الجمهورية الجزائرية الديمقراطية الشعبية

People's Democratic Republic of Algeria

وزارة التعـليـم العالي والـبحث الـعلـمي

Ministry of Higher Education and Scientific Research

جامعة الشهيد حمة لخضر الوادي

Echahid Hamma Lakhdar-EL OUED University

كلية التكنولوجيا

Faculty of Technology

قسم الهندسة الكهربائية

Department of Electrical Engineering

FINAL REPORT

Towards the completion of the Academic Master's degree in electrical engineering

Specialty: system and telecommunications

THEME

Study and simulation of 28 GHz coverage in the city of El-Oued with the Ray Tracing Technique

Presented By:

- ✓ **ACHIRI Rabie**
- ✓ **KEBSI Fatma Zahra**
- ✓ **SAADANI Abdelhak**

Before the jury composed of::

President		U. El-Oued
Examiner		U. El-Oued
Framer	**dr. AJGOU riadh**	U. El-Oued

University Year : 2021/2022

THANKS

As a preamble to this memoir

We thank ALLAH who helps us and gives us patience and courage .during these years of language study

We would like to extend our most sincere thanks to the people who who have helped and who have contributed to the development of this thesis

.as well as the success of this wonderful academic year

We would like to sincerely thank ***DR. AJGOU RIADH****, as a Supervisor, who has always been attentive and very available ,throughout the production of this thesis*

Finally, we address our most sincere thanks to all our relatives and friends, who have always supported and encouraged us during the realization of this dissertation.

Dedicace

I am dedicated this modest work to:

My very dear mother.

My very dear father.

My sisters and brothers

all my families

My partner

All my friends.

**All class 2021/2022.*

Rabie

Dedicace

I am dedicated this modest work to:

My very dear mother.

My very dear father.

My sisters and brothers

all my families

My partner

All my friends.

**All class 2021/2022.*

Zahra

Dedicace

I am dedicated this modest work to:

My very dear mother.

My very dear father.

My sisters and brothers

all my families

My partner

All my friends.

**All class 2021/2022.*

Abdelhak

Abstract:

In this project, we rely on ray tracing technology to study the 28 GHz coverage of a specific area in the city of El-Wad to make a hypothetical urban scenario with realistic coordinates and characteristics to obtain an accurate and close simulation of reality. For fifth generation applications as a result of being affected by buildings and obstacles. To do this work we need to map antenna arrays and analyze antenna performance, taking into account propagation effects. In addition to the design of antennas and antenna array, which are integrated into the system in advance. It will be possible to predict the scenario of radiofrequency propagation through the practical results of this study.

Keywords: Fifth generation, Path loss, beam tracking, millimeter wave channels.

Résumé :

Dans ce projet, nous nous appuyons sur la technologie du lancer de rayons pour étudier la couverture 28 GHz d'une zone spécifique de la ville d'El-Wad afin de créer un scénario urbain hypothétique avec des coordonnées et des caractéristiques réalistes pour obtenir une simulation précise et proche de la réalité. Pour les applications de cinquième génération à la suite d'être affecté par des bâtiments et des obstacles. Pour faire ce travail, nous devons cartographier les réseaux d'antennes et analyser les performances des antennes, en tenant compte des effets de propagation. En plus de la conception des antennes et du réseau d'antennes, qui sont intégrées au système à l'avance. Il sera possible de prédire le scénario de propagation des radiofréquences grâce aux résultats pratiques de cette étude.

Mots-clés : Cinquième génération, perte de piste, suivi de faisceau, canaux d’ondes millimétriques.

ملخص:

نعتمد في هذا المشروع على تقنية تتبع الشعاع لدراسة تغطية 28 جيجاهرتز لمنطقة محددة في مدينة الواد لعمل سيناريو حضري افتراضي باحداثيات وخصائص واقعية للحصول على محاكاة بشكل دقيق وقريب للواقع، تسمح هذه التقنية بتعقب مسارات الارسال بين الهوائي المرسل والهوائيات المستقبلة و تحليل السيناريوهات الممكنة لتطبيقات الجيل الخامس نتيجة التأثر بالمباني و العوائق. نحتاج للقيام بهذا العمل تثبيت صفائف الهوائي على الخرائط وتحليل أداء الهوائي، مع مراعاة تأثيرات الانتشار. بالاضافة الى تصميم هوائيات ومصفوفة الهوائي والتي يتم دمجها في النظام مسبقا. سيكون بالامكان توقع سيناريو انتشار الترددات الراديوية من خلال النتائج العملية لهذه الدارسة.

كلمات المفاتيح: الجيل الخامس ، فقدان المسار، تعقب الشعاع ، قنوات الموجة المليمترية.

TABLE OF CONTENTS

CHAPTERIII

TECHNICAL COVERAGE ANALYSISRAY TRACING

List of Tables

LIST OF FIGURES

Abbreviations and Acronyms

3G	Third Generation
4G	Fourth Generation
5G	Fifth Generation
AI	Artificial Intelligence
AMPS	Advanced Mobile Phone System
B_C	Coherence bandwidth
B_D	Doppler Spreading
BS	Base Station
DAS	Distributed Antenna Systems
DL	Downlink
eMBB	Enhanced Mobile Broadband
FR	Frequency Range
GBSM	Geometry Based Stochastic Modeling
3GPP	Third Generation Partnership Project
Gb	Giga bites
GHz	Giga Hertz
GSM	G lobalS ystem forMobile
HSPA	H-ighS peedP acketAccess
Hz	Hertz
IEEE	Institute of Electrical and Electronics Engineers
IMT	International Mobile Telecommunications
KPI	Key Performance Indicator
LOS	Line Of Sight
LTE	Long Term Evolution
MCL	M aximumC ouplingLoss
MHz	Miga Hertz
ML	M achineLearning

mMTC	Massive Machine Type Communication
NLOS	Non-Line-Of-Sight
NMT	Nordic Mobile Telephony
NR	New Radio
NSA	No Strings Attached
O2I	Object Oriented Interfaces
ODbL	Open Data base License
OSM	Open Street Map
PDP	Power Delay profile
PHY	Physical Layer
QOS	Quality Of Service
RAN	Radio Access Network
RF	Radio Frequency
RMS	Root Mean Square
RX	Receiving
SBR	Shooting and Bouncing Ray
SDU	Service Data Unit
TACS	Total Access Communication System
T_C	Coherence Time
TGad	Task Group ad
TG3c	Task Group 3c
Tm	Time spread parameters
TRP	Transmission/Receptionpoint
TX	Transmitter
UDN	Ultra Dense Network
UE	User Equipment
UL	Uplink
URLLC	Ultra Reliable Low Latency Communications

WPAN	Wireless Personal Area Network

INTRODUCTION

General introduction

In this research, we study the calculation of the transmitted signal loss ratio, which is done through Ray-Tracin method in the 28 GHz band on the fifth-generation network using Matlab simulation. Mobile radio communications have spread all over the world since a few decades ago, and reached people through mobile technology, which has become a necessary part of the urban environment and has been linked to various fields of work and services as it cannot be dispensed with. We find radio applications used in navigation and transportation communications and the use of robots, and it has medical uses as well as emergency situations, broadcasting, space, army, mobile radio, all of this is made possible by radio communications through specific wireless technologies on large scales and is developed over generations such as LTE technology to support radio applications mobile for emergency and public safety services.Wireless communication systems work by sending wireless signals from a transmitter to a receiver through multiple propagation paths that affect the ground and buildings in the transmitted signal, causing interference that makes the arrival of waves different from one receiver to another, due to the path that the wave crossed, each path requires an energy level different for each received frequency, this difference affects the quality of communications and the wireless network, this calls for checking the propagation characteristics and studying the diffraction, fading and shading and everything that affects the waves to count the various characteristics, among the known and most effective methods for estimating the propagation characteristics a method called ray tracing. Used in multiple systems MiMo. The first appearance of the first generation of mobile communications was in the 1980s, that is, forty years ago, and relied at its inception on analog transmission with the main technologies that North America developed and called it the AMPS advanced mobile system, and NMTs, the regular mobile phone system that was It was invented by the northern European countries, which was used for the first time in an Arab country and after a few months it spread in Europe, and the TACS system also appeared, the full access communication system used in the United Kingdom [1]. Mobile communication systems were used for voice services for the first generation and it was the beginning of The spread of cell phones to the general public. In the early nineties (1990)voice services remained the primary goal of mobile communications systems even with the advent of the second generation, where digital transmission was added to the wireless link, and this feature provided few data services and new technologies appeared for this generation, including GSM, the global system for mobile communications developed by The party of several European countries, and it spread widely, and then it was adopted in many countries of the world, and it controlled the second generation technologies, because it was a successful system, and the personal digital cellular PDC technology, which was adopted and developed by the State of Japan. CDMA-based IS-95 technology. The second generation made the use of mobile phones a necessity for the majority of people .Until the year 2000, when the third generation 3G appeared and was the first actual use of high-quality broadband with fast wireless Internet access, using HSPA technology, high-speed packet access.In the same generation, technologies were designed to operate in a dual spectrum [1]. Then the new data network appeared, known as the fourth generation 4G, using the LTE network, and it sought to make data transmission more rapid, followed by the fifth generation, which depends on broadbands and high frequencies, and made services more than just voice services, but will enter into many areas. [1]

CHAPTER I :

FIFTH GENERATION

I.1. Introduction:

The term 5G is used to refer to the specific wireless access technology of the new generation, or to define a specific technology such as radio communications, and it can be launched to much wider uses. Discussions about mobile phone communications for the fifth generation began around 2012, to include all possible services and that are provided by future mobile communications**.**

I.2. What is 5G ?:

Previous generations were concerned with ensuring communication and its success, such as 4G LTE, while the fifth generation technology seeks to develop technologies for more guarantee, facilitation, and provision of more services, by offering the cloud experience. The 5th generation technology has a maximum speed of 20 Gbps, which can improve the performance of applications and other digital experiences such as online games, video interviews and conferences, and self-driving cars.

5G enables open roaming between cellular access and Wi-Fi, and allows mobile phones to stay connected even when moving from an external wireless connection to an indoor wireless network without requiring users to authenticate. 5G networks provide simple transmission, users may need Wi-Fi 6 radios to provide better coverage and lower cost.

The new 5G network has a dense and widespread access architecture that allows for faster and faster transmission of data processing to users, and aims to improve communication performance in rural and urban areas**..[1]**

I.3. When will 5G be available and how will it expand?:

The last generation or the fifth generation, are services that have become available in some countries and are being used. Their advantage is that they are more advanced, provide faster mobility and low response time, provide extensive services and technologies in many areas, the 5G NSA service depends on the existing infrastructure of the network 4G LTE…[1]

I.4. THE 5G USE CASES:

5G has three different modes of Enhanced Mobile Broadband (eMBB (mMTC) massive machine type communication, Ultra Reliable Low Latency Communications (URLLC) as divided in the figure I.1. [2]

I.4.1. eMBB :

It provides more advanced and improved mobile broadband end-user services as it provides large volumes of data[2].

I.4.2. mMTC:

This case requires mainly to provide services at a very low cost of the device in addition to low power consumption, so it is characterized by a huge number of devices such as monitors, actuators, remote sensors and others mMTC does not support high data rates[2] .

I.4.3. URLLC:

5G use cases have been divided by default to simplify requirements for this new system. There are cases that require devices with very low costs and low battery life, and you may find other uses that are not in line with the three mentioned categories, meaning you may find services that require high reliability with less important access time. [2]

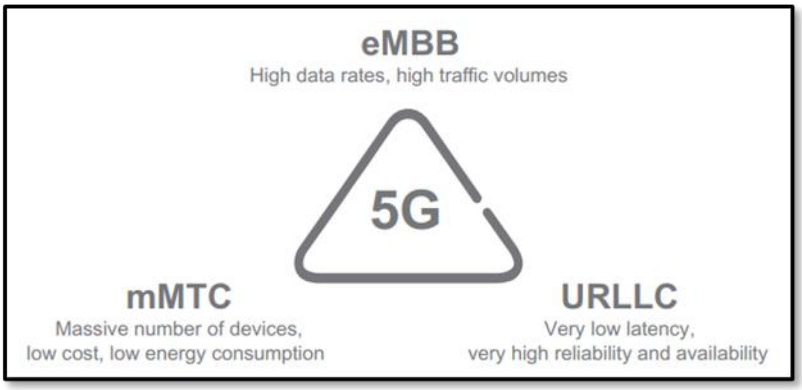

Figure -I.1 High-level 5G use-case classification. [2]

I.5. GLOBAL SPECTRUM SITUATION FOR 5G:

The spectrum of interest is divided into three bands with different frequencies. It is included in the global 5G network deployments, and it is supported by regulators in many countries.3GPP activities focus on bands of great interest. We distinguish low, medium and high frequency bands in the spectrum.

I.5.1. Low-frequency bands:

The range between 600 and 700 MHz is considered the most important, and 3 GPP defines the(NR n71 and n28) bands, because they are not wide bands in which the maximum bandwidth may reach 20 MHz, and this range alternates with LTE bands less than 2 GHz.

– The US adopts the 600MHz NR band.
– 700MHz Europe's leading band.
– NR band numbers are allocated and published gradually at a later time[2] .

I.5.2. Medium-frequency bands:

Provides a range of high frequency bands, which allows coverage and greater data capacity:

– (4200-3300MHz) and 3 Gbps bandwidth (NR n77 and n78) is considered the highest band that receives global attention.
– The bandwidth from (100 to 200 MHz) may be up to each operator in the bandwidth.
– (3400-3800MHz) Europe adopts this band, while India and China use (3300-600MHz), Japan seeks to use (3600-4200MHz).
– In the 26 GHz band, several LTE redistribution bands are available, which are considered NR bands[2].

I.5.3. High-frequency bands:

Millimeter wave is suitable to cover high-capacity bands and enables to provide high data rate if it is above 24 GHz, exactly (from 24.25 to 29.5 GHz), the bandwidth of 400 MHz is allocated for 3GPP NR n257 and n258 bands[2] .

