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COVERAGE ANALYSIS FOR 5G NETWORK IN METROPOLITAN AREA UNDER SIMULATIONS ON ICS TELECOM

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ABSTRACT

In this project has been made a study and coverage analysis for mobile telecommunication network in technology 5G in metropolitan area from the city of Bogota, Colombia. This begins, with an explanation of what is 5G and what is expect about this technology; watching some similar studies made around to world including Colombia. With this preamble we could establish the parameters and configurations that used in this study. The stage, on the other hand, they were chosen in order to analyze the case more presented in the moment to mobile telecommunications systems without line of sight (NLOS). The results show the signal loss in free space in the work frequency 5G which is from 3 GHz until 100 GHz, what it entails the use of millimeter-waves that generates in highest frequency more bandwidth by channel getting a highest speed.

KEYWORDS: Millimeter waves, 5G, Coverage study.

INTRODUCTION

In the actuality the existing networks such as 2G, 3G and 4G, they are practically reaching their limit; due to the spread and massification of what is called the Internet of Things (IoT), the industrial automation, domotic, the implementation of smart cities and other mechanisms that are involved in everything related to IoT. For the year 2020, This will generate that connected devices quintuple those of the year 2010 from 12.5 billion passing to 50 billion users worldwide, thus, the data generation will also increase from 1 to 10, which means that by 2010 approximately 2.4 exabytes of data were generated, the calculations suggest that by 2020 approximately EB will be generated.[1] It is in this aspect that 5G networks intro to supply the demand that will arise in the future, providing an improvement in latency and expanding the bandwidth per user that would vary from 0.7 gigahertz (GHz) to 7 GHz,[1] at most, depending on the working frequency which can be varied from 3 GHz to 100 GHz.[2] All this would become possible with the proper use of the radio spectrum, the location of the base stations, among other variables that must be taken into account to maximize the propagation of the signal in free space.[3]

Frequencies, they're usually named as millimeter waves they're quite susceptible to the environment in which it spreads, therefore, the work area of this project is unique in terms of environmental characteristics, which represents a challenge for 5G. Also, 5G has proposed several solutions for the propagation of the signal in adverse environments; one of them is the Massive MIMO system the which to try to guarantee both coverage and bandwidth to users that in previous technologies is not so widely used.

This article is presented as follows. In section 2 the simulation methodology is indicated, in section 3 the results of the simulations are presented and analyzed and the last part presents the conclusions.

I. Simulation Methodology

For simulations development It will be used ICS Telecom, what is a paid network design software. It has a wide range of propagation models depending on the frequency and the environment of stage. These models range from empirical to deterministic models; including climate environment models. Also models indoor coverage systems; which means that it can show the signal levels and penetration of the same in indoor environments such as rooms of houses, office buildings, among others.

Otherwise, It's necessary to choose between digital cartography of 50, 15 o 5 meters depending on the resolution that you want to give to the simulations, so for metropolitan areas, and especially for projects in 5G technology, the highest resolution possible should be used (5 meters) so that the analysis is the most related to reality; resolutions of 50 and 15 meters are used for rural projects, where too much resolution is not necessary due to terrain conditions and much smaller urban environments such as municipalities.

A. Study stage

Universidad Nacional de Colombia (campus Bogotá). This scenario has different characteristics for the propagation of signals, from the point of view of telecommunications engineering, within which we have leafy wooded areas with trees of great size in height and wingspan, these areas are located at various points within the university. Also, there are open areas both green and concrete. It is the perfect setting to analyze electromagnetic signals for NLOS systems (without line of sight); where no base station has the ability to have a direct line of sight.

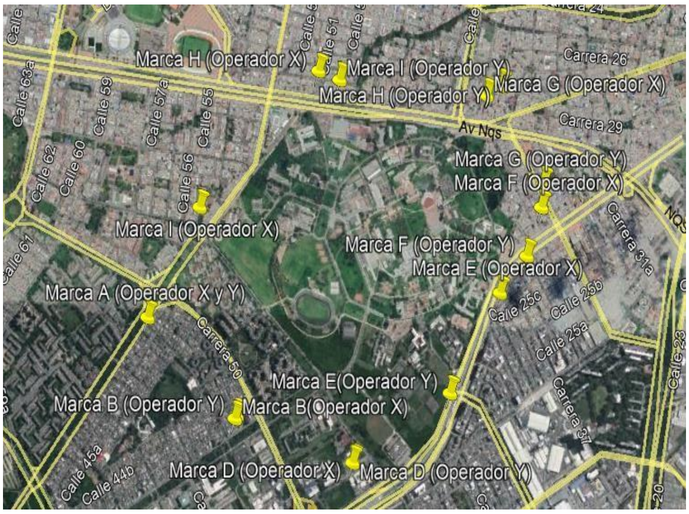

Figure 1. Study stage Universidad Nacional de Colombia campus Bogotá and some stations that provide coverage to the point.

