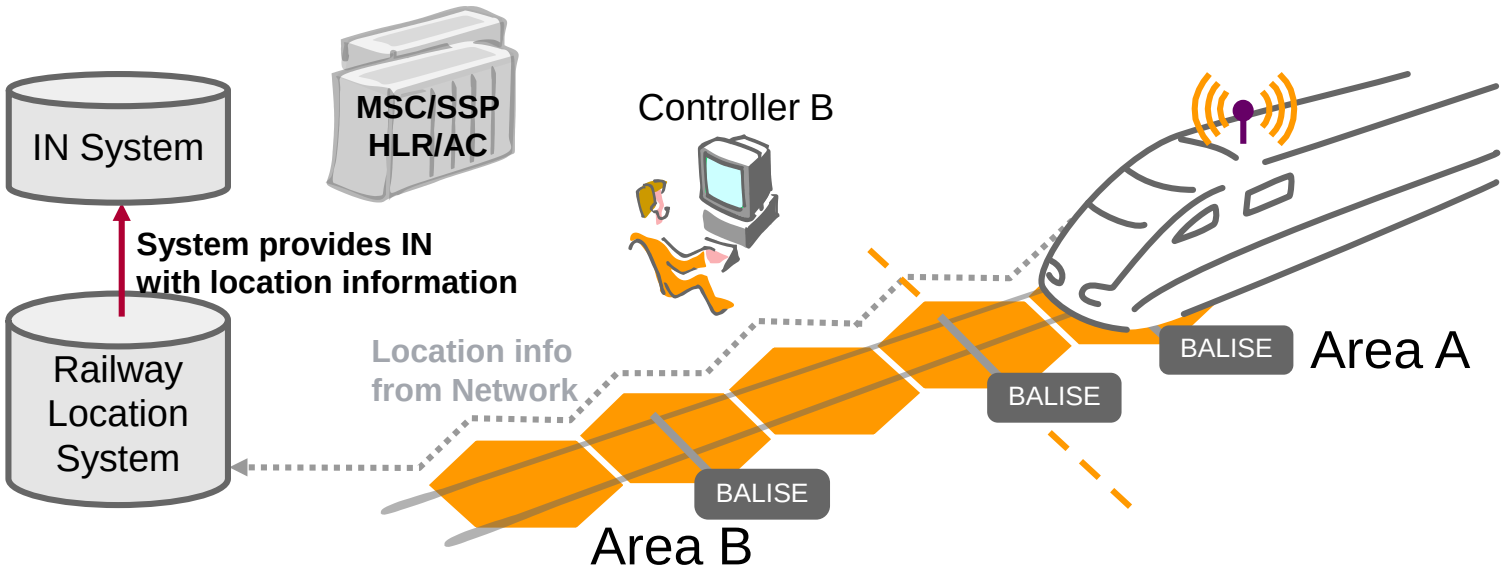
GSM-R Functionality
Railway Emergency Call



CSM GSM-R, 2009

Value added functionality for GSM-R Networks: enhanced Location Dependent Addressing

- With eLDA, the accuracy of the location dependant routing is further increased
- Positioning info from existing signalling systems can be used
- LDA (based on Cell Information) available for fall back solution



Benefits:

- Controller border can be placed independently from cell borders
- Parallel tracks (same cell) can be routed to different dispatchers

Praktická časť, plánovanie a design

Dimenzovanie

Green marked values are the input parameters
Orange marked values are the results

INPUT PARAMETERS	Coverage [km2]		Praha	ORP	OPOU
1800MHz FDD	CPE	USB	Urban vs. Rural distribution		
Dense urban	0.87	0.51	20.0%	0.0%	0.0%
Urban	2.37	1.34	45.0%	50.0%	0.0%
Suburban	21.87	11.37	25.0%	40.0%	70.0%
Rural	559.09	290.80	10.0%	10.0%	30.0%

Detailed Radio parameter specification refer to the PPF_dimensioningData.xls
CPE antenna gain UL is considered 5dB, USBmodems gain 0dB

RESULTS

Total quantity of eNodeB for **Modem CPEs**	1807
Total quantity of eNodeB for **USB dongles**	2942
% of inhabitants covered	50.1%
% of overall Czech km2	12.0%

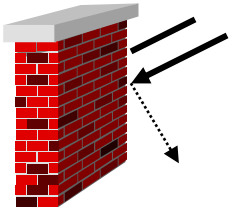
Signal propagation

Propagation in free space always like light (straight line)

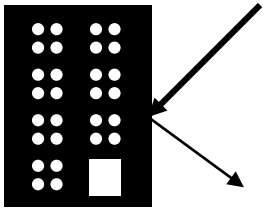
Receiving power proportional to $1/d^2$ (d = distance between sender and receiver)

Receiving power additionally influenced by

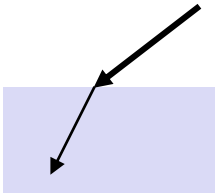
- fading (frequency dependent)
- shadowing
- reflection at large obstacles
- refraction depending on the density of a medium
- scattering at small obstacles
- diffraction at edges



shadowing



reflection



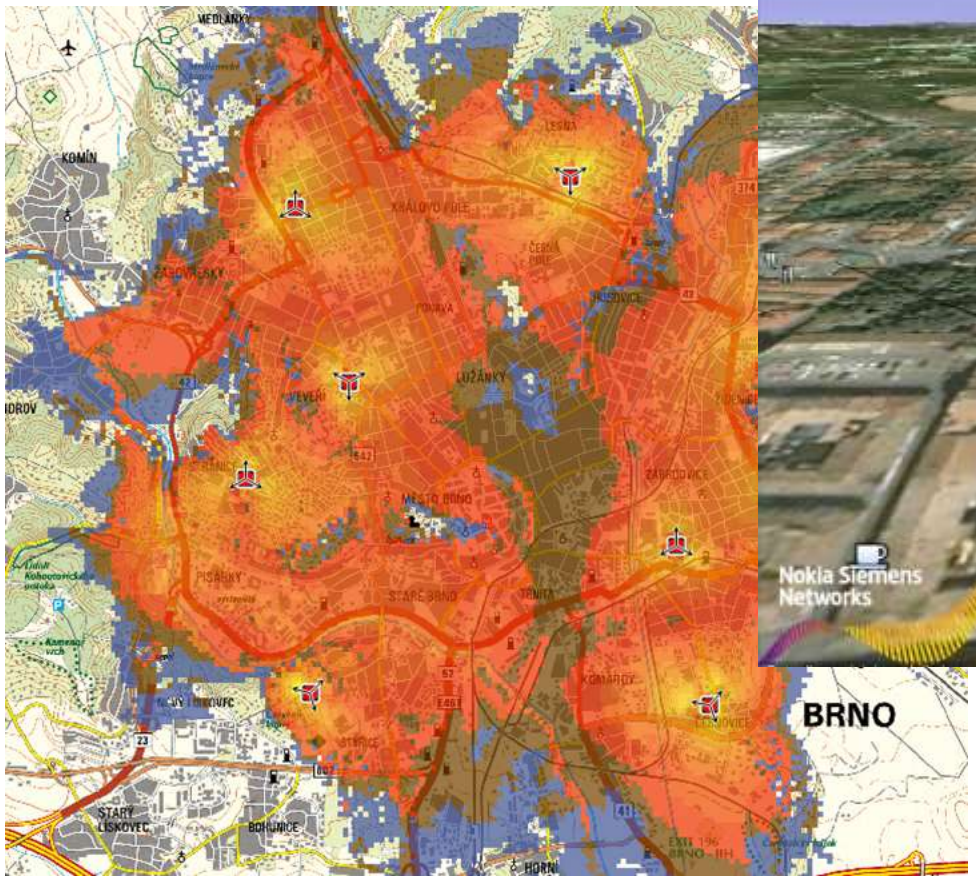
refraction

scattering

diffraction

Rádiové plánovanie

Site evaluation, ranking and low level design (reusing existing sites as much as possible)



Parametre modelovej siete

Spektrum: pásmo #20 E-UTRAN (832-862/791-821MHz) a šírka pásma 10MHz FDD.

