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SUBJECT

Data-driven handover optimization in LTE mobile network

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Dedication

I dedicate this work to my dear parents who have strongly supported me throughout my life and any project that I wanted to implement. All my feelings of gratitude and pride of them. Almighty God give them health and happiness throughout their lives, to all my brothers and friends who did not stop for a moment to support and encourage me so that I can move forward, to all those who m 'helped make this project happen, and finally, all doctors, nurses, teachers, and soldiers who fight against recent epidemic COVID 19.

Acknowledgments

We would like to express our gratitude to numerous people who help cased the way to fulfill such research, first of all, we would like to express our gratitude for our supervisor MR. Mohamed Benouis, who we have been honored to be his students for two years, as we feel indebted to him for his scientific generous spirit. We also would like to express our deep thanks to our teachers.

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General Introduction

Long term evolution or evolved packet system offers new services of mobile communication. Unlike traditional mobile network, which relies on the definition of certain access network functions and employs various switching network techniques to provide seamless service (particularly video-related services) to mobile customers, LTE has an important properly; data rates, latency, quality, and mobility.

This latter is considered as critical issue to keep always the connection between the user and base station whatever the mobile environment conditions. A single user may eligible either to move in the same area or other area networks while assuring the users traffic service. Thus, is achieved through the handover execution. So, the main goals of handover execution include minimizing call drops, minimizing radio link failures (RLF), minimizing unnecessary handovers, and minimizing idle mode problems. Generally, the most common parameters used to establish the handover decision are: time to trigger (TTT) and hysteresis margin (HM).

Many standard handover algorithms have been already carried out in realistic mobile network and almost met the principal user service requirements including throughput and the mobility in the coverage area, however the growing the number of users in small area as well the device of user mostly operates their daily services, which need law latency and mobile energy. To deal with this purpose, the current networks necessity more parameters to well perform the handover call in the network which not only seek to maintain the connectivity but also enhancing the entire network's performance and quality of service (QoS).

In the thesis, we are firstly focusing on the standard handover algorithm, called A3 to reduce the failure handover calls by defining a new time to trigger. This algorithm is validated and compared with the standard algorithm in a NS3 simulator. In the second work, we are calling the machine learning algorithm to design new inter face exchange between the user and the mobile station that may meet the mobile requirement managements. So, the main contributions of this work are: a) adjusting the principal parameters (TTT and HM) of standard handover to perform it in challenging scenarios such a high velocity, ping pong context b) a novel interface exchange by ignoring some handover steps.

As a result of the motivation for this study, the main objectives of this thesis can be summarized into the following points:

- To review the state of the art of LTE; handover procedures, especially the A3 algorithm in LTE network; handover control parameters; and handover decision algorithms, and to discuss and evaluate the proposed method.

- To reduce the failure handover within different velocity and optimization of the ping-pong handover ratio through dynamically adjusting the handover control parameters.

- To investigate machine learning performance on the handover optimization, in order to well learn the UE's information such as position and the best ENb target and then lead to make a reliable handover decision.

- To create a new interface communication scheme for handover control parameters, such that all UEs in the network no need a report of measure to get admission from the next cell;

the neglection of this step may offer an efficient mobility to the UE and reduce the number of messages transmitted from the base station.

The structure of this thesis is organized as follows:

In chapter 1, basic knowledge of LTE network and detailed architecture are introduced, followed by the introduction of two its most important services.

In chapter 2, first, a detailed handover procedure is explained, followed by the introduction of two important handover control parameters. Moreover, five different categories of handover decision algorithms are classified, and a literature review of the corresponding research is summarized and evaluated.

In Chapter 3, A modified-standard handover is proposed. The main idea is to study the behavior of A3 in LTE network. Through this study, we have proposed to adjust the standard parameter's A3 algorithm such as TTT and HM to reduce the number of failures within different velocity of user.

In chapter 4, A Q learning algorithm scheme is proposed. The main idea of this chapter is to design a new interface handover control between the user and mobile station. Through computing the UE position in the whole average area cell and the closed the best station, the Q learning algorithm is performed based on the user-location information. Instead of the standard exchange interface which need to collect the measurement report, our proposed algorithm will be ignored to this step and consequently lead to decrease the time consuming and also reducing the unnecessary handover messages.

In Chapter 5: Conclusion and future works: In this chapter, the conclusion of this work is presented, followed by proposed open research for future works.

1 LTE Technology Overview

1.1 INTRODUCTION:

In 2004, the consortium 3GPP has launched a new mobile generation, it baptized Long Term Evolution. Thus, mainly includes System Architecture Evolution (SAE) which has been established by combing the exiting mobile GPRS and 3G packet core network evolution [1].

LTE evolved from an earlier 3GPP system known as the Universal Mobile Telecommunication System (UMTS), which in turn evolved from the Global System for Mobile Communications (GSM). Even related specifications were formally known as the evolved UMTS terrestrial radio access (E-UTRA) and evolved UMTS terrestrial radio access network (E-UTRAN). First version of LTE was documented in Release 8 of the 3GPP specifications.

Long Term Evolution (LTE) improves the standardization protocols involved in the Third Generation Partnership Project (3GPP) to reach a new high-speed radio access method for mobile communication systems [2]. In order to successfully compete to other existing and future wireless, cellular and wire-line services, the network designers need to fully consider the technical constraints that influence the whole design process of this kind of networks.

1.2 The LTE standard:

LTE (Long Term Evolution): is an advanced mobile radio communication technology licensed d by the 3GPP organization. Access to the frequency channels used in the LTE standard are often frequency division (FDD) and time division (TDD). In addition, this technology is adopted new access radio technology such as OFDMA (Orthogonal Frequency Division Multiple Access) multiplexing which aim to manage the spectrum channel frequency for user by minimizing interference and improving throughput channel [3].

On other hand, the LTE network incorporates the multiple antenna technology MIMO (Multiple-Input Multiple-Output), which allows it possible to reach up a throughput rate of 75 Mbit /s in the upstream direction and 300 Mbit / s in the downstream direction [4]. In technical terms, this core network is called EPS (Evolved Packet System) [5]. It consists of two principal entities: the advanced LTE radio access network, and the advanced core network called SAE (System Architecture Evolution). Unlike the 2G and 3G networks where the circuit switching and packet switching domains were distinguished, the SAE core network contains only one packet domain called EPC (Evolved Packet Core). All services are based on IP including those which were previously offered by the circuit domain such as voice, videophone, SMS, etc.

The 3GPP standardization body has defined the different types of services supported by the LTE network. This technology has proposed fundamental changes from the conventional standards offered by 3GPP to improve the capacity of the LTE network architecture and provide value-added services. Indeed, the LTE network provides a high quality of service and reliable internet access thanks to its dynamic management of services as well as its routing of IP service. The LTE standard allows to support a wide range of mobile applications such as geolocation, personal mobile television, video conferencing.

1.3 LTE Architecture:

Like the 2G and 3G networks, the general LTE / EPC architecture is defined from a physical and a functional point of view.

1.3.1 Physical architecture:

From a physical point of view, the LTE / EPC architecture is made up of three domains (Figure 1: illustrates the general LTE / EPC architecture.):

• The UE: it is the User Equipment.

• The access network: called LTE or E-UTRAN (Evolved-UTRAN).

• The core network: called EPC (Evolved Packet Core).

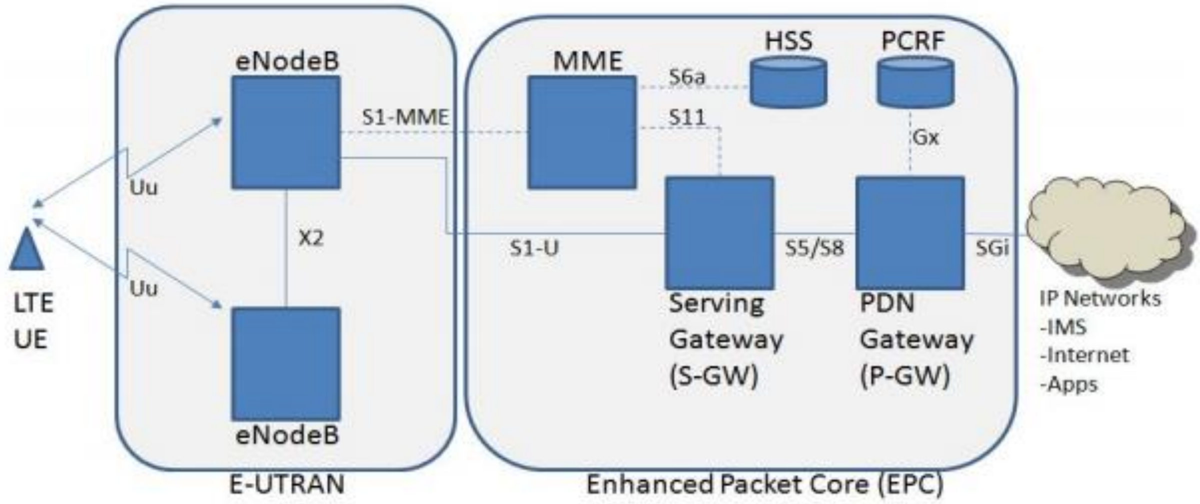

Figure 1:General architecture of the LTE network (EPS).

1.3.1.1 EPC core network (Evolved Packet Core):

The core of the network, called “EPC” (Evolved Packet Core), exploits “full IP” technologies for signaling which allows reduced latency times for the transport of voice and data. [6] This core network exchanges data over IP along routers with other remote eNodeBs, the networks of other mobile operators, fixed telephone networks and the Internet. The architecture of the EPC network is shown in Figure 2.

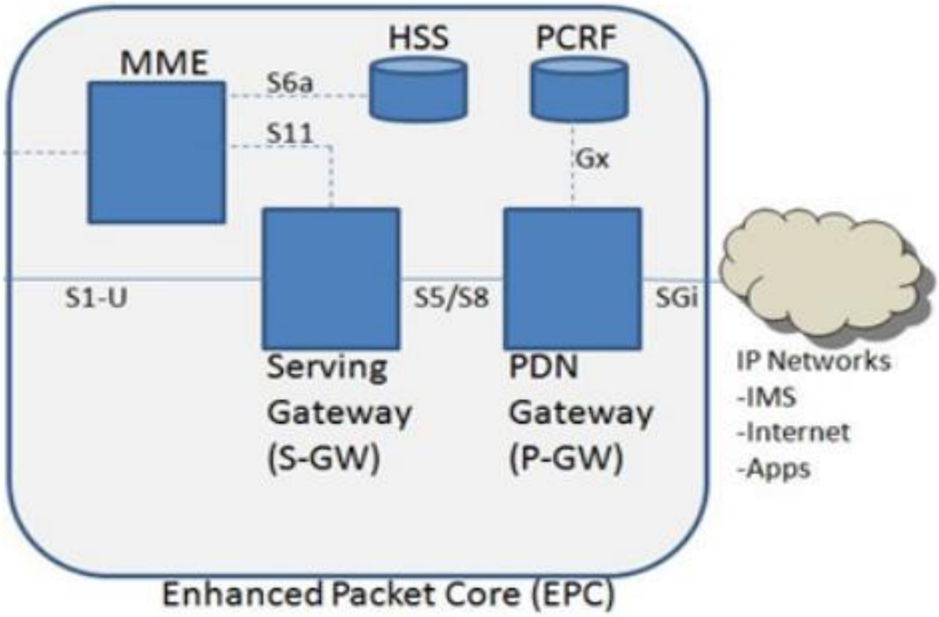

Figure 2 :architecture of Evolved Packet Core (EPC).

The EPC network consists of [7]:

- **MME (Mobility Management Entity)**:

is responsible for mobility management and user authentication. It is also responsible for paging when the user is in an inactive state. It selects the components dedicated to the types of user communication. It manages the inter-domain and inter-network handover.

- **HSS (Home Subscriber Server):**

Basically, the HSS is a database that contains user-related and subscriber-related information. It also provides support functions in mobility management, call and session setup, user authentication and access authorization.

- **PDN-GW (Packet Data Network Gateway):**

The PDN-GW is the point of interconnect between the EPC and the external IP networks. The PDN GW routes packets to and from the PDNs.

The PDN GW also performs various functions such as IP address / IP prefix allocation or policy control and charging.

- **PCRF (Policy and Charging Rules Function):**

Responsible for the main control decision. It provides an authorization QoS to decide the processing of data while respecting the users' subscription.

- **SGW (Serving Gateway):**

It is the main junction between the radio access network and the core Serving GetWay (SGW) network routes data packets, maintains the inter-eNodeB connection, then inter-system between LTE and GSM / UMTS and reserves the context of the mobile terminal (UE), such as the parameters of the service carrier and the routing of information (It plays the like role the router).

1.3.1.2 Evolved UMTS Terrestrial Radio Access Network (E-UTRAN):

The radio part of the network, called "E-UTRAN" is simplified compared to that of the 2G (BSS) and 3G (UTRAN) networks by integration into the "eNodeB" base stations with fiber optic links and links. IP connecting the eNodeBs to each other (X2 links). As well as control functions that were previously implemented in the RNC (Radio Network Controller) of 3G. UMTS networks. This block is responsible for radio resource management, carrier, compression, security, and connectivity to the advanced core network [8].

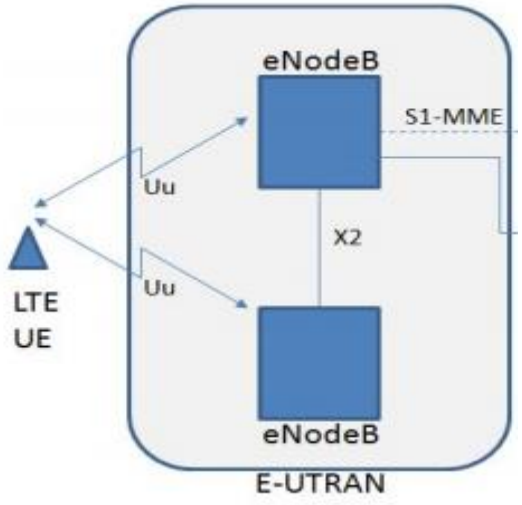

Figure 3 Architecture of the E-UTRAN radio part.

- **ENodeB:**

eNodeB is the equivalent of BTS in the GSM network and NodeB in UMTS, the handover functionality is more robust in LTE. These are antennas that connect the UEs with the LTE core network via the RF air interface. As they provide the functionality of the radio controller resides in eNodeB, the result is more efficient, and the network is less latent, for example mobility is determined by eNodeB instead of BSC or RNC.

1.3.1.3 User Equipment (UE)

Mobile device (or mobile station) used by the subscriber or user to connect to the network.

1.4 IMS part:

IMS is an architecture recently applied in mobile networks that allow telecom operators to offer value-added IP services. This new architecture allows multimedia sessions to be established regardless of the type of Internet access used. This architecture is also capable of supporting, on an all-IP network in the same session, real-time applications such as voice and video; and non-real-time applications such as Push to Talk and instant messaging. IMS is used by mobile terminals in GPRS and UMTS networks as well as by fixed broadband users, such as xDSL, cable, etc. IMS provides an interface to circuit-based networks, such as RTCP and GSM, and provides a standardized interface based on the SIP protocol for access to services.

➢ Examples of IMS services:

- Exchange of files during a call.

- A user can create a rule that shows him connected after a certain hour and rejects all calls from a caller in his professional group.

- A user can cut when his professional colleagues call and redirect them to a specific web page presenting the hotel where he spends his vacation.

- A user can activate the ringer on all their devices depending on the caller.

- Instant messaging and video conference

1.5 Protocol stack:

is an implementation of a computer networking protocol suite or protocol family. Some of these terms are used interchangeably but strictly speaking, the suite is the definition of the communication protocols, and the stack is the software implementation of them [9].

Protocol stacks for the control plane and user plane are illustrated in [Figure 4/Figure 5] [10]. The protocol for user plane includes package data convergence protocol (PDCP), radio link control (RLC), medium access control (MAC), and PHY protocol. The control plane stack additionally includes the radio resource control (RRC) and no access stratum (NAS). The functions of each protocol are summarized in [Table 1].

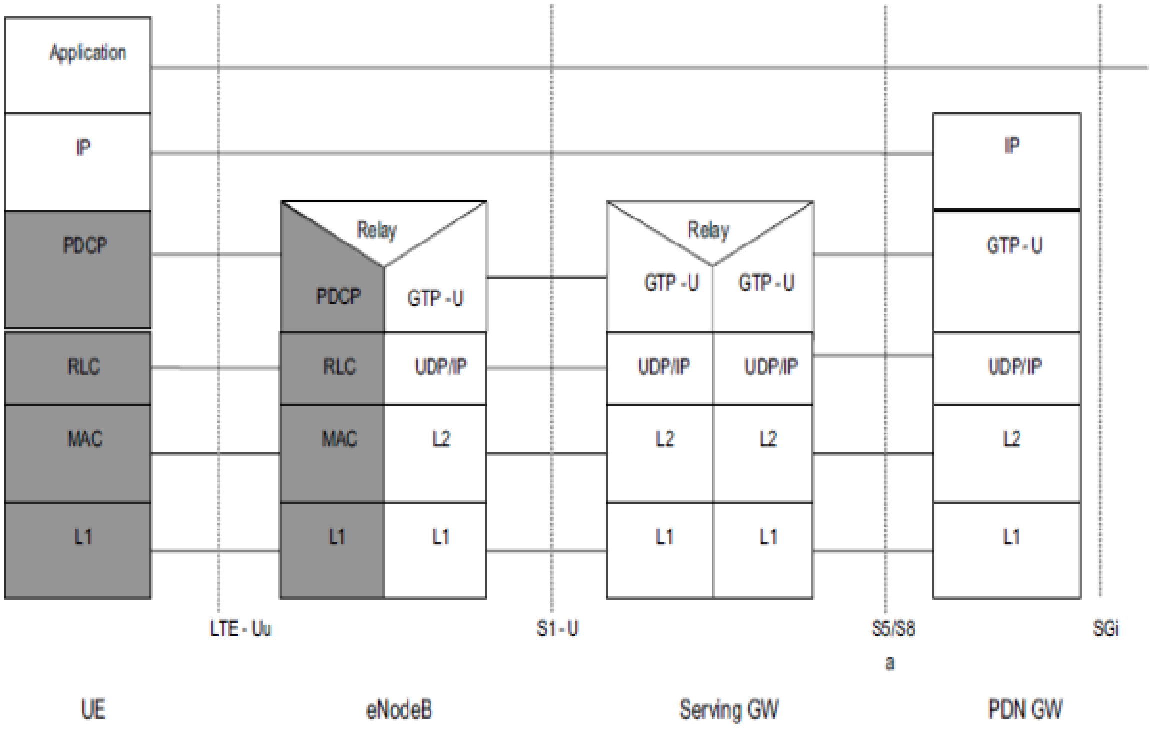

Figure 4: User Plane Protocol Stack [10].

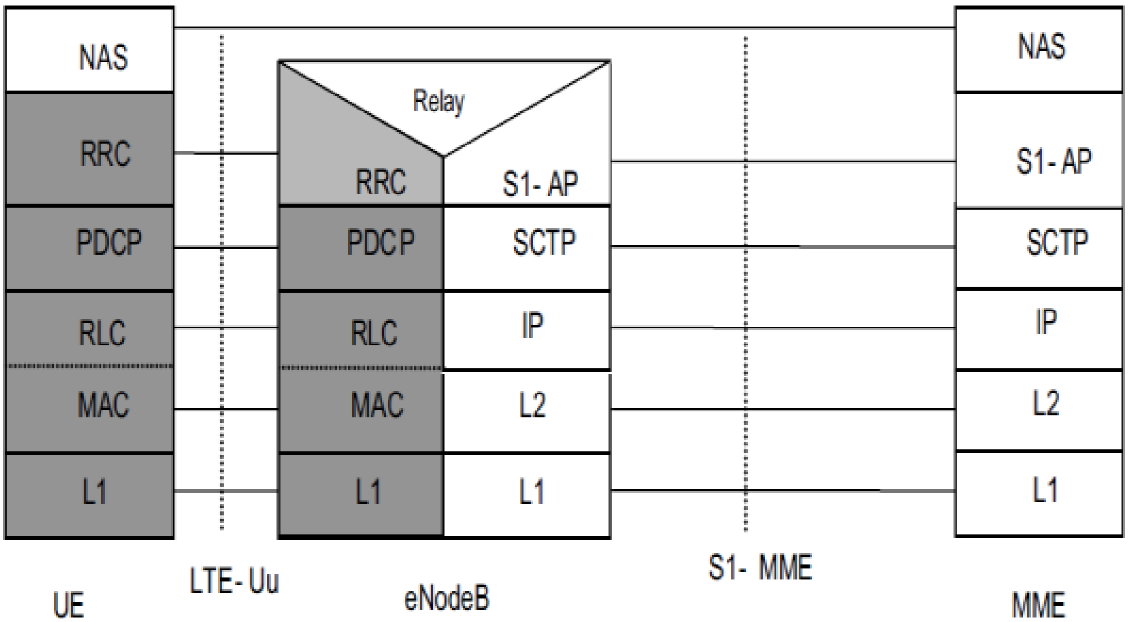

Figure 5:control Plane Protocol Stack [10].

