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*Evaluation and optimization of cellular mobile
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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

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Dedications

This thesis is dedicated to

My parents

My friends

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Acronyms

BCCH	Broadcast Control Channel
BER	Bit Error Rate
BH	Busy Hour
BLER	Block Error Rate
BS	Bearer Services
BSC	Base Station Controller
BSIC	Base Station Identity Code
BSS	Base Station Subsystem
BTS	Base Transceiver Station
CCCH	Common Control Channel
CDR	Call Detail Record
COST	European Cooperation in the field of Scientific and Technical research
CS	Circuit Switched
CSSR	Call Setup Success Rate
DT	Drive Tests
DTX	Discontinuous Transmission.
DRX	Discontinuous reception .
EDGE	Enhanced Data Rates for GSM Evolution
EGPRS	Enhanced General Packet Radio Service
E-NodeB	Evolved NodeB
EPS	Evolved Packet System
ERAB	E-UTRAN Radio Access Bearer
FER	Frame Error Rate
GERAN	GSM Edge Radio Access Network
GMSK	Gaussian Minimum Shift Keying
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile
IMSI	International mobile subscriber identity
ITU	International Telecommunication Union
KPI	Key Performance Indicator

Acronyms

LAPD	Link Access Protocol D-channel
LTE	Long Term Evolution
MA	Terminal Adapter
ME	Terminal Equipment
MIMO	Multi-Input Multiple-Output
MME	Mobility Management Entity
MS	Mobile Station
MT	Mobile Technologies
NMS	Network Management System
PIN	Personal Identification Number
PS	Packet Switched
QoS	Quality of Service
RAN	Radio Access Network
RAT	Radio Access Technology
RF	Radio Frequency
RRC	Radio Resource Control
RRCSSR	Radio Resource Control Success Service Modulation
SDCCH	Stand Alone Dedicated Control Channel
SIM	Subscriber Identity Module
SINR	Signal to Interference & noise Ratio
SQI	speech quality index
SSV	Single Site Verification
TA	Time advance
TASR	TCH assignment success rate
TCH	Traffic Channel
TEMS	Test Mobile Systems
TRX	Transceiver unit
UE	User Equipment
UMTS	Universal Mobile Telecommunications System
VAD	Voice Activity Detection
VoIP	Voice over IP
WCDMA	Wideband Code Division Multiple Access

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Introduction

Introduction

The radio interface is one of the most important parts of the mobile network, it is the access point of mobile phones for services. The access to the network is done through logical channels which makes it a very complicated task.

Most network operators try to enhance their existing radio networks by using monitoring tools and tasks. Among these important tasks, we can find planning and optimization. These two processes will be done simultaneously. The main goal of mobile network planning is to offer these networks a rentable solution in terms of coverage, capacity, and quality. Depending on whether capacity or coverage is the primary criterion, different regions have different design criteria for planning processes. A mobile network's design typically involves many network planning procedures, particularly in the radio interface.

In this master thesis we will present a case study about the evaluation and optimization of mobile networks in M'sila city. To evaluate the performance of mobile networks, two approaches are used: key performance indicators (KPIs) and drive test. The main work of our thesis is to collect samples from the drive test and analysis this samples using TEMS investigation and compare it with the collected statistics from business object data.

In this study, we try to optimize the mobile network using two procedures. The first one is manual (capacity and interference analysis) while the second one uses software tools (DT and business object).

In the first chapter, we will briefly present the different interfaces in the GSM network and beyond. In the same way, several basic concepts related to the planning of a mobile network, of different generations, are introduced, making it possible to understand many of the tasks of a radio engineer during planning such as creating a link budget and calculating cell capacity.

The second chapter focuses on the various processes for improving the mobile network and key performance indicators (KPIs). In this chapter, we will discuss the optimization goal, how this process is implemented and its most important components in different generations of the mobile network.

Introduction

In the third chapter, we have described the TEMS investigation tool. This software allows recording and reading log files during drive tests, which can monitor the network using deep analysis, improve the radio interface and address various problems.

In the last chapter, some statistics and KPIs will be presented. The data will be delivered by Mobilis operator for a given period for a dense area in the wilaya of M'sila (University of M'sila: pole). the delivered KPIs will be analyzed, then identifying the causes of deterioration and proposing appropriate solutions.

Chapter I
Network planning of different
generations

I.1 Objective

The main objective of mobile network planning is to enhance many parameters such as quality of service, capacity, and coverage. The process of network planning can be summarized as follows:

- a-** Gathering information about the environment to be covered (geographical and propagation characteristic).
- b-** Information about the area of deployment. **In urban areas**, the objective is to ensure sufficient traffic capacity (serve a high number of subscribers, where **in rural areas** (areas with low subscriber density), the objective is to ensure the most coverage possible (cell radius of about ten kilometers) without need for high capacity. In the same way, demographic information must be delivered.
- c-** Information concerning the subscribers to be served (population density, user incoming, number of users, Traffic per user)
- d-** The cost of radio and network infrastructure must be minimized depending on radio coverage, cell size, frequency plans, and network topology.
- e-** Coverage requirements, signal level for outdoor, and indoor with coverage probabilities.
- f-** Quality requirements, dropped call rates, call blocking.
- g-** Frequency band (limited which greatly reduces the capacity of the network),

All the network parameters and the satisfaction of the users must be considered. [1]

I.2 Radio Network Architecture

I.2.1 GSM Network Planning

I.2.1.1 An overview

The radio interface is called U_m , it connects the mobile station (MS) to the network. It is the weak link in the transmission chain because it is subject to various problems such as interference, signal fading, and other problems. [20]

As shown in Figure I.1, the radio network consists of the BTS, the MS and the interface between

them. This is the section of the network that is directly connected to the mobile user, for this reason it is very important. The base station should be able to communicate with the mobile station within a defined coverage area while preserving call quality standards. The connection between these two ends is ensured via a radio link which should be able to provide sufficient capacity and coverage [2].

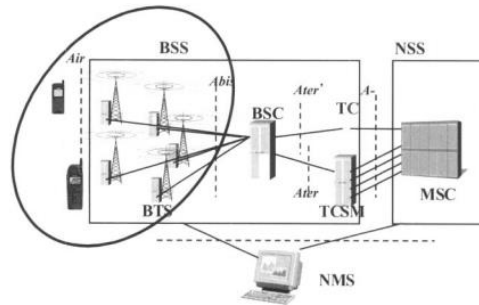


Figure I.1: GSM network architecture [2]

I.2.1.2 Shape of cells

A cell is a radio coverage area provided by a single BTS antenna system (see Figure I.2). A hexagon can represent a cell, which is the smallest building element in a mobile network.

There are two types of cells:

1. **Omni-directional cell:** An omni-directional cell (or *omnicell*) is served by a BTS with an antenna that broadcasts equally in all directions (360 degrees).
2. **Sectorial cell:** A sector cell is the coverage area of an antenna that only transmits in one direction. This might be 120 degrees or 180 degrees in a comparable omni-directional cell, for example. With a collection of BTS's at a site supporting more than one of these sector cells, phrases like two-sectored sites and, more typically, three-sectored sites come to mind [3, 4]

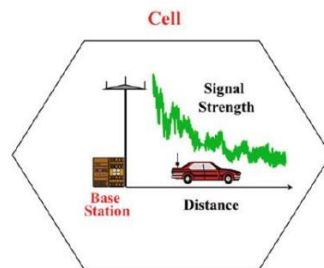


Figure I.2: Hexagonal cell [4]

The hexagonal shape of the cell is a man-made structure. This is the shape that is closest to the circular shape, which symbolizes the ideal coverage of the base station antenna's power transmission. The circular shapes are troublesome because they have overlapped covering zones. The cells take hexagonal shape as represented in Figure I.3. In a real network, cells will have non-geometrical shapes, with some places lacking the appropriate signal strength for various reasons [4]

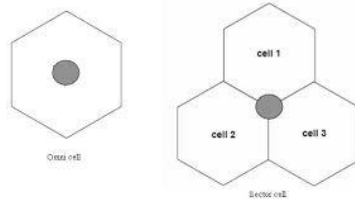


Figure I.3: Hexagonal shape of the cell

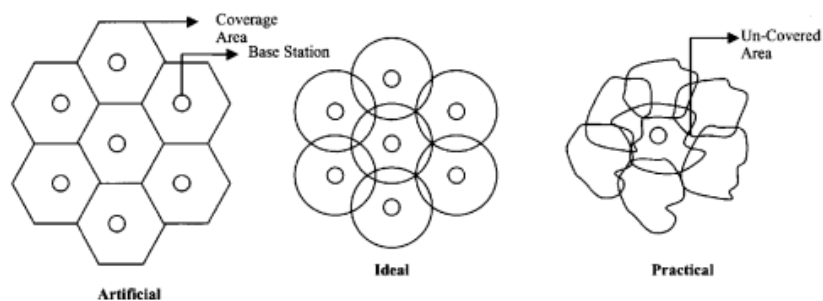


Figure I.4: Some cellular shapes [2]

I.2.1.3 Elements of a mobile network

➤ **Mobile Station (MS)**

Mobile station is a combination of mobile phone, SIM card, and software which is needed for communication with a GSM network.

Mobile station communicates the information with the user and modifies it to the transmission protocols of the air interface to communicate with the Base Station Subsystem (BSS).

The information of the user communicates with the MS through a microphone and speaker for the speech, keyboard and display for short messaging and wire and cable connection for other data terminals.

It consists of a terminal and a SIM card, the mobile terminal is Consisting of a transmitter / receiver, each terminal is differentiated from the others by a IMEI (international mobile Equipment identity) code which is a 15-digit number [6]

The SIM card is a mini database with memory and microprocessor it contains specific data such as PIN code and IMSI (international mobile subscriber identity) which is used to identify a subscriber in any GSM network. [6]

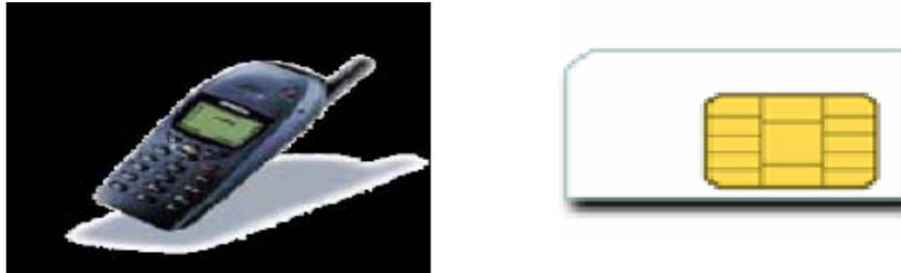


Figure I.5: Mobile station (terminal and SIM card) [6]

In GSM, MS consists of two main components:

- Mobile Equipment (ME)
- Subscriber Identity Module (SIM)

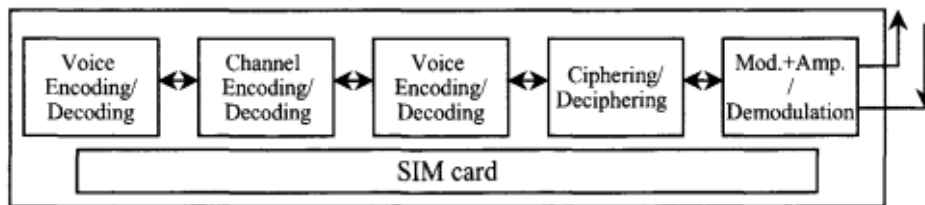


Figure I.6: Block diagram of a GSM mobile station [7]

GMSK modulation is used in radio interface transmission (MS-BTS). The SIM card is essentially a chip that works in conjunction with a memory card. The main function of the SIM card is to store data for the operator and subscriber. The SIM card meets the needs of both the operator and the subscriber because the operator can maintain control over the subscription and the subscriber can protect their personal information.

➤ **BTS base station (transceiver)**

From the radio engineer's point of view, BTS is the most important element of the network, as it provides physical connection to the mobile station via the aerial interface.

The BTS radio base station is a set of transceivers called TRX. It is responsible for radio transmission: modulation, demodulation, equalization, error-correcting coding. [5]

More generally, it manages the entire physical layer: TDMA (Time Division Multiple Access) multiplexing, slow frequency hopping, encryption. It also carries out all the radio measurements required to verify that communication in progress is proceeding correctly. These measurements are not operated by the BTS, but directly transmitted to the BSC (Base Station Controller). [5]

BTS manages the data link layer for signaling exchange between mobiles and infrastructure (LAP Dm) [5]

Finally, it manages the data link with the BSC to ensure the reliability of the dialogue (LAP D). The maximum capacity of a BTS is typically 16 carriers, i.e. it can support at most a hundred simultaneous communications. In rural areas, the BTS can be Restricted to the management of a single carrier with up to 7 simultaneous communications. In urban areas, BTS generally have 2 to 4 TRX that can flow about 14 to 28 simultaneous communications. [5]

I.2.2 UMTS mobile networks

I.2.2.1 An overview

Third generation 3G mobile networks were created for a different purpose than in 2G networks, the requirements have also changed compared to existing GSM networks. The main changes are as follows:

- ❖ Maximum bitrate of 384kbps.
- ❖ Efficient transfer between different operators and technologies (e.g. GSM and UMTS). Capacité de fournir la bande passante demandée.
- ❖ Ability to provide different services (CS and PS) with the required quality of service (QoS).
- ❖ The area of interest is quite similar to that of the GSM/GPRS network, as shown in Figure 1-7.

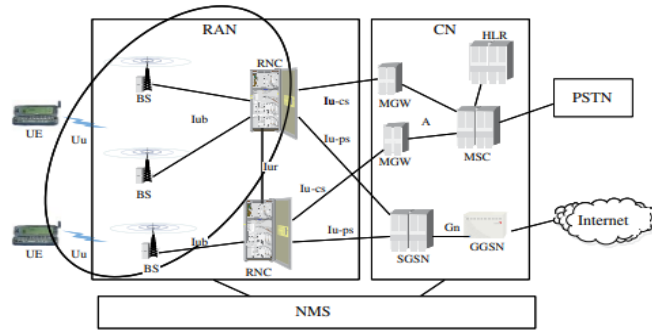


Figure I.7: Architecture of 3G mobile network [8]

I.2.3 LTE mobile networks

The process remains similar to the one discussed above. However, as the network architecture has changed significantly (more simplified); In addition to the fact that it is a data-driven network, the planning of this mobile network has undergone some changes compared to that in GSM/WCDMA networks.

I.2.3.1 An overview

Long-Term Evolution (LTE) is the fourth generation (4G) of cellular technology that follows the UMTS system.

It is the most effective mobile broadband technology to provide an excellent user experience. It offers the highest data rates and the shortest latency

The 4G network planning will cover, from the equipment point of view, the planning of eNode B, the Uu interface and the X2 interface.

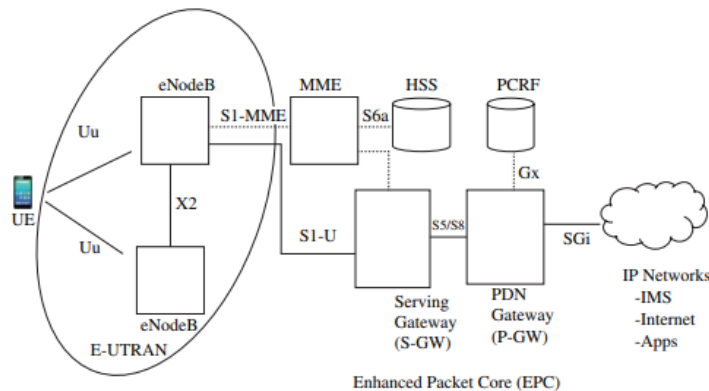


Figure I.8: LTE mobile network architecture [8].

I.3. Mobile network planning

The detailed planning of a mobile network can be divided into three subparts:

- (1) Power link budget.
- (2) Coverage and capacity planning.
- (3) Frequency planning.

I.3.1 Power link budget

Link MS-BTS, Link BTS-BTS

The power link budget aims to calculate the cell coverage area, and give the loss in the signal strength on the path between the mobile station antenna and base station antenna. One of the required parameters is radio wave propagation to estimate the propagation loss between the transmitter and the receiver. The other required parameters are the transmission power, antenna gain, cable losses, receiver sensitivity and margins, as shown in Figure I-9.

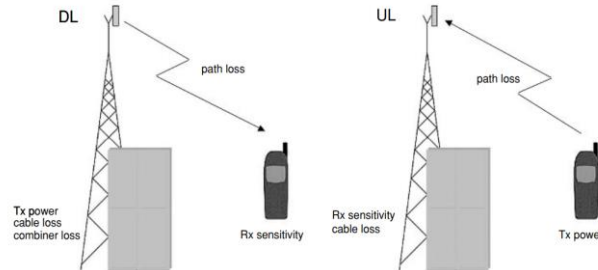


Figure I.9: Link budget parameters [8]

When defining the cell coverage area, the aim is to balance the uplink and downlink powers. The links are calculated separately and are different from the transmission powers. The BTS transmission power is higher than the MS transmission power and therefore the reception of the BTS needs to have high sensitivity.

I.3.1.1 Formula for Power link budget

$$P_{RX} = P_{TX} + G_{TX} - L_{TX} - L_{FS} - L_M + G_{RX} - L_{RX}$$

Where,

P_{RX} =Received Power (dBm)

P_{TX} =Transmitter Power Output (dBm)

G_{TX} =Transmitter Antenna Gain (dBi)

L_{TX} =Losses from Transmitter (cable, connectors etc) (dB)

L_{FS} =Free-Space Loss (dB)

L_M =Misc Losses (fade margin, polatization misalignment etc) (dB)

G_{RX} =Receiver Antenna Gain (dBi)

L_{RX} =Losses from Receiver (cable, connectors etc) (dB)

I.3.2 Coverage planning

I.3.2.1 Coverage planning in GSM networks

The target for coverage planning is to find optimal locations for base stations to build continuous coverage according to the planning requirements. Especially in the case of a coverage limited network the BTS location is critical. With a capacity limited network the capacity requirements also need to be considered. Coverage planning is performed with a planning tool including a digital map with topography and morthography information. The propagation model is selected and customised with model tuning mea- surements before the coverage planning phase has been started. The model selection is done according to the planning parameters, e.g. frequency, macro/micro cell environment, BTS antenna height. The cov- erage prediction is based on the map and the model and therefore the accuracy is dependent on those as well [8]

I.3.2.2 Coverage planning in 2.5 (GPRS and EDGE)

Typically The coverage planning aspects is centered around ensuring sufficient carrier- to- noise (C/N) ratios on both uplink and downlink to allow for successful data transmission across the coverage area. A particular range of C/N values for each network type is delivered for a given block error rate (BLER). Generally, it is found that the higher the level of error protection, the lower the required C/N. [27]

I.3.2.3 Planning for coverage in WCDMA networks

The fundamental process for coverage planning in the WCDMA system is quite similar to that of the GSM system. However, propagation models need to be adjusted to take into consideration the WCDMA technology. The cell range R can be calculated using the Okumara–Hata or the Walfish–Ikegami models. After this, the site area can be calculated, which is $2.6R^2$. However, in the WCDMA networks, some additional measurements and adjustments were done in the framework of European Cooperation in the Field of Scientific and Technical Research, also called COST.