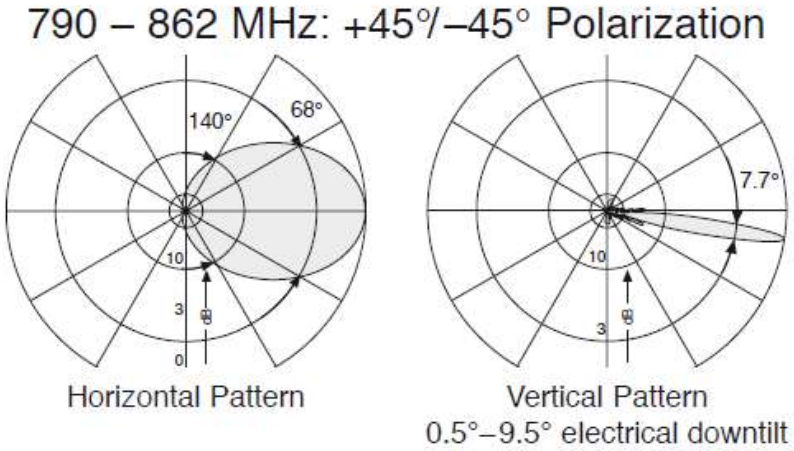
eNodeB : vysielací výkon 47.8dBm (60 W), anténa Kathrein, antény zisk 17 dBd.

UE (CPE) : vysielací výkon 23dBm, anténa Yagi, anténny zisk 8,85 dBd.

Štandardný model šírenia.

Všetky simulácie sú bez záťaže.

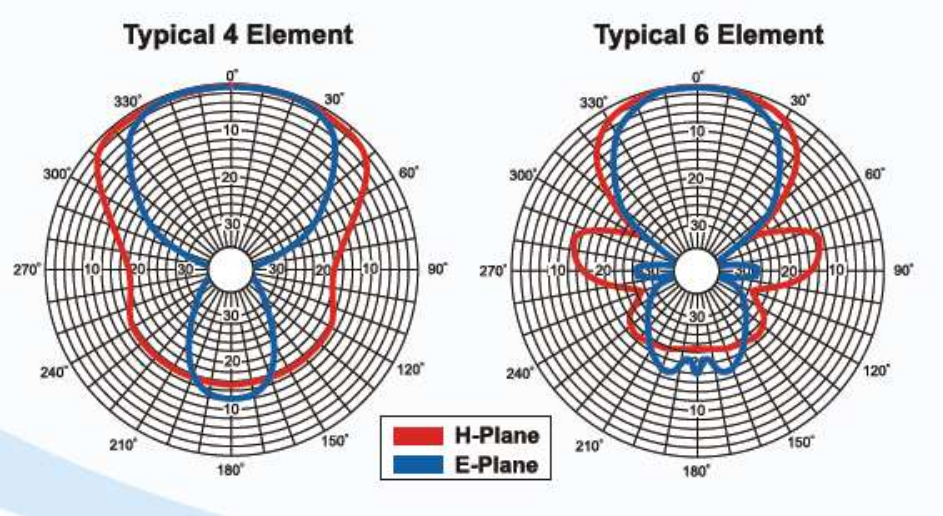
Vyžarovacia charakteristika



eNodeB - Kathrein

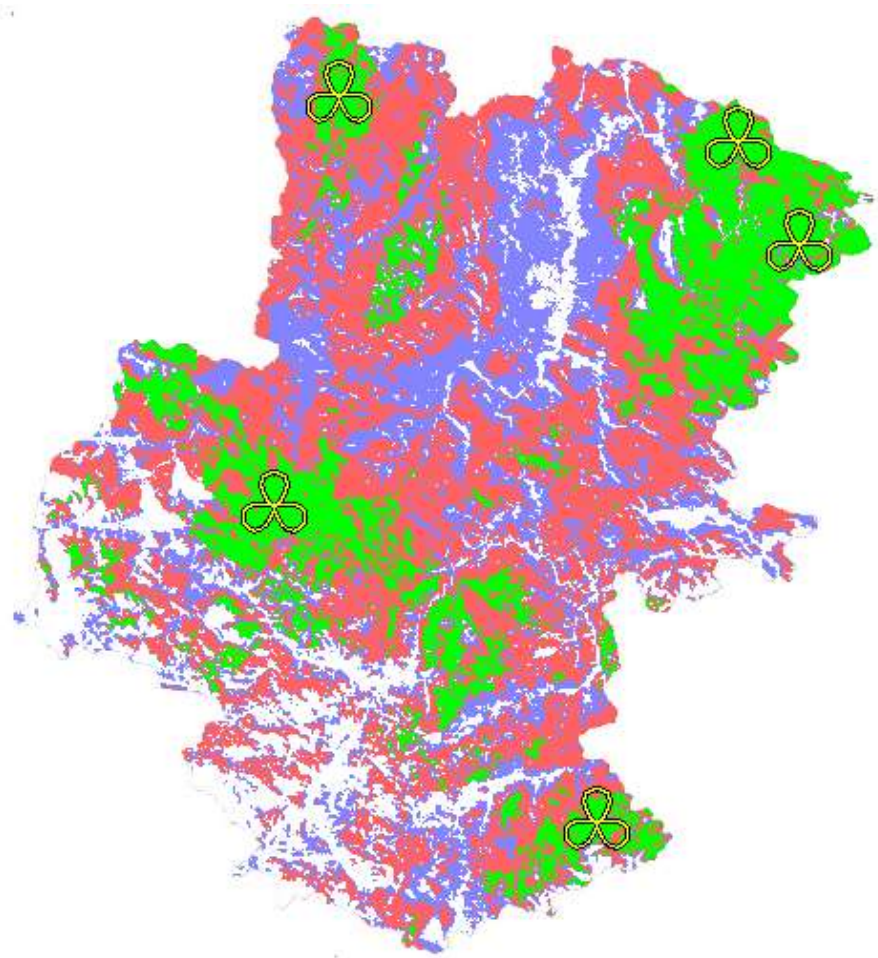
Vyžarovacie charakteristiky antén používaných v LTE sieťach nie sú štandardnou výbavou použitého
programu.

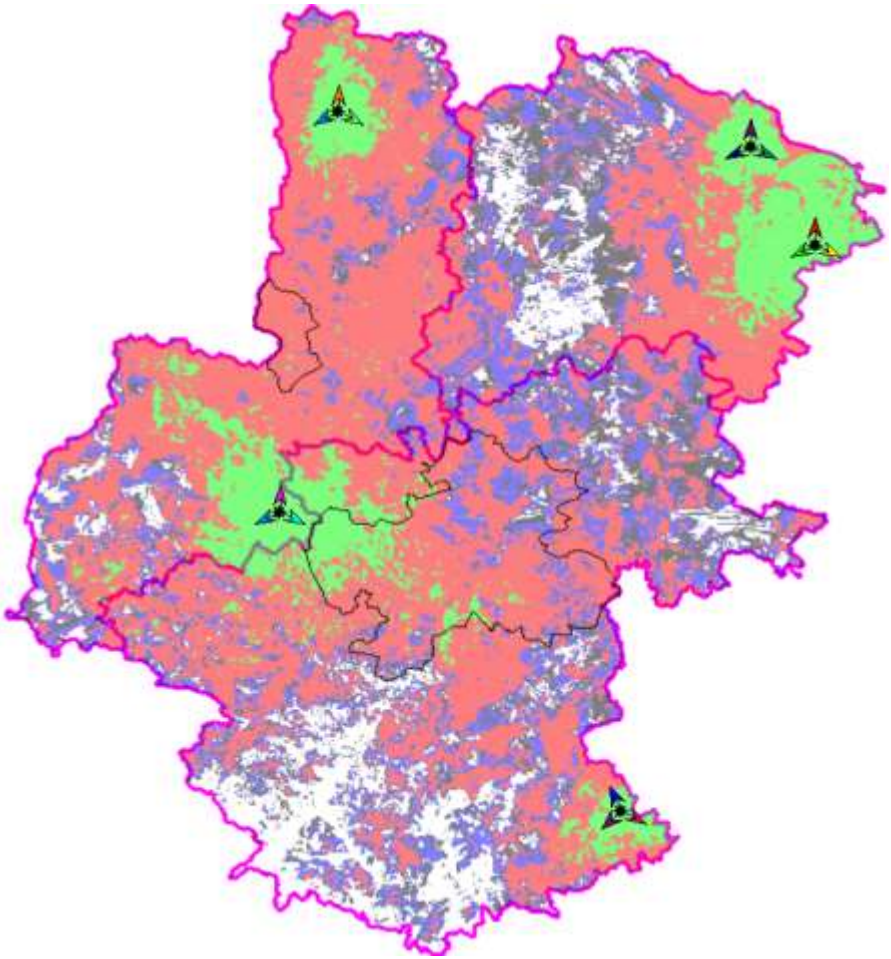
Preto som museli vytvoriť vlastný vyžarovací diagram podľa údajov od výrobcu antény Kathrein.
UE (CPE) využíva anténu Yagi.