I.6. 5G Technology work:

5G technology seeks to support a converged and heterogeneous network that includes many wireless technologies in order to provide more services to users, so the fifth generation technology depends on international standards, as it includes new antennas such as the massive MIMO that enables devices to send and receive multiple data transmission at the same time 5G provides a new technology called cloud and information technology, which is a flexible structure that allows users to access data at any time and anywhere. It is a software system that is a virtual simulation that will be used instead of devices, in addition to sub-network structures called network segments.In the 5G system, digital services will be improved through the use of automation, as it supports ML and artificial intelligence (AI). This will reduce the cost of infrastructure, enhance connected experiences, and improve traffic and services[3].

I.7. 5G SUB-6 GHZ:

It includes all mid, new and low bands, and frequencies less than 6 GHz. As these frequencies provide a better range than millimeter waves

Among the low frequencies, we distinguish between the band used in Europe for the fifth generation networks 3.4 and 3.8 GHz This band is used by the 4G LTE network and has a greater range[4]

I.8. WHAT ARE THE FREQUENCIES USED FOR 5G:

The frequencies used in 5G are divided into two large groups, the first containing just under 50 different frequency bands, and the second group containing only 4 different bands as defined by 3GPP.

- FR1 low-frequency 5G range sub-6, under 6 GHz
- FR2 mmWave high-frequency range, (24.25vGHz to 52.6 GHz)

Frequency bands that will be used for 5G sub-6:

– n78: 3.5GHz

Added to this are the mmWave frequency bands:

– n258: 26GHz

4G LTE frequency bands reused for 5G:

– n1: 2100MHz
– n3: 1800MHz
– n7: 2600MHz
– n20: 800MHz
– n28: 700MHz[4].

I.9. WHAT ARE MMWAVE MILLIMETER WAVES:

A new band used in the fifth generation networks is between 30 to 300 GHz, and between 24 to 30 GHz. It provides better and more productive services and varies according to the scope and ability to pass between walls Millimeter waves are named after the wavelength, as its length represents the distance it travels during the oscillation period when it propagates in a specific space, so that the longer the wave, the shorter the frequency It is possible that these lengths vary in the femtometer scale (10^{-15} th) of a meter for gamma waves to radio waves ranging from 1 to 100 km and from 300 MHz to 3 kHz.Millimeter waves in the fifgeneration are much smaller than the wavelengths traditionally used for radio waves, as the wavelength reaches a millimeter. [4]

Millimeter wave is based on a dual operator system, each of which is licensed for use in the same band, and contains restrictions on the maximum interference that may occur from the original network as shown in the figure I.20. [5]

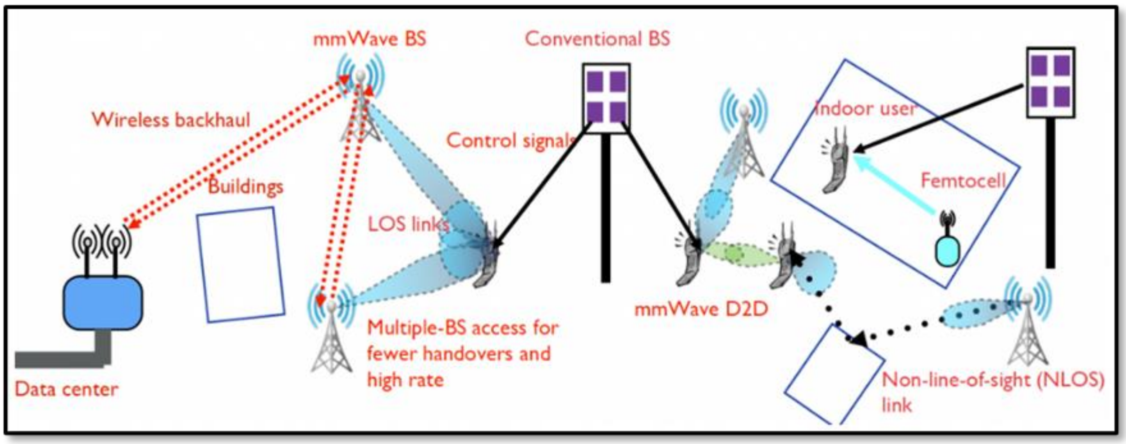

Figure -I.2 Analysis of millimeter wave systems for 5G.[5]

I.10. 5G Architecture:

The fifth generation seeks to provide wireless services that are provided to users through multiple access platforms and multiple networks, adding a data service that is fast and reliable more than previous generations. It provides a lot of advanced and advanced technologies in a dynamic, coherent and more effective framework and supports a variety of applications It is noted that 5G is a very smart structure, as it no longer adopts the traditional method in wireless access networks RAN restricted to the proximity of the base station, but seeks to make it detailed, flexible and virtual to create additional new access points. [6] The 5G structure is formed at multiple levels composed of macrocells and pico cells, femto cells. Femto cells are used to be more convenient and reduce congestion on the base station, as shown in the figure I.3 .

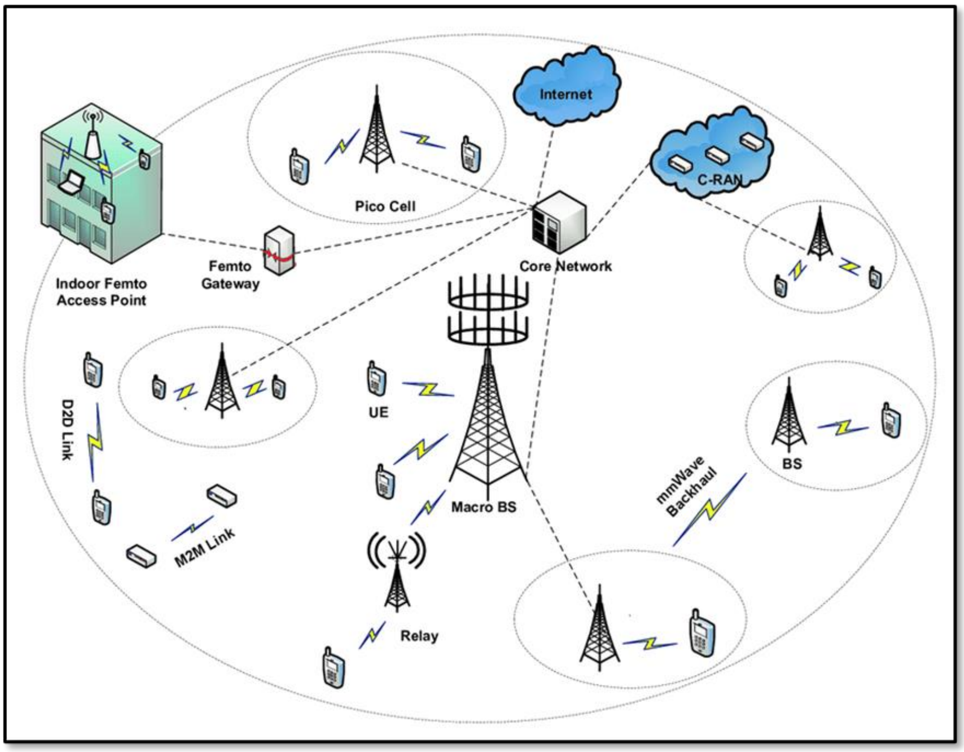

Figure -I.3 Architecture of 5G network.[7]

I.11. Detailed Technical Requirements:

I.11.1. Peak data rate:

In error-free conditions, we receive a data rate that represents the highest rate called the peak and is allocated to one mobile station. The peak data rate is 20 Gbps for the downlink and up to 10 Gbps for the uplink.[8]

I.11.2. Peak spectral efficiency:

The data rate received in error-free conditions is what is known as the spectral efficiency, the highest theoretical data rate that is measured by bandwidth and can also be assigned to a single mobile station. The maximum spectral efficiency strives to reach 30 bits/sec/Hz for the downlink and 15bits/Hz for the uplink.[8]

I.11.3. Bandwidth:

It is the maximum limit for the total system bandwidth It can be supported by an RF transmitter, it may be single or multiple.[8]

I.11.4. Control plane latency:

Transition level control time. It means the time between the state of battery efficiency until the start of the continuous data transfer. It is recommended that the transmission time of the control level be within 10 milliseconds.[8]

I.11.5. User plane latency:

The time taken to successfully deliver an application layer packet/message, the user level latency should be 4ms for UL and 4ms for download.[8]

I.11.6. Latency for infrequent small packets:

The time taken to successfully transfer an application layer packet/message from an entry point to an exit point of the Radio Protocol Layer 2/3 SDU in RAN.[8]

I.11.7. Mobility interruption time:

Represents the shortest period of time supported by the system for interruption of movement when in use, as the user packets cannot start with any base station during the transition period, so the interruption period must be zero.[8]

I.11.8. Inter-system mobility:

It means the ability to support the mobility of the IMT system. [8]

I.11.9. Reliability :

Based on the probability of successful transmission, reliability is evaluated. For example, 20 bytes within 1 millisecond is the time taken to deliver a small data packet from the moment it enters the radio protocol layer 2/3 SDU to the exit point of the radio surface. 1-105 in a second This is what reliability seeks to achieve.[8]

I.11.10. Coverage:

“The coverage target is 164 dB, so the maximum coupling loss (MCL) on the uplink and downlink between the device and the location of the antenna connectors is up to a data rate of 160 bits per second.[8]

I.11.11. UE battery life:

Battery life is determined by the battery life of the UE without recharging. This is for mMTC, UE battery life depends on the data transmission activity generated by the mobile devices and this is at maximum coverage, the data transmission activity consists of 200 bytes UL diaries followed by 20 DL of MCL of 164 dB, given that the stored power capacity is 5 watts,The goal is to achieve UE battery life of more than 10 years.[8]

I.11.12. UE energy efficiency:

The energy efficiency of the UE is the ability of the UE to maintain a better mobile broadband data rate while reducing the power consumption of the UE modem.[8]

I.11.13. 5th percentile user spectrum efficiency:

It is a point 5% of the cumulative distribution function of the normal transmission speed of the user, which means the average user throughput,and it represents the number of bits in the SDU units delivered to Layer 3 divided by the bandwidth,The user throughput and bandwidth on the specified carrier are used in the case of calculating the KPI for each wave.The target that is a starting point for eMBB deployment scenarios is within 3 IMT-Advanced requirements for the full bufferand improve capabilities shown in Figure I. 4.[8]

I.11.14. Cell/Transmission Point/TRP spectral efficiency:

TRP spectrum efficiency is the total throughput of all users, it means the number of bits present in the service data units (SDU)s as they are delivered to the third layer during a certain time. [8]

I.11.15. Connection density:

It is the total number of used devices that are available in a specific area estimated in square kilometres. The definition of QOS takes data and access requests and then sends and receives them during a certain time X . The connection density may reach up to 1,000,000 devices/km^2.[8]

I.11.16. Mobility:

It is the mobility capacity and it is intended to be the maximum speed of the user in the rate of km / hour, and then determines the quality of a specific service. Mobility aims to achieve 500 km/h.[8]

I.11.17. Network energy efficiency:

Provide better traffic capacity Possibility to reduce energy consumption RAN .[8]

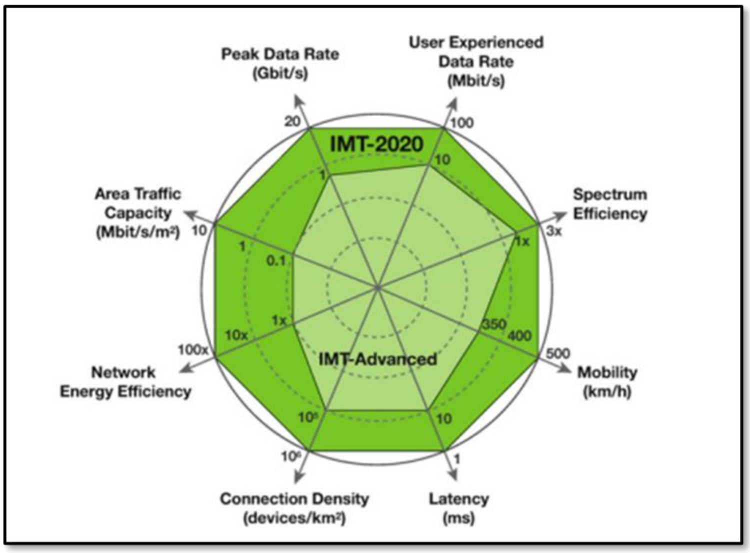

Figure -I.4 Enhancement of key capabilities from IMT-Advanced to IMT-2020. [8]

I.12. WORKS MASSIVE MIMO:

Massive MIMO is used in 5G updates because it provides the best possible coverage, especially for large and crowded places, it uses the same frequencies of the Raido at the same time as the transmitter , MIMO helps improve reliability and increase productivity ,Massive MIMO is made of multiple antenna elements in a two-dimensional matrix, up to hundreds of elements it is suitable for high bands and millimeter wave [9],It also works side by side with small cells, representing with each other a main enabler group for the fifth generation network, as shown in the figure I.5 . [10]

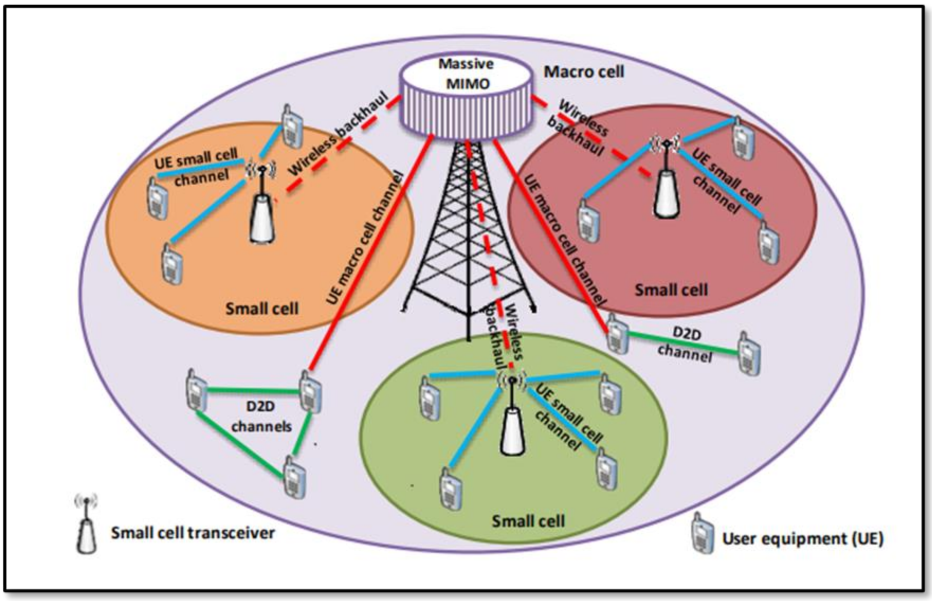

Figure.I-5 Heterogeneous architecture of 5G with combination of Massive MIMO and small cells.[10]

I.13 Beamforming: how does it work?