The validity for this extended Okumara–Hata model is:

- Frequency f : 150–2000 MHz
- Distance R : 1–20 km
- UE height: 10–200 m
- MS height: 1–10 m

The correction factor c is given as:

$$\begin{cases} 2\log_{10}^2\left(\frac{f}{28}\right) + 5.4 \\ 4.78\log_{10}^2(f) - 18.33\log_{10}(f) + 44.94 \end{cases} \quad (\text{I.1})$$

This correction factor is added to obtain the actual losses in the WCDMA environment. Similarly for the Walfish–Ikegami model, the COST model is applied, which is based on the typical antenna placements and has the validity range

- Frequency f : 800–2000 MHz
- BS height h_{bs} : 4–50 m
- UE height h_{ms} : 1–3 m
- Distance d : 0.02–5 km [27]

I.3.2.4 Planning coverage in 4G LTE

Coverage planning involves evaluating the budgets of DL and UL radio links. The maximum path loss is calculated based on the service rate defined by the airframe edge user who needed the SINR level to the receiver. The minimum of maximum path losses in UL and DL directions is converted to a cell radius, using a propagation model appropriate to the deployment area. The radio link budget is the most important element of the coverage planning exercise. The link budget includes key parameters such as antenna height, antenna gains, path loss, transmitted power, receiver sensitivity. The UL and DL that gives to provide a specific throughput to the cell edge user. The calculation of the LTE link budget is similar to that of other cellular technologies. The maximum permissible attenuation of the radio wave passing through the air interface excludes congestion data.

I.3.3 Capacity planning

I.3.3.1 GSM Network Capacity Planning

Capacity planning is a very important process in the network rollout as it defines the number of base stations required and their respective capacities. Capacity plans are made in the preplanning phase for initial estimations, as well as later in a detailed manner.

The number of base stations required in an area comes from the coverage planning, and the number of transceivers required is derived from capacity planning as it is directly associated with the frequency re-use factor. The frequency re-use factor is defined as the number of base stations that can be implemented before the frequency can be re-used. An example of frequency re-use is shown in Figure I.10. The maximum number of frequencies in a GSM 900 system is 125 in both the uplink and downlink directions. Each of these frequencies is called a channel. This means that there are 125 channels available in both directions. The minimum frequency re-use factor calculation is based on the C/I ratio. As soon as the C/I ratio decreases, the signal strength starts deteriorating, thereby reducing the frequency re-use factor.

Another factor to keep in mind is the antenna height at the base station. If the antenna height is too high then the signal has to travel a greater distance, so the probability that the signal causes interference becomes greater. The average antenna height should be such that the number of base stations (fully utilised in terms of their individual capacities) is enough for the needed capacity of the network.

There are three essential parameters required for capacity planning: estimated traffic, average antenna height, and frequency usage.

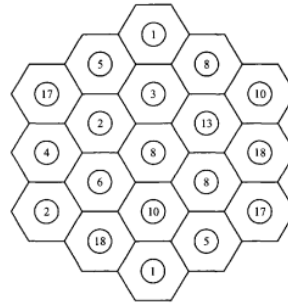


Figure I.10: Example of frequency reuse [21]

I.3.3.2 Capacity Planning 2.5 (GPRS EDGE)

❖ GPRS

Capacity planning of a GPRS network may be subdivided into two parts: capacity planning for the radio interface and capacity planning for the Gb interface. In this section, we deal with capacity planning for the radio interface [21]

The network has three kinds of traffic: voice, CS data and PS data. All these have to be considered when doing capacity planning for the radio interface. Circuit-switched traffic always has priority over PS traffic, but owing to the delay-sensitive nature of some PS services, some time slots are *dedicated* to carry the PS traffic only.

CS traffic calculations, as with GSM, pre-dominantly involves the Erlang B tables, blocking and *Cfl* thresholds. Assume the case shown earlier in Figure 5.5. There is one cell that has two TRXs. In ideal conditions (i.e. without blocking), 14 (voice) users can use the time slots continuously, so traffic of 14Erl would be generated if there is no blocking. If the number of voice users is reduced to eight, then the remaining six time slots can be used for data. It should be noted, however, that data which are not delay-sensitive could still be sent through the *gaps* in the air interface. Only the data that are delay sensitive need uninterrupted availability of time slots.

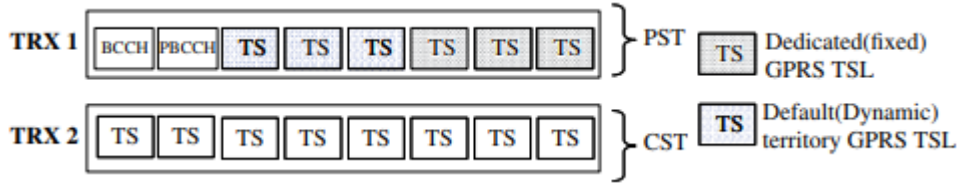


Figure I.11: GPRS timeslot allocation to CS and PS traffic. [8]

❖ EDGE

Capacity planning for EDGE networks is quite similar to that for GPRS networks. However, fundamental differences between the two technologies and the increase in throughput per radio time slot in EDGE are changing some aspects of capacity planning. A brief overview of these concepts and their effect on radio time rate is described in the following sections. The territorial aspects explained above, i.e. dedicated, default, etc., are the same for EDGE networks. The dedicated territory is specifically for PS traffic, CSW territory for CS traffic, and by default can be used for PS traffic if CS traffic does not use it (i.e., CS traffic takes precedence over PS traffic for the default territory). The number of slots assigned to each of these territories can be changed dynamically depending on load conditions.

I.3.3.3 Capacity Planning in WCDMA Networks

Capacity planning in WCDMA networks is much more complicated than in GSM/EGPRS. Factors that affect the coverage calculations are load, interference, traffic behaviour, speed of subscribers, etc

❖ UpLink

WCDMA is an interference system limited by the air interface. Hence, capacity planning would need to calculate the interference and the cell capacity, i.e. the amount of traffic that is supported by a base station. The amount of uplink interference has a great impact on the cell capacity and radius. The interference margin (η) indicates the total amount of interference (including thermal noise power) in comparison to the thermal noise

$$\eta_u = \frac{E_b RN}{W N_0} (1+i) \nu_j \quad (I.2)$$

Where

E_b/N_0 = signal energy per bit/noise spectral density.

N = Total number of users / cells

R = Bit rate

W = chip rate

i = other cell-to-own cell interference

v_j = activity factor of user j

❖ DownLink

In the downlink, the power transmitted by the BS is shared between all users. The capacity is determined by the power transmitted by the BS, locations of UE and interference. Thus, the parameters needed for downlink calculations include the power transmitted by BS and power allocation to the Common Control Channel (CCCH). Thus, in downlink the capacity is determined by the power transmitted by the BS, locations of UE and interference. This makes the calculations in downlink more complicated than the uplink directions, for in the uplink each user has its own amplifier to transmit the power. Thus, coverage becomes a function of the number of users. In DL the own cell interference is reduced by the factor $(1 - \alpha)$. This is due to the synchronised orthogonal channellisation codes, which are used in DL. The downlink load factor can be calculated as :

$$\eta_{DL} = \left[(1 - \alpha_j) + i \right] \sum_j^N load_j \quad (I.3)$$

$$load_j = \frac{1}{1 + (W / R_j) / (E_b / N_0)_j^{1/v_j}}$$

and the orthogonality factor α_j is between 0.4 and 0.9 (the ITU vehicular subscriber for the macro cell is 0.6 and the ITU pedestrian subscriber for the micro cell is 0.9).

In the WCDMA system, the traffic can be asymmetric in the uplink and downlink directions and thus the load can also be different in either direction. The DL load is, however, higher than the UL load. The link performance also differs in either direction (the noise figure is higher for the UE than the BS). Soft handover heads are only in the DL direction.

The load factor for different services has to be calculated separately. The total load is then the sum of different services in the cell area.

I.3.3.4 Capacity planning in LTE networks [27]

Capacity sizing allows us to find the maximum capacity Supported by a cell. Its purpose is to determine the number of sites needed User traffic for a given area. The capacity is limited by the number of eNodeBs installed in the network, it depends on several factors such as the type of zone, the service, the number of subscribers.

To calculate the capacity in dawnlink and uplink, the following parameters must be used:

LTE can provide very high speeds for uplink and downlink,

As with any broadband communication system, due to the increased spectral efficiency and available bandwidth. The spectral efficiency depends on the type of MIMO antenna, i.e. desired bit rate and bandwidth. It is represented by the following formula

$$\eta_{BW} = \frac{Debit_{Req}}{B_w} \quad (I.4)$$

Number of subscribers supported by a cell:

$$\begin{aligned} N_{subscriber/cell}^{U_p} &= C_{cell} / Throughput_{BH}^{U_p} \\ N_{subscriber/cell}^{D_l} &= C_{cell} / Throughput_{BH}^{D_l} \end{aligned} \quad (I.5)$$

Ccell : cell capacity

$N_{subscriber/Cell Up}$, and $N_{subscriber/Cell Dl}$: Number of subscribers per cell for uplink and downlink.

Throughput BH, Dl ThroughputBH: the flow at the peak time of the load in the upward and downward direction.

Number of eNodeBs required

In this part we will calculate the number of subscribers per site according to the number of subscribers per cell by taking three cells per site in both links (uplink and down).

$$\begin{aligned}
 N_{subscriber/Site}^{U_p} &= N_{subscriber/cell}^{U_p} * 3 \\
 N_{subscriber/Site}^{D_l} &= N_{subscriber/cell}^{D_l} * 3
 \end{aligned}
 \tag{I.6}$$

For the calculation of the total number of sites:

$$\begin{aligned}
 N_{subscriber/Site}^{U_p} &= \min < N_{subscriber/Site}^{U_p}, N_{subscriber/Site}^{D_l} > \\
 N_{Capacity}^{eNodeB} &= N_{Totalsubscriber} / N_{subscriber/site}
 \end{aligned}
 \tag{I.7}$$

Subscriber N_{Total} : is the total number of subscribers in the deployment area.

eNodeB $N_{Capacity}$: is the number of eNodeB required to satisfy the capacity constraint.

Final number of eNodeB required

We will determine the final number of eNodeBs, but for this we must consider

The minimum number of eNodeB required to establish the requested coverage is marked as $N_{couverture}$

The minimum number of eNodeB required to meet capacity requirements

$N_{Capacity}$ of eNodeB. In this case, ask for the number of sites that meet the coverage constraint

The capacity is given by the following expression:

$$N^{eNodeB} = \min < N_{Capacity}^{eNodeB}, N_{couverture} >
 \tag{I.8}$$

I.3.4 Frequency planning

Frequency planning is an implementation of capacity planning. frequency planning together with capacity planning tries to maximise the information flow (voice or data) over the radio interface and simultaneously to maximise the efficiency of the radio network infrastructure. In cellular radio system planning the same frequencies are reused as often as possible in order to maximise capacity and thus minimise the radio network investments. The target is to have the maximum number of transceivers (a transmitter and receiver pair) at each base station without reducing radio quality, it has already been explained that frequency planning (together with capacity

planning) begins with the specification of the required frequency channels (transceivers) at each base station. This work is related to the frequency reuse factor and was covered in detail in the capacity planning discussion. [22]

I.3.4.1 Frequency hopping

Frequency hopping is a feature of the GSM system used to decrease the simultaneous usage of the same frequencies and in this way averages the interference level. Compared to normal frequency re-use, which is static, frequency hopping provides a benefit by allowing the dynamic frequency to change. In practice, by using the frequency hopping algorithm the carrier frequency changes either cyclically or randomly. By frequency hopping the interference is averaged more effectively, which increases the overall perceived quality. Frequency diversity and interference averaging can be gained using frequency hopping.

Frequency hopping (FH) is a technique that basically improves the channel to interference (C/I) ratio by utilising many frequency channels. Employment of the FH technique also improves the link budget due to its effects: frequency diversity and interference diversity.[27]

I.4 Radio Planning Process

The network planning process illustrated in Figure I.12 is an endless cycle, is divided into five main phases, four of which are located before the network launch, and the last is located after the network launch [12]. Actually, the network planning process is a never ending cycle due to changes in the design parameters.

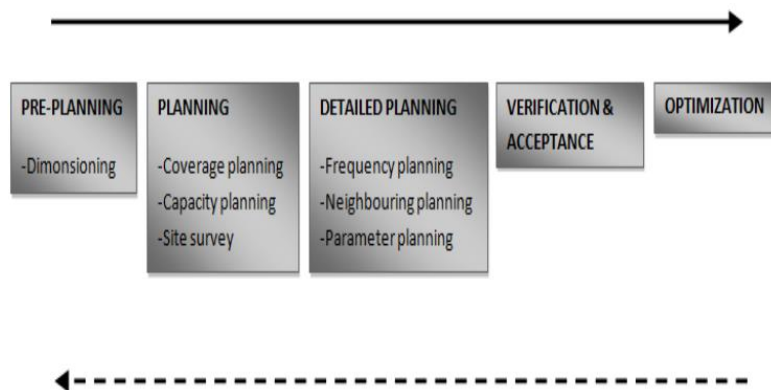


Figure I.12: Planning process steps

The network planning process starts with the pre-planning phase, which covers assignments and preparation before the actual network planning is started. The main activity in the pre-planning phase is dimensioning, it gives a preliminary output network plan, which is then completed in the coverage and parameter planning steps to create a detailed plan [12].

The process continues with the planning phase, taking input from the dimensioning. This is the basis for nominal planning, which means radio network coverage and capacity planning with a planning tool. The nominal plan is a starting point for the site survey in order to find a real site location. The result of this phase is the final, detailed coverage and capacity plan [13].

Once the planning phase has finished and the site location is known, detailed planning can be started, which gives the frequency, neighbour and parameter plan. Therefore, the network is ready for the verification and acceptance phase, which ensures the optimal operation of network and completes the pre-launch activities. After the launch of the network, activities continue with the optimization, for this phase the needed input is all available information about the network and its status [12].

After the network has been launched, the planning and optimization related activities do not end because network optimization is a continuous process

The primary goal of radio network planning is to create a cost-effective radio network solution in terms of coverage, capacity, and quality. Depending on the dominant aspect, such as capacity or coverage, the network planning process and design standards differ from region to region. The radio network design process is not the only process in the overall network design; it must work in tandem with the core and, in particular, transmission network planning procedures [2].

I. 5 Conclusion

In this chapter, I have described general radio network planning processes, the basic notions concerning radio network planning for different generations (GSM, UMTS, LTE). Network planning is one of the most important tasks of the network operator, which determines, significantly, the quality of service offered to the users. After planning, optimization must be taken into consideration. This task will be the subject of the next chapter.

Chapter II
Mobile Network Optimization

II.1 Introduction

Radio optimization begins after the planning phase, is one of the main steps in improving the performance of telecommunication networks. To enable the resolution of various problems received after a network is put into operation, radio optimization allows the management, verification, and improvement of the network's performance. It begins after the planning phase. A cellular network covers a wide area and provides the capacity to serve its subscribers with good communication quality. So to ensure the proper functioning of the network, several parameters are variable and must be permanently adapted to the radio link. In this chapter, we will discuss the goal of optimization, how this process is implemented, and its important components in the different generations of the mobile network.

II.2 Objective of Radio Optimization

The objective of optimization is to ensure that the network operates at optimal performance and within the defined constraints of QoS. This is achieved by implementing corrective measures and procedures to rectify identified network problems. Thus, the optimization of a cellular network is motivated by two main objectives: improving the QoS offered to users and the increase in the traffic volume carried by the network with existing equipment [14]

II.3 Basics of Radio Network Optimization

Radio Network Optimization is part of the network planning process. The main goal of this procedure is to monitor, verify, and improve the functioning of radio network. Because the cellular network serves such a big number of people, there are numerous variables that must be regularly checked and addressed in order to maintain network coverage, capacity, and quality. Beyond this, the network is always in a growth phase, i.e., subscriber numbers are continually expanding, traffic is increasing, the establishment of new retail centers means that capacity requirements at these “hotspots” are increasing, and so on. This means that the optimization process should be carried out in the network at regular intervals, resulting in increased network efficiency and income generation [2]

Coverage, capacity, and frequency planning are the three key aspects that radio network planners concentrate on. They proceed to the rest of the activities based on these three, such as

location selection, parameter planning, and so on. The same criteria are prioritized in the optimization process: coverage, capacity, and frequency planning. The only difference now is that sites have been chosen and antenna placements have been determined, but the subscriber remains as mobile as ever, with continued expansion.

With the lengthening interval between launch and radio network optimization, optimization duties become increasingly arduous. After a radio network has been designed, it is evaluated for performance. This is accomplished by monitoring the network and comparing it to the key performance metrics established. Figure II.1 shows how optimization can be thought of as a distinct process or as part of the network planning process. Power control, quality, handovers, subscriber traffic, and resource availability (and access) measures are all areas where radio network optimization is focused.

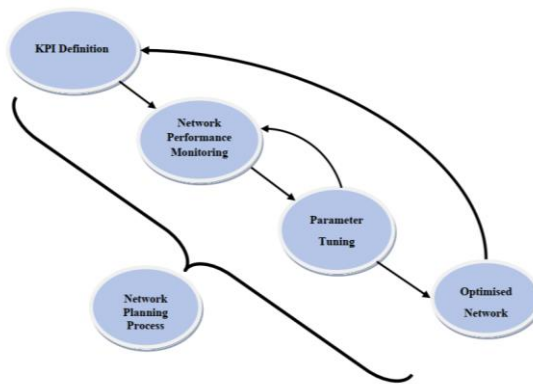


Figure II.1: Radio network optimization [2]

II.4 Optimization process

Radio network optimization can be considered as a part of the network planning process. The task of this process is to monitor, verify and improve the performance of the radio network. It simultaneously begins somewhere near the last phase of radio network planning, i.e., parameter planning. As the cellular network covers large areas, which can provide capacity to a large number of users, there are many parameters involved which are variable and must be continuously monitored and corrected in order to maintain network coverage, capacity and quality. Also, the network is still in the growth phase, i.e. by always increasing the number of subscribers, the increase in traffic, the creation of new shopping centers means that the capacity needs in these "hot spots"

increase, etc. This means that the optimization process should be conducted in the network at regular intervals, which increases the efficiency of the network and generates revenue from the network.