B. Simulation parameters

The ICS Telecom simulation tool has the characterization to simulate 5G transmission within its configuration options. Table 1 shows the main simulation parameters.

Table 1. Simulation parameters on base stations.

Parameter	Value
Transmission potency	10 W
Antenna gain	23 dBi
Antenna arrangement	4x4
Frequency	3-100 GHz
Modulation	64 QAM

For the simulation model, the deterministic model ITU - R 525/526 was selected [4] tight with Diffraction Geometry Model and Delta Bullington Subpath Attenuation Model. Also, we've the propagation losses referred to the effects of gases contemplated in the ITU - R 676 standard, the effects of fog with the norm ITU – R 840 and the effects of rain with the norm ITU – R 838/530. For Bogotá, among the necessary parameters we have the temperature, which is recorded with a maximum measure of 19.9, a minimum measure of 17,8 and an average of 14,9 degrees Celsius. The atmospheric pressure, we've a maximum of 752,1 hPa, a minimum of 751,1 hPa and an average of 751, 6 hPa. rainfall we've a maximum of 129 mm, a minimum of 39 mm and on average 89 mm,[5] the humidity of the air which is composed of the vapor value (Absolute humidity) which normally is 12 g/m3 and the water (Relative humidity) which is normally located in 0.025.[6]

For the location of the base stations, the coverage maps of the existing 4G mobile network of two mobile telecommunications operators were used. (Operator X and Operator Y).[7]

For the rest of the base station configuration (height, sectorization, etc.) recommendation ITU-R M.2412-0 was used.[8]

C. Simulation procedure

After locating the base station points in the digital cartography of Bogotá, we proceed to configure the base station parameters first with a frequency of 3, 10, 22, 32, 47, 60, 72, 82 and 100 GHz. Coverage simulations of the received power level are carried out from which the results are obtained for analysis in the study area with the established settings.

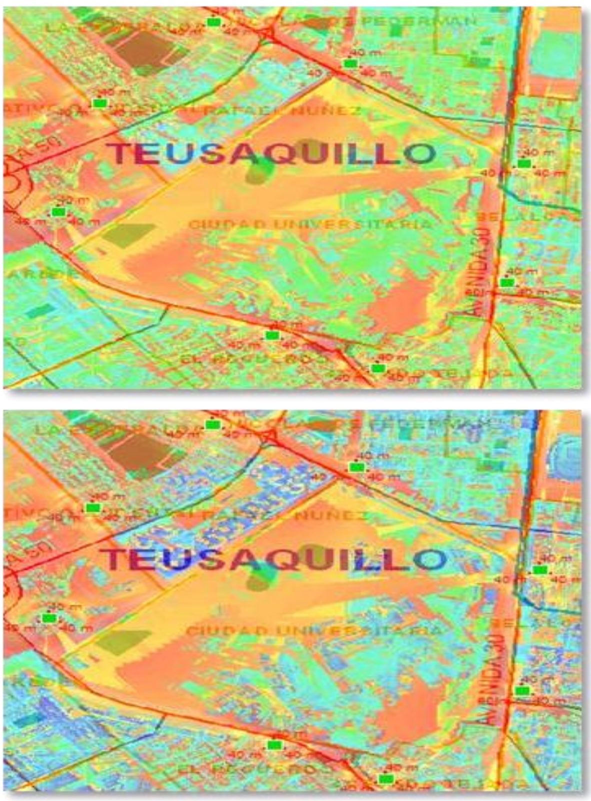

Figure 2: Simulation samples (Up at 3GHz-Down at 100 GHz).

II. RESULTS OF THE SIMULATIONS

To perform the analysis of the results, signal measurement points were established; coverage is given by the base stations located at different points; from here it travels to the users arriving through reflections, diffraction and other effects that the signal faces in free space as it normally exists in an NLOS system. It will take several measurement points (Figure 3) distributed in the cardinal points and a central point, with which the majority of the area is to be analyzed.

Figure 3.Ubicación de puntos de medición.

A. Analysis of the results

For the analysis of the results, ICS Telecom uses the Friis equation, taking the power in the air depending on the distance. Although, in addition to this, it also analyzes the dispersion generated by obstacles. It is determined that signals greater than -150 dBm would be in a coverage range of low coverage seen by users (taking into account the power of the receiving station, it will be set between 1 W[9]) with a level between 90-100 dBm there would be a low signal reception but with accessibility to services., this subject to diffraction and reflection from nearby elements.

