Network Simulation and Implementation of 5G NR Network in Tarhounah City

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الملخص:

في الوقت الحالي لا يستطيع نظام الاتصالات المتنقلة من الجيل الرابع (G4) تلبية بعض المتطلبات الخاصة بما في ذلك كثافة حركة المرور العالية والعدد الكبير من الاتصالات والتنقل العالي. لذلك ، من المتوقع أن يبدأ تسويق ونشر أنظمة الاتصالات المحمولة من الجيل الخامس (G5) في عام 2020 لخدمات الهاتف المحمول الجديدة في ثلاث ميزات رئيسية ، وهي النطاق المتنقل المعزز ، والاتصالات الضخمة من نوع الماكينة ، والموثوقية الفائقة والمنخفضة. لذلك ، بناءً على البحث الأولي لتوحيد(G5)من قبل قادة صناعة الاتصالات منذ عام 2012 ، حدد الاتحاد الدولي للاتصالات وأعلن عن رؤية(G5) ومؤشرات الأداء الرئيسية بشأن كفاءة الطيف ، وكفاءة الطاقة ، ومعدل بيانات الذروة ، وكثافة حركة المرور ، والاتصال بالأجهزة ، والراديو زمن الوصول والموثوقية لتحقيق تقديم خدمة أكثر شمولاً وأفضل. في هذا السياق ، سيتم العمل الذي يبدأ بعرض تقديمي كامل عن الأجيال السابقة ، ثم نحدد جميع النقاط المهمة لهذه التكنولوجيا الجديدة بالإضافة إلى أهدافها ومراحل توحيدها من قبل الاتحاد الدولي للاتصالات و(GPP3)، التخطيط وتصميم شبكة المحمول(G5) باستخدام "Atoll ". يهدف هذا العمل إلى دراسة نشر G NR5 باستخدام أداة التخطيط اللاسلكي الاحترافية المسماة" Atoll" في مدينة ترهونة من خلال وضعها على شبكة G NR5.

Abstract:

At present, the fourth generation (4G) mobile communications system is not able to satisfy some special requirements including high traffic density, high number of connections and high mobility. So, it is anticipated that the Fifth Generation (5G) mobile communication systems will start to be commercialized and deployed in 2020 for new mobile services in three key features, namely، enhanced Mobile Broadband, massive Machine Type Communications, and Ultra-Reliable and Low Latency Communications. Therefore, based on the preliminary research for 5G standardization by telecom industry leaders since 2012, the International Telecommunication Union has identified and announced the 5G vision and Key Performance Indicators on spectrum efficiency, energy efficiency, peak data rate، traffic density, device connectivity, radio latency and reliability for achieving more comprehensive and better service provisioning. It is in this context will take place the work that begin with a complete presentation on the previous generations, we then define all the important points of this new technology as well as their objectives and their stages of standardization by the ITU and 3GPP, the planning and designing of the 5G mobile network using "Atoll ". This work is intended to study the deployment of 5G NR using the professional radio planning tool called Atoll in a region of Tarhounah City by placing it a 5G NR network.

Keywords: 5G NR ,MIMO. ATOLL, Beamforming

Introduction

The area of telecommunications has made great strides in the technological evolution of networks mobile devices and enabled the emergence of new devices and services. Radio signals used by 1G are transmitted in analog mode, and were not able to handle the traffic voice in digital mode. During the 1990s, the second generation of mobile networks marked a breaking point with the previous technology due to the digital system introduced by the GSM standard (Global System for Mobile Communication), which has enabled the creation of new data transmissions. After that, mobile communications experienced rapid development of a new generation on a global scale in the early 2000s called: 3G including the international standard is the UMTS (Universal Mobile Telecommunications System) which has made it possible to provide better quality of service and paved the way for new multimedia applications and uses in particular, video telephony and internet access, which marked the advent of smartphones. In 2010, the fourth generation of switchboards was born, based on all IP, its deployment uses the LTE (Long Term Evolution) standard, which has improved the capacity of the system and user experience. However, these technologies are now reaching their limits. Through example in terms of coverage, capacity and complexity of infrastructures (Chapman T., Larsson E. et al. (2015)).The introduction of 5G will significantly increase capacity in terms of data transmission, and development of new digital services. What brought telecommunications operators and industry experts to engage in research and development of this new network.5G networks represent a revolution in the field of mobile communication since they open the door to new fields of application, in particular in the field of the Internet of Things, machine-to-machine communications, ultra-wideband applications, autonomous cars… etc. The object of my work is that I have chosen some areas of Tarhounah city as case study and we will plan, design a cell sites for emerging 5G Networks. The main purpose of the planning is fewer base stations per network, greater system efficiency and capacity, improved voice quality and a reduction or elimination of interference and multipath problems. All of which result in improved services and greatly reduced network cost. Ensuring that the RF coverage is sufficient within the network should start naturally with a good RF network plan(ITU-R (2015)).

Background

Mobile Communication Systems

The telecommunication industry is seeing rapid growth in the last few decades. The wireless mobile communication standards are the major contributors. This growth has seen many generations from 1G, 2G, 3G, 4G and 5G,as show in figure 1 (ITU-R (2015)).

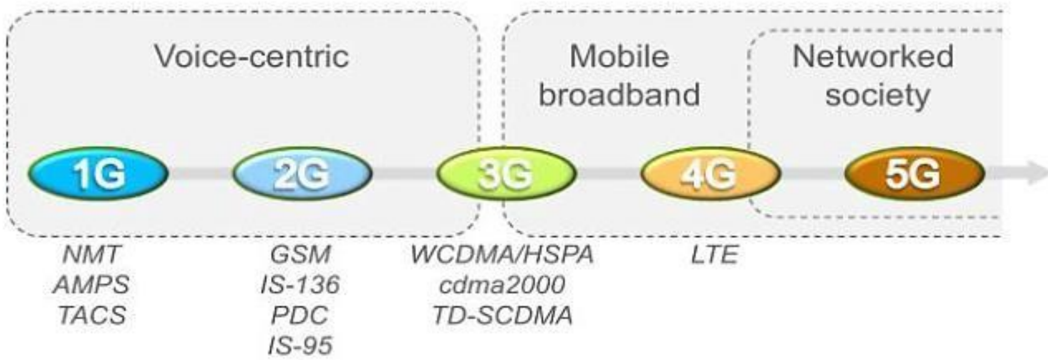


Figure 1: Mobile Communication Systems

First Generation Mobile Communication System

Nippon Telephone and Telegraph Company (NTT) in Tokyo deployed the first generation of mobile network in Japan during 1979. In the beginning of 1980s, it gained popularity in the US, Finland, UK and Europe. This system used analogue signals and it had many disadvantages due to technology limitations

Second Generation Mobile Communication System

Second generation of mobile communication system introduced a new digital technology for wireless transmission also known as Global System for Mobile communication (GSM). GSM technology became the base standard for further development in wireless standards later. This standard was capable of supporting up to 14.4 to 64kbps (maximum) data rate, which is sufficient for SMS and email services. Code Division Multiple Access (CDMA) system was also introduced and implemented in the mid 1990s. CDMA has more features than GSM in terms of spectral efficiency, number of users and data rate (ITU-R (2014)).

Third Generation Mobile Communication System

3G Third generation mobile communication started with the introduction of UMTS – Universal Mobile Terrestrial / Telecommunication Systems. UMTS that support video calling for the first time on mobile devices, after the introduction of 3G mobile communication system, smart phones became popular across the globe. Specific applications were developed for smartphones, which handles multimedia chat, email, video calling, games, social media and healthcare.This generation set the standards for most of the wireless technology. Web browsing, email, video downloading, picture sharing and other Smartphone technology were introduced in the third generation. Introduced commercially in 2001, the goals set out for third generation mobile communication were to facilitate greater voice and data capacity, support a wider range of applications, and increase data transmission at a lower cost (ITU-R (2014)).