In the planification, engineer planners focus on three main points: coverage, capacity and frequency planning. However, in the optimization process the same points are addressed, with the difference that sites are already selected and antenna locations are fixed, but subscribers are as mobile as ever, with continuous growth taking place.

The main focus of radio network optimization is on areas such as power control, quality, handovers, subscriber traffic, and resource availability (and access) measurements.

The optimization process includes two kinds of measurements: at the network (statistics) and drive test measurements. At the light of these measurements, an engineer can locate and analyze potential problems. Also, customer complaints can be used to do parameter tuning which can optimize the network.

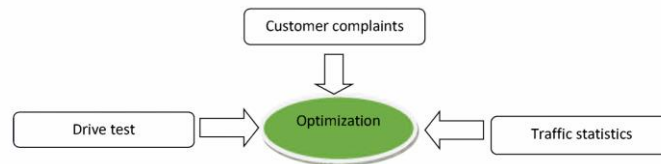


Figure II.2: Inputs for optimization process

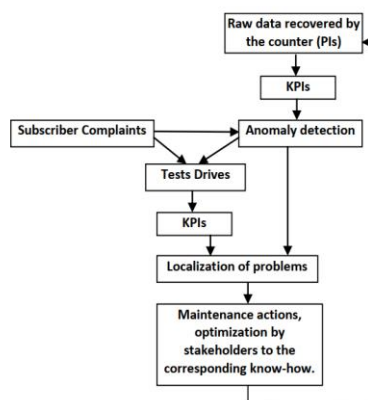


Figure II.3: General diagram of the optimization process

II.5 Basic methods used in radio optimization

II.5.1 The coverage

The problem of lack of coverage presents a low signal level and poor signal quality at the same time, which causes: [15]

- A high rate of communication cut-offs.
- A high rate of handover due to poor quality and low signal level in the downlink.
- A small percentage of handover type to a better cell.

To solve the problems associated with coverage, you must:

- Check the antenna system such as height, azimuth (the direction in which the antenna emits its most important power, The azimuth is an angle that is counted in degrees, positively clockwise, starting from the north (0°). In this way, the azimuth 90° corresponds to the east, the azimuth 180° to the south, etc.) and tilt (tilt is the angle of inclination (in degrees) of the main lobe of the antenna in the vertical plane).
- check the transmission power of the BTS in relation to the power budget. [15]

II.5.2 Interference

The interference is defined by the presence of a high signal level and poor signal quality at the same time, which causes:

- Congestion in the SDCCH and TCH channels.
- A small percentage of handover type to a better cell.
- A high rate of handover due to poor downlink/uplink quality and handover due to interference.

To solve interference problems, one must

- Change the interference frequency.
- Reduce the carrier transmit power (frequency), you can also change the tilt and orientation of the antenna.

If the interference is external (non-GSM), the interfered carrier is changed with the external frequency. [15]

II.5.3 The power budget

The problem of an unbalanced power budget presents a large difference in path losses between uplink and downlink. This problem appeared as:

- A high rate of handover due to poor quality of the uplink.
- A rarely successful incoming handover.
- A high rate of communication cuts.

Generally, the causes of the power budget problem are of the hardware type.

II.5.4 Handover performance:

The execution of a handover can fail because of different reasons. So to improve the performance of the handover, we must avoid: [16]

- severe interference,
 - An inappropriate relationship between the service cell and the neighbouring cell.
 - poor coverage.
 - False installation of the antenna.
 - bad plan by BSIC and BCCH. - a shortage of TCH resources.
 - Incorrect evaluation of cell parameters. [16]

I.6 Key Performance Indicators (KPI)

Key performance indicators (KPIs) can be defined as a set of results that measure performance in the busy hour or average period on the entire network.

For radio network optimization (or for that matter any other network optimization), it is necessary that the key performance indicators or KPIs be in place. These KPIs are parameters that are to be observed closely when the network monitoring process is going on. Network performance can be broadly characterized into coverage, capacity and quality criteria that cover the speech and data aspects also.

II.6.1 Categorization of Network Performance KPIs

In order to optimize a radio network, key performance indicators must be determined.

- Accessibility
- Retainability
- Mobility
- Service integrity
- Availability
- Utilization
- Traffic

II.6.1.1 KPI Accessibility

The accessibility performance indicator is defined as the ability of mobile stations to get access to the network (requested service) in a given operation conditions. For GSM, It can be found as a percentage of how a user can/cannot access to the network:

- SDCCH congestion/blocking
- SDCCH drop
- TCH blocking/congestion
- TCH assignment success rate (eTASR)

These KPIs are used to measure the probability whether services requested by a user can be accessed within specified tolerance in the given conditions.

➤ **RRC Setup Success Rate (service)**

This KPI is calculated based on the counters measured at eNodeB when the eNodeB receives an RRC connection Request from the UE, as shown in Figure II.4. To illustrate the KPI calculation procedures, we briefly discuss how the related counters (number of RRC Connection setup attempts (service) and number of successful RRC setup (service)) are collected. The number of RRC connection attempts is collected by the eNodeB at measurement point A and the number of successful RRC connection is counted at measurement point C.

The RRCSR evaluates service-related causes in an involved cell or cluster and is based on the meters measured at eNB upon receipt of the RRC connection EU request as indicated in the relationship below.

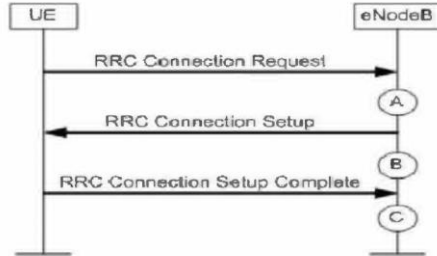


Figure II.4: Measurement point for RRC connection setup

The RRC setup success rate (service) KPI is defined as the number of RRC connection setup successful times over the number of RRC connection attempts, which can be calculated based on the following formula:

$$Service_CDR = \frac{ERABAbnormal\ Release}{ERAB\ Release} \cdot 100\% \quad (II.1)$$

➤ RRC Setup Success Rate (signaling)

This KPI evaluates the RRC setup success rate of the signaling-related cause (mo-signaling) in a given cell or cluster.

The present KPI is defined as the RRC connection setup attempts (signaling) and the RRC connection setup success rate (only when the "establishmentCause" is set to mo-signaling) in a cell or cluster. Its formula is given by

$$RRCS_SR_{other} = \frac{RRCConnectionSuccess_{other}}{RRCConnectionAttempt_{other}} \cdot 100\% \quad (II.2)$$

➤ ERAB Setup Success Rate (VoIP)

The counters related to this KPI are measured when the eNodeB receives an ERAB setup Request message or an initial Context setup request from the MME, as shown in Figure II.5

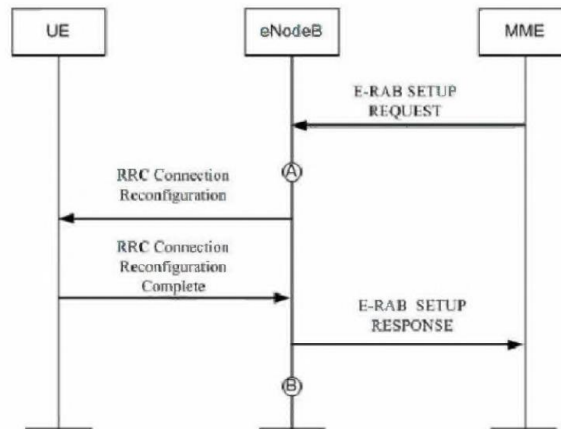


Figure II.5: Measurement point for MME-initiated ERAB setup

The ERAB is part of the evolved Packet Service (EPS) bearer. An ERAB is one or more Service Data Flows between UE and EPC. The ERAB identity remains unique for the UE even if the UE -associated logical S1-connection (S1 Bearer) is released during periods of user inactivity. The ERAB consists of both ERAB radio bearer (between eNodeB and UE, same as the radio bearer defined in the EPS bearer) and corresponding S1 bearer (between eNodeB and MME).

There are two scenarios can be shown in Figure II.5 and 6. MME-initiated ERAB setup (scenario A) and UE-triggered ERAB setup (scenario B). Scenario B is triggered by the radio bearer setup. Initial context setup request messages are exchanged between eNodeB and MME. If the ERAB setup Request message or initial Context Setup request message requires multiple ERAB setups at the same time, specific counters are incremented for each ERAB.

The ERAB setup success rate (VoIP) KPI can be calculated as follow

$$VoIPERABS_SR = \frac{VoIPERABSetupSuccess}{VoIPERABSetupAttempt} \cdot 100\% \quad (II.3)$$

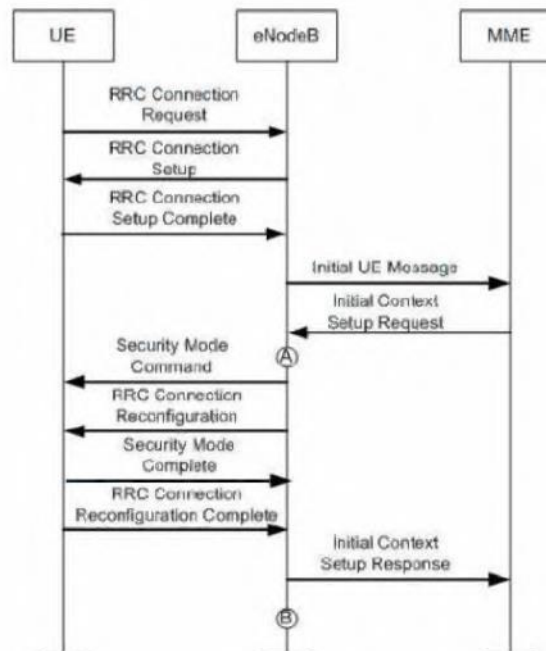


Figure II.6: Measurement point for UE-triggered ERAB setup

➤ ERAB Setup Success Rate (All)

This KPI can be used to evaluate the ERAB setup success rate of all services including the VoIP service in a cell or a cluster.

The ERAB setup success rate (All) KPI can be calculated as follow:

$$ERAB_SR = \frac{ERABSetupSuccess}{ERABSetupAttempt} \cdot 100\% \quad (II.4)$$

➤ Call Setup Success Rate

This KPI can be used to evaluate the call setup success rate of all services including the VoIP service in a cell or cluster. This KPI is calculated based on the KPI of RRC setup success rate (service) and the KPI of ERAB setup success rate (All).

The Call setup success rate is calculated based on multiplying the KPI of RRC Setup success rate (service) and the KPI of ERAB setup success rate (All).

The Call Setup Success Rate can be defined as:

$$CSSR = \frac{RRCConnectionSuccess_{service}}{RRCConnectionAttempt_{service}} \cdot \frac{ERABSetuoSuccess}{ERABSetupAttempt} \cdot 100\% \quad (II.5)$$

II.6.1.2 Retainability KPI

Retainability KPIs are used to evaluate the network capability to retain services requested by a user for a desired duration once the user is connected to the services. These counters can be calculated per cell or per cluster. The KPI at the cluster level can be calculated by aggregating all the cell counters. Retainability KPIs are important in evaluating whether the system can maintain the service quality at a certain level.

➤ Call Drop Rate (VoIP)

This KPI can be used to evaluate the call drop rate of the VoIP services in a cell or cluster. The call drop rate is calculated by monitoring the VoIP ERAB abnormal release rate. Each ERAB is associated with the QoS information. The voice service can be distinguished by the specific QCI=1. ERAB includes both ERAB radio bearer and the corresponding S1 Bearer. Any abnormal release on either bearer causes call drop and therefore is counted in call drop rate. The abnormal release is identified by the CauseIE. The call drop rate (CDR) is defined as Abnormal ERAB release/AII released ERAB.

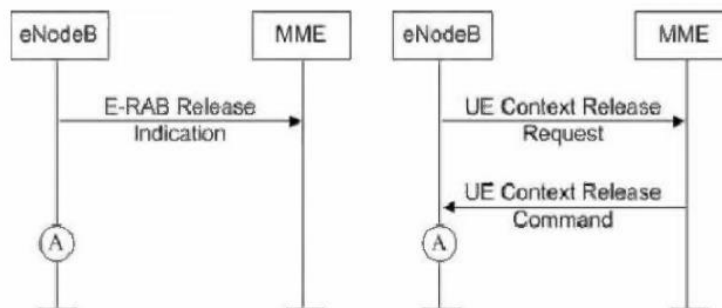


Figure II.7: Abnormal ERAB release

As shown in Figure II.7, the abnormal ERAB release counter is incremented when the eNodeB sends an ERAB release Indication to the MME or receives an UE Context Release Command message from the MME and the release causes are not Normal Release, User Inactivity,

Partial Handover, or Handover triggered. If the message contains several ERAB ID IEs (in the ERAB to be release List IE), the counter will be incremented for each individual ERAB. For the eNodeB initiated abnormal ERAB release, the eNodeB knows whether it is a normal or abnormal ERAB release. The call Drop Rate (VoIP) is defined as

$$VoIP_CDR = \frac{VoIPERABAbnormal\ Release}{VoIPERAB\ Release} \cdot 100\% \quad (II.6)$$

➤ **Service Drop Rate (All)**

This KPI can be used to evaluate the call drop rate of all services in a cell or cluster, including VoIP service. The service Drop Rate (All) is defined as:

$$Service_CDR = \frac{ERABAbnormal\ Release}{ERAB\ Release} \cdot 100\% \quad (II.7)$$

II.6.1.3 Mobility KPI

Mobility KPIs are used to evaluate the performance of E-UTRAN mobility, which is critical to the customer experience. Many categories of Mobility KPIs are defined based on the following handover types: intra-frequency, inter-frequency, and inter-Radio Access Technology (RAT).

➤ **Intra-frequency transfer success rate**

KPI is used to evaluate the success rate of HO outputs at the cell or cluster level

$$IntraHOOutSR = \frac{IntraFHOOOutSuccess}{IntraHOOutAttempt} \cdot 100\% \quad (II.8)$$

➤ **Inter-frequency transfer success rate**

This KPI is used to evaluate the transfer success rate at the cell or cluster level

$$IntrrHOOutSR = \frac{IntrrFHOOOutSuccess}{IntrrHOOutAttempt} \cdot 100\% \quad (II.9)$$

➤ **Inter-RAT Transfer Success Rate (LTE to WCDMA)**

The KPI is used to evaluate the success of the HO rate of LTE to WCDMA in a cluster

$$IRATHO_L2W_SR_{out} = \frac{IRATHO_L2W_SuccessOut}{IRTHO_L2W_Attempt} \cdot 100\% \quad (II.10)$$

➤ **Inter-RAT transfer success rate (LTE to GERAN)**

The KPI is used to evaluate HO success rate from LTE to GERAN

$$IRATHO_L2G_SR_{out} = \frac{IRATHO_L2G_Success}{IRTHO_L2G_Attempt} \cdot 100\% \quad (II.11)$$

II.6.1.4 Service integrity KPI

The service integrity KPIs indicate the E-UTRAN impacts on the service quality provided to the end-user. The service integrity KPIs can be calculated per cell or per cluster. The KPIs at the cluster level can be calculated by aggregating all the cell counters.

➤ **Service Downlink Average Throughput**

This KPI consists of nine sub-KPIs that are mapped to nine QCI. These sub-KPIs can be used to evaluate the busy-hour downlink (DL) throughput of a service with a specific QCI per user in each cell. It reflects the end-user experience.

The service downlink average throughput is defined in the following formulas. There are nine different sub-KPIs for each QCI. The formulas for each KPI are mapped to corresponding counters.

DLAverage Throughput_QCI_1
 DLAverage Throughput_QCI_2
 DLAverage Throughput_QCI_3
 DLAverage Throughput_QCI_4
 DLAverage Throughput_QCI_5
 DLAverage Throughput_QCI_6
 DLAverage Throughput_QCI_7
 DLAverage Throughput_QCI_8
 DLAverage Throughput_QCI_9

➤ **Service Uplink Average Throughput**

This KPI consists of nine sub-KPIs that are mapped to nine QCI. These sub-KPIs can be used to evaluate the busy hour uplink (UL) throughput of a service (with a specific QCI) per user in each cell. It reflects the end-user experience.

The service uplink average throughput is defined in the following formulas. There are nine sub-KPIs for each QCI. The formula for each KPI is mapped to its corresponding counter.

ULAverage Throughput_QCI_1
 ULAverage Throughput_QCI_2
 ULAverage Throughput_QCI_3
 ULAverage Throughput_QCI_4
 ULAverage Throughput_QCI_5
 ULAverage Throughput_QCI_6
 ULAverage Throughput_QCI_7
 ULAverage Throughput_QCI_8
 ULAverage Throughput_QCI_9

➤ **Cell Downlink Average Throughput**

This KPI evaluates the cell downlink average throughput when there are data transferring at downlink.

$$CellDLAveThp = \frac{CellDLRrafficVolume}{CellDLTransferTime} \text{ in Kbit /s} \quad (II.12)$$

➤ **Cell Uplink Average Throughput**

This KPI evaluates the cell uplink average throughput when there are data transferring at uplink.

$$CellULAveThp = \frac{CellULRrafficVolume}{CellULTransferTime} \text{ in Kbit /s} \quad (II.13)$$

➤ **Cell Downlink Maximum Throughput**

This KPI evaluates the cell downlink maximum throughput when there are data transferring at downlink.

$$CellDLMaxThp = \frac{CellDLTrafficVolumforEachls(bit)}{1000(ms)} \text{ in Kbit /s} \quad (II.14)$$

➤ **Cell Uplink Maximum Throughput**

This KPI evaluates the cell uplink maximum throughput when there are data transferring at uplink.

$$CellULMaxThp = \frac{CellULTrafficVolumforEachls(bit)}{1000(ms)} \quad (II.15)$$

II.6.1.5 Availability KPI

Availability is the percentage of time that a cell is available. A cell is available when the eNodeB can provide EPS bearer services. Availability can be measured at the cell level for a variety of hardware/software faults.