Beaverming's work is based on a principle similar to that of television speakers. So that it receives the appropriate signal for the user and at the same time does not emit noise to others. The principle of the beam work is that it uses a group of small transmitters and then collects the signals and then sends packets to the device that requests them (smartphone, tablet or laptop, etc.). And he cancels it in the place he does not need it, it works according to the needs of the user,The fifth generation network targets this feature for all users to gain energy by using huge antennas as it does not waste energy[11] .

I.14 Ultra-dense network UDN:

It is a network within the fifth generation scheme, networks consisting of more base stations than the number of active users, and networks with a density of 103 cells/km². It can be applied by increasing the piecs for each area and distributing the antennas of the DAS system [12] . The ultra-dense network system provides thousands of access points per square kilometer. Hex traditional system The following table I.1 shows the difference between them [13].

Item	UDN	Traditional cellular network
Deployment scenarios	Indoor, Hotspot	Wide coverage
Site/AP density	More than 1000/km2	3–5/km2
User density	High	Low/medium
Site/AP coverage	Around 10 m	Several hundred meters and more
Deployment	Heterogeneous, Irregular coverage	Single layer, Regular cell
Site engineering	User deployment	Operator deployment
AP style	Small-cell,Pico, Femto,UE relay, Relay	Macro/micro BS
AP Backhaul	Ideal/non-ideal, Wired/wireless	Ideal, Wired
User mobility	Low mobility	High mobility
Traffic density	High	Low/medium
Typical bandwidth	Hundreds of MHz	Tens of MHz
Spectrum bands	>3 GHz (up to mm Wave)	<3 GHz

Table I.1 Comparison between UDN and the traditional cellular network[13] .

I.15 conclusion:

The latest generation of wireless communication systems is the 5th generation, where the 5th generation vision provides an explanation for services, architecture and other areas, through the development and expansion of the performance limits of mobile networks. More advanced modern technologies such as massive MIMO systems and millimeter wave radio systems greatly influence the design of cellular architecture. It is important that 5G technology maintains massive traffic due to the increased efficiency of wireless link and cell density, and to facilitate the coordination process it is necessary Transforming the network into a cloud structure, which in turn coordinates between cells and overlaps during network deployment, and by using more technologies, other goals can be reached in the 5G network system.

CHAPTER II :

CHARACTERISTICS OF RADIO CHANNELS

II.1. Introduction :

It is necessary to know the characteristics and mechanisms of the electromagnetic wave propagation channel in space, for this reason the field of wireless networks is interested in knowing what the propagation channel includes and its interactions with the environment in order to be able to provide conditions and control the establishment of a wireless link between the transmitter and receiver and predict the chances of its success.

In this chapter, we study the characteristics of the propagation channel and the phenomena affecting it, as well as propagation models and their current types, and their main role in determining what happens to the transmitted signals during their transmission using algorithms that allow prediction of the signal transmission scenario .

II.2. Free space propagation :

For the transmission system, the advantage of the absence of obstacles, the electromagnetic wave emitted in free space is subject to the influence of the propagation environment. The power density W in free space is known as a function to estimate the distance gain d between the transmitter and receiver, and in terms of transmitting antenna gain Ge and transmitting signal power Pe, the equation is written as: [14].

$$w = \frac{P_e G_e}{4\, nd^2} \qquad \text{(II.1)}$$

The available signal strength at the tips of the receiving antenna, Pr, is related to the power density W, and is written as :

$$p_r = w\frac{\lambda^2 G_r}{4n} \qquad \text{(II.2)}$$

λ represents the wavelength the working frequency count. The signal attenuation in the free space can be calculated using the previous two formulas ,this formula is used only if there is a large field between the transmitting antenna and the receiving antenna as follows :

$$\frac{p_r}{p_t} = G_t G_r \left(\frac{c}{4nfd}\right)^2 \qquad \text{(II.3)}$$

c represents the speed of light which can be expressed as = fλ.

To apply the above formula, it is required that the distance (d) between the antenna (receiving - transmitting) is greater than the Fraunhofer (dr) distance related to the largest distance of the transmitting antenna :[14]

$$d_f = 2\frac{D^2}{\lambda} \quad \text{(II.4)}$$

D represents the size of the transmitter antenna Calculate the free space loss with the following formula: [14]

$$P_L = 10\log_{10}\left(\frac{P_t}{P_r}\right) = -10\log_{10}\left[G_t G_r \left(\frac{\lambda}{4\pi d}\right)^2\right] \quad \text{(II.5)}$$

II.3. Multipath propagation:

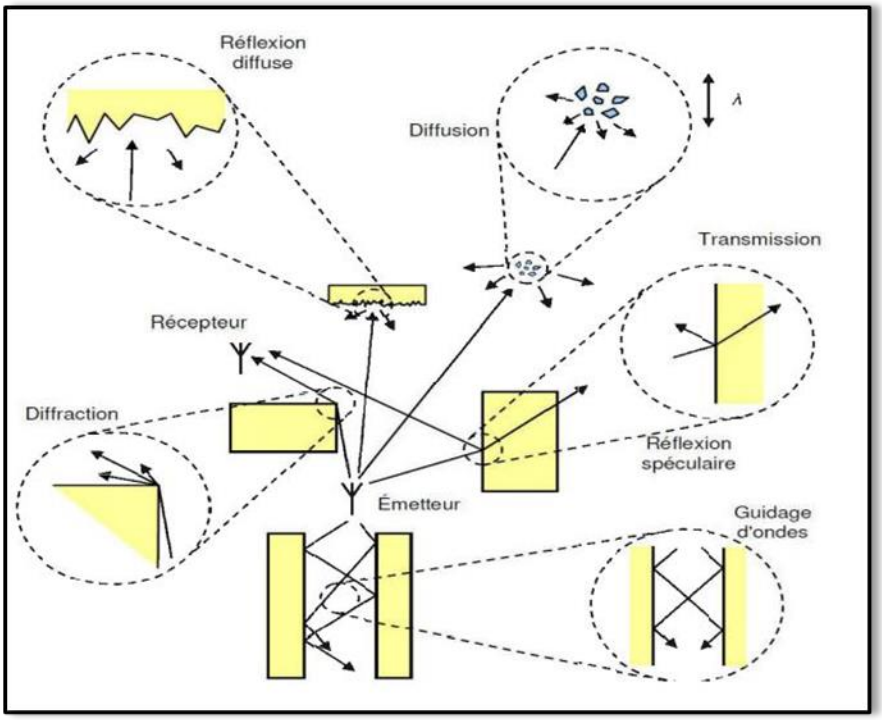

Figure -II.1 Main propagation phenomena [14]

The same signal reaches the receiver from several different paths. This may happen due to the reflection of the transmitted signals on the surface of the earth, buildings, or others. This is caused by the effect of the propagation environment on the transmitted wave. The effect is called multipath diffusion. Among these phenomena is the phenomenon of reflection, diffraction, refraction, scattering.

the figure II.1 shows some phenomena The propagated wave can be subject to more than one phenomenon in one transmission. The phenomena can cause the signal to be obstructed, or it may be a auxiliary factor for it. An example is when the transceiver is in the LOS state, reflection disrupts the access, while the NLOS state ensures diffraction and scattering . [14]

II.4. Parameters for characterizing a channel :

Mobile radio channels have characteristics determined by certain parameters that allow the identification of a multipath propagation channel. There are four types of parameters.

II.4.1. Time spread parameters T*m* :

When receiving an identical signal at the destination at different times, what is called time dispersion occurs, which is the time difference between the moments of arrival of the first and last component. Figure II.2 shows the time dispersion Tm.

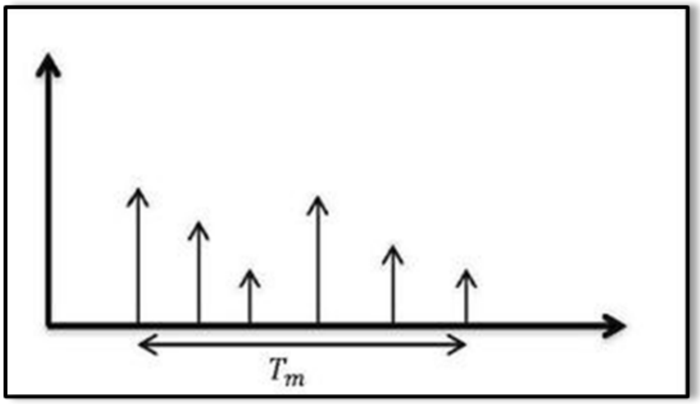

Figure -II.2 The temporal dispersion [14]

It is important to know the average delay (mean excess delay) τ in the time dispersion parameters which is the first moment of the power profile given by the relation (II.12), and the standard flare delays τ RMS are calculated by the relation (II.13) :

$$\bar{\boldsymbol{\tau}} = \frac{\sum_k \; p(t_k)t_k}{\sum_k \; p(t_k)} \qquad \text{(II.12)}$$

The standard deviation describes the dispersion of the signal through multipath propagation. Considering the delay of all paths upon reception, depending on the first received path,τRMS determines the channel selectivity that can cause a deterioration in the performance of the communication system, calculated by the following equation:

$$\tau_{RMS} = \sqrt{\bar{\tau}^2 - \bar{\mathrm{T}}^2} \text{ Avec un moment } \bar{\tau}^2 : \bar{\tau}^2 = \frac{\sum_k p(t_k)t_k^2}{\sum_k p(t_k)} \qquad \textbf{(II.13)}$$

The τ max parameter is defined by this relationship :

$$\tau_{max} = \tau_X - \tau_0 \quad (II.14)$$

τx is the maximum delay in which the energy drops by X dB

τo is the first path delay.

II.4.2. Coherence bandwidth Bc :

We consider the channel to be flat (non-selective) when the bandwidth of the transmitted signal in the broadband B is greater than the coherence band Bc. The coherence range is related to the effective extension of the delay and is given by the following relation :

$$B_c \simeq \frac{1}{\alpha\sigma_\tau} \quad (II.15)$$

In the case of the presence of the amplitude correlation pe = 50%, the value of Bc becomes a function of the frequency correlation and the previous relation is given by this formula:

$$B_c \simeq \frac{1}{5\sigma\tau}\text{Hz} \quad (II.16)$$

And if we have pe = 90% then the equation becomes :

II.4.3. Doppler Spreading BD :

Doppler spreading is caused by the time variation of the channel. It is defined as the frequency band where the received Doppler spectrum is nonzero. It is equal totwo times the maximum Doppler frequency.

$$B_c \simeq \frac{1}{50\sigma\tau}\text{Hz} \quad (II.17)$$

The Doppler frequency shift is given fD by this formula:

$$f_D = f_m \cos\alpha = \frac{V_{eff} f_c}{c} \quad (II.18)$$

II.4.4. Coherence time TC :

The coherence time indicates the period during which the channel is stable. If two signals arrive with a frequency greater than the Tc, the two signals are affected differently. Figure II.3 shows the difference between the third and fourth signals.

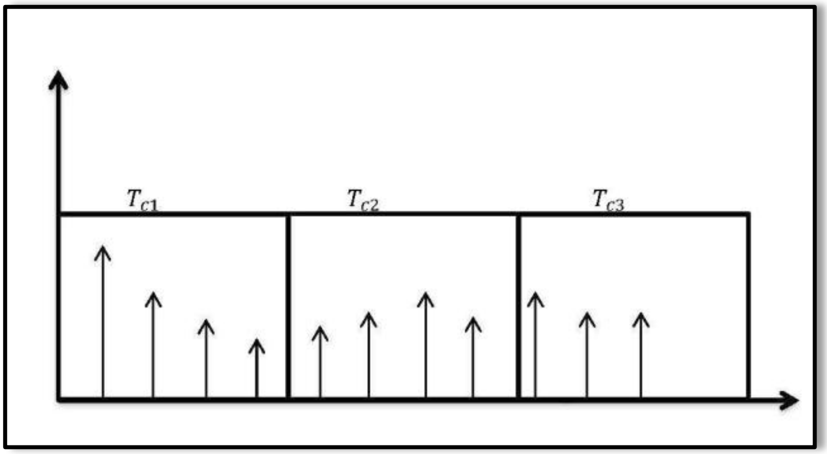

Figure.II.3 Time of coherence [14]

The coherence time is equivalent to the Doppler spread in the time domain and is in one of the following three formulas: [14]

$$T_c \simeq \frac{1}{B_d} = \frac{1}{2 \cdot f_{d,max}}$$
$$T_c = \frac{9}{16\Pi \cdot B_d} \qquad \text{(II.19)}$$
$$T_c = \sqrt{\frac{9}{16\Pi}} \cdot \frac{1}{B_d} = \frac{0.423}{B_d}$$

II.5. Propagation channel modeling :

- **<u>The impulse response :</u>**

It is defined as a function of the variable T, which expresses the variance of time with respect to the specified reference value, and the variable τ, which represents the delay of the multiple paths of the channel. The impulse response allows evaluation of the impact of multiple channels on the transmission system, and its observation allows distinguishing the different paths and the relative amplitude of each path. Figure II.4 shows a representation of the impulse response of a mobile radio channel . [14]

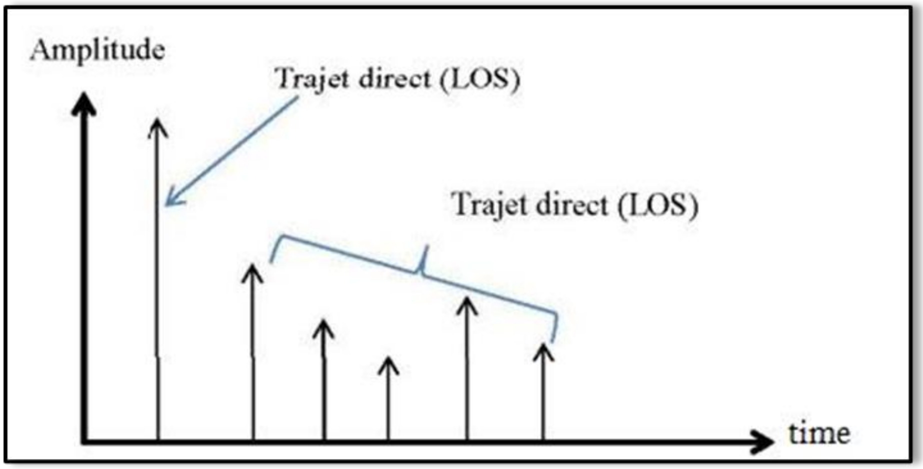

Figure -II.4 Representation of the impulse response of a mobile radio channel[14]