Fourth Generation (4G)

LTE (Long-Term Evolution) technology is a specified standard used by the organization 3GPP standardization to improve the UMTS standard of 3G cellular networks, towards fourth generation, to cope with technological developments. It was developed from start for packet data support and has no support for switched voice from circuit, unlike 3G where HSPA was an "add-on" to provide packet data high performance on top of existing technology. Mobile broadband services were the center of attention, with strict requirements on high data rates, low latency and high capacity(Dahlman E, Parkvall S.& SKLD J.(2018)). There are three ways to increase data speed and improve the network: improving the efficiency of the system, using new technologies like in 5G and increasing the frequency.The following table1 summarizes the main characteristics of 4G networks compared to new 5G networks(Dahlman E, Parkvall S, Skld J.(2016)).

Table 1: Comparison of 4G and 5G technologies.

Specification	4G	5G
Data rate (rate perceived by user) and peak flow (throughput)	The average 25 Mbps Peak 300 Mbps	100 Mb /s on average 20 Gb /s peak
Latency	~10 – 50 ms	~1 ms
Spectral efficiency	DL – 6 bits/Hz UL- 4 Bits/Hz	X3 better DL-30 bits/Hz UL-15 bits/Hz
User density	~ 2000 users / square Km	~ 1million user / square Km
Energy efficiency	Moderate	x100 better
The services offered	MBB	eMBB ,mMTC and URLLC

5G NR Model

The fifth generation of the wireless access technology is known as 5G New Radio (5G NR) and it has been developed by the Third-Generation Partnership Project (3GPP) over the past years with the goal to address a variety of scenarios to be enabled by future enhanced mobile technologies. 5G NR presents many improvements when compared to LTE, the previous radio access technology, some of improvements are:

- The operation on higher frequency bands, aiming to use wider transmission bandwidths and, therefore, higher data rates.
- Its ultra-lean design reduces the amount of “always-on” signals, enhances the energy efficiency and reduces the interference.
- The forward compatibility allows 5G NR to prepare for future use cases and technologies by maximizing the time/frequency resources that can be flexibly utilized.
- Latency decrease up to 1 ms.
- Extensive use of beamforming and massive MIMO used for both control and user plane (ITU-R (2014).

Massive MIMO

MIMO systems are an integral part of current wireless systems, and in recent years they have been used extensively to achieve high spectral efficiency and energy efficiency. Before the introduction of MIMO, single-input-single-output systems were mostly used, which had very low throughput and could not support a large number of users with high reliability. To accommodate this massive user demand, various new MIMO technology like single-user MIMO (SU-MIMO), multi-user MIMO (MU-MIMO) and network MIMO were developed. Standard MIMO networks typically use two or four antennas to transmit data and the same number to receive them.Massive MIMO increases the number transmitting antennas (tens or more than 100 elements) on a base station as shown in figure 2 (ITU-R (2017)).

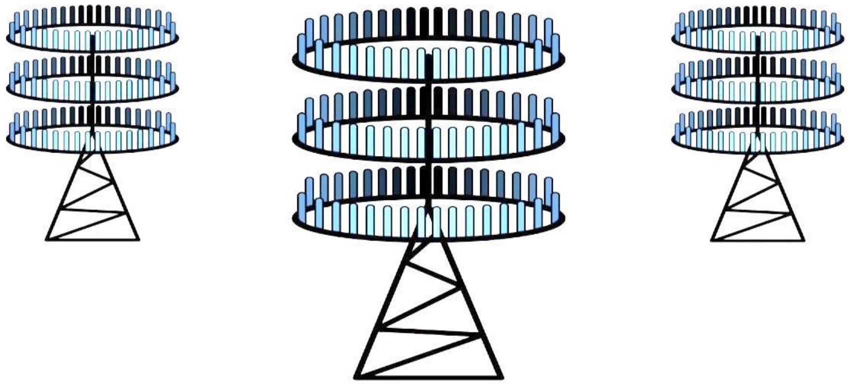


Figure 2: Massive MIMO

Small Cells

The 5G small cells are low power mini base stations spread across the region to be served. They are basically low power wireless APs (Access Points) which operate in licensed spectrum. They are managed by telecom operators. Due to their small sizes, they can be installed easily in indoor places and space constrained places. Hence, they help in improving the cellular coverage and to fill coverage holes. Small cells are available throughout the region to be served and hence they maintain quality of the signal everywhere. Small cells receive the 5G signal from main NB and relay the same to users. When the user moves behind the obstacle, the cell phone automatically switches to mini Bas station i.e. small cell to keep the connection intact. This helps 5G users to avail uninterrupted 5G network coverage. The figure 3 depicts the typical installed 5G network of small cells along with main 5G-NB (or 5G Base Station(Benosman. R.. Sidhoum. A.(2013)).

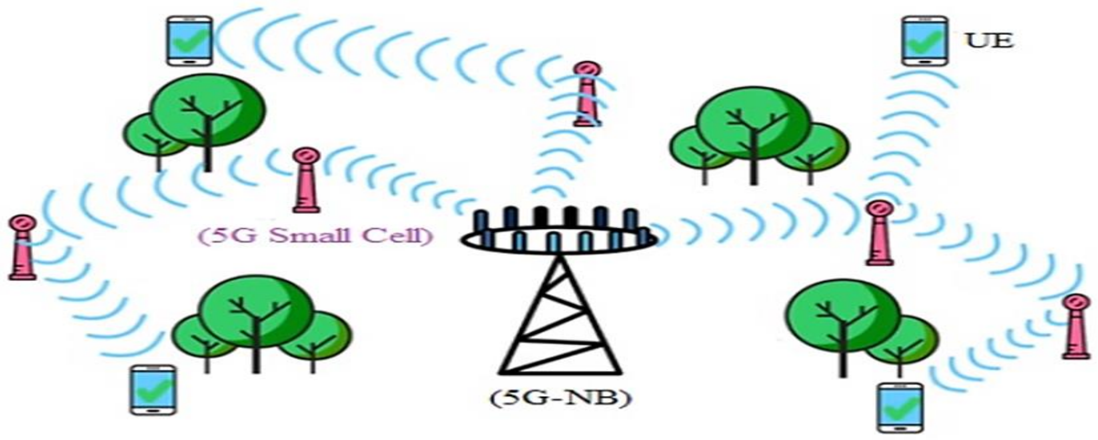


Figure 3: 5G network of small cells along with main 5G Base Station

5G NR Model Link budget

The link budget is the calculation of the gain and the total loss in the system to conclude the received signal level (RxSL) at the receiver (UE). The level of the received signal is then compared to receiver sensitivity (RxS) to check whether the channel status is good or bad. The channel status is "Pass" if the level of the received signal (RxSL) is better than the sensitivity of reception (RxS), otherwise it is "Fail". Figure 4 shows some examples of values for illustrate the different input parameters used for the calculation of the link budget (ITU-R(2017).

