UNIVERSITAT POLITÈCNICA
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BARCELONATECH

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Wireless Laboratory

230689 - WLAB

Practice 2
Planning of 5G NR networks
Laboratory work

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1 Objectives

The objective is this case study is to carry out, using ATOLL, the planning and dimensioning of a 5G network in order to meet coverage and application / service performance requirements. The target service region is a 2x2 km2 area in Barcelona around the “Parc de la Ciutadella”.
This work includes decision making on the type of infrastructure to be deployed (macrocells and / or small cells) and their locations as well as the specification of the traffic demand maps based on the applications / services to be provided (e.g. connected car services on city streets, massive IoT services, celebration of social events gathering thousands of users at specific locations –open area concerts, demonstrations -, etc.).

The covered area is findable on figure 1. This representation takes into account vegetation, buildings and height.

Figure 1 – Area of interest

The expected results are as follows :

— Definition and description of the specific coverage and application / service performance requirements to be fulfilled (services / applications, distributions of users / terminals connected).

— Description of the deployment criteria adopted.

— Description of the deployed infrastructure and features (site locations, characteristics of transmitters, antennas, cell configuration - powers, numerologies, etc.).

— Achieved performance (predictions and simulations) vs requirements.

2 Model Design

2.1 performance requirements

2.1.1 Typer of users

The map is filled by standard and business users with the **performance requirements** of figure 2 and 3.

Service	Terminal	Calls/hour	Duration (sec.)	UL Volume (KBytes)	DL Volume (KBytes)
Broadband	5G Smartphone	0.05	65	10,000	50,000
Video Call	5G Smartphone	0.01	600		
Voice Call	5G Smartphone	0.2	240		

Figure 2 – Business profile requirement

Service	Terminal	Calls/hour	Duration (sec.)	UL Volume (KBytes)	DL Volume (KBytes)
Internet	5G Smartphone	0.1	70	2,000	15,000
Voice Call	5G Smartphone	0.2	240		

Figure 3 – Standard profile requirement

2.1.2 Number of users

Barcelona density population is fixed to 16 000 $\frac{people}{square\ meter}$(see *this link*). Then we fix the whole map density population to this number.
Furthermore we decide to separate this population density between 25% of business users and 75% of standard users leading to

1. Standard user density = 12 000 $\frac{people}{square\ meter}$
2. Business user density = 4 000 $\frac{people}{square\ meter}$

Finally, as an approximation we decide to apply this population density on whole the covered area.

2.1.3 Services

The service required in our case are Broadband, Internet, Video and voice calls with a throughput demand $\in [0; 10Mbps]$.

2.2 Radio Network Equipement definition

We first decided to place 3 sites on the map, each made of 3 transmitters. The antenna operate on the n78 band (3.5 GHz) with the beamforming parameters set to 64T64R 90deg 24dBi.

The transmitters full specifications are findable in figure 4.

Site	Azimuth (°)	Number of Transmission Antennas	Number of Reception Antennas	Noise Figure (dB)	Main Propagation Model	Main Resolution (m)	Frequency Band	Beamforming Model	Radio Access Technology	Carrier
Site0	0	64	64	5	Okumura-Hata	50	n78	64T64R 90deg 24dBi Low & Mid-bands	5G NR	50 MHz - NR-ARFCN 621667
Site0	120	64	64	5	Okumura-Hata	50	n78	64T64R 90deg 24dBi Low & Mid-bands	5G NR	50 MHz - NR-ARFCN 621667
Site0	240	64	64	5	Okumura-Hata	50	n78	64T64R 90deg 24dBi Low & Mid-bands	5G NR	50 MHz - NR-ARFCN 621667
Site1	0	64	64	5	Okumura-Hata	50	n78	64T64R 90deg 24dBi Low & Mid-bands	5G NR	50 MHz - NR-ARFCN 621667
Site1	120	64	64	5	Okumura-Hata	50	n78	64T64R 90deg 24dBi Low & Mid-bands	5G NR	50 MHz - NR-ARFCN 621667
Site1	240	64	64	5	Okumura-Hata	50	n78	64T64R 90deg 24dBi Low & Mid-bands	5G NR	50 MHz - NR-ARFCN 621667
Site2	0	64	64	5	Okumura-Hata	50	n78	64T64R 90deg 24dBi Low & Mid-bands	5G NR	50 MHz - NR-ARFCN 621667
Site2	120	64	64	5	Okumura-Hata	50	n78	64T64R 90deg 24dBi Low & Mid-bands	5G NR	50 MHz - NR-ARFCN 621667
Site2	240	64	64	5	Okumura-Hata	50	n78	64T64R 90deg 24dBi Low & Mid-bands	5G NR	50 MHz - NR-ARFCN 621667

Figure 4 – transmitters full specifications

The propagation model was defined to Okumura-Hata as the Aster propagation model led to simulation problems. The transmitters position is represented in figure 5.

