Development of a System Level Simulation Tool Based on a Web Interface for LTE/LTE-A

by

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Telecommunications

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ABSTRACT

The objective of this researched was to develop a system-level simulation tool based on web interface for LTE and LTE-A. A number of radio models were rigorously investigated during the research process. First stage of this tool constitutes a 4G advanced mode model which eventually serves as a preparation tool for a 5G network simulator, the second phase of the project. Conceptually, this tool has two approaches, static and dynamic. The static approach assumes that we take only a static snapshot of the network and observe what network performances behave. Whereas the dynamic approach follows the dynamics of the system in terms of call arrivals and departure. Basically, it calculates all network performances as observed in real network metrics, for instance, user throughput, a user holding time, call blocking and dropping ratio. In this researched we successfully build web-interface simulation tool which is expected to benefit the user with a drone eye view of network traffic and help in analyzing and estimating the budget of network elements. In this research MATLAB version, 2017a and Netbeans 8.2 were used for coding and evaluating the scenario.

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API	Application Programming Interface
BSS	Basestations
CSI-RS	Channel State Information-Reference Signal
CSS	Cascading Style Sheets
CSV	Comma Separate Value
D2D	Device to Device
DL	DownLink
eFD- MIMO	Enhanced Full-Dimension Multiple-inputs Multiple-outputs
eMBB	Enhanced-Mobile broadband
eNB	Evolved Node
GUI	Graphical User Interface
HTTP	Hypertext Transfer Protocol
ISR	Interference to Signal Ratio
KPIs	Key Points Indicators
LTE	Long-Term Evolution
mMTC	Massive Machine Type Communication
MS	Mobile Station
NR	New Radio
PRBs	Physical Resources Blocks
QoS	Quality Of Service
REST	Representational State Transfer
RSSI	Received Signal Strength Indicator
RSRP	Reference Signal Receive Power
SINR	Signal to Interference Plus Noise Ratio
SOAP	Simple Object Access Protocal
SL	System Level
UE	User Equipment
Wise	Wireless Simulator Evolution

CHAPTER 1

INTRODUCTION

1.1 Overview

5G technology is on the verge of deployment, some countries are in the process of deployment and some other countries claim that by the end of 2019 they will have a fully functioning 5G telecommunication system. But still, 5G telecommunication is in an infant stage and lot of research are undergoing on it. A 5G cellular communication system includes different application areas which are enhance-mobile broadband(eMBB), massive machine-type communication(mMTC) and Ultra-reliable and low latency communications. Nevertheless, LTE(Long Term Evolution) continues to provide a promising service and is still being used in a lot of nations. To perform the practical implementation of any network or research output it needs a lot of time and money. So to compensate time and money we need a simulator, which gives liberation to build any kind of network scenario according to our desire parameters and conditions.

To analyze the performance of the cellular communication system different types of simulations can be implemented such as link-level simulation, System-level simulation, and network-level simulation.

This research is focused on developing a web-based interface system-level simulation using programming language. So that user can easily analysis system simulation varying different Radio parameters. System-Level simulation is powerful simulation tools to understand any cellular network communication system, therefore, it is extensively used and preferred.

1.2 Problem Statement

System level simulation of the cellular network is a comprehensive study of the network, it gives a perfect insight into the radio scenario, so it has been widely accepted and used in various fields. In (**Müller et al.**,2018) they claim to develop the 5G system-level simulator but those simulations are not web interface and consider only simple scenarios. In (Cho et al.,2017) they highlighted the characteristics of the 5G simulator and give a brief idea for constructing system-level simulator with GUI (Graphical User Interface) only. If we consider all literature till today they are licensed based or GUI system-level simulation of 4G/5G, so this internship develops 4G system-level simulation in the web-based interface which help user to analysis the scenario, understand the performance metrics with out installing software in physical device and paying fees for licensed.

1.3 Research Objectives

- Analysing the existing 4G and 5G NR system level simulation technology.

- Investigate radio models on LTE/LTE-A, 5G NR on system level simulation.
- Develop a web-based interface for system level simulation of LTE/LTE-A.

1.4 Scope and Limitation

This researched successfully developed LTE system-level simulation. Tool consider practical scenario as far as possible. This tool is still in infant stage, so it have some limitation. This tool can be used for general scenario, it does not include beamforming in dynamic pattern , joint processing, up-link and adaptive TDD, etc. Nevertheless this tool is very much helpful and promising for future simulator.

1.5 Contribution

There was 3.5 G system level simulation tool in Matlab, so research adapted that tool and enhance it to LTE/LTE-A system level tool. Later on in this LTE/LTE-A system level simulation tool research included 3D spatial beamforming too. Research developed the web-based interface tool using java language and provides web services using map and graphical output.

1.6 Organization of Report

This report is organized as follows.

- Chapter 2 Reviewed the existing literature of system-level simulation.
- Chapter 3 Present our methodology of the proposed 4G/5G system-level simulation.
- Chapter 4 Report present the simulation tools output and analysis those output.
- Chapter 5 Report talk about conclusion of this research and end with Recommendations and future work.

CHAPTER 2

LITERATURE REVIEW

2.1 System Level simulation

System-level (SL) have become inseparable tools for predicting and investigating the behaviors and performance of a radio network system. Therefore its focus on network-related aspects, like capacity, latency, coverage, efficiency, resource allocation, etc. To understand the potential of novel technology, system-level simulation is an undoubtedly best and efficient tool. System-level encompasses the larger number of network elements.

In a work by Muller et.al, they argue that system-level simulations are essential to evaluate the impacts of cell planning, scheduling, or interface management methods on the performance of the network technologies (**Müller et al.**,2018). At the system level, we consider the behaviors of traffic flow among different nodes, merging and splitting , each flow using links to moves from different node to node. System-level simulation generally consists of a network with multiple BSs and MSs. The system-level simulation focuses on the application layer performance metrics as expressed by system throughput, user fairness, user-perceived quality of services, handover delay, etc . System-level simulation emphasis above the physical layers(**Müller et al.**,2018).

2.2 Link Level simulation

Link level simulation evaluates the link between a user equipment(UE) and base station. In chenand2011 system paper it was said that link simulations explore the performance of the link. In this simulation point to point physical layer technologies with propagation model is included, which reflects that it is based on single terminal scenario and single-cell(**Chenand et al.**,2011).

Link–level simulation is a crucial aspect of performance analysis. Link level simulation is generally to examine the performance of different physical layer technologies. Link –level simulations are mainly for developing receiver structures, coding schemes, etc. The link-level simulation emphasis on the operation between base stations (BSs) and mobile stations (MSs). In common terms link-level simulation focus on the physical layer. From link-level simulation one can obtain demodulation/modulation or decoding/coding schemes which can be used for researched studies. In link-level simulation link between a BS and UE is analyzed, whereas in SL simulation larger number of BSs and UEs in the huge site is consider where traffic between UEs and BSs may interfere with each other. So, the network performance including UE throughput, handover rate, fairness , packet re-transmission number, packet loss rate, latency, cell spectrum efficiency, cell edge user spectrum efficiency etc, can be analysed comprehensively. These days system-level simulation has been vastly used for equipment verification, network planning, specification development, and academic research.

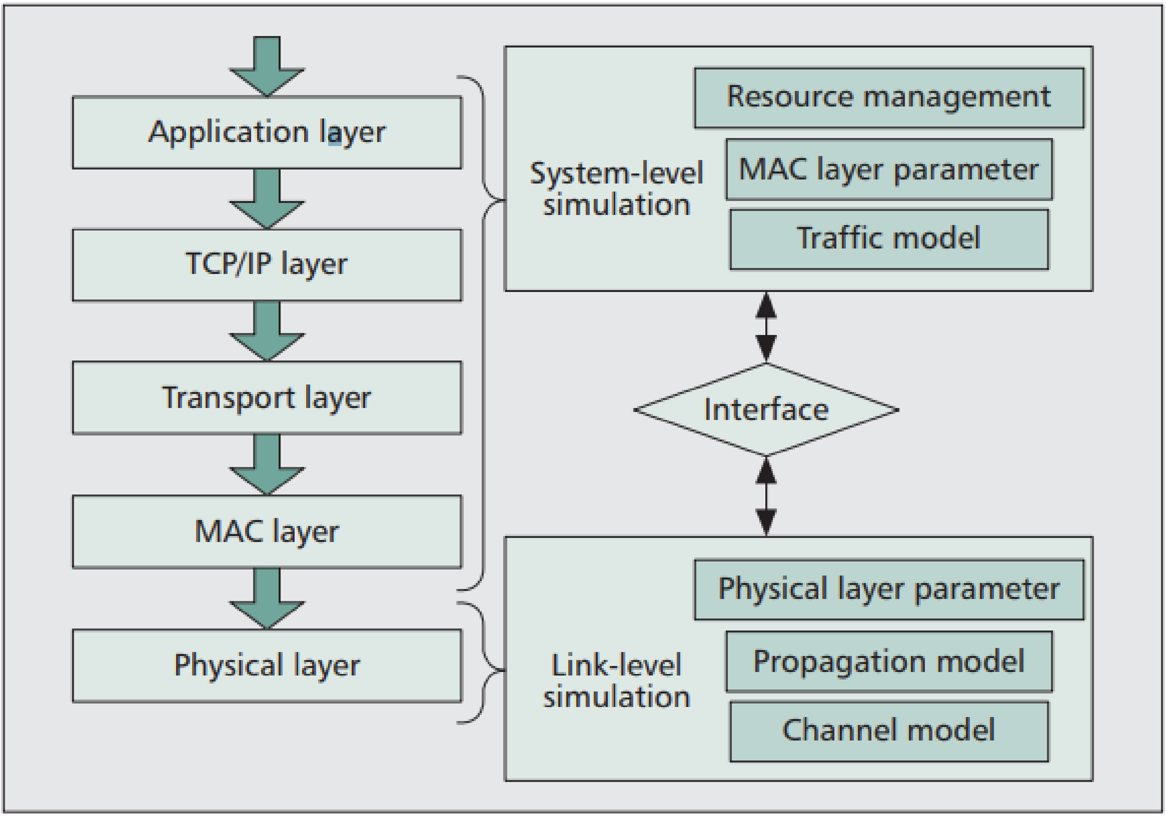

Figure 2.1: Difference between system level and link level

(**Chenand et al.**,2011)

2.3 Related work

In (**Jao et al.**,2018) author presented a Wireless Simulator Evolution (WiSE) to measure performance evolution of 4G/LTE mobile networks. WiSE was originally developed for LTE networks regarding the LTE specifications. Currently, it supports LTE Rel-14 with enhancements on full- dimension multiple- input multiple outputs (eFD- MIMO), beamformed channel state information-reference signal (CSI-RS) transmission, Class A precoder for 32 antenna ports, and advance CSI feedback. It has extended its simulation to includes key designs for 5G NR (New Radio) (**Jao et al.**,2018).

5G NR has a large number of MIMO precoding matrices, which demands large memory, especially for NR type II code-book. Usually precoding matrices pre-generated and store for reducing the simulation time. Moreover it doesn't follow the same phenomena it separates the precoding matrices as a product of two matrices W1 and W2 only W1 and W2 are pre-store which reduces a huge amount of memory. The most challenging task is to handle beam sweeping mechanisms, where multiple high – gain beams with narrow beamwidth are applied at both transmitter and receiver and UE sides (**Jao et al.**,2018). The transmitter and receiver sides sweep a TX radio beam sequentially in time while UE maintains a proper Rx beam to confirm that reception of selected Tx beam. If an urban scenario is undertaken, then it will take more then 30 hours for simulation time so to overcome this challenge WiSE takes a smart mechanism under which it considers only significant links. With this mechanism, with negligible loss of precision more then 60 percent of simulation period can be reduce. It can efficiently perform in a huge- scale cloud server system utilizing parallel processing methods. Due to all these qualities simulation time is greatly improved in WiSE.

It is furnished with GUI tools so we can studied simulation system behaviors and graphically correct the simulation code. In the figure 2.2, we can see that WiSE tool provide an easier and fastest way for inputting the simulation parameters and starting the operation of the simulator. In same figure we can see that tool can illustrate network layout and UE location in the simulated environment and summarized the parameters and UE wide-band information on the right-hand side. Figure 2.3 presents information for the UE regarding scheduling. The wise simulator used object-oriented programming C++ it needs continuously upgraded with functionalists of the latest communication systems technology.

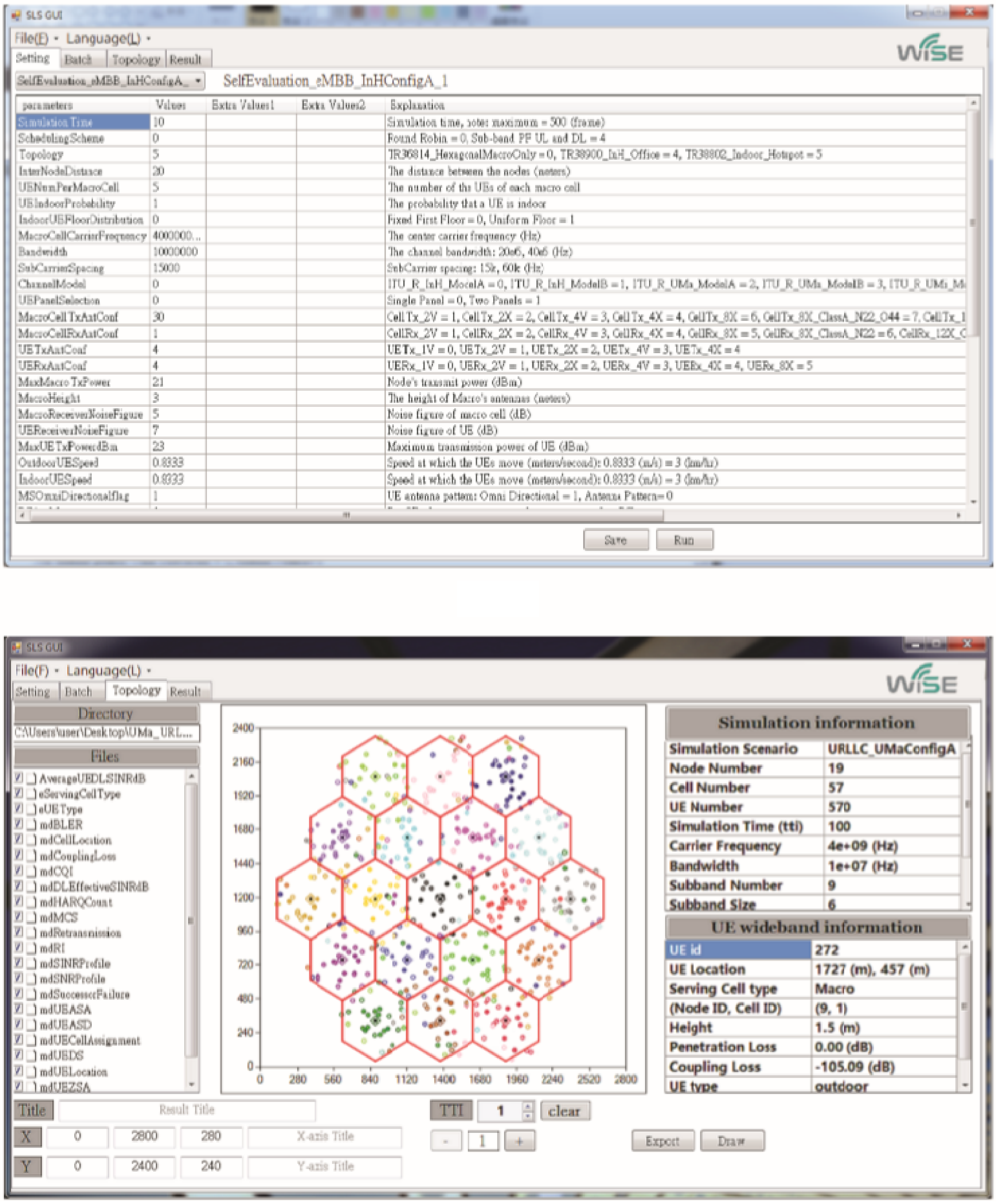

Figure 2.2: Graphical User interface of Wise

(**Jao et al.**,2018)

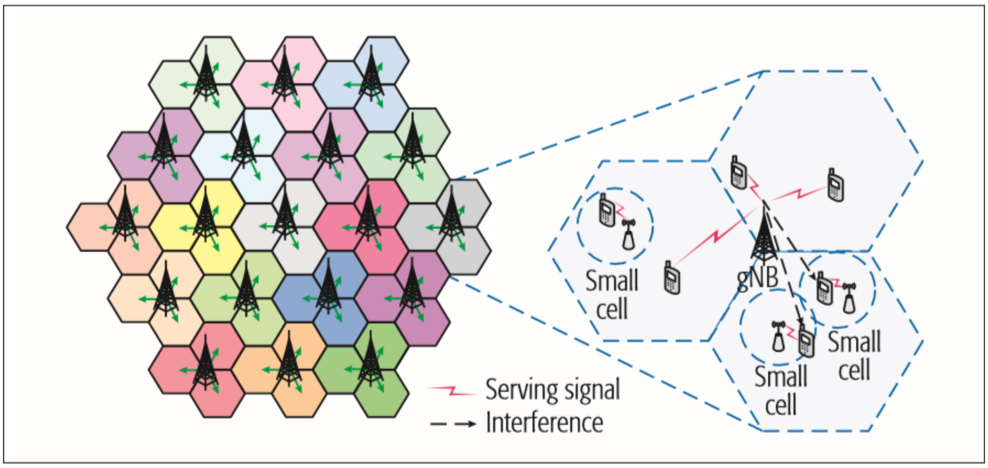

Figure 2.3: System Level Simulation network layout.