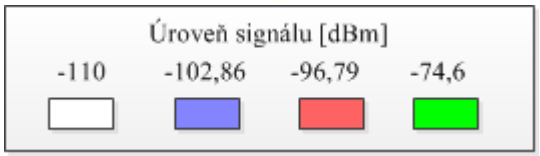


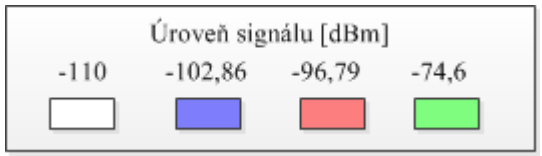
UE (CPE) - YAGI

Návrh pokrytia #1

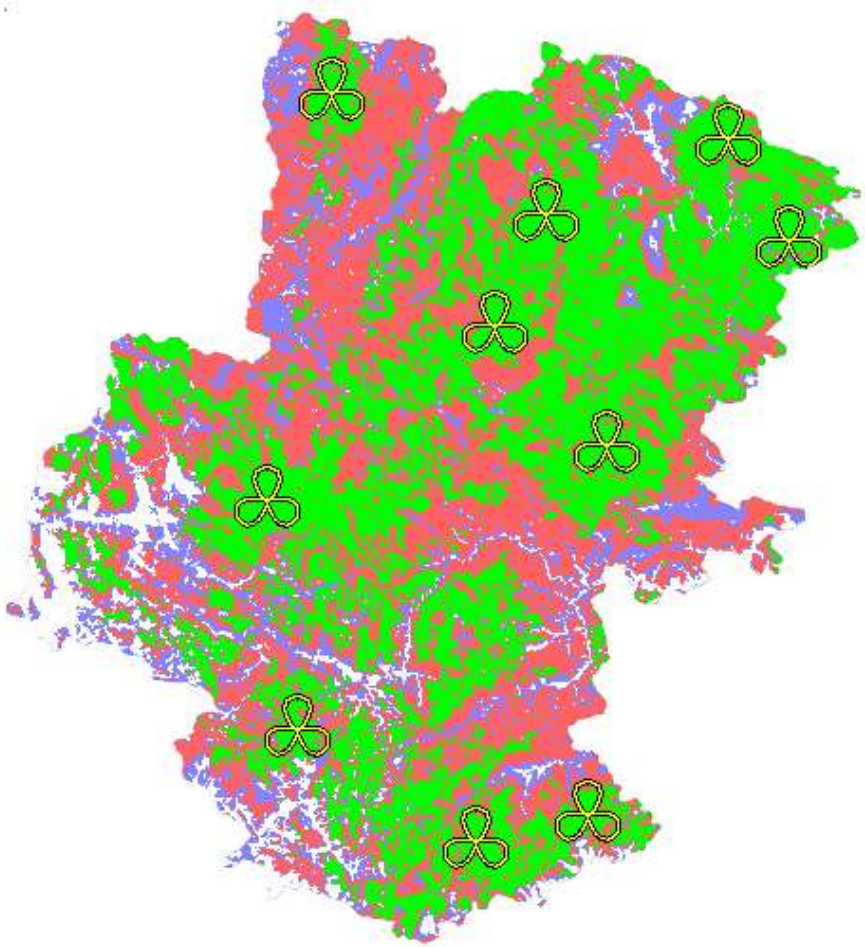


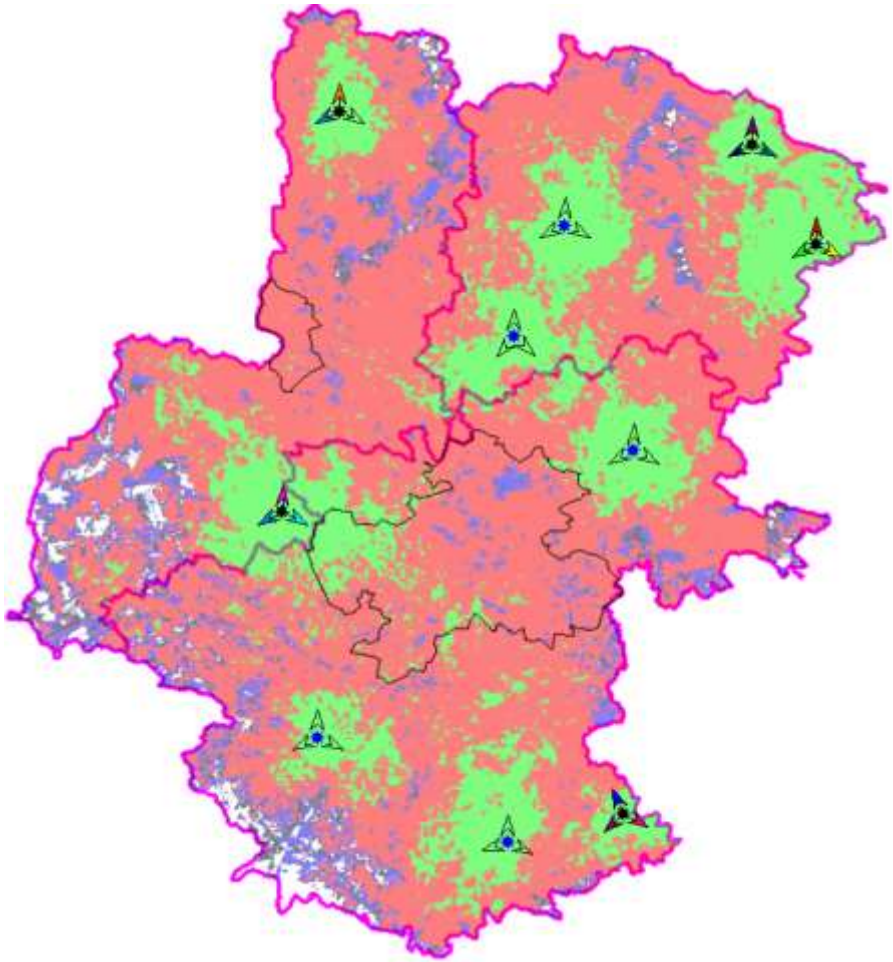


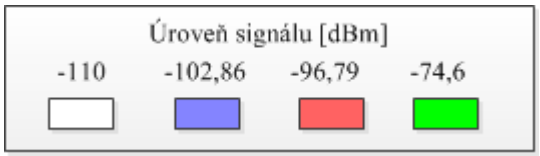


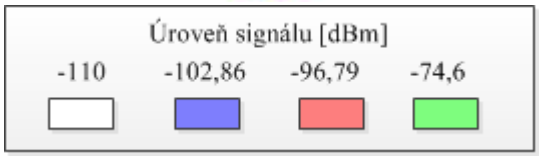


Návrh pokrytia #2







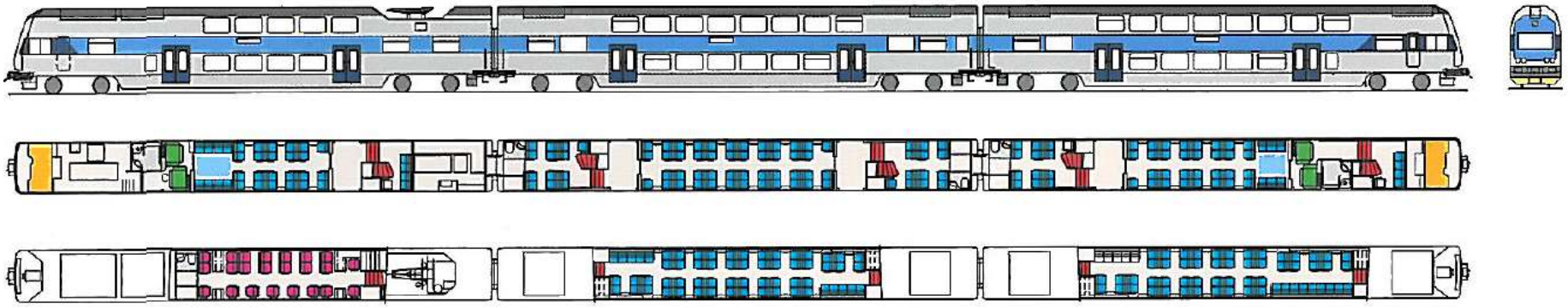


Prehľad výsledkov

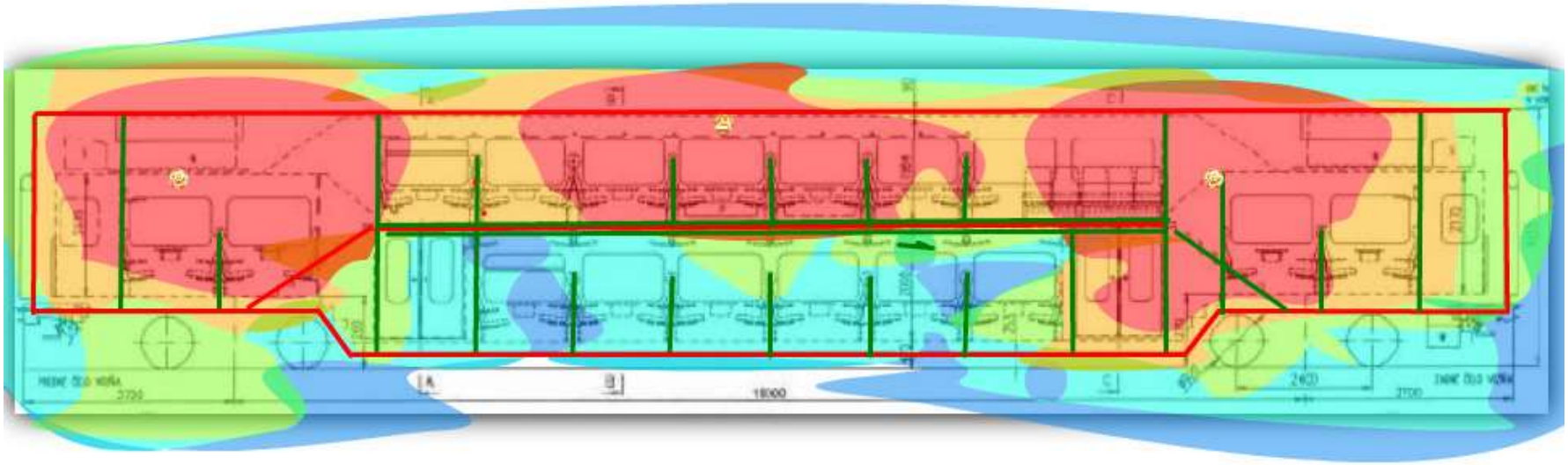
- Na profil šírenia signálu má najväčší vplyv umiestnenie vysielača.
- Nevhodné umiestnenie vysielača nie je možné vyvážiť ďalšími parametrami.
- Veľký vplyv použitej rádiovej frekvencie.
- V rovinatejšom teréne je možné pri nízkych frekvenciách dosiahnuť jednou anténou pokrytie oblasti s veľkosťou až niekoľko desiatok štvorcových kilometrov. Pri použití vyšších frekvencií je dosah vysielača oveľa menší.
- Všeobecne sa využíva možnosť pokrytia väčšieho územia s menším počtom užívateľov na nižšej frekvencii, a menšie územia s vyšším počtom užívateľov, napríklad v mestách, pokryť vyššou frekvenciou ktorá má dostupné aj širšie spektrum.