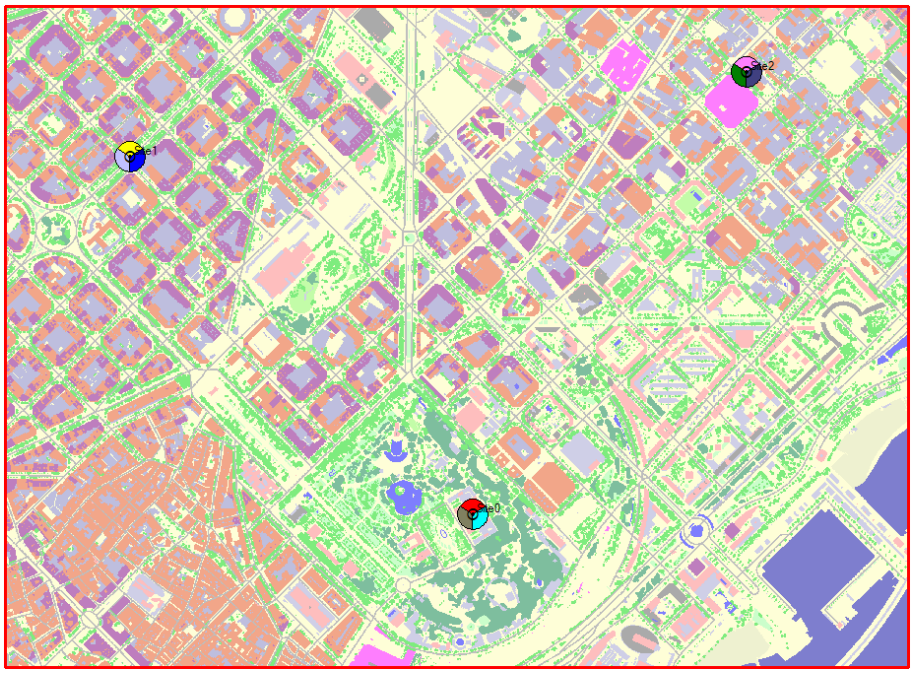

Figure 5 – Map with Transmitters

The goal of the next sections will then to check this disposition and make it evolve such that the requirements are full-filed if it is not the case.

3 Model Performances

3.1 Downlink - Uplink Coverage prediction

Based on the previously defined parameters, we get the following coverage predictions :

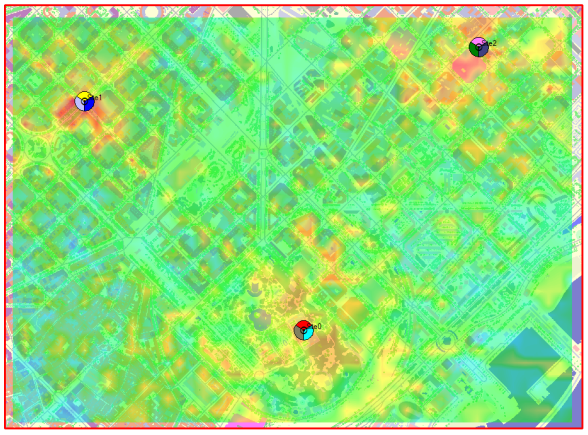

Figure 6 – Downlink Prediction Coverage

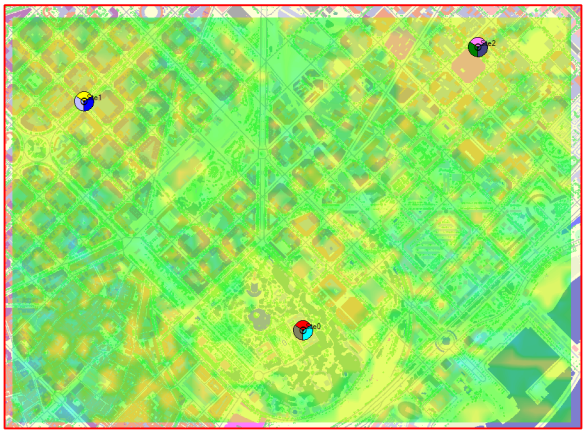

Figure 7 – Uplink Prediction Coverage

With the following legend :