➤ Radio Network Unavailability Rate

This KPI is calculated based on the time of all cell service unavailability on the radio network (cluster)

$$RAN_Unavail_Rate = \frac{\sum_{cluster} CellUnavailTime}{TheTotalNumberOfCellsInCluster * \{SP\} * 60} \cdot 100\% \quad (II.17)$$

II.6.1.6 Utilization KPI

Utilization KPIs are used to evaluate the capability to meet the traffic demand and other characteristics in specific internal conditions.

➤ Resource Block Utilizing Rate

This KPI consists of two sub-KPIs. These two sub-KPIs can be used to evaluate the busy-hour DL and UL RB utilizing rate in each cell or cluster.

The UL and DL RB utilizing rate KPIs are defined by the following formulas. These two KPIs are calculated by dividing the total number of used RBs by the number of available RBs.

$$RB_UR_{DL} = \frac{RB_Used_{DL}}{RB_Available_{DL}} \cdot 100\% \quad (II.16)$$

$$RB_UR_{UL} = \frac{RB_Used_{UL}}{RB_Available_{UL}} \cdot 100\%$$

II.6.1.7 Traffic KPI

KPIs based on several types of traffic: radio bearer, downstream and upstream. They are primarily used to measure traffic at the LTE Access Network (RAN) level.

The fundamental KPIs used for traffic:

- Radio Bearers
- Average of Traffic User
- Average of Downlink /Uplink traffic volume
- Maximum User Number [26]

II.6.2 Drive test

Drive test is a step as important as the study of traffic is the drive test, it is an operation that aims to measure the level and quality of the signals broadcast by the BTS. The drive test is done by a car using three specific mobiles in different modes, three external antennas placed on the roof of the car, a Global Positioning System (GPS) to localize the position of quality degradation precisely, and also a special software TEMS Investigation installed on a laptop computer for the acquisition, recording and processing of recovered measurements [17].

In the drive test operation, each mobile can be in one of three modes:

- **Idle mode:** established during the drive test process, the Mobile Station (MS) is on, but no calls were made during this period.
- **Dedicated mode / long call:** make continuous calls during the drive test process, and the call will not end until the end of the route.
- **Dedicated mode / short call:** make short calls during the drive test process.

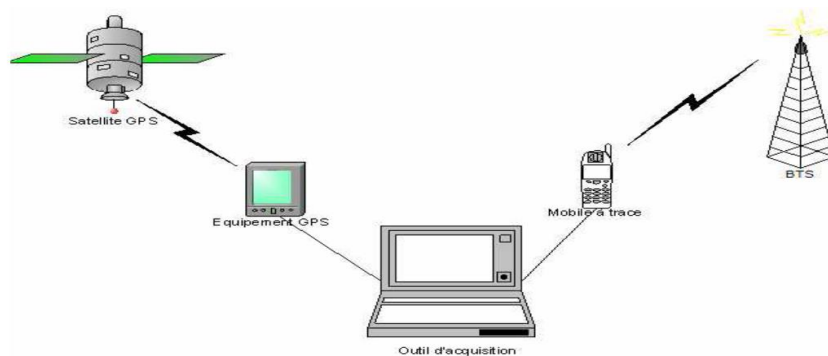


Figure II.8: Drive-Test measurement chain

II.6.2.1 Types of Drive Test

There are two main types of drive test:

➤ *Single Site Vérification*

The purpose of the SSV is to verify that the base station is functional from an RF point of view during the commissioning stage. It is, in fact, to test and evaluate the following elements, such as the establishment and quality of calls, handover... etc.

➤ *Cluster drive test*

Unlike the SSV test, which aims to evaluate the performance of each site independently of the others, the cluster drive test is used to optimize the performance of a given cluster in order to reach the acceptance thresholds already set. The area concerned by optimization is subdivided into separate domains called clusters. The drive test consists of walking through the streets of each of its clusters by recording the required information. This includes: coverage and capacity optimization, interference and pilot-pollution between cells as well as mobility problems.

To reach the accept threshold that has been set. Areas involved in optimization are subdivided into separate domains called clusters. These clusters must be classified by recording the required information of each one. This includes:

- Optimization of coverage and capacity.
- Interference and Pilot-Pollution between cells.
- Mobility problems.

Note that the tools used during these road tests are the same as those used during SSV tests.

However, the cluster drive test involves the following tests: LC, SC, DL, UL, and MOS (mirroring voice quality)

The following should be taken into account when driving the driving test:

- Test paths must be covered.
- Avoid repeating the same trip.
- Overcome as many obstacles as possible.
- Browse the entire specified area.
- Explore the area in the same day.

- Try to test at the same speed (30 to 50 km/h).

II.6.3 Network Management System Statistics [11].

After the launch of the network, drive tests are performed periodically. In contrast, the statistics are monitored on the NMS daily with the help of counters. The NMS usually measures the functionalities such as call setup failures, dropped calls, and handovers (successes and failures). It also gives data related to traffic and blocking in the radio network .

II.6.3.1 Coverage

Drive test results will give the penetration level of signals in different regions of the network. These results can then be compared with the plans made before the network launch. In urban areas, coverage is generally found to be less at the farthest parts of the network, in the areas behind high buildings and inside buildings. These issues become serious when important areas and buildings are not having the desired level of signal even when care has been taken during the network planning phase. This leads to an immediate scrutiny of the antenna locations, heights and tilt. The problems are usually sorted out by moving the antenna locations and altering the tilting of the antennas. If optimization is being done after a long time, new sites can also be added .

Coverage also becomes critical in rural areas, where the capacity of the cell sites is already low. Populated areas and highways usually constitute the regions that should have the desired level of coverage. A factor that may lower the signal level could be propagation conditions, so study of link budget calculations along with the terrain profile becomes a critical part of the rural optimization. For highway coverage, additions of new sites may be one of the solutions .

II.6.3.2 Capacity

Data collected from the network management system is usually used to assess the capacity of the network. As coverage and capacity are interrelated, data collected from drive tests is also used for capacity assessment. The two aspects of this assessment are dropped calls and congestion. Generally, capacity-related problems arise when the network optimization is taking place after a long period of time. Radio network optimization also includes providing new capacity to new hot-spots, or enhancing indoor coverage. Once the regional/area coverage is planned and executed in the normal planning phase, optimization should take into consideration the provision of as much

coverage as possible to the places that would expect high traffic, such as inside office buildings, inside shopping malls, tunnels, etc

II.6.3.3 Quality

The quality of the radio network is dependent on its coverage, capacity and frequency allocation. Most of the severe problems in a radio network can be attributed to signal interference. When interference exists in the network; the source needs to be found. The entire frequency plan is checked again to determine whether the source is internal or external. The problems may be caused by flaws in the frequency plan, in the configuration plans (e.g. antenna tilts), inaccurate correction factors used in propagation models, etc

II.6.3.4 Parameter Tuning

The ending of the assessment process sees the beginning of the complex process of fine-tuning of parameters. The main parameters that are fine-tuned are signaling parameters, radio resource parameters, handover parameters and power control parameters. Expected KPI values should be achieved after the process is complete.

The major complexity of this process is the inhomogeneity of the radio network. During network deployment, some more measurements are made and the parameters are fine-tuned again. Once the network goes ‘live’, the drive test and NMS statistics help in further fine-tuning of the parameters, and it is at this point that a set of default parameters is created for the whole network.

Radio network optimization must be a continuous process that begins during the prelaunch phase and continues throughout the existence of the network.

II.7 Conclusion

In this chapter, we have discussed the optimization process, its methods, and the most important criteria on which it is based. We conclude that Radio optimization begins after the planning phase, is one of the main steps in improving the performance of telecommunication networks, Which is the most important and especially the most difficult part, it is to monitor, verify and improve the performance of the radio network. In this chapter, we will discuss the goal of optimization, how this process is implemented, and its most important components in the different generations of the mobile network.

Chapter III

Drive test Analysis of mobile network; Wilaya of Msila

III.1 Introduction

In the previous chapters, we have seen planning and optimization processes and their steps to enhance the quality of service for a given mobile network. In this chapter, a drive test will be shown. To familiarize with this radio task, some examples concerning some logfiles of drive test in the wilaya of Msila. These collected logfiles will be analyzed using Tems investigation.

III.2 Tasks of a drive test engineer

- Data acquisition (collecting and analyzing network data)
- Initial tuning
- Development of new evaluation protocols and methods
- Planning of new sites

III.3 Geographical area to be studied.

The following figure shows an overview of the area studied during our drive test project.



Figure III.1: View of M'sila according to Google Earth (on red)

This area is the area of M'sila is characterized by a high population density and a diversity of morphological class

III.4 Drive test

The purpose of this drive test was to get an idea of the quality perceived by the subscriber for the MOBILIS network in the wilaya M'SILA during normal working hours of the day when the network should be quite busy. Another objective was to recommend changes to the radio network in order to improve the quality of service of the MOBILIS network.

During the measurement campaigns, the technician tests:

- The establishment of the call (absence of failure).
- Maintaining communication for a certain period of time (absence of cut).
- The quality of communication. [28]



Figure III.2: Drive Test Measurement Chain

III.4.1 TEMS investigation

TEMS Investigation is an excellent tool for verification, optimization and maintenance of wireless networks. Offering all-in-one data collection, real-time analysis, and post-processing, TEMS Investigation is a complete solution for all of a wireless network operator's daily network optimization tasks.

III.4.1.1 TEMS Software Overview

a) The Workspace

The TEMS software is equipped with different windows and task bars like any other software. We find the **workspace** (work area), **worksheets** (worksheets) and **toolbars** (task bars).

The workspace is the environment that stores all windows and arrangements necessary for a function. The arrangements include information related to external devices. This area is configured where we find all the sectors and reliefs of a territory .An update of this map is established each time a new site is deployed. By default a work area is opened for each data collection by the TEMS. The Figure III.4 following represents a Workspace. [23]

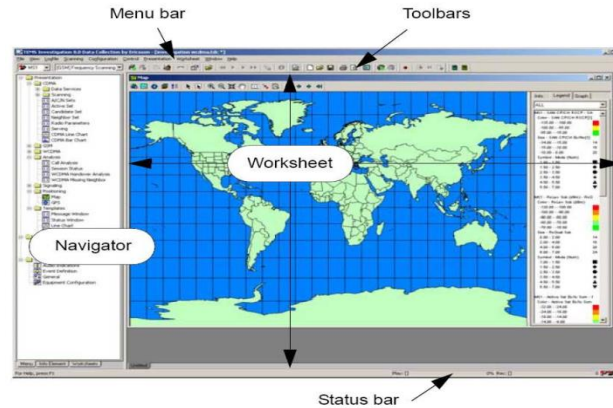


Figure III.3: Workspace of TEMS investigation

b) Worksheets

The work area is divided into several parts called worksheets. They are used for different functions. They are manipulated by the menu of worksheets, an example of worksheets is given in Figure III.4

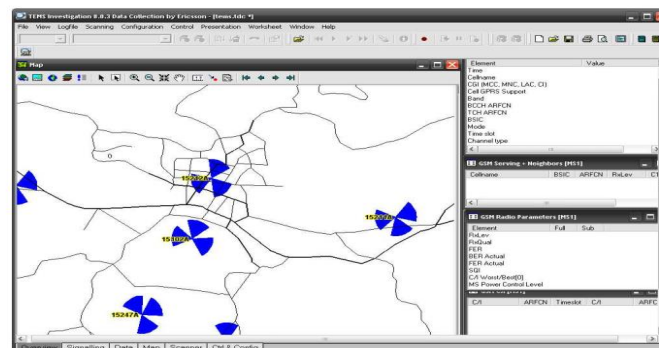


Figure III.4: Worksheet of TEMS[23]

c) The Toolbar

The task bar of the main window leads to quick access to the main functions of the TEMS data collection. This bar has different icons necessary for the drive test.





III.4.1.2 TEMS-controlled parameters

The mobile transmits a number of parameters to the base station to control the quality of the link. We introduce now five parameters which are: The level of the received signal (RxLevel), the quality of the signal (RxQual), speech quality (SQI), interference (C/I), Time advance (TA).

a) RxLev

RxLev is the reception signal strength which states the magnitude of the signal received at the receiving side (Mobile Station). The RxLev value is a value indicating the signal strength level, which is expressed in the minus dBm range. The smaller the RxLev value (the greater the minus dBm at RxLev), the weaker the received signal strength at MS. The TEMS classifies the received signal level according to the following color code:

Table III.1: Color code for RxLevel.

	Color	Value ranges	Signal level
	Green	-75 down to 0dBm	Good
	Yellow	-90 Up to -75dBm	Average
	Orange	-96 Up to -90dBm	Acceptable
	Red	-110 Up to -96dBm	Bad




b) RxQual

RxQual is the quality of the voice signal (voice) measured in BER. This RxQual value serves as a marker of signal quality, whether it is good or not. The range of RxQual values is between 0 to 7, where the value is affected by the number of BERs that occur. The greater the RxQual value, the worse the signal quality [24]

RxQual measurement can be used for the illustration of how good coverage is provided from BS sites and how much interference is generated. There is no set standard for the RxQual value, and each operator has a different threshold. However, because RxQual is used as a measure of the performance between MS and BS, it is necessary to determine the minimum RxQual to obtain adequate system performance. [24]

RxQual values are color-coded as shown in the table below: [28]

Table III.2: Color code for RxQual.




	Color	Value ranges	Signal quality
	Green	0 up to 4	Good
	Yellow	4 up to 6	Mean
	Red	6 up to 8	bad

c) Interference (C/I)

TEMS monitors interference between TCH traffic channels and BCCH broadcast. Note that the higher the level of interference, the better the call quality decreases until cut. [19]




For TCH channels, the color code is given in the following table:

Table III.3: Color coding for C/I (TCH)

Color	Value ranges	Interpretation
 Red	0 up to 9	Strong interference
 Yellow	9 up to 12	Average interference
 Green	12 up to 100	Low interference

• For BCCH, the color code is given in the following table:

Table III.4: Color coding for C/I (BCCH)




Color	Value ranges	Interpretation
 Red	0 up to 9	Strong interference
 Yellow	9 up to 12	Average interference
 Green	12 up to 30	Low interference

d) speech quality (SQI)

SQI can be interpreted as an indicator of voice quality in a calling state (dedicated mode). This SQI value ranges from -20 to 30. The higher the SQI value, the better the sound quality. The SQI value is calculated by TEMS automatically which is updated every 0.5 seconds. SQI is calculated based on FER and BER. The SQI score standard for each provider is different. [24]

The TEMS also controls the quality of speech during a call, the software classifies the Speech quality according to the color code given by the table [28]

Table III.5: Color Code for speech

Color	Value ranges	Speech quaity
 Red	0 up to 16	Bad
 Yellow	16 up to 22	Mean
 Green	22 up to 31	Good




e) Time advance (TA) [28]

This parameter is used to calculate the distance between the mobile terminal and the BTS, this distance is between: $TA * 554m$ and $(TA + 1) * 554$. The TA parameter takes values in a scale from 0 to 62 (62 is the maximum value, it corresponds to 35 Km).

Example: for $TA = 4$, the distance between the MS and the BTS is between 2.2Km and 2.8Km. We notice that the TA parameter increases as the mobile moves away from the BTS.

The distance between the BTS and the mobile is given by a color code as shown in the following table:

Table III.6: Color coding for TA

Color	Value ranges	Distance MS-BTS
 Green	0 up to 4	Between 0 and =3 km
 Yellow	4 up to 6	Between 3 km and 5 km
 Red	6 up to 62	Between 5 km and 35 km

III.4.2 Used Equipment [30]

To be able to perform the drive test, the operator must have the following Hardware and software tools:

- **A vehicle:** is used to move by making measurements. To make the measurement, we must follow the road tracks traced before the DT.

- **Converter:** it allows to supply the equipment used for the DT and whose purpose is to transform the 12V DC voltage of the battery into an alternating voltage of 220V-50Hz.
- **A trace mobile or modem:** a trace mobile also called test mobile is equipped with special software and is used for radio measurements (digital measurements). Using the Hyper Terminal and a serial cable, it is possible to type commands that turn off the mobile or call someone, but its real usefulness lies in the fact that it can calculate all the radio parameters (signal level, quality of the signal... etc.) and communicate them to the PC following receipt of commands on its modem. In general, a trace mobile makes it possible to make all possible scenarios for each canton measured.
- **GPS (Geographic Positioning System) equipment:** for the exact location of the geographical position of each measurement point. It is essential to identify points in the environment where there are radio problems.



Figure III.6: GPSMAP 60 of the brand GARMIN

- **A dongle:** Without this hardware, you cannot perform a measurement because it contains the "license" of the software to be used and must always be connected to the computer to be able to launch the software.



Figure III.7: Dongle TEMS investigation [25]

- **A computer or mobile phone with a special tool:** Allowing the acquisition, processing, and recording of measurements retrieved from the trace mobile (radio parameters) and GPS receiver (geographical coordinates) in special files. By viewing on the computer screen the various measurements made, it allows the engineer to see the state of the network on site.

The following figures show the equipment and the connections between them during the drive test:



Figure III.8: Drive Test materials [30]



Figure III.9: Connecting equipment[30]

IV.5 Drive test analysis and optimization.

During these test drives, the engineers went through all the regions concerned, equipped with the hardware mentioned above and with the investigation software. The route traveled was indicated as and when on the radio geographical map.

They scanned all frequencies in these regions and took all measurements related to the radio signal. These measurements were saved in so-called Log files .

The first phase of the experiment in this study is the data collection phase which requires the use of drive testing tools. These tools are connected to store, as log files, network data in real-time for post-processing and analysis. The tools used in this study include TEMS Investigation, used to capture real-time drive test data, and Test Mobile System (TEMS) used to monitor and analyze mobile networks' performance.

Upon returning to Mobilis headquarters, the engineers used the measurements taken to understand their meanings, the problems encountered on the radio interface and their possible solutions.

III.5.1 The steps to get the log file distribution graphs.

