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Communications Engineering Department

Investigation of Resource Allocation Schemes for 5G Network with Network Slicing

By

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M.Sc. Thesis
In
Communication Engineering

Supervised by

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Thesis Submitted
By
Omar Ghanim Salim Altaee

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Supervised by

Asst. Prof. Younis Abbosh (Ph.D.)
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Supervisor's Certification

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"Praise be to ALLAH, Worlds, who says in the Holy Quran"

﴿رَبِّ أَوْزِعْنِىٓ أَنْ أَشْكُرَ نِعْمَتَكَ ٱلَّتِىٓ أَنْعَمْتَ عَلَىَّ وَعَلَىٰ وَٰلِدَىَّ وَأَنْ أَعْمَلَ صَٰلِحًا تَرْضَىٰهُ﴾

May peace and blessings be upon the first teacher of humanity, our master Muhammad, may God bless him and grant him peace.

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Abstract

The recent wireless and cellular communications technologies are the 5th generation (5G) systems. These technologies enhance the network design for mobile user equipment and devices alone toward systems that connect many types of devices operating at high speeds. The main key features of the 5G system include improved spectrum efficiency, very-high bitrate, very low latency, and very-high connection density. These features support communicating multimedia, voice, video, Internet, and new broadband user's application services.

One of the main key parameters of the 5G system is the network slicing which is a talented technique to create adapted end-to-end logic network path including shared resource. Resources scheduling and distribution of network slices show an essential effect in network performance, resource deployment, and load balancing.

This thesis compares many resource scheduling schemes in the 5G system with network slicing. Many resource scheduling algorithms, best CQI (BCQI), Round Robin (RR), proportional fair (PF),were compared to assess each scheme performance. It is found when we need high throughput that BCQI algorithm is the best among three schemes But when you compare it in all respects as throughput, fairness and latency that PF algorithm is the best taking into consideration the user’s throughput.

Moreover, this thesis proposes an adaptive scheduling scheme that the system scheduler switches dynamically to the optimum behaviour of the scheduling algorithm among mentioned three schemes with the network slicing for optimized the traffic, user throughput, and cell capacity.

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LIST OF ABBREVIATIONS

Abbreviation	Name
3GPP	3rd Generation Partnership Project
4G	Fourth Generation
5G	Fifth Generation
BCQI	Best Channel Quality Indicator
BDMA	Beam Division Multiple Access

BS	Base Station
BSS	Business Support System
CNE	Core Network Element
CP	Control Plane
DL	Down Link
E2E	end-to-end
eMBB	enhanced Mobile Broad Band
FBMC	Filter Bank Multi-Carrier Multiple Access
gNB	Next Generation Node B
FDM	Frequency Division Multiplexing
FDS	Frequency Domain Scheduling
HetNet	Heterogeneous Network
IoT	Internet of Things
IP	internet protocol
KPI	Key Performance Indicators
LTE	Long Term Evolution
MAC	Medium Access Control
MANO	Management and Network Orchestration
MCS	Modulation and Coding Scheme
MEC	Mobile Edge Computing
MIMO	Multiple-Input Multiple-Output
mMTC	Massive Machine Type Communications
mmWAVE	Millimeter Waves
NF	Network Functions
NFP	Network Function Pool
NFV	Network Function Virtualization
NOMA	Non-Orthogonal Multiple Access
NSM	Network Slice Manager
OFDM	Orthogonal Frequency Division Multiplexing

OSS	Operations Support System
OTT	One-Trip Time
PF	Proportional Fair
PMI	Precoding Matrix Indicator
QoE	Quality of Experience
QoS	Quality-of-Service
RAN	Radio Access Network
RI	Rank Indication
RL	Reinforcement Learning
RLC	Radio Link Control
RNM	Radio Node Management
RR	Round Robin
RTT	Round-Trip Time
SB	sub-band
SDN	Software-Defined Networking
SDR	Software-Defined Radio
SE	spectral efficiency
SNR	Signal to Noise Ratio
SO	Slice-Owners
TDD	Time Division Duplex
TDS	Time Domain Scheduling
TTI	Transmission Time Interval
UDRAN	Ultra-Dense Radio Access Networks
UE	User equipment
UL	Up Link
UP	User Plane
URLLC	Ultra-Reliable Low Latency Communications
WFQ	Weighted Fair Queueing algorithm
WNV	Wireless Network Virtualization

Chapter One
Introduction

1.1 Background:

Many years ago, the world witnessed some huge developments in the wireless, cellular and telecommunication systems. In the coming future, the mobile communication networks have to be developed according to the user's demand and developed services and applications.

The Fifth generation (5G) system was released with Beam Division Multiple Access (BDMA) and the new Filter Bank Multi-Carrier (FBMC). By contemplating the instance of the base station (BS) communicating with the User equipment (UE), beam division multiple access BDMA technique conception is explicated. In this transmission, an orthogonal ray is distributed to each UE and the BDMA technique divides the ray of antenna according to the UE, which is in a corresponding perfect with network's capacity [1].

5G mobile networks resolved many complications that are not successfully resolved by long term evolution (LTE) network, which give massive device connectivity, higher data rate, higher capacity, Quality of Experience (QoE) and lower End-to-End latency [2].

5G uses new technologies like software-defined networking (SDN) and network function virtualization (NFV) to reach their goals. 5G provides data transmission rates of up to 10Gbps, which is 100 times higher than 4G-LTE [3].

1.2Literature Review:

Ordonez-Lucena et al, (2017) presented the network slicing concepts, with a particular focus on its applications to 5G system. They started by investigating the important key features which enable the realization of network slices. They claimed that, although such architecture covers the method for network slicing employment, it is still weak in some essential capabilities that can be supplied by NFV. Finally, they presented a scenario that combined SDN and NFV technologies to address the realization of network slices [4].

Then, Devlic et al, (2017) presented a network slicing management framework. They provided a brief description of business scenarios and potential customers of network slicing. Based on specific customer goals, they proposed a solution enabling the automation of end-to-end (E2E) network slice management and orchestration in multiple resource domains that distinguished between two main design time and runtime components [5].

Zhang et al, (2017) introduced a 5G structures based on a logical architecture for network slicing. They presented a structure for managing mobility among access networks based on network slicing. Finally, they discussed many issues in network slicing based on the 5G network, including network slicing cooperate with other 5G technologies [6]. Then, Li et al, (2017) discussed the challenges of network slicing and future research directions [7].

Esswie AA et al , (2018) presented an developed a joint multi-users pro-active scheduling scheme strategy to cross-enhance system spectral efficiency with reduced latency. At each scheduling chance, existing URLLC traffic was always given higher priority. When irregular URLLC traffic looks during the transmission time interval (TTI), offered scheduler discoveries for appropriate the URLLC-eMBB traffic in some multi-users transmissions [8].

Jain et al, (2018) mainly focused on 5G networks architecture, 5G radio spectrum, Ultra-Dense Radio Access Networks (UDRAN), traffic offloading of mobile, Software-Defined Radio (SDR), SDN, and 5G network impact on the society [9].