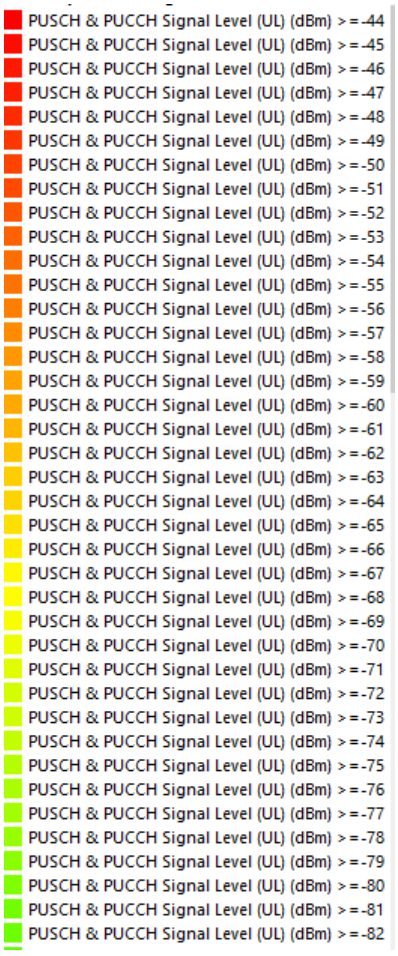

Figure 8 – Coverage Prdiction Legend

We see that the coverage as first seen looks good enough to launch a simulation.
We can then validate or not the requirements by the model.

3.2 Simulation

The simulation 1 demonstrates pretty good results with 97.8 % of the users connected. The demand and results are shown below : We can then launch more predictions to validate this simulation.

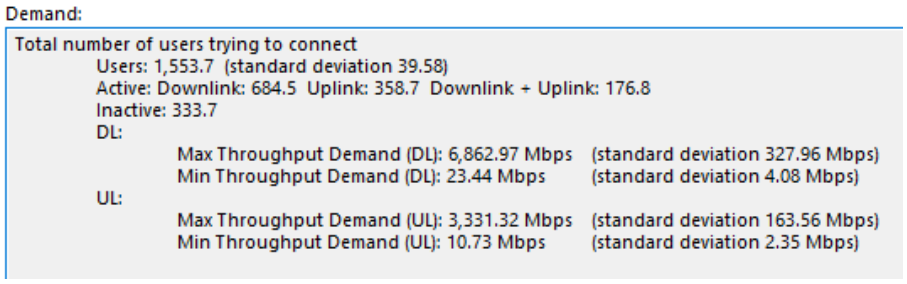

Figure 9 – Simulation Demand

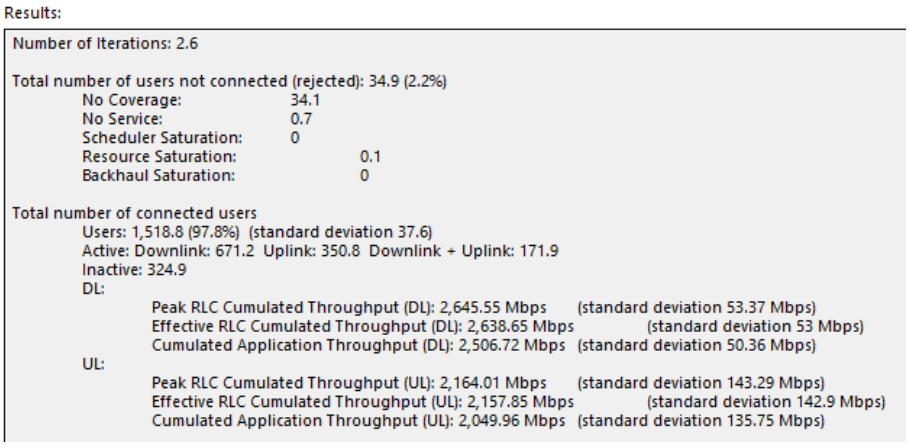

Figure 10 – Simulation Results

To go more into details, let´s look at the broadband throughput informations : We see that both in