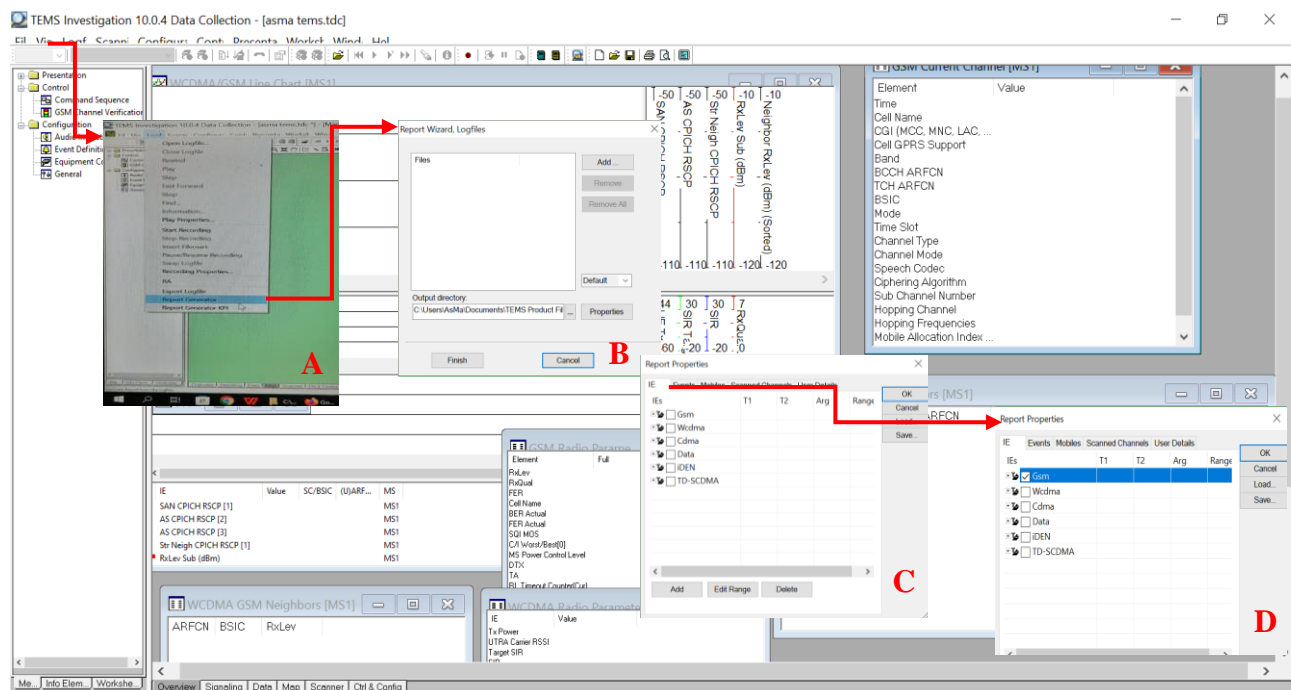


Figure III.10: The steps to get the log file distribution graphs

A- Open the TEMS Investigation 10.0.4 software on the PC → then we click on Generate report.

B- We click Add (we add the log file) → properties

C- Choose IE

D- Choose GSM

III.5.2 Application: The Drive Test carried out in M'sila

The purpose of this drive test was to get an idea of the quality perceived by the subscriber for the MOBILIS network in the wilaya M'SILA during normal working hours of the day when the network should be quite busy. Another objective was to recommend changes to the radio network in order to improve the quality of service of the MOBILIS network.

III.5.2.1 Drive test road

Choose MAP from worksheet

*The route travelled during this drive test (MAP) is shown in the figure below:

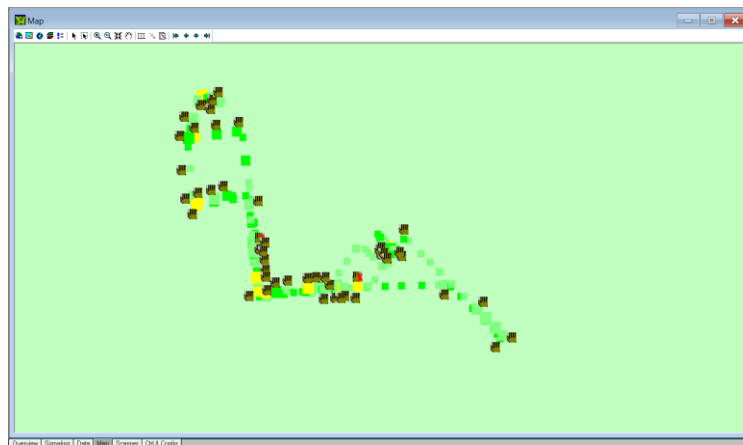


Figure III.11: Drive Test route

* It's all the events in our driving test

MS1		Handover	Source cell.	BCCH ARFCN: ...
MS1		Handover	Source cell.	BCCH ARFCN: ...
MS1		Handover Failure		
MS1		Handover	Source cell.	BCCH ARFCN: ...

Figure III.12: Explanation of events

III.5.2.2 The measurements taken during the drive test

-The level of the received signal (RxLevel)

The mobile continuously performs measurements of the level of the received signal, in standby mode and in dedicated mode, with the waitress cell and with neighboring cells. This allows him to periodically evaluate the radio link. This is why the level of the received signal "RxLevel" is the first measurement made during the drive test.

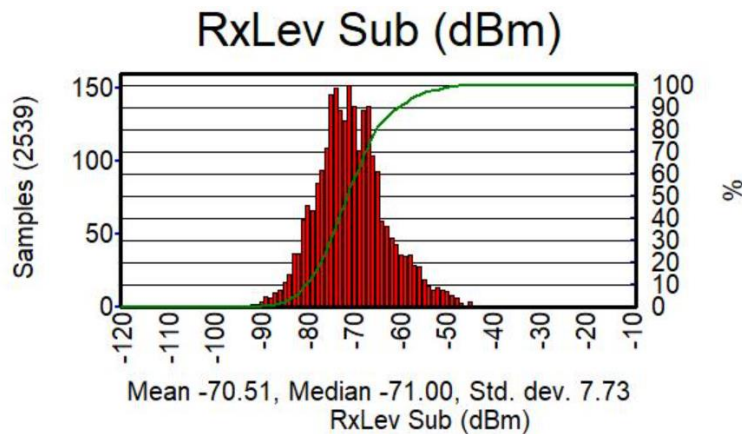


Figure III.13: Percentage of samples collected for RxLevel.

Interpretation of the diagram

- 02% of samples greater than -45 which gives a very good level of signaling
- 80% of the samples have values between [-85; -45] dBm. This corresponds to a good signal level.
- 16% of samples belong to the range]-95,-83[dBm .the signal level is considered acceptable.
- 02% of samples have values below -95dBm which gives a bad signal.

- The quality of the received signal:

The quality of the received signal (RxQual) is the second measure that is examined during the investigation of the radio link.

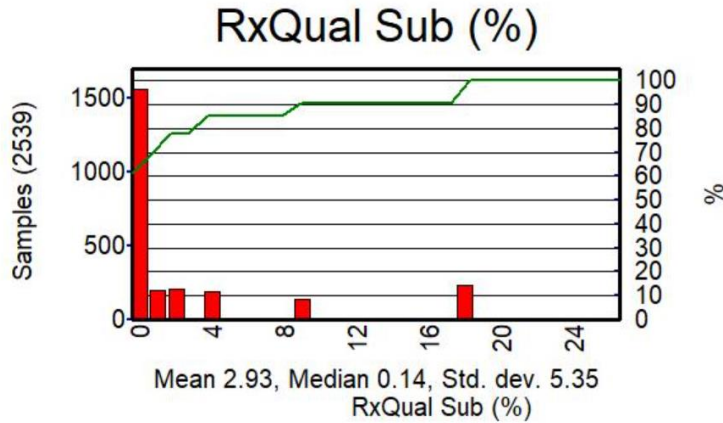


Figure III.14: Percentage of samples taken from RxQual

Interpretation of the diagram

- 94% of the recorded samples represent a signal quality less than or equal to 4 the received signal is of good quality.
- 11% of the samples belong to the interval [9;18], the signal quality is acceptable.
- The remaining 4% have RxQual values within the range [18; 26]; These samples have poor signal quality.

- Timing advance

The Advance Time represents the round trip time between MS-BTS and is one of the parameters estimated by the network during a communication. It makes it possible to compensate for the delay of the signals emitted during the journey between the mobile and the BTS.

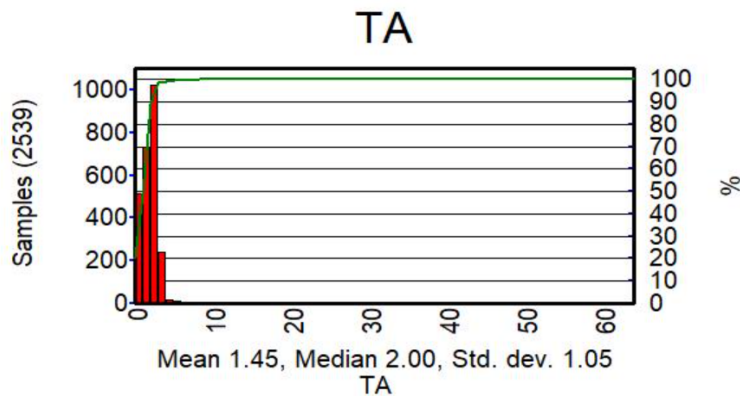


Figure III.15: Percentage of samples taken TA

Interpretation of the diagram

- 96% of the registered samples are in the interval [0; 4]; which is a good step ahead.
- 9% of samples have their values between [4;6]; which presents an acceptable head start.

- C/I interference:

Interference is one of the most important parameters measured during the drive test, it must always remain optimal since interference has a very negative impact on the quality of service offered to subscribers.

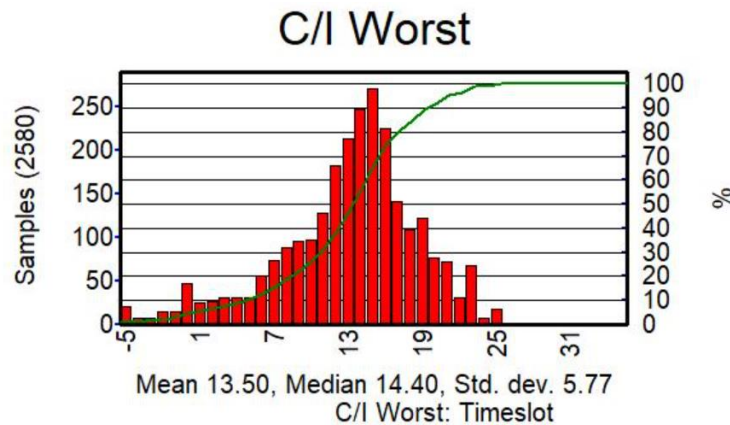


Figure III.16: Percentage of samples collected for interference

Interpretation of the diagram

- 10% of registered samples have values less than or equal to 6; which has a poor signal-to-noise ratio.
- 90% of the samples recorded have values within the range [6; 16]; The quality of speech is poor.
- 10% of the registered samples have values greater than or equal to 6; which has a poor signal-to-noise ratio.

-The quality of SQI speech

The measurement of speech quality (SQI) is combined with the two previous measures, RxLevel and RxQual in order to deepen the investigation of the quality of service offered to subscribers.

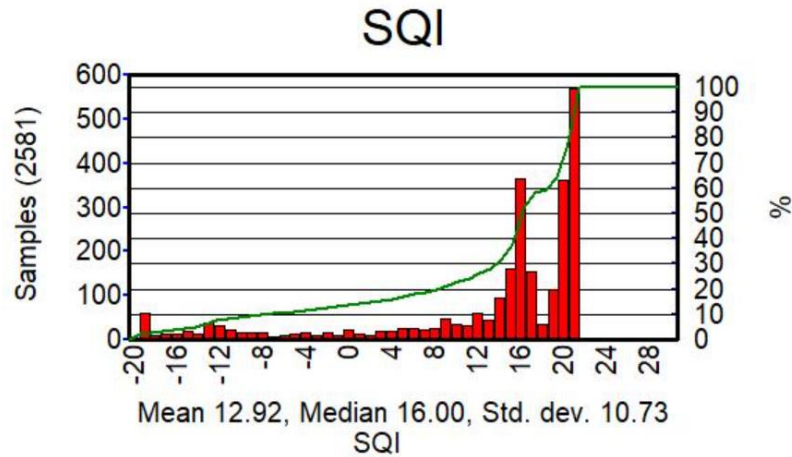


Figure III.17: Percentage of collected SQI samples.

Interpretation of the diagram

- 5% of recorded samples have values in the range [-20; -8]; The quality of speech is poor.
- 100% of the samples taken have values between [-8; 22]; speech quality is average.

III.5.2.3 Problems and solutions

1. The problems of co channel interference

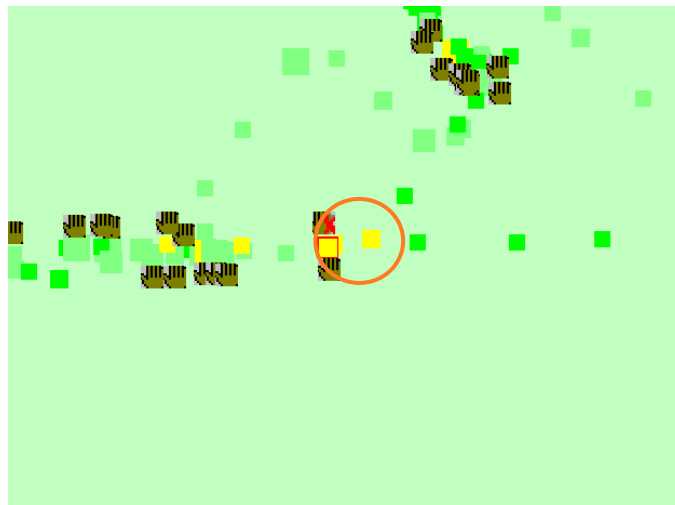


Figure III.18: Log File which present problem in area

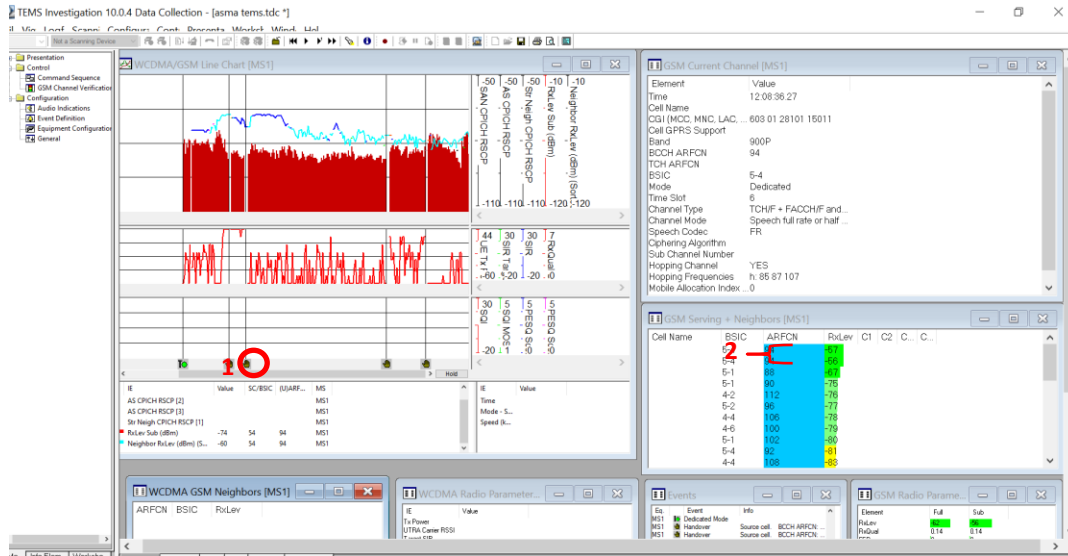


Figure III.19: Example of co-channel interference

This problem causes

- Cell reselection
- Call attempt

Identification of the problem :

Using the same frequency: ARFCN 94-94

Co-channel interference : Due to emissions from other equipment on the same frequency band.

When signals transmitted on one frequency are interfered with by other signals transmitted on the same frequency, there is co-channel interference. [27]

Proposition of solution: We must change the second frequency from 88 to 112

2. The problems of adjacent channel interference

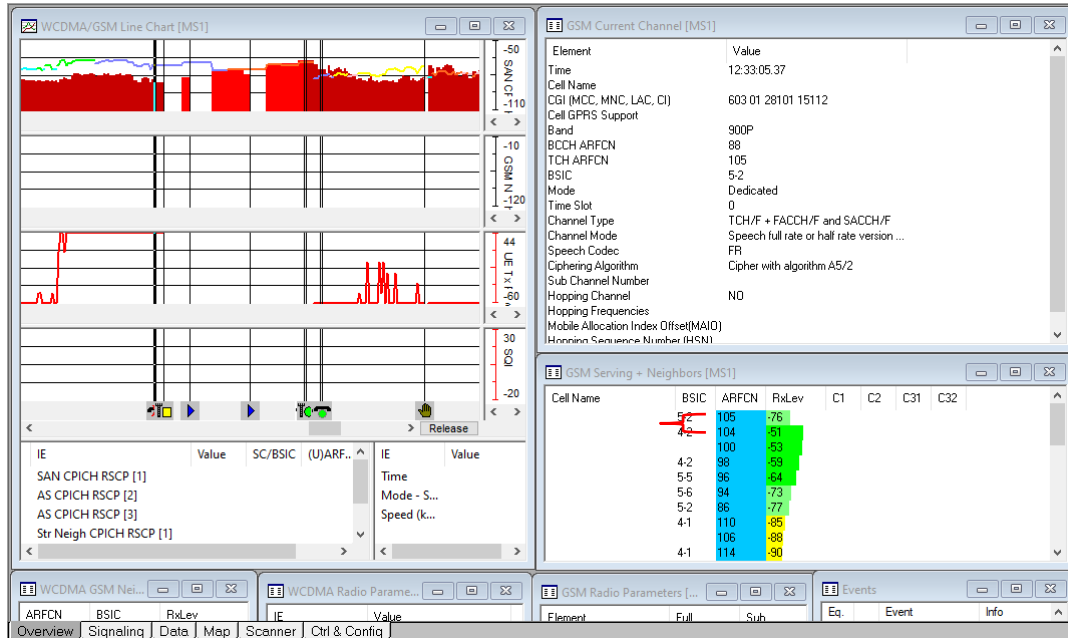


Figure III.20: Example of adjacent channel interference

This problem causes

- dropped call

Identification of the problem:

ARFCN : 105-106

Interference from adjacent channels: Due to emissions by other BTS on adjacent frequencies. The origin of this type of interference is the use of channels very close to each other in the frequency spectrum. This choice is intended to maximize the spectral efficiency of the system.