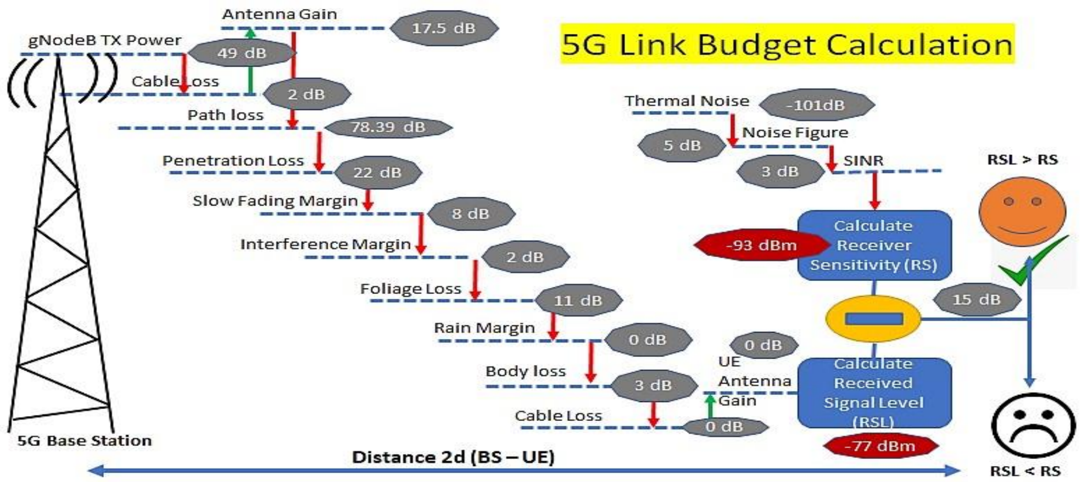


Figure 4 : 5G NR link budget

Predictions and Simulations

Atoll provides a comprehensive and accurate modeling of 5G NR and LTE networks. It supports all frequency bands and carrier widths along with detailed OFDMA frame structure modeling. All downlink control signals, and control and traffic channels are modeled. Atoll supports intra-band and inter-band carrier aggregation and coordinated multipoint transmission and reception (CoMP).Atoll also includes comprehensive modeling of different MIMO techniques (diversity, SU-MIMO, MU-MIMO) and beamforming smart antennas(Forsk (2019) . To design the network, Atoll presents the possibility to model several parameters along with equipment. In this configuration, there are three main layers to take into consideration, the sites configuration, the transmitters configuration and equipment and finally the cells configuration . Atoll determines the serving cell for each pixel using the standard cell selection mechanism. Then, depending on the prediction definition, it calculates the required effective signal or parameter. Pixels are colored if the display threshold condition is fulfilled(Forsk(2018)).In case of a 5G network, Atoll manages the 5G resources as depicted in the following scheme.

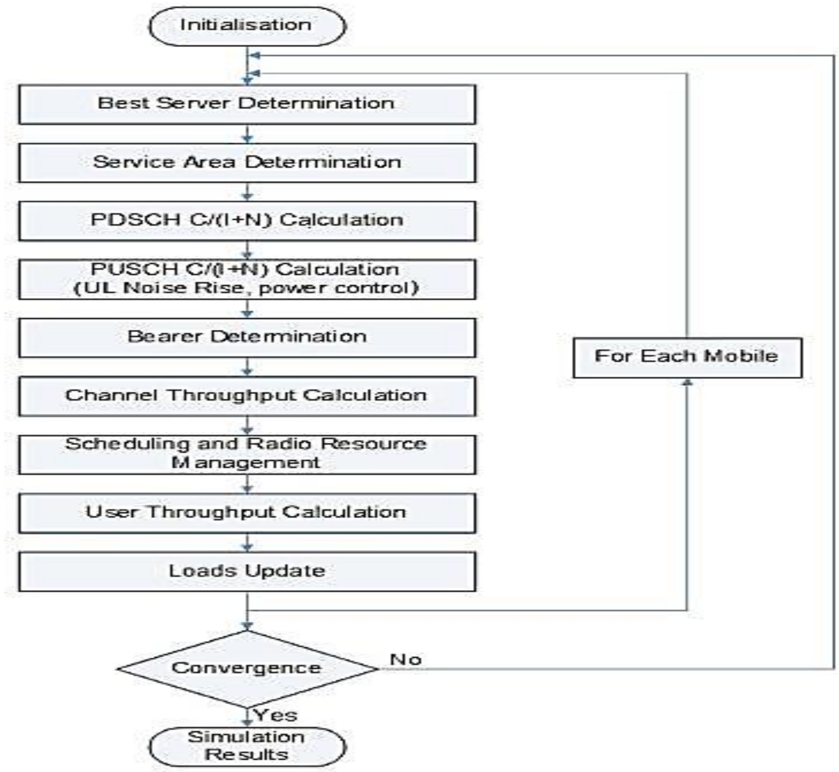


Figure 5: 5G simulation algorithm scheme.

Design targets requirement for the 5G NR Network will be evaluated to validate the target network Requirement. Some signal values for the 5G NR and its level and evaluation of these signals shown below.

Table 2: 5G RSRP Parameters.

Range	RSRP (dBm)		
	- 40 to -150		
	mmWave	Sub 6 GHz	Sub 1 GHz
Excellent	>= - 90	>= - 70	>= - 60
Good	-90 to -110	- 70 to -100	- 70 to -90
Average	-110 to -130	-100 to -120	- 90 to -110
Poor	< -140	< -140	< -140

Table 3: 5G RSRQ Parameters.

Range	RSRQ (dB)		
	- 40 to 20		
	mmWave	Sub 6 GHz	Sub 1 GHz
Excellent	>= - 10	>= - 10	>= - 10
Good	-12 to -10	-12 to -10	-12 to -10
Average	-16 to -12	-16 to -12	-16 to -12
Poor	< -16	< -16	< -16

Table 4: 5G SNR Parameters.

Range	SNR (dB)		
	- 40 to 20		
	mmWave	Sub 6 GHz	Sub 1 GHz
Excellent	>= 15	>= 15	>= 15
Good	10 to 15	10 to 15	10 to 15
Average	5 to 10	5 to 10	5 to 10
Poor	< 5	< 5	< 5

Coverage Prediction by Transmitter

Coverage prediction by transmitter allows prediction of coverage areas by transmitter in each pixel. Predicts the maximum area a base station can cover. The extent to which transmitters have been placed is shown in the coverage of the transmitter map in Figure 6. When we create a transmitter, ATOLL automatically creates a cell for the transmitter using the configuration parameters. For a transmitter with more than one cell, the coverage is calculated for the cell with the highest power. For coverage forecast by transmitter Once you have created a coverage forecast, you can calculate it to save the selected coverage forecast. A first study finds out the area that covers each cell.

Figure 6: 5G Coverage by transmitters.

Coverage Prediction by Signal level

Coverage is defined as the ability to obtain a service with specific network requirements in signal quality conditions. Predicting coverage by signal level allows us to predict coverage by the signal strength of the transmitter within the calculation area. The signal level in the cell handles the highest signal strength of the best server in the studied area. Accordingly, coverage prediction results are shown in Figure 7 and the target area is covered by a strong signal i.e. -70 dB near the sites and -100 dB away from the center of the site. This signal prediction result has acceptable coverage as we can see from the simulation the result below. The coverage of each site is indicated by different colors according to the reception The signal level is measured in decibels.Coverage analysis is based on prediction of the SS-RSRP and SSS (DL) signal level in the downlink. For each site, the percentage of the calculation area covered by SS-values of RSRP and SSS above a certain threshold was calculated. Figure 7 shows the expected DL coverage for the 3.5 GHz (sub-6 GHz) and 26 GHz (millimeter frequencies) bands. DL coverage of the 3.5 GHz and 26 GHz bands is measured by the synchronization-reference signal-receipt power (SS-RSRP).