RRC	Broadcast system information related to Non-Access Stratum (NAS) and Access Stratum (AS) · Establishment, maintenance, and release of RRC connection · Security functions including key management · Mobility functions · QoS management functions · UE measurement reporting and control of the reporting · NAS direct message transfer between UE and NAS
PDCP	Header compression · In-sequence delivery and retransmission of PDCP Session Data Units (SDU's) for acknowledge mode radio bearer at handover · Duplicate detection
RLC	Error correction through Automatic Repeat Request (ARQ) · Segmentation according to the size of transport block and re-segment in case a retransmission is needed · Concatenation of SDU's for the same radio bearer · Protocol error detection and recovery · In-sequence delivery
MAC	Multiplexing/demultiplexing of RLC PDU's · Scheduling information reporting · Error correction through HARQ · Local channel prioritization · Padding
PHY	Transmission of electric signals · Modulation · Line coding · Synchronization

Table 1: The functions of protocol stack .[10]

1.6 Basic characteristics of LTE:

1.6.1 speed and frequencies:

LTE technology operates in a variety range of frequencies depending on the geographic area covered: 700 MHz in the United States for the Version Wireless network, 2.6 GHz and 800 MHz in Europe, and 2.1 GHz for the Japanese network of NTT DoCoMo (Japanese operator).

The maximum throughput objectives defined for LTE are:

100 Mbit / s downlink for an allocated bandwidth of 20 MHz, giving a peak spectral efficiency of 5 bit / s / Hz.

- 50 Mbit / s upstream for an allocated bandwidth of 20 MHz, giving a peak spectral efficiency of 2.5 bit / s / Hz.

1.6.2 Latency:

1.6.2.1 Control plane latency:

The objective set for LTE is to reduce the latency of the control plane with respect to UMTS, via a transition time of less than 100 MS between a standby state of the EU and an active state authorizing the establishment of the user plan. [12]

1.6.2.2 User plane latency:

The latency of the user plane is known by the transmission time of a packet between the IP layer of the EU and the IP layer of a node of the access network or vice versa. In other words, the latency of the user plane refers to the delay of transmission of an IP packet whiling the access network. LTE targets a user plane latency of less than 5 MS under conditions of low network load and for small IP packets [12] [13].

1.6.3 Spectrum flexibility:

The LTE must be able to operate on carriers of different slots to well manage the various spectral allocations. The bandwidths initially required were subsequently challenged to become the following: 1.4 MHz, 3 MHz, 5 MHz, 10 MHz, 15 MHz and 20 MHz in the uplink and downlink directions**.** [13]

1.6.4 Access method:

The use of OFDMA (Orthogonal Frequency Division Multiple Access) coding is a radio coding technology of type "Frequency division multiple access" (FDMA) for the downlink and of SC-FDMA (single-carrier). Unlike the CDMA, FDMA is a frequency division multiple access radio coding technology allow to define sub carrier for each user while reducing the interference in the same frequency band by using orthogonality frequency. This latter is compatible with the MIMO antenna technique [12] [13].

1.6.5 LTE duplex mode:

The LTE specifications provide for operation in dual mode: frequency multiplexing (FDD) and time multiplexing (TDD). In FDD (Frequency Division Duplexing) mode, transmission and reception take place at different frequencies. In TDD mode, transmission and reception pass at the same frequency, but at different times. This is the first mode (FDD) which is currently implemented in telecom equipment and deployed in most of the first authorized 4G LTE networks. The second mode (TDD) operates on separate frequency bands.

1.6.6 Mobility:

Mobility is a key function for mobile networks. LTE aims to remain functional for UEs traveling at high speeds (up to 350 km / h, and even 500 km / h depending on the frequency band), while being optimized for EU speeds low (between 0 and 15 km / h). The effect of intra-system handovers (mobility procedure between two LTE cells) on voice quality is less than in GSM, or equivalent. The system also includes mechanisms that optimize delays and packet loss during an intra-system handover.

1.6.7 Adaptive modulation and coding:

4G mainly uses QAM (Quadrature Amplitude Modulation) with 16 states. This modulation makes it possible to double the transfer capacity compared to the modulation used for UMTS, QPSK (Quadrature Phase Shift Keying) which is based on two carriers of the same frequency phase shifted by 90 degrees, i.e. 4 states of information. For its part, the 16-QAM combines two amplitude levels with two quadrature carriers, i.e. 16 information states, each of these modulations is used for a specific link such as [14]:

- Downlink modulations: QPSK, 16QAM and 64QAM.
- Uplink modulations: QPSK and 16QAM

1.7 The Interfaces of LTE:

The LTE / SAE system consists of several internal interfaces and with the other 2G / 3G systems.

1.7.1 Interface Uu:

Interface between user equipment and the UTRAN access network. It allows communication with UTRAN via CDMA technology [15].

1.7.2 Interface S1:

- **S1-MME:** Reference point for the control plane protocol between E-UTRAN and MME.

- **S1-U:** Reference point between E-UTRAN and Serving GW for the per bearer user plane tunneling and inter eNodeB path switching during handover [15].

1.7.3 Interface X2:

The X2 interface defines the connection between the eNodeB elements. It is intended for inter-eNodeB Handover procedures, as well as for the management of signaling of inter-cell radio resources and the signaling of interface management. [15].

1.8 LTE Channel:

The LTE system uses the channel concept to identify the types of data transported over the radio interface, the associated quality of service characteristics, as well as the physical parameters related to the transmission. There are three classes of channels, depending on the layers of the OSI model to which they are attached.

1.8.1 The logical channels:

The RLC/MAC block is the basic transport unit on the radio interface that is used between the mobile and the network. It is used to carry data and RLC/MAC signaling [16].

1.8.2 The transport channels:

It made to manages all the signaling necessary for their allocation the data either user or plan (i.e. the MAC layer) [16].

1.8.3 The physical channels:

Generally, it offers the different features that characterize the physical characteristics such as band width, antenna type martials, channel access, radio frequency processing and so on. [16]

1.9 LTE-Advanced:

In LTE-Advanced focus is on higher capacity: The driving force to further develop LTE towards LTE–Advanced was to provide higher bitrates in a cost efficient way and, at the same time, completely fulfil the requirements set by ITU for IMT Advanced, also referred to as 4G.

-Increased peak data rate, DL 3 Gbps, UL 1.5 Gbps

-Higher spectral efficiency, from a maximum of 16bps/Hz in R8 to 30 bps/Hz in R10

-Increased number of simultaneously active subscribers

-Improved performance at cell edges, e.g. for DL 2x2 MIMO at least 2.40 bps/Hz/cell.

The main new functionalities introduced in LTE-Advanced are Carrier Aggregation (CA), enhanced use of multi-antenna techniques and support for Relay Nodes (RN). [17]

1.9.1 Carrier Aggregation:

Carrier Aggregation is an important characteristic which has given a plus for the standardization of LTE-Advanced. In the upstream or downlink carrier aggregation, the carriers in the frequency bands are contiguous or non-contiguous can be grouped together. Each aggregated carrier is considered to be a set of carriers. This set can have a bandwidth of 1.4, 3, 5, 10, 15 or 20 MHz, and a maximum of five constituent carriers can be combined. Hence the maximum bandwidth is 100MHz.

The best way to organize aggregation is to use contiguous constituent carriers in the same frequency band, called **contiguous intra-band**. This may not always be possible, due to frequency allocation scenarios. For **non-contiguous** allocation, it could either be **intra-band**, i.e. the constituent carriers belong to the same operating frequency band, but are separated by a frequency interval, or it could be **inter-band**, in in this case, the constituent carriers belong to the operating frequency of different bands [17], see figure below.

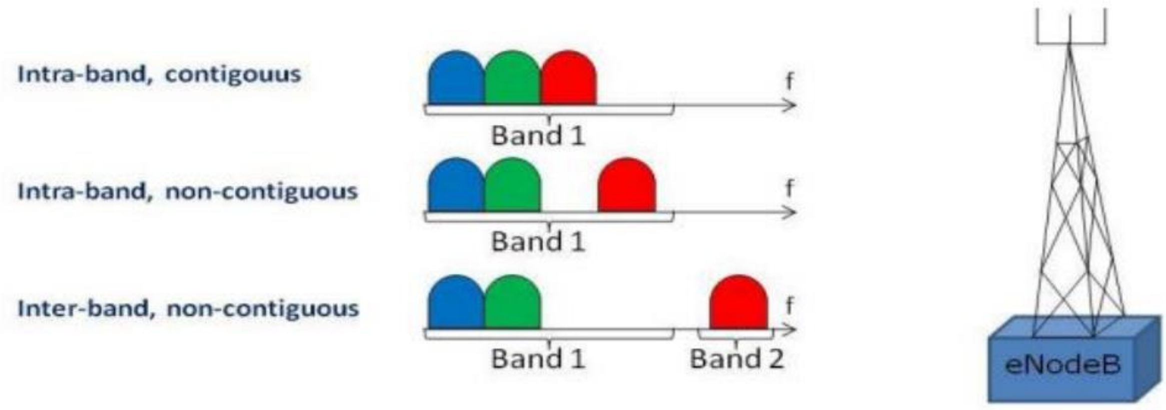

Figure 6 LTE-Advanced different type assemble Carrier Aggregation [17].

1.9.2 MIMO:

in LTE-Advanced by the introduction of the MIMO 8x8 system in the DL (DownLink) and 4x4 in the UL (UpLink). The MIMO technique can be used when S / N (signal / noise ratio) is high. For situations with low S / N, it is preferable to use other types of multi-antenna techniques, for example by means of TX-diversity [18].

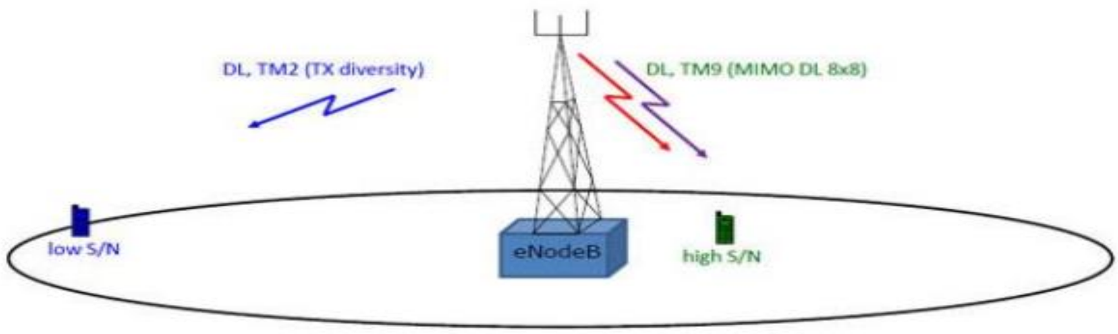

Figure 7: MIMO is recommended for high S / N and TX diversity is preferably used for low S/N [18].

1.9.3 Coordinated MultiPoint (CoMP):

LTE CoMP or Coordinated Multipoint is an installation which is developed for LTE - Advanced, most installations are still under development and may change as standards define the different elements of CoMP more precisely. LTE CoMP is essentially a range of different techniques that allow dynamic coordination of transmission and reception over a variety of different base stations [18]. The objective is to improve the overall quality of the user as well as improving the use of the network.

Essentially, LTE Advanced CoMP transforms inter-cell interference, HERE, into a useful signal, especially at the cell boundaries where performance can be degraded.

- **Principle of LTE CoMP**

The CoMP transmission and reception databases actually designate a wide range of techniques which allow the coordination of transmission and reception with several geographically and dynamically separate eNBs. Its aim is to improve overall system performance, and use resources more efficiently and to improve the quality of service for the end user.

One of the key parameters for LTE as a whole, and in particular 4G LTE Advanced is the high data rates that are achievable. These rates are relatively easy to maintain near the base station, but as the distances increase, they become more difficult to maintain.

Obviously, the edges of the cell are the most difficult. Not only is the signal lower in strength because of the distance between the base station (eNB), but also interference levels from neighboring eNB are likely to be higher as the EU will be closer to them.

4G LTE CoMP, requires close coordination between a number of geographically separate eNBs. They coordinate dynamically to provide planning and transmission of joints as well as evidence of common processing of received signals. In this way, a UE at the edge of a cell is capable of being served by two or more eNBs to improve the reception and transmission signals and to increase the bit rate in particular under edge conditions of the cell [37].

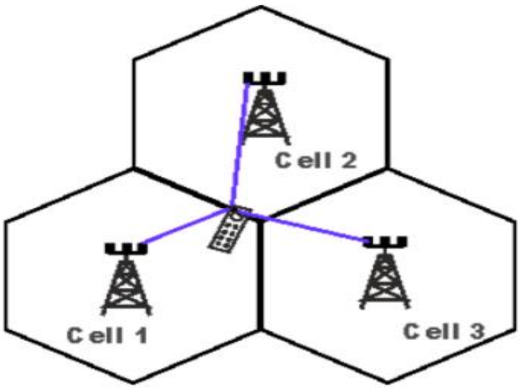

Figure 8: Concept of LTE Advanced COMP "Coordinated Multipoint"[37].

1.9.4 Heterogeneous Network (HetNet):

Heterogeneous networks, often called HetNet (Heterogeneous Network), do not mention a specific technology, but they correspond to the technique of multilayer deployment. In other words, several access techniques, several cell formats, several types of coverage are implemented in the same deployment area. The need arises from the fact that most deployment areas have a certain degree of heterogeneity in terms of speed coverage requirements, delay, etc. Indeed, a macro cell makes it possible to achieve the largest coverage radius, a Pico cell or

Femto cell is characterized by a smaller coverage area, so it serves fewer subscribers which obeys the capacity constraint.

The idea is therefore to deploy several cell formats in the same area, to guarantee both:

- Capacity: by setting up a hotspot layer composed of several small cells (Pico / Femto) and relay nodes, these are less expensive, easy to install and they also provide coverage to the inside users' buildings (offices, houses, etc.)

- Coverage: using a macro cell capable of extending coverage in the entire area. A user can connect to a HetNet type network according to the technology that best meets their needs: ad hoc, Wi-Fi, etc. HetNet therefore consists of a macro station which cooperates with several small cells of reduced size by transparently in order to increase network capacity and coverage. [38]

1.10 Self-Organizing Networks:

This technique is used to manage and coordinate multiple small and large cells, in terms of automatic cell installation and maintenance, minimization of interference, which can simulate adjacent cells, detect areas of weakness in the network and apply appropriate solutions, It wil allow rapid deployment of new BTS, Unlike previous generations detect the transport link and establish a connection with the elements of the core network, for example minimizing drop call rate, or maximizing handover success rate [39].

1.10.1 Architectures SON:

Self-Organizing Networks can be divided into three classes:

1.10.1.1 Centralized SON:

In Centralized SON, optimization algorithms are executed in the OAM System. In such solutions SON functionality resides in a small number of locations, at a high level in the architecture. Figure 9 shows an example of Centralized SON [19].

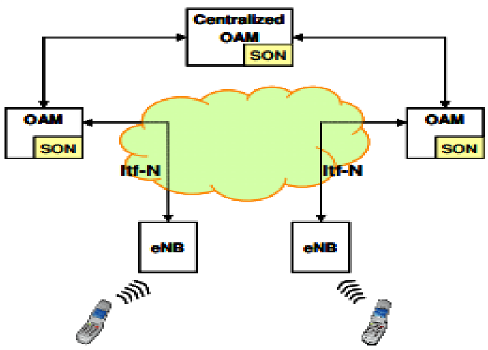

Figure 9:Centralized SON Exemple.[39]

1.10.1.2 Distributed SON

In Distributed SON, optimization algorithms are executed in eNB. In such solutions SON functionality resides in many locations at a relatively low level in the architecture. Figure 10 shows an example of Distributed SON [19].

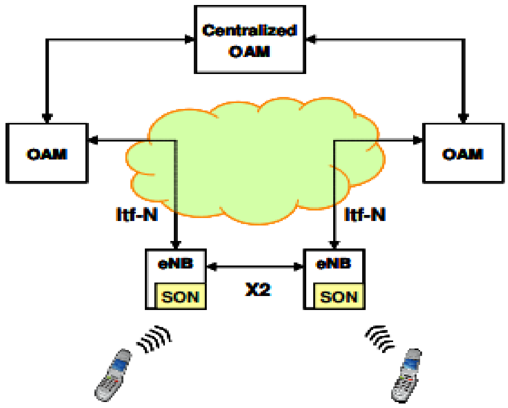

Figure 10 : Distributed SON Example. [39]

In Distributed SON, all SON functions are located in eNB, so it causes a lot of deployment work. And it is also difficult to support complex optimization schemes, which require the coordination of lots of eNBs. But in Distributed SON it is easy to support those cases, which only concern one or two eNBs and require quick optimization responses. For Distributed SON, X2 interface needs to be extended.

1.10.1.3 Hybrid SON:

In Hybrid SON, part of the optimization algorithms is executed in the OAM system, while others are executed in eNB. Figure 11 shows an example of Hybrid SON. In Hybrid SON, simple and quick optimization schemes are implemented in eNB and complex optimization schemes are implemented in OAM. So it is very flexible to support different kinds of optimization cases. And it also supports the optimization between different vendors through X2 interface. But on the other hand, it costs lots of deployment effort and interface extension work [19].

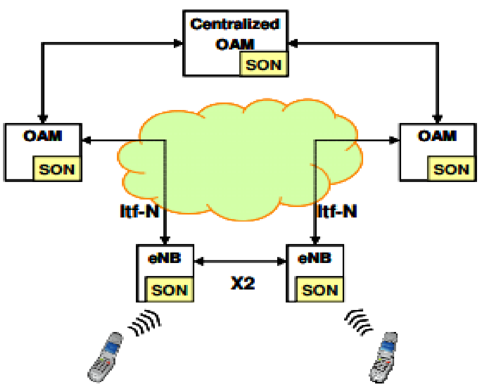

Figure 11: Hybrid SON Example. [39]

1.10.2 Main Functionality of SON:

The main functionality of SON includes: self-configuration, self-optimization and self-healing.

1.10.2.1 Self-configuration:

Self-configuration process is defined as the process where newly deployed nodes (eNBs) are configured by automatic installation procedures to get the necessary basic configuration for system operation. Self-configuration process works in preoperational state, which starts from when the eNB is powered up and has backbone connectivity until the RF transmitter is switched on. self-configuration includes two stages: basic setup and initial radio configuration. The whole procedure is shown in Figure 12 [19]:

- An IP address is allocated to the new eNB and the information of the Self-Configuration Subsystem of OAM (Operation and Management) is given to the eNB.
- A GW is configured for the new eNB so that the eNB can exchange IP packets with other internet nodes.
- The new eNB provides its information, including type, hardware and etc., to the Self-Configuration Subsystem for authentication. Necessary software and configuration data are downloaded from the Self-Configuration Subsystem.
- The new eNB is configured based on the transport and radio configuration data.
- The new eNB connects to the normal OAM subsystems for other management functions.
- S1 and necessary X2 interfaces are established.

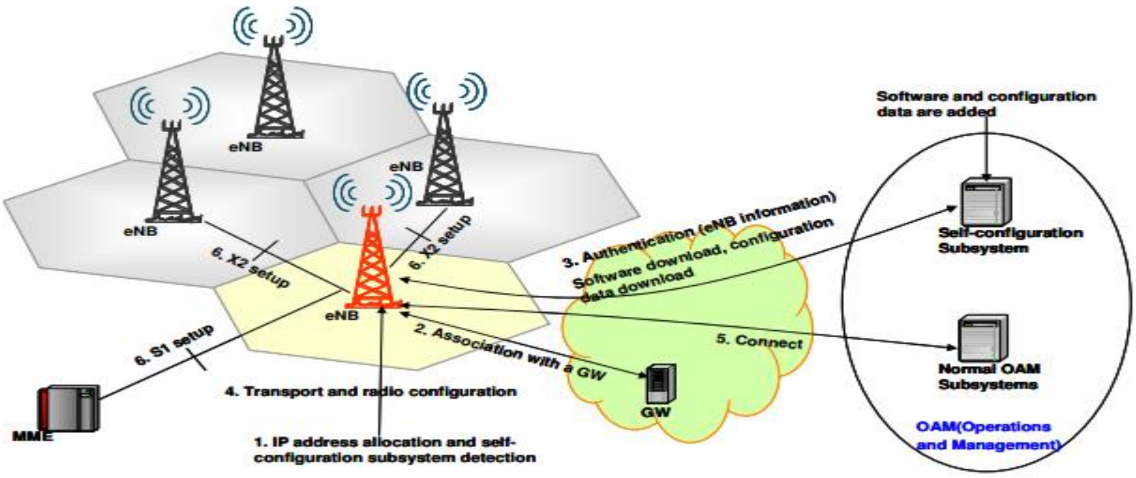

Figure 12:Self-configuration Procedure . [39]

1.10.2.2 Self-optimization

Self-optimization process is defined as the process where UE & eNB measurements and performance measurements are used to auto tune the network. This process works in operational state, which starts when the RF interface is switched on. The self-optimization process collects measurement information from UE and eNB and then with the help of external optimization tool, it auto-tune the configuration data to optimize the network. A typical example is neighbor list optimization [19].

1.10.2.3 Self-healing

Self-healing function aims at automatic detection and localization of most of the failures and applies self-healing mechanisms to solve several failure classes, such as reducing the output power in case of temperature failure or automatic fallback to previous software version [19].

1.11 Conclusion

In this chapter, we have presented an overview of the various components and characteristics of LTE technology. Then, we go deeply into the different recent LTE technologies and Finally we define Het-Network and Self Organizing Networks.