Príklady návrhu

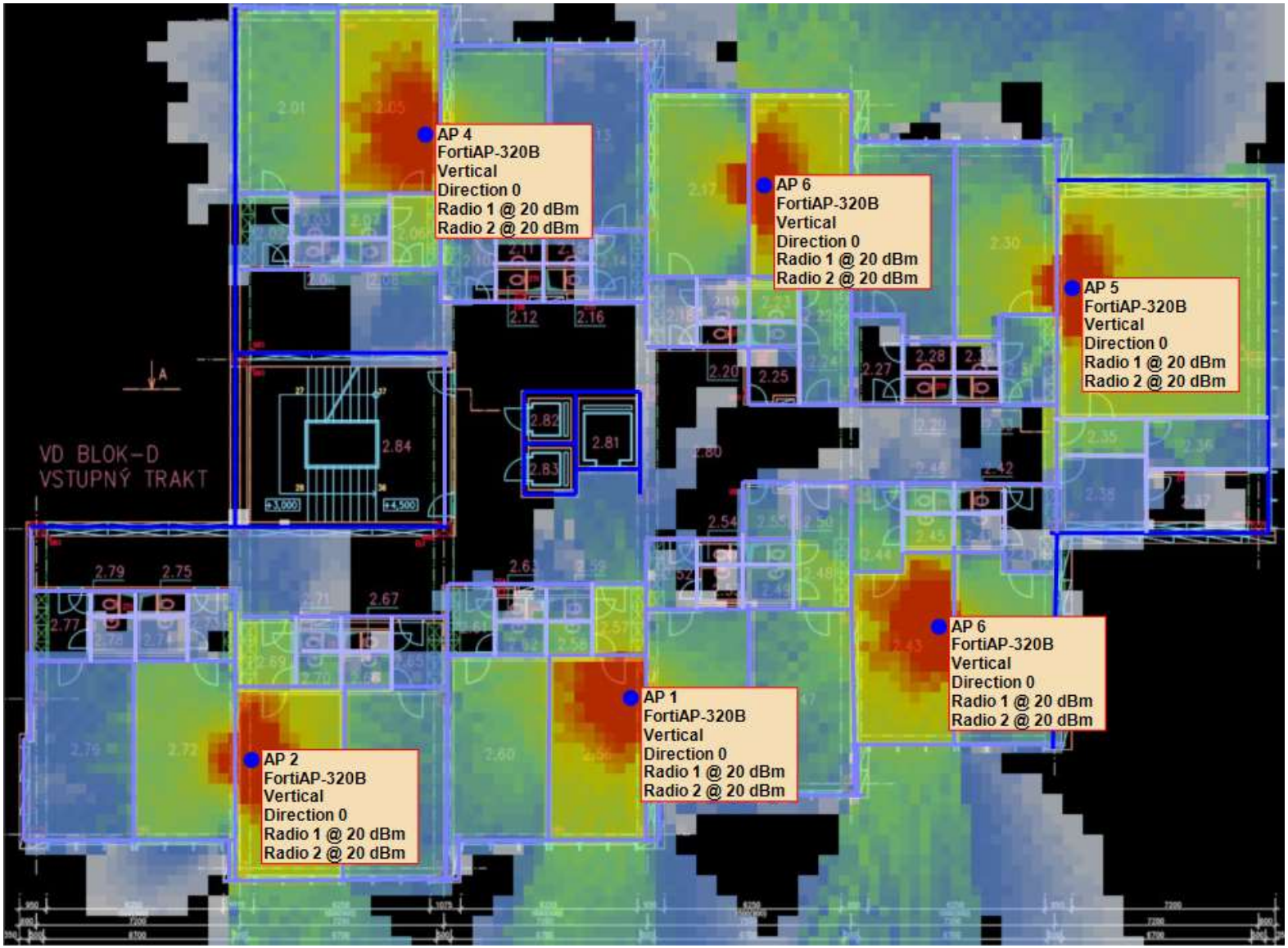
Železnice, modernizácia vozňov



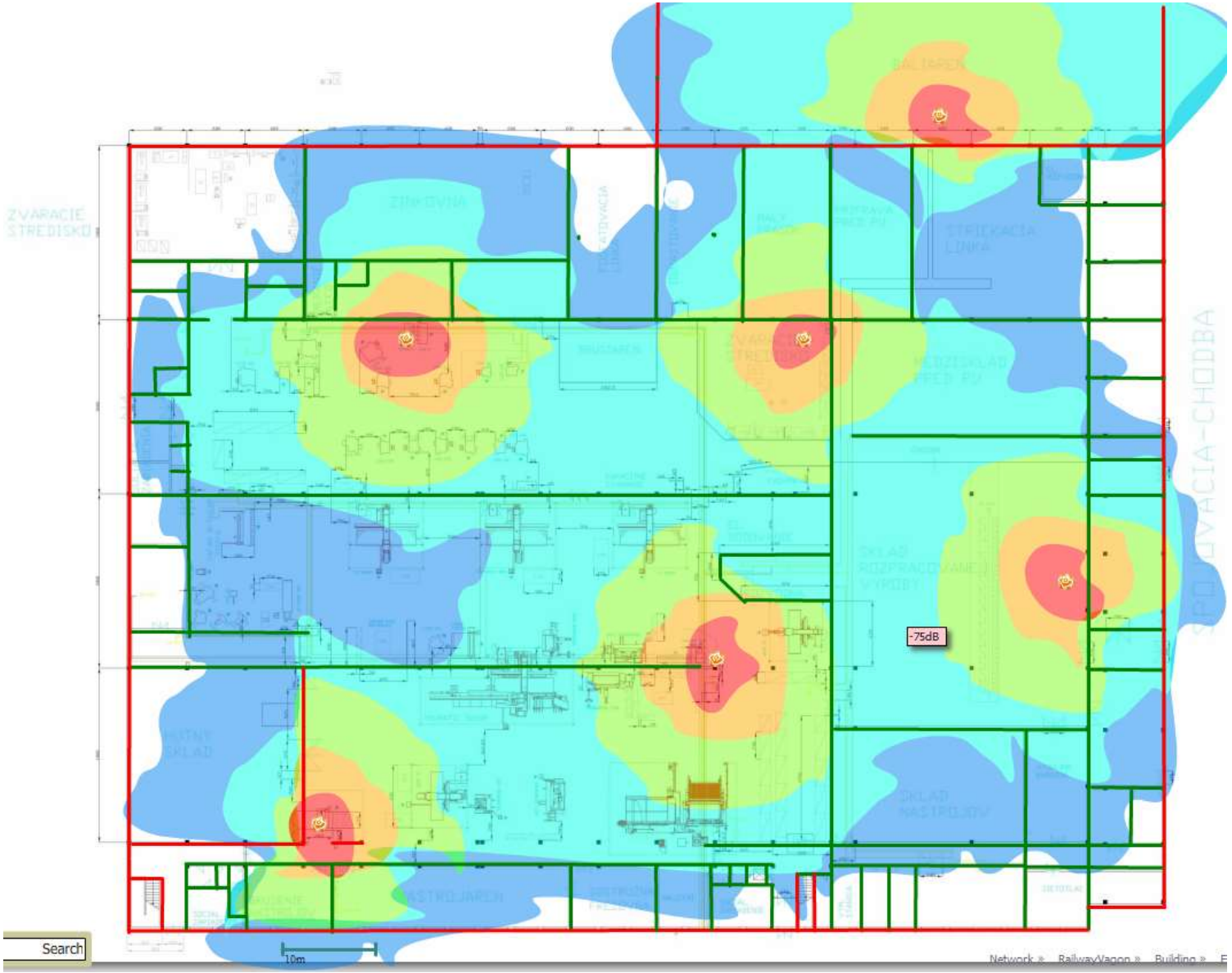
Železnice, modernizácia vozňov