(**Jao et al.**,2018)

2.3.1 Device to Device System-Level simulation

Device to device communication technologies receive lot of attention because it play pivotal role for reducing traffic pressure from cellular base station and for enhancement of network performance. It is technology that enable device for transmitting and receiving data directly without help of any technical equipment such as like base station.

In (Choi et al.,2012) they presented that in LTE- Advance network UE can communicate directly with help of evolved node (eNB), if transmitting device and receiving device are near, they can receive signals and transmit directly or if they are far then they can use eNB. For the purpose of efficiently analyzing the performance of it under-laying cellular networks. Using Monte Carlo event-driven simulation techniques system- level simulator for D2D communication was carried in this paper. This process consists of five modules, packet scheduler, CAC, channel modeling, traffic generator, and mobility management modules, to emulate realistic LTE-A network and system environment. They have developed GUIs of the tool to show operation and serviceability of the simulator, it's architecture is shown in 3.1 . Using this simulator, they analysis interference between UEs and D2D intensively under up and down-link, afterward they came to conclusion that performance of D2D UEs in case of up-link and down-link is affected by the interference from cellular entity.

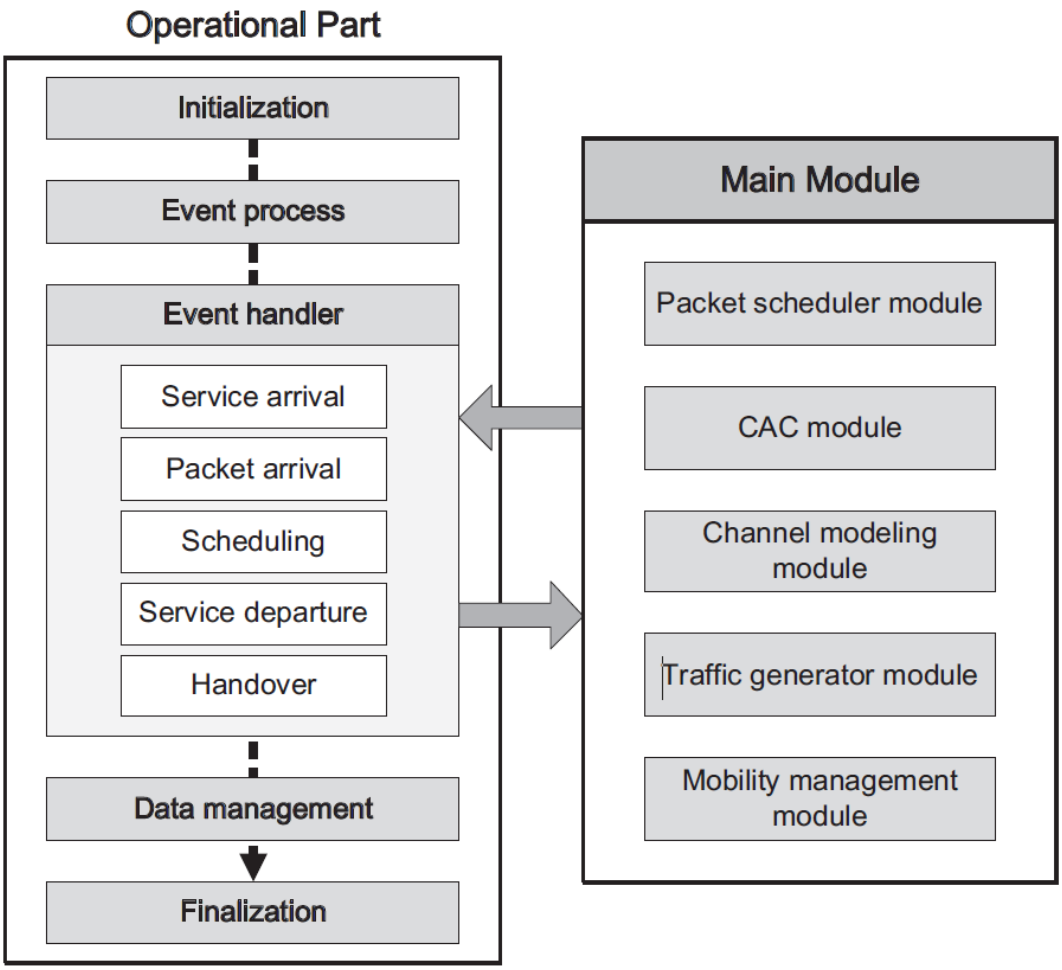

Figure 2.4: Device to Device communication Simulator

(**Choi et al.**,2012)

2.3.2 LTE-A System Level Simulation

In (**Taranetz et al.**,2015) paper the idea of runtime- precoding was introduced, which provides accurately abstract many coherent transmissions while keeping additional complicity at minimum as possible. This paper incorporate-precoding functionality into the Vienna LTE-A down-link system level simulator. It empowers the simulations of coherent signal transmission from spatially separated transmission point on system level. This approach alters the link quality model while preserving the complexity gains which can be obtain by state-of-the-art link abstraction models.

Run time - precoding features slowed down the simulations of the coordinated- scheduling by 3.7x. It provides the convenient tool for simulating in large -scale coherent multi-point transmission scenarios, in which link level evaluation is complex and tedious. The masterpiece of this paper is they presented the runtime -precoding concept which is shown in figure. They compare their result with simulation run times as obtained with the enhanced and the legacy model also with link level simulations.

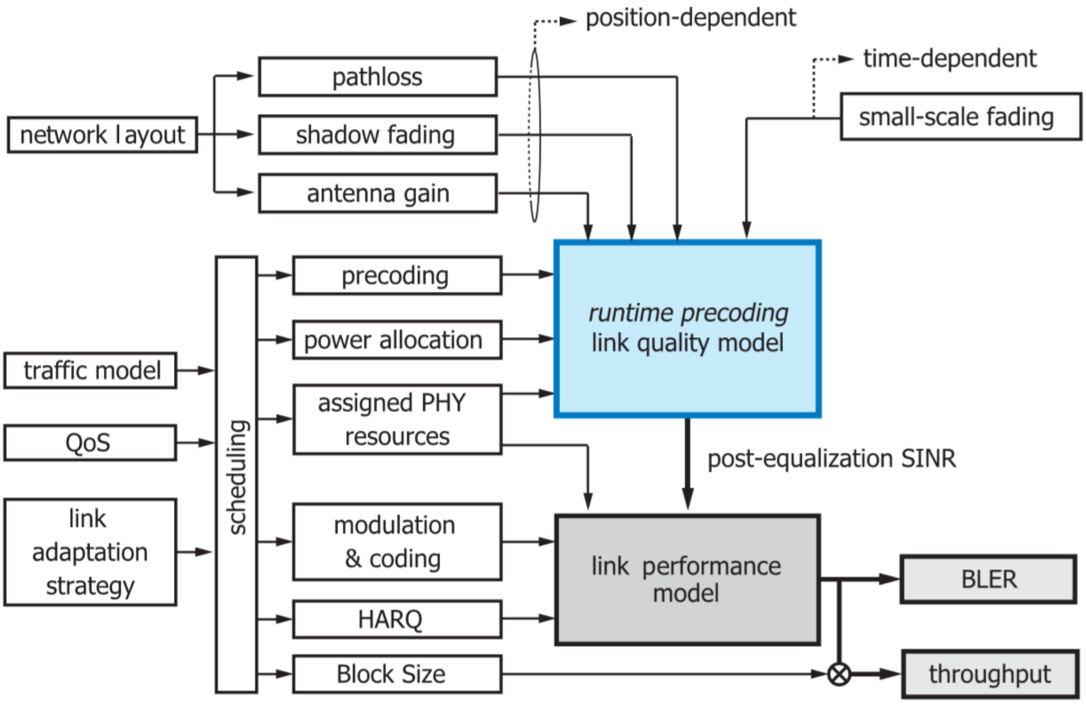

Figure 2.5: Vinnea LTE-A system level simulator v1.8 r1375

(**Taranetz et al.**,2015)

2.3.3 5G communication Systems Level simulation

In paper(**Cho et al.**,2017) they have pointed out the requirements for 5G simulators which are following

1. Reliability, Scalability and Flexibility.
2. Multiple Level of abstraction.
3. Multiple Level of abstraction.
4. Parallel processing.
5. Integrated simulator.

Features and software characteristic of the simulator present are

- Modular and Flexible Structure: The system level simulator which is in under developing stage supports high levels of readability and consistency, also modularity and flexibility for user to easily modify and extend the simulator. Operation of simulator can be change by changing the parameters of simulator.
- Simulation parameters: Simulation parameters can be change, modify according to user by changing simulation files.
- Main function: There can be multiple main function and different procedures of simulation.
- Simulation configuration file: We can change the version of simulator by changing some modules with other using the configuration file.

Figure 2.6 show how the simulator be classified.

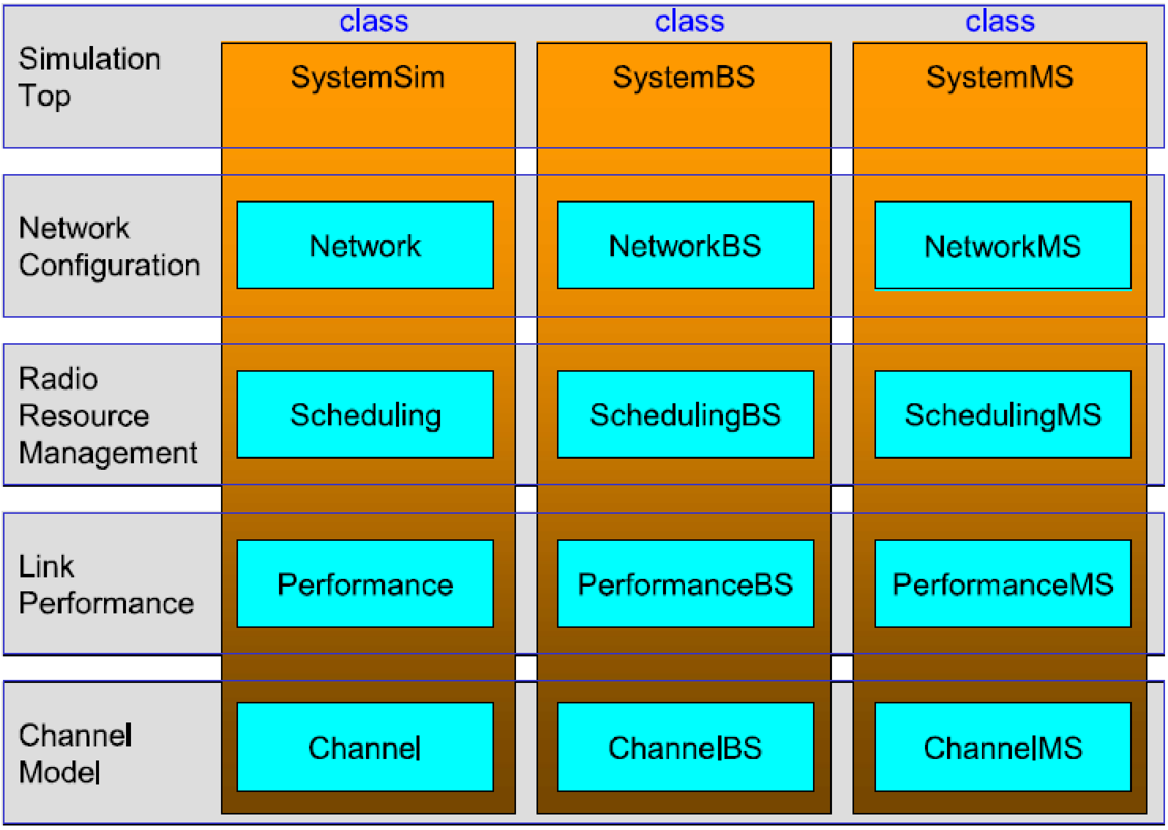

Figure 2.6: Main class

(**Cho et al.**,2017)

CHAPTER 3

METHODOLOGY

This research is focused on building simulation tool based on a web interface using MATLAB simulation and JAVA programming. Following steps were taken into consideration for evolving this tool:

- Firstly, the investigation was carried to a developed system-level simulation code for the LTE/LTE-A network in MATLAB.
- Secondly, researched was focus on calculating throughput, data rate, SINR etc.
- Thirdly, intensive research was performed to code all these MATLAB codes in JAVA language.
- Lastly, final output as the web interface was developed.

3.1 System Overview

The input data was provided to the tool and with help of these data research has been done to create the network scenario and calculation system-level performance, then researched was carried to developed web-interface tool. Later on comparison of results form MATLAB and JAVA were performed for verification of simulator. The overall simulation process is shown in figure 3.1.

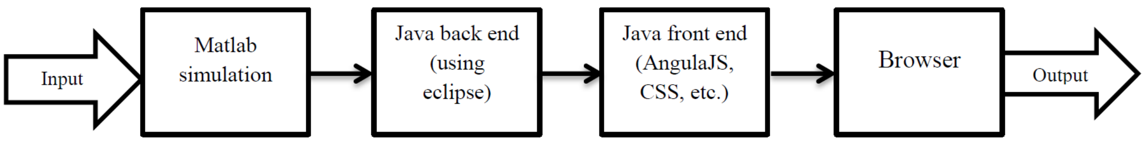

Figure 3.1: System Overview

Algorithm 1 Pseudo-Algorithm for System Level Simulation

Result: Throughput, Average data, bit-rate,etc

initialization

Upload the Traffic file (Csv)

Calculate best cell (Calculate RSRP

Create neighbor cell list matrix

if *mode =1(dynamic)* **then**

    Generate Traffic in network map

    Select Best cell depending on RSRP

    for *index= simulation time* **do**

        Traffic

          If number of mobile station (NewMBS= 0)

          Select Best cell

          Test Admission

    end

else

    Result;SINR Map, RSRP map, RSSI map etc.

end

3.2 Flow chart

From the figure 3.2 we can see that first we initialize the parameters in our tool, there are some parameters values in simulator which can easily modify by user. Then tool will performers operation to select the best cell according to the RSRP(Reference Signal Receive Power). This research was carried for both static scenario and dynamic scenario.

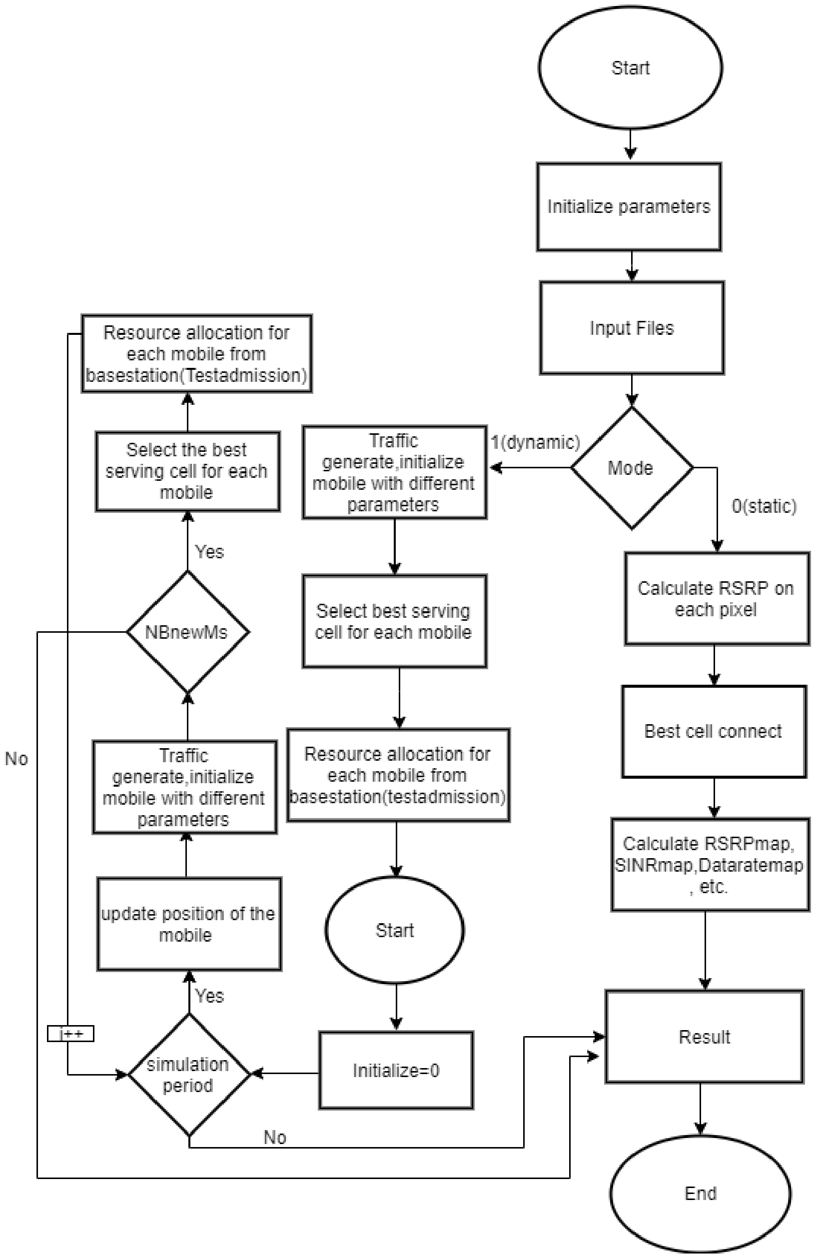

Figure 3.2: Flow chart for System Level Simulation

Table 3.1: Initialize parameters and values

Parameters	Value	Remarks
Resolution	40	Number of Pixels in a given axis
Area	[-2000,2000, -2000, 2000]	meters [xmin, xmax, ymin, ymax]
PRBwidth	180000	Bandwidth by PRB resources 180 khz
SubCarrierwidth	15000	Each PRB comprises of 12 sub-carrier of 15KHz
ThNoisePerHertz	174	dBm/hertz
Pathloss	b+a*log10(distance(BS,MS)+ logNormalShadowing (dB)	distance in km
SigmaShadow	3	in dB
MobileNum	10	It is number of mobile in given area or cell
Speed	8.33	km/hr
Volume	1000	Volume of information to download in kilobits
Lamda	1	Arrival rate used in dynamic simulation per second
Frequency Modulation	FDD	

Above table 3.1 show the initial parameters used in researched. After Initializing value four input files was given as input, this input contains all the information regarding base station which are following, The first file we name it $\boldsymbol{Basestation}$ file which contains the information regarding base station parameters which are

- Coordinates of base station(Xaxis, Yaxis);
- Azimuth angle,
- Height,
- Frequency
- Bandwidth
- Used Bandwidth
- Bspower
- RSRPpower(dbm)
- Average load(in percentage)
- Antenna Gain(dbi) etc.