2 Study the Handover algorithm in LTE

2.1 Introduction:

LTE mobile technology has been increasingly deployed in the past decade, offering higher multimedia service, greater security and convenience than traditional services of mobile network. Although channel throughput's quality heavily affects a mobile network system's performance, prior research on evaluating quality is limited. Quality is a critical issue in mobility and security, especially in adverse scenarios involving high dense, high speed, outdoor environment and so on.

This chapter analyzes what factors negatively impact user connectivity in the whole LTE network (i.e., This is done so that a user in communication does not lose his current connection, while reducing the latency caused by the cell change in order to meet the deadlines required by real-time traffic.), how to ensure it, and which exiting protocols are established into LTE systems. Technically, to ensure this grantee of service in these challenges, the mobile network performs a mechanism, called Handover, which switches the EU to the best cell that can accommodate it. This mechanism is generally based on radio measurements carried out by the EU on the waiter cell and neighboring cells. The network then chooses, essentially based on these measurements, the target cell and the way to switch the EU to this cell. A review of the state of the art in these matters gives an overall framework for the challenges of user mobility in LTE network and the different mechanisms of Handover belong in the LTE.

2.2 Mobility within the LTE:

Connected mode refers to a situation where the UE has an active signaling connection with the network. The location of the UE is known with the precision of a cell, and it does not have to be paged to be reached. Mobility in the connected mode is managed by a HANDOVER process. This section begins with the introduction of general types of transfer. The measurement model used to provide the eNodeB with the measurements is discussed next. After the measurements, the transfer processes of transfers X2 and S1 are described with complete signaling diagrams [20].

The S1 inter-cell transfer procedure is carried out between two eNBs without the X2 interface. X2 transfer is used when direct connectivity between source and target eNBs exists. X2 transfer is faster.

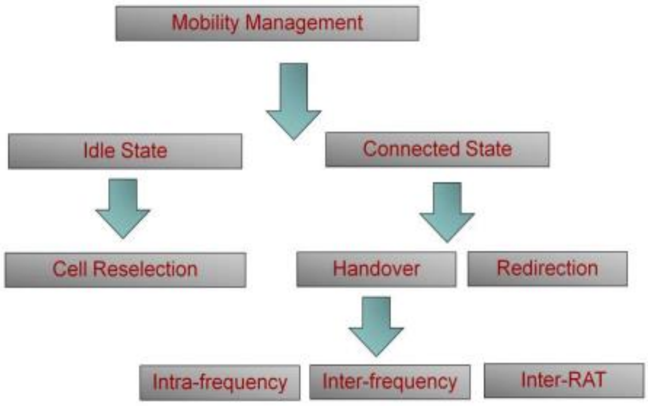

Figure 13: Mobility within the LTE. [20]

2.2.1 IDLE states:

A UE which is energized but does not have an RRC connection to the radio network, is defined as being in IDLE mode. In the case of IDLE mode management, the eNodeB sends Configurations by information from the broadcasting system, and therefore selects appropriate cells [40]. IDLE mode management can increase the success rate of access, improve the quality of service and ensure that UE campaigns on cells with good signal quality.

Cell Reselection:

If the user does not have an RRC connection to the radio network, the network can Use the S1 interface procedure to move the user into RRC_IDLE, E-UTRAN relies on the UE to detect adjacent cells where the user can rely on the measurements of the source cell and delete its measurements if they meet the necessary criteria and the UE will simply analyze all possible carrier frequencies (Intra-frequency- Inter-frequency) [21].

2.2.2 Connected States:

2.2.2.1 Handover:

The Handover is an essential mechanism which ensures mobility in an LTE network and its main function is to maintain the Quality of service weather the user dancing in the cell network. The idea behind this is simple: when a UE loses radio coverage of source eNodeB as it approaches other eNodeB radio coverage, a new connection must be established on that new base station and the connection with the old must be canceled. Consequently, the transfer generally occurs when the service eNodeB signal deteriorates, which causes poor quality of communication between UE and the network.

In addition, handover may be necessary to promote network load balancing even if the signal strength and quality of the current base station are good. Performing handover process are the need for UE for better QoS, lower costs, more bandwidth, etc., which can lead UE to seek base stations offering better conditions of service [22].

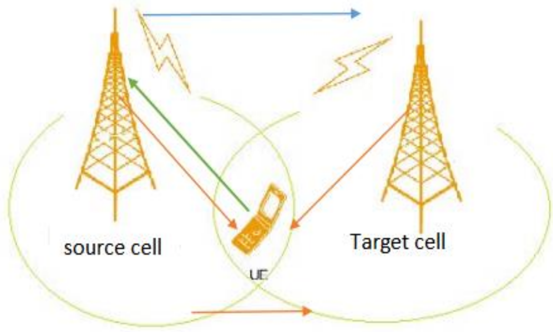

Figure 14: Handover decision and execution. [22]

2.2.2.2 Handover phases:

This section presents the steps for carrying out a Handover in general, that is to say without addressing the specific features of the LTE system. These will be described in the section "The Handover within the LTE system". We can distinguish three phases in the realization of a Handover [6]:

- the measurement phase on the serving cell and on neighboring cells, the eNodeB uses the RRC connection reconfiguration message to provide the measurement configuration to the UE and waits for a measurement report from the UE.
- the preparation phase of the target cell, which involves exchanges between the source and destination base station controllers, as well as between these controllers and the core network, the eNodeB verifies the measurement results reported by the EU and determines whether to initiate a transfer.
- the execution phase, that is to say the switching of the UE and of the data flows, then the release of the resources in the original cell, the eNodeB controls the procedure for transferring the UE to the target cell according to the decision, to execute the transfer.

2.2.2.3 Types of Handover inside LTE:

Transfers can be classified by the target system, frequency or by the method they execute. Intra LTE transfers include transitions to the same or different carrier frequency in an LTE system. These can further be classified in the following cases [20]:

- Intra-eNodeB transfer refers to a case where the source and target cell reside in the same eNodeB. In this case, no X2 procedure is required to deliver.

- Inter eNodeB transfer represents a situation where the two target cells are located in two different eNodeBs. This case assumes that MME will not change following the transfer. S-GW may or may not be relocated. X2 or S1 the transfer process must be started.

- Inter eNodeB transfer with MME change. The X2 transfer process cannot handle an MME relocation, so the S1 procedure must be used instead.

2.2.2.4 Handover trigger scenario:

The following table shows the trigger scenarios in relation to the type of Handover:

Handover type		**Measurement trigger**
Cover Base	**intra-frequency**	The measurement configuration is performed when UE establishes a radio carrier, UE performs an intra-frequency measurement by default
	inter-frequency **inter-RAT**	The eNodeB delivers the measurement configuration to 'UE' when the signal quality in the service cell is below the associated threshold
Service	**inter-frequency** **inter-RAT**	ENodeB initiates measurements after finding that only the voice service works on the UE
UL Quality of Service	**inter-frequency** **inter-RAT**	ENodeB initiates measurement after detecting insufficient UL power at UE
Distance	**inter-frequency** **inter-RAT**	Measurements are triggered by distance if they exceed the specific threshold

Table 2:The different types of Handover.

2.2.2.5 Handover signal measurements:

2.2.2.5.1 Reference Signal Received Power (RSRP):

RSRP is the most basic measurement made by the physical layer of the UE, making it possible to obtain an average value of the power received from the reference signal (RS) transmitted by the base station by RE (Resource Element). The measurement is expressed in Watt or in dBm. The value is between -140 dBm to -44 dBm in 1db steps. [23]

Since the RS reference signal is only emitted at a given time on a single frequency band, the measurement is only carried out in this frequency band (corresponding to a RE: Resource Element). The figure 14 below shows the position of the reference signals in a RB (transmitted on symbols 1 and 5 in this figure or on symbols 0 and 4 depending on the numbering of the first symbol). [23]

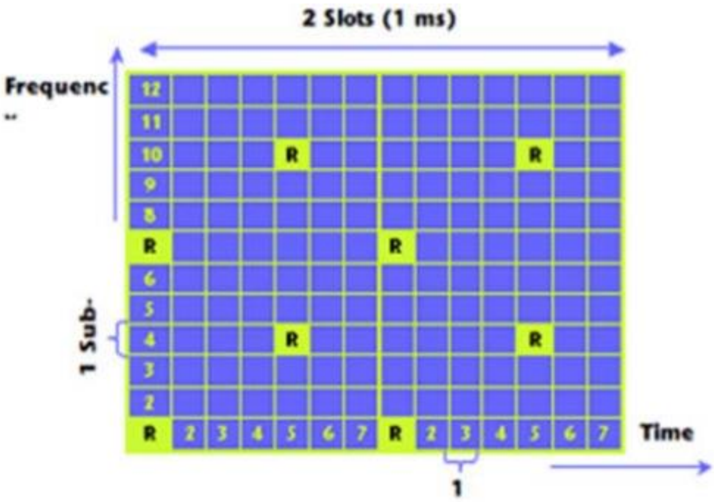

Figure 15 :Position of the reference signals in a RB (Basic Resource).

2.2.2.5.2 Reference signal reception quality (RSRQ):

Although RSRP is an important measure, it does not provide information on the amount of transmission. The LTE then relies on the RSRQ indicator, defined as the ratio between the RSRP and the RSSI (Received Signal Strength Indicator). The RSSI represents the total power of the received signal, this includes the transmitted signal, noise and interference [23].

$$\mathbf{RSRQ = 10 * Log(N *} \frac{RSRP}{RSSI}\mathbf{)}$$

(N being the number of resource block)

Measuring the RSRQ is particularly interesting at the cell boundaries, positions for which decisions must be made to complete Handovers and change cell references. The RSRQ measured varies between -19.5dB to -3dB in steps of 0.5dB. The RSRQ is only useful during communications, that is to say during the connected state. The absolute precision (intra- and inter-frequency) varies from ± 2.5 to ± 4 dB [23].

2.2.2.5.3 The Received Signal Strength Indicator (RSSI):

Signal strength on the 5 MHz band, so this is the power measured from all base stations [23]

2.2.2.5.4 Signal to interference plus noise ratio (SINR):

This measure is used to optimize the level of transmission power for a target quality of service by participating in Handover decisions. Accurate SINR provides more efficient system estimation and better user-perceived quality of service. SINR is defined as the ratio between the signal strength at combined noise and interference power:

$$\mathbf{SINR} = \frac{P_{signal}}{P_{bruit}+P_{interference}}$$

(P is the average power; the values are generally indicated in dB)

2.2.3 Handover Parameters:

The Handover procedure with parameters that are used to improve its performance and setting these parameters to optimal values is a very important task. In LTE, the triggering of the Handover is generally based on the measurement of link quality and other parameters in order to improve performance. [40] The most important are:

2.2.3.1 Handover initiation threshold level RSRP and RSRQ:

This level is used for the initiation of the Handover. When the handover threshold decreases, the probability of a late handover decreases and the ping-pong effect increases. It can vary according to different scenarios and propagation conditions to obtain better performance [41].

2.2.3.2 The hysteresis margin:

The hysteresis margin also called HO margin is the main parameter that governs the HO algorithm between two eNBs. The Handover is initiated if the quality of another link cell is better than the quality of the current link by the hysteresis value. It is used to avoid the effects of ping pong. However, it can increase remission failure as it can also prevent necessary handovers.

2.2.3.3 Time-to-Trigger (TTT):

The Handover is only triggered if the trigger condition is fulfilled during a time interval. This setting can decrease the number of unnecessary transfers and effectively avoid ping pong effects. But it can also delay the intercellular handover which then increases the probability of failures [40]

2.3 Handover Events in LTE:

2.3.1 Event A1:

The signal quality in the source cell is above a target threshold. The eNodeB stops inter-frequency or inter-RAT measurements.

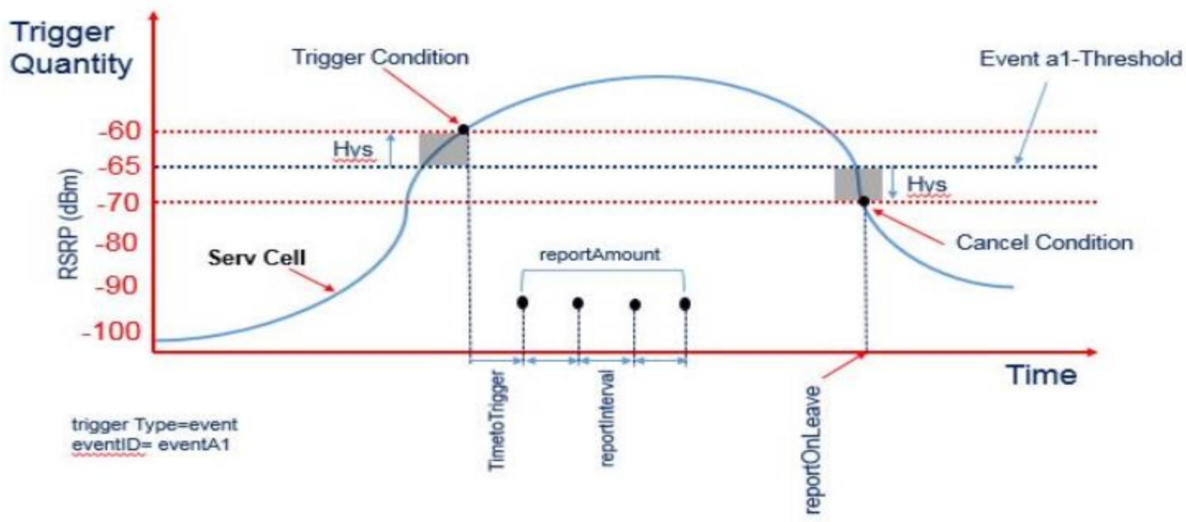

Figure 16: Event A1.

- Entering condition:

$$Ms - Hys > \text{Threshold A1}$$

- Leaving condition:

  Ms + Hys < Threshold A1

2.3.2 Event A2:

The signal quality in the cell source is below a threshold, the eNodeB starts inter-frequency or Inter-RAT measurements.

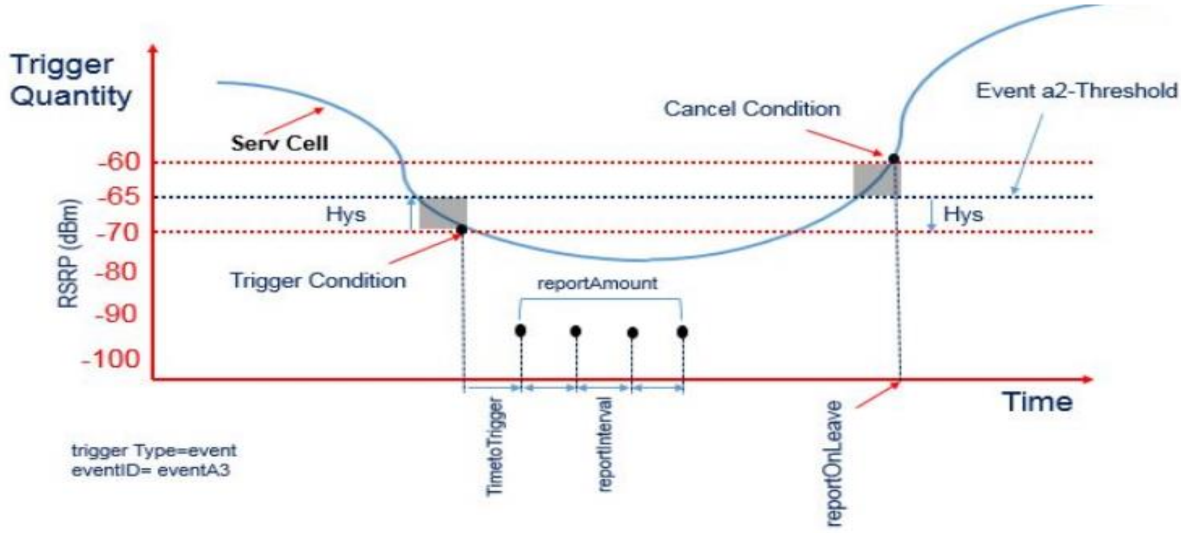

Figure 17:Event A2.

- Entering condition:

  Ms + Hys > Threshold A2

- Leaving condition:

  Ms - Hys < Threshold A2

2.3.3 Event A3:

The signal quality in at least one neighboring inter-frequency or intra-frequency eNodeB is higher than cell source. Source eNodeB sends an intra frequency or inter frequency Handover request

- Entering condition:

  Mn + Ofn + Ocn – Hys > Ms + Ofs + Ocs + Off

- Leaving condition:

  Mn + Ofn + Ocn + Hys < Ms + Ofs + Ocs + Off

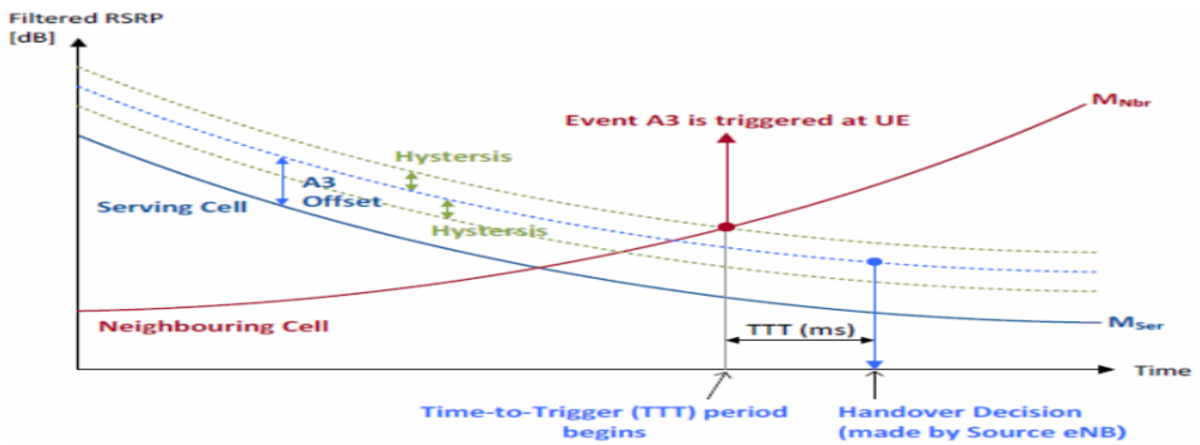

Figure 18:Event A3.

2.3.4 Event A4:

The signal quality is above a threshold specified in at least one neighboring intra-frequency cell, Source eNodeB sends an inter-frequency Handover request

- Entering condition:

  $$Mn + Ofn + Ocn - Hys > \text{Threshold A4}$$

- Leaving condition:

  $$Mn + Ofn + Ocn + Hys < \text{Threshold A4}$$

2.3.5 Event A5:

The signal quality in the cell source is below a threshold, the eNodeB starts inter-frequency or Inter-RAT measurements and The signal quality is above a threshold specified in at least one neighboring intra-frequency cell, Source eNodeB sends a request Inter frequency handover.

- Entering condition:

  $$Ms + Hys < \text{Thresh 1 and } Mn + Ofn + Ocn - Hys > \text{Thresh 2}$$

- Leaving condition:

  $$Ms - Hys > \text{Thresh1 and } Mn + Ofn + Ocn + Hys < \text{Thresh2}$$

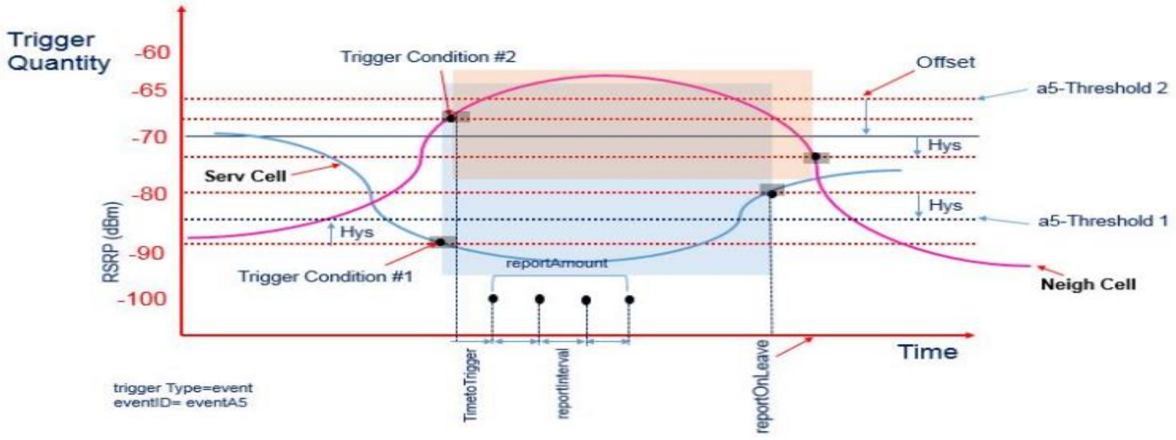

Figure 19: Event A5.

2.3.6 Event B1:

Event B1 can be used for inter-RAT handover procedures which does not depend upon the coverage of the serving cell.

- Entering condition:

  Mn + Ofn − Hys > Thresh

- Leaving condition:

  Mn + Ofn + Hys < Thresh

2.3.7 Event B2:

Event B2 is triggered when a primary serving cell becomes worse than threshold1, while a neighbor inter-RAT cell becomes better than threshold2. This can be used to trigger inter-RAT mobility procedures when the primary serving cell becomes weak. Inter-system neighbor cell measurements arc used to ensure that the target cell provides adequate coverage.