While, Toon et al, (2018) presented an outline of 5G requirement as stated by 3GPP SA1. The main drivers of the 5G system where the requirements is to afford enhanced capacity and higher data rates and the requirements to support different ‘vertical’ sectors with ultra-reliable and low latency communications. He discussed the basic requirements that are new to the 5G system and provided the performance requirements [10].

Kukliński et al, (2018) presented a generic network slicing framework that includes embedded in each slice management and operations related mechanisms in order to cope with slice management scalability and to address the multi-tenancy issues. They presented solutions that used NFV, MANO for slice orchestration [11].

Also, Lagen et al, (2018) considered some resource allocation problems to efficiently support multiple numerologies simultaneously. They assumed frequency division multiplexing (FDM) of numerologies in a time division duplex (TDD) systems with a self-contained slot format. They focused on optimizing the numerology sub-band (SB) configurations, as well as the duplexing ratio between uplink and downlink paths within each SB [12].

Yan et al, (2019) proposed an intelligent resource scheduling scheme for 5G radio access network (RAN) slicing. The main part was to exploit a collaborative learning framework which consists of deep learning (DL) in conjunction with Reinforcement Learning (RL). Precisely, DL was used to perform the timescale resource allocation, while RL was used to perform on-line resource scheduling for tackling small timescale network dynamics, including inexact predictions and unexpected network state [13].

Noohani et al, (2020) discussed the security associated with the 5G network, various types of efficient antennas developed for 5G, 5G as an energy efficient network and state-of-the-art specifications for the internet of things (IoT) services and applications along with their related communications technology [14].

Davyt E et al , (2021) discussed the occasion that has arisen to deepen information in this field of study. This technology is included in phases of standardization and definitions . One of these aspects is the scheduling. The objective of the project is the 5G technology studio as its general construction is exposed for the longest time with respect to LTE in the cover one and cover two. Then, there is concentration on the MAC undercoat to study different algorithm options scheduling that can be applied to the new telephone generation [15] .

Kumar N et al , (2021) authors have been carried out stated that, real-time and non-real-time UEs are scheduled individually. More, some UEs perhaps left without getting any resource blocks (RB)s [16].

Finally, Alsenwi et al, (2021) studied the resource slicing problems in the adaptive multiplexing scenario of two distinct 5G services, namely Ultra-Reliable Low Latency Communications (URLLC) and enhanced Mobile Broad Band (eMBB). In view of this, the resource slicing problem was formulated as an optimization problem that aims at maximizing the eMBB data rate subject to a URLLC reliability constraint, while considering the variance of the eMBB data rate to reduce the impact of immediately scheduled URLLC traffic on the eMBB reliability [17].

1.3 Research Objectives:

The thesis aims to investigate and discuss the following objectives:

1. The radio access network (RAN) slicing, resource scheduling, and packet scheduling
2. Investigating the different categories of network slices and investigate how to improve or enhance the network performance.
3. comparing three types of the most network utilizing scheduling schemes to get the best result for the user.
4. The thesis proposes a new dynamic scheme to switch among the three schemes to optimize the network performance.

1.4 Thesis Outline:

This thesis deals with various scheduling algorithms and scenarios that are provided to evaluate the network slicing performance in 5G , The thesis consists of Five chapters :

- Chapter Two overviews the 5G system in the beginning introduction of the history of 4G then overview the main technologies, architecture and key requirement of 5G.
- Chapter Three presents the Introduction for network slicing and talking about RAN and Core Network Slice. In addition ,It exhibits Architecture, Security and Resource Allocation in Network Slices.
- Chapter Four presents the Performance of Symbol-Based Schedulers with Network Slicing with three schedulers. It also presents the system model and configuration results. Finally, a new proposed Dynamic Scheduling Scheme is presented and the proposed scheme steps also Anticipated results.
- Chapter Five presents the conclusions and suggestions for future research.

Chapter Two

An Overview of 5G System

2.1 Introduction:

Modern advances in wireless and cellular communications systems have enabled networks operator's and researchers to develop and improve the user's tasks and demands, and modern communications devices. Networks accumulate, share, and divide resources between different entities to get a gainful life that were unreasonable before the modern communication network. In the last two decades, the wireless and cellular communications have developed at an exceptionally quick pace to have a complete and productive digital future. In this chapter, a brief overview explains the fourth generation. Then, a detailed explanation and importance of architecture of the 5^{th} generation system is presented.

2.2 The Fourth Generation (4G):

The fourth-generation standard was released (R8) as called long term evolution (LTE) as the new generation of cellular system. 4G-LTE provided a high data rate, high quality of video and voice of the wireless communications channel. 4G technologies are mainly based on the LTE technology, a global internet protocol (IP)-based which is concerned with technologies for data transmission in cellular communications. Figure (2.1) shows the architecture of a 4G-LTE system [18].

LTE systems use orthogonal frequency division multiplexing (OFDM), adaptive modulation and coding scheme (MCS) technique which provided an adaptive bandwidth (1, 1.4, 5, 10, 15, and 20) Mhz . 4G-LTE systems use also, multiple input and multiple output (MIMO) technique to enhance user's throughput. It uses, also, the coordinated multipoint (CoMP) technique to enhance user's throughput at the cell edge. 4G-LTE-A systems use many types of cells according to size and covere; macro, micro, pico, and femto cell [19].