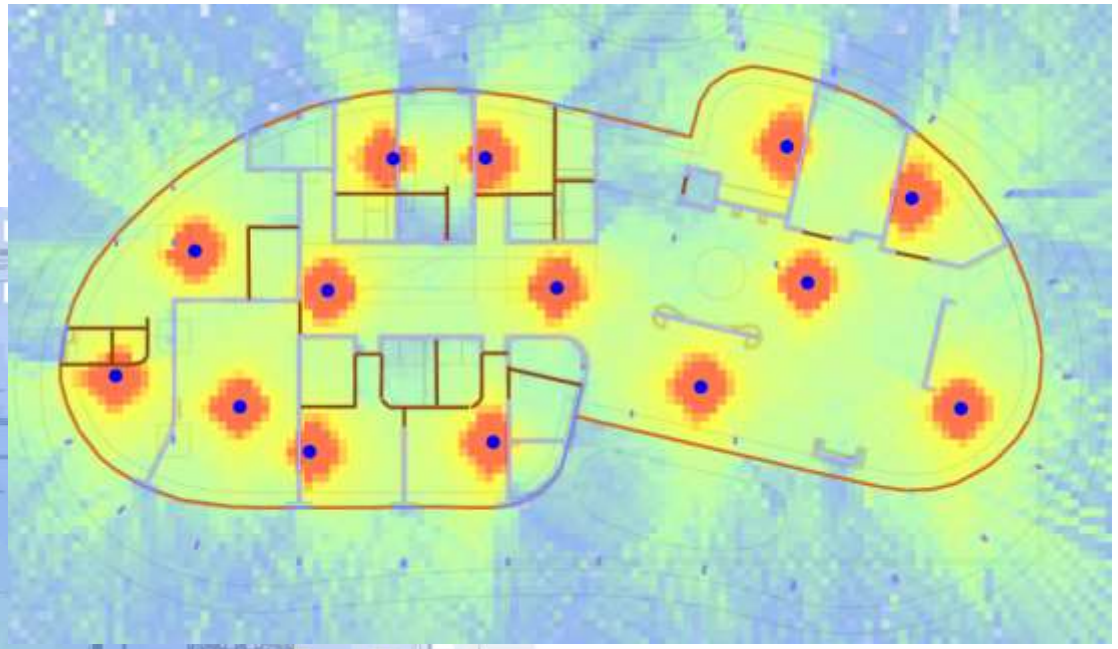
Študentský internát

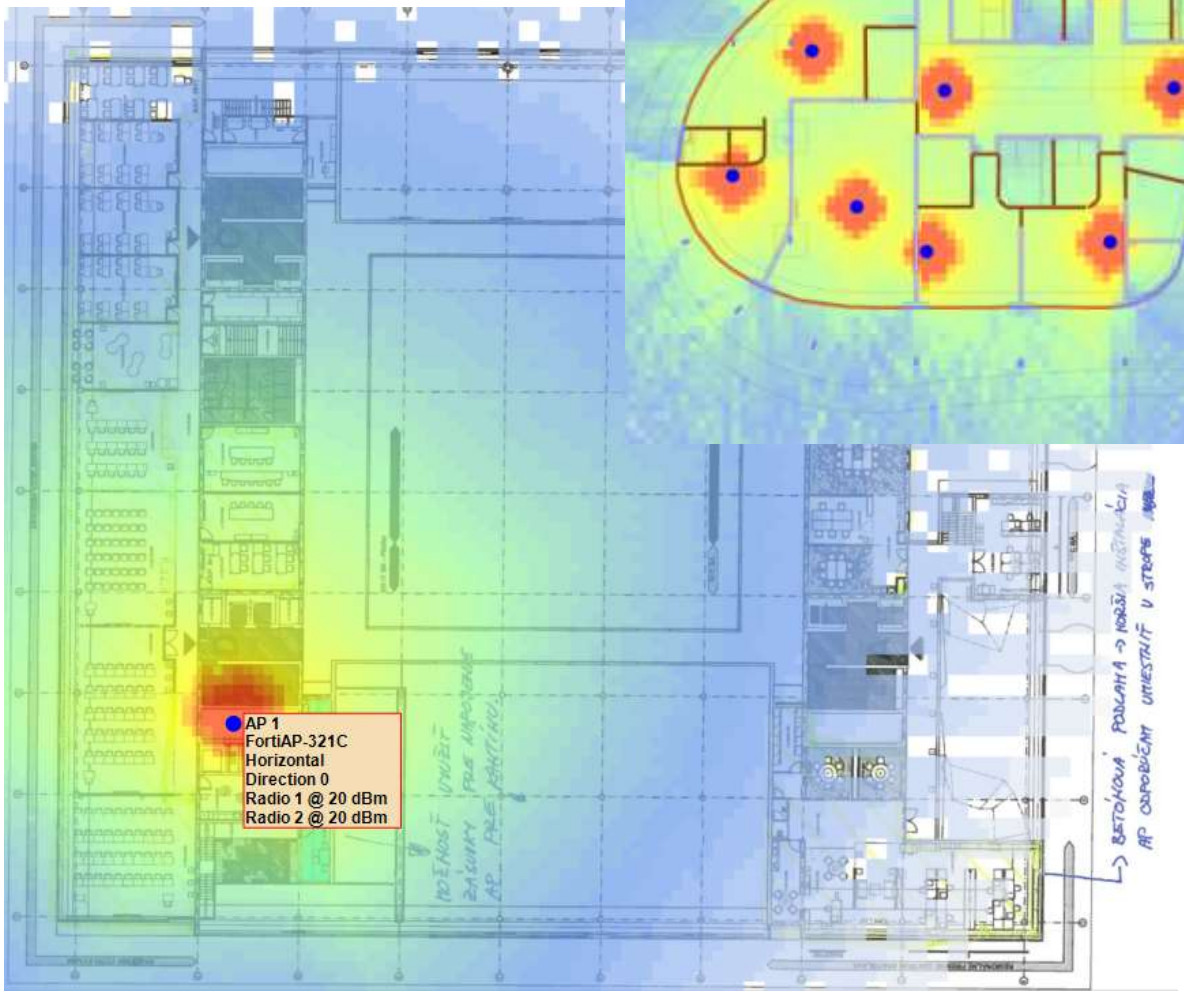


Výrobná hala

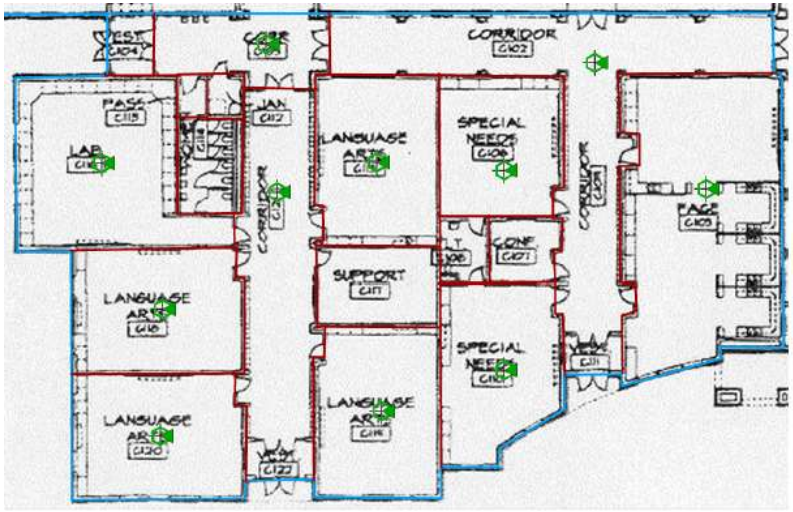