BSCode	Xaxis	Yaxis	Height	Azimuth	Frequenc	Bandwidtl	UsedBand	Bspower (dBm)	RSRPpower (dBm)	paOffsetP	AverageLoad (%)	AntennaGain (dBi)
BS01A	0	0	0	90	2600	20	1	49	18	0	50	17.5
BS01B	0	0	0	210	2600	20	1	49	18	0	50	17.5
BS01C	0	0	0	330	2600	20	1	49	18	0	50	17.5
BS02A	600	0	0	90	2600	20	1	49	18	0	50	17.5
BS02B	600	0	0	210	2600	20	1	49	18	0	50	17.5
BS02C	600	0	0	330	2600	20	1	49	18	0	50	17.5
BS03A	300	520	0	90	2600	20	1	49	18	0	50	17.5
BS03B	300	520	0	210	2600	20	1	49	18	0	50	17.5
BS03C	300	520	0	330	2600	20	1	49	18	0	50	17.5
BS04A	-300	520	0	90	2600	20	1	49	18	0	50	17.5
BS04B	-300	520	0	210	2600	20	1	49	18	0	50	17.5
BS04C	-300	520	0	330	2600	20	1	49	18	0	50	17.5
BS05A	-600	0	0	90	2600	20	1	49	18	0	50	17.5
BS05B	-600	0	0	210	2600	20	1	49	18	0	50	17.5
BS05C	-600	0	0	330	2600	20	1	49	18	0	50	17.5
BS06A	-300	-520	0	90	2600	20	1	49	18	0	50	17.5
BS06B	-300	-520	0	210	2600	20	1	49	18	0	50	17.5
BS06C	-300	-520	0	330	2600	20	1	49	18	0	50	17.5
BS07A	300	-520	0	90	2600	20	1	49	18	0	50	17.5
BS07B	300	-520	0	210	2600	20	1	49	18	0	50	17.5
BS07C	300	-520	0	330	2600	20	1	49	18	0	50	17.5
BS08A	1200	0	0	90	2600	20	1	49	18	0	50	17.5
BS08B	1200	0	0	210	2600	20	1	49	18	0	50	17.5
BS08C	1200	0	0	330	2600	20	1	49	18	0	50	17.5
BS09A	900	520	0	90	2600	20	1	49	18	0	50	17.5
BS09B	900	520	0	210	2600	20	1	49	18	0	50	17.5
BS09C	900	520	0	330	2600	20	1	49	18	0	50	17.5
BS10A	600	1040	0	90	2600	20	1	49	18	0	50	17.5
BS10B	600	1040	0	210	2600	20	1	49	18	0	50	17.5
BS10C	600	1040	0	330	2600	20	1	49	18	0	50	17.5

Figure 3.3: Base station parameters file

The second file is $\boldsymbol{Traffic}$ which contains the information about traffic on the given area, following are the parameters in traffic file

- Area code,
- xmin,
- xmax,
- ymin,
- ymax,
- Traffic(weight of traffic in specific area or given area code).

Table 3.2: Traffic parameters file

AreaCode	Xmin	Xmax	Ymin	Ymax	Traffic
Area01	-1000	0	1000	0	0.25
Area02	-1000	0	0	1000	0.25
Area03	0	1000	0	1000	0.25
Area04	0	1000	1000	0	0.25

The third input file named as $antenna$ which contained the angle and antenna pattern loss. which can be seen as in figure 3.4
The fourth file named $Linkcurve$. This file consists of SINR and bitrate in respective columns, this file help to calculate bitrates depending upon the SINR calculated by tool. These files were used as lookup table for correlating Bit rate and SINR. In 3.5 figure we can see linkcurve file structure.

Angel	Pattern
0	0
1	0.1
2	0.1
3	0.1
4	0.2
5	0.2
6	0.3
7	0.3
8	0.4
9	0.4
10	0.5
11	0.6
12	0.69
13	0.69
14	0.8
15	0.89
16	1
17	1.1
18	1.2
19	1.29
20	1.39
21	1.6
22	1.7
23	1.79
24	1.89
25	2.09
26	2.2
27	2.4
28	2.5
29	2.59
30	2.79
31	3
32	3.09
33	3.29
34	3.5
35	3.59
36	3.79
37	4
38	4.19
39	4.4
40	4.59
41	4.8
42	5
43	5.19
44	5.4

Figure 3.4: Antenna parameters file

SINR	Bitrate
-10	30
-9	33.7
-8	38.9
-7	45.8
-6	55.6
-5	71.2
-4	90
-3	110.9
-2	130
-1	150.2
0	171.8
1	196.6
2	223.3
3	251.7
4	280.6
5	309.4
6	338
7	369.2
8	402.7
9	437.7
10	475.7
11	517.7
12	560.1
13	603
14	645.9
15	688.9
16	732.1
17	775.2
18	821.2
19	864.9
20	907.1
21	935.3
22	958.7
23	971
24	975.4
25	977
26	977
27	977
28	977
29	977
30	977
31	977
32	977
33	977

Figure 3.5: Link Curve parameters file

Now presenting how this research was carried with help of each function or class we build

3.2.1 Best cell

In this class researched was carried to generate pixel or point according to resolution which can be given by equation,

$$xpixels = \frac{x_{max} - x_{min}}{resolution} + 1 \quad \text{(Equation 3.1)}$$

$$ypixels = \frac{y_{max} - y_{min}}{resolution} + 1 \quad \text{(Equation 3.2)}$$

1 was added because to cover all pixel in defined area. After calculating pixels path loss of base station(k) to pixel(each pixel) was performed.

$$Pathloss = b + a * log10(distance(BS, MS)(km) + logNormalShadowing)dB \quad \text{(Equation 3.3)}$$

where b and a are coefficient factors depending on carrier frequency, antenna height and propagation model. We use propagation model is Okumura-Hata model to 2.6Ghz frequency band. Here RSRP was calculated as

$$RSRPpixel = RSRPixel + pathloss + antloss \quad \text{(Equation 3.4)}$$

$$RSRPpixel = basestationRSRpower + basestationAntennaGain - RSRpixel \quad \text{(Equation 3.5)}$$

RSRPpixel is the received signal of base station k at each pixel. Antenna loss was calculated using file name antenna. Tool calculated parameters like;

- RSRP (Reference Signal Receive power): It was calculated using path loss and antenna loss.
- RSRQ (Reference Signal Received Quality): It signified of signal considering RSSI and resourced blocks. It provide additional information when it is not sufficient to make a cell reselection decision. It can be summarized as

$$RSSQ = N * RSRP/(E - utraCarrierRSSI). \quad \text{(Equation 3.6)}$$

- Interference: Interference from neighbour cells and other loss like shadowing, thermal noise was considered.
- RSSI (Received Signal Strength Indicator): It provides information about total received wideband power including all interference and thermal noise. which is generalized in below 3.6

equation. RSSI = wideband power = noise+serving cell+power+interference power

$$RSSI = 12 * N * RSRP \tag{Equation 3.7}$$

where $RSSI$ is measured over the entire bandwidth,
N is number of RBs across the RSSI.

$$RSRP(dbm) = RSSI(dBm) - 10 * log(12 * N). \tag{Equation 3.8}$$

3.2.2 SINR

It is signal to noise ratio, it is reference value used in the system level simulation. Also can be defined as SINR for a specific sub- carriers(or for a specific resource elements). which can be defined as in equation Equation 3.9.

$$SINR = \frac{S}{I + N} \tag{Equation 3.9}$$

where,
S is signal power.
I is interference power.
N is Noise power.
Tool calculate ISR(Interference Over Signal Ratio)(FFactor);

$$ISR(FFactor) = \frac{\sum_{i \neq servingcell} RSRP_i}{RSRP_{servingcell}} \tag{Equation 3.10}$$

where, $\sum_{i \neq servingcell} RSRP_i$ is summation of all RSRPS detected by mobile(UE) except serving cell.
This concluded analyzing static simulation. If simulation mode is dynamic then simulation will be carried further as following.

3.2.3 Generate Traffic

At this stage, investigation was done to generate a mobile station or user equipment depending upon initialize parameters. Number of mobile can be initialize by user or can be generate using binomial randomness. User can also fixed the number of new arrival(λ) mobile in scenario. Furthers this tool calculate mobile position, using traffic file which was provided as input by user, which was depends on the index area, here index area was generated discretely using traffic weight from Traffic file. Then afterward tool assign following parameters to mobile.

Table 3.3: Initial Parameters assign value with User equipment(Mobile Station)

Parameters	Value	Remarks
Direction	2*pi *rand()	We give the direction for mobile movement
start	0	It is provided from main function at this stage it is zero(it means simulation start)
End	0	It is end of simulation or connection for that user
RSRP	[]	At this instant it is empty array(we will include list of RSRP here)
SINR	0	It indicate sinr when mobile in connection with base station
VolumeInfo	1000	Volume of information to download in kilobits
bitRate	0	Number of bit receiving by user per second
Max (PRB)	3	Initialize value(Maximum resources it can be allocated)
Min (PRB)	1	Initialize value(Minimum resources it can be allocated)
Num PRB	0	It is number of occupied chunk, it can be rational
Averagebitrate	0	Average bit receiving by user
Bsindex	0	Basestation assigned number
downloadtraffic	0	It is amount of data user can downlaod
Honumber	0	Number of handover it is performing
State(etat)	0	

3.2.4 SelectBestcell

In this stage tool help to find the mobile location with given formula,

$$xPos = ((x - x_{min})/Resolution) + 1 \qquad \text{(Equation 3.11)}$$

$$ypos = ((y - y_{min}/Resolution)) + 1 \qquad \text{(Equation 3.12)}$$

where, x_{min}, y_{min} and resolution were initialize value. Using this index position value tool calculated the best cell for each user equipment.

3.2.5 Testadmission:

In this stage simulator performed resources allocation to each mobile . This operation was carried based upon the following algorithm,

Algorithm 2 Pseudo-Algorithm for testadmission

Result: Interference, SINR,bitrate

initialization nms = length of basestation, RSRPMin = -140 dB

for $m = 0$ *to* nms **do**

BSindice = MSindexBSmax

if *RSRPBESR ¡ RXLevAcessMin* **then**

MS etat = 1; Mobile blcoked because of coverage shortage

else if *occupied prb + Mobile minimum prb capacity* **then**

MS etat = 2 Mobile blocked because of lack of prb

else

MS etat = 5 mobile accepted in the network

end

Resource allocation rest resource = capacity of mobile * (1-load in mobile)

if *Ms maxcprb restresources* **then**

MS Numberprb = Ms maximum prb

else

MS Number prb = rest resource

end

Calculation of SINR = RSRP power based on BSindice- Interference in dB.

Bitrate = MS prb * bitrate obtain with help of linkcure file.

Throughput = Basestation througput + MS bitrate

end

3.2.6 UpdateMS

In this function simulator update position of the mobile. Mobile position was updated using direction and speed of mobile using following equation,

$$theta = mod(Direction + rand(1, N)) * pi/4 - pi/8, 2 * pi) \qquad \text{(Equation 3.13)}$$

where N is number of x coordinates of mobile.

$$x = X + speedofmobile * cos(theta)y = Y + speedofofmobile * sin() \qquad \text{(Equation 3.14)}$$

where x and y are coordinate point of mobile current location. Researched check whether mobile is in previously define an area or not, if mobile was outside the specified area then researched forcefully bring them to our initialize area, and again x and y position were calculated with the help of x and y point, simulator performed resource allocation depending upon download traffic and volume. An important point here to be noticed was mobile parameter status (etat). Depending upon the value of status tool determine whether the mobile was rejected due to lack of PRB or lack of coverage or mobile is accepted in the destination cell. Remaining function was similar as testadmission. Tool defined mobile state as following,

Table 3.4: Initialize parameters and values

State	Remarks
0	Waiting for connecting with basestation
1	Blocked due to the coverage shortage
2	Blocked due to the lack of PRB(chunks)
3	Rejected due to the coverage
4	Rejected due to the lack of resources
5	Accepted in network
6	End communication in the network

3.3 Beamforming

The researched was able to consider beamforming only in static portion of Matlab. Massive Multiple antenna technologies including 3D beamforming are new topics of research. Due to beamforming signal strength at receiver is increases which decrease in interference to achieve high throughput and high spectrum efficiency. Existing base stations(BSs) have sector antennas which provide antenna patterns in horizontal dimension taking in account of azimuth angle only, considering fixed vertical radiation pattern and downtilt. Research consider both horizontal and vertical dimension to improve signal strength at the receiver side.
In (**Błaszczyszyn & Karray**,2015) author have analyzed performances of a sectorized random network in terms of SINR, author were also successful to show that antenna azimuth's distribution is insensitive to SINR distribution.
Researched considered both vertical and horizontal dimensions, including the randomness of the user in the consider sector. Simulator analyzed performance in terms of coverage probability of SINR.

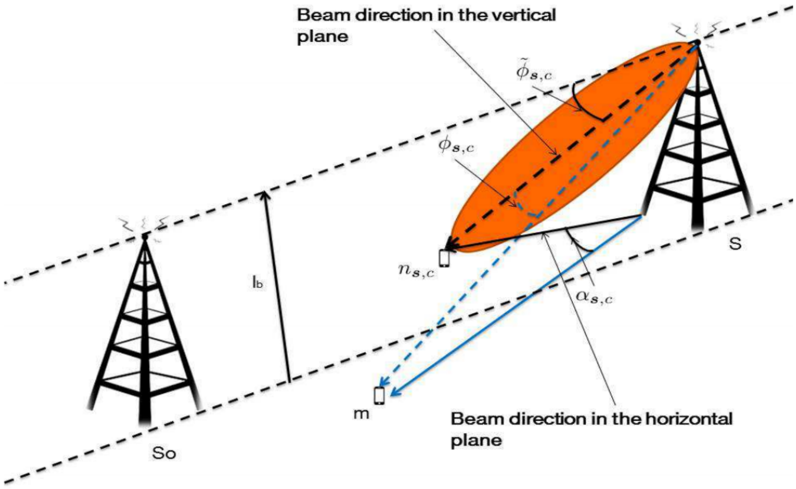

Figure 3.6: 3D beamforming illustration

(Rachad et al.,2019)

3.3.1 Network model

Research was conducted on similar scenario as described by the Rachad etal. in their work(A 3D Beamforming Scheme Based on The Spatial Distribution of User Locations)(**Rachad et al.**,2019). A regular hexagonal with tri-sectorized network considering Λ taking account of infinite number of sites given as s with inter-distance consider as δ. For each site $s \in \Lambda$ there exists a unique (u,v) $\in Z^2$, such that s = (δ u+$e^{\frac{i\pi}{3}}$), research denote serving cell located at origin R^2, unlike omni-directional antennas. In corner of the each hexagons antennas were located with BSs having the same height l_b,transmit same power level each hexagonal sector were covered by directional antennas denoted as $c \in (1, 2, 3)$ (**Rachad et al.**,2019). Azimuth of antenna v_c, where radiation is maximum considered to real axis and it was given by

$$v_c = \frac{\pi}{3}(2c - 1) \qquad \text{(Equation 3.15)}$$

In the complex plane polar coordinates is denote by $\eta_{s,c}$, such that $s \in \Lambda^*$, where Λ^* is the lattice of Λ. Location $\eta_{s,c}$ was expressed as

$$\eta_{s,c} = s + r_{s,c^{e^{i\theta}}} \qquad \text{(Equation 3.16)}$$

Where,
$r_{s,c}$is distance and
$\theta_{s,c}$ is the angel(complex argument) between $\eta_{s,c}$ and s.