II.6. Mobile Radio Channel :

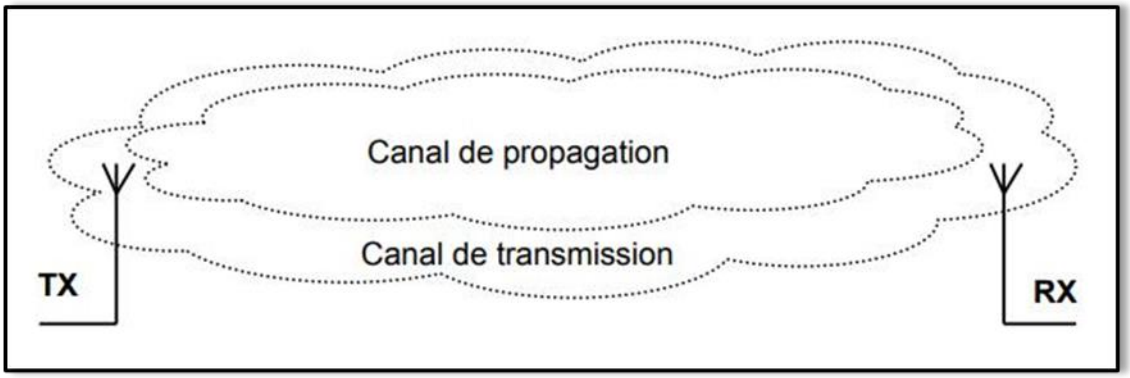

Figure -II.5 Definition of the transmission channel and propagation [15]

II.6.1. The propagation channel :

A form of electromagnetic radiation that represents the propagation behavior of radio waves as they travel from one point to another in a vacuum using an antenna. It is a device that radiates (the transmitter) or captures (the receiver), as shown in the figure II.5 . This propagation has phenomena that affect the waves and the radio system in general.[16]

II.6.2. Types of propagation :

channels is a more abstract notion because its characteristics are not directly measurable. It can be defined simply as the transmission channel without the effect of antennas types of propagation channels:

- linear propagation channel
- Reciprocal propagation channel
- TV channel [16]

II.6.3. Channel (Uplink - Downlink) :

Uplink Channel	**Downlink Channel**
Mobiles to BS	BS to Mobiles
Asynchronous transmissions	Synchronous transmissions
Glare effect (near-far, near-far)	Low glare effect

Table-II.1 Channel (Uplink - Downlink) [16]

II.7. The Three Types of Fading :

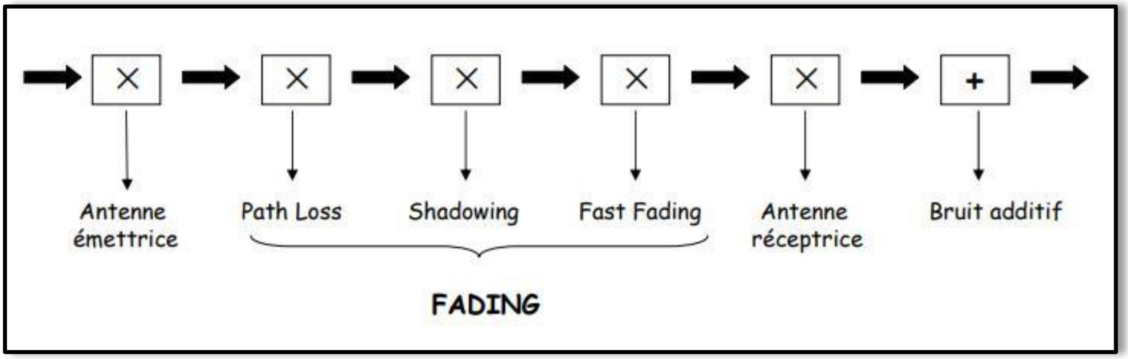

Figure -II.6 types of Fading [16]

II.7.1. PATH LOSS :

1-Linear path loss: The path loss can be calculated using an experimental model if the environment is complex and with obstacles, according to the distance, and the linear path loss of the channel is determined as the ratio of transmitting power to receiving power.

– s (t) is the energy P t transmitted over a specified channel

– The received signal r (t) is averaged for power P r over any random variations due to shielding.

$$P_L = \frac{P_t}{P_r} \qquad \text{(II.6)}$$

– The channel path loss is given in dB .

$$P_L \mathrm{dB} = 10\log_{10}\frac{P_t}{P_r}\,\mathrm{dB}\ \text{(nonnegative number)} \qquad \text{(II.7)}$$

2- Path loss modeling for total urban O2I: Total path loss for line-of-sight (LoS) and non-line-of-sight (NLoS) was modeled as follows .[17]

$$L_{P_{TOT}} = L_{P_{TYP}} + L_{P_{TB}} + L_{P_{IB}} + Z(0, \sigma_P^2) + Z(0, \sigma_{SF}^2) + \mu \quad \text{(II.8)}$$

II.7.2. SHADOWING :

Signal power fluctuations occur due to the presence of obstructing objects in the propagation path between the transmitter and receiver causing a phenomenon called shading, one of the three types of fading shown in the figure II.6 .The fluctuations are determined by the local short-term average forces in order to be able to remove the fluctuations caused by the multi-path fading .[18]

II.7.3. FAST FADING OR SMALL-SCALE FADING :

By the coherence time of the channel and the duration of the signal code, the channels are classified as either fast fade channels or slow fade channels .If the coherence time is greater than the symbol duration, the channel is halved as a slow fading channel .But if the coherence time is less than the symbol duration, and the impulse response change rate is faster than the symbol duration, the channel is classified as a fast fade channel. The signal sent through the path changes in each case it passes through, as shown in the figure II.7.[19]

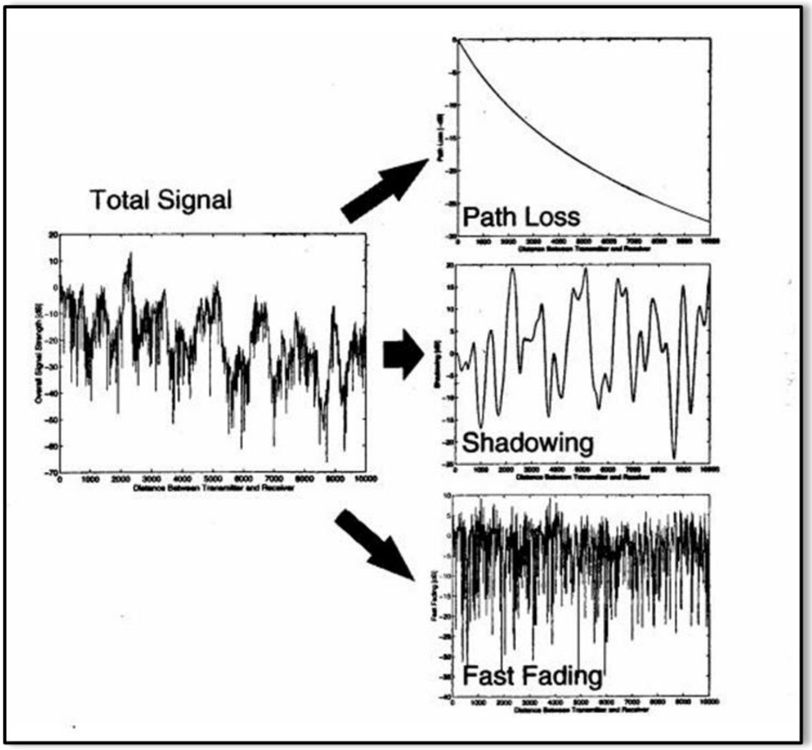

Figure -II.7 Example of signal in mobile radio [20]

II.8. Caractéristiques du canal radio-mobile :

In the mobile system, information is sent on the radio channel from a base station to a mobile station or vice versa (uplink or downlink). The link is done by default and is subject to changing conditions according to the environment note figure II.8, which produces propagation characteristics, including:

- **reflection :**

It occurs as a result of the electromagnetic wave encountering smooth surfaces that have large dimensions much greater than the wavelength (λ) such as building, walls and ground surface.

- **diffraction:**

If the electromagnetic wave is exposed to a thick obstacle that is greater than its length between the transmitter and receiver, diffraction occurs, resulting in other waves propagating behind the obstacle.

- **scattering:**

When the wave is exposed to an obstacle of thickness equal to the length of the wave, scattering occurs like exposure to street lamps.

- **dispersion:**

The phenomenon of scattering occurs when the wave is exposed to obstacles with high speeds higher than its frequency, such as sound, light, or seismic waves .

- **Transmission:**

The transmitted wave is exposed to obstacles that cause its weakness, due to the propagation environment, and the wavelength affects its quality and direction due to the variation in the refractive index of the material, so part of the wave is sent.

- **Wave guiding:**

Occurs as a result of successive reflections between two parallel obstacles, resulting in a displacement of the electromagnetic wave, which occurs mostly in cities in the narrow street. [21]

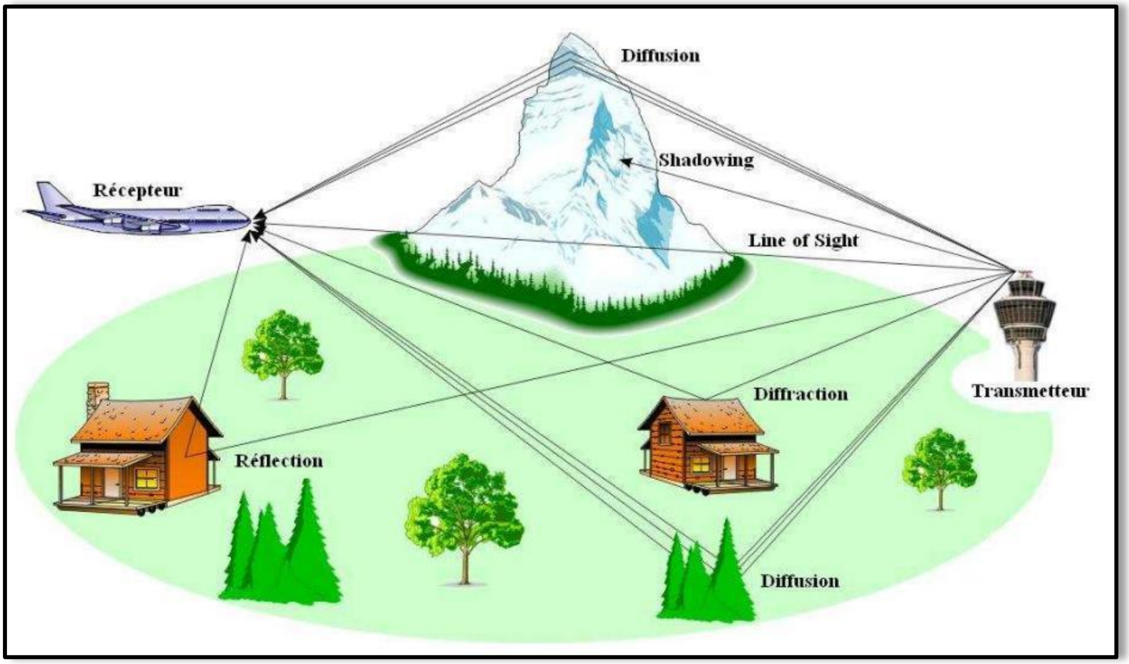

Figure -II.8 Typical radio-mobile propagation scenario [21]

II.9. Representation of the propagation channel :

- **Mathematical formulation :**

for multipath propagation, the received signal (t) is a cascade of differentially delayed and attenuated replicas of the transmitted signal e (t): the propagation channel thus behaves like a linear filter and the propagation channel is represented by the impulse response (RI) h (τ)), which is consistent with the channel response to a Dirac-type pulse. We then have :

$$s(t) = \int_{-\infty}^{\infty} e(t-\tau)h(\tau)d\tau \qquad \text{(II.9)}$$

Most radiocommunication systems depend on the transmitted signal on a frequency band that is not based on zero, so the signal x (t) can be represented by its complex envelope yx (t) in this form :

$$x(t) = \Re\{\gamma_x(t)e^{j2\pi f_0 t}\} \qquad \text{(II.10)}$$

Between the two stands is the real part of a complex number and f0 is a frequency in the dependent range.

In the base range of x (t), there are two ways to express (the base range filter heq (t) is equivalent to the real range filter h (t)) :

$$h_{eq1}(t) = \frac{1}{2}\gamma_h(t)$$
$$h_{eq2}(t) = h(t)e^{-j2\pi f_0 t}$$

(II.11)

The three representations of Figure II.9 are equivalent in order to note the effect of the channel on the transmitted signal.