Problem solution:

The second frequency must be changed from 100 to 114

3. The problems of overshooting area

Coverage gaps in the south of the city of m'sila

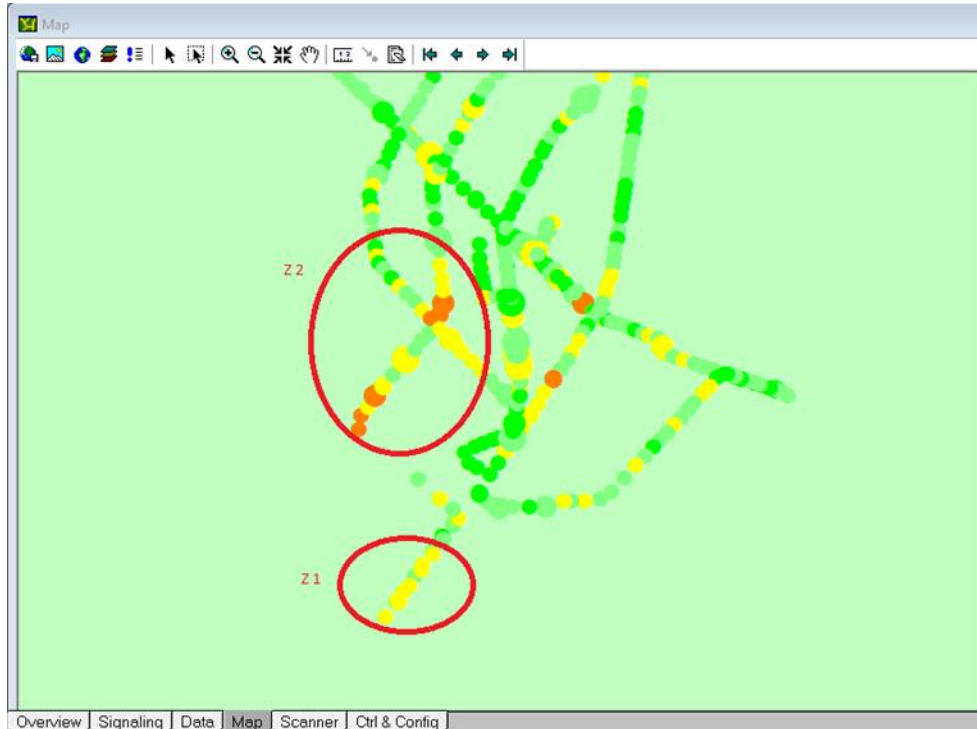


Figure III.21: Logfile which presents two interfered areas.

Identification of the problem :

➤ **Z1 Analysis:**

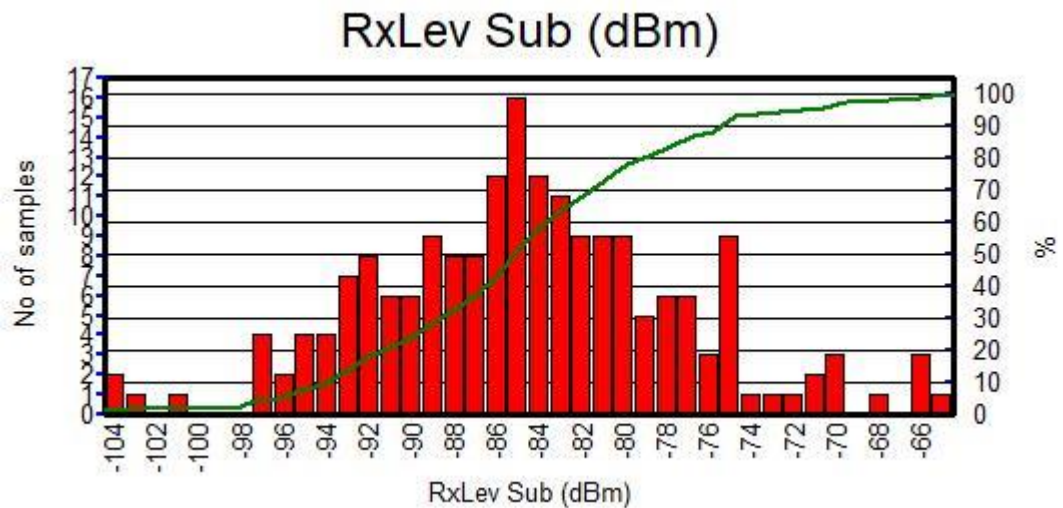


Figure III.22: Percentage of samples collected for RxLevel.

- 80% of the samples have their values between [-95; -75] dBm. Gives a weak signal

- 8% of samples belong to the range $-104;-95$ [dBm .the signal level is considered bad.
- 12% of samples have values above -75 dBm which gives a good signal level.

This problem causes:

- Signal level is poor
- Overshooting

To solve this problem:

- Planning a new site
- Tilting electric or mechanical

4. The problems of handover failure



Figure III.23: Handover failure in Zone Z2

We notice that the Handover failure event repeated several times.

The problems:

- Handover failure

Handover: is a mobile telecommunication and communication process in which a connected cellular call or data session is transferred from one cellular server (base station) to another without disconnecting the section.

Identification of the problem:

- Cross feeder: reversal of the position of the conductor cables coming from the antennas to the radio base station.
- High populated area

Proposition of solutions:

-The mechanical correction of the cross feeder

-We added E1 or new site

III.6 Conclusion

In this chapter, I presented the drive test operation for a mobile network. This task is used to improve coverage and quality of service. To do the driving test, the TEMS investigation tool is used to collect data (log files), analyze the collected data, and suggest solutions for some problems. Some real examples are done in the area of Msila.

Chapter IV

*KPIs optimization of a Mobilis
network; Wilaya of M'sila as a
study case*

IV.1 Introduction

Optimization engineers analyze statistics collected by KPIs to detect potential network issues. Then they identify the causes of these problems and provide appropriate corrective actions. As part of our training at the Mobilis operator, we were able to understand the methodology for analyzing optimization engineers. In this chapter, we will describe all the optimization phases of some KPIs and will assess the quality of service of the GSM network in the wilaya of M'sila.

IV.2 KPI statistics

In any Mobile operator, quality of service is very important. Radio engineers evaluate several performance indicators every morning from the Business Object (BO) program and then the careful analysis phase begins to identify problems on the different cells of the network and then make sufficient corrections.

During the period 29-05-2023 to 05-06-2023, we were able to get some KPI statistics for different cells in the GSM Mobilis network in M'sila. These KPIs are listed below:

- KPI Random Access Success Rate (%) in the cell 283004O
- KPI Random Access Success Rate (contention) (%) in the cell 283004O
- KPI Random Access Success Rate (Handover) (%) in the cell 283004O
- KPI Random Access Success Rate (Service) (%) in the cell 283004O
- KPI RRC Setup Success Rate (Signaling) in the cell 283004O.
- KPI RRC Setup Success Rate (%) in the cell 283004O.
- KPI RRC Connection Attempt (times) in the cell 283004O.
- KPI RRC Setup Failures (times) in the cell 283004O.
- KPI Call Drop Rate (All) in the cell 283004O.
- KPI Call Drop Rate (Always Online) (%) in the cell 283004O.
- KPI L.Traffic.User.SRS.Avg in the cell 283004O.

IV.3 Statistics of ARPT agency

IV.3.1. Subscribers and customers in Mobile networks in Algerian market

Mobile subscribers account for 10.90.22% of the total number of subscribers to the fixed and mobile networks of 52.11 million subscribers, compared with only 9.78% for fixed telephony.

Compared to the previous year, the number of subscribers to the fixed and mobile networks increased slightly by 3.52%, from 50.34 million subscribers at the end of 2020 to 52.11 million at the end of 2021.



Figure IV.1: Structure of the overall telephony fleet in Algeria (year 2021)

PARC D'ABONNÉS	2020	2021
Abonnés au réseau fixe	4 784 306 9,50%	5 097 059 9,78%
Abonnés aux réseaux mobiles	45 555 673 90,50%	47 015 757 90,22%
Total abonnés aux réseaux fixes et mobiles	50 339 979	52 112 816

Sources : Algérie Télécom, pour le parc d'abonnés fixe & Parc d'abonnés actifs pour la téléphonie mobile

Figure IV.2: Statistics of active subscriber for mobile telephony in Algeria

IV.3.2. Traffic stats of consumption in the wilaya of M'sila

In this part, the traffic of voice and data for the wilaya of M'sila will be delivered for the period May 16th to 28th May 2023. (See the following table).

TableIV.1: M'sila traffic 2G,3G, and 4G (CS and Ps) in the period 15May-28May 2023

2G CS Traffic															
TCH traffic	15-mai	16-mai	17-mai	18-mai	19-mai	20-mai	21-mai	22-mai	18-mai	23-mai	24-mai	25-mai	26-mai	27-mai	28-mai
M'sila	179420	176381	183484	184118	170133	187975	193847	192940	191782	191029	185919	170178	188087	194884	195804
3G CS PS															
Traffic Speech (Erl)	15-mai	16-mai	17-mai	18-mai	19-mai	20-mai	21-mai	22-mai	18-mai	23-mai	24-mai	25-mai	26-mai	27-mai	28-mai
M'sila	304711	300626	300632	298408	261246	299196	311326	309453	308076	309319	302608	261756	301048	315105	317020
PS Volume (Gbyte)	15-mai	16-mai	17-mai	18-mai	19-mai	20-mai	21-mai	22-mai	18-mai	23-mai	24-mai	25-mai	26-mai	27-mai	28-mai
M'sila	44193	44374	45466	44629	44625	43373	43253	43097	43122	43860	43726	44896	43702	43307	43284
4G PS															
PS Volume (Gbyte)	15-mai	16-mai	17-mai	18-mai	19-mai	20-mai	21-mai	22-mai	18-mai	23-mai	24-mai	25-mai	26-mai	27-mai	28-mai
M'sila	112572	112775	116872	118092	123421	120418	122014	121950	122053	121479	123723	125784	124222	122227	122521

According to the reported stats in Table IV.1, M'sila has a huge consumption in data as well as in traffic voice, especially the weekend (18-19 May) for data and the other days for speech. The evolution of traffic PS and CS are illustrated in Figures IV.3, IV.4, IV.5, and Figure IV.6.

This exponential growing in traffic makes M'sila among the highest traffic areas in Algeria.

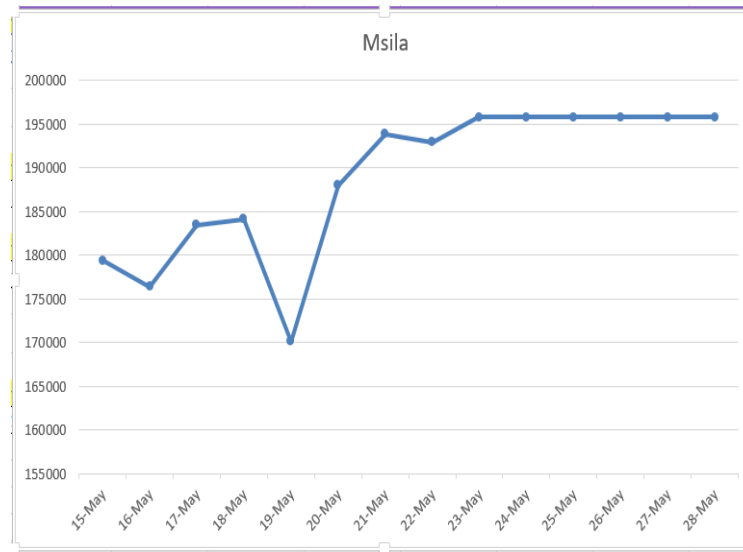


Figure IV.3: M'sila traffic 2G CS in the period 15May-28May 2023 (in Erl)

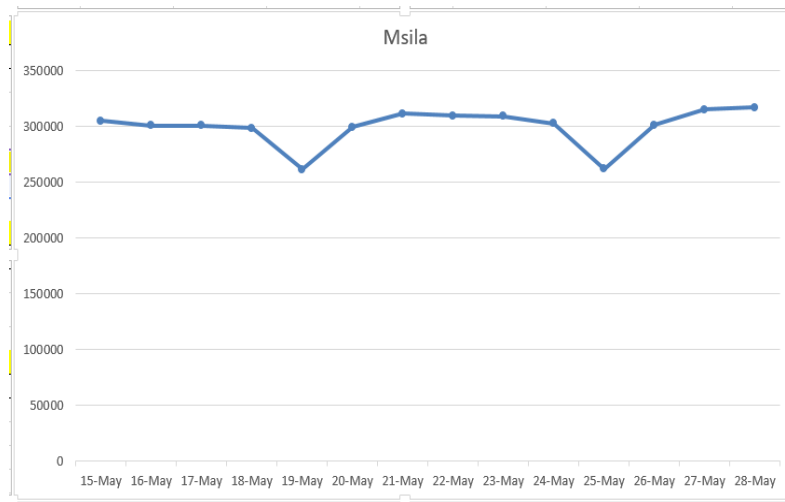


Figure IV.4: M'sila traffic 3G CS in the period 15May-28May 2023(in Erl)

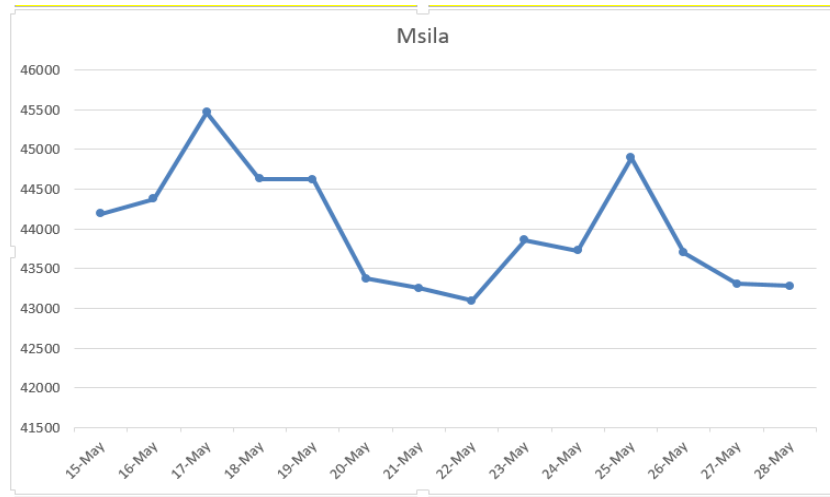


Figure IV.5: *M'sila 3G PS volume in the period 15May-28May 2023 (in Gbytes)*

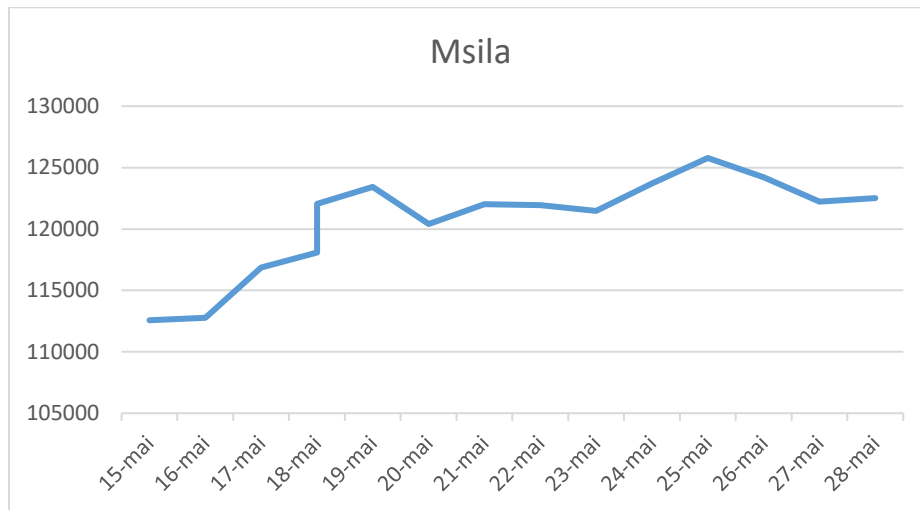


Figure IV.6: *M'sila 4G PS volume in the period 15May-28May 2023 (in Gbytes)*

The results show the importance of the wilaya of Msila in terms of high traffic consumption.

IV.4 Optimization process

After network planning, an optimization process must be mandatory. To do this important task, each mobile company must offer a given process. There are many steps of the optimization process such as data collection, analysis reports, detection of problems, and the preposition of solutions.

a. **Data collection:** For Algérie Télécom, there are many collect KPI data tools are used following to the company and the corresponding operator. For example, one can cite U2000, imanager, NetAct, NetNumen, OSS_RC. In our case, the **U2000** was used.

Table IV.2: Report of KPI Data collected as Excel file (M’sila enodeB 281004)

	Time	GBSC	Site Name	Cell CI	Cell LAC	Cell Name	Cellindex	DL frequency	Integrity	TCHF DL_RXQUAL 0	TCHF DL_RXQUAL 1
1											
2	2023-05-29 00:00	MSILA_6910_GU	281004	10046	28102	281004F	751	DCS1800	100%	1563	16
3	2023-05-29 00:00	MSILA_6910_GU	281004	10045	28102	281004E	750	DCS1800	100%	3196	410
4	2023-05-29 00:00	MSILA_6910_GU	281004	10044	28102	281004D	749	DCS1800	100%	2756	12
5	2023-05-29 00:00	MSILA_6910_GU	281004	10043	28102	281004C	748	GSM900	100%	2681	103
6	2023-05-29 00:00	MSILA_6910_GU	281004	10042	28102	281004B	747	GSM900	100%	0	0
7	2023-05-29 00:00	MSILA_6910_GU	281004	10041	28102	281004A	746	GSM900	100%	13377	110
8	2023-05-29 01:00	MSILA_6910_GU	281004	10046	28102	281004F	751	DCS1800	100%	1482	13
9	2023-05-29 01:00	MSILA_6910_GU	281004	10045	28102	281004E	750	DCS1800	100%	1785	18
10	2023-05-29 01:00	MSILA_6910_GU	281004	10044	28102	281004D	749	DCS1800	100%	116	0
11	2023-05-29 01:00	MSILA_6910_GU	281004	10043	28102	281004C	748	GSM900	100%	948	11
12	2023-05-29 01:00	MSILA_6910_GU	281004	10042	28102	281004B	747	GSM900	100%	0	0
13	2023-05-29 01:00	MSILA_6910_GU	281004	10041	28102	281004A	746	GSM900	100%	16001	1
14	2023-05-29 02:00	MSILA_6910_GU	281004	10046	28102	281004F	751	DCS1800	100%	16	0
15	2023-05-29 02:00	MSILA_6910_GU	281004	10045	28102	281004E	750	DCS1800	100%	244	7
16	2023-05-29 02:00	MSILA_6910_GU	281004	10044	28102	281004D	749	DCS1800	100%	0	0
17	2023-05-29 02:00	MSILA_6910_GU	281004	10043	28102	281004C	748	GSM900	100%	101	2
18	2023-05-29 02:00	MSILA_6910_GU	281004	10042	28102	281004B	747	GSM900	100%	0	0
19	2023-05-29 02:00	MSILA_6910_GU	281004	10041	28102	281004A	746	GSM900	100%	6854	6
20	2023-05-29 03:00	MSILA_6910_GU	281004	10046	28102	281004F	751	DCS1800	100%	109	21

b. **Analysis reports:**

The following figure illustrates view of ebodeB which is situated in the university of M’sila area (281004).