3.3.2 Beamforming Model

For reason of tractability researched consider Mogensen model to describe the vertical and horizontal antenna radiation pattern in linear scale which shown as,

$$H(\alpha) = [\cos(\alpha)]^{-2\omega_h} \qquad \text{(Equation 3.17)}$$

$$V(\alpha) = [\cos(\alpha)]^{-2\omega_v} \qquad \text{(Equation 3.18)}$$

where,
$\omega_h = \dfrac{\ln(2)}{\ln(\cos(\frac{\theta_{h3dB}}{2})^2)}$ and $\omega_v = \dfrac{\ln(2)}{\ln(\cos(\frac{\theta_{v3dB}}{2})^2)}$.
Also θ_{h3dB} and θ_{v3dB} were respectively the vertical and horizontal half power beam widths. Thus antenna radiation pattern received in a user location m from an interfering site s is define by,

$$G_s(m) = \sum_{c=1}^{3} \alpha_{s,c} H(\alpha_{s,c}) V(\phi_{s,c}) \qquad \text{(Equation 3.19)}$$

where, $\alpha_{s,c}$ angle between the mobile(m) and the beam direction to a mobile $\phi_{s,c}$ is the angle between the beam direction in the vertical plane and the mobile m.

Angle $\alpha_{s,c}$ was expressed based on the complex geometry as,

$$\alpha_{s,c} = \psi(m, s) - \theta_{s,c} \qquad \text{(Equation 3.20)}$$

where $\psi(m, s)$ = arg$(m - s)$, $\theta_{s,c}$ = $\psi(\eta_{s,c}, s)$ is complex argument of $\eta_{s,c}$ relatively to s. In same manner for the vertical dimension angle $\phi_{s,c}$ was expressed as

$$\phi_{s,c} = a\tan(\frac{l_b}{|m - s|}) - \tilde{\phi}_{(s,c)} \qquad \text{(Equation 3.21)}$$

where, $\tilde{\phi_(}s, c)$ = $a\tan\dfrac{l_b}{r_{s,c}}$ refers to the antenna downtilt. which varies the distance $\gamma_{s,c}$ = —$\eta_{s,c}$-s— between mobile $\eta_{s,c}$ and s varies between 0, to 2$\frac{\delta}{3}$U($\theta_{s,c}$ - ϑ_c) such that U($\theta_{s,c}$ - ϑ_c) was the radiation pattern of antenna in a sector(65 degrees is half power beam width). When angle s and is equal to $\eta_{s,c}$ the antenna azimuth radiation will be maximum (**Rachad et al.**,2019).

3.3.3 Propagation model

This researched consider standard power-law path loss model as in Rachad et al. based on the distance between *s* and user, mobile *m* where path loss is given as,

$$L_{(s,m)} = a|s - m|^{2b} \qquad \text{(Equation 3.22)}$$

where, *2b* is the path loss exponent, *a* is a propagation factor depends on the type of the environment(Indoor, Outdoor etc.) and a *s*.

3.3.4 Interference characterization

This paper consider cumulative ISR(interference over signal ratio) from all the interfering sites including two other sectors of the serving site s_o, such that $s \in \Lambda$ of all the individual ISRs

$$I(m) = -1 + \sum_{s\in} r^{2b}|s-m|^{-2b} G_s(m) 10^{\frac{\tilde{Y}}{10}} \qquad \text{(Equation 3.23)}$$

In jacod2012probability paper it is proved that,

$$\mathbb{E}|I(m)| = -1 + \mathbb{E}|10^{\frac{Y}{10}}| \sum_{s\in} r^{2b}|s-m|^{-2b} \mathbb{E}|G_s(m)| \qquad \text{(Equation 3.24)}$$

It was also known that E—I(m) is less then infinity and E—I(m)— is converges almost surely. DL(Downlink) coverage probability $\prod$ as threshold probability that pixel successful to achieve SINR denoted my γ

$$\prod(\gamma) = \mathbb{P}(\theta)(m) > \gamma), \qquad \text{(Equation 3.25)}$$

where $\theta)(m)$ SINR of pixels can be given as,

$$\theta)(m) = \frac{1}{I(m) + y_o} \qquad \text{(Equation 3.26)}$$

such that $y_o = \dfrac{aN_r^{2b}}{AP_{\chi_o}}$.

3.4 Web-Interface

After successfully completed Matlab simulation researched was focused on to build web-based interface tool. For this one can use python or java our project is based in Java programming using Eclipse Kepler service release 2 and Netbeans IDE 8.2. Web- interface can be shown as,

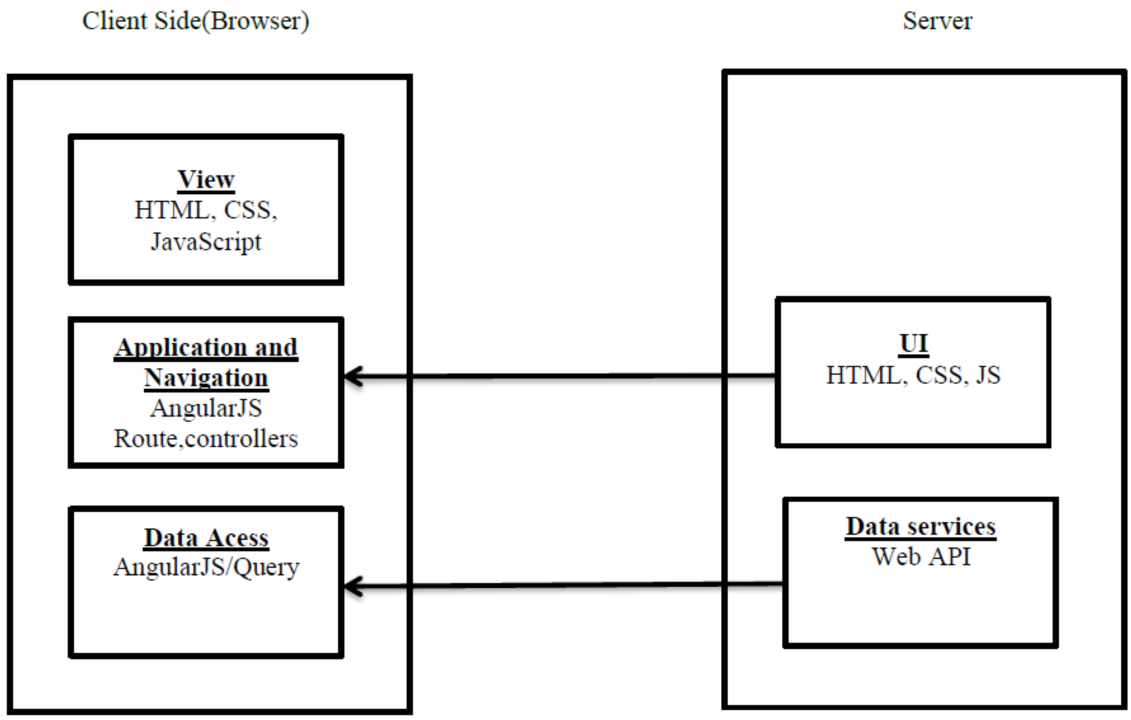

Figure 3.7: Architecture diagram of web interface

In this tool there are two parts back end and front end part, which are discuss as follows,

- Back end : This is a core part of tool, here all Matlab code was converted on Java code, the back end is a very important part of a web interface, request from the front end is served by the back end in a programmatic manner. It's consist of core application logic, database, application integration, API, etc. There are two way to code back end, first one is *file oriented* in which similar way like Matlab created the file researched can created a class in java this process was complicated but this process is less time consuming, so this is our first step. Another is *object oriented* if the program are coded this way code is more clear and readable otherwise results are similar.

- Front end : This is the second part of this tool. This part created the front of the website, in this part tool are designed to take input, upload files buttons, representing its result all these kind of stuff are deal in the front end. In this tool backend generated some result, those results were converted in JSON and JSON result was feed in AngularJS thus, with help of angular js and bootstrap, this research was able to show the result in a graphical chart and map. Thus, this project first developed Matlab simulation, then developed the same simulation using Java , HTML, CSS, AngularJs as front end which generates output and show in a web browser. This project was example of Software as service. Figure 3.8 below show the operation between back end and front end

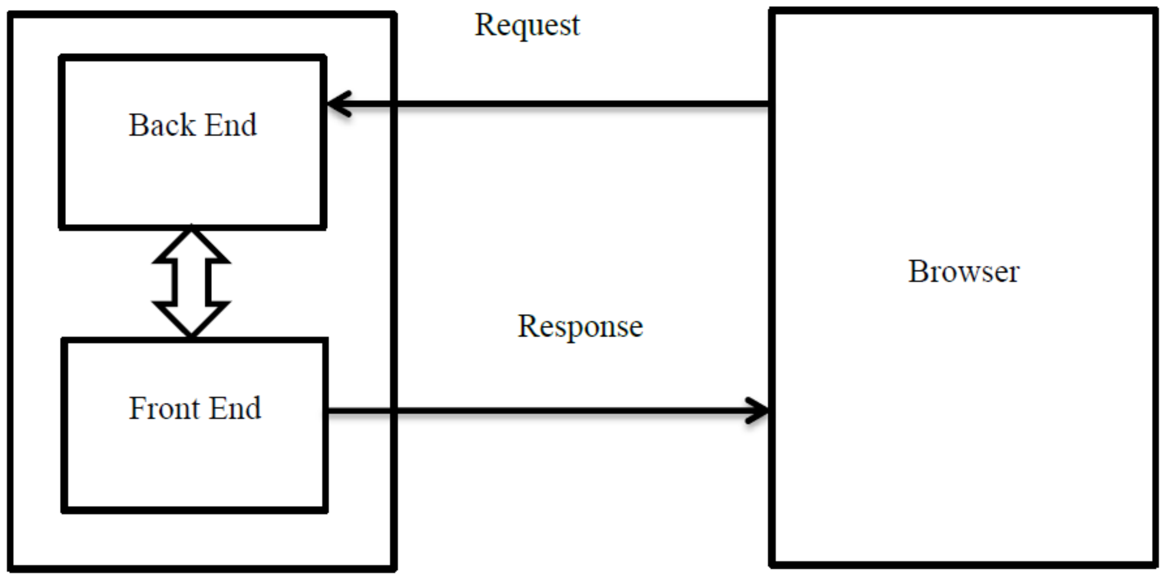

Figure 3.8: Block diagram of showing back end and front end

As building API(Application Programming Interface) it is always best to talk about SOAP and REST, both of them are common and popular API paradigm. Often SOAP and REST are compared but they are different, SOAP is protocols while REST is an architecture style.This research was based on the REST API. Some differences between REST and SOAP are,

- SOAP:
  SOAP which stands for(Simple Object Access Protocol) is a protocol that is complicated then REST. These build-in protocols carry high overhead but it can be very helpful for organizations that require a wide range of security, transaction, and ACID(Atomicity, Consistency, Isolation, Durability). SOAP should be used because,
  - SOAP has tighter security: If the user wants to use them it is able to provide more enterprise-level security features.
  - Functionality for reliable messaging : REST doesn't have a standard messaging system and it address communication failure by retrying. Whereas SOAP has successful/retry logic built-in and provides end-to-end reliability even intermediaries.
  - SOAP has built-in ACID compliance: It decrease anomalies and protects the integrity of a database by suggesting exactly how database can interact with transactions, ACID is conservative than other that why it is more favored when dealing with financial or other sensitive transactions.
- REST(Representational State Transfer):
  It is a web services API, It is based on URIs(Uniform Resource Identifier), HTTP protocol, and use of JSON for a data format which is browser-compatibility. The reason why must of API are RESTFUL are the following,
  - REST is all about simplicity because it uses HTTP protocols.

- REST APIs facilitate client-server communication and architectures.
- REST APIs use a single uniform interface which gives a lot of advantage on developing the application.
- REST optimized the web services since it uses JSON as its data format which makes it compatible with browsers.
- REST is known for its excellent performance and scalability.

CHAPTER 4

SOFTWARE DEMONSTRATION AND SIMULATION RESULTS

From the input provided by a user, it performed the complex calculation, analysis the parameters metricise and generate the results. In this tool all results were presented in the web interface with help of graph and map. This report present the result in two categories, MATLAB and Web interface result also results were classified in two patterns static and dynamic.

4.1 Simulation Parameters

The simulation was carried in both MATLAB and web interface. Many parameters need to be initialize by user which are listed as in table 4.1,

Table 4.1: Initialize parameters and values

Parameters	**Value**	**Remarks**
Resolution	40	Number of Pixels in a given axis
Area	[-2000,2000, -2000, 2000]	meters [xmin, xmax, ymin, ymax]
PRBwidth	180000	Bandwidth by PRB resources 180 khz
SubCarrierwidth	15000	Each PRB comprises of 12 sub-carrier of 15KHz
ThNoisePerHertz	0	dBm/hertz
Pathloss	b+a*log10(distance(BS,MS)+ logNormalShadowing (dB)	Distance in km
SigmaShadow	3	in dB
MobileNum	10	It is number of mobile in given area
Speed	8.33	km/hr
Volume	1000	Volume of information to download in kilobits
Lamda	1	Arrival rate used in dynamic simulation per second
Frequency Modulation	FDD	Frequency Division Duplex
Min PRB	1	Minimum resource allocation in a slot
Max PRB	3	Maximum resource allocation in a slot

4.2 Result From Matlab

Matlab simulation generated the result for static and dynamic, this simulator saves the output generated from dynamic patttern in .mat file it doesn't show any graphical or visual result for dynamic scenario. Figure 4.1 show the output from Matlab simulation in static scenario

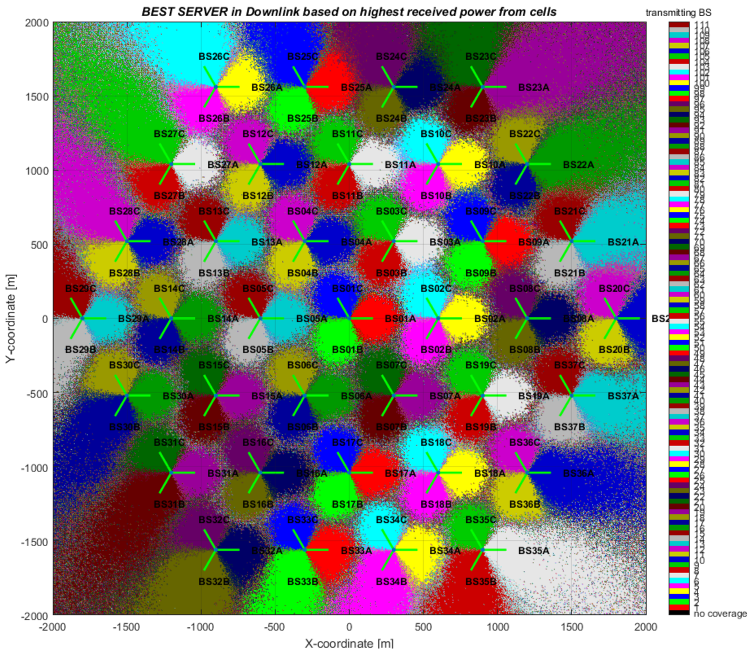

Figure 4.1: Bestserver in downlink based on highest received power from cells

Above figure clearly show that for each basestation sites which are near from them are best cell or in other words pixels which were near to basestation antenna can receive best signal. All these color near to antenna show their best serving cell, Color are used randomly. Area consider for this simulation is [-2000 2000 -2000 2000], [xmin,xmax,ymin,ymax] and resolution is 4. Figure show 30 basestation each having 3 sector antenna. For static pattern simulator generate CCDF(Complement Cumulative distribution Function), coverage probability which can be seen as

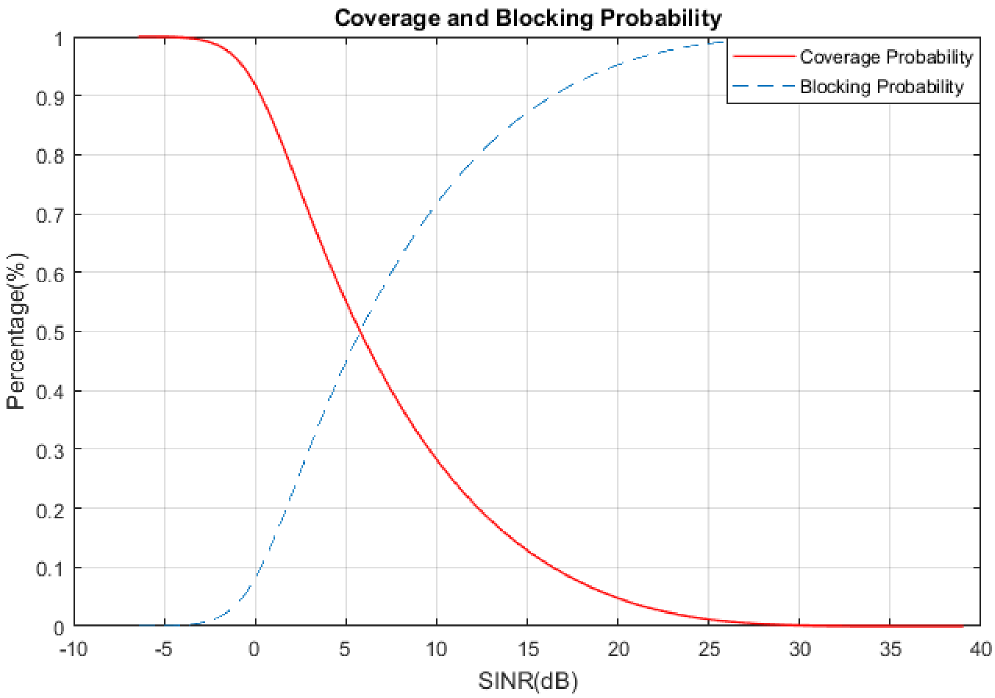

Figure 4.2: Coverage Probability of SINR

From the figure, we can see that more than 80 percent of the pixel has 0 SINR, which is very good. An upward moving graph(Skyblue) is blocking probability while the downward-moving graph(red) is coverage probability. In Matlab, a simulator was able to consider beamforming. In this research simple beamforming was used using average RSRP power in static parts, sadly due to time limit and limitation of other resources. Tool was not able to perform beamforming in dynamic and web-interface.