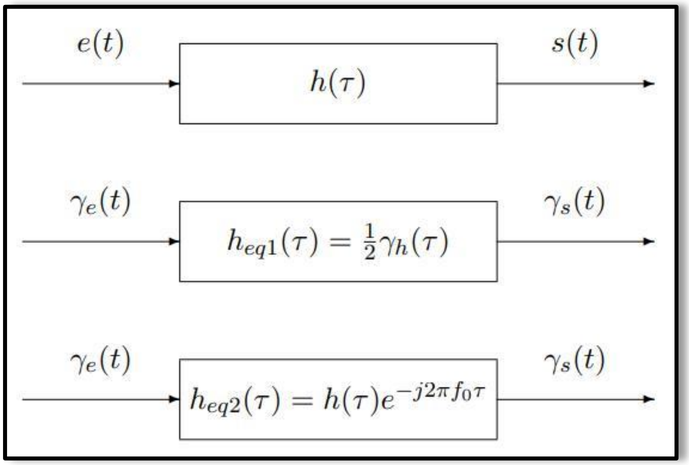

Figure -II.9 Equivalent representations of a static mobile radio channel [22]

II.10. Power Delay profile PDP :

The energy delay can be identified by the amplitude distribution and the delay distribution in the paths. Usually, Rician and Rayleigh power distributions are used for line-of-sight case, the signal is transferred from the transmitter to the receiver directly, and in the case of non-line-of-sight, the transmitted signal reaches the receiver after encountering obstacles that reduce its severity in the case of applying a Rayleigh distribution, but in a Rician distribution it reaches a higher capacity. [23]

II.11. Radio channel modelling :

II.11.1. Narrowband Models :

Narrow bands define if the signal bandwidth is less than the coherent channel bandwidth and because the signal bandwidth is narrow, the fading mechanism will affect all frequencies in the signal traffic band equally. Therefore, a narrow-band channel is often referred to as a flat fade channel. Figure II.10 shows interferences in this band.[24]

II.11.2. Wideband Models :

They are the bands in which the bandwidth exceeds the bandwidth of the channel coherence, i.e. uses a relatively wide range of frequencies and this can cause time dispersal, which allows interference between users and noise .[24]

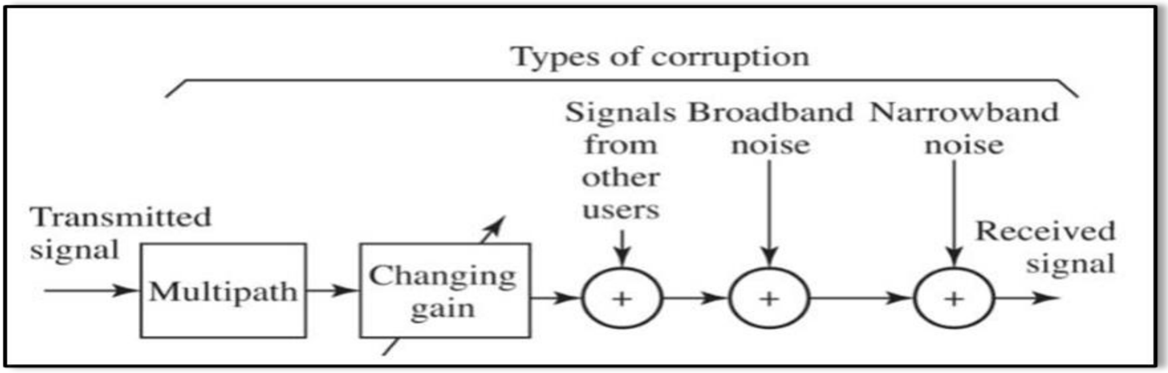

Figure -II.10 Sources of interference, changing channel gains, interference fromother users, broadband noise, and narrowband interferences [25]

II.12. Different families of Propagation models :

To model the different radio propagation channels, several different methods are needed. Since the transmitted signals are subject to different effects such as reflection or diffraction around buildings, a simplified and approximate modeling types of wireless communication channels can be used. Channel models are divided into two categories (deterministic - random) for each section a specific basic data type as shown in the figure. II.11 .

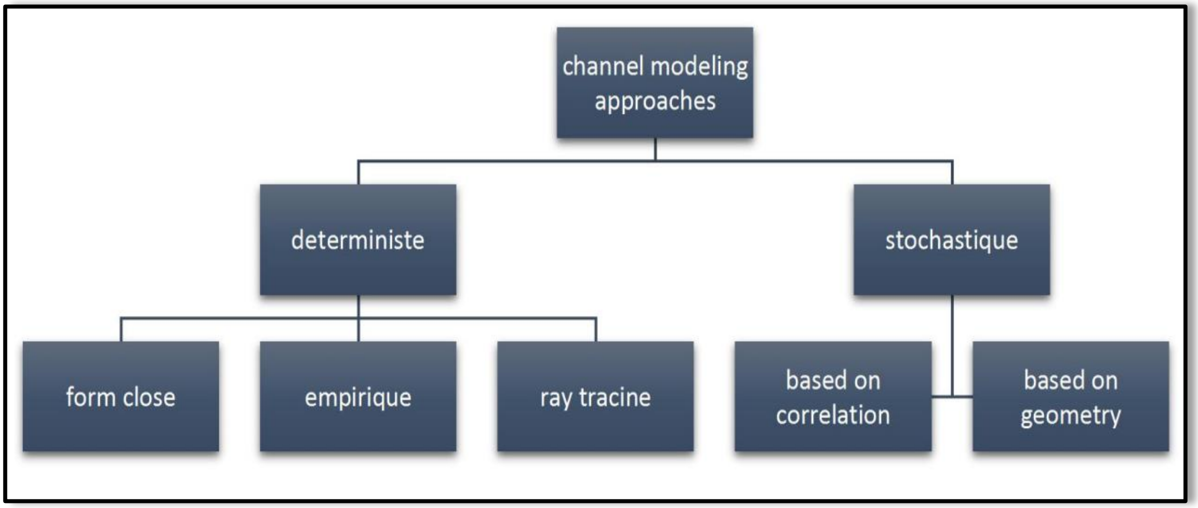

Figure -II.11 Classification of channel modeling approaches[26]

-

- **The purpose of using the model :**

– In order to improve the performance of the base station (BS) by providing a database of wireless network designers

– Discover the difficulties of designing and testing wireless systems. [26]

II.12.1. Deterministic modeling :

– The deterministic model is divided into three subcategories

– Experimental approach This category relies on extracting channel information from data collected from channel measurements accurately under specific study environment conditions

– Closed model does not allow a realistic scenario representation of the environment under study ray tracing approach .[26]

II.12.2. Stochastic modeling :

Stochastic modeling allows providing sufficient accurate information about the channel. Data are collected from a wide range of locations in the study environment for the purpose of providing a statistical representation of the channel in order to calculate the random models.

There are two categories of stochastic approach

– A random geometry-based model (GBSM) or as it is called a ray-based model, in which the diffusers are distributed in a certain way on a pre-determined geometric shape, such as a circle, between the transmitter (TX) and the receiver (RX) to mimic the effect of wave propagation

– Correlation-based model that is widely used to model multi-antenna systems and second-order channel castration. [26]

II.12.3. Different existing models :

- **Okumura Model:**

The model is used at frequencies from 150MHz to 1920MHz and at distances from 1km to 100km. The antenna base station height ranges from 30 rn to 1000 rn. It is often used for signal prediction modeling in urban areast the model can be represented by the following formula.

$$Path\ Loss = L_F + A(f,d) - G(h_{te}) - G(h_{re}) - G(_{AREA}) \qquad (II.12)$$

- **Model of Hata :**

Represents a formula based on the graphical path loss data provided by the Okumura model, applicable to frequency up to 2 GHz The Hata model for urban environments .

$$Lu=69.55+26.16\log_{10}f-13.82\log_{10}h_B - C_H+[44.9-6.55\log_{10}h_B]\log_{10}d \quad \text{(II.13)}$$

– For small or medium-sized city

$$CH = 0.8 + (1.1\ \log10 f - 0.7)hM - 1.56\log10 f \qquad \text{(II.14)}$$

– and for large cities

$$CH= \begin{cases} 8.29(\log10(1.54hM))2 - 1.1 \ , \ if\ 150 \leq f \leq 200 \\ 3.2(\log10(11.75hM))2 - 4.97 \ , \ if\ 200 < f \leq 1500 \end{cases} \qquad \text{(II.15)}$$

- **Model Tapped delay line :**

This model can be used to represent the pulse response of a multipath channel, and it is based on a separate pulse number, and it is represented by the following formula .

$$h(t,\tau) = \sum_{i=1}^{N} C_i(t)\delta(\tau - \tau_i) \qquad \text{(II.16)}$$

- **Spencer's model:**

This model is based on the dual group phenomenon and by measurements at 7 GHz, trips arrive in groups for each delay region and angle separately, the power profile of the impulse response is written in this way :

$$h(t) = \sum_{l=0}^{\infty} \sum_{k=0}^{\infty} \beta_{k,l} e^{j\theta_{k,l}} \delta\left(t - T_l - \tau_{k,l}\right) \qquad \text{(II.17)}$$

- **Model IEEE 802.15.3c :**

The IEEE 802.15.3 3c (TG3c) working group in the year 2005 and then worked to develop a high-speed millimeter wave greater than (1 Gbps) as an alternative to support the personal wireless network (PHY) 802.15 (WPAN) to provide services such as high-speed Internet access or data download rates at rates High bitrates of more than 2 Gbps .

- **Model 802.11 ad :**

(TGad) has worked on improving two types of models that are under development from the IEEE 802.11 ad channel model, the first model was used for ray tracing on statistical models to reduce the measurement effort, note that it is not accurate enough, and the second type is based on the measurement channel to obtain Statistical channel model. [26]

II.13. conclusion :

The most important physical phenomena affecting the propagation of radio waves in free space have been discussed in this chapter. We also mentioned the characteristics of the propagation channel and its mathematical representation, as well as modeling (radio propagation models), which allowed prediction of the wave behavior and define a prior scenario for it to improve the performance of wireless access systems

.

CHAPTER III :

TECHNICAL COVERAGE ANALYSIS RAY TRACING

III.1. Introduction :

In this part, we rely on the most common technique (ray tracing) for its ability to accurately and naturally generate effects such as sharp reflections, refractions and shadows, and provides results that are close to reality. Using the MATLAB programming language, the analysis of radiofrequency propagation for wireless communications is studied by means of a three-dimensional map, and the antennas are located on it as a first step. By applying a specific algorithm that contains information about the antennas, the correct location coordinates, the frequency rate used, and the file of the three-dimensional map, the results are determined and the path of the beam is traced from the transmitter to the receiver between buildings and roofs, and the phenomena affecting it are revealed .

III.2. Ray tracing :

Ray Tracing is a technique that depends on monitoring the movement and path of the ray from its starting point to another point. It monitors every refraction or reflection that occurs along the ray, as well as the shadow ray. It is a repetitive algorithm that tracks the rays closer to reality. The primary rays are traced from their starting point to their intersection with the geometric shapes at the point IPS As shown in the figure III.2 , and from this point the secondary rays are traced to other intersection points [27].It is a method that uses geometry by examining the paths of wireless radio signals as if each path were a ray of light that reflected on the surfaces. To get good ray tracing predictions, detailed information about the area must be available. The steps can be summarized in the figure III.1.

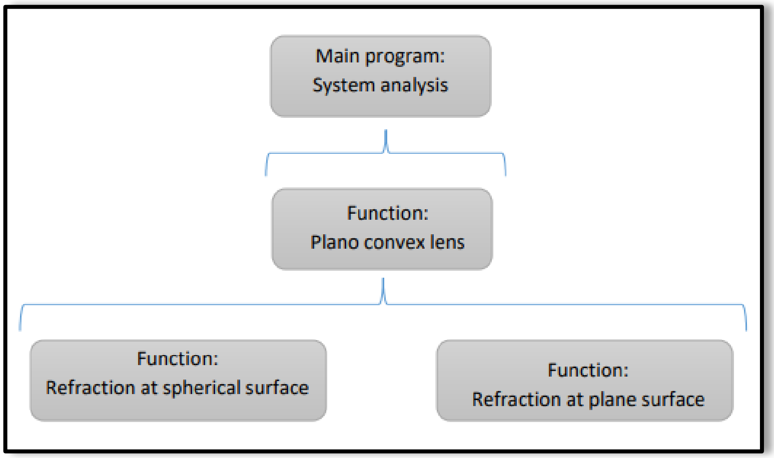

Figure-III.1 Structure of the geometric ray tracing program for a plano-convex lens.

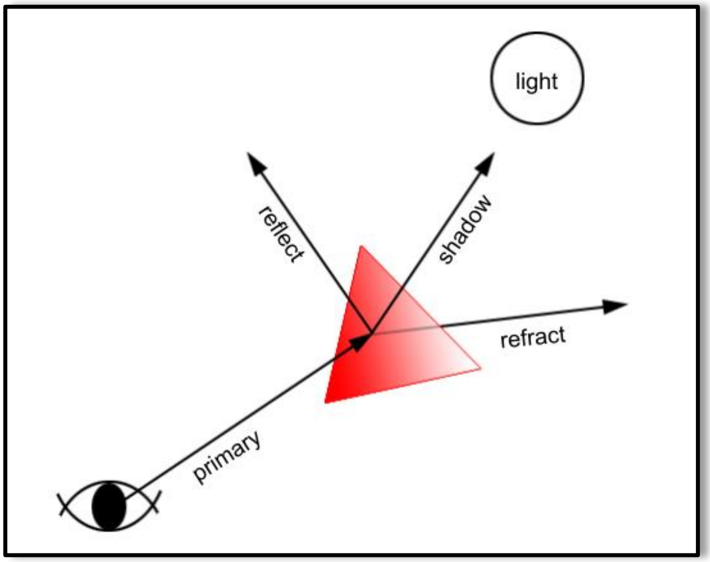

Figure-III.2 Ray tracing diagram where primary ray is traced from the eye to the scene casting secondary rays.[27]

III.3. Ray Tracing Methods :

Ray tracing technology is based on the use of the propagation model and the functions of ray paths and tracks what affects them in the line-of-sight path (LOS) and non-line-of-sight (NLOS) paths.