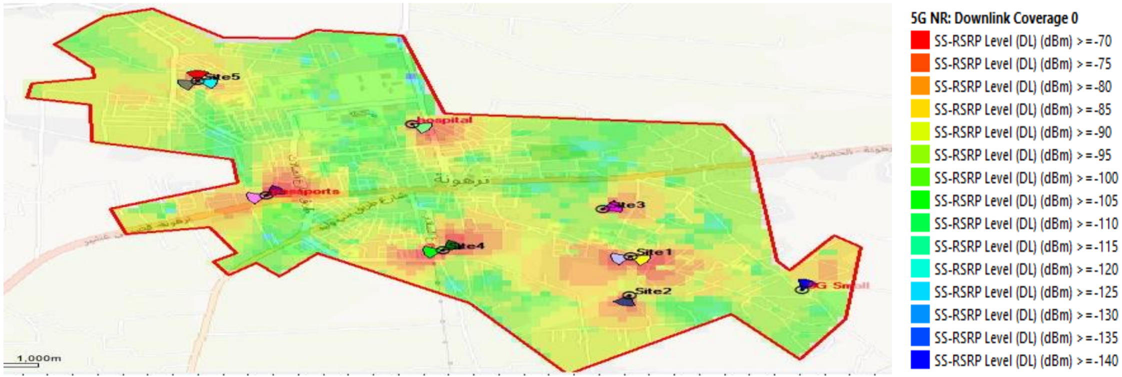


Figure 7: DL RSRP Coverage.

The picture shows that the coverage is excellent in most places, where the percentage of the received signal ranges from 70 close to the center of the site and the farther away the signal is 100, as the lowest signal to receive is 140 ,Figure 8 and 9 shows.

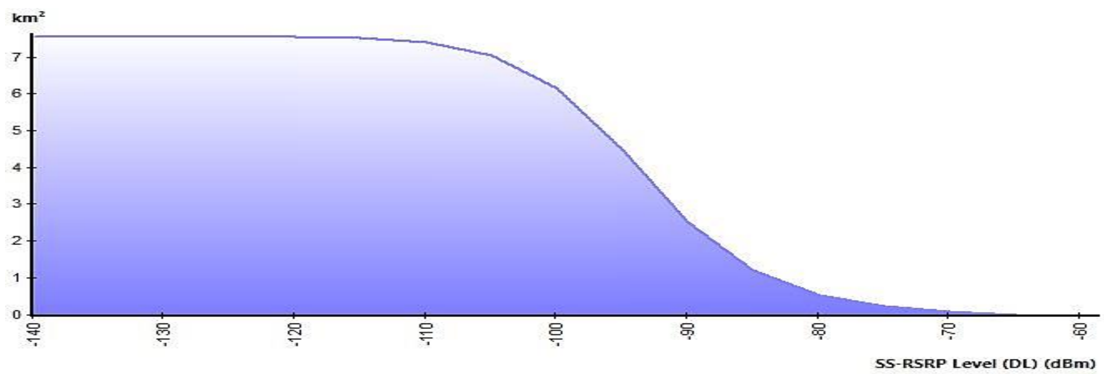


Figure 8: SS-RSRP CDF by covered area

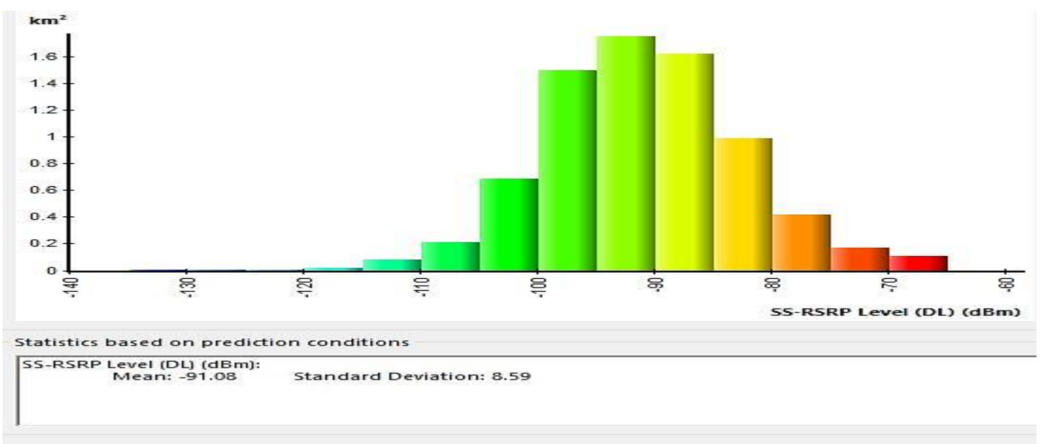


Figure 9: Histogram of Signal Level

Coverage Prediction on Overlapping Zones

Another anticipation of coverage performed on the selected region is overlapping regions, meanwhile cells are considered overlapping. The overlapping region occurs frequently in mobile networks and can reduce the quality of the network, particularly the region in which it occurs. The overlapping region is the presence of several regions in which the cell is dominant (best server), but this is outside the normal coverage area. It is mainly caused by antennas located in the upper and lower regions, but also by reflections in the environment. Hence, large overlapping regions reduce performance. The best server prediction for 5G is shown in Figure 10. As a condition for this indicator from Figure 11, the area is defined as the proportion of 4 or more servers that must be less than 2% which 1.2 % and the area as 1 or the number of servers must be more than 35% which 88.4 %.