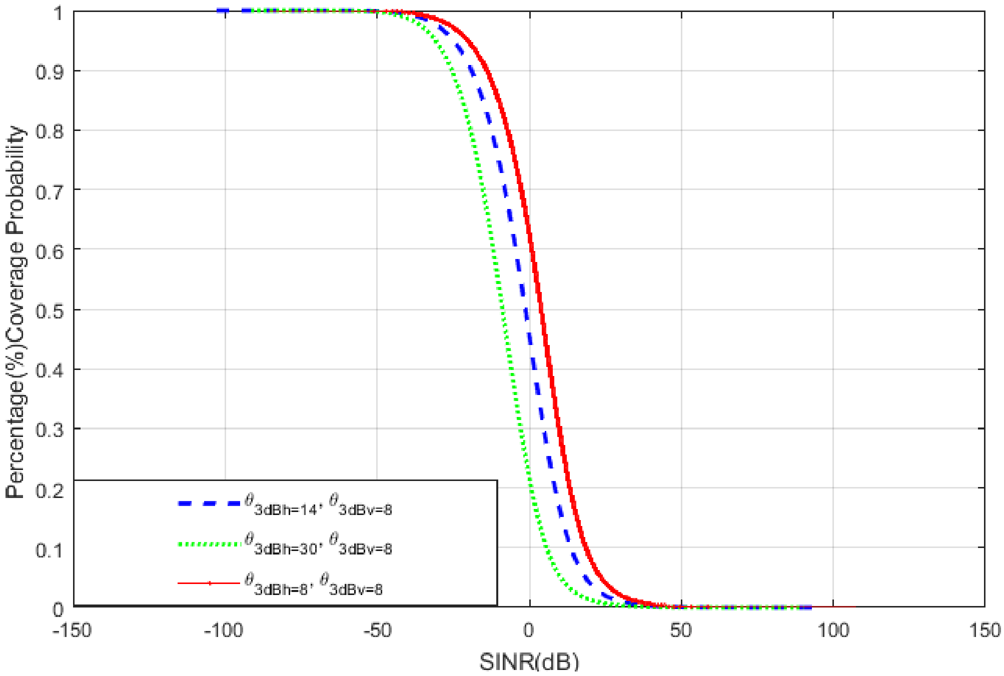

Figure 4.3: Coverage Probability of SINR

It can be easily visible that when tool used beamforming its increase the number of the pixel having less SINR, more than 90 percent have 0 SINR. which can be considered a very good condition. As we keep decreasing the horizontal angle we can see that coverage probability is increasing it is due to beam width as beam width decrease transmit antenna is increased which makes signal focus increase in one specific cell and interference decreases. This output is almost resemble with paper (**Rachad et al.**,2019) which is shown in 5.1 appendix, which validate our result.

4.2.1 Results from web-Interface tool

True purpose of this research was to evolved web-interface. This research accomplished this purpose. First home page of these tools is shown below in figure 4.4.

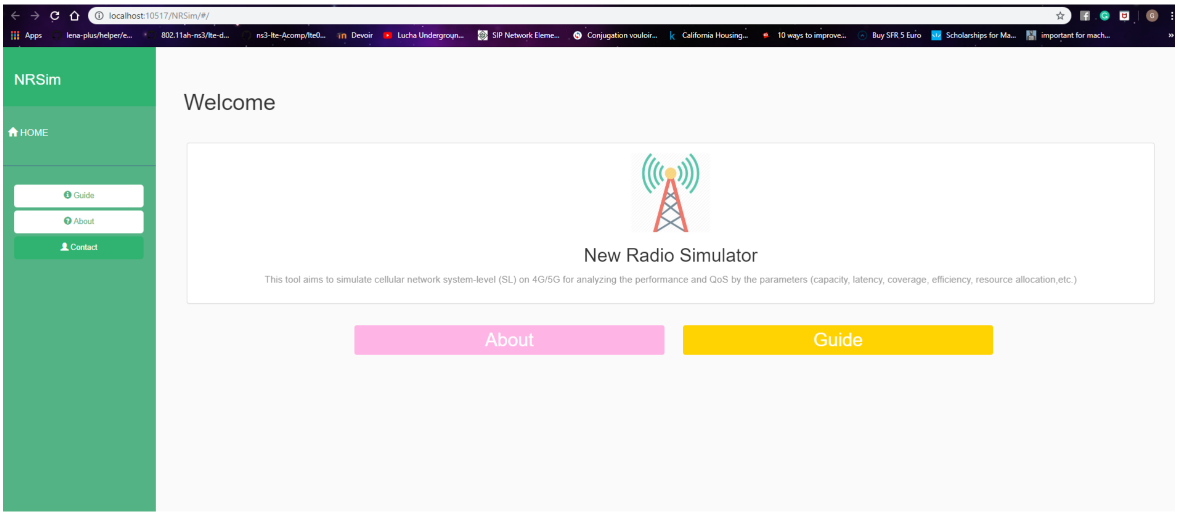

Figure 4.4: New Radio Simulator homepage

The figure shows the homepage of NR simulator, on the left side we can see a button for Guide, About tools information and including contact, if user want to use this tools or want to go further ahead user need to click on New Radio Simulator tab where there is mobile tower image.

when user go ahead user will find control panel which looks as shown in figure 4.5.

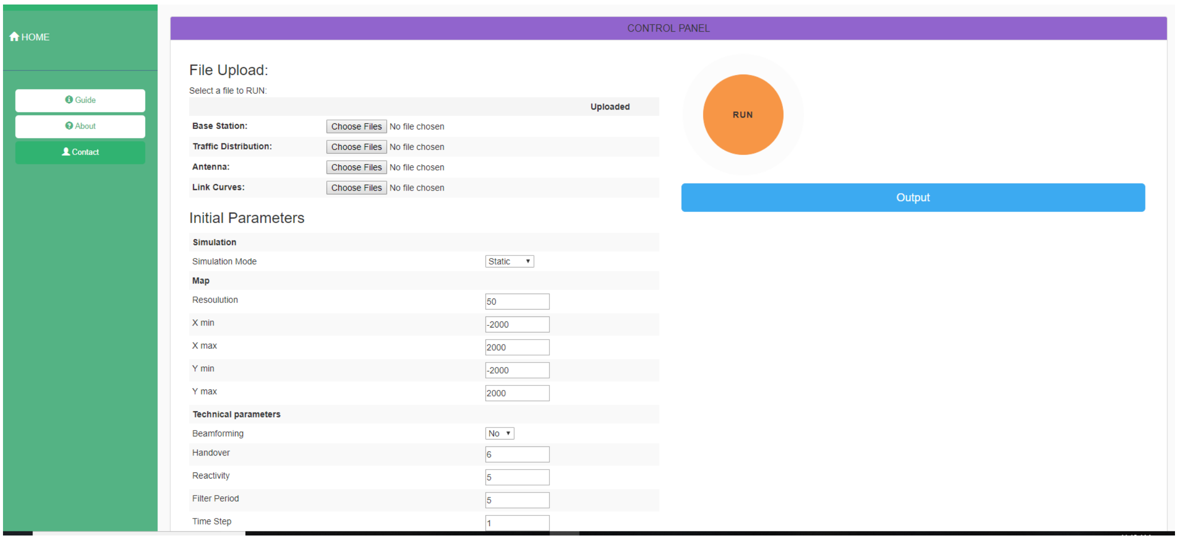

Figure 4.5: New Radio Simulator Control Panel

Figure show there are four tabs for uploading file i.e Base station, Traffic distribution, Antenna, Link Curve. There are also an Initial parameter tab where the user can set different parameters of tool. Initial parameters includes simulation parameters like, map, technical parameters, after setting all parameters and uploading all files user need to run simulator and see output. The important things here to notice is in initial tab is option, which indicate for static or dynamic. According to the user demand user can choose scenario and run simulator and see the result. Another important point to be noted here is the user can only upload CSV file other extension file are not allowed to upload here.

4.2.2 Static Scenario Output

In this tool when a user chooses static scenario after uploading all required files and setting all parameters then it will generate output depending upon the parameters and file upload which can be shown in figure 4.10. The static output is presented in two parts one is map another is a graph chart. For generating the map researched use leaflet library which is opens source, setting present location latitude and longitude on this library tool was able to show our current location and demonstrate the area initialize by a user. Tool created square at each point in this specified area to generated pixel and show result. Square is generated using two-point, resolution and area coordinates.

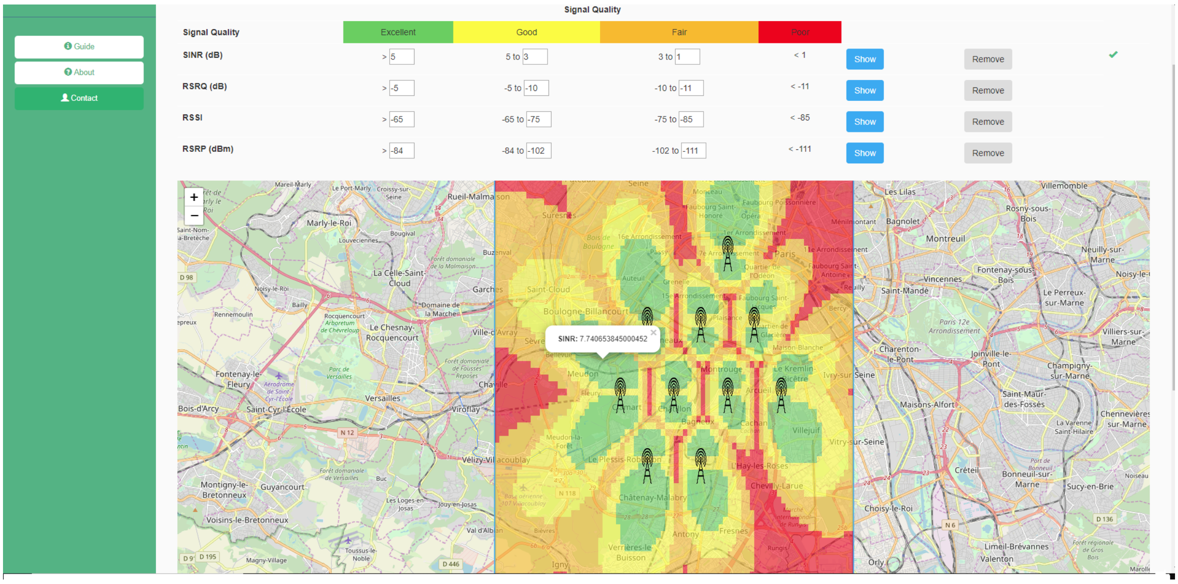

Figure 4.6: Graphical output for static scenario

It is seen that in the figure that user can see SINR, RSRQ, RSRP, RSSI on map. We fixed our map coordinate in Chatillon. At the top of figure signal quality is define which are classified as:

- Green - Excellent
- Yellow - Good
- Orange - Fair
- Red - Poor

It can be seen that the range of each parameter are given in this tool can be varies according to user desire and see how it will change or effect result in a given scenario. It should be noted that the range can be given in descending order. After clicking on the remove button of any parameters other parameters result can be seen. When user click on any part of the map within the result display area then pop will arise which will display the value of the parameter on that instant point.

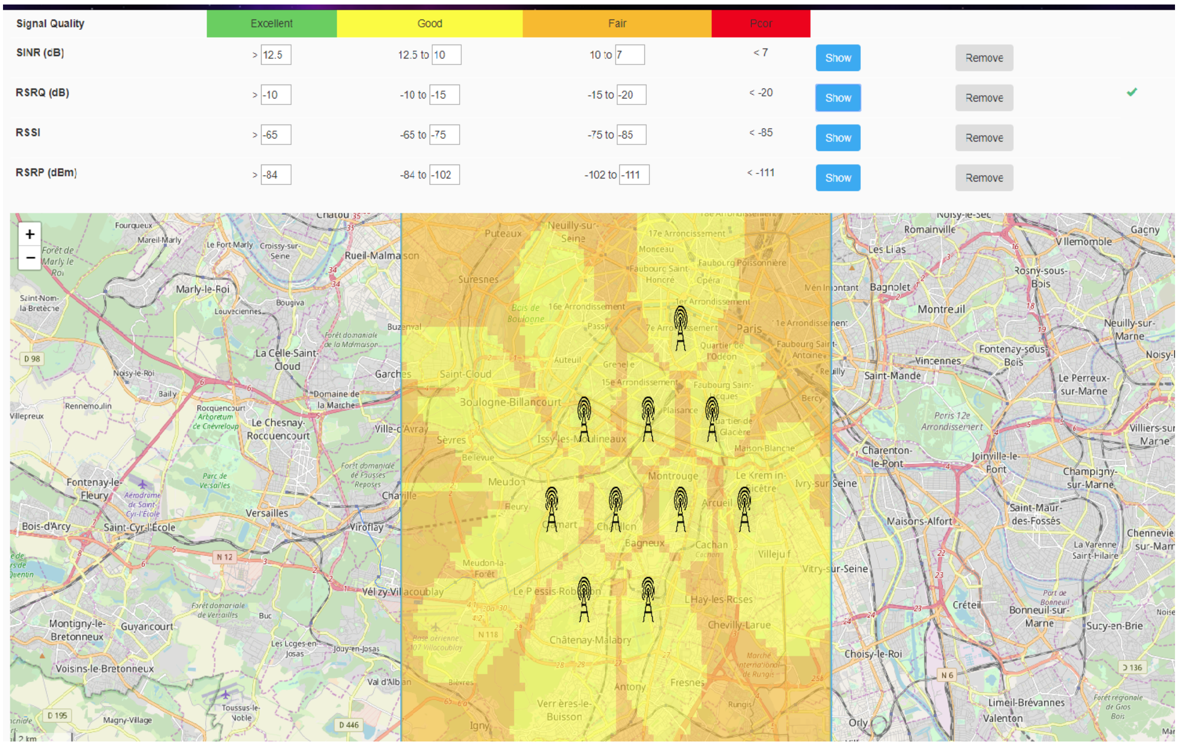

Figure 4.7: Graphical output for static scenario of RSRQ

Form figure 4.7 it can be seen that RSRQ is in between good and fair.

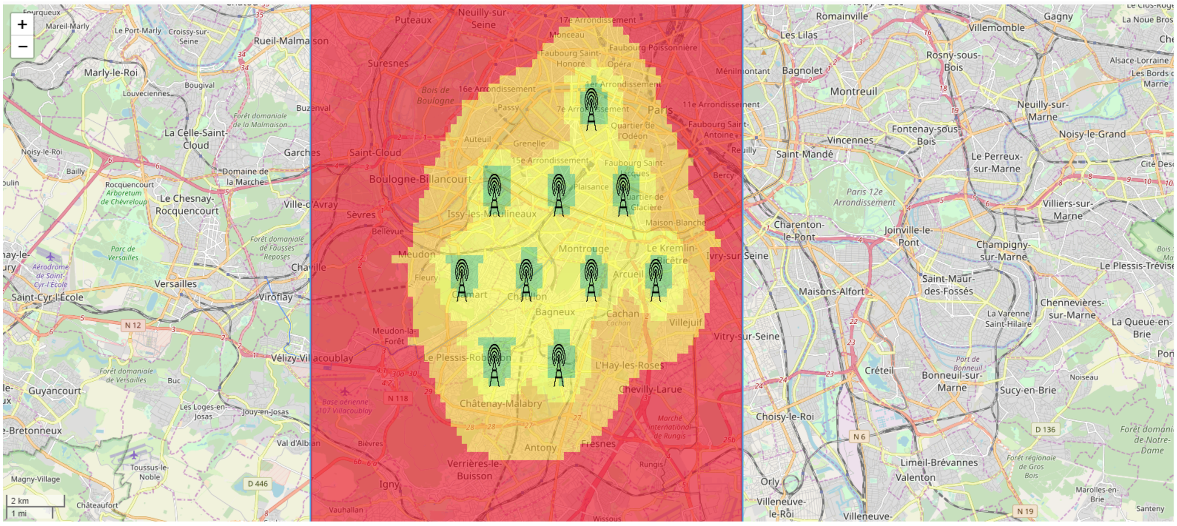

Figure 4.8: Graphical output for static scenario of RSSI

Figure 4.8 is about RSSI(Received Signal Strength Indicator) it can be seen that near to basestation it has excellent signal after that few kilometers it has fair and good signal strength.