B. Analysis of losses in free space

From the established points, the station that provides the best coverage for measurements was found. Starting from this analysis, we can establish how the power loss is from a frequency of 3 GHz to 100 GHz in the different measurement points for the scenario for both the X and Y operator, which is shown in figure.

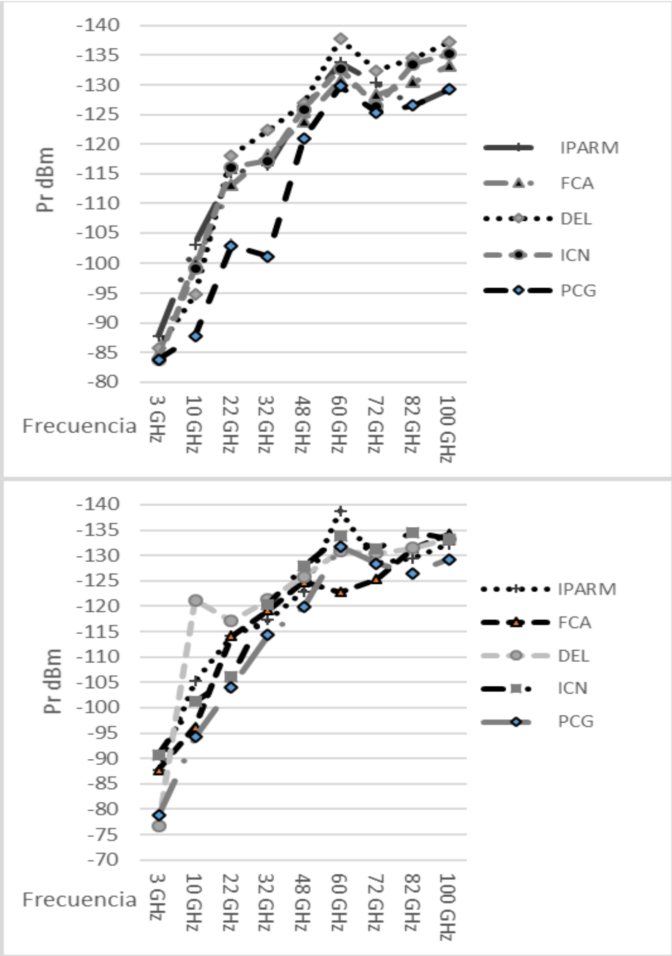

Figure 4: Loss of signal in free space (up operator X-down operator Y).

One of the main disadvantages of 5G mobile networks is the great loss of power when you have no line of sight. This is the most prone scenario when designing mobile networks because there is no prior knowledge of where the user is specifically located and even worse when the obstacles that exist between the Tx and the Rx are not known.. This can be understood with the results obtained, in the Universidad Nacional stage, where the stations never have a direct line of sight due to the obstacles in the path, which weakens the signal causing a fading that is reflected in the signal level received and / or captured in the different areas.

The increase in frequency significantly worsens the negative effects caused by the fading of the signal caused by the loss of line of sight between the Tx and Rx. for operator X the free space losses are approximately 40 dBm from 3 GHz to 60 GHz, but after 60 GHz the signal power tends to stabilize at levels between -125 and -140 dBm, as seen in figure 4.

For the case of Y operator, we have a similar scenario we have a similar scenario in terms of power to the previous one, where we have a signal loss of approximately 45 dBm for a frequency between 3 and 60 GHz, but also, the power stabilizes after 60 GHz between -120 and -135 dBm as shown in figure 4.

III. CONCLUSIONS

The results presented establish that there is a power of -83.76 dBm and -103.76 dBm for a frequency between 3 GHz and 22 GHz, which shows a signal power loss of 24.1% for these frequencies.; but from 22 GHz to 100 GHz, respectively, the signal strength is -103.22 dBm and -135.22 dBm, where losses are higher and reach 31.06%. In consequence, 5G in the studied scenario loses between 3 GHz and 100 GHz 61.43% of the signal power in free space.

Based on what is related to simulations, it is possible to observe that the NLOS scenarios, which of which will be the most common when deployment time comes, They come to make the great challenge to be able to provide a good level coverage to users where it can be seen that any obstacle generates losses especially at frequencies above 30 GHz where the electromagnetic signal is little affected by interference and can have a great bandwidth but after this the signal suffers more fading in its path, which shortens its transmission distance; added to this the signals in high frequencies, or better in millimeter frequencies, They would not be powerful enough to project through obstacles such as walls, glass, and other materials commonly found in any metropolitan environment.

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