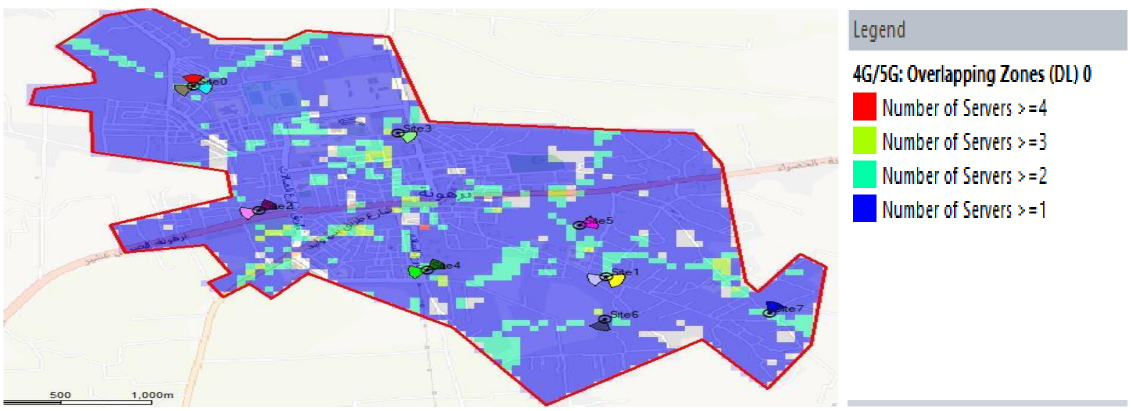


Figure 10: Coverage Prediction by Overlapping Zones

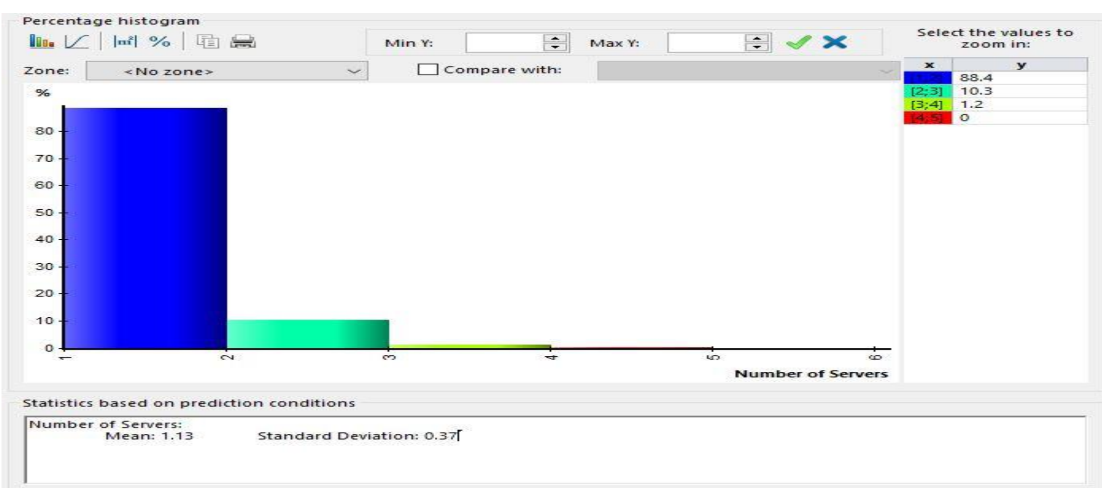


Figure 11: Histogram of Overlapping Server

5G Coverage Prediction by SNR

Coverage predictions by SNR level assess the levels of interference and signal-levels of interference in the target network under study. This indicator allows analysis of the signal quality profile, by calculating the ratio between received power, interference and noise. Figure 12 shows the coverage prediction with a SNR value from the simulation result obtained by ATOLL when the transmitter power is 50 dBm.

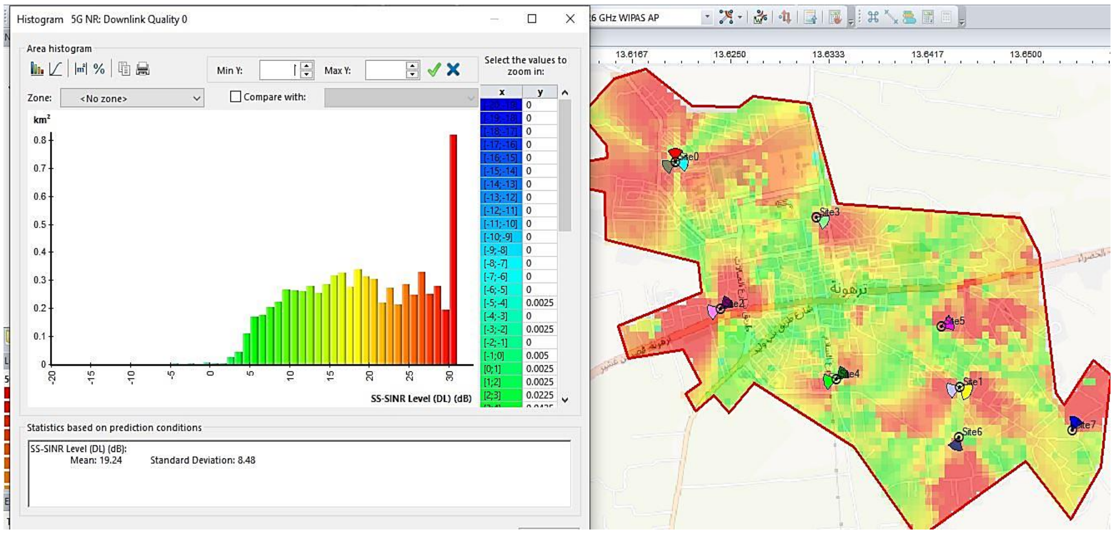
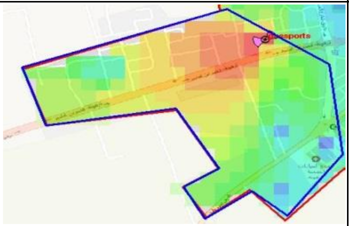
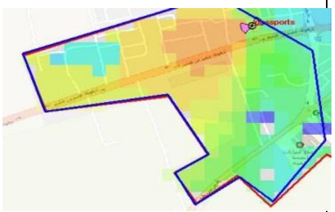


Figure 12: Coverage by C/ (I+N) Level Downlink

Comparison of Coverage between 3.5 and 26 GHz Millimeter Frequencies

A second study was performed in order to compare the coverage plot of the sites represented in Table 5.6 In addition to the 26 GHz band, predictions examining the use of the 3.5 GHz band were also considered for the same comparison. In general, it can be seen that the covered area is higher in all values for the 3.5 Now focusing on numerical values, Table 5 provides a summary of the amount of area covered (in km2) for each site at both 3.5 GHz and 26 GHz for different levels of SS-RSRP.In Site passports that corresponds to the site pointing to an urban area, the amount of covered area with High levels of signal is on average higher with the site in 3.5 GHz than that corresponding to 26 GHz.In Site 5G Small that corresponds to the site pointing to a dense urban area, the amount of covered area with High levels of signal is on average higher with the site in 3.5 GHz than that corresponding to 26.In the both sites, the amount of covered area with better level of signal (SS-RSRP ≥ -140 dBm) is around four times higher with the site in 3.5 GHz than that corresponding to 26 GHz.Table 6 show Results of the SS-RSRP simulation based on coverage area. It is important to analyze a case with better level of signal, taking the case of SS-RSRP. Table 7 show Statistical Calculation SS-RSRP Parameters GHz case.

Table 5: Downlink coverage SS-RSRP predictions per each site.

<table>
<tr><th>Site</th><th>3.5 GHz</th><th>26 GHz</th><th>Legend</th></tr>
<tr><td>passports</td><td></td><td></td><td rowspan="2">
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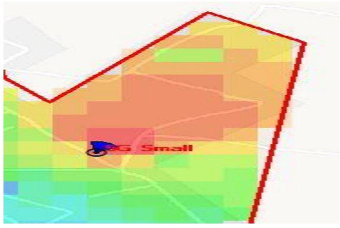
<tr><td>5G Small</td><td></td><td></td></tr>
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.Table 6: Downlink coverage SS-RSRP.

	SS-RSRP		Percentage %	Area (km2)
7.55 (km²)		70-85 dBm	22.25	1.681
		85-100 dBm	64.46	4.865
		100-115 dBm	12.89	0.973
		115-130 dBm	0.37	0.028
		130-140 dBm	0.03	0.003

Table 7: Statistical Calculation SS-RSRP

Raster Statistic	Value (dBm)
Minimum	-140
Maximum	-70
Mean	-95

The average SS-RSRP obtained from the prediction using 8 sites with 12 of gNodeB was -91.08 dBm. This means that the signal strength is very good in the previous technology (5G). Meanwhile, this study showed SS-RSRP with a minimum value of -140 dBm and a maximum value of -70 dBm.

Capacity Analysis

In this study, ATOLL downlink and uplink throughput plotters calculate the downlink and uplink data rate and cell capabilities.The prediction calculated to evaluate the capacity is Peak RLC channel throughput (DL) (kbps), which is the maximum RLC channel throughput attainable using the highest bearer available at the subscriber location in the downlink. The configuration in the cells is set to 100% for TDD DL OFDM Symbols and 100 % for Traffic load DL.Figure 13 and 14 show the prediction result for uplink and downlink effective radio link throughput.