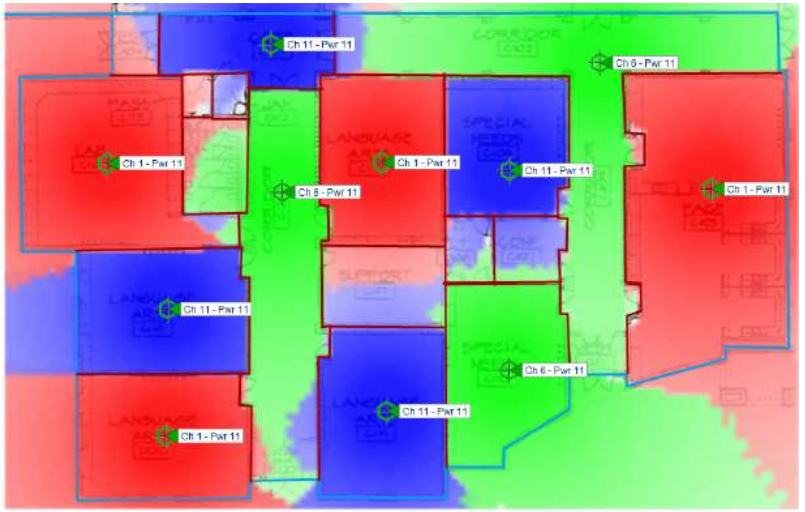
Rôzne budovy



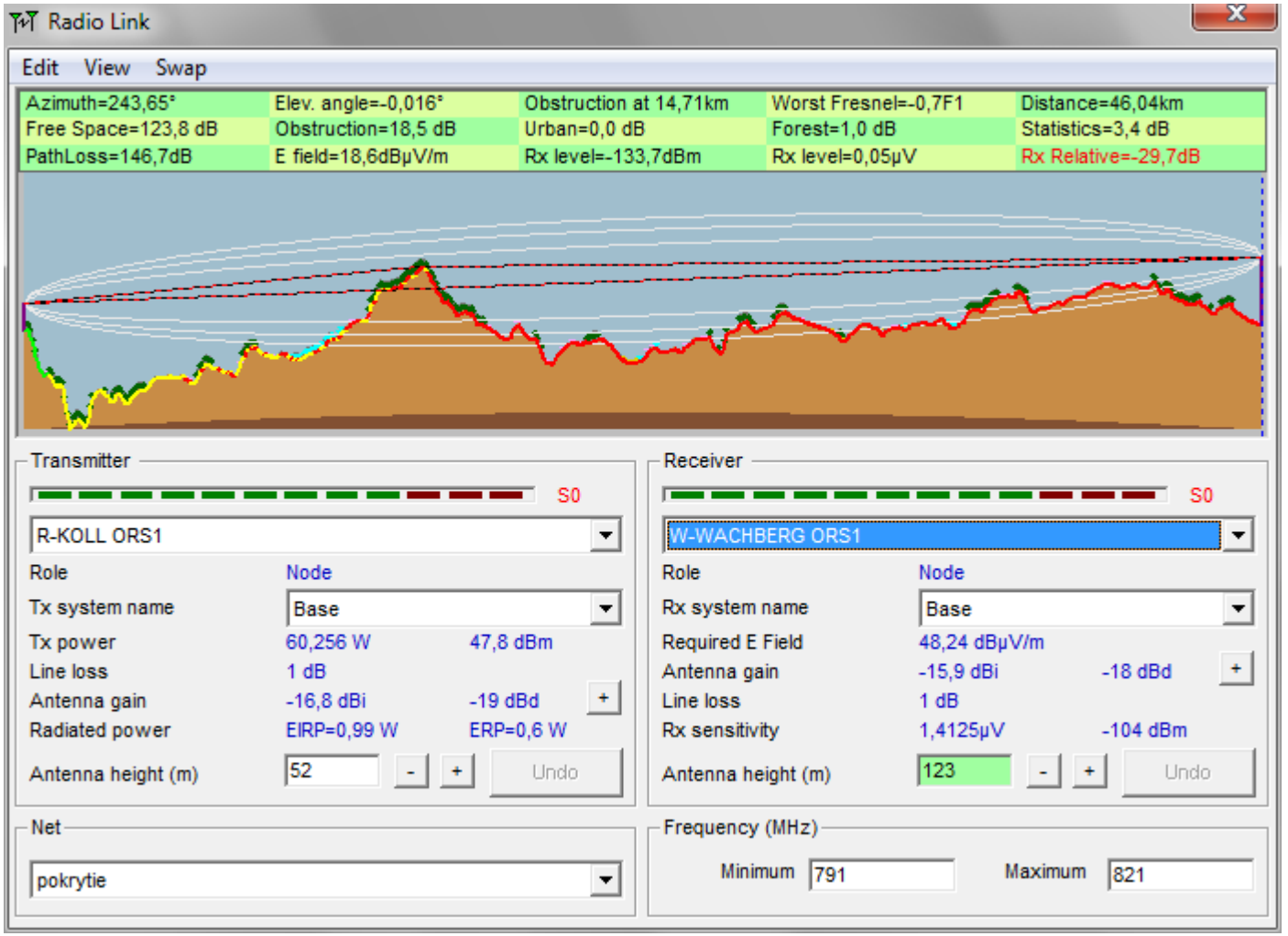


WiFi frekvenčné plánovanie (controller toto robí automaticky)