Figure 4.9: Graphical output for static scenario of RSRP

Figure4.9 show that near to basestation it is good and fair for few kilometers and rest is poor.
Another part of static is a graph where tool presented different charts according to user demands. For a generation of a chart, we use the free library name fusion chart. Users can also save the figure directly in the form of .png,.jpg,.pdf, etc just clicking on the right corner of the graph.

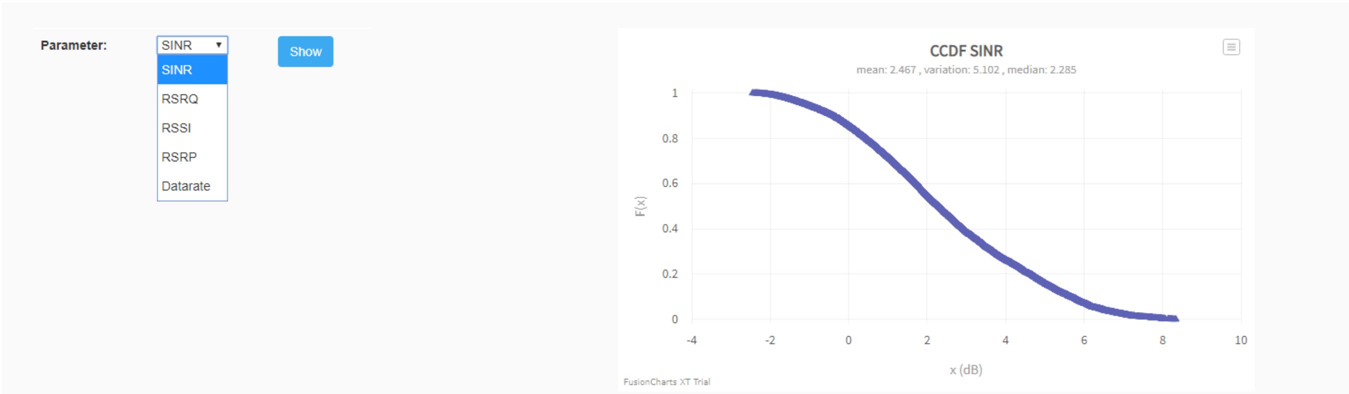

Figure 4.10: Coverage Probability of SINR

It can be seen that in the left side of figure user can choose different parameter and see the graph of those parameters on right-hand-side of a figure. In chart user can see the variation, mean and median of data which help the user to see a clear distribution of data and analysis them.

In above figure 4.10 we can see ccdf(complementary cumulative density function) of SINR(Signal-to-interference- plus- noise-ratio) which clearly show that more than 80 percent of pixels have 0 dB SINR.

Also, tool shows the RSRQ result which is shown below 4.11, it shows that more than 90 percent of the pixel have -17dB RSRQ, which confirmed our web-interface is operating in proper way.

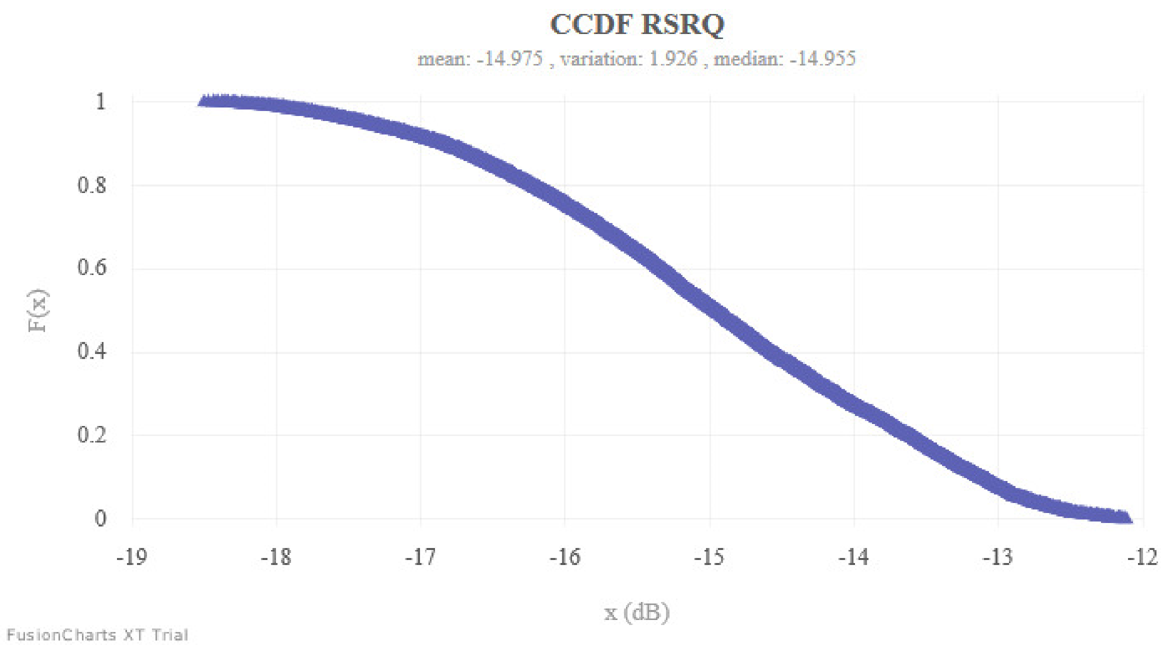

Figure 4.11: Complementary Cumulative density function of RSRQ

This tool also generate a graph for RSRP which can be seen in figure 4.12 it can be noticed that more than 90 percent of the pixel have -17 dB which is fair. Mean and median of data were also not different from each other. Figure 5.7 show the receive signal strength indicator with probability density -100 dB.

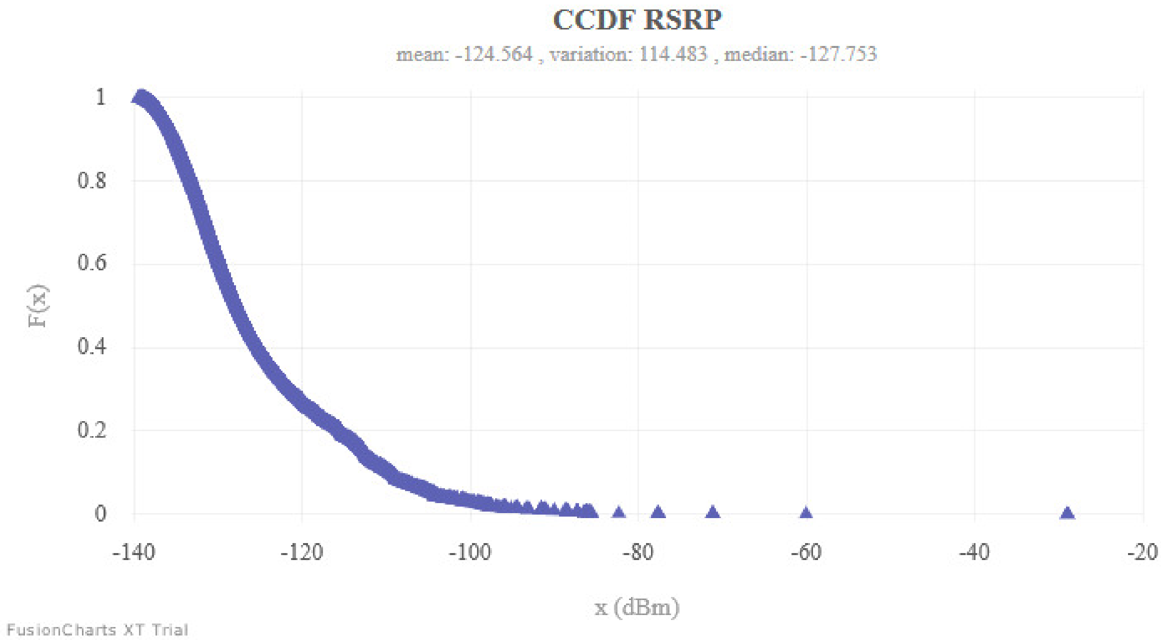

Figure 4.12: Complementary Cumulative density function of RSRP

Data-rate of this system can be seen in figure 4.13 which clearly show that more than 70 percent of user or pixels have 20 dB data rate which is the expected throughput for LTE. Mean and median of this data is almost similar.

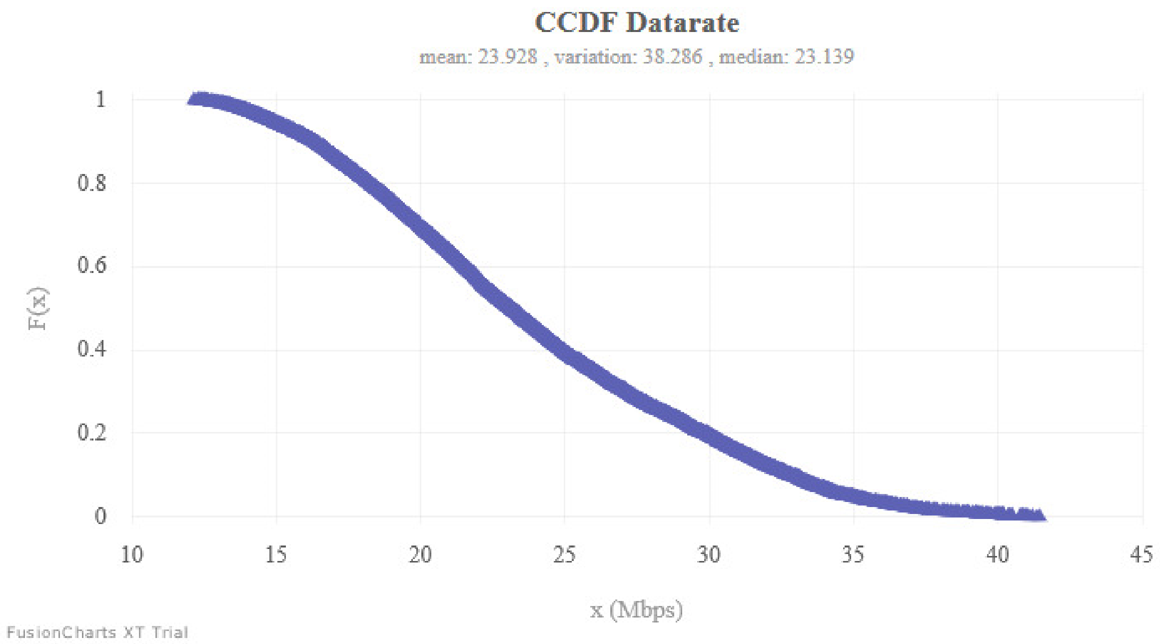

Figure 4.13: Coverage Probability of Datarate

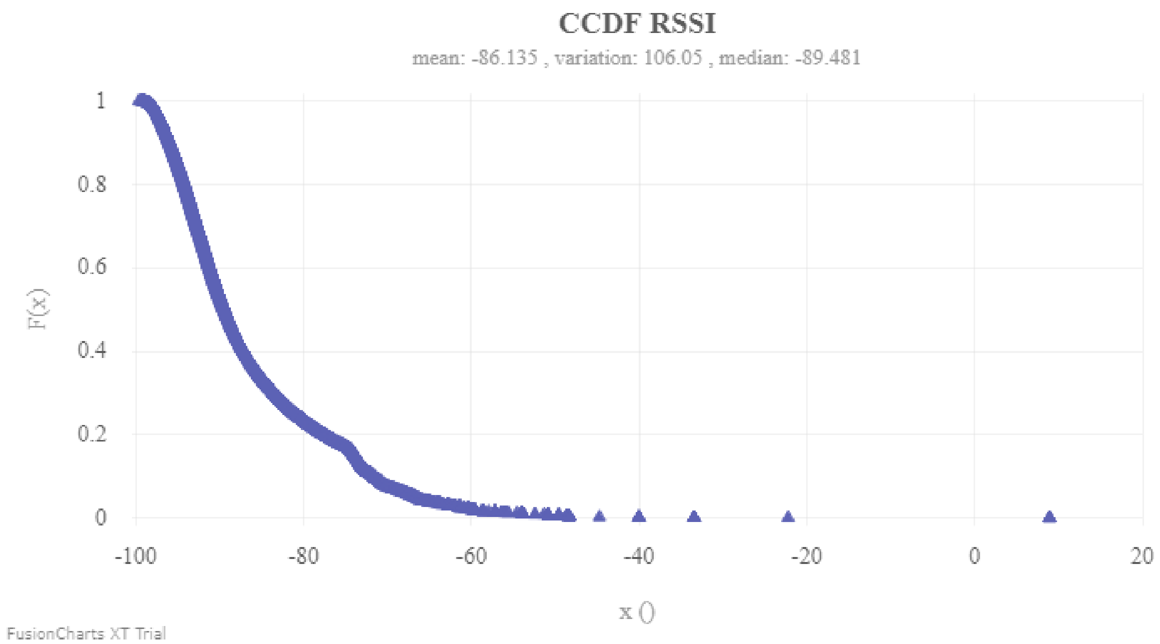

Figure 4.14: Coverage Probability of RSSI

Figure 5.7 above show the receive signal strength indicator with probability density -100 dB. As the distance from basstation is increased the coverage probability is decrease. Which is verified by the graph. It can be clearly seen in the map which was shown before in figure 4.8on this report.

4.3 Dynamic scenario output

It is the scenario which deals with arrival rate of UE. They moved within specified area given by user, if mobile try to go beyond given area then tool forced them to stay in predefined area. In initial parameter tab there is section name dynamic parameter using these parameters user can control all parameter regarding dynamic such as speed of mobile, arrival rates, number of mobile users, etc. Which can be seen in figure 4.15

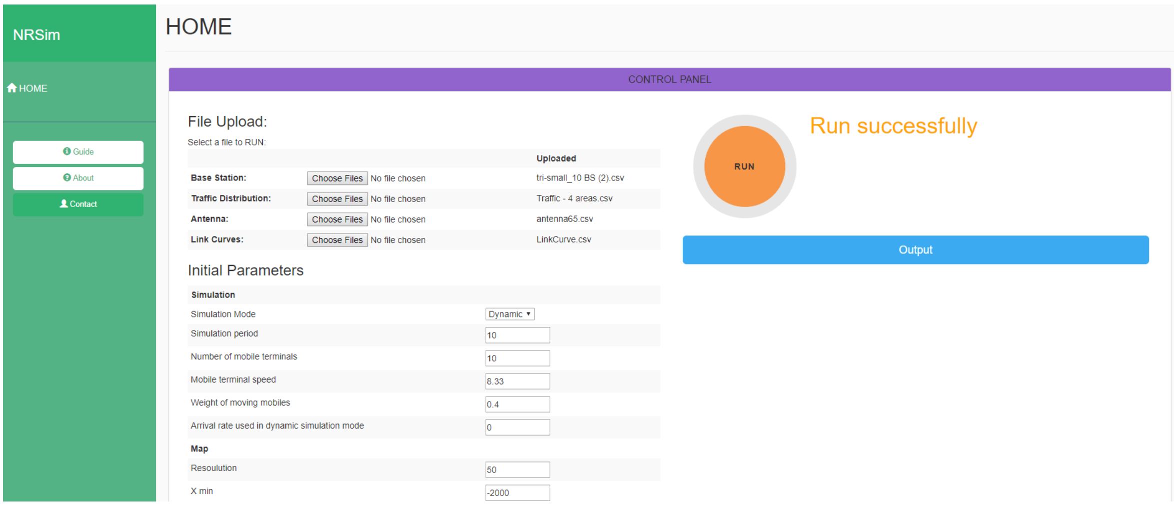

Figure 4.15: Dynamic Scenario parameters

After setting all initial parameters and uploading all required file user can click on run and output button to see the output, which will appear as shown in figure 4.16. Blue color in figure indicate area initialize by a user.