- The model of paths on the line of sight (LOS) depends on the way the beam is launched from the device from the transmitter to the receiver in the event that the beam does not interact with the surfaces before reaching the receiver, we say that the LOS path exists.
- The non-line-of-sight paths (NLOS) model works using SBR and the method of use is determined by the applied propagation model function.[28]

III.4. Work steps in ray tracing :

III.4.1. Importing buildings 3D map data and displaying it on the site viewer:

Through the website https://www.openstreetmap.org, we obtained the map data. where we have imported an OpenStreetMap (osm) file that is compatible with hospital in el-oude, algeria. We downloaded the file,through which we can access mass-source map data around the world. The data is licensed under the Open Data Commons Open Data base License (ODbL). Building information in the osm file is imported and visualized in the site viewer.

```
viewer = siteviewer("Buildings","C:\hopital_eloude.osm","Basemap","satellite");
```

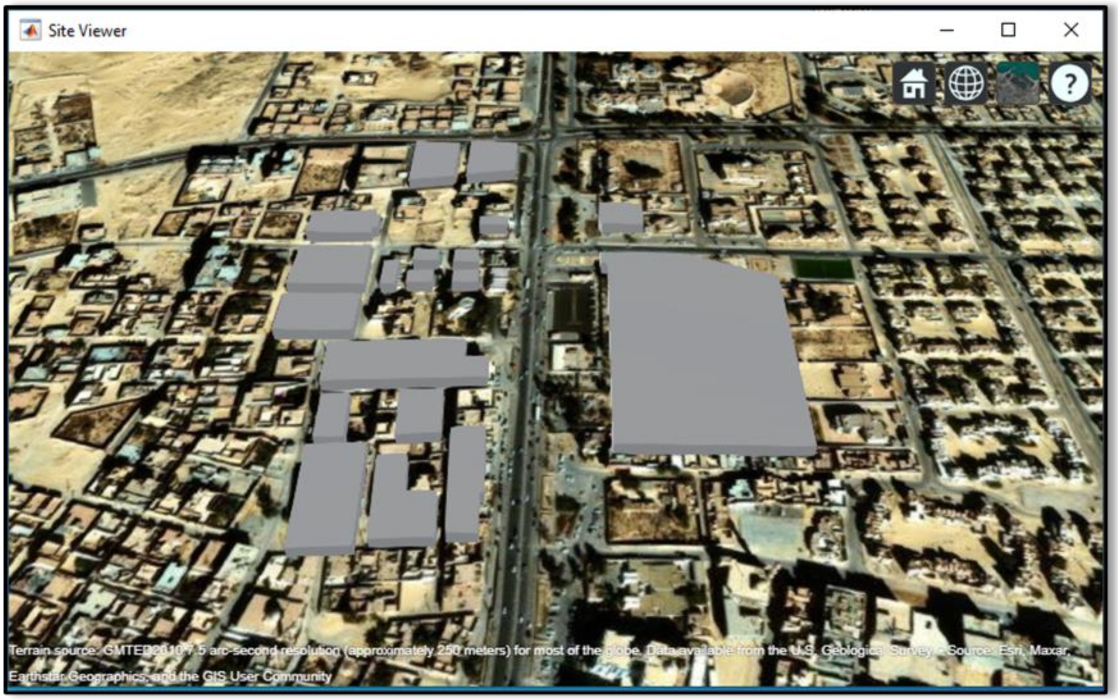

Figure-III.3 Satellite map of the hospital in the city El oued

III.4.2. different types of antennas and installation scenarios:

In MATLAB, we start by loading an antenna object that was designed with antenna Toolbox.

```
f = 28e9;
c = physconst('lightspeed');
lambda = c/f;
N = 8;
dx= 0.48*lambda;
dipole_L = lambda/2;
dipole_W = lambda/200;
dp = dipole;
dp.Length = dipole_L;
dp.Width = dipole_W;
dp.TiltAxis = 'Z';
dp.Tilt = 90;
fmin = f - .05*f;
fmax = f + .05*f;
minX = 0.0001; % Minimum value of reactance to achieve
trim = 0.0004; % The amount to shorten the length at each iteration
resonant_dipole = dipole_tuner(dp,f,fmin,fmax,minX,trim);
```

```
helement = figure;
show(resonant_dipole)
axis tight
```

```
dipole_array = linearArray;
dipole_array.Element = resonant_dipole;
dipole_array.NumElements = N;
dipole_array.ElementSpacing = dx;
hArray = figure;
show(dipole_array)
axis tight
```

We get the following results shown in the figures (III.4 , III.5 , III.6 , III.7) .

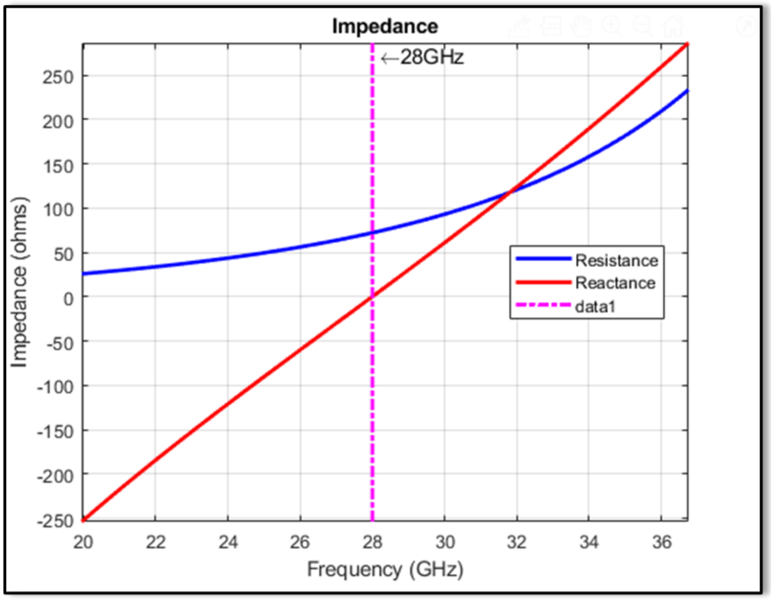

Figure -III.4 Impedance as a function of frequency 28 GHZ

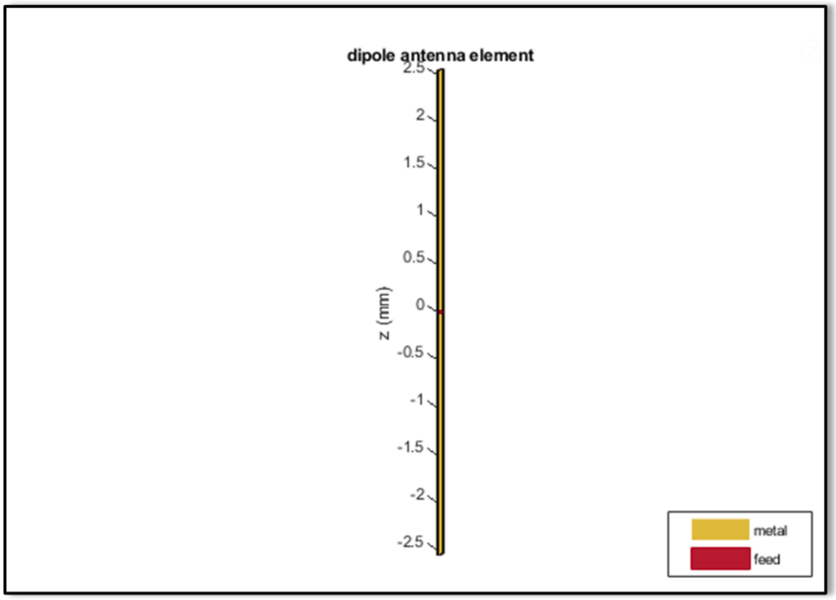

Figure -III.5 Dipole antenna element

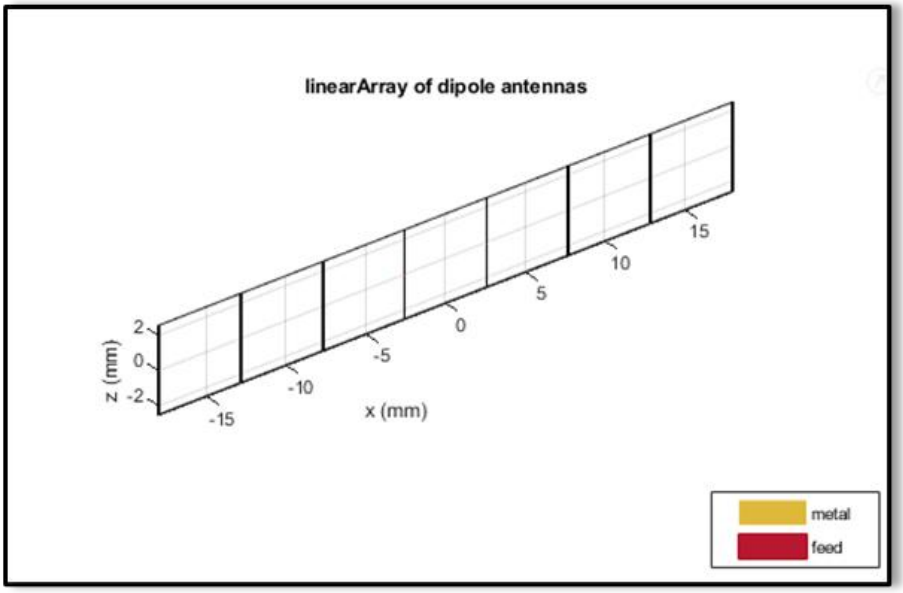

Figure -III.6 Line matrix of a dipole antenna

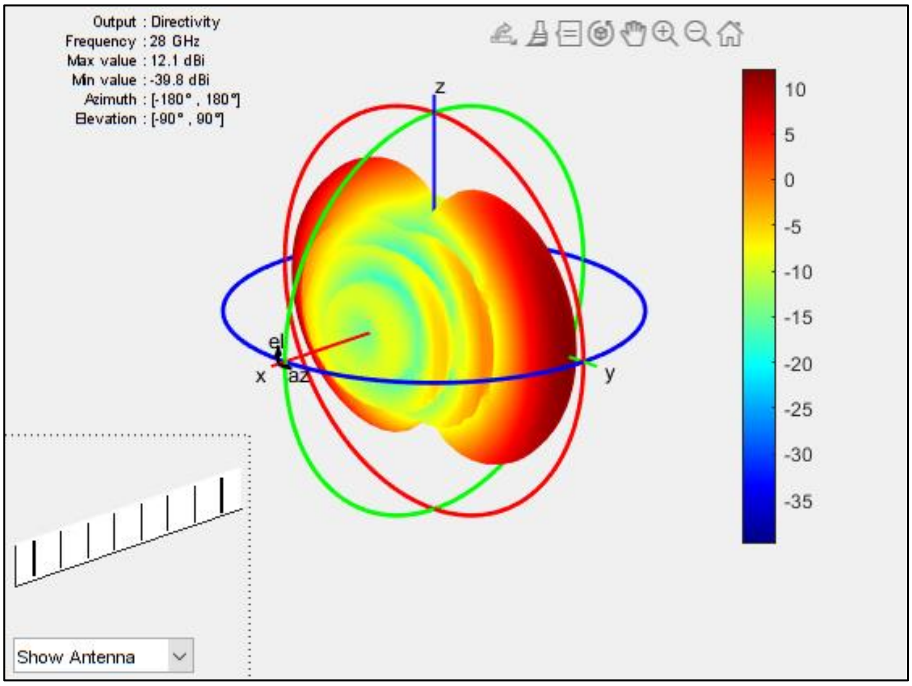

Figure -III.7 3D antenna coverage.

III.4.3. Create and determine the transmitter antenna in the 28 GHz frequency:

- **Locating the transmitter antenna:**

We select the location of the TX transmitter base station for the propagation model of the cell within an area with a dense urban environment. The TX antenna is 10 meters long and has a power of 5 watts, with a transmitting frequency of 28 GHz, as shown in the figure.III.8

```
f = 28e9;
tx = txsite("name","Lang01", ...
 "Latitude", 33.393608, ...
 "Longitude", 6.871569, ...
 "TransmitterPower",5, ...
 "TransmitterFrequency",f);
show(tx)
```

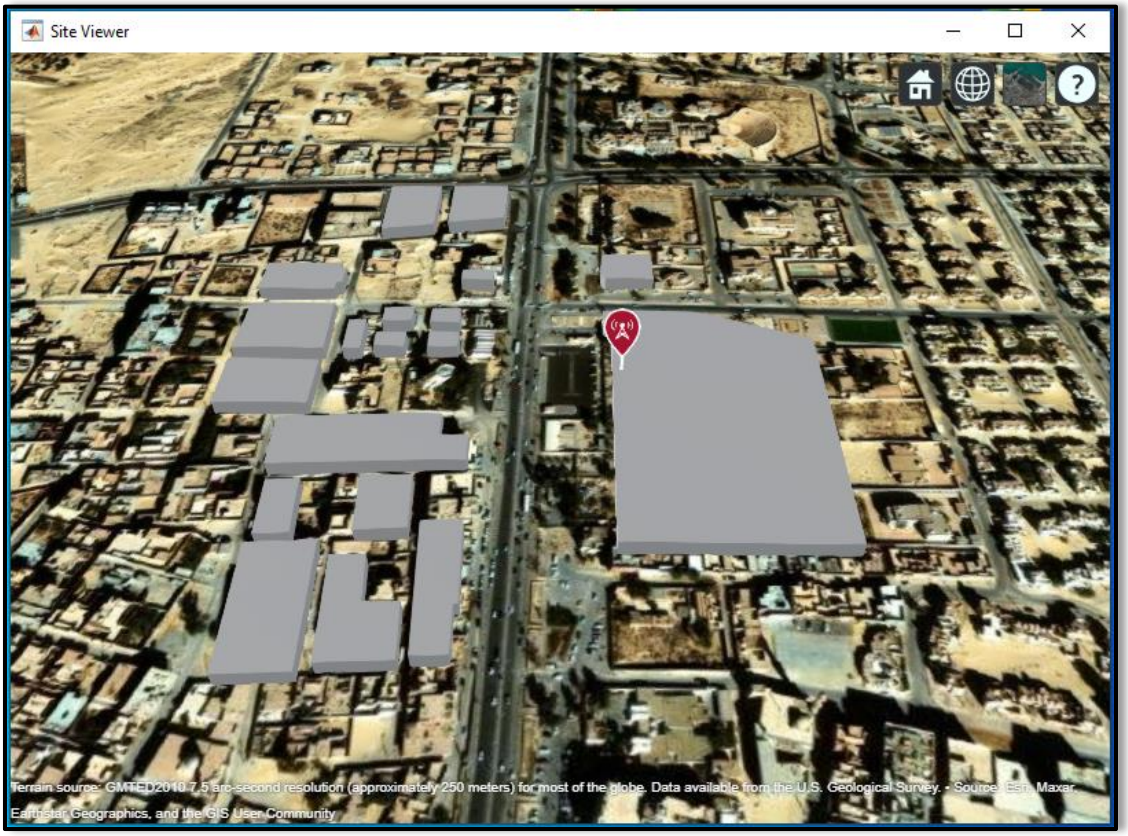

Figure -III.8 Satellite map of Eph Ben Amor Djilani El-Oued

The transmitter is located in the city of el oued, within the vicinity of the public hospital, exactly with the following coordinates:

– Longitude 33.393608
– Latitude 6.871569

- **Locate the receiving antenna:**

After choosing the location of the antenna according to virtual characteristics, then we track the paths of the line of sight to detect surfaces and obstacles between the TX and the RX

Two antennas were chosen to receive around them at different distances. The figure (III.9 - III.10) shows the coordinates of each receiving antenna.

```
rx01 = rxsite("Name","counter", ...
    "Latitude",33.394692, ...
    "Longitude",6.870632);
rx02 = rxsite("Name","fast food", ...
    "Latitude",33.39560, ...
    "Longitude",6.871811);
rxs = [rx01, rx02,];
show(rxs)
```

Figure -III.9 The coordinates of the receiving antennas are in MATLAB

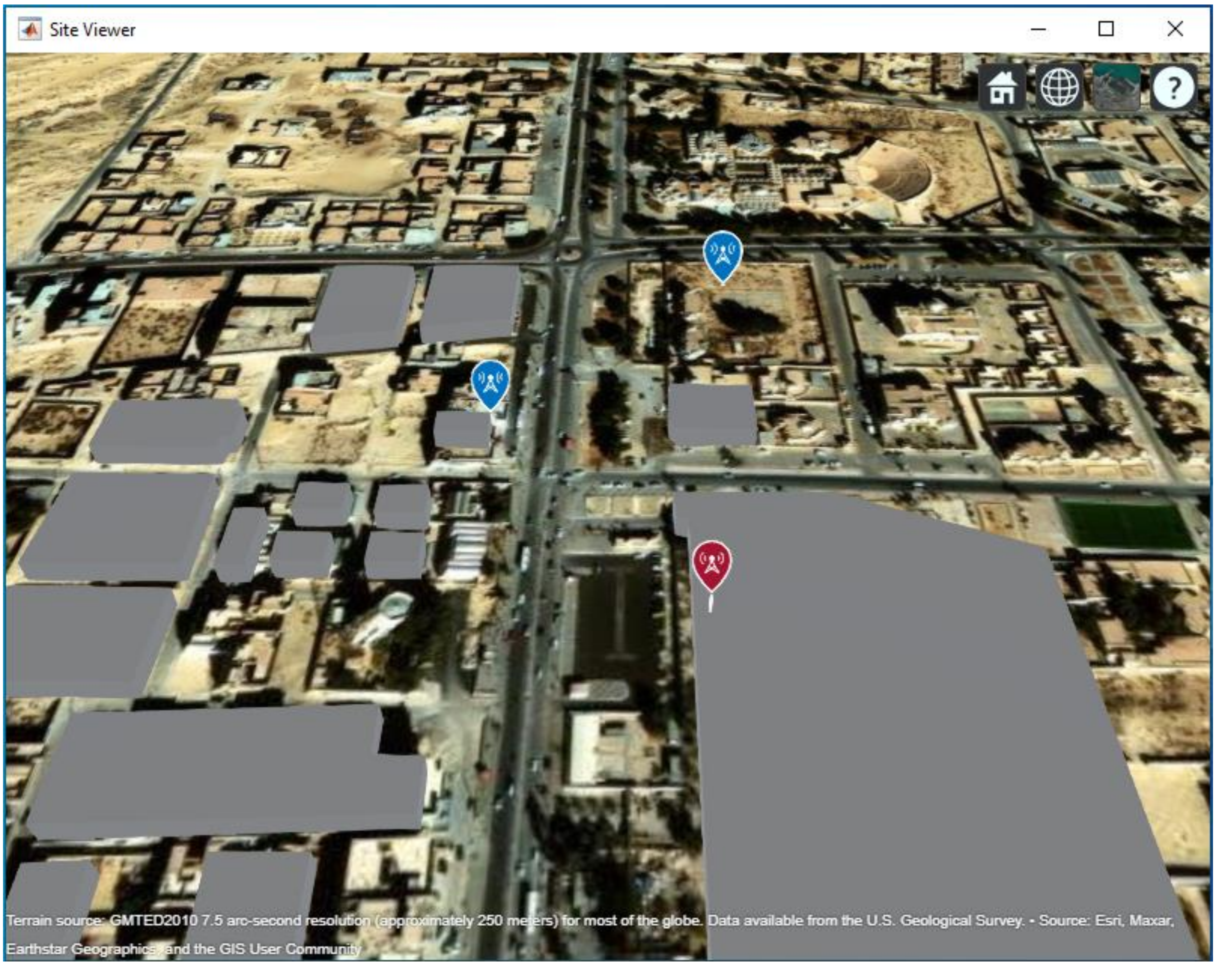

Figure -III.10 The receiver and the transmitter site array

III.4.4. Tracks directly between antennas :

Figure shows III.11 the signal paths without being exposed to obstacles such as buildings and other terrain that will impede access and consequently the transmission loss.

```
los(tx,rxs)
```

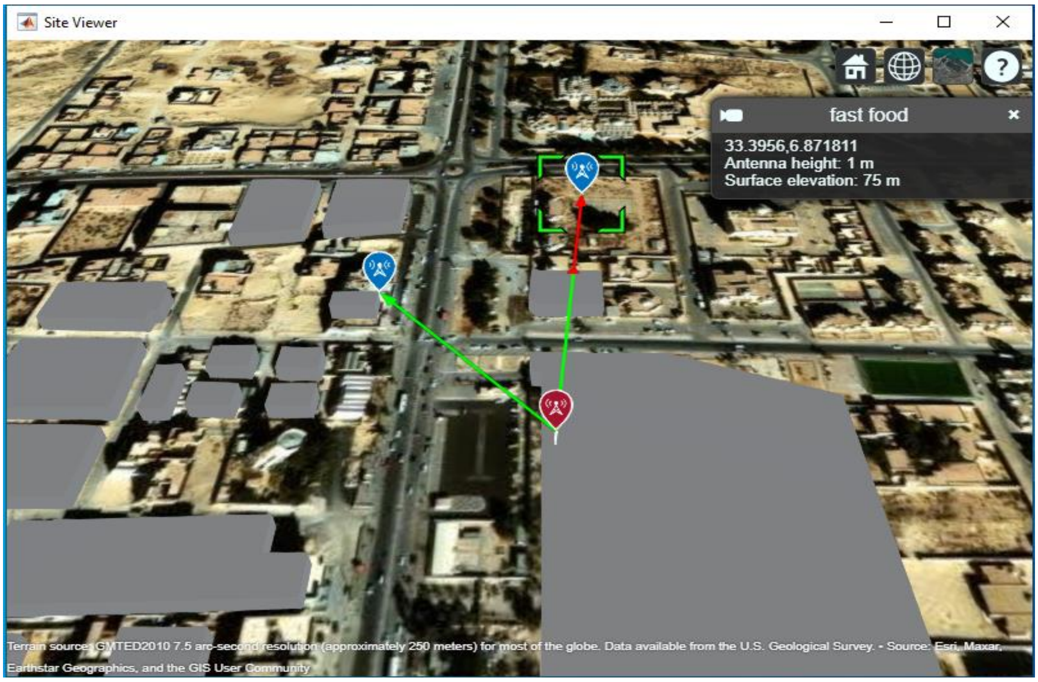

Figure -III.11 paths between TX and RX

To avoid obstacles that may be encountered by the receiving antenna on the line of sight, the height of the RX02 antenna is set at a distance of 7 meters.

```
rx02.AntennaHeight =7;
```

We locate a transmitter to model a small cell scenario in an urban area perennial a base station placed on the pole of the next area is the transmitter site the surrounding area, which includes a hospital and an adjacent car park. Antenna length 10m each 28 GHz level Power 5watts.

```
tx = txsite("name","Lang01", ...
 "Latitude", 33.393608, ...
 "Longitude", 6.871569, ...
 "AntennaHeight",10, ...
 "TransmitterPower",5, ...
 "TransmitterFrequency",28e9);
tx.Antenna = dipole_array;
pattern(tx)
show(tx)
```

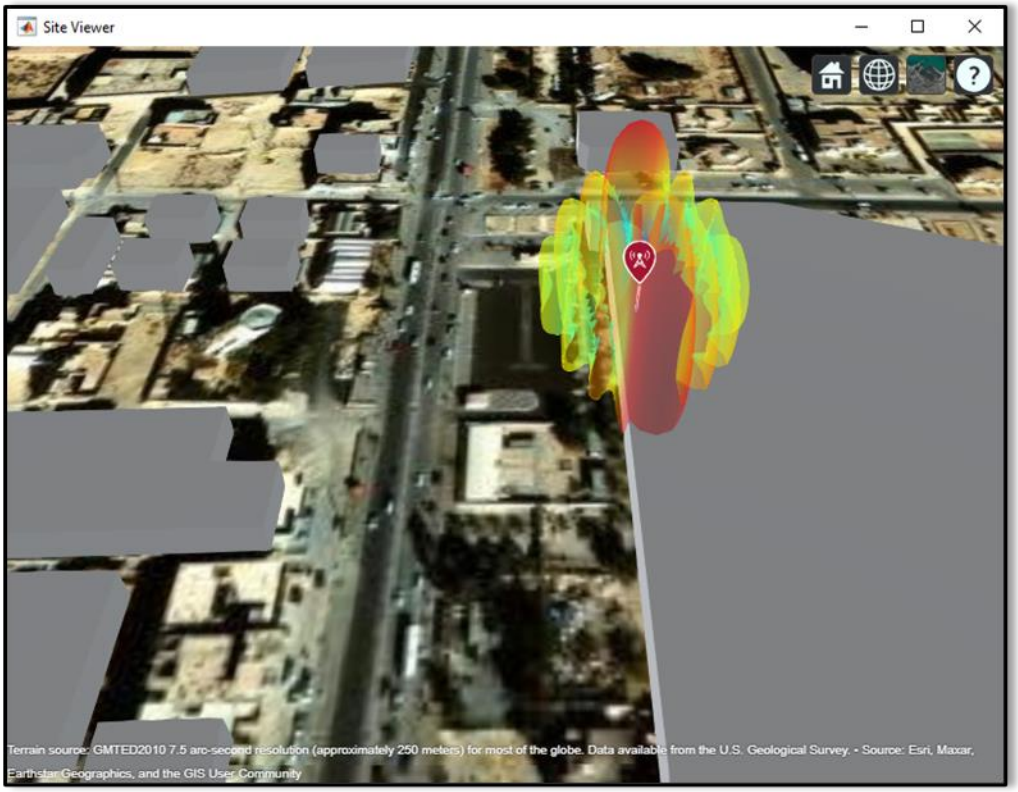

Figure -III.13 3D antenna coverage

- **Transmitter antenna coverage :**

We have a coverage map the received power of the receiver is at each ground location but it is not calculated for building tops or sides.And we display the coverage map that we have applied, which corresponds to a maximum range of 250 meters from the base station and the signal strength is estimated as follows (-130:-5).

```
PM = propagationModel("raytracing-image-method","BuildingsMaterial","concrete", ...
    "TerrainMaterial","perfect-reflector")

coverage(tx,"SignalStrengths",-130:-5,"MaxRange",250,"Resolution",4,"Transparency",0.8)
```

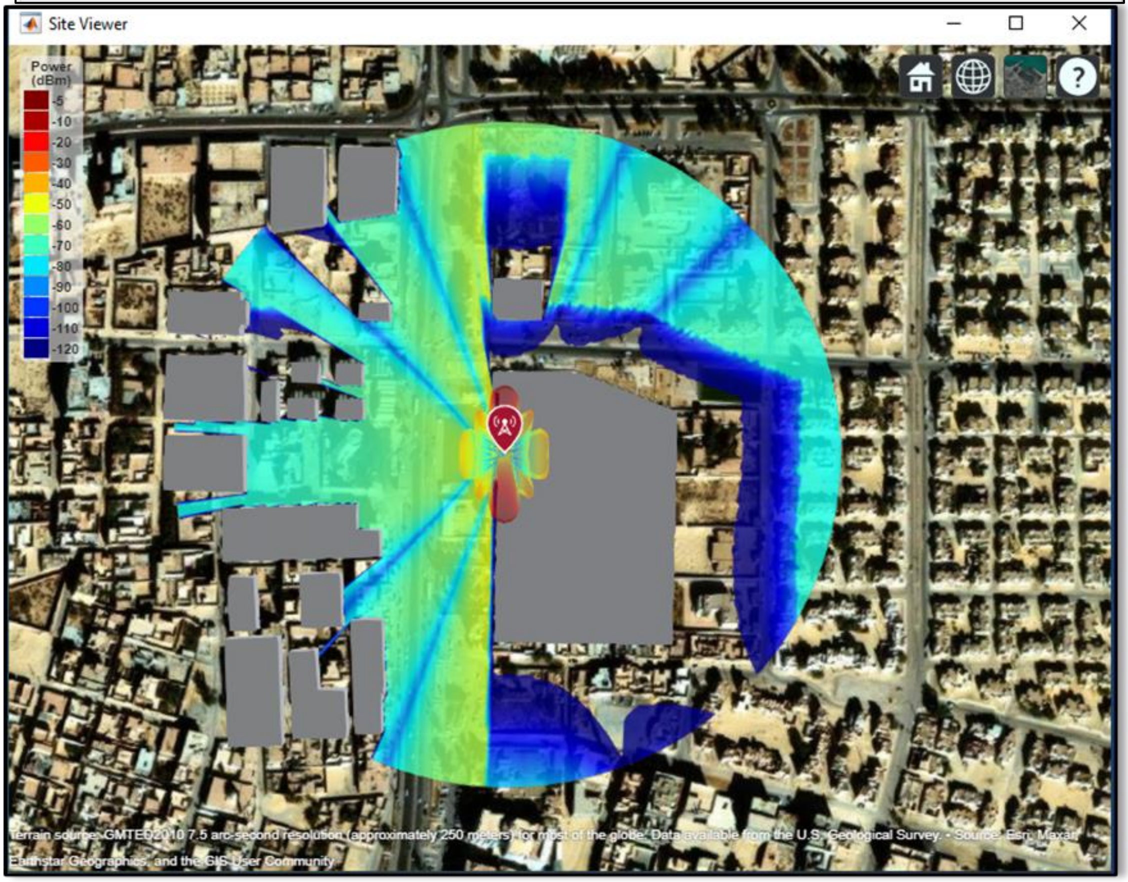

Figure -III.14 . The area covered by the transmitter

III.5. Diffusion modeling in Los and NLos :