- Entering condition:

  Ms + Hys < Thresh1

  Mn + Ofn − Hys > Thresh2

- Leaving condition:

  Ms − Hys > Thresh1

  Mn + Ofn + Hys < Thresh2.

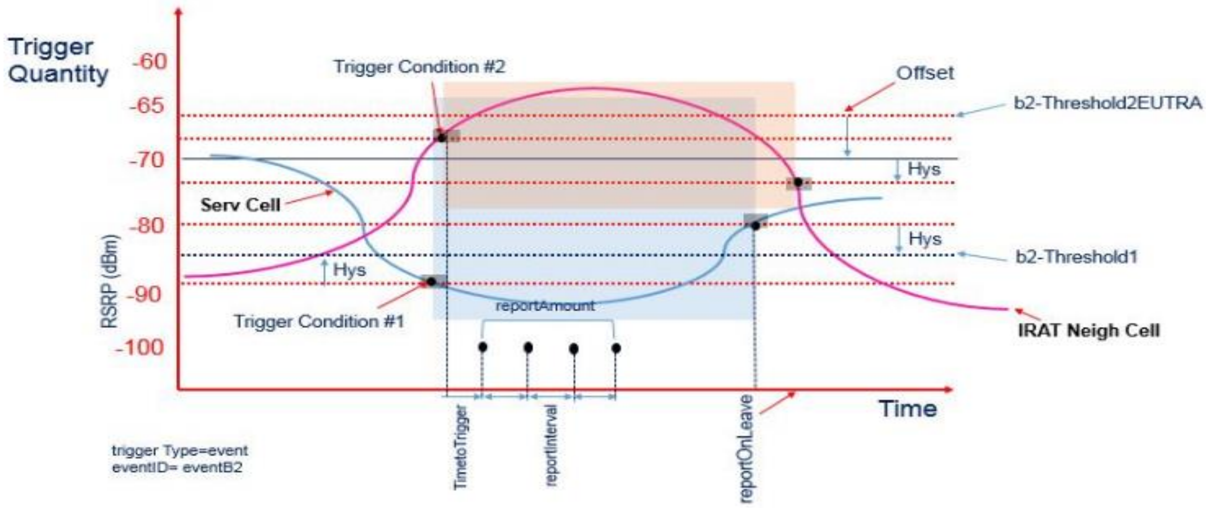

Figure 20 :Event B2.

2.4 Summary of the handover decision reviewed algorithms:

Scheme	Decision input parameters	Technique	Performance Evaluation matrices	Evaluation method	Simulator
Chen et al. [31]	P1, P2, P3 RSRP θ,D	Selecting the target cell based on the UE moving direction, cosine function, weight adjustment function and distance between UE and neighbor cells	Packet delay: reduced by 33% Packet loss: reduced by 30% Throughput: improved by 11%	Simulation	LTE-Sim
Wang et al. [32]	RSRP,RSRQ DT, CT, CF	Adding time-domain and connection frequency parameters to both UE’s mobility information history and to the mobility pattern matching	Ping-pong rate: reduced by 20% Handover failure rate: reduced by 66%	Simulation	Matlab

Lee et al. [33]	**RSRP, V** **Load balance** **Service priority**	**Adapting hysteresis threshold through weighting and normalizing of input parameters**	**Handovers failure rate: reduced by 11.1%**	**Simulation**	**Computer Simulation**
Yang et al. [34]	**RSRP,RSRQ** **V**	**Optimizing event3 by replacing TTT with statistical parameter to trigger handover Procedure**	**Handovers success rate: improved by 10.6%** **Handovers number: reduced by 35%**	**Simulation**	**Matlab**
Chen et al. [35]	**V** **Hr, Hs, Hg, Rn,**	**New technique for forwarding data transmission between DeNB and RN**	**Transmission cost : reduced by 1.2%**	**Analytical**	**-**
Tao et al.[36]	**DT, CT, CF** **P**	**Information history of UE's mobility within intelligent recognition for determining the next UE roaming cell**	**Handover latency: reduced by 40%** **Throughput: improved by 14%**	**Analytical and simulation**	**NS2**

Table 3:Summary of the handover decision reviewed algorithms .[56]

2.5 Conclusion

In this chapter, LTE handover procedures, handover decision algorithm classification are reviewed. In the overview of handover procedures, handover classification is introduced, followed by the handover entry events summary and the introduction of handover implementation. The handover control parameters are emphasized as the TTT and HO directly influence the system handover performance. In the review of handover decision algorithms, five categories of algorithm are introduced.

The A3 algorithm considers one the well-known handover decision used in LTE network which more accurate on the RSRP and TTT, but often argued due to frequent HO, high packet losses and bad user experience mostly in high-speed user equipment (UE) scenarios. In the next chapter, we propose a new handover algorithm that deal with context-aware parameters such as UE travelling speed, received power filtering and HO failure probability. Detailed simulation results are provided to highlight the impact of UE speed, and time-to-trigger (TTT) parameters on the HO performance. We show that the for a given UE speed can effectively reduce the number of HOs, improve UE throughput, and lower the chance of ping-pong HOs and HO failures with low complexity.

3 LTE Handover Parameters Optimization

3.1 Introduction:

One of the main factors affecting the performance of the Handover A3 event, and Handover failures due to the unreliability of the RLF radio link failure, and ping-pong, are the errors most possibly to occur related to the user or rather related to the user's speed. Reducing the number of unnecessary Handover, including ping-pong, too early Handover and too late Handover by adjusting Time To Trigger (TTT HO) parameters, as well as reducing the number of packets to /and from the user to avoid loss of the transmitted information.

The eNodeB gather the statistics of handovers too late handovers, RLF, too early handovers, ping-pong and calculate handover rate then changes hysteresis and TTT values According to information collected from the user, these statistics constantly seek to improve network performance in an automated manner. As well as The expert interfering to choose the necessary conditions in the algorithm to reach satisfying results for the user. In this work, we study many scenarios compared to a traditional A3 HO event with our Ho Algorithm of Adaptive Hys and Time To trigger for LTE network in all possibly speed vehicles.

3.2 Handover Failures:

The handover procedure depends on the handover parameter threshold value. In some cases, the configuration of these parameters is unsuitable, and results in Handover failures, the sequence of Handover failures leads to RLFs. Therefore, these failures force the UE to reconnect with the serving cell or with the nearest neighbor cell and restart the handover procedure again. In this subsection, we define the topics of handover failures as follows:

3.2.1 Too-early handovers:

These types of failures occur when the handover procedure is triggered at the incorrect time, too early (i.e. low value of TTT). Radio link failure occurs in the target cell after a handover has been completed, and the UE attempts to re-establish its radio link in the source cell. Alternatively, radio link failure occurs in the target cell during the handover procedure, and the UE attempts to re-establish its radio link in the source cell. [25] (Figure 21 illustrates this case more clearly). if a handover is triggered too early it uses the network resources in an inefficient way and an UE does not succeed to connect to the target network.

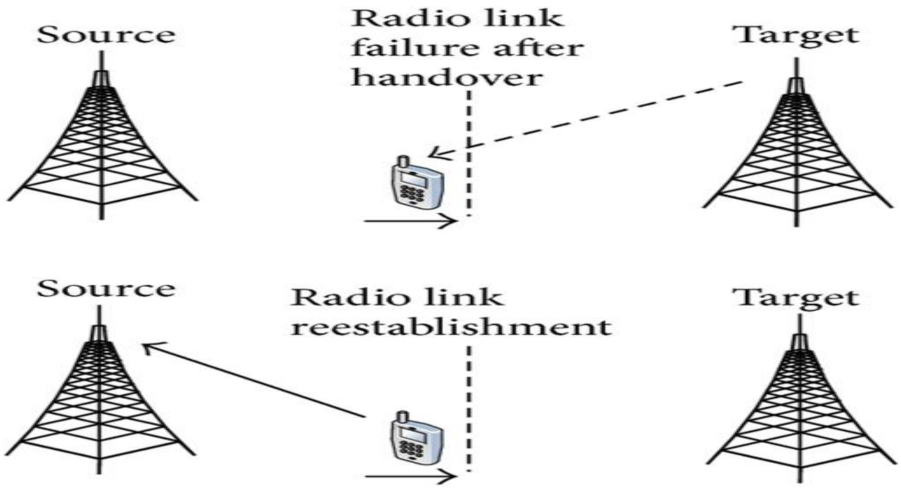

Figure 21 : Handover too early.

3.2.2 Handover Too Late:

Radio link failure occurs in the source cell before a handover was initiated, and the UE attempts to re-establish its radio link in another cell. Alternatively, radio link failure occurs in the source cell during the handover procedure, and the UE attempts to re-establish its radio link in the target cell. [26] (Figure 22 illustrates this case more clearly)

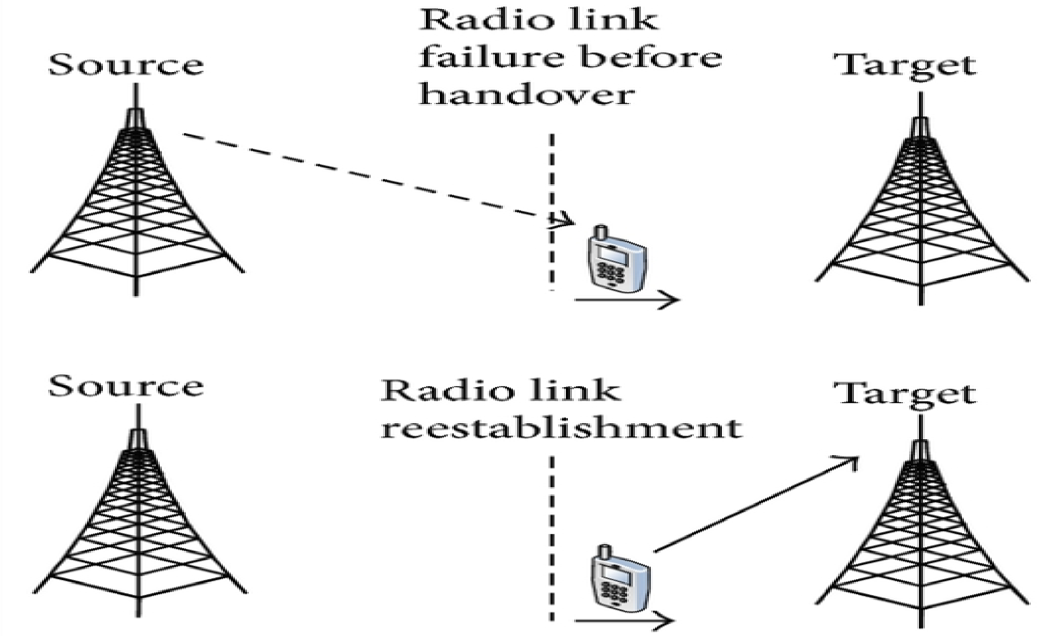

Figure 22 :Handover too late. [54]

3.2.3 handover to the wrong cell:

Radio link failure occurs in the target cell after a handover has been completed, and the UE attempts to re-establish its radio link in a cell which is not the source cell nor the target cell. Alternatively, radio link failure occurs in the target cell during the handover procedure, and the UE attempts to re-establish its radio link in a cell which is not the source cell nor the target cell. [27] (Figure 22 illustrates this case more clearly)

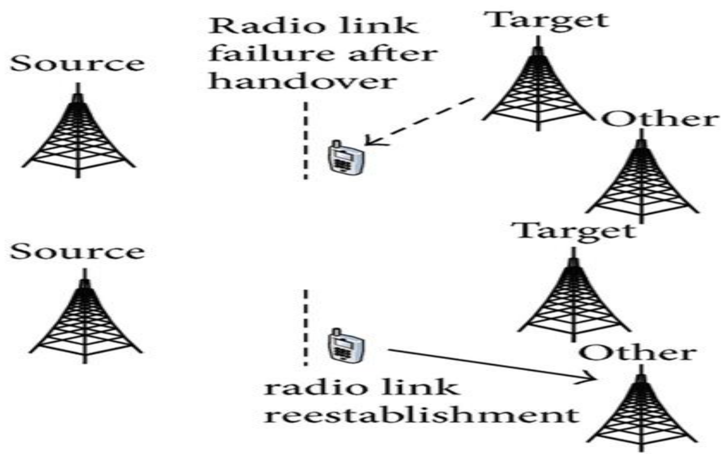

Figure 23:Handover to the wrong cell.[54]

3.2.4 Ping-pong handover:

This type of failure occurs when the UE is located on the edge of serving cell, thus intersecting with the edge of the target cell in the overlapped area and vice versa. In this situation, the UE hands off to the target cell and stays in the target cell for less than 5 s and then returns back to the previous cell. [28]

3.3 Presentation of the NS-3 software: [24]

The NS3 simulator was created in 2006 by students at the University of Washington (Thomas R, Henderson and Summit Roy). The NS3 is a powerful research tool for studying protocol design and interactions, and large-scale performance issues, its design is oriented towards community and open source software development practices to encourage community participation. research and general education.

The NS-3 was written from scratch. Designed to improve scalability, modularity, coding style and documentation. Its kernel and its models are implemented in C ++, but with a Python script interface, built as a library which can be static or dynamic linked to a main C ++ program which defines the simulation topology and starts the simulator. NS-3 also exports almost all of its API for Python, allowing Python programs to import a "ns3" module in the same way that the ns-3 library is linked by executables in C ++.

Under the terms of GNUGPLv2; being open-source the project strives to maintain an open environment for researchers to contribute and share their software. The ns-3 system uses several components of the GNU "toolchain" for development, for example: gcc, GNU binutils, and gdb. It only works under a Linux type environment. For those running Windows, there are environments that simulate the Linux environment to varying degrees. A compilation set can be generated to allow a python script to interact with the NS-3 API which will normally be accessible from a C ++ script.

3.3.1 NS3 simulator modules:

- **Core module:**
  Which allows you to create a hierarchical class structure that derives from the base object class. and this basic module is independent, among which: object aggregation, active registration (Type ID) with public attributes ... etc.

- **Common module:**
  Allows you to manage the actions related to the transmission and reception of packets, centered on the Packets class used for network simulation at the packet level are use allows to optimize memory management by using the copy / paste method The most of the other modules use its functionality.

- **Simulator module:**
  Allows you to manage the simulation of events, it explicitly provides for the possibility of planning them at different times and then executing them. The Time class represents simulated time at high resolution using an integer of 128 bits, and this class is the most important class of the simulator.

- **Mobility module:**
  This module makes it possible to define the position of the nodes and associates a movement model with the agents of the simulation.
- **Helper module:**
  This model can be considered as a high level conditioning. It facilitates the construction of complex simulation scenarios and the installation of different modules in different agents.
- **Application module:**
  Some applications are integrated and provided by NS3. They are installed in the nodes and can be started / stopped at specific times in the simulation.
- **Devices module:**
  Components of this type represent network devices and transmit packets over a virtual channel to other instances of the same NetDevice class.
- **Routing Module:**
  Two routing algorithms are available in NS3. The first called GlobalRouter, uses static routes and the second implements the OLSR protocol for dynamic ad-hoc networks.

Figure 24 illustrates the basic modules of NS-3:

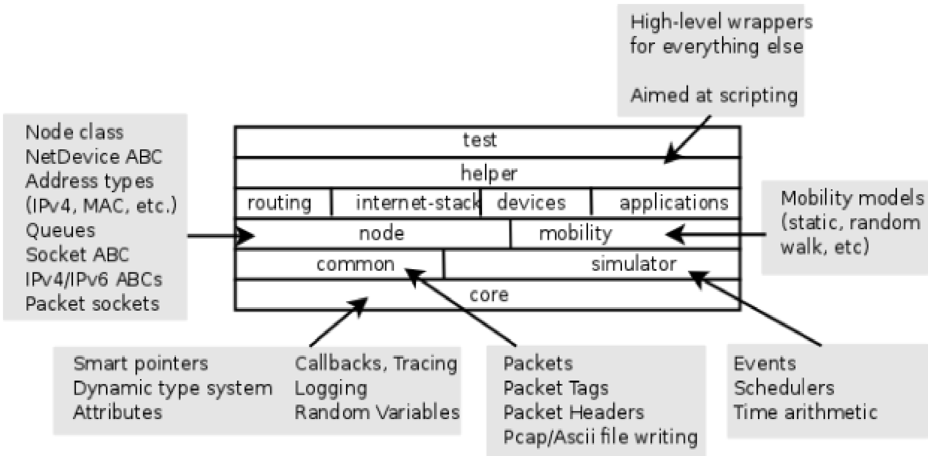

Figure 24 : NS3 simulator modules.

3.4 Project Simulation Script Structure:

In this section, an overview of the NS-3 network simulation script which has been used to create our LTE network topology using the Ns-3 LTE-EPC module. The network topology consists of a specific number of eNBs (six eNBs), constant number of users (one user), which can be change depend on running case. Most of the utilities described in the design documentation of the LTE-EPC module will be used giving more emphasis on how we will evaluate our LTE network rather than the design of the LTE-EPC module itself. Our simulation script is written in C++ program language and we will use figures that show an overview of the commands we used.

3.4.1 Basic Simulation Program:

To verify the proposed HO algorithm, simulations were conducted using the NS-3 network simulator with the LTE module [55]. As the LTE link module is already available for ns-3, we used the LTE scratch link module Lena-LTE, and we have implemented the LTE measurement reporting and handover parameter configuration procedures in ns-3. For this simulation, a topology shown in Figure is used. Other simulation parameters are very similar to those used in the baseline LTE-NS3.

3.4.1.1 eNB configuration:

For example, the transmission power is set to 43 dBm for all cells. Some parameters for ns-3 simulations are summarized in figure. Because ns-3 performs a link-level simulation in detail, it takes a long time to simulate? h of network operation. In ns-3 simulations, we shortened the simulation time to 5 min.

- Implement an EPC based on Point-to-Point links: use Point-to-Point links for the connection between the eNBs and SGW (S1-U interface) and among eNBs (X2-U and X2-C interface).
- Ltehelper: this will instantiate some common objects (e.g., the channel object) and provide the methods to adds eNBs and UEs and configure them.
- Mobility: configure the mobility model for all the nodes (for each eNB is constant position mobility).
- number of eNB: is consists 6 eNBs .
- inter site distance: distance between adjacent eNBs sites. (100 m).
- Epc: enable EPC mode.
- Transmission power for each eNB which has a constant value of 43 dBm
- EUTRA band selection: the selection of the working frequency of the propagation model has to be done with the standard ns-3 attribute system by means of the DlEarfcn and UlEarfcn (100 MHz and 18100 MHz respectively).
- eNB bandwidth: configure to 25 MHz in both of them.

```
Ptr<LteHelper> lteHelper = CreateObject<LteHelper> ();
Ptr<PointToPointEpcHelper> epcHelper = CreateObject<PointToPointEpcHelper> ();
lteHelper->SetEpcHelper (epcHelper);


/*-------------------------config eNDB-----------------------------------------------*/
Config::SetDefault ("ns3::LteEnbPhy::TxPower", DoubleValue (eNodeB_txPower)); // power of ENDB
Config::SetDefault ("ns3::LteEnbPhy::NoiseFigure", DoubleValue (2));//
lteHelper->SetEnbDeviceAttribute ("DlEarfcn", UintegerValue (100)); //2120MHz
lteHelper->SetEnbDeviceAttribute ("UlEarfcn", UintegerValue (18100)); //1930MHz
lteHelper->SetEnbDeviceAttribute ("DlBandwidth", UintegerValue (25)); //5MHz
lteHelper->SetEnbDeviceAttribute ("UlBandwidth", UintegerValue (25)); //5MHz
Config::SetDefault ("ns3::LteEnbRrc::HandoverJoiningTimeoutDuration", TimeValue (MilliSeconds(200))); //200
Config::SetDefault ("ns3::LteEnbRrc::HandoverLeavingTimeoutDuration", TimeValue (MilliSeconds(500))); //500
```

```
MobilityHelper mobility;
mobility.SetMobilityModel ("ns3::ConstantPositionMobilityModel");
mobility.SetPositionAllocator (positionAlloc);
mobility.Install (enbNodes);
```

Figure 25 :eNB configuration and mobility in NS3.

3.4.1.2 user Configuration:

The active UE measurement configuration in a simulation is dictated by the selected so called "consumers". To select it create Users is defined to take some parameters:

- -the power TX
- -Attach user to eNB.
- -Configure mobility user model which is «Constant Velocity Mobility Model.
- -Ltehelper.
- -Number of users consists (1 user).

```
*/-----------------------------------UE configure ------------------------------------
Config::SetDefault ("ns3::LteUePhy::TxPower", DoubleValue (24));
Config::SetDefault ("ns3::LteUePhy::NoiseFigure", DoubleValue (9));
Config::SetDefault ("ns3::LteUePhy::EnableUplinkPowerControl", BooleanValue (true));
Config::SetDefault ("ns3::LteUePowerControl::ClosedLoop", BooleanValue (true));
Config::SetDefault ("ns3::LteUePowerControl::AccumulationEnabled", BooleanValue (true));
```

Figure 26 :User configuration in NS3

3.4.1.3 Handover Configuration:

Handover procedure can also be triggered "automatically" by the serving eNodeB of the UE. The logic behind the trigger depends on the handover algorithm currently active in the eNodeB RRC entity. Programmer may select and configure the handover algorithm that will be used in the simulation. In this simulation the type of handover algorithm used is the "Strongest Cell" handover algorithm named as "A3 RSRP handover algorithm".

```
//------------------------------------algorthihm (A3)----------------------------------------
  lteHelper->SetHandoverAlgorithmType ("ns3::A3RsrpHandoverAlgorithm");
  lteHelper->SetHandoverAlgorithmAttribute ("Hysteresis", DoubleValue (3));
  lteHelper->SetHandoverAlgorithmAttribute ("TimeToTrigger", TimeValue (MilliSeconds (TimeToTriggerr)));//256
```

Figure 27 :A3 configuration TTT and Hys in NS3.