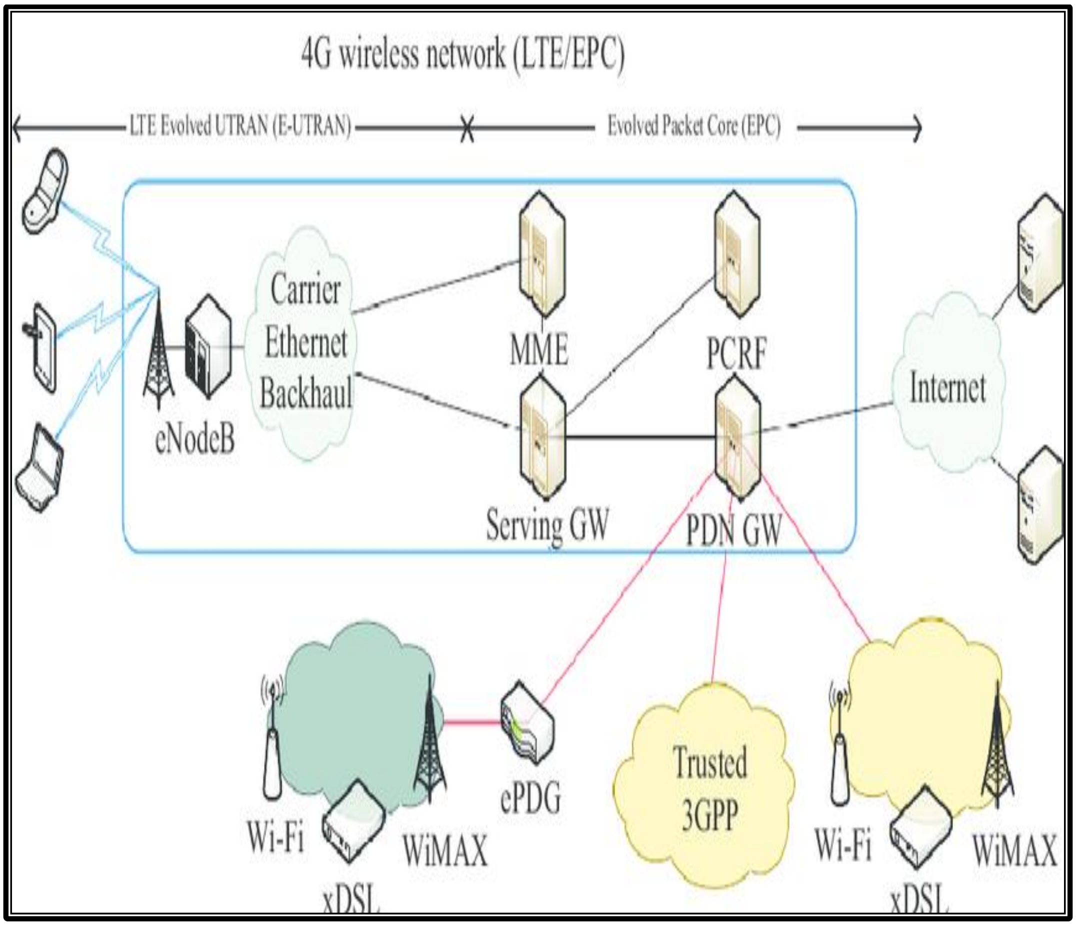


Fig 2.1. 4G LTE architecture [20].

2.2.1. Multiple Input Multiple Output (MIMO) techniques:

In radio and wireless communications, MIMO technology is a method of multiplication of the capacity of a radio channel utilizing many transmission and receiving antennas to adventure the multipath propagation. MIMO technique has become an important element of wireless cellular communications standard, including Wi-Fi, WiMAX, and 4G systems. In recent utilization, "MIMO" in particular denotes a technique for transmitting and detecting multiple data signal simultaneously over the single channel by using multipath propagation [21],[122].

2.2.2. Orthogonal Frequency Division Multiplexing (OFDM):

The concept of frequency orthogonality and multiplexed division is to use the division of radio channel (carrier) into many subcarriers, so that many signals can be sent, in time, in parallel with maintaining a very-high spectral efficiency (SE). Each subcarrier sends the data of the UE which cause simple OFDM access (OFDMA) which achieves different services and media such as speech, streamed video, high-accurate graphics, other data to be sent within the same channel. According to a specific type of services (real or non-real time) and their Quality-of-Service (QoS) requirements specify the system quality of features such as performance, availability, scalability, and serviceability. QoS requirements are driven by business needs specified in the business requirements [23],[24].

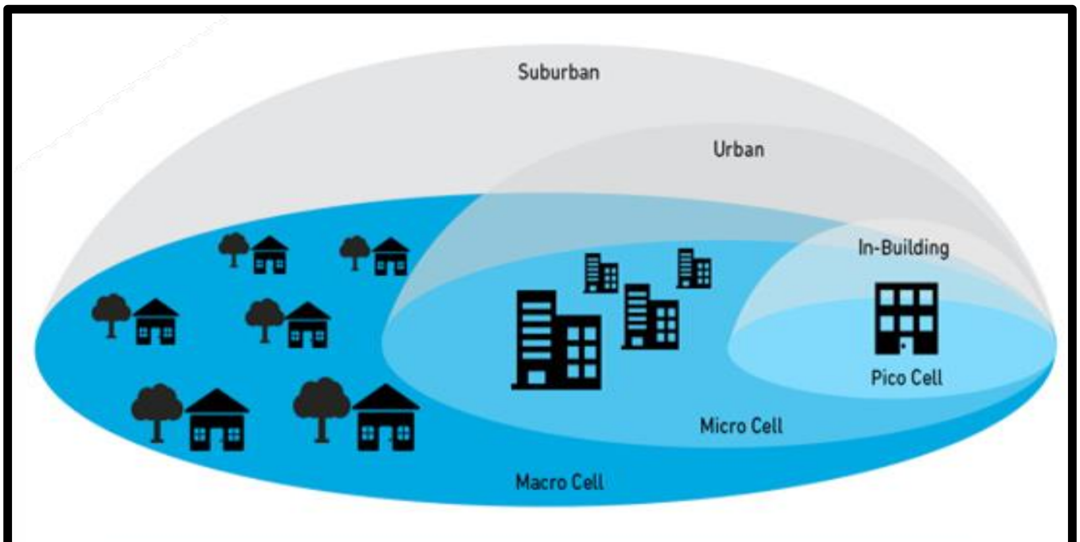
2.3 5G (Fifth Generation):

5G is the fifth-generation technology standard for broadband wireless and cellular networks. The cellular network operators began deploying the 5G networks worldwide in 2019. In 5G, all UEs and wireless devices in a cell are connected to the Internet and mobile BS system via the millimeter waves (mmWave) with the massive MIMO technique. The advantages of the modern network are that they provide wider bandwidth, and a bit rate up to 10 gigabits per second (Gbit/s) [25],[26].

2.3.1 main 5G Technologies:

5G system uses six technologies that are utilized to integrate the system and to enhance the system performance. They are:

- **Millimeter Waves**: 5G uses mmWave band which starts from 18GHz and above . The disadvantages of using mmWaves are the low distance. They have very low penetration through buildings or obstacles, and its power can be highly absorbed by rain [27].
- **Small Cells**: Small cell is miniature BS that transmits very low power which requires very low supply to operate. Small cells can be mounted at any place and altitude to form a Heterogeneous Network (HetNet) that receives signals from any other BS and send them to the UEs in different directions and locations. Small cell can be pico, micro, femto-cells and can comprise of indoor/outdoor systems [28] as shown in Figure (2.2).



Cell Type	Output Power (W)	Cell Radius (km)	Users	Locations
Femtocell	0.001 to 0.25	0.010 to 0.1	1 to 30	Indoor
Pico Cell	0.25 to 1	0.1 to 0.2	30 to 100	Indoor/Outdoor
Micro Cell	1 to 10	0.2 to 2.0	100 to 2000	Indoor/Outdoor
Macro Cell	10 to >50	8 to 30	>2000	Outdoor

Fig 2.2. The Tx power, cells and the transceiver of the small cells [28].

- **Massive MIMO**: In this technology , each BS is provided with a very large number of beam elements (antenna), generally several hundred antennas, with several orders of magnitude higher than the number of antennas in 4G-LTE MIMO system. It is assigned to each UE a single beam and can serve multiple UEs at the same time-frequency shared resources [29]. The simple basic massive MIMO is shown in figure (2.3).