- **Line of sight (LOS) :**

The result of the propagation coverage of the transmitting antenna of the line-of-sight shows the appearance of shadows due to the presence of obstacles. The location of the receiver is determined so that a handheld receiver is modeled in an obstructed location, then the line-of-sight path is determined to show the path obstructing the transmission.

```
rx = rxsite("Name","Long02", ...
 "Latitude",33.394321, ...
 "Longitude",6.870325, ...
 "AntennaHeight",3, ...
 "ReceiverSensitivity",-109);
show(rx)
los(tx,rx)
```

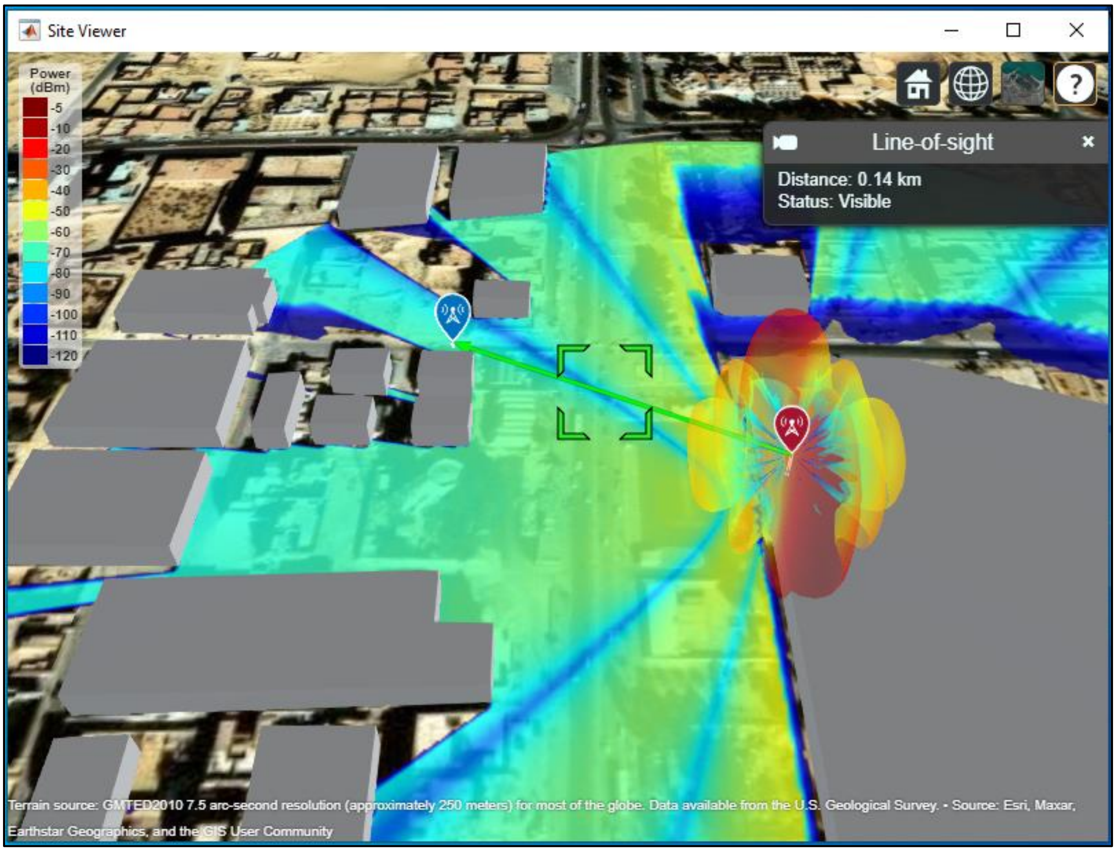

Figure -III.15 Coverage map for line-of-sight propagation

- **No line of sight (NLOS) :**

We create a ray tracing propagation model by using the firing and recoil (SBR) method. The SBR propagation model relies on ray tracing analysis to calculate propagation paths and their corresponding path losses. The path loss is calculated from the free space loss, material reflection loss, and antenna polarization loss.

```
pm.MaxNumReflections = 1;
clearMap(viewer)
raytrace(tx,rx,pm)
```

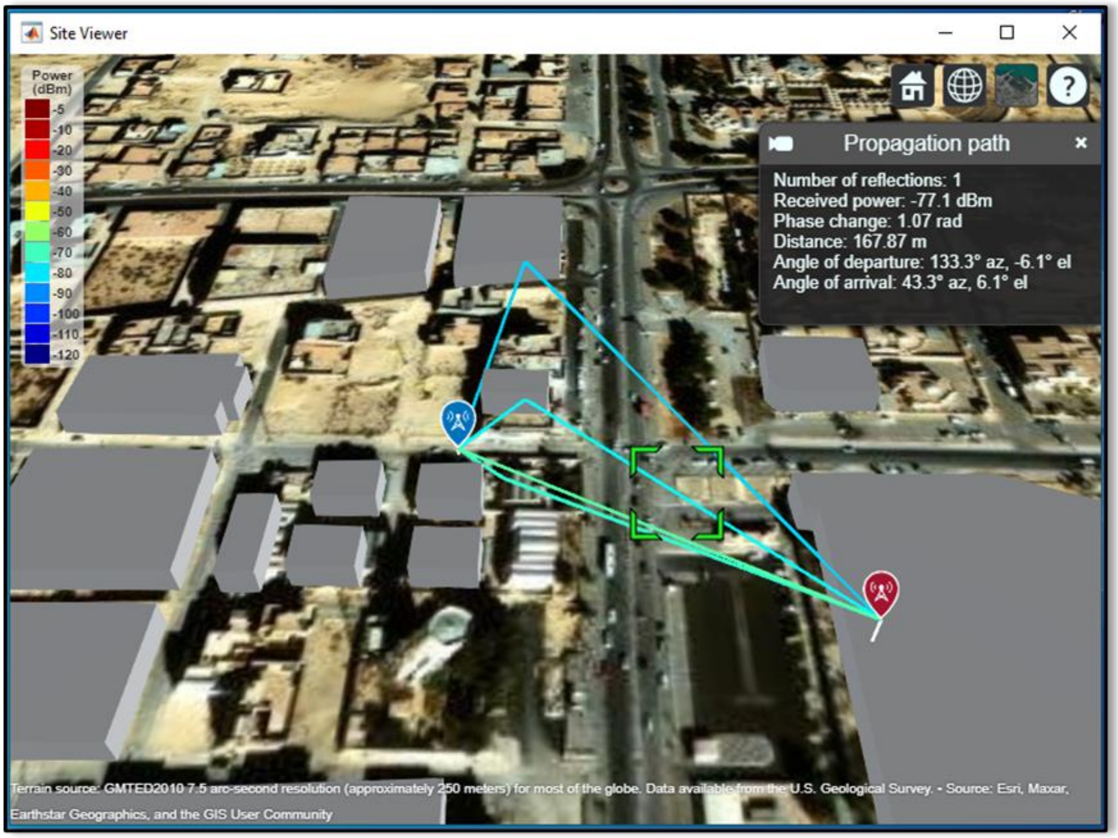

Figure-III.16 Indicates that the path between the TX and the RX is broken

III.6. Signal strength analysis and material effect

We calculate the received power by using the diffusion model that was prepared previously to model an ideal diffusion. Then we assign sleep to a material close to reality and recalculate the received power. Then we update the rays shown in the site viewer. Using realistic physical reflection results in a power loss of about 1 dB compared to ideal reflection.

III.6.1. Show analysis :

- **In the ideal case :**

```
ss = sigstrength(rx,tx,"gas");
disp("Received power using perfect reflection: " + ss + " dBm")
```

```
Received power using perfect reflection: -67.421 dBm
```

- **In the case of realistic materials :**

```
pm.BuildingsMaterial = "concrete";
pm.TerrainMaterial = "concrete";
raytrace(tx,rx,"raytracing-image-method")
ss = sigstrength(rx,tx,"rain");
disp("Received power using concrete materials: " + ss + " dBm")
```

```
Received power using concrete materials: -68.4646 dBm
```

III.7. Conclusion:

Propagation prediction is used in many wireless communication systems to improve their performance. Ray tracing technology as the latest method of propagation modeling has witnessed tremendous progress and after using the ray tracing method in this part of the work we can say that it has proven useful and effective in treating propagation environments in high frequency systems. Ray tracing is a more general method than other methods such as empirical models and can be applied to many propagation scenarios. This technology will play a major role in smart future modeling tools.

GENERAL CONCLUSION

GENERAL CONCLUSION

In this thesis, we touched on general topics about the latest technology in wireless communications, which is called the fifth generation, and the additional services and features it provides to the world of communication technology, and the most important cases of its use in various frequency bands.

We also learned about the types and characteristics of radio channels and their propagation paths. In addition to explaining the natural phenomena affecting these channels, as well as the propagation models in general.

And to study the coverage in a specific area and track the paths that the rays take using radiation tracing, which allows simulation close to the truth through calculations and information about the area and the antennas used, the results are extracted, based on which the model can be applied in the ground.

The aim of this work is to study and simulate 28 GHz coverage in El-Oued city using ray tracing technology. Four receiving antennas were used for the transmitting antenna (the base antenna), the length of which does not exceed 10 meters, on Los and Loss. We studied the propagation characteristics of this band as the simulation results show.

Millimeter wave signal Transmitter access can be available in the LOS path.

REFERENCES BIBLIOGRAPHIQUES

Références bibliographiques

[1] Cisco 5g usher in a new ear of improved network performance https://www.secureitstore.com/5g.asp copyright © 2000-2022. All rights reserved. Site terms and privacy policy.

[2] book - 5G NR: The Next Generation Wireless Access Technology - Erik Dahlman Academic Press is an imprint of Elsevier -copyright © 2018 elsevier ltd. All rights reserved.

[3] 5g and wi-fi 6 resources - ©2022 cisco systems, inc. Https://www.cisco.com/c/en/us/solutions/what-is-5g.html#~faqs

[4] Reseau 5g: deploiment,fonctionnement,usages et smartphones compatibles en france - https://www.frandroid.com/telecom/488716_reseau-5g-tout-ce-qui-va-changer-quels-usages-et-pourquoi-la-technologie-est-importante - 6 octobre 2021.

[5] Http://www.profheath.org/analysis-of-millimeter-wave-systems-for-5g/.

[6] https://www.viavisolutions.com/en-us/5g-architecture

[7] https://www.researchgate.net/figure/architecture-of-5g-network_fig1_339306634

[8] Book - 5g mobile communications - wei xiang - isbn 978-3-319-34206-1 isbn 978-3-319-34208-5 (ebook) doi 10.1007/978-3-319-34208-5 library of congress control number: 2016950231 © springer international publishing switzerland 2017.

[9] Book introduction to mobile network engineering gsm, 3g-wcdma, lte and the road to 5g alexander kukushkin phd, australia - this edition first published 2018 © 2018 john wiley & sons ltd.

[10] Book - deep learning based massive mimo beamforming for 5g mobile network taras maksymyuk -the 4th ieee international symposium on wireless systems within the international conferences on intelligent data acquisition and advanced computing systems 20-21 september, 2018, lviv, ukraine.

[11] 5g:antennes adaptatives massive mimo,beamforming …a quoi ça sert https://reseaux.orange.fr/actualites/5g-antennes-mimo - publie le 27-01-2021

[12] Book - ultra dense networks deployment for beyond 2020 technologies departamento de comunicaciones universitat polit`ecnica de val`encia a thesis submitted for the degree of doctor por la universitat polit`ecnica de val`encia valencia, july 2017-sonia gim´enez col´as.

[13] book - user-centric ultra-dense networks for 5g - shanzhi chen - library of congress control number: 2017945668 © the author(s) 2018.

[14] étude et caractérisation d'un canal de propagation pour les réseaux v anet - mémoire présenté comme exigence partielle de lamaî1rise en ingénierie université du québec en abitibi-témiscamingue .

[15] relation entre canal de propagation et canaux virtuels mimo : etude et experimentation patrice pajusco, nadine malhouroux-gaffet.

[16] canal de propagation 3eme annee telecom-reseaux 2007-2008 martial coulon .

[17] path loss ,ee4367 telecom. switching & transmission prof. murat torlak ,https://personal.utdallas.edu/~torlak/courses/ee4367/lectures/lecturer dio.pdf

[18] chapter :wirelesschannels ,shadow http://www.wirelesscommunication.nl/reference/chaptr03/shadow/shadow.hm

[19] mimo wireless communications over generalized fading channels - brijesh kumbhani rakhesh singh kshetrimayum © 2017 by taylor & francis group, llc crc press is an imprint of taylor & francis group, aninforma business -international standard book number-13: 978-1-1380-3300- 9 (hardback).

[20] methods for path loss prediction- school of mathematics and systems engineering reports from msi - rapporter från msi- cem akkaşli.october 2009-växjö university issn 1650-2647.

[21] estimation de canal radio-mobile a evolution rapide dans les systemes a modulation ofmd hussein hijazi-traitement du signal et de l’image [eess.sp]. institut national polytechnique de grenoble - inpg, 2008. français. fftel-00373806.

[22] caracterisation et modelisation du canal de propagation radio en contexte ultra large bande pascal pagani insa de rennes, 2005. français. fftel-00011220.

[23] measurements and models for the wireless channel in a ground-based urban setting in two public safety frequency bands william f. young - electromagnetics division national institute of standards and technology 325 broadway boulder, co 80305 january 2011.

[24] http://www.differencebetween.net/technology/difference-between-narrowband-and-wideband/.

[25] https://www.jobilize.com/course/section/narrowband-noise-modelling-corruption-by-openstax.

[26] modélisation d'un canal à 60 ghz en utilisant les réseaux de neurones perceptron multicouches mémoire présenté comme exigence partielle de la maîtrise en ingénierie par chaimaa benkirane aout,2013.

[27] fast ray tracing techniques by john a. tsakok a thesis presented to the university of waterloo in fulfillment of the thesis requirement for the degree of master of applied science in electrical and computer engineering waterloo, ontario, canada, 2008 c john a. tsakok 2008.

[28] https://www.mathworks.com/help/comm/ug/ray-tracing-for-wireless-communications.html.