In a3 algorithm, the value of time TTT and Hys are fixed, and their value is given by the expert, this is not consistent with the nature of the user's movement, the adaptation of the TTT and Hys values must be taken into account together the user speed.

3.5 structure general of scenarios with algorithm A3:

In 4G standard has determined the various parameters of the LTE network. One of these most common parameters is the TTT, in order to allow users to have continuity of service, i.e. a safer handover. The 4G organization has set up conditions on the two signals received by the EU, it is applicable on the serving cell and the neighboring cell as indicated below:

$$\mathbf{RSRP\ n > RSRP\ s + hysteresis} \quad \mathbf{(1)}$$

3.5.1 Structure general of scenario Existing:

The handover procedure in the LTE is based on the measurements of the UE user equipment, Handover’s decisions are generally based on downlink channel measurements which consist of Reference Signal Received Power (RSRP) made in the EU and sent to eNB regularly. LTE Event A3 is triggered when a neighboring cell becomes better than the serving cell. The event is triggered when condition (1) is met. The algorithm awaits the duration of the TTT, then Handover occurs. [30]

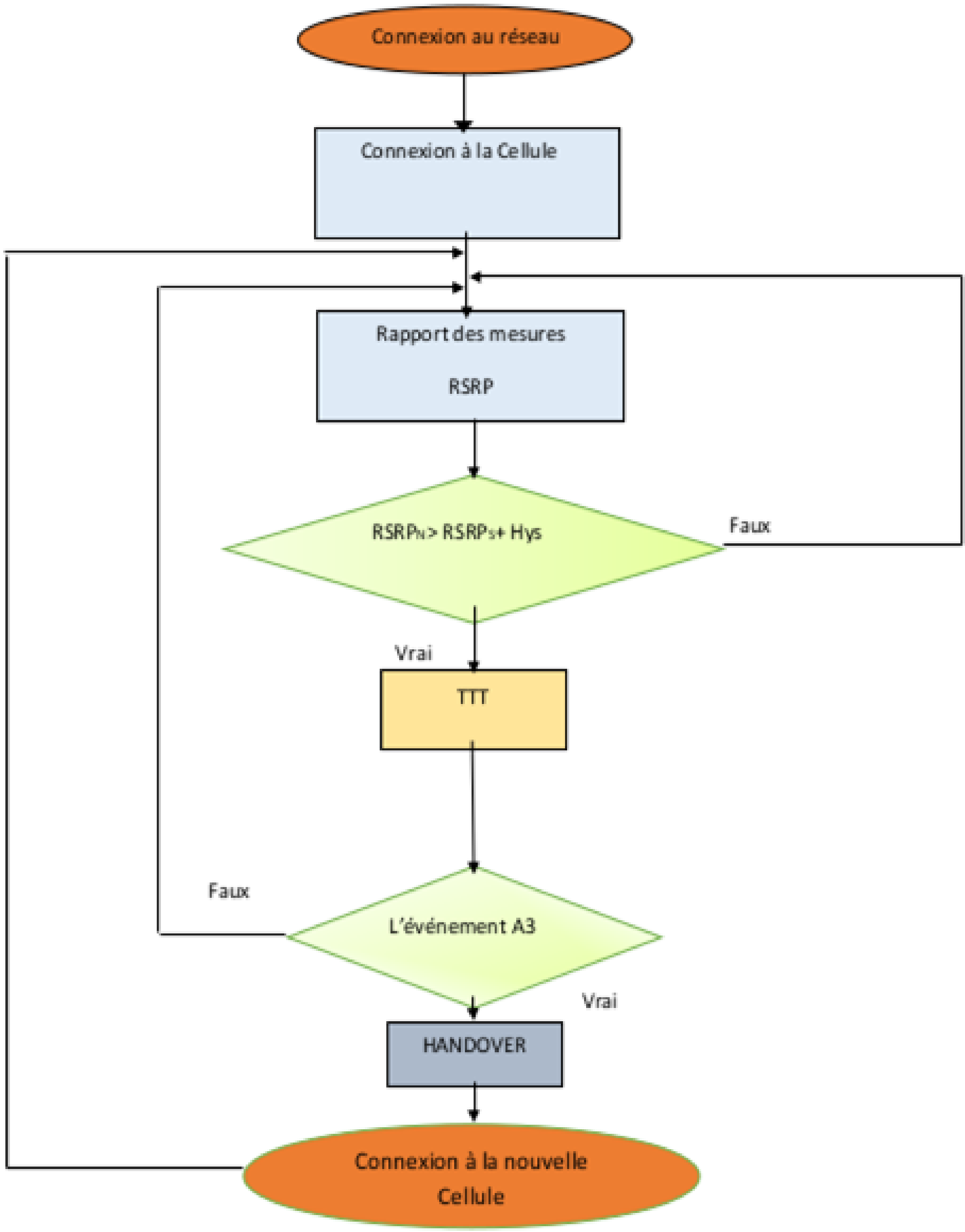

Figure 28 :structure general of A3 scenario.

3.5.2 Structure general of Proposed scenario:

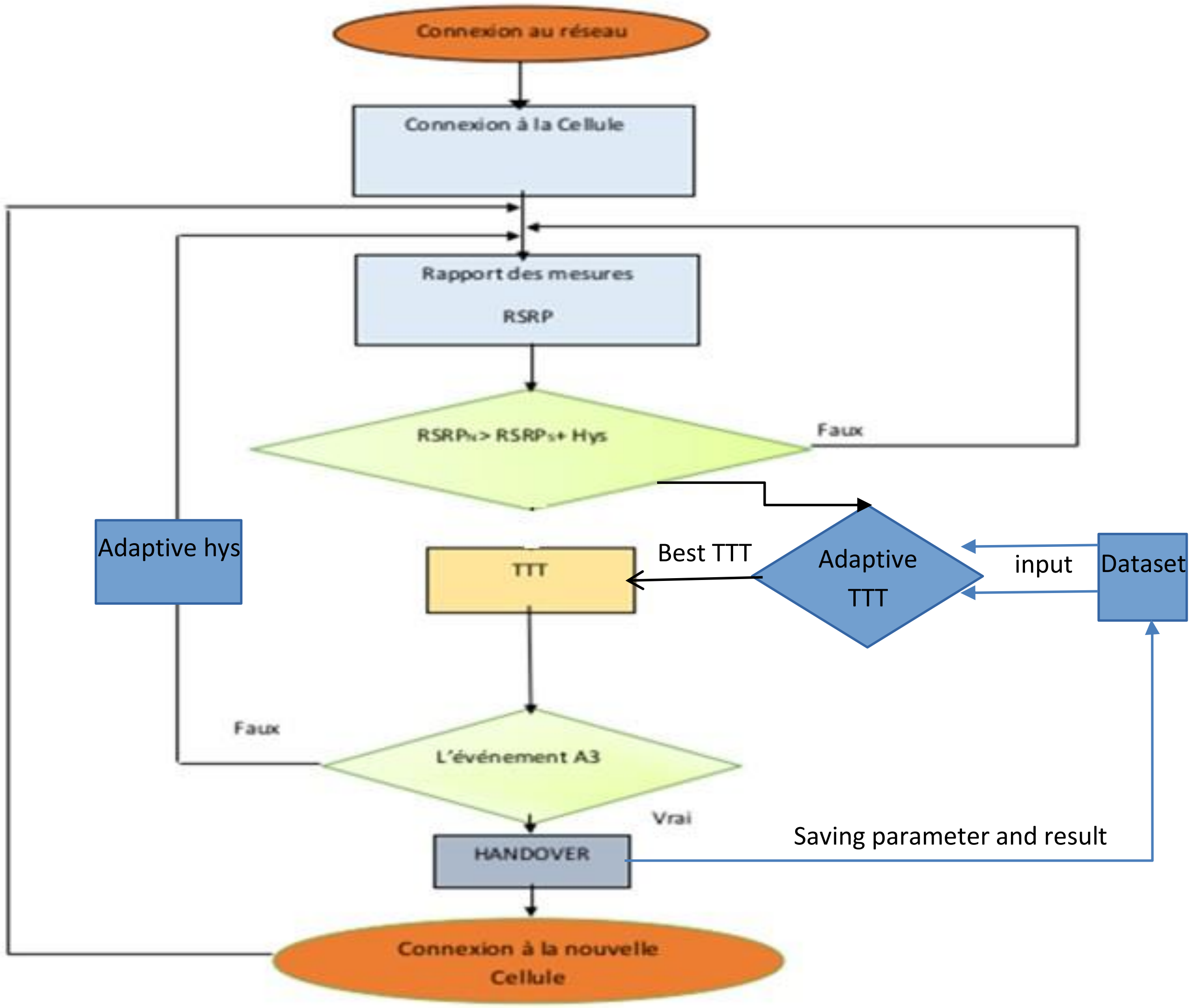

Figure 29 :structure general of proposed scenario.

3.6 Adaptive TTT:

For adaptive TTT, it's based on Handover Too Late/too Early and packet loos from /to user with conditions selected by communication experts, for example These conditions were established to choose the best value of TTT in given speed:

Coefficient UE=1 Coefficient eNodeB =1 Handover too Late =0 Handover too Early =0 min packet loos from UE min packet loos to UE

Adaptive TTT algorithm:

```
algorithm: Adaptive TTT

var :
      best-timeUe=0,best-timeENB=0 , minpacktloosUe=100 , minpacktlooseNB=100 :type double ;
       matrices x[][] type double ;
       i type integer ;

read (condition_tooEarly);
read (condition_tooLate);
read (condition_CoeffitionUe);
read (condition_CoeffitionENB);

begin:
  x[6][25]←reading text ;
while i<25 do :
 if x[2][i]=condition_tooEarly  and  x[3][i]=condition_tooLate  then:
        if minipacktloosUe > x[4][i] then :
               minipacktloosUe ← x[4][i] ;
               best-timeUe← x[1][i];
          end-if;
        if minipacktloosENB> x[5][i] then :
              minipacktloosENB ← x[5][i] ;
              best-time-ENB ← x[1][i];
         end-if;
 end-if;
best-time ← ((best-timeUe*CoeffitionUe)+(best-time-ENB*coeffitionENB))/
                    (coeffitionUe+ coeffitionENB)
open res.text
write in res.txt(x[0][0]  best-time)

end ;
```

3.7 Adaptation of HH(Hysteresis) By The Variation of Speed:

$$HH_{adj} = HH_{def} - \log_{10} HH_{def} \left(\frac{V_{max} - V_c + 1}{V_{max}}\right)$$

where HH_{def} denotes the default hysteresis for UE, V_{max} is the maximum speed of the vehicle and V_c is the current speed of the vehicle, which includes vehicle context information, The maximum speed of a high-speed train is currently 350 km/h if the velocity of the train increases, [29].

3.8 Results and Analysis:

In this part, LTE simulations run multiple times, with the eNB number not changing while the distance between eNB and the number of users is constant. With the change in user speed from 5 meters per second to 140 meters per second, and every time we change the speed, it is accompanied by a change in TTT from 10 to 250 milliseconds. In each run, we record the parameters and results in a written file in order to study the changes and apply the optimization algorithm later. In this work, we intend to record the results related to loss in packages and late and early Handover. All experiments were carried out on Ubuntu 18.04 NS-3 Ver 3.29.

Firstly, we have studied the influence of speed on the number of Handover Too late and Too early, show changes in number Handovers in different speeds with increased TTT values.

In case speed 5M/s:

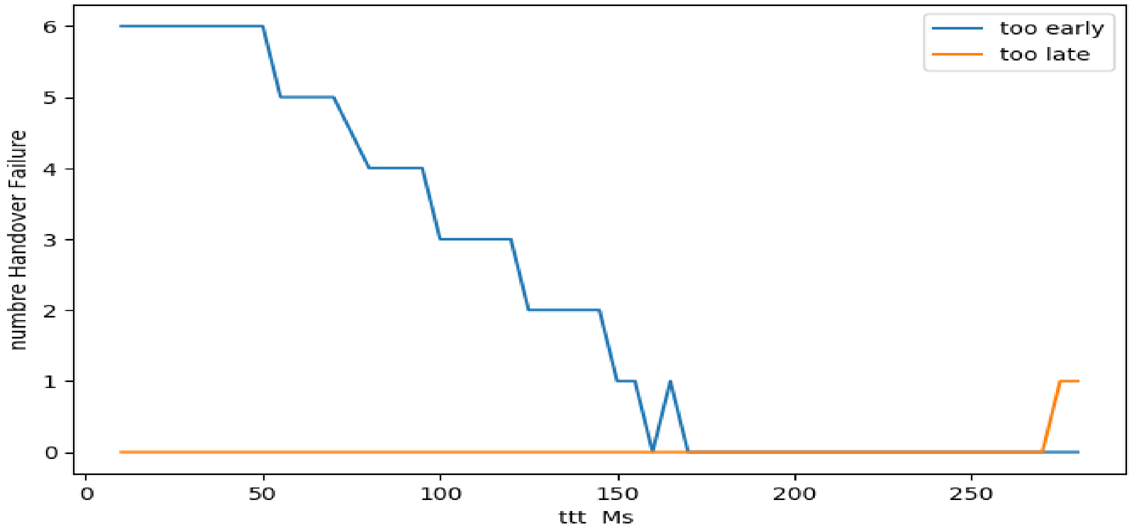

Figure 30 :Handover too late and too early in speed 5m/s.

In figure 30 a drop in to early handover between a value of 0 to a value of 160 milliseconds, and in the range 160 to 260 the value of RLF is null, in values above 260 milliseconds we begin to record to late handover, and according to the adaptive TTT algorithm, there is a best time between the two values of 170 and 260 milliseconds, (i.e. no RLF).

In case of speed 30 M/s:

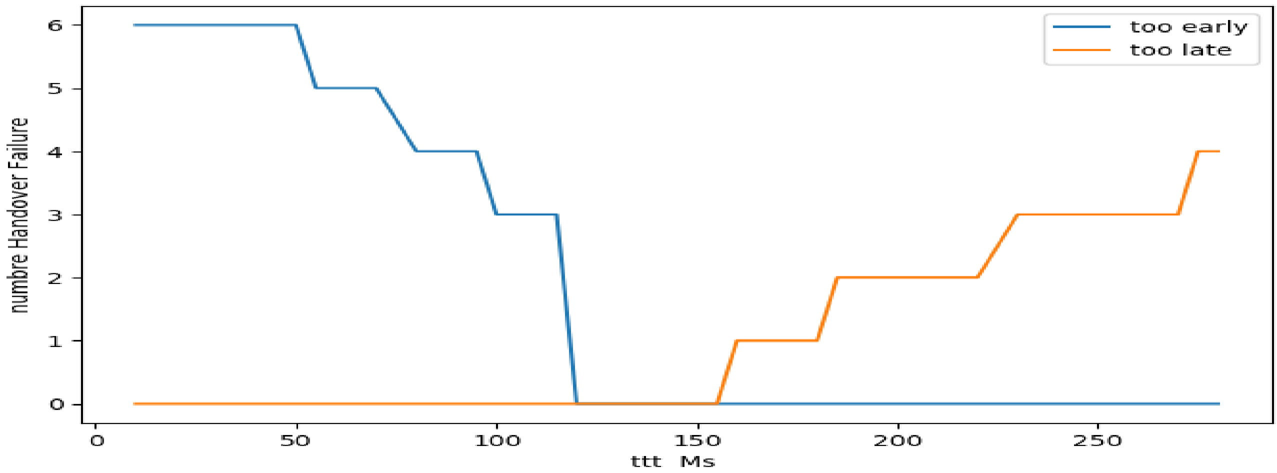

Figure 31 :Handover too late and too early in speed 30m/s.

In this case the BEST TTT value existing between the values 130 and 160 milliseconds.

- **in case of speed 60 M/s:**

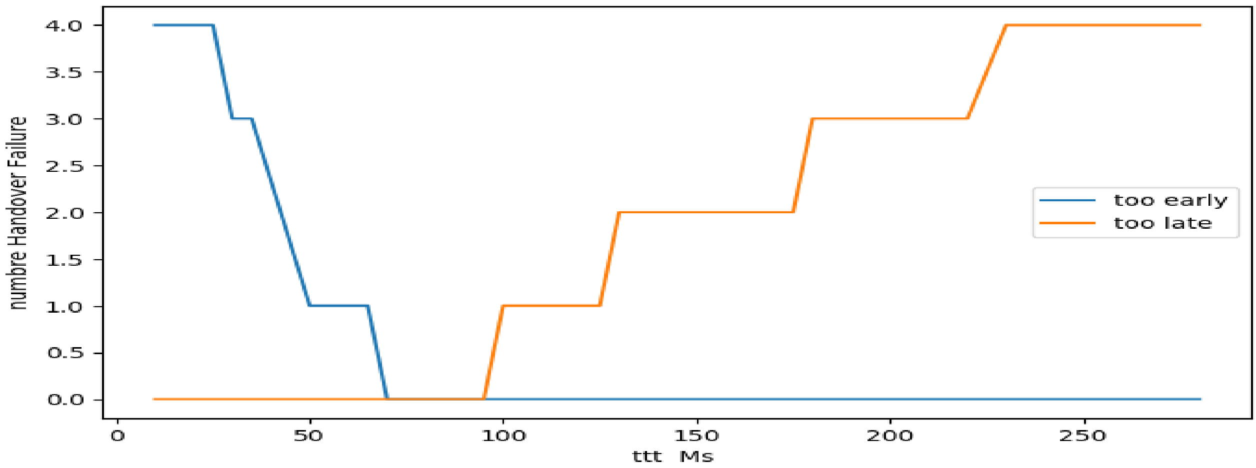

Figure 32 :Handover too late and too early in speed 60m/s.

other case '60m/s' In this graph, we note a low value in the early handover numbers as well as an increase in the number of late handover, due to the relatively high user speed compared to a speed of 5 or 30 m/s. best time is existing between 70 and 90 milliseconds.

- **in case of speed 90m/s:**

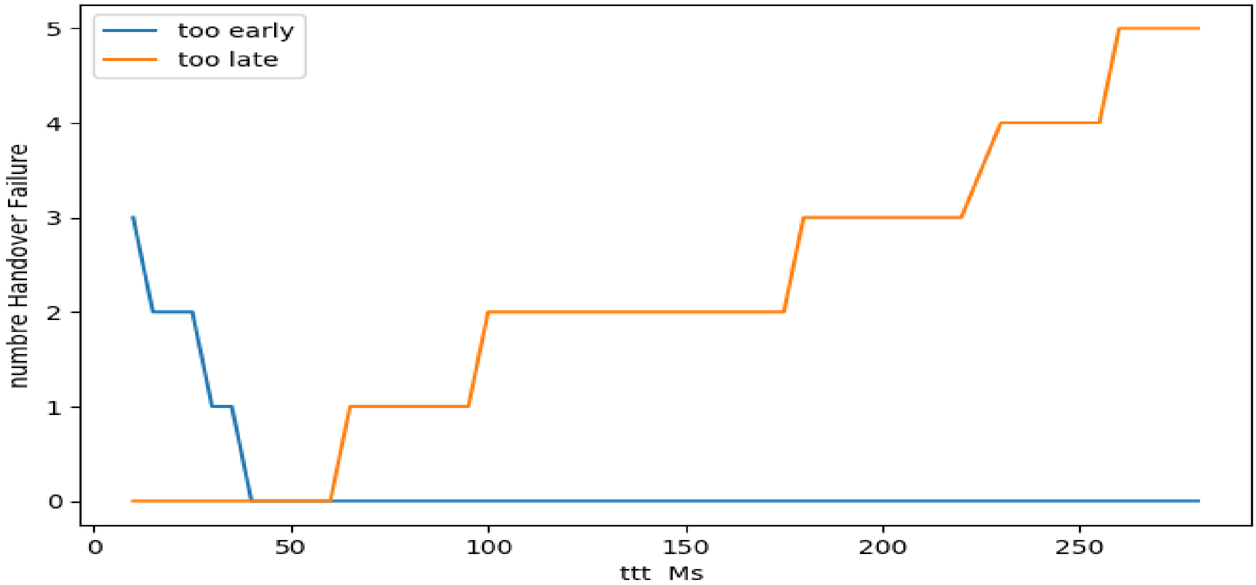

Figure 33 :Handover too late and too early in speed 90m/s.

In this case best TTT value existing between 70 and 90 milliseconds.

- **in case of speed 120 m/s:**

In this case, we note a continuous decrease in the number of too early handover, on the other hand, an increase in the number of too late handover, and this is due to the increase in the speed of the user 120 m/s, which is more than 400 km/h. Figure 34 Shows results.