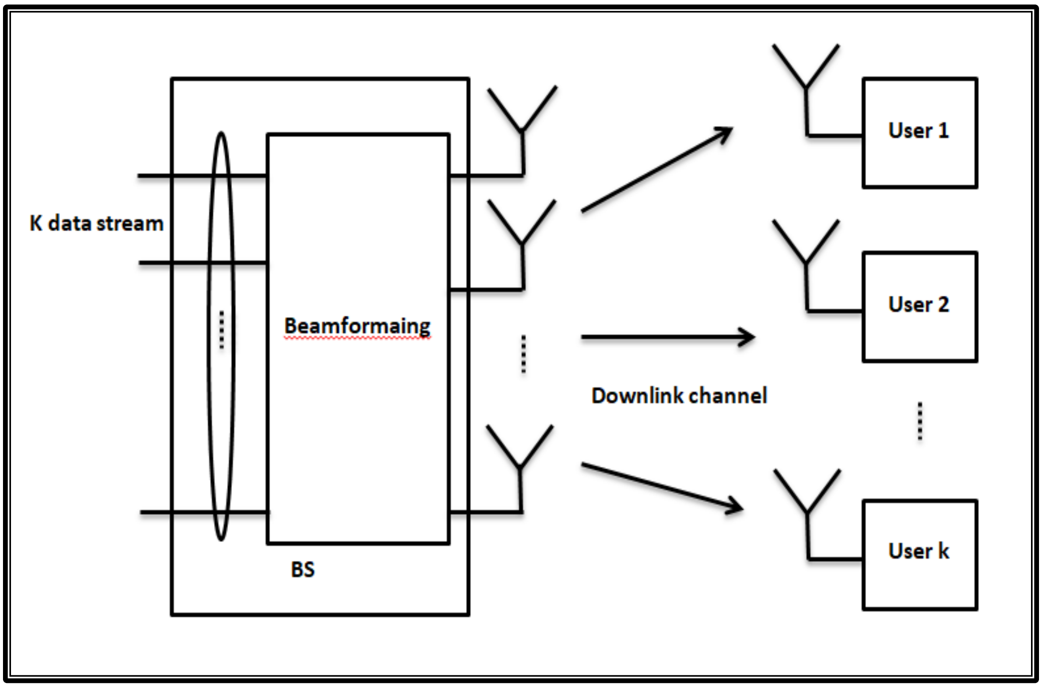


Fig. 2.3. The Basic model of massive MIMO [29].

5G BSs are provided with hundreds of antenna arrays, each one can accommodate many more antennas and thereby can transmits to / and detects signals from UEs [27] as shown in Figure (2.4).

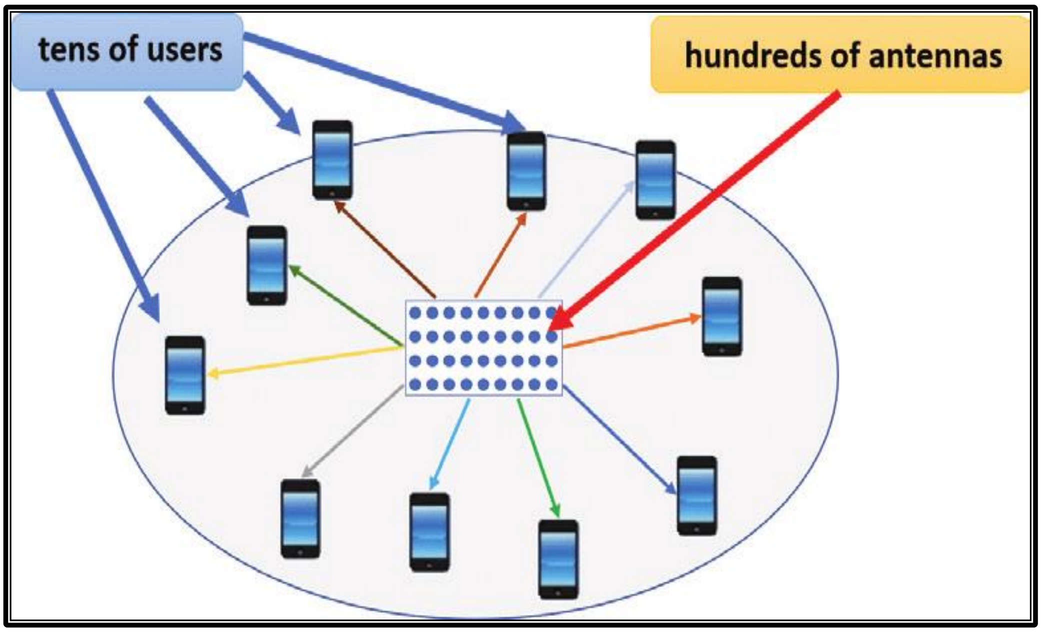


Fig. 2.4. Massive MIMO operation principle [30].

- **Beamforming**: is a process formulated to produce the radiation beam patterns of the antenna completely forming the processed each signal in the desired direction of the UE and cancelling beams of interfering signals [31], as shown in Figure (2.5).

Beamforming can support massive MIMO beams for more exploration utilization of the spectrum. At BSs, the best transmission route is designed by means of signal-processing schemes to transmit or send individual data packets in diverse directions, lively them off buildings and any object in exactly coordinated pattern. Beamforming permits exchange of data between the UEs and antennas on the massive MIMO beams or arrays by creating the packet's arrival time [27].

The application of beamforming in the massive MIMO system has the following main advantages: improved SE, improved energy efficiency, augmented security, and applicability for mmWAVE frequencies [31].

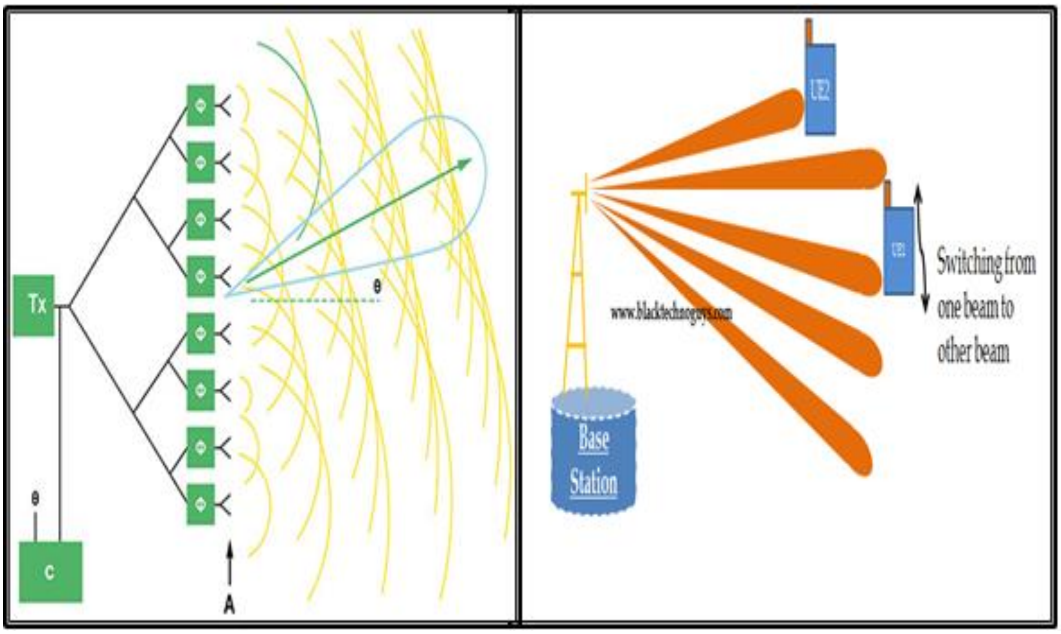


Fig. 2.5. Simple beamforming [31].