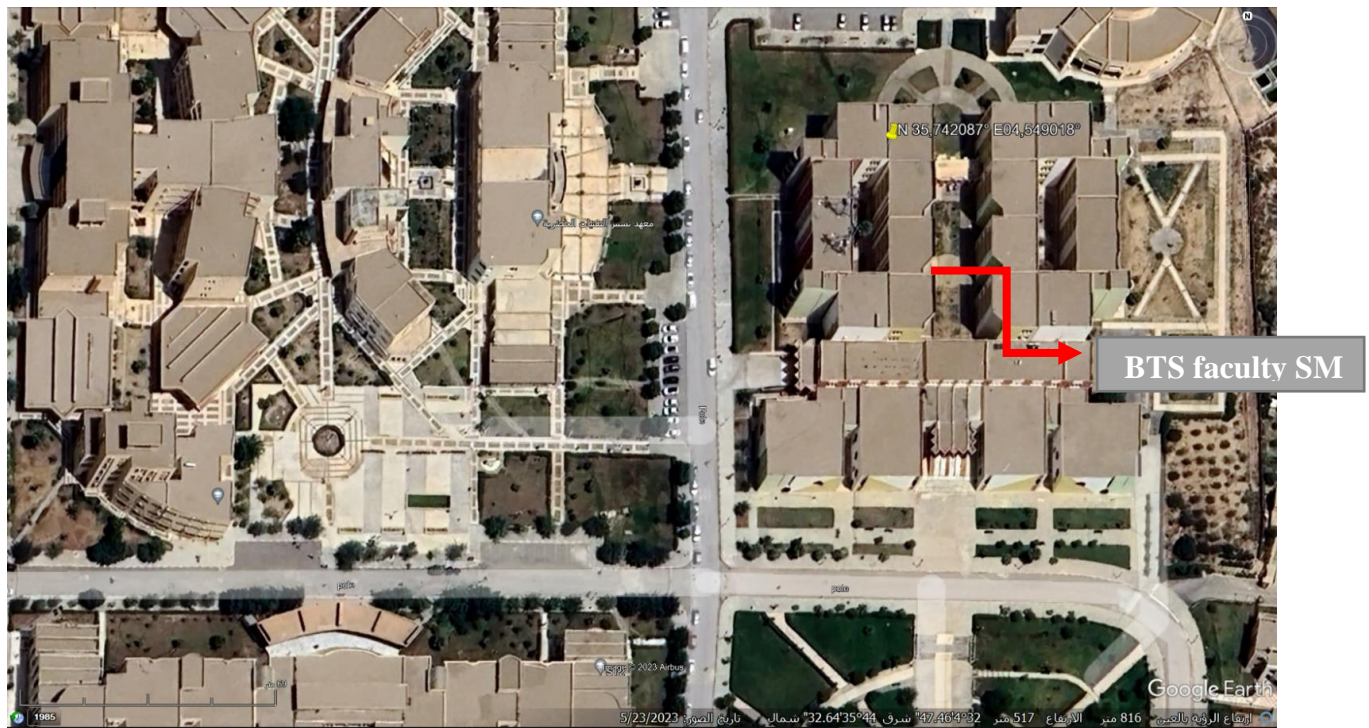


Figure IV.7: Photo of the site 2830040 from Google Earth

IV.4 .1 Study of some KPI

Figure. Represent the diagram of Random Access Success Rate (%) in the cell 283004O This cell covers an area with a high density of subscribers.

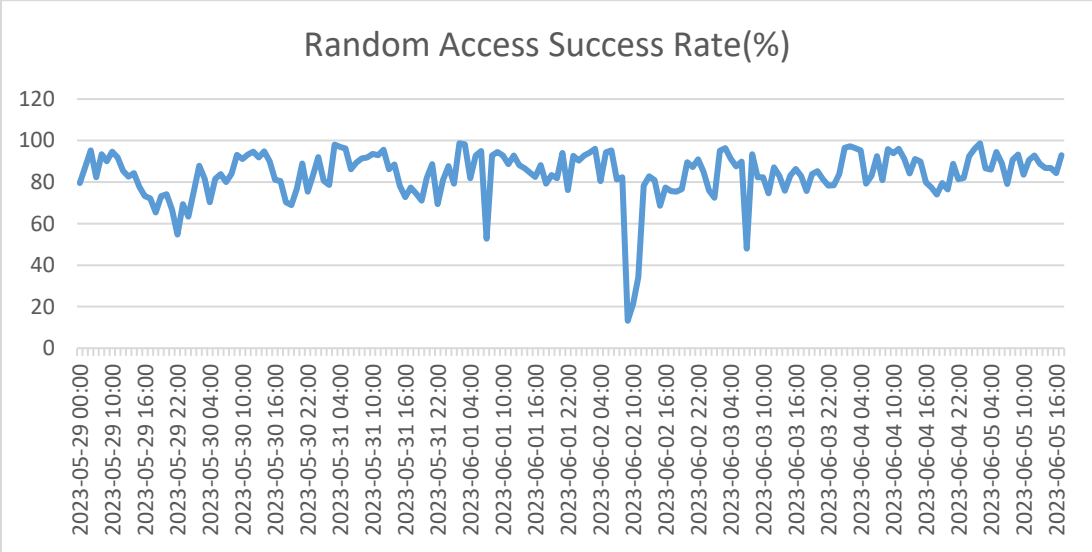


Figure IV.8: KPI Random Access Success Rate (%) in the cell 283004O

High KPI Random Access Success Rate (%) indicates that the network is able to handle a large number of random-access requests without any issues, which results in better connectivity and user experience for mobile users. On the other hand, a low KPI Random Access Success Rate (%) indicates that there are issues with the network, such as congestion or poor coverage, which can result in dropped calls or slow data speeds.

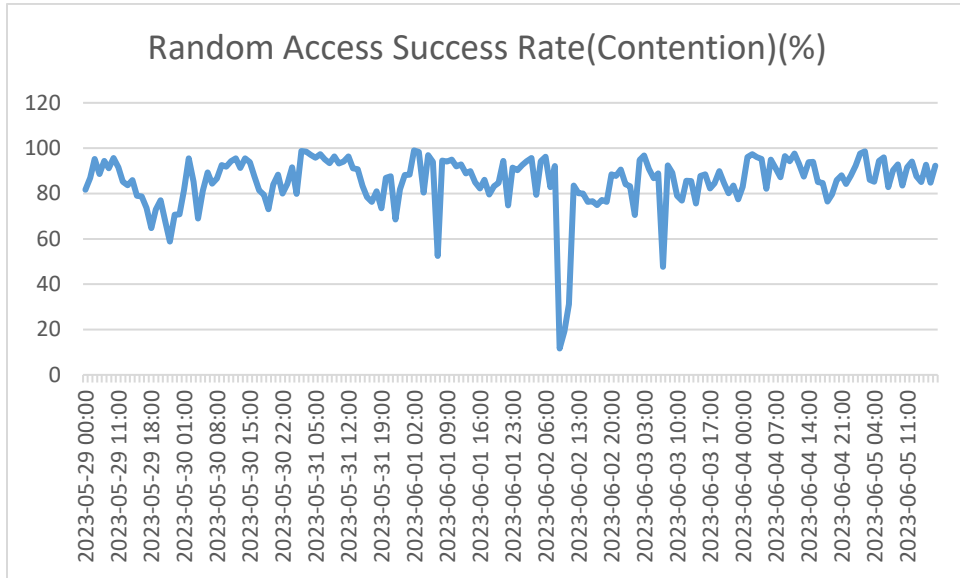


Figure IV.9: KPI Random Access Success Rate (contention) (%) in the cell 2830040

A high Random Access Success Rate indicates that the network is able to handle a large number of devices and that there is minimal contention for access. This is important because it ensures that devices can connect to the network quickly and reliably, which is essential for applications such as real-time video streaming, online gaming, and voice over IP (VoIP). A low Random Access Success Rate, on the other hand, indicates that there are too many devices trying to access the network at once, leading to congestion and delays in transmission. This can result in poor performance and user experience. Therefore, monitoring and optimizing the Random Access Success Rate is crucial for ensuring optimal network performance and user satisfaction.

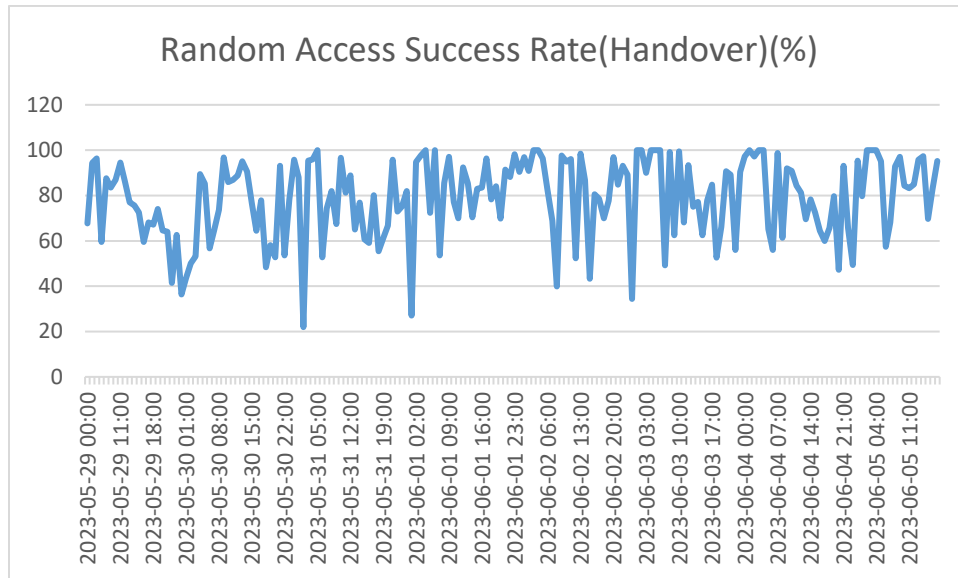


Figure IV.10: *KPI Random Access Success Rate (Handover) (%) in the cell 2830040*

The significance of this KPI is that it reflects the quality of service provided by the mobile network operator. A high success rate indicates that the network is able to seamlessly transfer calls and data sessions between cells without any interruption or drop in quality. This leads to a better user experience and higher customer satisfaction.

On the other hand, a low success rate indicates that there are issues with the network's ability to handle handovers, which can result in dropped calls, poor call quality, and frustrated customers. This can lead to customer churn and loss of revenue for the operator.

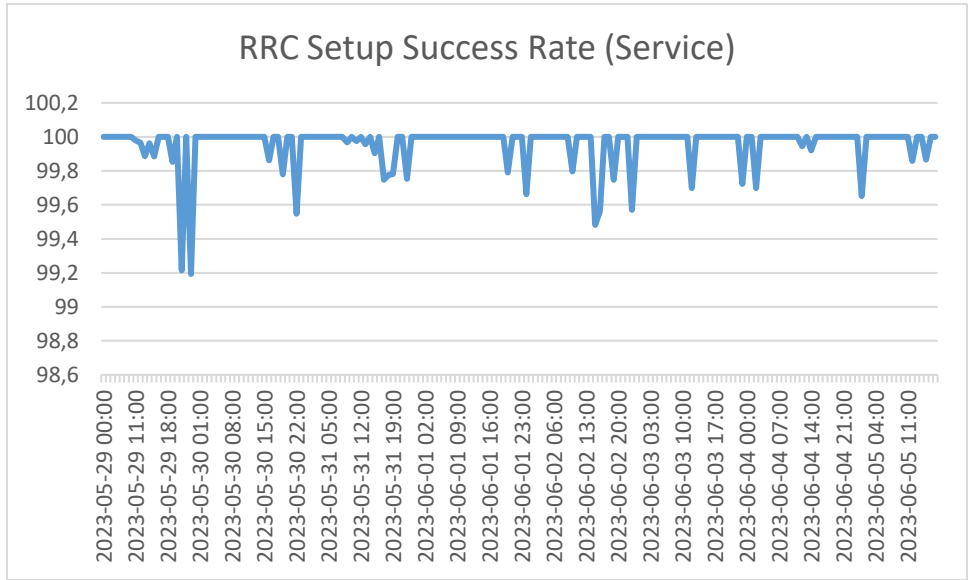


Figure IV.11: *KPI Random Access Success Rate (Service) (%) in the cell 2830040*

A high Random Access Success Rate indicates that the network is performing well, and users are able to connect to the service quickly and easily. On the other hand, a low Random Access Success Rate may indicate issues with network congestion, poor signal strength, or other technical problems that need to be addressed.

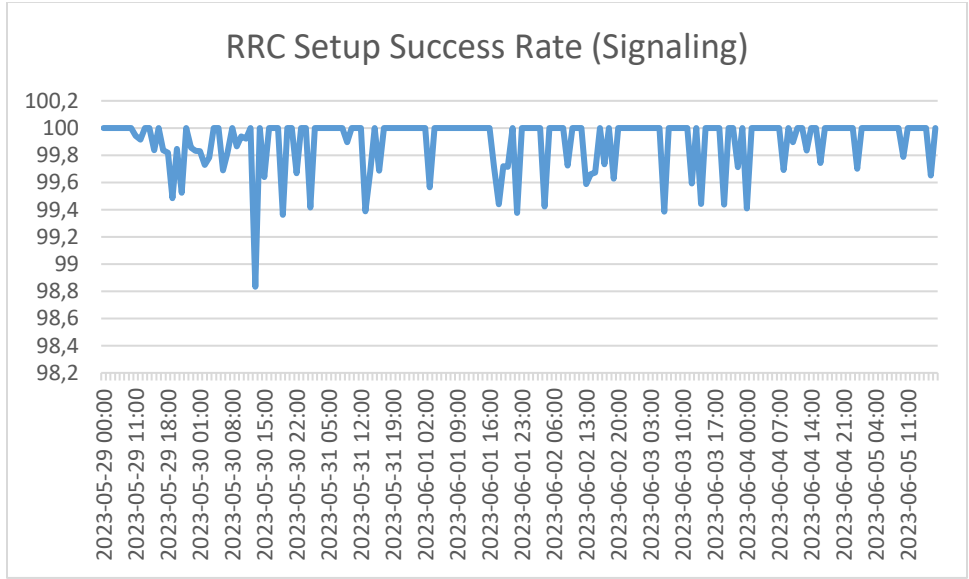


Figure IV.12: *KPI RRC Setup Success Rate (Signaling) in the cell 2830040*

A high RRC Setup Success Rate means that most of the signaling messages sent by the UE are successfully received and processed by the network, resulting in a successful connection

establishment. This indicates that the network is performing well and can provide reliable communication services to its users.

On the other hand, a low RRC Setup Success Rate indicates that there are issues with the signaling messages being sent or received, which can lead to connection failures or poor quality of service. This can result in dissatisfied customers and revenue loss for the service provider.

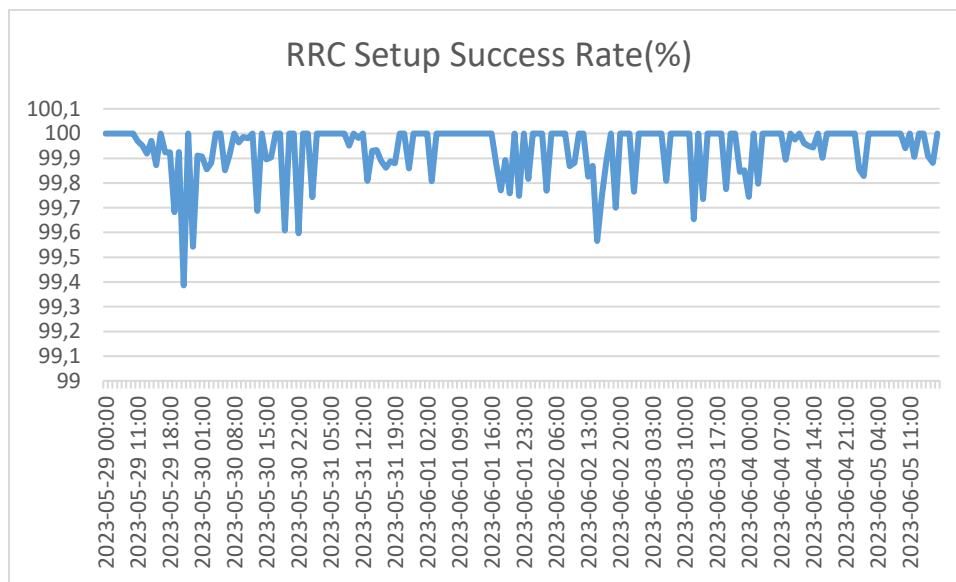


Figure IV.13: KPI RRC Setup Success Rate (%) in the cell 2830040

A high RRC Setup Success Rate indicates that the network is able to successfully establish and maintain connections with mobile devices, which leads to better call quality, faster data transfer rates, and improved overall user experience. A low RRC Setup Success Rate can indicate issues with network coverage, capacity, or configuration, which can lead to dropped calls, slow data speeds, and poor user experience. Therefore, monitoring and improving this KPI is crucial for ensuring optimal network performance and customer satisfaction.

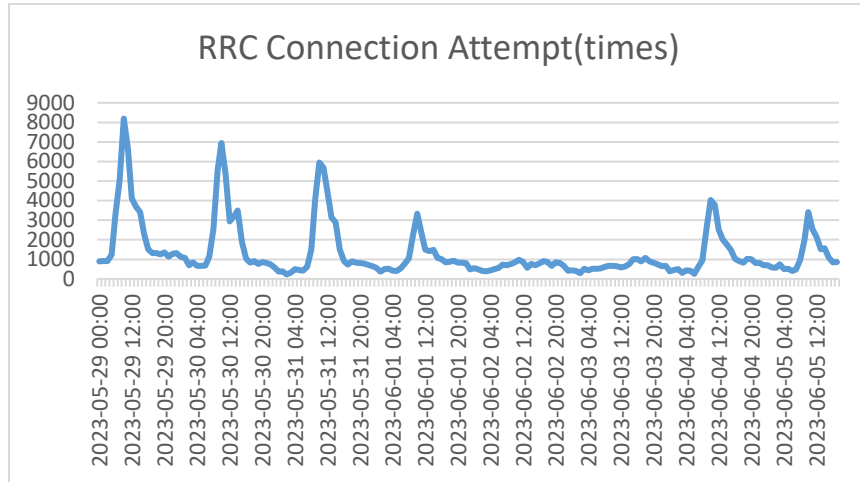


Figure IV.14: KPI RRC Connection Attempt (times) in the cell 2830040

A high number of RRC connection attempts may indicate issues with network coverage, interference, or congestion, while a low number may indicate efficient network performance. By monitoring this KPI, operators can identify and address any issues that may affect network performance and user experience.