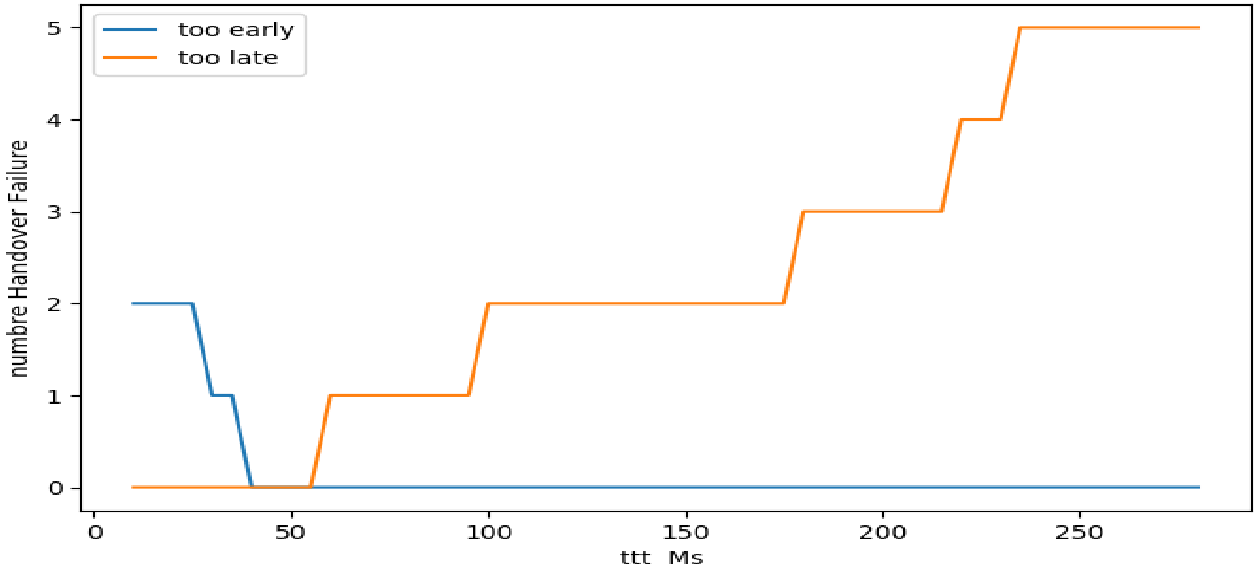

Figure 34 :Handover too late and too early in speed 120m/s.

- **in case of speed 150 m/s:**

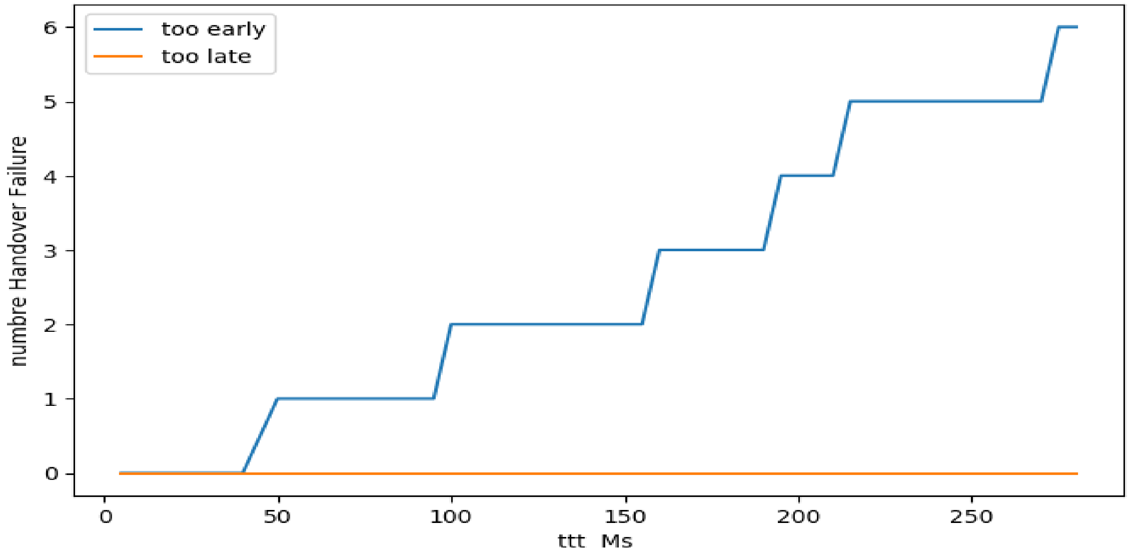

Figure 35 :Handover too late and too early in speed 150m/s.

At a speed of 150 m / s we note that no too early handover was recorded and an increase in too late handover.

Secondly, we have studied the influence of speed on rate packet loss, show changes in rate loss in different speeds with increased TTT values.

In case of speed 5 M/s:

At the speed of 5 m / s, we note the recording of the highest loss value to and from the user in the packages at the time 10 to 50ms and the value was 12% and 6%, respectively. The lowest value of the packet loss to and from the user at the time of 260ms and the value of the loss is 1%. Figure 36 shows the results.

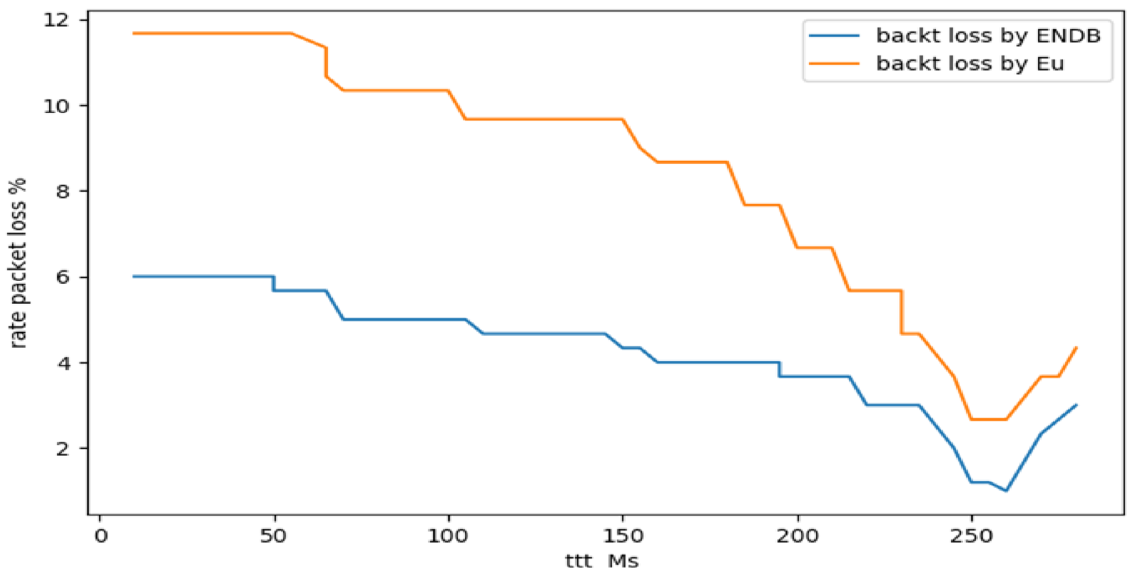

Figure 36 :packet loss in speed 05 m/s.

- **In case of speed 30 m/s:**

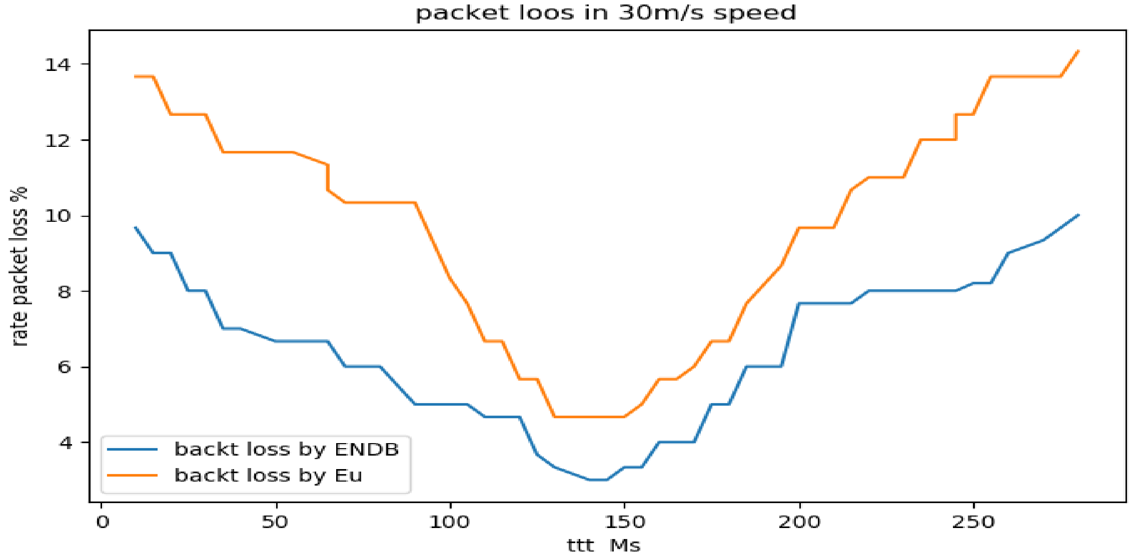

Figure 37 :packet loss in speed 30 m/s.

At the speed of 30 m / s, we note the recording of the highest loss value to and from the user in the packages at the time 260ms and the value was 15% and 11%, respectively. The lowest value of the packet loss to and from the user at the time of 140ms and the value of the loss is 3%.

- **in case of speed 60 M/s:**

other case, the speed of 60 m / s, we note the recording of the highest loss value to and from the user in the packages at the time 10 to 60ms and 130 to 260ms, the value was 87.3% and 37%, respectively. The lowest value of the packet loss to and from the user at the time of 80ms and the value of the loss is 16 % by user and 13% by eNB. Figure 38 shows more details.

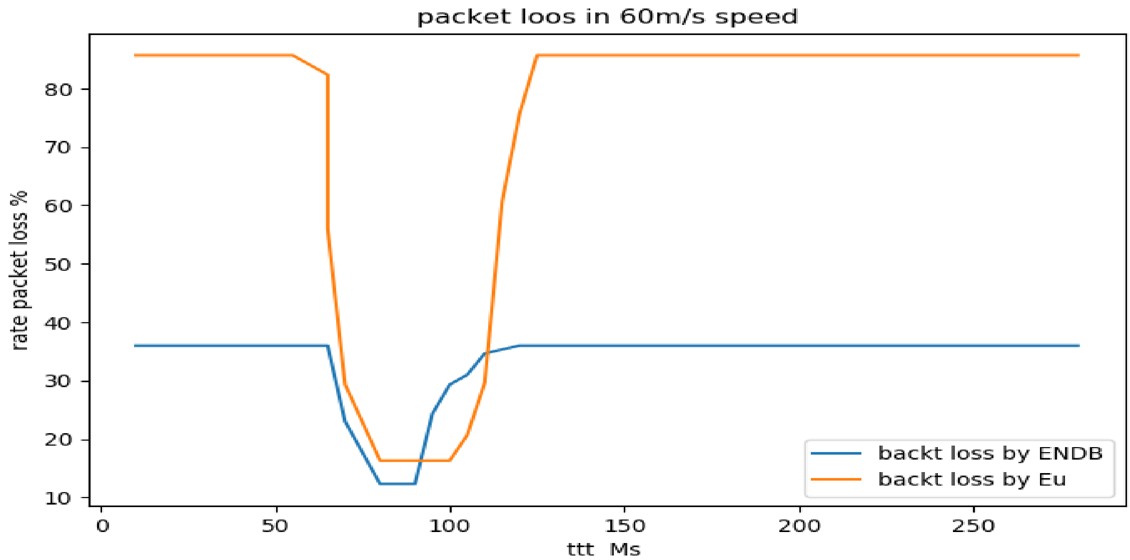

Figure 38 :packet loss in speed 60 m/s.

- **in case of speed 90 M/s:**

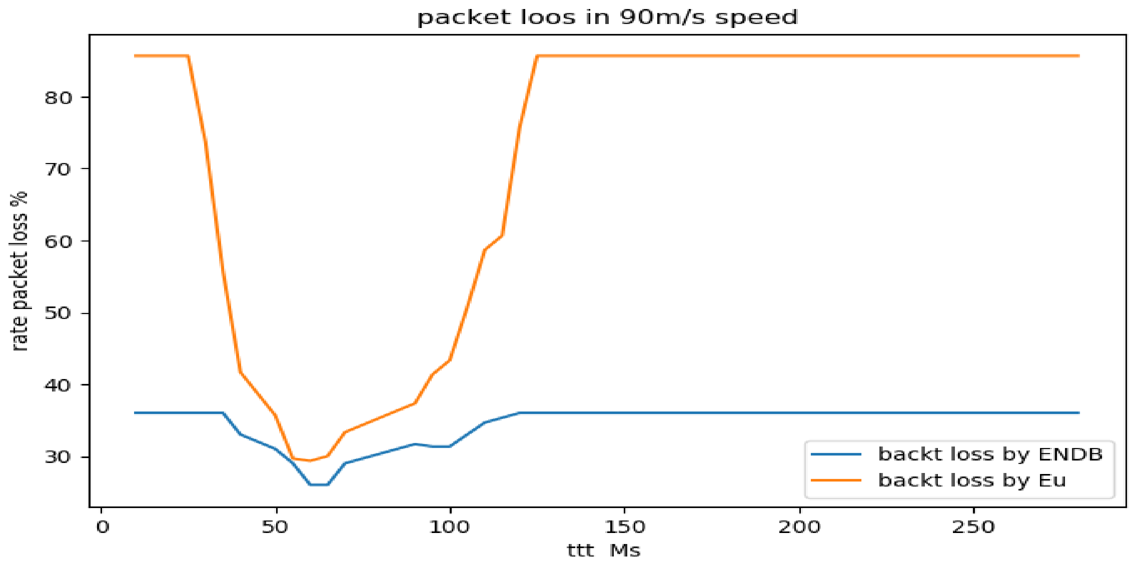

Figure 39 :packet loss in speed 90 m/s.

In this case, shows in Figure 39 speed of 90 m / s, we note the recording of the highest loss value to and from the user in the packages at the time 10 to 40ms and 120 to 260ms, the value was 87.3% and 37%, respectively. The lowest value of the packet loss to and from the user at the time of 60ms and the value of the loss is 32 % by user and 24% by eNB.

- **in case of speed 120 M/s:**

In this case, shows in Figure 40 speed of 120 m / s, we note the recording of the highest loss value to and from the user in the packages at the time 10 to 20ms and 110 to 260ms, the value was 87.3% and 37%, respectively. The lowest value of the packet loss to and from the user at the time of 60ms and the value of the loss is 34 % by user and 26% by eNB.

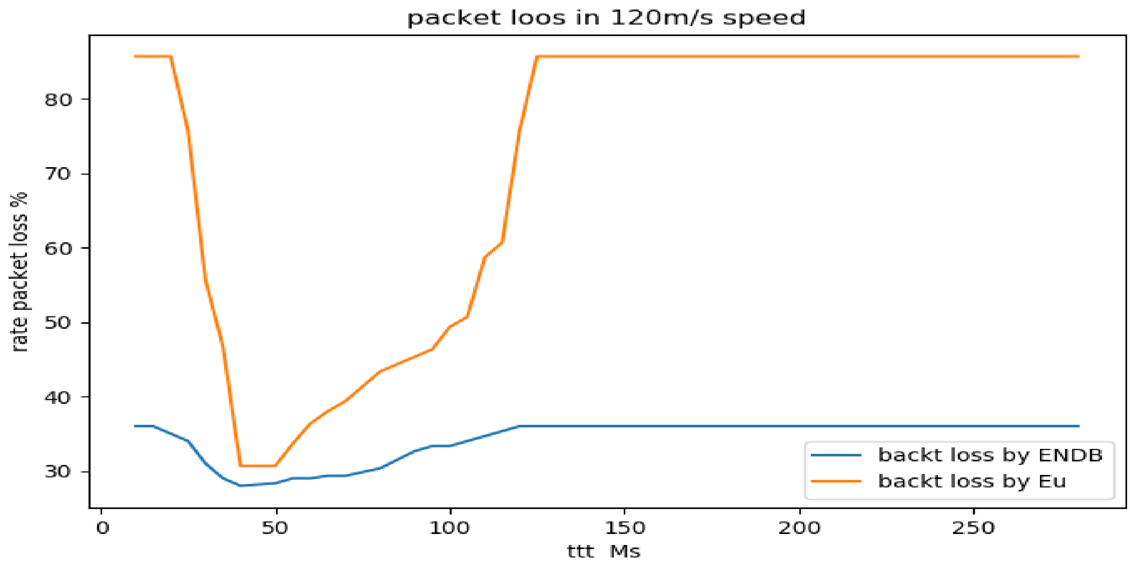

Figure 40 :packet loss in speed 120 m/s.

Finally, we applied the previously mentioned algorithm TTT to choose the appropriate time for each speed based on the data and simulation results. The results were as follows:

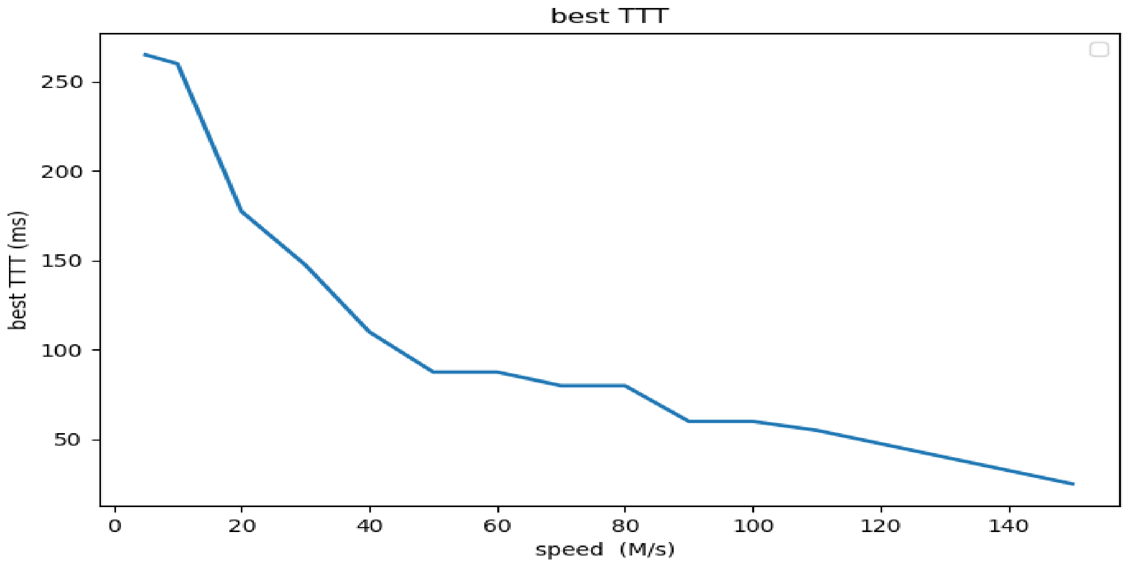

Figure 41 :Best TTT values by speed.

After extracting the results shown in Figure 41, we used the results obtained in the proposed algorithm, and these comparative results obtained between the existing algorithm and the proposed algorithm, in figure 42 a comparison between the lost packages from ENB, followed by the missing packages from the user in figure 43, and in figure 44 the rate of improvement between the two algorithms.

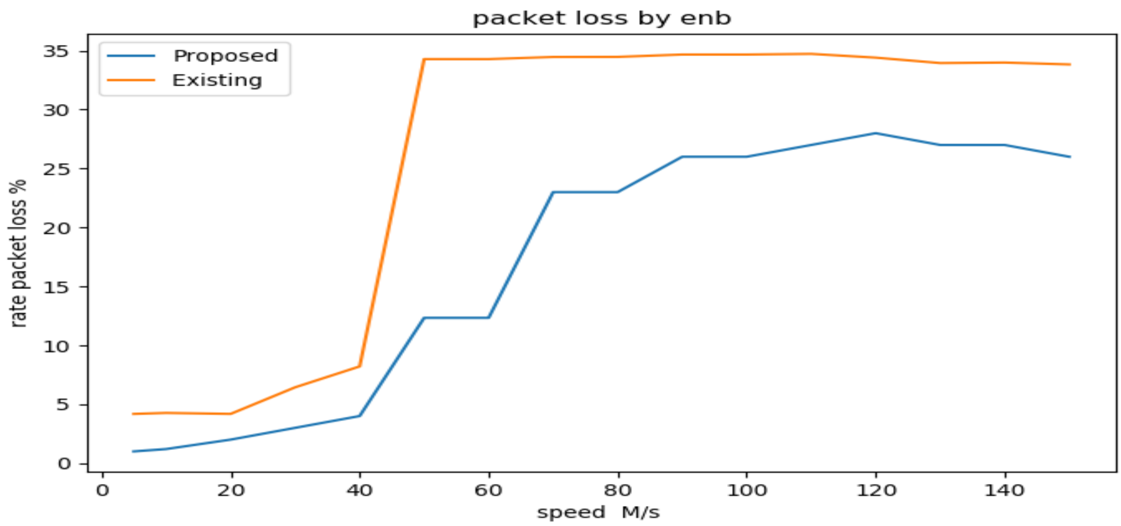

Figure 42:rate packet loss by ENB.

There is a noticeable difference between the two algorithms in terms of packet loss by ENB, especially in the speed between 40 to 60 m / s. The difference reaches 25%, but in other speeds the difference is between 4 to 16%, in general the rate of improvement is 8%.