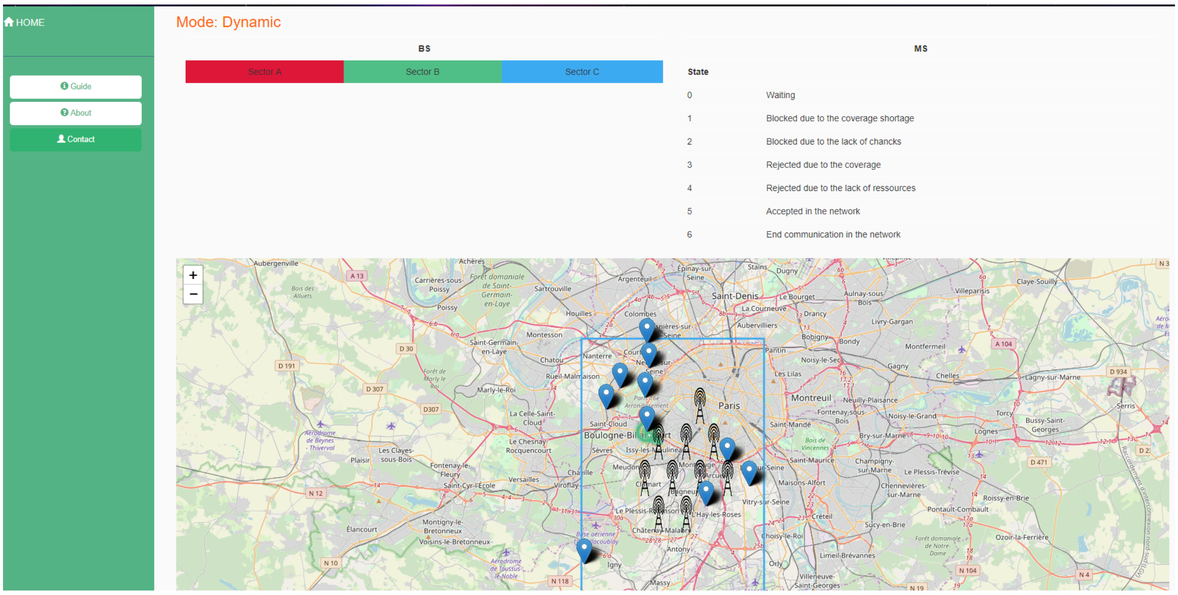

Figure 4.16: Dynamic Scenario

In the figure 4.16 on the top left the different name of the sector is give like sector A with red color, sector B with green color and sector c with blue color. Tool created this sector dividing bsindex of a mobile station by 3. We have three sector because tool use three sector antenna. On the right side of the figure, different types of state are shown such as 0,1,2,3..etc. Each state provide information about why mobile is connected or not connected with basestation.

On the center of the figure, in the map, there is a lot of markers those markers indicate the mobile. Line passing between basestation and marker indicated connection of base station and user. When a user click on the marker a pop-up box will appear which shows the list of parameters such as SINR, RSCPBest, download traffic, etc. It can be seen in 4.18. Fusion chart library were used for generating chart in this research.

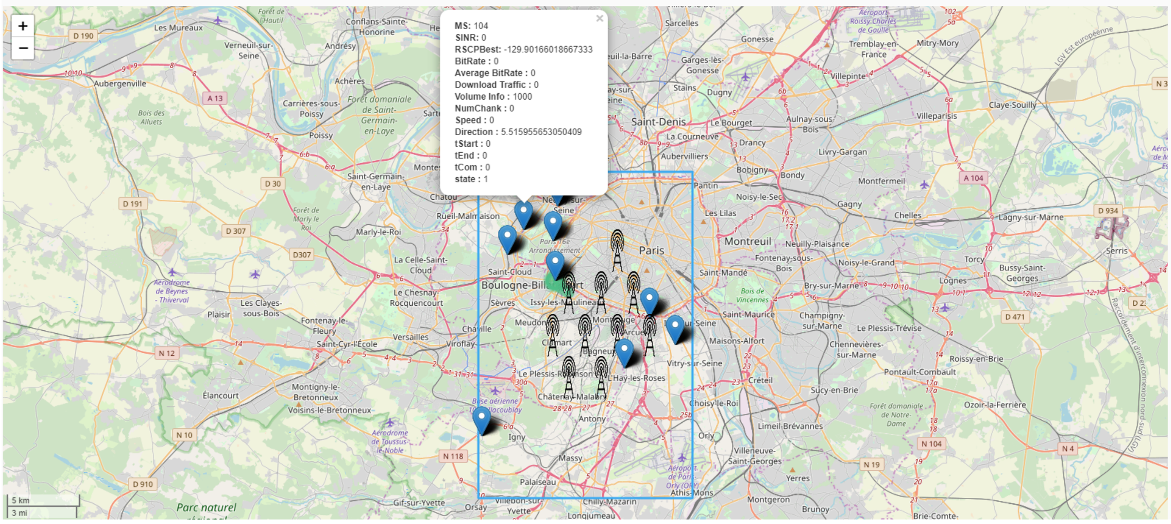

Figure 4.17: Dynamic Scenario

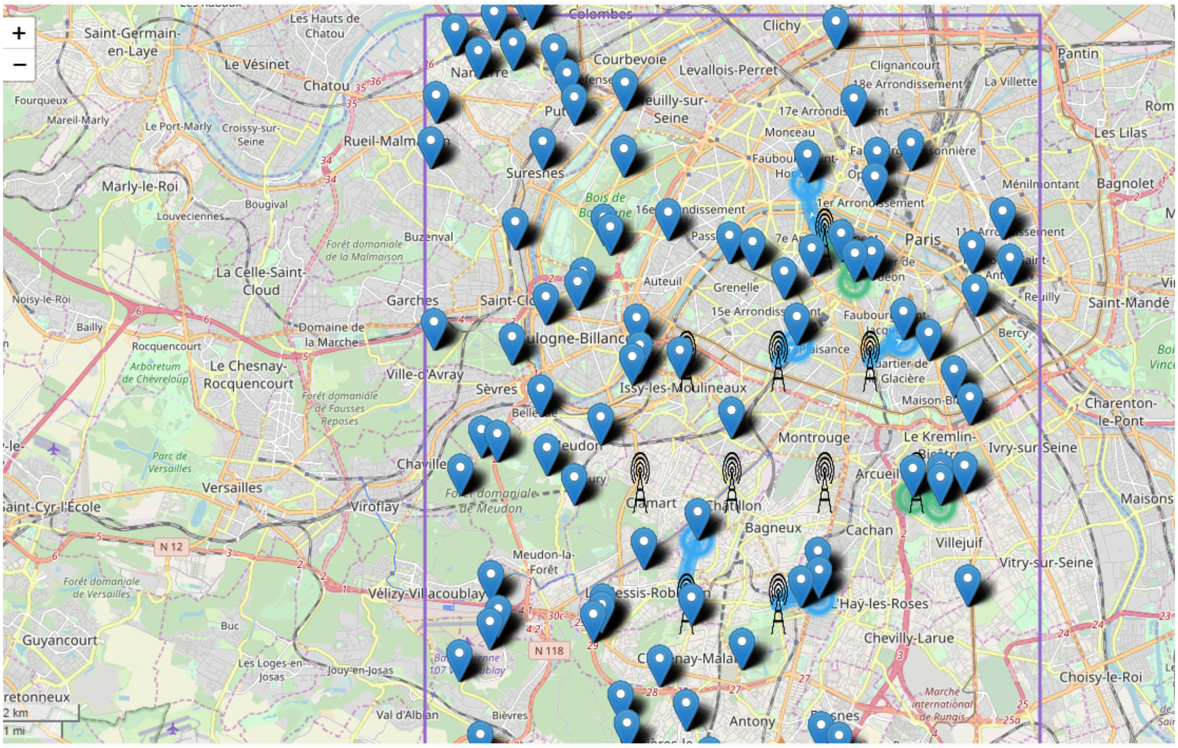

Figure 4.18: Dynamic Scenario more then 10 mobile users

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The objective of this internship was to develop a 5G radio simulator which was performed in two phases. First phase consisted of investigating network models including propagation, call arrivals and departure, user mobility as well as random user distribution for implementation in Matlab. It is worth noting that there already exists a 4G simulator developed and enhanced in the present project. Second phase intended to transform the code developed in Matlab into a Java code with graphical user interface. Conceptually, the simulator is performed in static and dynamic schemes. The static pattern is like an instantaneous snapshot of the network. At each location in a studied map, radio metrics are calculated. Radio metrics are RSRP, SINR, RSRQ, RSSI, maximum user throughput per location. Statistics of that metrics were also investigated to provide more insight into the understanding of metrics distribution and variation, i.e., CCDF, average and standard deviation of the main metrics are provided. The dynamic pattern is a characterization of the dynamics of the network by simulating its evolution in time. It is related to user call arrival and departure as well as user's mobility inside the studied map. Likewise, different metrics were recorded and showed in the web interface developed with Java code. In contrast to the static pattern, the dynamic simulator is likely to model the reality of the network. The provided performances should be close to real network metrics. Therefore, the operator could have a concise view of the performances of the future network before its deployment and then estimate the budget for the deployment accordingly.

5.2 Recommendations and Future Works

Although system-level simulation tool is expected to be efficient and convenient one, owing to time constraint and limited resources, it was not possible to consider various aspects of telecommunication such as beamforming in a dynamic pattern, handover, etc. There are still some bugs in the web-interface which need to be fixed taking a more complex scenario into consideration. In the future, one can analyze several features of radio networks, such as massive MIMO, adaptive TDD, etc. This tool is still in its infancy, even though it could possibly become a stepping stone to understand any scenario, network topology and protocol.

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APPENDIX A

Matlab Code

```
%The main function of the simulator, only relevent code are shown here.
%
%  Revised by Ghoshana bista,
% Date: 19-03-2007, modified 12-03-2019
% needed m-files: initialize, lin2log, log2lin, BSread, initializeRS,
%InterferTable, Trafficread, Bestcell, AntPattern, generateTraffic,
%GenererLoiBinomiale, generatediscrete, SelectBestcell, testAdmission,
%mapwin, BSplot, BestServerMap, coverageMap, calculBitRatebis, updateMS,
%updateMSposition, filterIndicator, adaptHoMargin, HandleResult
%
function main()
clear all;
lamdavar=2;
modef=1;
T1glob=clock;
StructParam=initialize();
% for Fuzzy Q-learning
%[inputVar,outputVar,QLParam]=RL_inputParam();
%[rule NbRules]= RL_Rules(inputVar);
%qL=zeros(length(outputVar),length(rule));
%visit=zeros(length(outputVar),length(rule));
% end of FQL parameters' initialization
StructParam.lamda=lamdavar;
StructParam.mode=modef;
% Generate RSRP coverage file
GenerateRSRPFile=1;
% Generate FFactor, SINR, RSRQ and RSSI files
GenerateSINRFile=1;

thNoisePRP=lin2log(StructParam.PRBwidth)+StructParam.thNoisePerHertz+
StructParam.NoiseFigure;
[basestation, numBSs] = BSread(StructParam.bsFilename);
[resultMS resultSNR]=initializeRS();

HOmargin=StructParam.Hodefault*(ones(numBSs)-eye(numBSs));
IntMatrix = InterferTable([basestation.UsedBand]);
AreaAndResolution=[StructParam.resolution StructParam.area];
[Traffic, numAreas] = Trafficread(StructParam.trafficFilename);
RSRPMin=-115;

% propagation file generation
```

```
if (GenerateRSRPFile)
RSRPPixel= Bestcell(StructParam,basestation);
else
    if(~exist('RSRPPixel.mat','file'))
    msgbox('RSRP file does not exist, you have to set GenerateRSRPFile
    parameter to a value different of 0','LTE Simulator 1.0.0');
    return
    end
end
load RSRPPixel

if (GenerateSINRFile)
CreateSINR(RSRPPixel,basestation,thNoisePRP,StructParam.PRBwidth);
else
    if(~exist('SINRFile.mat','file'))
    msgbox('SINRFile file does not exist, you have to set GenerateSINRFile
    parameter to a value different of 0','LTE Simulator 1.0.0');
    return
    end
end
load SINRFile

% Neighbour cell list generation
if(~exist('NeighbourList.mat','file'))
[NeighbourCellList PortionArea]=NeighbourList(RSRPPixel);
else
%load NeighbourList;
end
%%%
hMainWnd = mapwin;
% BSplot(basestation, hMainWnd,AreaAndResolution);
 BestServerMap(basestation, RSRPPixel,hMainWnd,AreaAndResolution);
% coverageMap(basestation, RSRPPixel,hMainWnd,AreaAndResolution);
% FFactorMap(basestation, dataRate,hMainWnd,AreaAndResolution);
% % beamforming
if(~StructParam.mode)
return
end
[MSnew, NBnewMS]=generateTraffic(StructParam,Traffic,0);
MSnew=SelectBestcell(MSnew,RSRPPixel,AreaAndResolution);
[basestation, MSnew,Rst]=testAdmission(MSnew,basestation,IntMatrix,RSRPMin,
thNoisePRP,0);
MS=MSnew;
resultMS.NBAccess=Rst(1);
resultMS.NBAccept=Rst(2);
h = waitbar(0,'Please wait the simulation');
HoAdapt=HOmargin;
loadTime=zeros(StructParam.simulPeriod,numBSs);
```

```
filtredLoad=zeros(StructParam.simulPeriod,numBSs);
for indexT=1:StructParam.simulPeriod
    waitbar(indexT/StructParam.simulPeriod)
    [basestation,MS,resultSNR]=updateMS(MS,basestation,resultSNR, RSRPPixel,
    AreaAndResolution ,IntMatrix,HoAdapt,RSRPMin,thNoisePRP,indexT);
    [MSnew NBnewMS]=generateTraffic(StructParam,Traffic,indexT);
    if (NBnewMS~=0)
     MSnew=SelectBestcell(MSnew,RSRPPixel,AreaAndResolution);
 [basestation MSnew, Rst]=testAdmission(MSnew,basestation,IntMatrix,RSRPMin,
 thNoisePRP,indexT);
        resultMS.NBAccess=resultMS.NBAccess+Rst(1);
        resultMS.NBAccept=resultMS.NBAccept+Rst(2);
    end
    MS=[MS MSnew];
    % here the state of each cell

    loadTime(indexT,:)=[basestation.load];
    filtredLoad(indexT,:)=filterIndicator(loadTime,StructParam.filterPeriod,
    indexT);

    %Autotuning is here
    if((mod(indexT,StructParam.reactivity)==0)&&(StructParam.mode==2))

    end
end
resultBS.throughputBS=[basestation.throughput];
resultBS.filtredLoad=filtredLoad;
resultBS.loadTime=loadTime;
resultMS=HandleResult(MS,resultMS);
switch StructParam.mode
    case 2
        cd resultAdap

    case 1
        cd result
    otherwise
        cd result
end
fileresultSNR=strcat('resultSNR',num2str(lamdavar));
fileresultMS=strcat('resultMS',num2str(lamdavar));
fileresultBS=strcat('resultBS',num2str(lamdavar));
save(fileresultSNR,'resultSNR')
save(fileresultMS,'-STRUCT','resultMS')
save(fileresultBS,'-STRUCT','resultBS')
close(h)
cd ..
%pause
```

```
T2glob=clock;
timeexcut=strcat('The time excusion of the simulator is: ',
num2str(etime(T2glob,T1glob)),' seconds');
msgbox(timeexcut,'LTE Simulator 1.0.0');
clear all
%close all

Initilaze fucntion
%The initialize function contais all the frequently changed
%system and control paramters needed
%
%Author: Ridha Nasri,
% Date: 19-03-2007

function Initilize=initialize()

%the mode of simulation 0: static, 1: dynamic, 2: auto-tuning of hondover
%parameter
Initilize.mode = 0;
Initilize.Hodefault=6;
Initilize.reactivity=5;
Initilize.filterPeriod=5;

%
%Study map
Initilize.resolution = 4;
Initilize.area = [-200 200 -200 200]; % meters [xmin,xmax,ymin,ymax]

%%%aaaaaaaaaaaaaaaaaaaaaaaa%% time unit is second
Initilize.simulPeriod=10;
Initilize.timeStep=1;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%%%%%%%%%%%%%
Initilize.PRBwidth=180000; % bandwidth by PRB resources 180 kHz
Initilize.SubCarrierwidth=15000;
Initilize.thNoisePerHertz=-174; % dBm/hertz
Initilize.NoiseFigure=8;
Initilize.mobilestationAntennaGain = 0;% dBi
Initilize.mobilestationBodyLoss = 1;   % dB
%Propagation model pathloss=b+a*log10(distance(BS,MS)(km))+
logNormalShadowing (dB)
Initilize.pathloss.Acoefficient=37.6;
Initilize.pathloss.Bcoefficient=128;  %dB
Initilize.pathloss.SigmaShadow=3;% standard deviation of the
log normal shadwing [dB]

%%%%%%services used in the LTE simulator%%%%%s
```

```
Initilize.mobileNum=10;
Initilize.speed=8.33;
Initilize.weight=0.40;
Initilize.type=2;
Initilize.volume=1000; % volume of information to download in kbit
Initilize.minChancks=1; % ;
Initilize.maxChancks=3; %;
Initilize.lamda=1;  %Arrival rate used in dynamic simulator
%2 tier scenario
Initilize.msParamFile = ’’; % file of mobile stations
Initilize.BSFolder=strcat(pwd,’\Scenarios\Tri’);
Initilize.bsFilename = strcat(Initilize.BSFolder,’\Tri-small2.txt’);
%’BSFile1.txt’;
% file of base station
Initilize.trafficFilename=’Traffic-small.txt’;%small
```

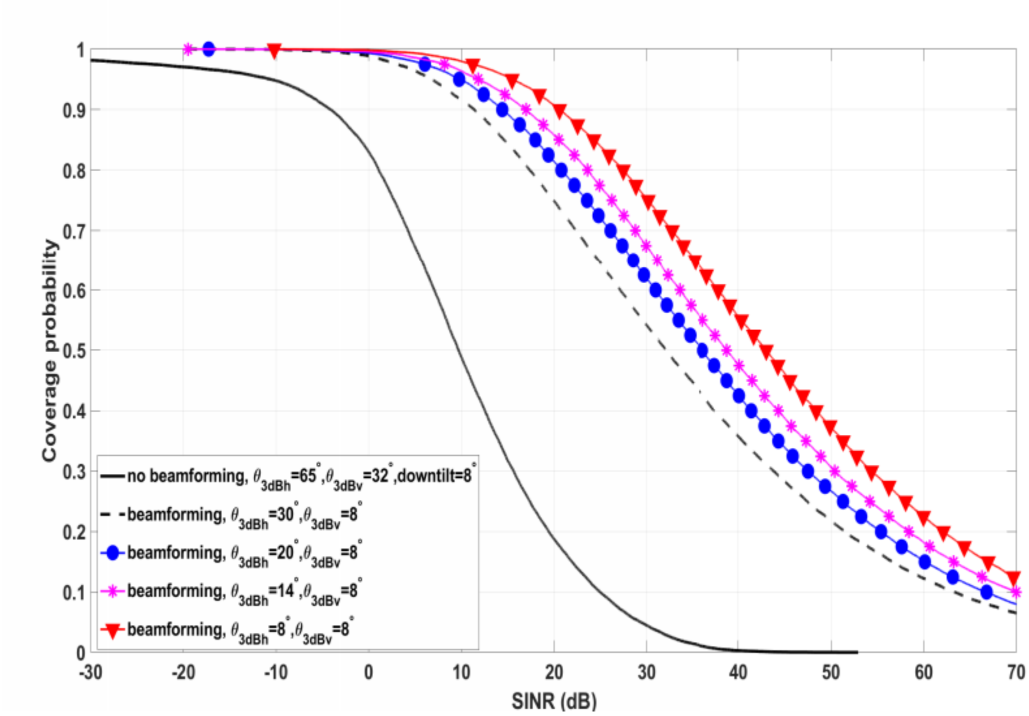

Figure 5.1: Coverage probability of SINR

(Rachad et al.,2019)

There are some figures which show the undergoing progress in this researched.