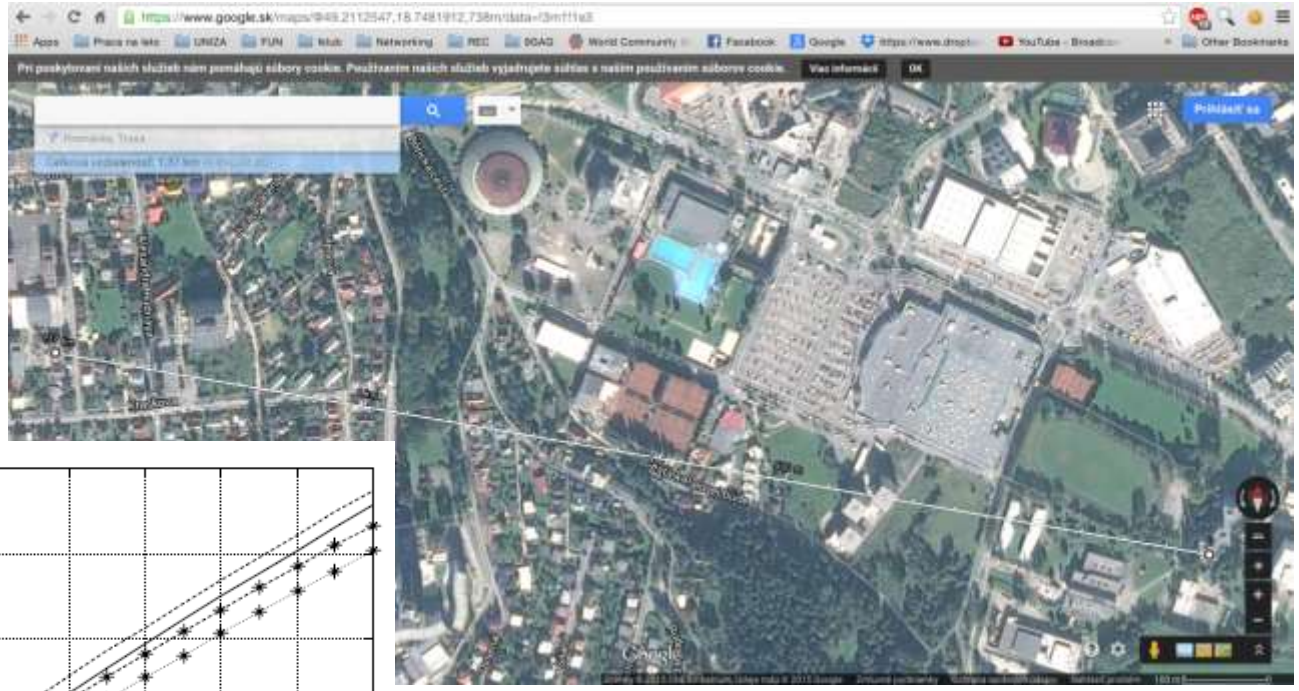


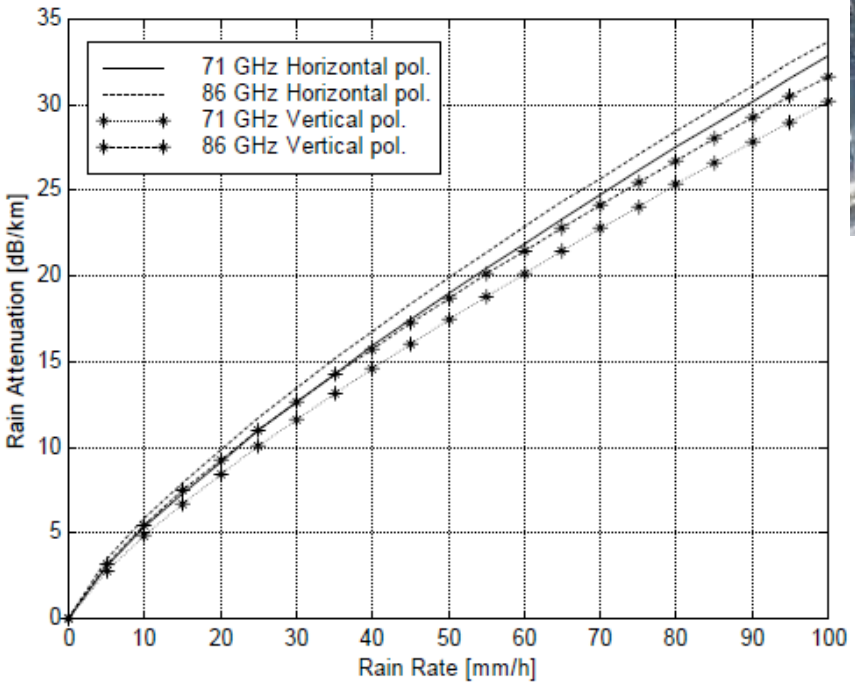
Mikrovlnný spoj Telco providera



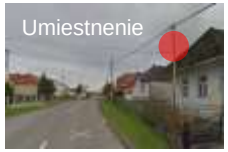
Vždy je potrebná **priama viditeľnosť** medzi dvoma anténami.