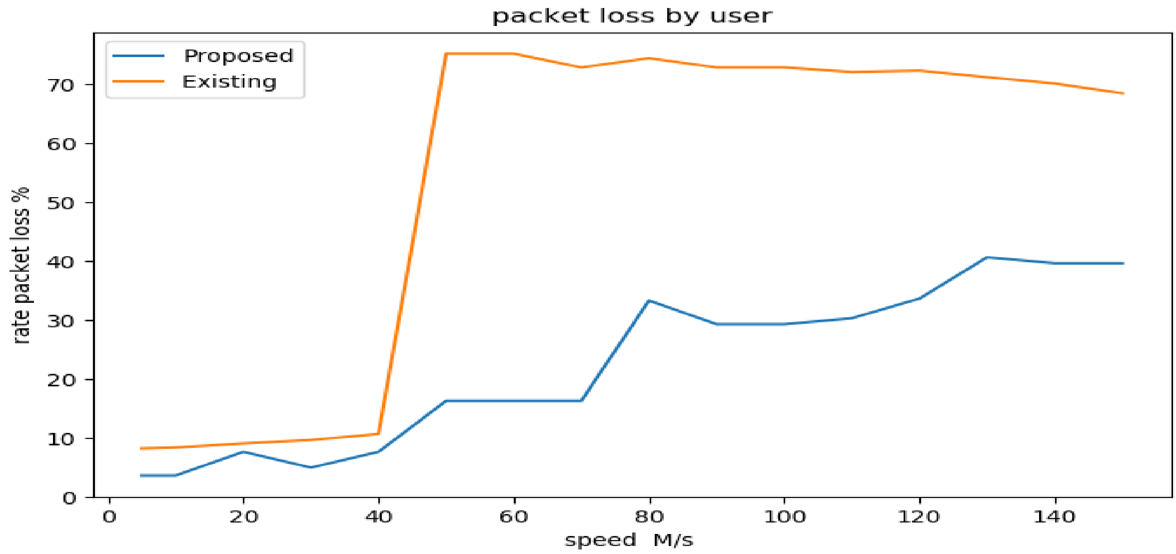

Figure 43 :rate packet loss by user.

As for the packet loss from user, we record different values between the two algorithms and the results are as follows, the highest difference value was at a speed of 50 to a speed of 70 m / s and a difference is 55%, in a speed of 10 to a speed of 40 the difference between 2 to 5% is The lowest percentage, in general the rate of improvement is 30%. This is a good rate to improvement in handover.

- We obtained **figure 44** from the following calculation:
  X=speed [].
  Y=packtENB1 + packtUE1 – packetlossENedB2 – packetloosUe2

  packtENB1: rate packet loss by ENB at speed x in algorithm existing.
  packtUE1: rate packet loss by user at speed x in algorithm existing.
  packetlossENedB2: rate packet loss by ENB at speed x in algorithm proposed.
  packetloosUe2: rate packet loss by user at speed x in algorithm existing.

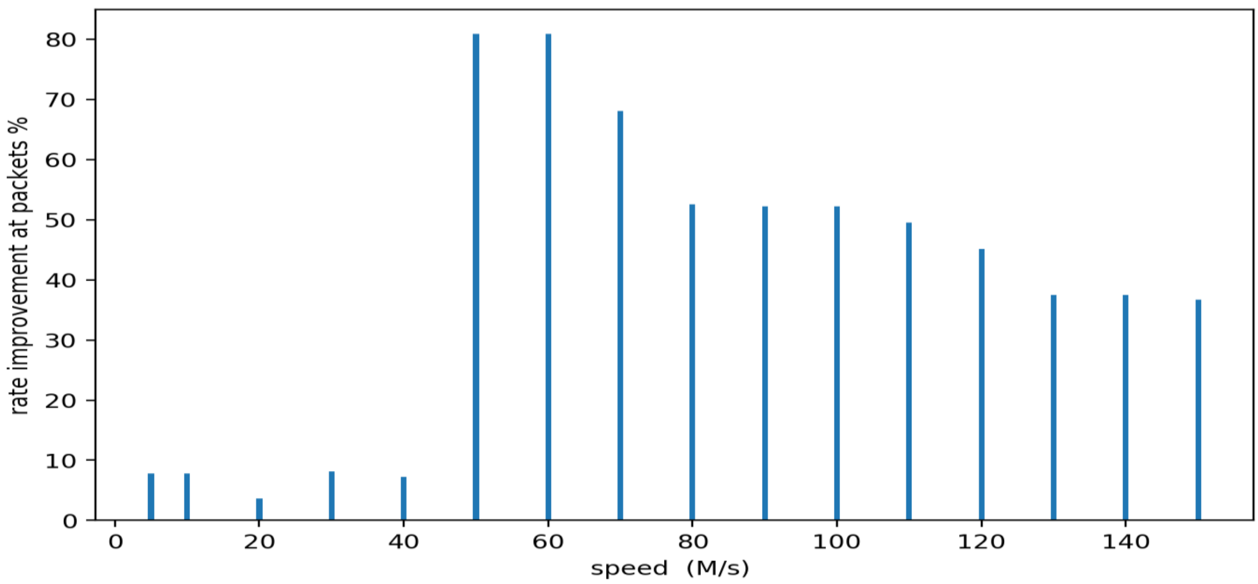

Figure 44 :rate improvement .

We record the best value for improvement at a speed of 50 and 60 km / s, come to 78%, and the slightest improvement for a speed of 20 m / s, which is 3%, and the overall rate of improvement **is 39.22%.**

3.9 Conclusions:

The purpose of this chapter was to self-improve the delivery process (HO) generated from the statistics collected from event a3. By analyzing the performance results of the proposed algorithm on a comparison basis with A traditional A3 algorithm on the issue of different speeds.

In this work, we intended to know the tradeoff between Hys and TTT parameter, as well as late and early handover. The simulation results demonstrated that the proposed algorithm offers better performance to reduce the rate of delivery very late and very early delivery at slow speeds and high speeds in a row and make the parameters dynamic according to network performance and user speed, and this makes them more improvement in future network performance or less harmful in case Network malfunction.

4 Optimization Handover by Q-learning algorithm

4.1 introduction:

Although the data transmission rate has reached a high throughput compared to the previous generation of cellular mobile communication systems, the mobility of the user is small coverage and its service demands still face big challenges. To deal with these issues, we have studied the user's behavior in the area coverage to optimize the handover (HO) process while moving from one BS to another. In mobile network, the user path is assessed by his range of velocity and destination are eligibility that meet the user's demand services.

While the user movement, the user needs a slot time to be attached to the next cell or stay in the current station, this slot time is called 'time of reflection''. The map of a user in the coverage is computed by its previous path and from another users' path. As results, the user is delayed by processing time to select the optimal path that lead to reduce the resources of mobility management such as handover decision, latency and bandwidth. Random waypoint (RWP) is one of the mobility models widely used in the performance's analysis of the wireless and mobile networks. It represents well the individual movements which include the stop, the starting up and the other actions bound to the individual movements in cities. In this context, we will propose an algorithm, called reinforcement learning to improve the mobility user in area network by using real data offered in [52].

4.2 Machine learning:

is a field of Artificial Intelligence (AI) that launched how to develop an algorithm to extract and classify the pattern from any data processed by the machine. This field support many applications in the world wide such as computer science, robotic, engineering, mobile network, medicine, agriculture, chemical human being and so on [42]. In the literature, we found three kind of machine leering that is categorized as depicted in the flowchart following:

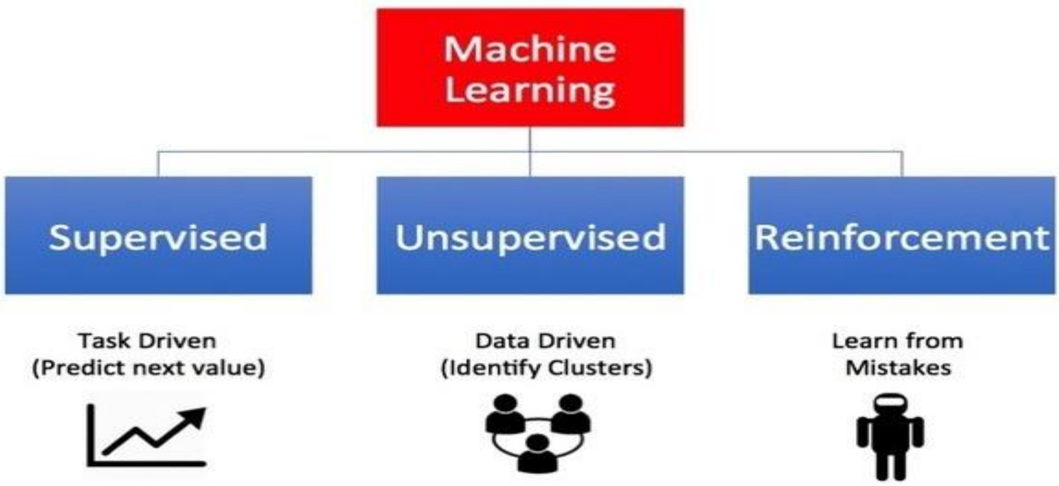

Figure 45 type of machine Learning.

4.2.1 Supervised learning:

is where an algorithm is trained using a training set of data. This set of data includes inputs and the known outputs for those inputs. The training set is used to fine-tune the parameters in the algorithm. The purpose of this kind of algorithm is to learn a general mapping between inputs and outputs so that the algorithm can give an accurate result for an output data regarding the input label. This type of algorithm is generally used in classification tasks [45].

4.2.1.1 List of Common Algorithms [45]:

- Nearest Neighbor
- Naive Bayes
- Decision Trees
- Linear Regression
- Support Vector Machines (SVM)
- Neural Networks

4.2.2 Unsupervised learning:

This kind of these algorithms make a decision about the label of output data without any class' input information. The goal of such an algorithm mostly support the clustering and regression task [46] .

4.2.3 Reinforcement learning:

uses an intelligent agent to perform actions within an environment. Any such action will yield a reward to the agent and the agent's goal is to learn about how the environment reacts to any given action. The agent then uses this knowledge to try and maximize its reward gains.

In reinforcement learning an intelligent agent is learning what action to do at any given time to maximize the notion of a reward. In the beginning the agent has no knowledge of what action it should take from any state within the learning environment. It must instead learn through trial and error, exploring all possible actions and finding the ones that perform the best. The trade-off between exploration and exploitation is one of the main features of reinforcement and can greatly affect the performance of a chosen algorithm.

A reinforcement learning algorithm must contemplate this trade-off of whether to exploit an action that resulted in a large reward or to explore other actions with the possibility of receiving a greater reward. Another main feature of reinforcement learning is that the problem in question is taken into context as a whole. This is different from other types of machine learning algorithms, as they will not consider how the results of any sub-problems may affect the problem as a whole [46].

The basic elements required for reinforcement learning is as follows:

- A **Model (M)** of the environment that consists of a set of **States** (S) and **Actions** (A).
- A **reward** function (R).
- A **value function** (V).
- A **policy** (P).

4.2.3.1 The model of the environment:

is used to mimic the behavior of the environment, such as -predicting the next state and reward from a state and taken action. Models are generally used for planning by deciding what action to take while considering future reward [47]

4.2.3.2 The reward function:

Defines how good or bad an action is from a state. It is also used to define the immediate reward the agent can expect to receive. Generally, a mapping between a state-action pair and a numerical value is used to define the reward that the agent would gain. The reward values are used to define the policy where the best value of state-action pair is used to define the action to take from a state.

While the reward function defines the immediate reward that can be gained from a state, the value function defines how good a state will be long-term. This difference can create possible conflicts of interest for an agent; so while its goal is to collect as much reward as possible, it has to weigh up the options of picking a state that may provide a lot of up front reward but not much future reward against a state with a lot of future reward but not much immediate reward. This trade-off is similar to that of exploration versus exploitation as it can define how successful a reinforcement algorithm is [46].

4.2.3.3 The policy:

is a mapping between a state and the best action to be taken from that state at any given time. Policies can be simple or complex; with a simple policy consisting of a lookup table, while more complex policies can involve search processes. In general, most policies begin stochastic so that the agent can start to learn what actions are more optimal [47].

4.2.4 Q-Learning:

Q-Learning is a type of reinforcement learning algorithm where an agent tries to discover an optimal policy from its history of interactions within an environment. What makes Q-Learning so powerful is that it will always learn the optimal policy (which action a to take from a state S) for a problem regardless of the policy it follows, as long as there is no limit on the number of times the agent can try an action. Due to this ability to always learn the optimal policy, Q-Learning is known as an Off-Policy learner [48]. The history of interactions of an agent can be shown as a sequence of **State-Action-Rewards**:

$$< s\,0 , a\,0 , r\,1 , s\,1 , a\,1 , r\,2 , s\,2 , a\,2 \ldots >$$

This can be described as the agent was in State 0, did Action 0, received Reward 0 and transitioned into State 1, then did Action 1, received Reward 1 and moved into State 2, and so on. The history of interactions can be treated as a sequence of experiences, with each experience being a tuple.

$$< s, a, r, s >$$

The meaning of the tuple is that the agent was in State **S**, did Action **a**, received Reward **r** and transitioned in State **S,** the experiences are what the agent uses to determine what the optimal action to take is at a given time. The general process of a Q-Learning requires that the learning agent is given a set of states, a set of actions, a discount factor γ and step size α. The agent also keeps a table of **Q-Values**, denoted by **Q (s, a)** where **s** is a state and **a** is an action from that state. A **Q-Value** is also an average of all the experiences the agent has with a specific state-action pair. This allows for good and bad experiences to be averaged out to giving a reasonable estimation of the actual value of state-action pair [48]. The process of averaging out experiences is done using Temporal Differences. It could be said that the best way to estimate the next value in a list is to take the average of all the previous values.

$$A_K = \frac{(v_1+\cdots+v_k)}{k} \tag{1}$$

Therefore

$$K\,A_k = v_1 + \cdots + v_k \tag{2}$$

$$= (K-1)A_{k-1} + v_k$$

Then dividing by k gives:

$$A_k = (1 - \tfrac{1}{k})A_{K-1} + \frac{v_k}{k} \tag{3}$$

Then let α k = 1/k:

$$A_k = (1-\alpha_k)A_{K-1} + \alpha_k + v_k \tag{4}$$

$$= A_{k-1} + \alpha_k(v_k - A_{k-1})$$

The part of Equation 4 where the difference vk − Ak−1 is seen is known as the Temporal Difference Error or TD Error. This shows how different the old value Ak-1 is from the new value vk. The new value of the estimate, Ak, is then the old estimate, Ak-1, plus the TD error times k. The Q-Values, therefore, are defined using temporal differences and Equation 5 shows the formula to calculate the values, where is a variable between 0 and 1 and defines the step size of the algorithm. If the step size were 0 then the algorithm would ignore any rewards received and if the step size were 1 the algorithm would consider the rewards gained just as much as the previous experiences of a state-action pair. The discount factor is also a variable between 0 and 1 and defines how much less future rewards will be worth compared to the current reward. If the discount factor were to be 0, then the future rewards would not be considered a lot. If the discount factor were to be 1, then the future rewards would be worth as much as the current rewards. The possible future rewards (maxaQ(s,a)) is the maximum of the Q-Values of all possible state-action pairs from the action selected [4-8]

$$Q\ [s,\ a] = Q\ [s,\ a] + \alpha\ (r + \gamma max_{a'} Q\ [s',\ a'] - Q\ [s,\ a]). \tag{5}$$

The table of Q-Values can either be initialized as empty or with some values pre-set to try and lead the agent to a specific goal state. Once the agent has initialized these parameters it observes the starting state. The starting state can either be chosen by random or be a predetermined start state for the problem. The agent will then choose an action. Actions are chosen either stochastically or by a policy. Once an action has been chosen the agent will carry out the action and receive a reward. This reward is used to update the table of Q-Values using Equation (5). Finally the agent moves into the new state and repeats until termination which can be either when the agent discovers a goal state or after a certain number of actions have be taken.

Require:
S is a set of states
A is a set of actions
γ the discount reward factor
α is the learning rate
1: **procedure Q-Learning(S, A, γ, α)**
2: real array Q[S, A]
3: previous state s
4: previous action a
5: initialize Q[S, A] arbitrarily
6: observe current state s
7: **repeat**
8: select and carry out an action a
9: observe reward r and state s′
10: $Q[s, a] \leftarrow Q[s, a] + \alpha\,(r + \gamma \max_{a'} Q[s', a'] - Q[s, a])$
11: $s \leftarrow s'$
12: **until** termination
13: **end procedure**

Q-learning pseudocode [46]

4.3 LTE mobility and handover behavior based Q-learning:

In a mobile telecom network, the locations of the User Equipment's (UEs) are tracked so that incoming data packet can be delivered to the UEs. Typical mobility management procedures include location update and handover. When a UE moves from one location to another location, the UE reports its new location to the network through the location update procedure. When an incoming call to the UE arrives, the network identifies the location of the UE via the paging procedure [50]. Before the handover, UE normally measure the cell power (signal quality) of the target cell and report it to the network, so that network can make a decision whether to allow UE to handover to the target cell or not [51].

4.4 Proposed Approach for HO optimization:

4.4.1 Proposed Approach path of user:

Based on the user data that contains a set of important information to make any action in the area network according to the user in anytime and anywhere, as well as the connected antenna information and the signal values of RSRP, RSRQ, RSSI and others. For instance, figure 46 represents the content of report measurement.

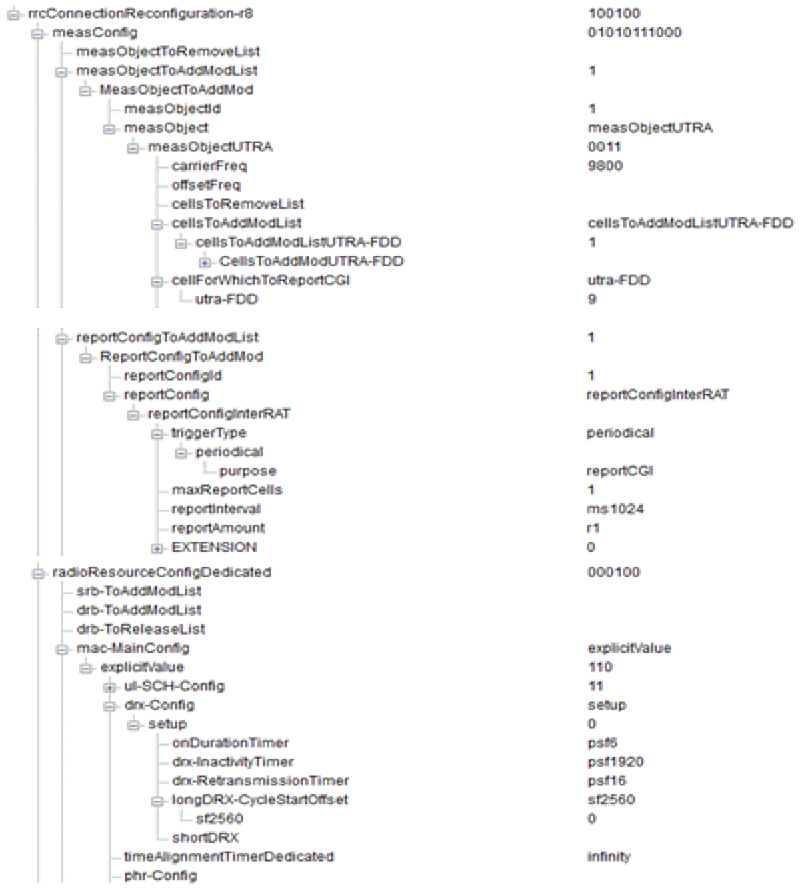

Figure 46 :User's report measurement.

Depending on the information received from the previous report, we use it to draw the user's movement map as shown in Figure 47. In the area network, the user can follow different paths according to his destination, so the AI agent's aim is to learn the shortest path among other that guaranteed a high throughput with low resources managements such as Ho and latency.

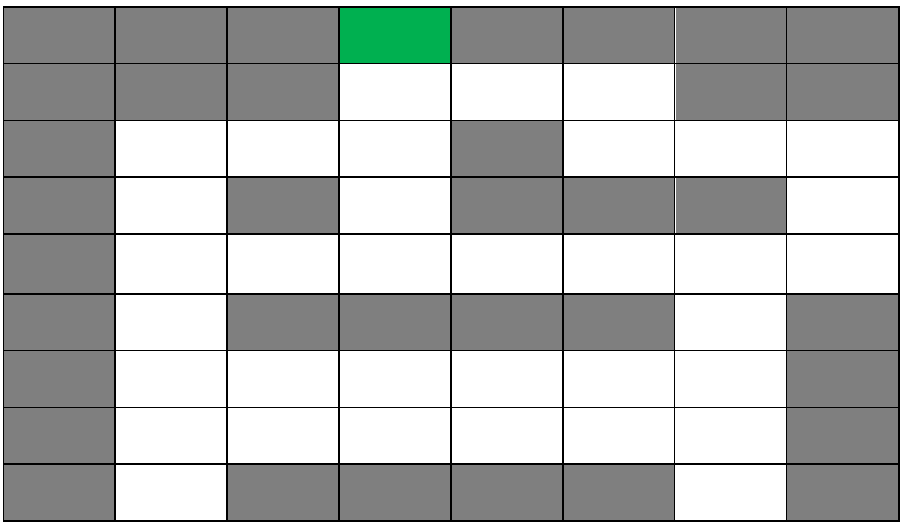

Figure 47 :user movement map.