- **NOMA:** 5G system uses non-orthogonal multiple access (NOMA), which is one of the best capable wireless and radio access techniques. The idea of NOMA is to serve many UEs with the shared resources in terms of frequency, time, and space. The principle of NOMA permits many UEs to share the common resources which causes interference in the system. Figure (2.6) below shows the NOMA scheme. Accordingly, all resource management and interference cancelation techniques, mainly for ultra-dense networks, need to be reentered for the incorporation of additional interference brings NOMA technology [32].

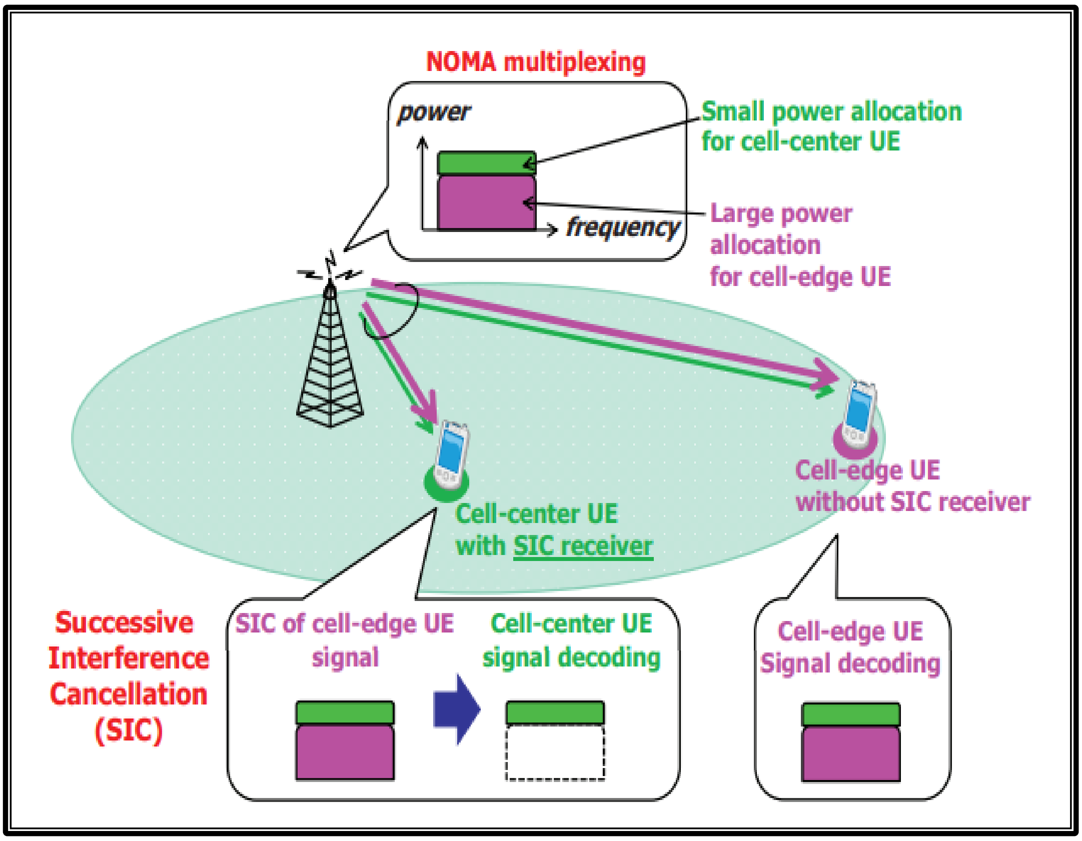


Fig. 2.6: NOMA scheme [33].

- **Mobile Edge Computing (MEC):** The network architecture concepts that permit cloud computing capability and a service environment at the edge of the wireless cellular network use mobile edge computing (MEC). The main idea achieved by MEC is by running the user's applications and performing related processing task closer to the UE, network congestion is mitigated, and applications implement better, as shown in Figure (2.7).

MEC technology is developed to be implemented at the wireless cellular BSs or other edge nodes, and enables flexible and rapid deployment of new services for UEs [34].

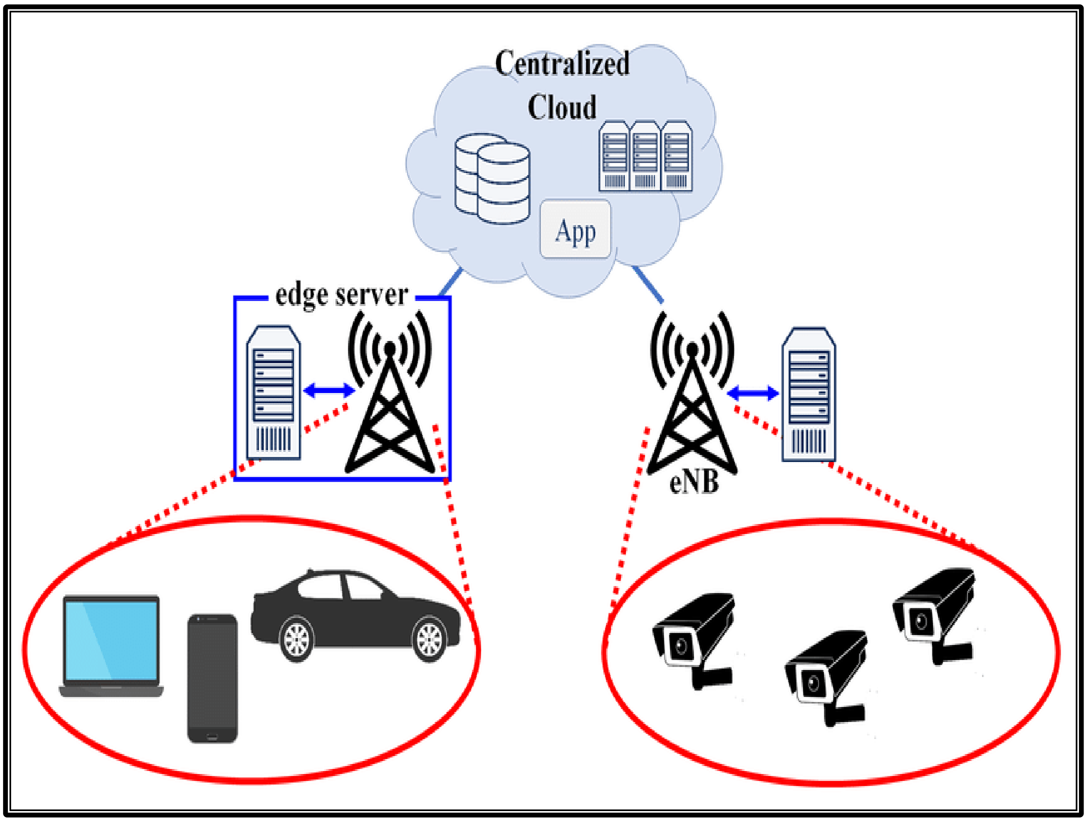


Fig. 2.7. Simple MEC scheme [35].