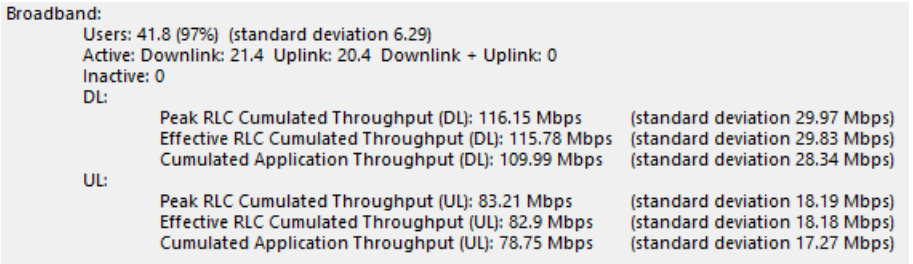

Figure 11 – broadband throughput

UL and DL the figures are good enough for our requirements.

3.3 Further predictions

All the following predictions are made for downlink as the uplink results are very close and evolve in the same way.

3.3.1 Quality Service

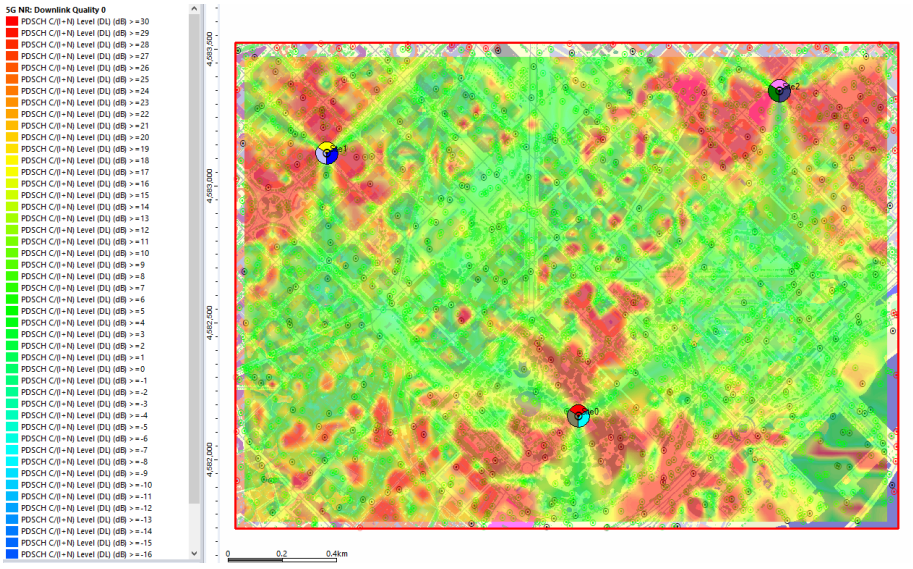

Figure 12 – Quality service prediction

3.3.2 Service Area

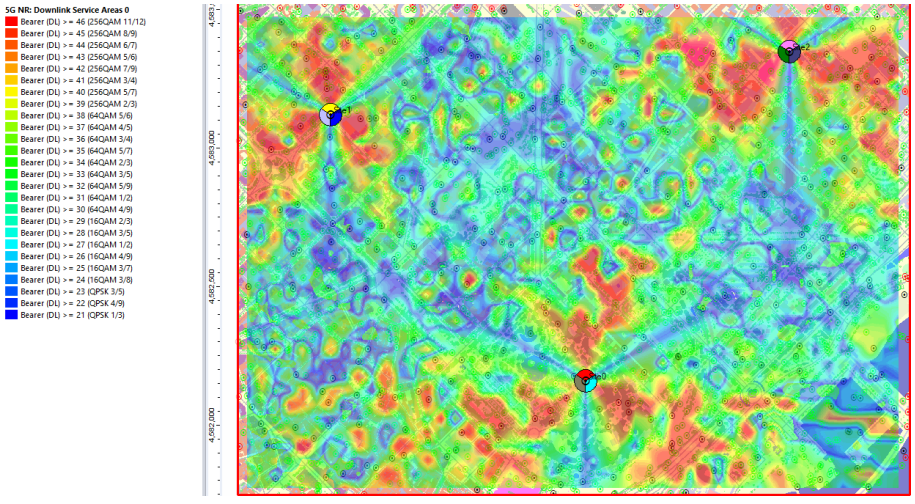

Figure 13 – Service Area prediction

3.3.3 Capacity

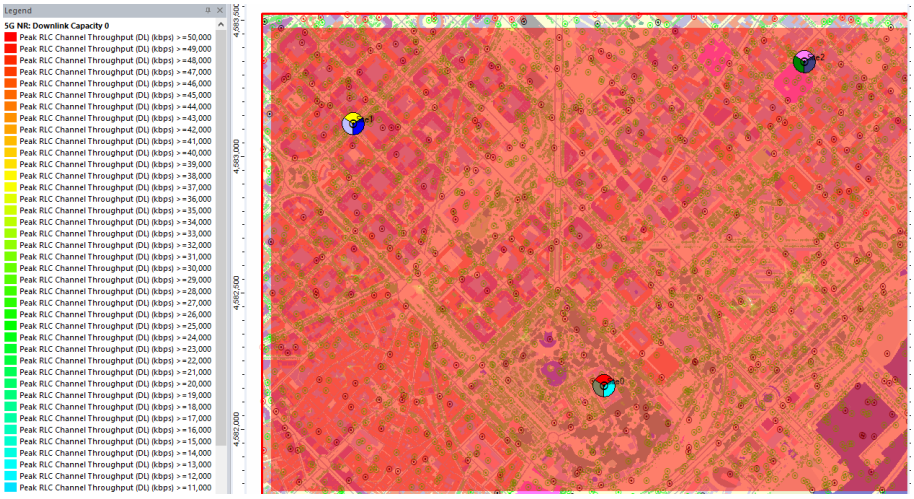

Figure 14 – Capacity prediction

3.4 Conclusion