As shown in the figure 47 above, there are 64 possible states (locations) within the map. These states are arranged in a grid containing 8 rows and 8 columns. Each location can hence be identified by its row and column index. The other location are pathways that the user may use to move in the area map (white boxes). The green box indicates the current area of the user.

Rewards:

The last component of the environment that we need to define are the rewards, to learn the AI agent, each state (location) in the map is assigned a reward value, so the agent may start form any white square, but it goal is to maximize its total rewards. We report the negative rewards (i.e., punishments) all states except the goal. This encourages the AI to identify the shortest path to the goal by minimizing its punishments.

As shown in the figure 48 above, matrix map has to maximize its cumulative rewards (by reducing cumulative penalties), the AI agent will need to find the shortest paths between the launch area (green square, its value of 100) and all other locations within the map where the user is allowed to move in (white squares with value of -1). The agent will also need to learn how to avoid crashing into any locations are not visited yet (black squares, value -100).

-100	-100	-100	100	-100	-100	-100	-100
-100	-100	-100	-1	-1	-1	-100	-100
-100	-1	-1	-1	-100	-1	-1	-1
-100	-1	-100	-1	-100	-100	-100	-1
-100	-1	-1	-1	-1	-1	-1	-1
-100	-1	-100	-100	-100	-100	-1	-100
-100	-1	-1	-1	-1	-1	-1	-100
-100	-1	-100	-100	-100	-100	-1	-100

Figure 48 :map rewards .

Epsilon greedy method:

At each step, a random number is generated by the model. If the number was lower than epsilon in that step (exploration area) the model chooses a random action and if it was higher than epsilon in that step (exploitation area) the model chooses an action based on what it learned.

Train algorithm:

Our next task is for our AI agent to learn about its environment by implementing a Q-learning model. The learning process will follow this step:

1. Choose a random, non-terminal state (white square) for the agent to begin this new episode.
2. Choose an action (move *up*, *right*, *down*, or *left*) for the current state. Actions will be chosen using an *epsilon greedy algorithm*. This algorithm will usually choose the most promising action for the AI agent, but it will occasionally choose a less promising option in order to encourage the agent to explore the environment.
3. Perform the chosen action, and transition to the next state (i.e., move to the next location).
4. Receive the reward for moving to the new state, and calculate the temporal difference.
5. Update the Q-value for the previous state and action pair.
6. If the new (current) state is a terminal state, go to #1. Otherwise, go to #2

Figure 49 :Q-learning pseudocode Proposed.

This entire process will be repeated across 10000 episodes or then more, depending on the size of the matrix, thus, provide the AI agent sufficient opportunity to learn the shortest paths between the item start area and all other locations in the map where the user is allowed to move in map while simultaneously avoiding crashing into any of the item is not visited (not white). If the AI agent has been well trained, the user will be provided the shortest path according to the objective function goal that is fixed by Q-Learning algorithm.

4.4.2 Proposed Approach for choice best eNB at position:

in LTE system Since the user moves from current cell to new target cell, this latter should ensure the user's connectivity by offering a high throughput according to the previously mentioned parameters in 4-4, which are depending on the RSRP and RSRQ. The above function (pseudocode) is proposed to determine the best cell for communication according to the largest RSRP condition, its parameters are defined by the value x and y values on an user's map area, and this function returns the address of the best cell among the available cells in the average network.

```
Function best_eNDB_ID(x,y)
Var : max_RSRP,ID_Cell
  For I in length(eNDBs_matrix )do :
    If matrix[i][x][y]>max_RSRP then :
       ID_Cell=i;
       Max_RSRP= matrix[i][x][y]
     Endif
endfor
Return ID_Cell
```

Pseudocode function is to select the best eNB

The output of the previous algorithm with the other data (Q learning values initialization) is fed into the proposed algorithm following.

Step01:
Collection data
	Import data : walking of user ,measurement;
	Writ: walk_map_matrix[][] ; // from walking of user data
	Write : eNDBs_matrix[][][]; // from measurement data
	Rewards <-walk_map_matrix ;
	Read: learning rate α, discount rate β;

Step02:
Get best way
	Q_Learning algorithm application(Rewards,α,β) //look figure 49
	path[]<- short path form Q_leaning result // path is array contents (X and Y)

Step03: Get best eNDB Id based on measurement(s)	for k=0 to length(path) add best_eNDB_ID(path[i]) to Finaly_path[i][2]

The proposed algorithm

4.5 Evaluation:

In this part, the data in [52] provides a 4G trace dataset composed of client-side cellular key performance indicators (KPIs) collected from two major Irish mobile operators, across different mobility patterns (static, pedestrian, car, tram and train). The 4G trace dataset contains 135 traces, with an average duration of fifteen minutes per trace, with viewable throughput ranging from 0 to 173 Mbit/s at a granularity of one sample per second. This data is generated from a well-known non-rooted Android network monitoring application, G-NetTrack Pro. This tool enables capturing various channel related KPIs, context-related metrics, downlink and uplink throughput, and also cell-related information [52].

After applying the proposed algorithm on trace dataset, for instance, we depict the user's movement between two points in the following figure (50).

	0	1	2	3	4	5	6	7	8	9	10	11
0	100	-1	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100
1	-100	-1	-1	-100	-100	-100	-100	-100	-100	-100	-100	-100
2	-100	-100	-1	-100	-100	-100	-100	-100	-100	-100	-100	-100
3	-100	-100	-1	-1	-100	-100	-100	-100	-100	-100	-100	-100
4	-100	-100	-1	-1	-100	-100	-100	-100	-100	-100	-100	-100
5	-100	-100	-1	-1	-1	-100	-100	-100	-100	-100	-100	-100
6	-100	-100	-100	-100	-1	-100	-100	-100	-100	-100	-100	-100
7	-100	-100	-100	-1	-1	-100	-100	-100	-100	-100	-100	-100
8	-100	-100	-100	-1	-1	-100	-100	-100	-100	-100	-100	-100
9	-100	-100	-100	-100	-1	-100	-100	-100	-100	-100	-100	-100
10	-100	-100	-100	-100	-1	-1	-100	-100	-100	-100	-100	-100
11	-100	-100	-100	-100	-1	-1	-1	-1	-100	-100	-100	-100
12	-100	-100	-100	-100	-100	-100	-1	-1	-1	-1	-1	-100
13	-100	-100	-100	-100	-100	-100	-100	-1	-1	-1	-1	-1
14	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-1
15	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100
16	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100
17	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100
18	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100

Figure 50 :example map user and RSRP map.

	0	1	2	3	4	5	6	7	8	9	10	11
0	-83	-200	-200	-200	-200	-200	-200	-200	-200	-200	-200	-200
1	-200	-51	-200	-200	-200	-200	-200	-200	-200	-200	-200	-200
2	-200	-200	-71	-200	-200	-200	-200	-200	-200	-200	-200	-200
3	-200	-200	-101	-200	-200	-200	-200	-200	-200	-200	-200	-200
4	-200	-200	-200	-105	-200	-200	-200	-200	-200	-200	-200	-200
5	-200	-200	-200	-61	-200	-200	-200	-200	-200	-200	-200	-200
6	-200	-200	-200	-200	-61	-200	-200	-200	-200	-200	-200	-200
7	-200	-200	-200	-200	-61	-200	-200	-200	-200	-200	-200	-200
8	-200	-200	-200	-79	-200	-200	-200	-200	-200	-200	-200	-200
9	-200	-200	-200	-200	-87	-200	-200	-200	-200	-200	-200	-200
10	-200	-200	-200	-200	-87	-200	-200	-200	-200	-200	-200	-200
11	-200	-200	-200	-200	-81	-87	-200	-200	-200	-200	-200	-200
12	-200	-200	-200	-200	-200	-200	-77	-75	-200	-200	-200	-200
13	-200	-200	-200	-200	-200	-200	-200	-67	-75	-93	-83	-200
14	-200	-200	-200	-200	-200	-200	-200	-200	-200	-200	-200	-95
15	-200	-200	-200	-200	-200	-200	-200	-200	-200	-200	-200	-200
16	-200	-200	-200	-200	-200	-200	-200	-200	-200	-200	-200	-200
17	-200	-200	-200	-200	-200	-200	-200	-200	-200	-200	-200	-200
18	-200	-200	-200	-200	-200	-200	-200	-200	-200	-200	-200	-200

Figure 51 :example map user and RSRP map.

```
In [5]: runfile('/home/mooh/source/ns-3.29/algorithm/finjobs.py', wdir='/
home/mooh/source/ns-3.29/algorithm')
Training complete!
[[19, 19], [18, 19, 0], [18, 18, 7], [17, 18, 7], [16, 18, 0], [16, 17, 7],
[15, 17, 0], [15, 16, 7], [15, 15, 7], [15, 14, 0], [15, 13, 7], [14, 13,
0], [14, 12, 0], [14, 11, 5], [13, 11, 0], [13, 10, 5], [12, 10, 0], [12,
9, 0], [12, 8, 0], [12, 7, 5], [11, 7, 0], [11, 6, 0], [11, 5, 5], [10, 5,
0], [10, 4, 6], [9, 4, 6], [8, 4, 0], [7, 4, 6], [6, 4, 6], [5, 4, 0], [5,
3, 6], [4, 3, 0], [3, 3, 0], [3, 2, 2], [2, 2, 2], [1, 2, 0], [1, 1, 2],
[0, 1, 0], [0, 0, 2]]
fin
```

Figure 52 : result of algorithm proposed.

In figure 52 Represents the results obtained from our algorithm, the first number represents the x-coordinate, the second number is the y-coordinate, and the third number is the endb_id. for example, [18,19,0] this means in position [x=18, y=19] the best RSRP is for eNB number 0.

From the results of the proposed algorithm, the LTE system is aware of upcoming events in the network, this allows it to take handover actions without applying measurement report phase, and just remains to get confirmation of admission from the operator, and this confirmation is made once the user is located at the point where the handover is necessary required.

This algorithm should attach a change to the structure of the handover procedure so that the transfer of user data from an eNB serving and an eNB target is prior to the preparation phase of the handover. Figure 53 represents the standard handover procedure in LTE network. Figure 54 represents our modified handover procedure in LTE network.

The difference between the two structures is the time consuming during the HO preparation process and the HO execution which is reported that the user has to wait from measurement report to HO confirm. In this end, the difference between the two structures is that our algorithm ignores the time of the measurement report in order to have made a HO confirmation.

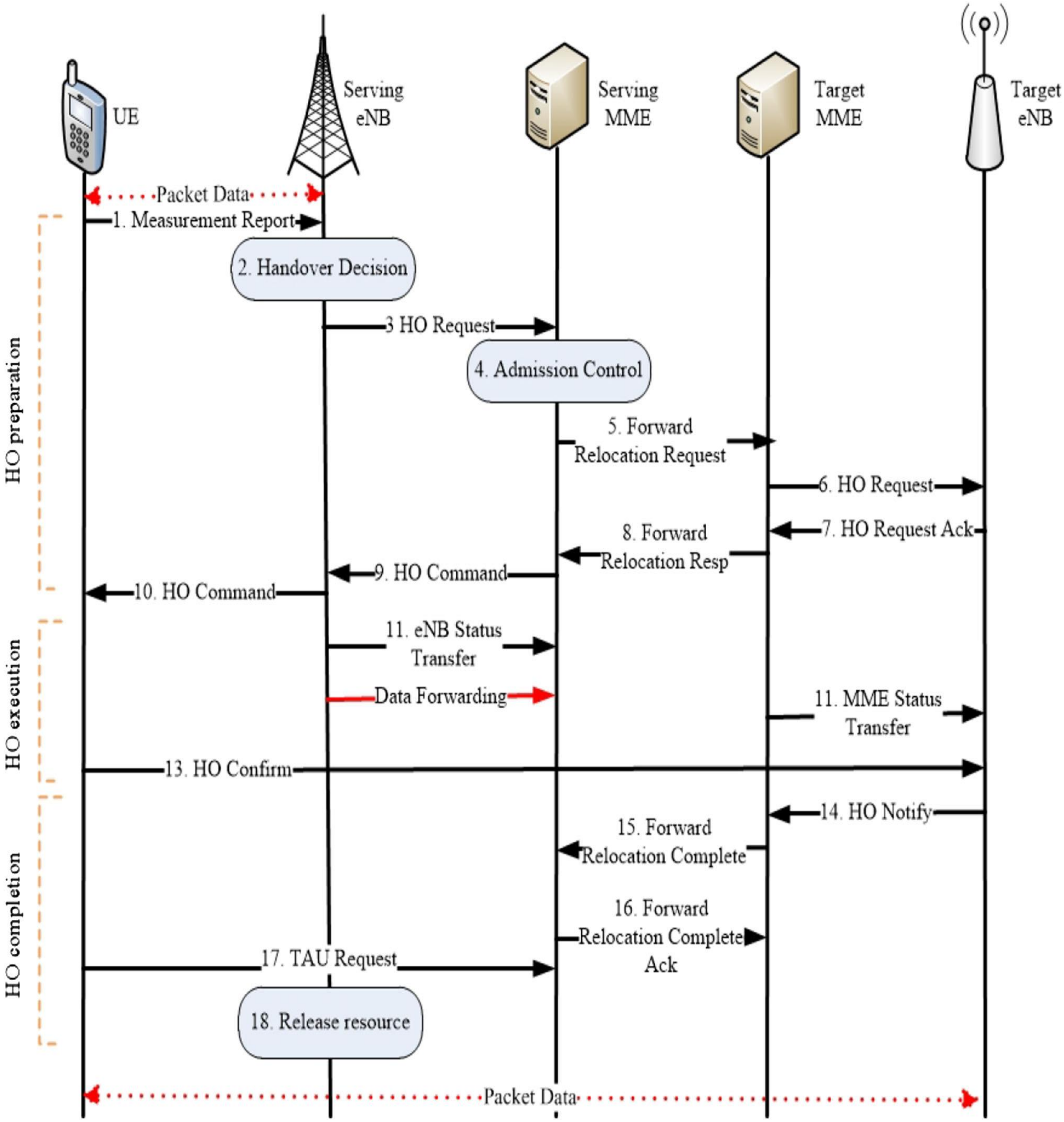

Figure 53 :S1-based handover procedure[12].

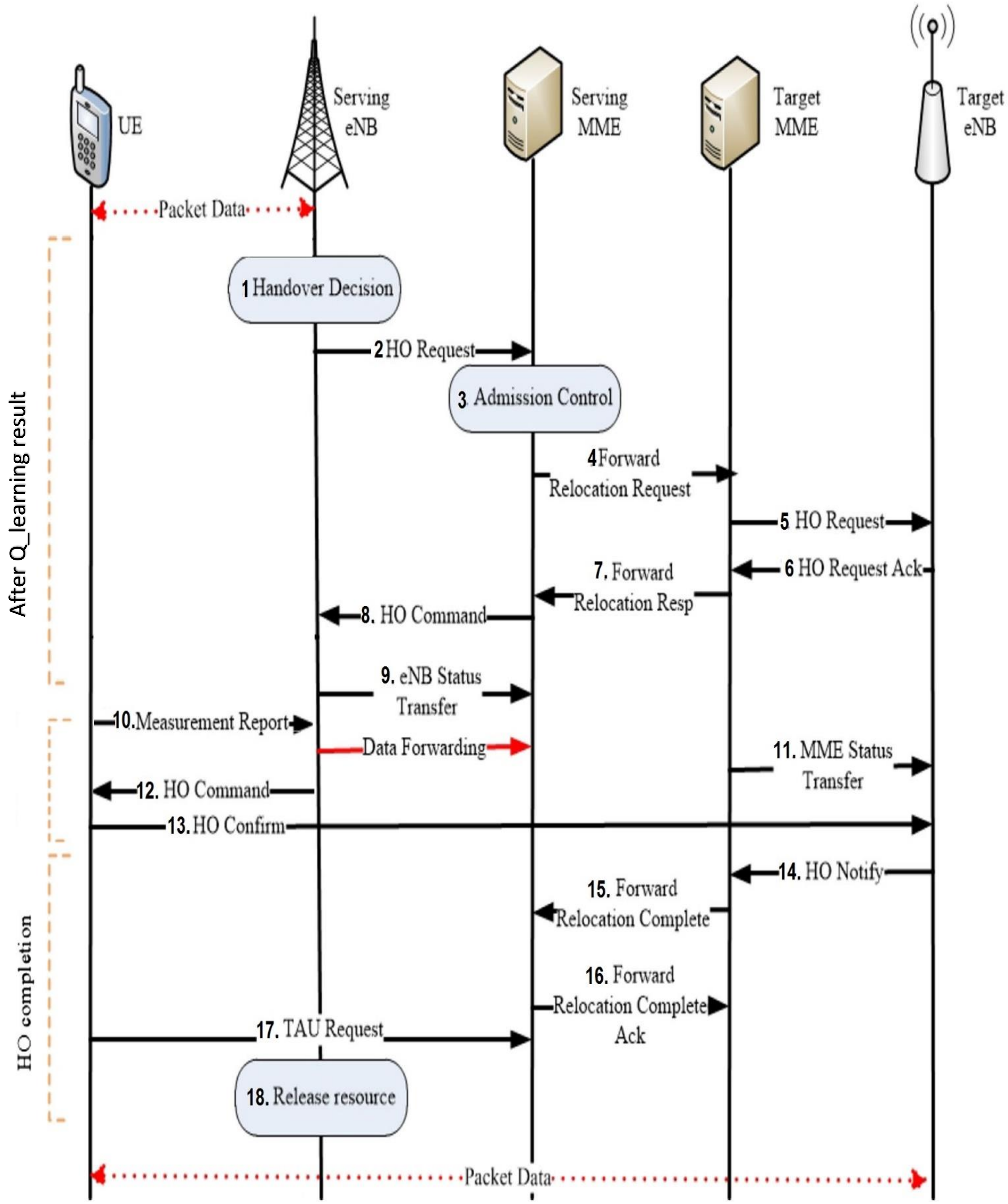

Figure 54 : S1-based handover procedure proposed.

4.6 Conclusions:

In this work, a proposed technique based on Q-learning was carried out on real data to learn and select the best path of user associating with the best RSRP values to target eNB.

The proposed algorithm has proved that the proposed Q-Learning may effectively improves the whole network performance while performing the handover decision in term latency (reducing delivery time, increasing system productivity, reducing system delay, predicting user paths and selecting the optimal eNB according to data).

5 General Conclusion:

This thesis addresses the problem of handover strategies in LTE network.

Motivated by the outstanding performance of the next generations networks in the world wide, we study the behavior of handover functions in LTE in order to enhance the network mobility and optimize its resources according to the users demand.

In the first part of this thesis, we consider the A3 algorithm is the well-kwon algorithm used in the current network which is assessed by two fundamental parameters and HW. These both pervious parameters are adjusted to enhance the handover efficiently within high velocity. This algorithm aims at reducing the cost, lost packets, and latency of handover operations.

In the second part of this work, we design a new interface exchange between the user and base station by calling the machine learning algorithm to learn the mobile user environment and then to ignore some step from the conventional interface for handover execution.

As perspectives to these works, we plan to continue our researches in next mobile generations. The virtualizations functions consider the new feature is introduced in the 5G network which can lead to further enhancements on mobility management.

Another field that can be tackled is the behavior of the user in different area cells which help to decrease the signalization with the core network and keep to control its performance in the edge network. Deep learning and theory of mind is one of the most famous and efficient mathematical tools to be used in this scenario.

Finally, we will be interested in the mobility management in the Fifth Generation Networks (5G) since they include a variety of access networks and communication types such as Device To Device (D2D) and Vehicular Networks.

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ملخص :

الهدف من هذا العمل هو دراسة وتحليل تنقل المستخدمين في شبكات المحمول.

التنقل بين الشبكات غير المتجانسة ، وهذا يعني أن جهاز المحمول الخاص بك يغير نقطة ارتباطه.

تطلبت الدراسة التي تم إجراؤها تنفيذ خوارزميات دقيقة لجعل قرار تغيير الارتباط اكثر ديناميكية مع التنقل المستخدم ، من أجل ضمان استمرارية و جودة الخدمة المقدمة .

تطبيق خوارزمية التعلم العميق باستخدام برنامج بايثون من اجل تحسين خوارزمية التسليم.

الكلمات المفتاحية : LTE, Handover , mobility , Q-learning , NS-3

Résumé:

L'objectif de ce travail est d'étudier et d'analyser la mobilité des utilisateurs dans les réseaux mobiles.

En naviguant sur des réseaux hétérogènes, cela signifie que votre appareil mobile change de point de liaison.

L'étude qui a été menée a nécessité la mise en place d'algorithmes précis pour rendre la décision de changer le lien plus dynamique avec la mobilité de l'utilisateur, afin d'assurer la continuité et la qualité du service fourni.

Appliquez un algorithme d'apprentissage en profondeur à l'aide du programme Python pour améliorer l'algorithme de Handover.

Mots clés : LTE, Handover, mobilité, Q-learning, NS-3.

Abstract:

The aim of this work is to study and analyze user mobility in mobile networks.

Navigating heterogeneous networks, this means that your mobile device changes its link point.

The study that was conducted required the implementation of accurate algorithms to make the decision to change the link more dynamic with the user's mobility, in order to ensure the continuity and quality of the service provided.

Apply deep learning algorithm using Python program to improve the delivery algorithm.

Key words: LTE, Handover, mobility, Q-learning, NS-3