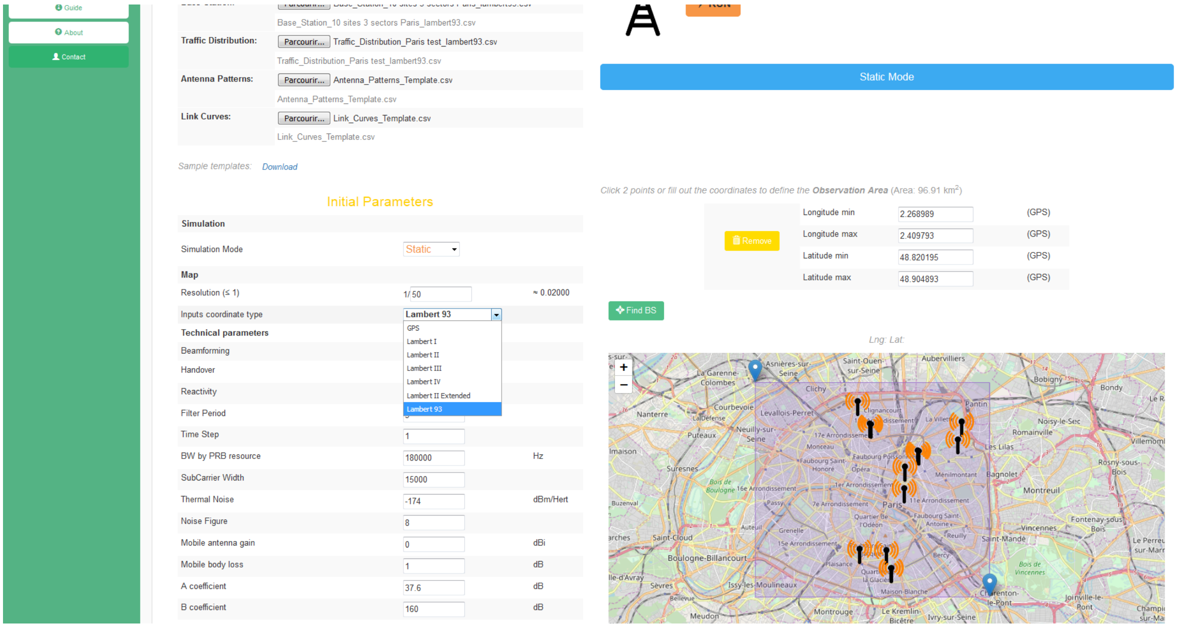

Figure 5.2: Simulation tool layout

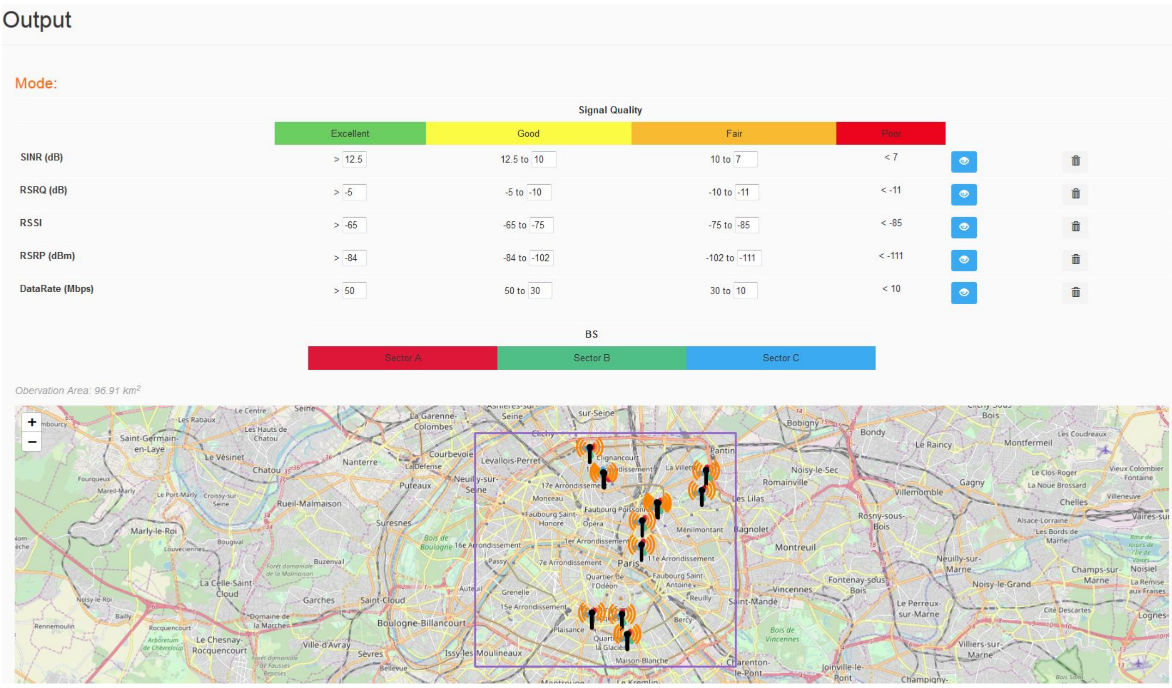

Figure 5.3: Static simulation scenario

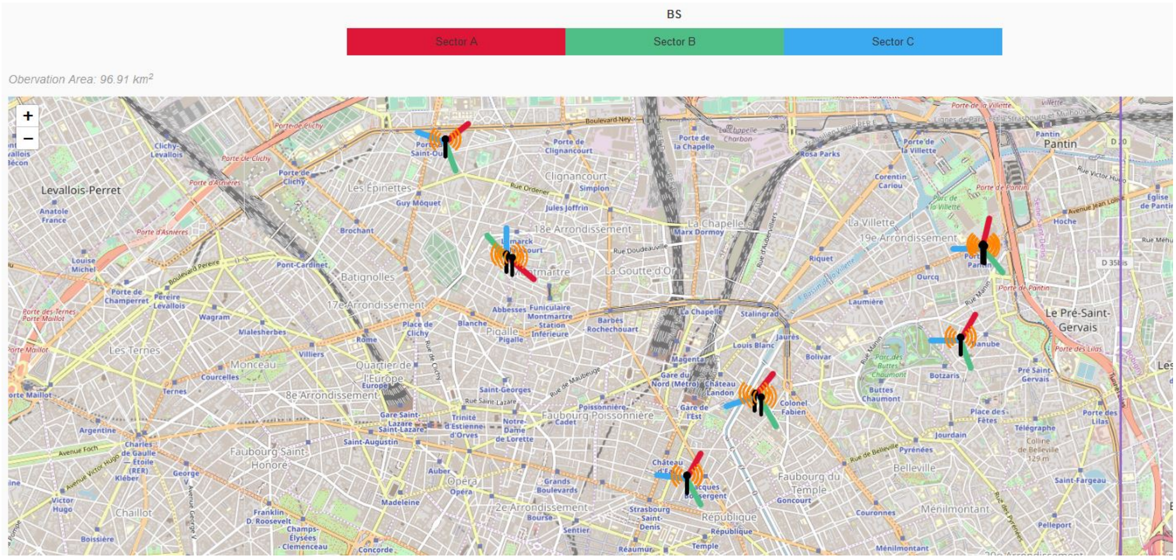

Figure 5.4: Showing basestation sector

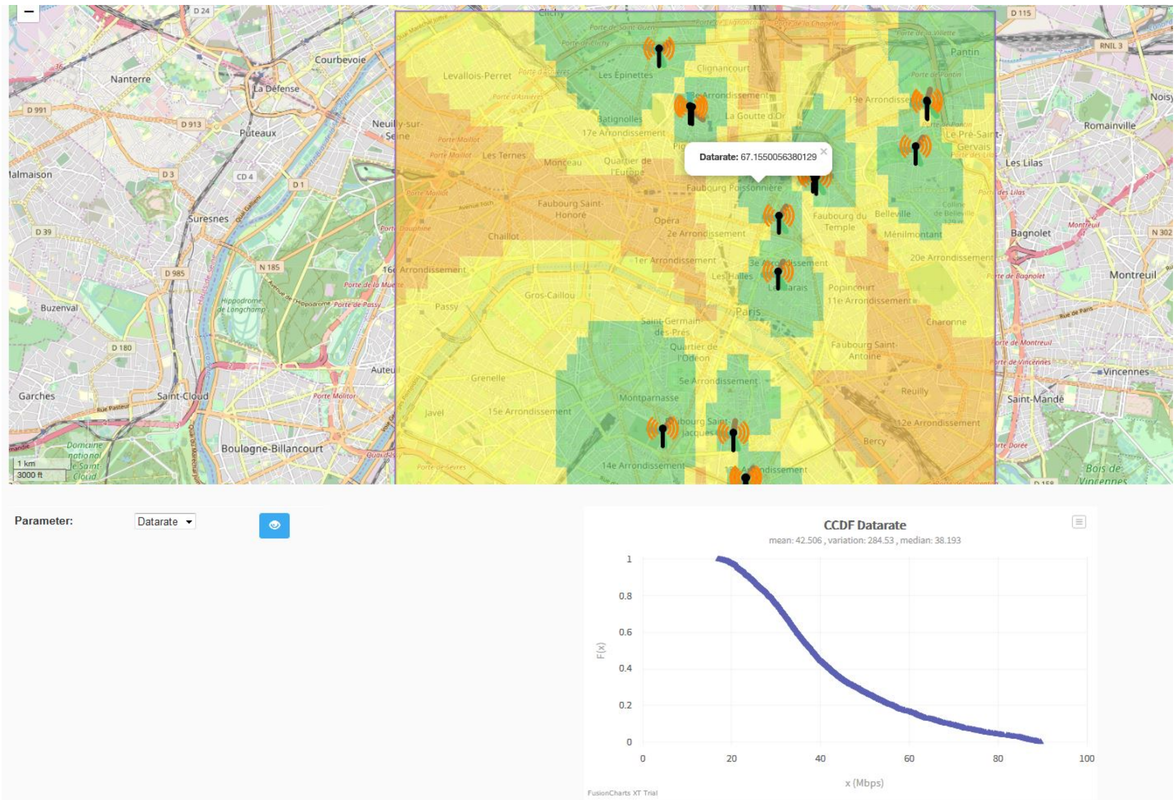

Figure 5.5: Static simulation scenario

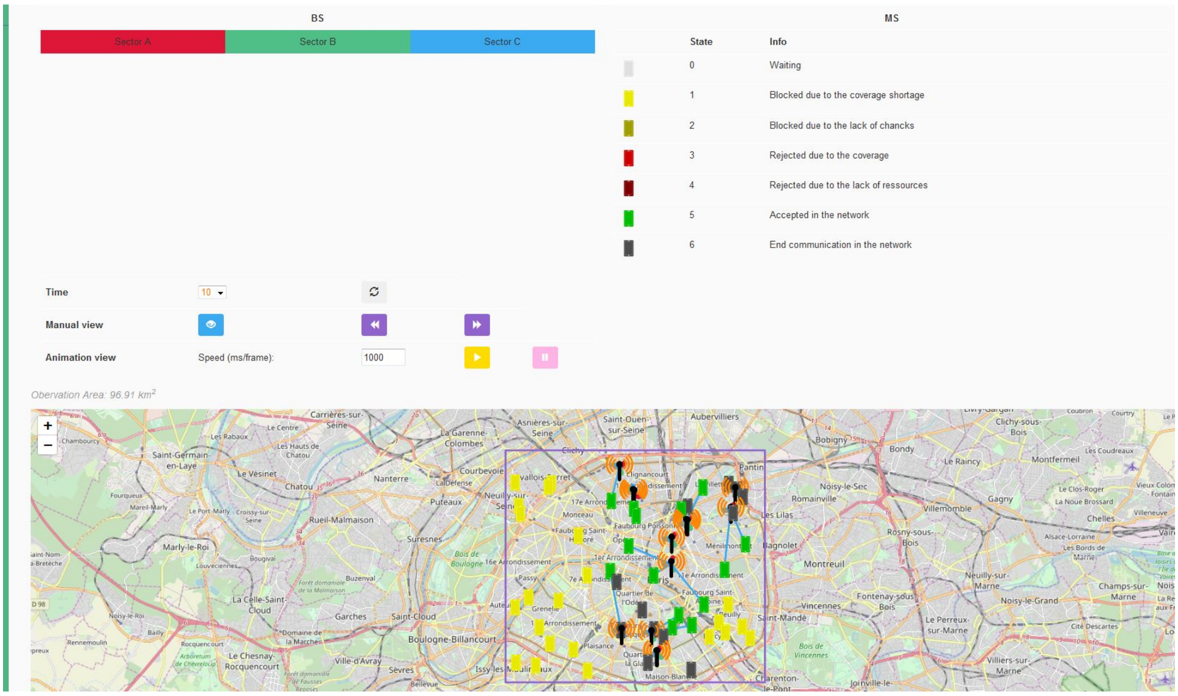

Figure 5.6: Dynamic simulation scenario

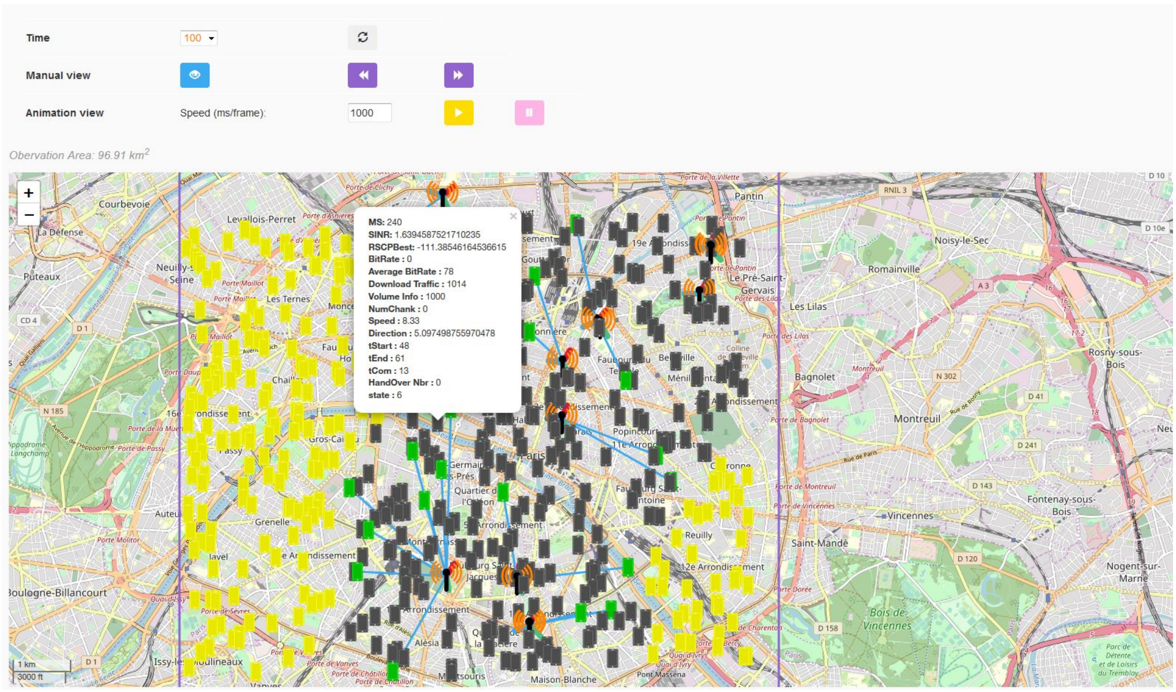

Figure 5.7: Output of dynamic simulation