2.3.2 5G Architecture:

The scheme of a wireless and cellular mobile network architecture intend at defining network elements; BSs, routers, UEs and their interfaces in order to confirm a reliable operation. As 5G systems have to integrate an excess of partly challenging requests, enablers ; Network Function Virtualization (NFV) and Software Defined Networking (SDN) are to be functional in order to provide the desirable flexibility of forthcoming networks, mainly for the core network. Applying these technologies involves a reconsidering some aspects of network architecture design [36].

NVFs were planned to physical nodes to improve the performance of the integrated networks. In that logic, 5G architecture follows the same design principles as LTE networks. However, in 5G network the introduction of SDN and NFV models enable, also, a reconsidering of imagination in the context of basic protocol stack approaches.

The idea behind NFV and SDN is mainly to be enabled by flexible requirement on the core network [34]. NFs are accumulated in a Network Function Pool (NFP). The NFP assembles control functions and data processing which allows to be obtainable. It contains data on the functional classification, and interfaces.

RAN related functions can be allocated to the following blocks:

• Central management entity includes a principal network function that are positioned at main node.

• Radio Node Management (RNM) affords function that usually affect more than one wireless node to be operated at selected radio nodes.

• Air Interface function affords functionality mainly related to the air interface between the wireless node and UEs.

The 5G orchestrator has the responsibility for instantiating VNFs, NFs within the physical network. Core Network Element (CNE) and Radio Network Element (RNE) are logical node and hardware platforms (NF) or host virtualized functions (VNF).

The 5G SDNs Controller compliantly arranges the elements set up by the 5G Orchestrator according to service, user, and operator requirements. Thus, it sets up the information rate via the physical nodes and performs the C-plane functionality including scheduling scheme and hand-over function.

The physical network involves access networks, transport networks, and UE networks. The transport network, data centers, and host physical elements deal with big data packets as well as the core network and fixed network traffic functionalities. The architecture of the 5G system is presented in Figure (2.8).

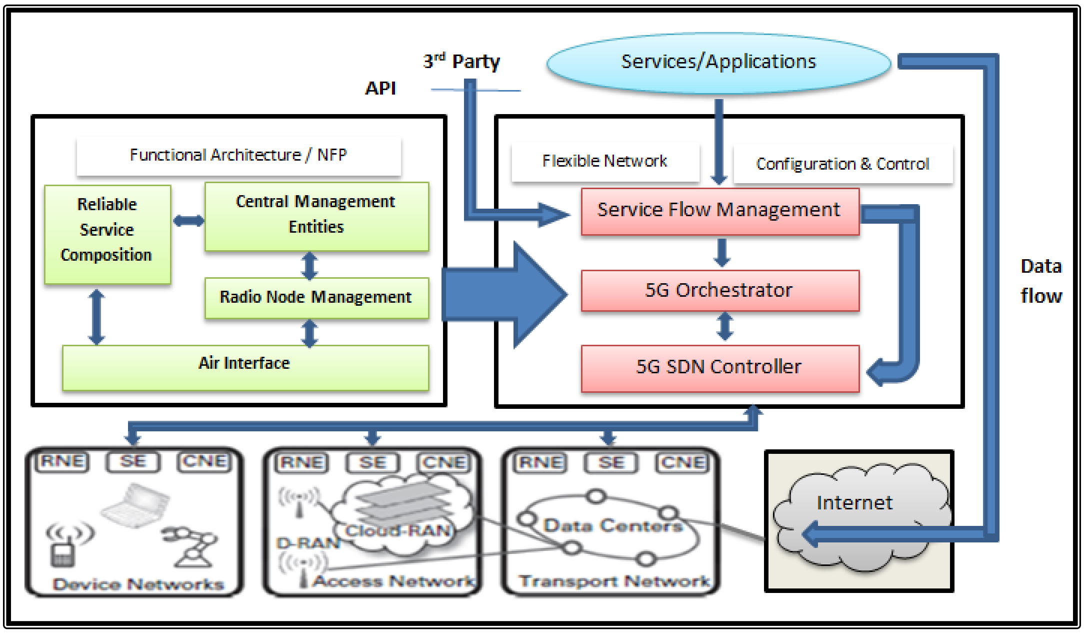


Fig 2.8. The 5G architecture [37].

The main SDN concept permits for the formation of modified virtual networks utilizing the shared network slices. Virtual network can be utilized for the realization of optimized resource management to various services such as MBB and mMTC which allow for resource sharing between operators [36].

2.3.3 5G Requirements and key performance indicators (KPI):

A simple explanation of the Key Performance Indicators (KPI)s in 5G is given below [38]- [41]:

- **Availability:** is explained as the percentage of communication links for which the Quality of Experience (QoE) requirements is satisfied with the certain coverage and geographical area.
- **Connection density:** is explained as the number of simultaneous UEs or active devices in the considered area through a predefined time span divided by the coverage area.

• **Energy consumption:** is explained as the energy per information bit and as a power per area unit (applicable in suburban or rural environment).

• **Experienced UE throughput:** is explained as the whole amount of data traffic an end-user UE achieves on the medium access control (MAC) during a pre-defined time span over the time span.

• **Latency:** is the latency of the information traffic on the MAC-layer of the wireless interface. Two definitions are applicable: One-Trip Time (OTT) and Round-Trip Time (RTT) latency.

• **Reliability:** is generally explained as the probability when a certain amount of information has been successfully sent from a sending port to a receiving port before a certain target (deadline) expires.

• **Security:** The security of a specific communication taking place is difficult to measure. One possible way to quantify the security would be to measure the time take place for a skilled hacker to access the data.

• **Traffic volume density:** is defined as the total amount of traffic switched by all UEs or devices in the predefined area during a specified time span over the area size.

Chapter Three

Network Slicing Technology in 5G

3.1 Introduction:

The 5G networks integrate services into a unique physical network infrastructure, and offered all services with an adapted network slicing. 3GPP recognized network slicing is the most important key technologies to achieve the main targets of 5G system [42].

5G Network slicing is use of network virtualization to divide single network connections in to multiple distant virtual connections that provide different amounts of resources to different types of traffic . The virtual network optimizes and architects for a definite service and application. The network slices are self-contained networks with its own virtual shared resources, traffic flow, and topology. There might be different network slices to meet the explicit communications requirements of different UEs in 5G network [43].

Slices are logically fully isolated, while the common resources are shared among slices. Every slice has a private network architecture and protocol. 5G network slicing embraces slicing the 5G RAN, 5G core networks, and end-UEs. 5G RAN slicing may be employed via logical abstraction of physical resources and components design of the BS [44].

NFV and SDN can flexibly organize the virtual resources, which include server processing ability, bandwidth, and network element processing competency, to perform the core network slicing for exact service requirement [45].

3.2 Architecture of Network Slicing:

The basic network slicing architecture consists of three layers [46], as revealed in Figure (3.1).