All this predictions and simulations can let use conclude that there is no need of an enhancement of the transmitters features or locations.
Some pists of optimisations could be to optimise the relative location or number of transmitters.

4 Limit of the model

In this bonus section we will increase the population density by a factor 10 to simulate a day of big occupation and see to what value the mean percentage of connected users goes.

As shown on the figure 15, the mean percentage of connected users falls to 89.7 %, we then have a still good coverage unless this strong increase of population density.

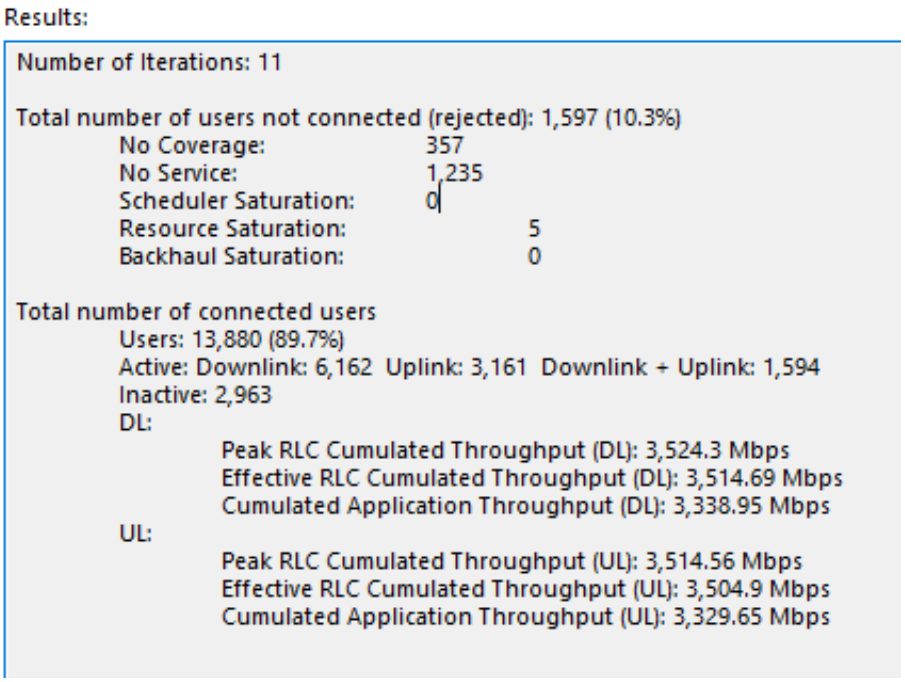

Figure 15 – Capacity prediction