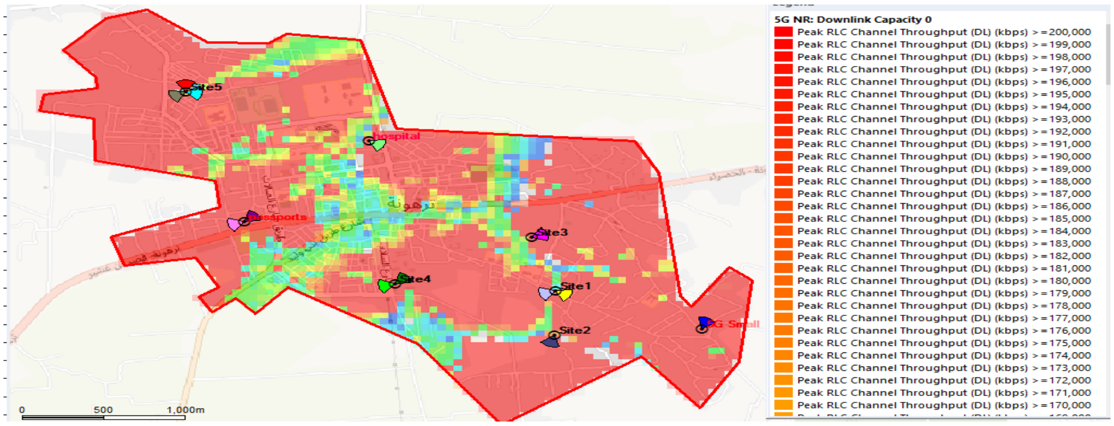


Figure 13: DL Throughput Predictions

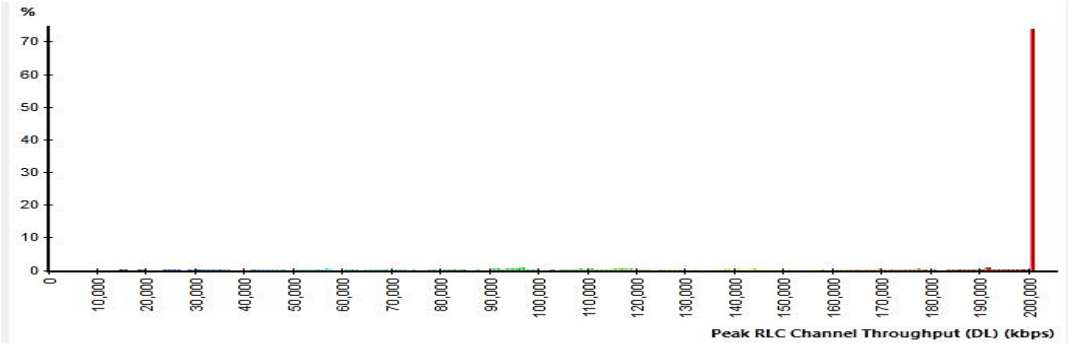


Figure 14: Histogram of Data Throughput

Table 8: Statistical Calculation Data Rate Parameters

Raster Statistic	Value (Mbps)
Minimum	20
Maximum	250
Mean	120

Results of the data rate simulation based on coverage area can be seen at Table below.

Table 9: Simulation Results of Data rate

Data Rate Value	Percentage %	Color
250_200 Mbps	73.78	
200_150 Mbps	6	
150_100 Mbps	8.88	
100_50 Mbps	7.83	
50_10 Mbps	3.18	

The average data rate obtained from the prediction using 8 sites with 12 of gNodeB was 240 Mbps. This means that the data rate is good in the previous technology (5G). Meanwhile, this study showed SS-RSRP with a minimum value of 20 Mbps and a maximum value of 250 Mbps.

Comparison in Data Transfer Speed between 3.5 GHz And 26 Ghz

The bandwidth of the carrier is set to 100, 60 and 80 MHz for 3.5 GHz and 400 MHz and 200 MHz for 26 GHz.The following image shows the data transfer rate at the specified location (Site 5) for both frequencies, as show in figure15.

Figure 15: Downlink Capacity predictions for the university site with its computation zone the left (3.5 MHz) and the right (26 GHz).

A representation of the capacity plot for site 5 is represented in Figure 15. In addition to the 26 GHz band, predictions considering the use of the 3.5 GHz band have been also accounted for the same of comparison. we using the Peak RLC channel throughput (DL), which is the maximum RLC channel throughput attainable using the highest bearer available at the subscriber location in the downlink and even with beamforming there are some areas on the map that are not covered or not assigned to a modulation scheme.It provides the maximum data rate value that is 500 Mbps, with subcarrier spacing of 15 kHz, 64QAM as maximum modulation and 100, 80, 60 MHz of bandwidth for **3.5 GHz**. And for **26GHz** with subcarrier spacing of 120 kHz, 256 QAM as maximum modulation and 200, 400 MHz of bandwidth for.

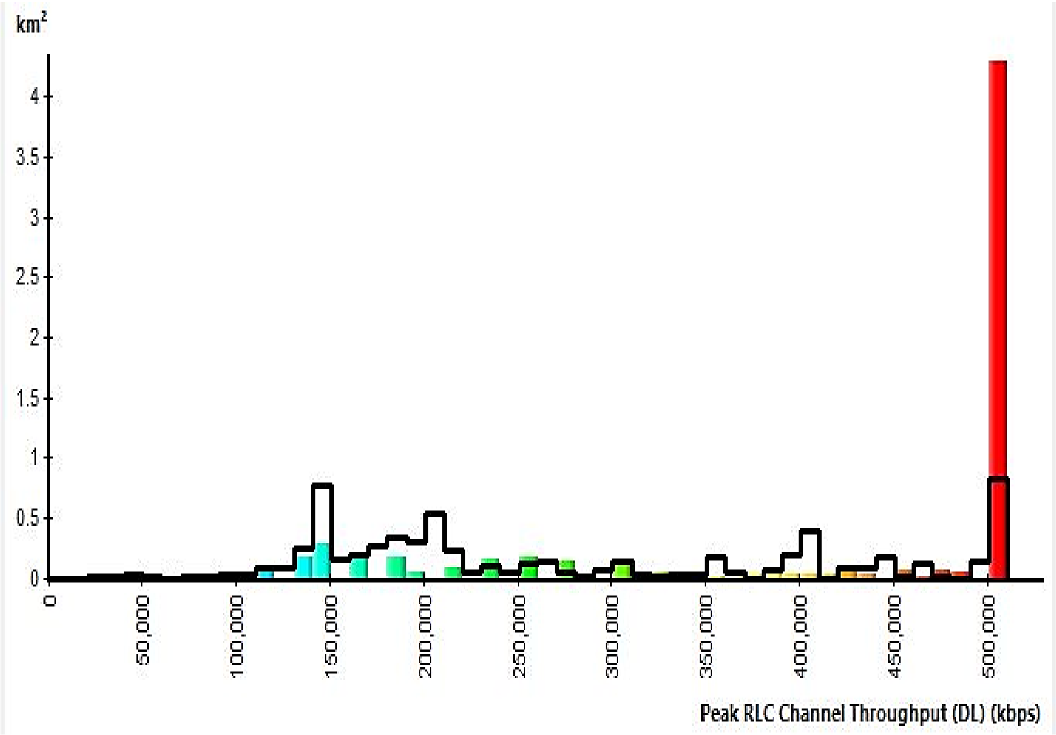


Figure 16: Comparison of Throughput between low frequencies in black and millimeter high frequencies in color

Figure 16 shows graphically how the site in **26 GHz** have higher covered area with all the capacities than **3.5 GHz** Because of its high channel width.