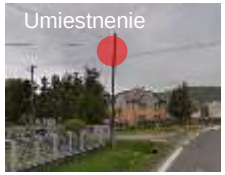
Mikrovlnný spoj 80GHz

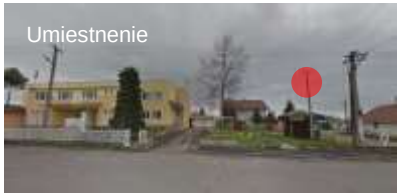




Mikrovlnný spoj pre Kamerový systém obce



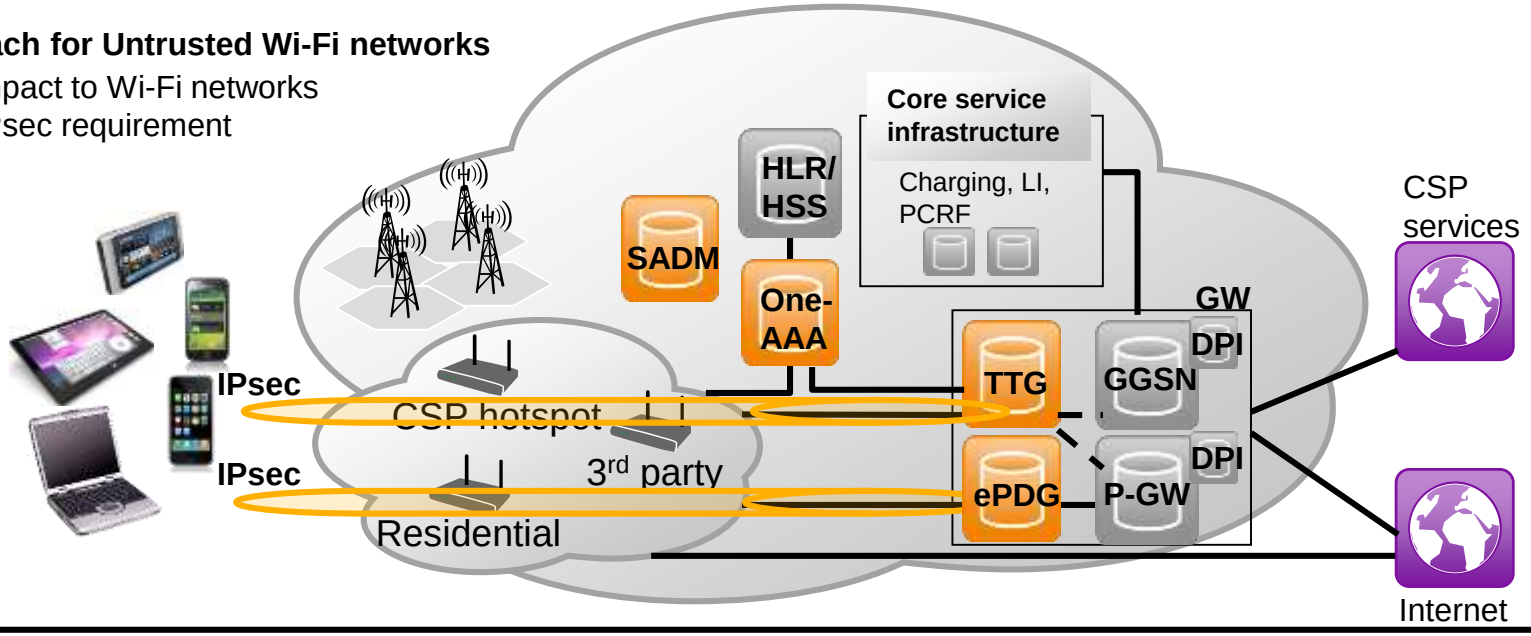




Approaches for Untrusted and Trusted Wi-Fi networks

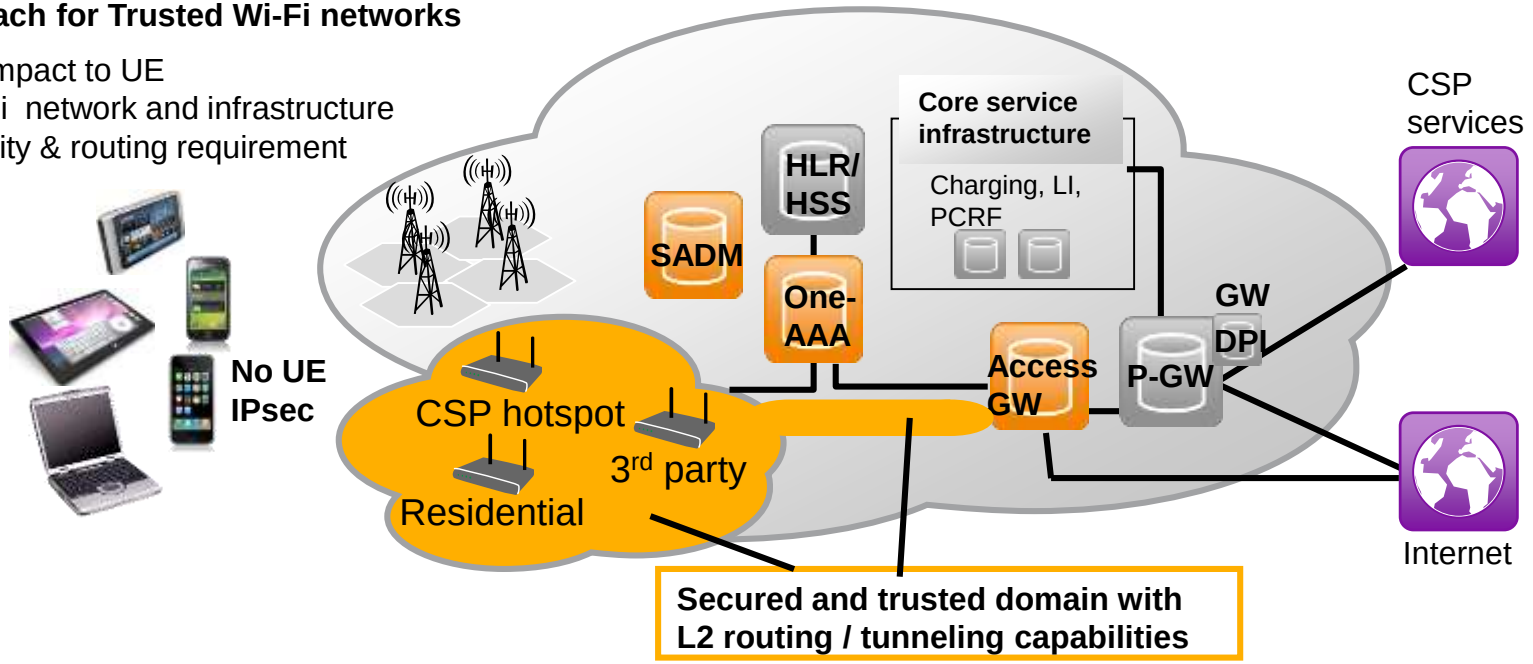
Approach for Untrusted Wi-Fi networks

- No impact to Wi-Fi networks
- UE IPsec requirement

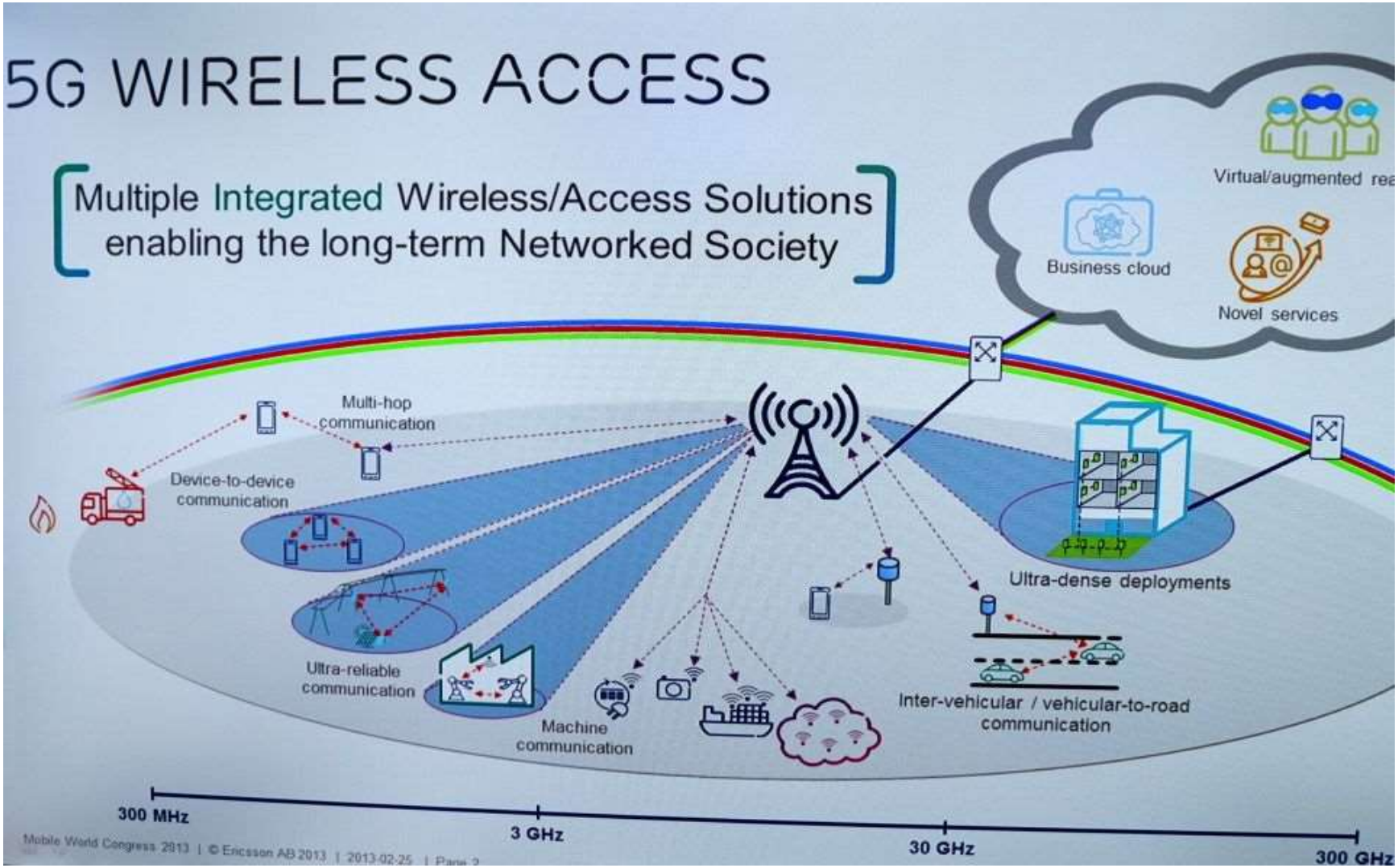


Approach for Trusted Wi-Fi networks

- No impact to UE
- Wi-Fi network and infrastructure security & routing requirement



5G WIRELESS ACCESS



FEATURE OF WIRELESS TECHNOLOGY