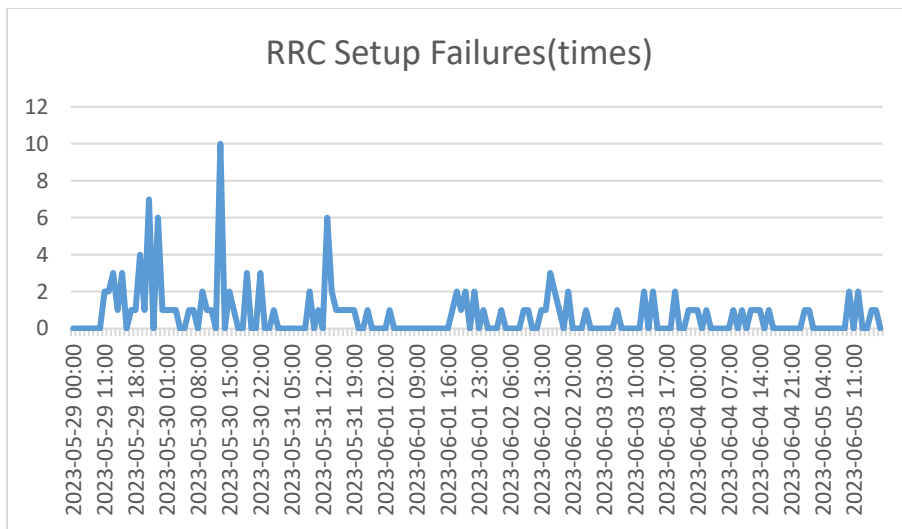


Figure IV.15: KPI RRC Setup Failures (times) in the cell 2830040

A high number of RRC setup failures can result in poor user experience, dropped calls, and reduced network efficiency. It can also indicate issues with network coverage, capacity, or

configuration. Therefore, monitoring this KPI helps network operators identify and address potential problems before they impact the user experience.

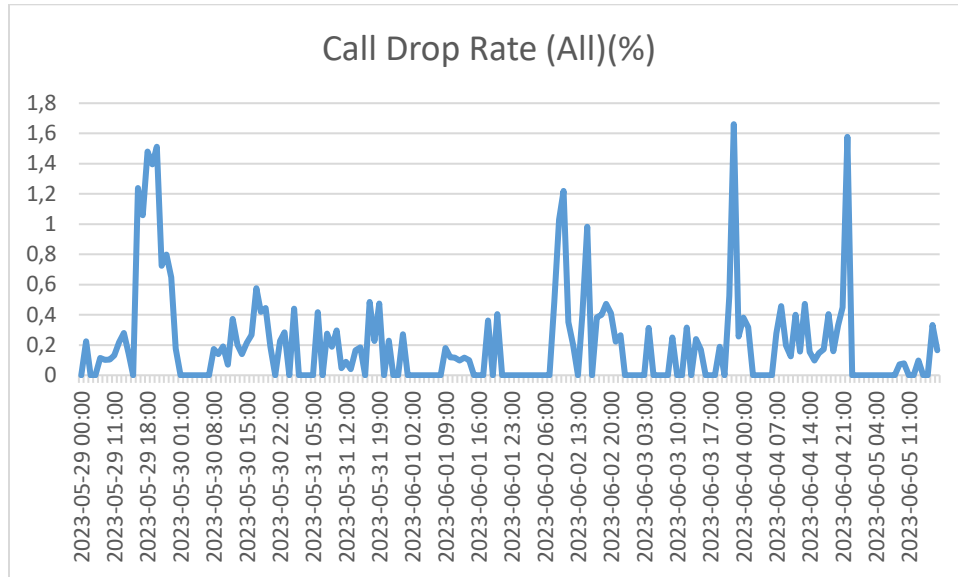


Figure IV.16: KPI Call Drop Rate (All) in the cell 2830040

The significance of Call Drop Rate (All) Key Performance Indicators (KPIs) lies in their ability to measure the quality and reliability of a telecommunications network. Call drop rate refers to the percentage of calls that are prematurely terminated or dropped before completion.

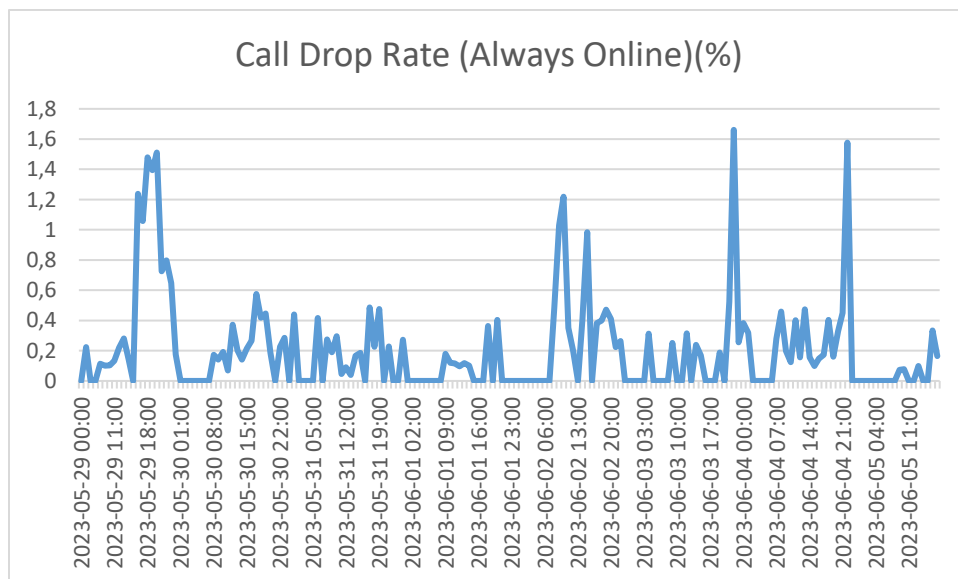


Figure IV.17: KPI Call Drop Rate (Always Online) (%) in the cell 2830040

A high call drop rate implies a poor user experience, as calls are frequently interrupted or abruptly terminated. This can lead to frustration for users and may impact their ability to communicate effectively. Monitoring and minimizing call drop rates is essential for service providers to ensure reliable connectivity and maintain customer satisfaction.

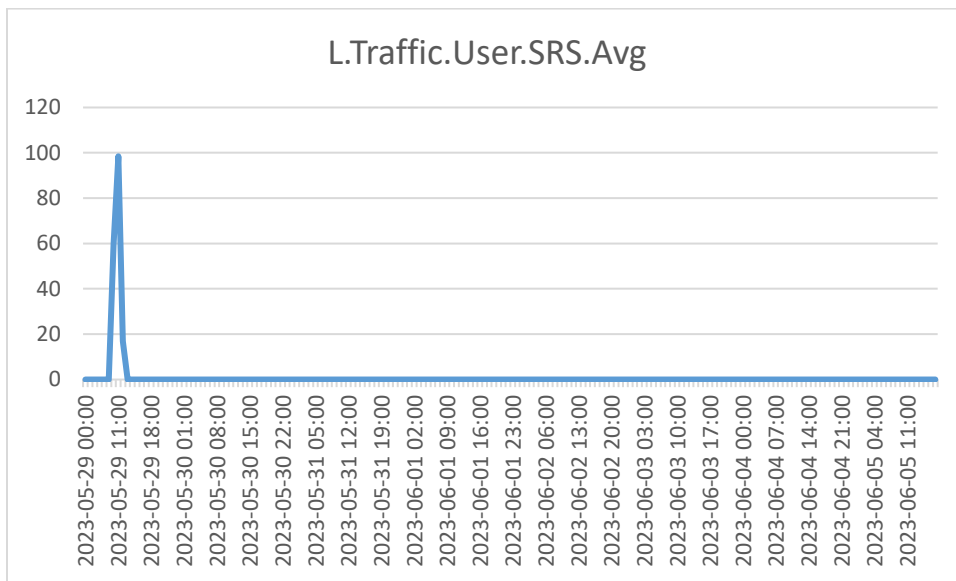


Figure IV.18: KPI L.Traffic.User.SRS.Avg in the cell 2830040

The significance of L.Traffic.User.SRS.Avg KPIs lies in its ability to measure the average success rate of signaling radio bearers (SRBs) for user traffic in a telecommunications network. SRBs are responsible for carrying control and user plane data between the user equipment (UE) and the base station.

L.Traffic.User.SRS.Avg KPIs provide valuable insights into the efficiency and effectiveness of a telecommunications network in handling user traffic, enabling operators to deliver better services to their customers.

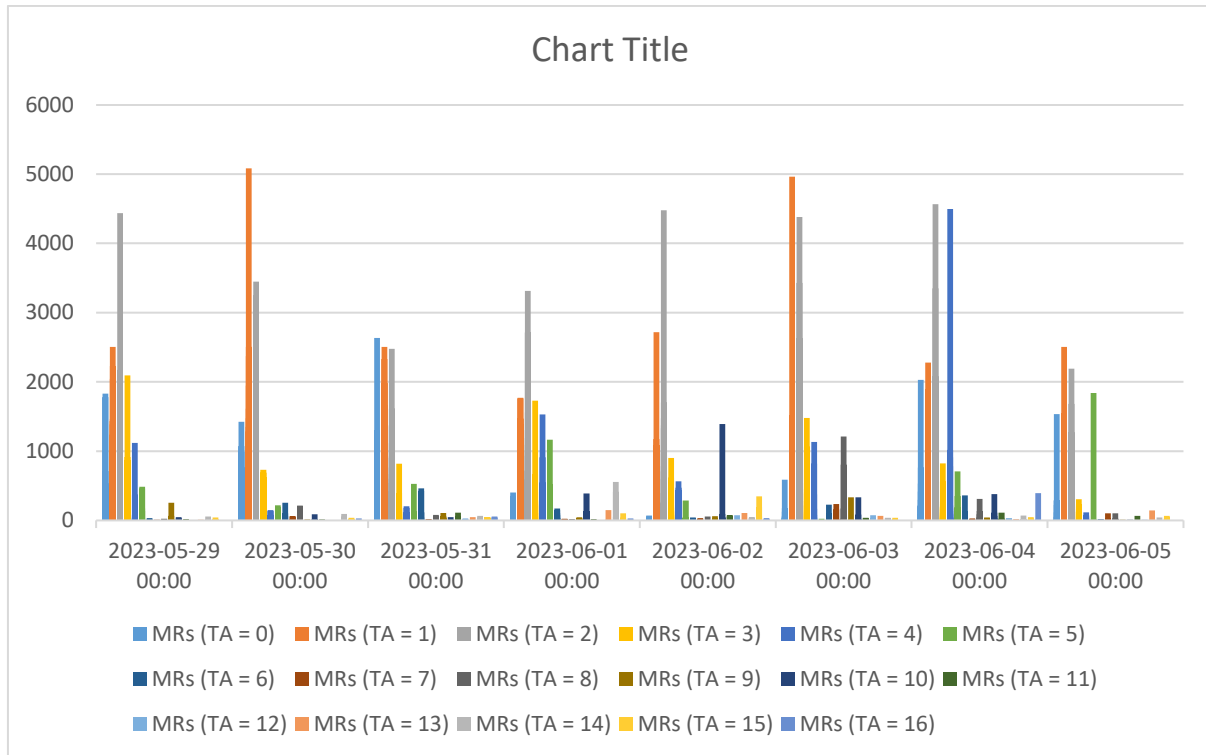


Figure IV.20: Timing advance statistics for the site 281004

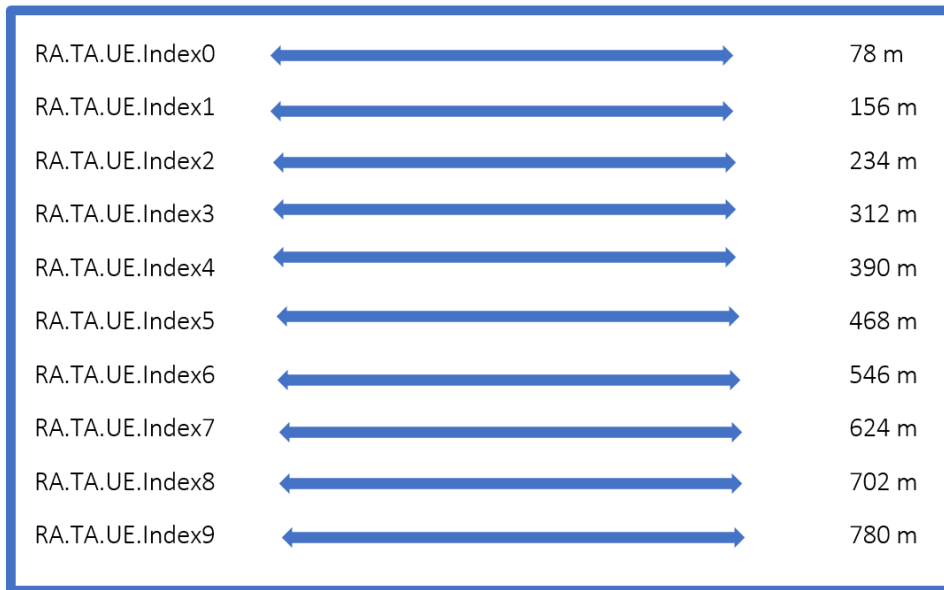


Figure IV.21: Timing advance index for 4G (LTE)

We analyze a TA counter, which is called Timing Advance (TA). These last counters are used to collect the number of attempts to access the network from users who are in different distance intervals from the location of the site. These intervals are cut out uniformly.

IV.5 Conclusion

In this chapter we analyzed some KPIs of 2830040 cells of the Mobilis network in M'sila, we were able to identify the causes of the anomalies, and finally gather some solutions to remedy them. From the results of our analysis, we can say that the Mobilis network is in the standards and responds well and well to the requirements of their subscribers. The analysis of KPIs is perpetual in the optimization service to keep the network in good working order to offer a good quality of service to subscribers.

Conclusions

In this thesis, a planning and optimization of mobile network, in the wilaya of M'sila, is done. The present work is divided into two parts. The first one concerns Drive test study, while the second part concerns KPI analysis based on experimental data. For the driving test, TEMS investigation was used to do data collection, analysis, creating report, and suggest some solutions. Drive testing has been used for both planning and optimization of GSM mobile network for some cellular sites in M'sila area. In the second part, an analysis of key performance indicators has been done. The analysis of many mobile network generations has been done based on experimental data for one week (from 29th May 2023 to 06th June 2023). Data was obtained from a very dense area (the enodeB 28 1004) presented in the pole university of M'sila. Data was collected using BO (business Objects) and has been analyzed using Excel.

The main objective of this project was to familiarize with tools of planning and optimization of a mobile network. This study allowed us to learn about a radio engineer tasks within the team and take experience of the available software tools.

As perspective for future work, we will try to evaluate and optimize mobile networks for 5G generation and beyond.

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ملخص

في هذه الأطروحة ، تم تخطيط وتحسين شبكة الهاتف المحمول ، في ولاية المسيلة. ينقسم هذا العمل إلى جزأين. أول واحد يتعلق بدراسة اختبار القيادة. بالنسبة لاختبار القيادة ، تم استخدام TEMS Investigation لجمع البيانات وتحليلها ومن ثم إنشاء تقرير واقتراح بعض الحلول. تم استخدام اختبار القيادة من اجل تخطيط وتحسين شبكة الهاتف المحمول GSM لبعض المواقع الخلوية في ولاية مسيلة. ومن جهة ثانية، وبناء على بيانات تجريبية لمدة أسبوع واحد (من 29 ماي 2023 إلى 6 جوان 2023) ، تم إجراء تحاليل لمؤشرات الأداء الرئيسية، وهذا للعديد من أجيال شبكات الهاتف المحمول. تم الحصول على البيانات من منطقة كثيفة جدا تتمثل في هوائي القطب الجامعي بالمسيلة (enodeB 281004). تم جمع البيانات باستخدام BO و من ثم تحليلها باستخدام Excel. كان الهدف الرئيسي من هذا العمل هو التعرف على أدوات تخطيط نمذجة شبكة الهاتف المحمول. سمحت لنا هذه الدراسة بالتعرف على مهام مهندس الراديو وتجربة الأدوات البرمجية المتاحة في شركات الاتصالات.

كلمات مفتاحية : تخطيط شبكة النقل-نمذجة شبكة النقل-اختبار القيادة ، مؤشرات الأداء الرئيسية ، تحليل البيانات

Abstract

Dans cette thèse, une planification et une optimisation du réseau mobile, dans la wilaya de M'sila, est réalisée. Le présent ouvrage est divisé en deux parties. La première concerne l'étude d'essai Drive. Pour l'examen de conduite, l'enquête TEMS a été utilisée pour recueillir des données, les analyser, créer un rapport et suggérer des solutions. Les tests de conduite ont été utilisés pour la planification et l'optimisation du réseau mobile GSM pour certains sites cellulaires dans la région de M'sila. Dans la deuxième partie, une analyse des indicateurs de performance clés a été effectuée. L'analyse de nombreuses générations de réseaux mobiles a été réalisée sur la base de données expérimentale pendant une semaine (du 29 mai 2023 au 06 juin 2023). Les données ont été obtenues à partir d'une zone très dense (l'enodeB 281004) présentée dans le pôle université de M'sila. Les données ont été collectées à l'aide de BO (Business Objects) et ont été analysées à l'aide d'Excel. L'objectif principal de ce projet était de se familiariser avec les outils de planification et d'optimisation d'un réseau mobile. Cette étude nous a permis de nous familiariser avec les tâches d'un ingénieur radio au sein de l'équipe et de prendre l'expérience des outils logiciels disponibles au sein des sociétés des télécommunications mobiles.

Mots clés : Planification-Optimisation-Drive test (DT)- Key performance Indicators KPIs - Analyse des données,