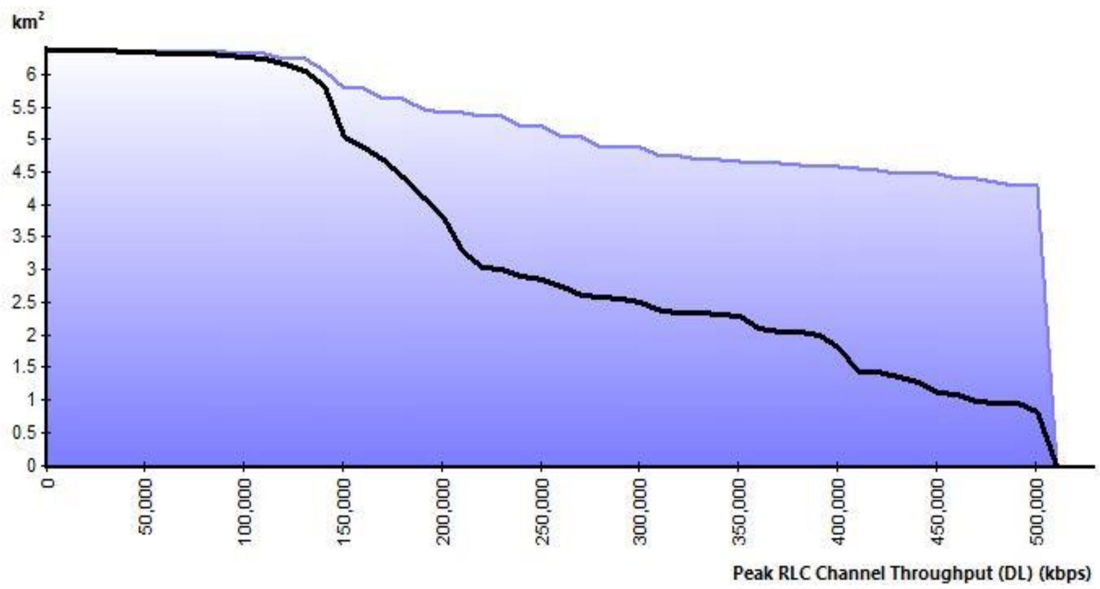


Figure 17: Distribution of peak cell capacity for the site in different frequency bands and channel width.

In figure 17 the Curve in **black** correspond to peak capacity of 3.5 GHz with Max channel width of 100 MHz and the colors correspond to peak capacity of 26 GHz with Max channel width of 400 MHz.

Impact of Beamforming Features on 5G Radio Planning

The analysis of capacity predictions has been done for different beamforming configurations. We compare the behavior in macro cell scenarios, in which the transmitter is configured with and without beamforming, working in the 26 GHz band with 200MHz carrier bandwidth. When the transmitter configuration is set to the option ‘Without Beamforming’, a specific antenna must be chosen. In this study, the 70deg 17dBi 3Tilt antenna has been selected.

Impact of Beamforming Features on 5G Radio Planning

The analysis of capacity predictions has been done for different beamforming configurations. We compare the behavior in macro cell scenarios, in which the transmitter is configured with and without beamforming, working in the 26 GHz band with 200MHz carrier bandwidth. When the transmitter configuration is set to the option ‘Without Beamforming’, a specific antenna must be chosen. In this study, the 70deg 17dBi 3Tilt antenna has been selected.

Table 10: Beamforming Antenna Parameters.

Parameters	Beamformer	Beamformer 2
Columns (N)	8	16
Rows (M)	8	16
Transmission ports	64	64
Reception ports	64	64
Azimuth range	-45º to 45º	-45º to 45º
Tilt range	-5º to 5º	-5º to 5º
Boresight gain (dB)	26.0618	26.0412

First, the Cell scenario has been studied. The site 5 has been selected to do the current capacity analysis. In table 11, it is noticeable that the covered area is lower when an antenna without beamforming is used. Also, the site, when antenna with default Beamforming configuration is used, has almost all higher values of covered areas for each capacity values than the other configurations, and it has the highest values in the better capacity values.

Table 11: Downlink Capacity predictions using different beamforming configurations

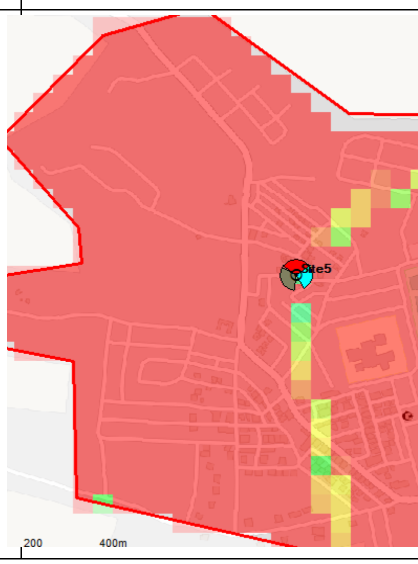
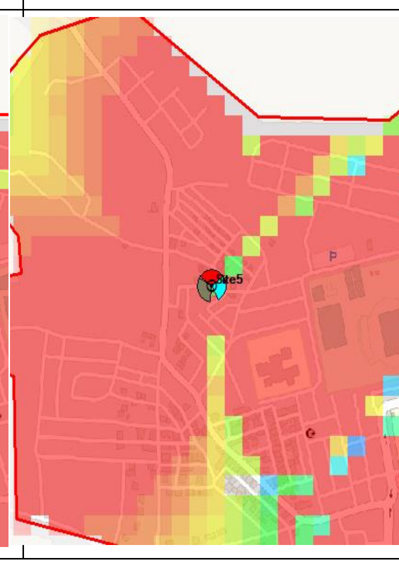
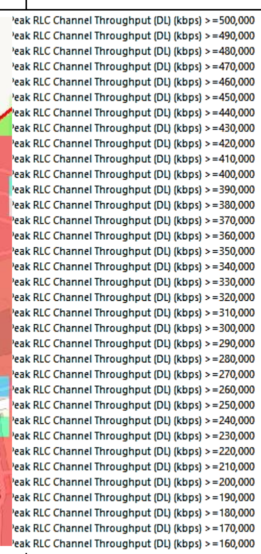
Type	With Beamforming	without Beamforming	legend
			

Figure 18 and 19 shows graphically how the site with beamforming has higher covered area with all the capacities than in case without using beamforming.

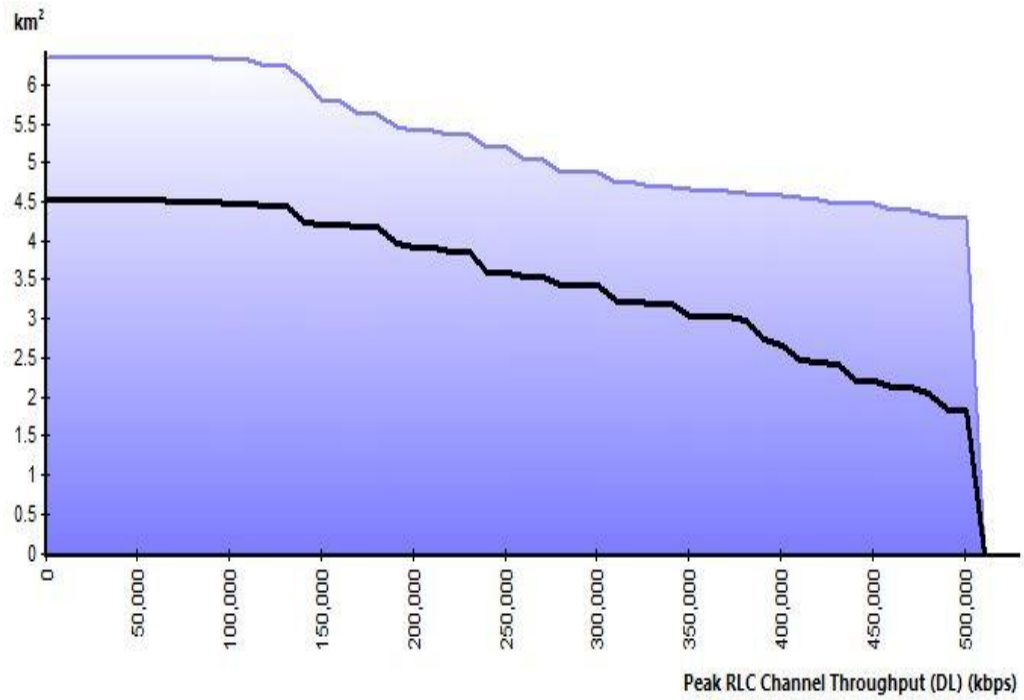


Figure 18: Downlink Capacity using default beamforming and without beamforming configurations.