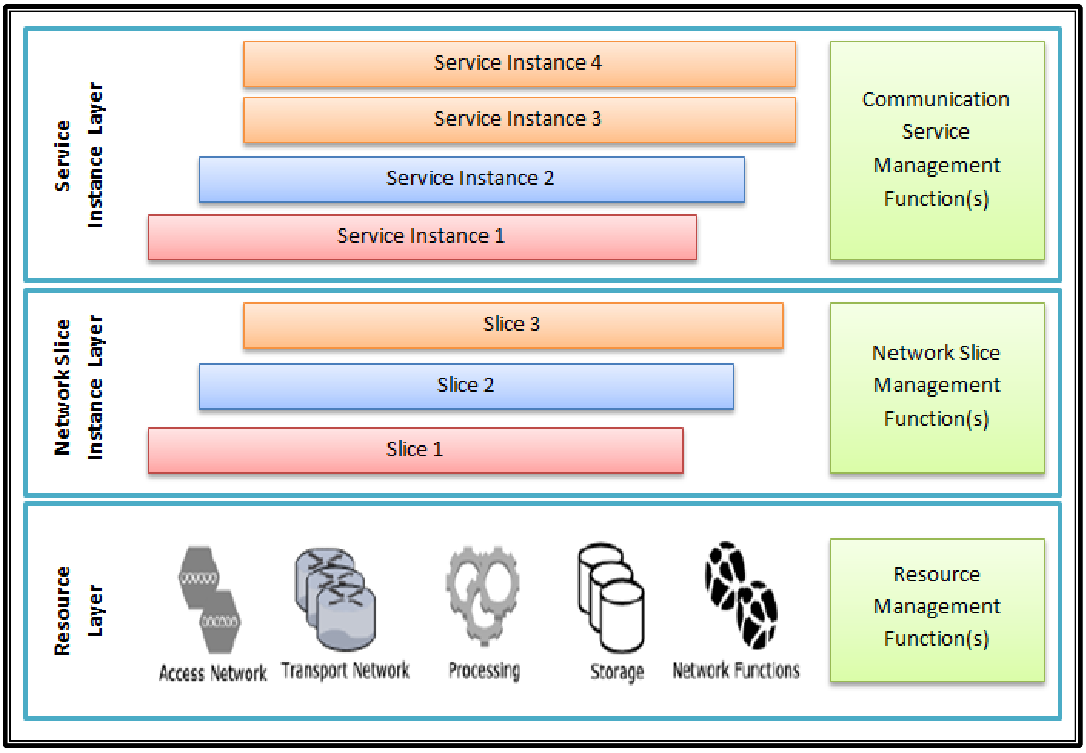


Fig. 3.1: General architecture of network slicing [46].

1) **Resources layer:** it is the bottom layer of the network slicing architecture which comprises of network common resources and all network functions that serving to provide all services to end UE-based on demand. Together network and resources functions can be either virtual or physical. An example of network functions; switching function, slice selection function, and authentication function [46].

2) **Network slice instance layer:** it is the middle layer of the network slicing architecture which contains slices; a slice offers network capability vital by the service instance. A slice can run over the system shared radio resources, or over an alternative slice to assist one or multiple service instances .

   The NSM must be capable for tracking the function and flows interactions through the slices, within their directorial domains. The NSM is responsible for the abstracted virtual network and functions, within the slices.

3) **Service instance layer:** it is the upper layer of the network slicing architecture which consists of service instances which consumes the slices and are obtainable to UEs. The resource management function relates to the underlying resources and network functions (NF). The network slice management function achieves the cycle of the slices and interrelates with the other related functions. The communication service managing function administers the life cycle of the services and react with the slice management functional [46].

   One promising technology that can support to deliver, is wireless network virtualization (WNV) [47]. Virtualization of shared resources in the information centers has to improve the performance by qualifying abstraction and shared resources between competing units [48]. WNV is a new notion for virtualizing the RAN of 5G wireless network. Generally, WNV ranges from spectrum sharing, infrastructure and to air interface virtualization [49].

3.3 Principles on Network Slicing Security:

Significantly, an operative network slicing solution needs to address a high security. It is vital that attacks achieved against any slice do not interrupt the others, therefore demanding that security function performance self-sufficiently . Secured network slicing solution confirms the main security principle, authentication, integrity and authorization . The network slicing security principles [50]:

- **Confidentiality**: confirms all packets are ready and available only for the slices that generated them. The information contained in these packets within the NFs that process they must not be assigned to other than end-UE.
- **Authentication**: must identify and validate UEs that are interacting with the system. When an OSS/BSS interrelates with the NSM, both parties must verify and authenticate equally. The same requirements apply to OSS/BSS interactions made on behalf of Slice-Owners, the ones with the NFV Management and Orchestrator (MANO), in order to achieve network elements [46],[50].
- **Authorization**: to define whether a tried interaction is permitted to go through. End-UEs, Slice-Owners, Infrastructure Providers, and elements such as the NSM or NFs have diverse abilities within the system. End-UEs may only be permitted to interact with slices that the Slice-Owners (SO) have decided access to SOs must only accomplish their own slices, or control the permitted interaction with all slices.

- **Availability**: the system should be accessible as in prospect when it is essential. This means that the NSM and NFs need to be maintaining accessible at all time, while the application part of the NFs must be accessible as long as the contracted infrastructure resources are not exceeded.
- **Integrity**: the system must not be capable to be undermined, either by interfering with data or by replacing its functionality [50].

3.4 Resource Allocation Schemes in Network Slices:

The huge development of wireless and cellular technology for 5G and the increased demands for the services and applications with QoS requirement, the managing of the common resources develop a permanently more inspiring phase which involves properly considering in order to enhance networks performance [51]. So, network slicing is successful as an active method to introduce a flexible allocation of shared resource [52]. A slice is an assembly of shared resources that is selected to fulfil the demand of QoS of all services carried by the slices [53].

The aim of network slicing is to present a flexible use of shared resource by contributing only the resources necessary to fulfill the requirement of the slices enabled in the system [54]-[57].

Due to the various QoS demands and the limitation of network resources, efficiently allocate network resources between service slices and User Equipment’s (UEs) is a major issue [58].

Definitely, the main feature to be considered is the method of the shared radio resources that are allocated to diverse slices in order to realize the requirement of each slice. The duty related to the resource allocation converts more motivating with network slicing, as it presents a two-tiers priority in the network. The first tier denotes the priority of diverse slices, as each slice has its own priority defined according to the agreements between the network operator and the slice holder. The second tier refers to the priority between the UEs of the same slice [59].

The allocation schemes, as shown in Fig (3.2), to achievements a two-tiers primacy levels. The allocation schemes, based on the primacy of the slice, adopts about service of each slice. Finally, according to the slice priority, the virtual network allocates the physical wireless radio resource to each user of the acknowledged slices [60].