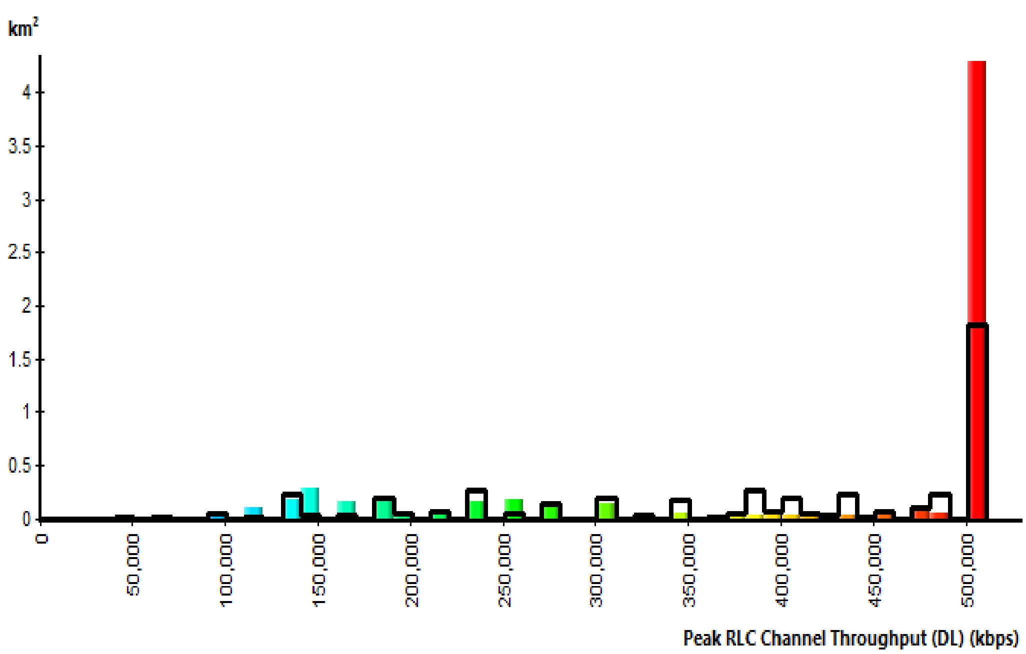


Figure 19: Comparison of capacity using beamforming colored and without beamforming black

Simulations results

I am going to use the map to display the distribution of traffic that is generated by all simulations according to activity status. The simulation will be done for the sites set as active in its corresponding network. It is important to take care about the coherent settings. Some numerical and graphical results of simulations are showed in the following.

Table 12: Simulations results

Results		Sites							
		small	hospital	passport	Site 1	Site 2	Site 3	Site 4	Site 5
Total user trying to connect		18	116	174	222	83	155	147	346
Rejected Users	Percentage from the total number of users (%)	100	100	100	100	100	100	100	99.71
	No Coverage	0	0	0	0	0	0	0	0
	No Service	0	0	0	0	0	0	0	0
	Resource Saturation	1	0	0	0	0	0	0	0
Connect Users	Active Downlink	8	44	47	73	27	52	57	112
	Active Uplink	10	72	127	148	56	102	90	234

Conclusions

In this work, Atoll has been used to design and test a network, including modeling of services and users, configuration of transmitters and cells, predictions that can be used either as a design support or as a network testing tool, and finally simulations that bring all of these together to create a realistic environment for comprehensively examining network behavior:

- 5G systems provide improved hardware and network capabilities, faster data transmission, lower latency, lower power consumption, an increased number of devices, and broad bandwidth.
- 5G accelerates cellular data transmission speeds from 100 Mbps to a peak rate of 20 Gbps. Furthermore, 5G networks are able to achieve latency rates of less than milliseconds under ideal conditions which makes the technology highly suitable for critical applications that require rapid response, such as remote vehicle control.
- This work designed and improved 5G NR networks, models and parameters NR planning was studied and the main objective was to develop a study allowing implementing the dimensions of 5G networks, and then implementing the 5G / NR network planning for some areas in Tarhounah using the simulation program "Atoll".
- For this work, Atoll was used to implement coverage predictions, quality predictions, amplitude predictions, and realistic simulations in order to study signal propagation using different propagation models and the benefits of using beamforming and massive MIMO.Results from coverage analysis predictions and from amplitude predictions were obtained for large and small cell deployments with representative sites in two frequency bands: 26 GHz and 3.5 GHz to compare their behaviors. Coverage analysis is based on SS-RSRP prediction in the downlink. For each site, the percentage of the computation area covered with SS-RSRP values above a certain threshold was calculated. The computed prediction for the amplitude evaluation is the peak data transmission for the RLC channel (DL) (kbps).
- In coverage analysis, the area covered when sites are at 3.5 GHz is higher than when sites are at 26 GHz.
- In the capacity coverage analysis, 3.5 GHz with carrier bandwidth set to 100 MHz in all cases, lower than sites at 26 GHz with carrier bandwidth set to 200 MHz and 400 MHz.

References

[1] Chapman T., Larsson E., von Wrycza, P. Dahlman E., & Parkvall, J. (2015) , “HSPA Evolution The Fundamentals for Mobile Broadband,” Academic Press.
[2] ITU-R (2015), IMT Vision—Framework and overall objectives of the future development of IMT for 2020 and beyond. Recommendation ITU-R M.2083,.
[3] D.Jyotsna Agrawal (2015), Evolution of Mobile Communication Network:

From 1G to 4G,Physics and Electronics Department, India
[4] ITU-R (2014), Future technology trends of terrestrial IMT systems. Report ITU-R M.2320,.
[5] Dahlman E, Parkvall S, Skld J.(2016), 4G LTE-Advanced Pro and the Road to 5G Elsevier.
[6] ITU-R (2017), Guidelines for evaluation of radio interface technologies for IMT-2020. Report ITU-R M.2412 .
[7] ITU-R(2017), Minimum requirements related to technical performance for IMT-2020 radio inter-Face (s). Report ITU-R M.2410.
[9] 3GPP(2018),, "System Architecture for the 5G System (Release 15), TS 23.501.
[12] Dahlman E, Parkvall S.& SK LD J(2018). 5G NR: The Next Generation Wireless Access Technology Elsevier.
[14] Benosman. R.. Sidhoum. A.(2013)l. "Studies and simulation of the performance of small cells in 5g systems". Diss..
[18]http://www.techplayon.com/5g-nr-cell-search-and-synchronization-acquiring-system-information/.May 2020
[20] Forsk(2019), "Atoll 3.4.0: User Manual for Radio Networks".
[21] Forsk(2018), "Atoll 3.4.0: Technical Reference Guide for Radio Networks".