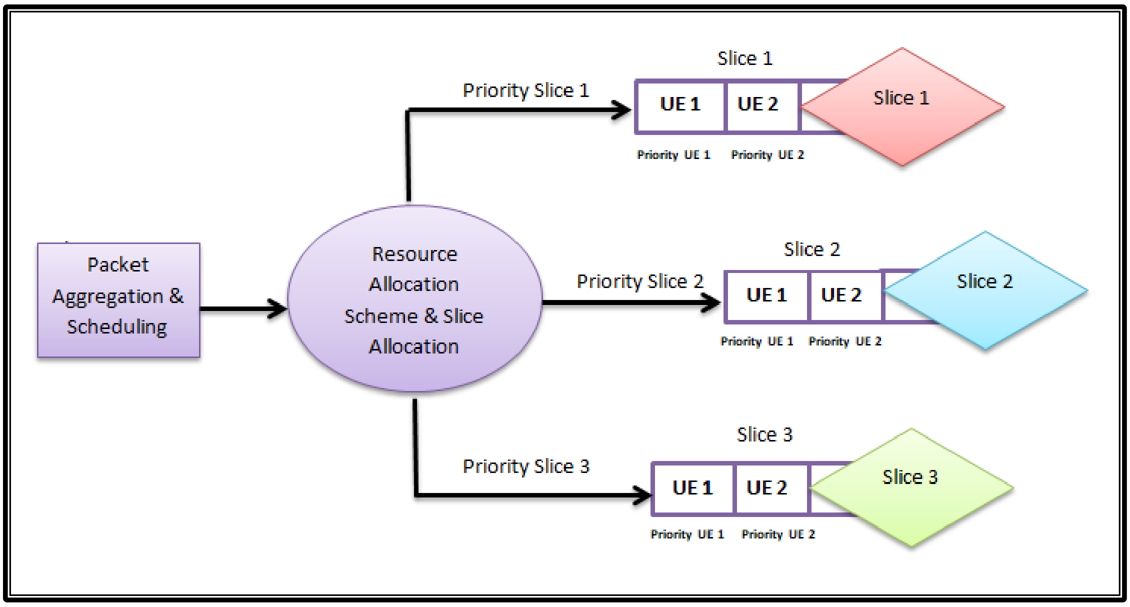


Fig 3.2. Resource Allocation Schemes [60].

Chapter Four

5G Performance of Symbol-Based Schedulers with Network Slicing

4.1 Introduction:

5G systems are intended to support a wider range of applications and business models. This is probably arises by some very high diversity requirement on network performance to achieve some important parameters; peak rates up to 10Gbps, and latency equal to 1 ms. To optimize the above network parameters for low latency with high user's throughput can achieve peak data rate comes with reduced spectral efficiency (SE). In this situation, utilizing the network slicing technique with 5G system has become an initial necessity to enhance 5G system developers to comprise a logical network with precise functionality, without sacrificing the quality of the infrastructure. This logical network, denoted as slices, can be personalized to achieve two purposes. First, to offer a particular network behavior over utilization of control plane (CP) or user plane (UP) function to enhance exact services domain (enhanced Mobile Broad-Band (eMBB)), massive Machine Type Communication (mMTC), Ultra-Reliable and Low Latency Communication (URLLC). Second, to offer particular tenant via specified level of guaranteed network shared resources and isolation with respect to the operation of all simultaneous slices [61].

There are many scheduling algorithms and schemes developed to share resources among users. This chapter, deals with the comparison of scheduling schemes used with network slicing. Many resource allocation and scheduling schemes have been developed for LTE, LTE-A systems and finally for 5G systems, at the uplink and downlink , by many researches related to performance comparison in terms of packet delay, throughput and, fairness. Some articles , as well, investigate the network performance at high-speed UE.

4.2 Schedulers Overview:

This section compares the performance and delay of many types of scheduling schemes which are: RR, BCQI and PF.

4.2.1 Round Robin (RR) Algorithm:

RR scheme is a non-aware scheduling scheme that permits UE to take tries in utilizing the common resources, without taking the channel states into consideration while offering high fairness for all UEs in the radio channel assignment. This degrades the UE throughput [62]. Figure (4.1) shows the round robin scheduler operation. The following code is used to depict the work of RR scheduling scheme.

```
function [selectedUE, mcsIndex] = hNRSchedulingStrategyRR(schedulerInput)
selectedUE = -1;
mcsIndex = -1;
scheduledUE = schedulerInput.lastSelectedUE;
for i = 1:length(schedulerInput.UEs)
    scheduledUE = mod(scheduledUE, length(schedulerInput.UEs))+1;
    index = find(schedulerInput.eligibleUEs == scheduledUE, 1);
    if(~isempty(index))
        bufferStatus = schedulerInput.bufferStatus(index);
        if(bufferStatus > 0)
            selectedUE = schedulerInput.eligibleUEs(index);
            mcsIndex = schedulerInput.mcsRBG(index, 1);
            break;
        end
    end
end
end
```

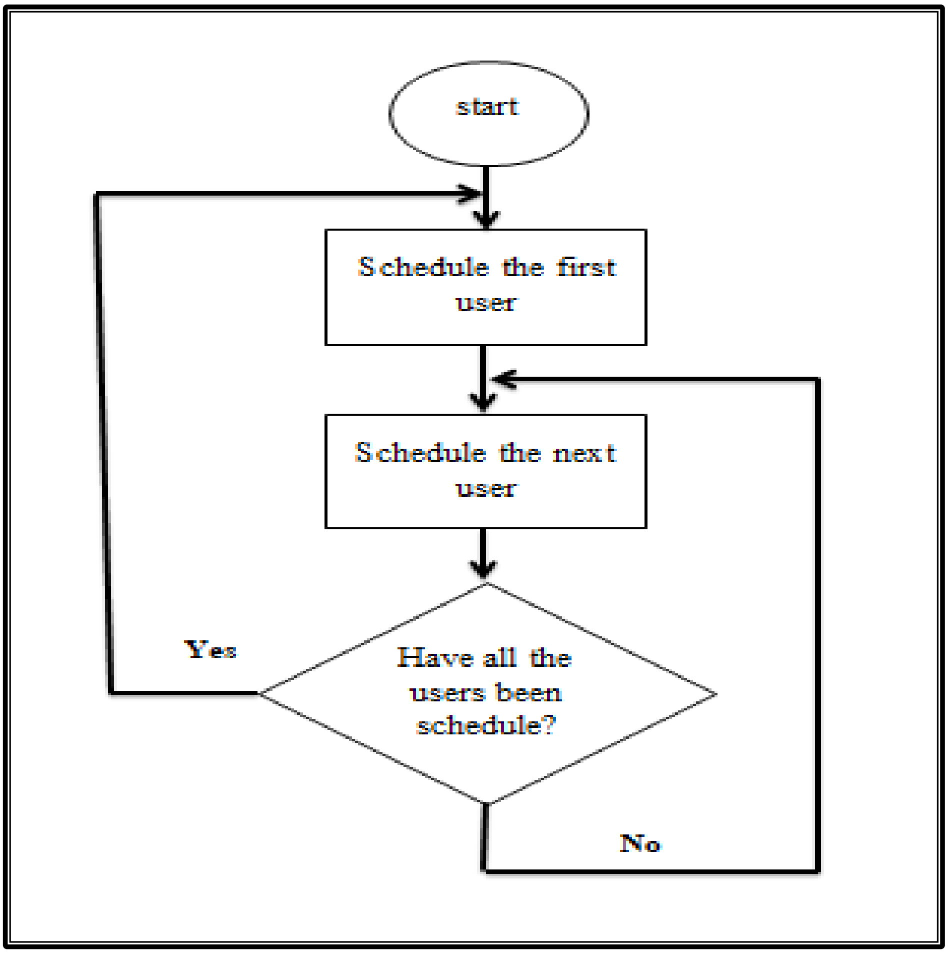


Fig (4.1): Flow chart of Round robin Scheduling [63].

4.4.2 Best CQI Algorithm:

This scheme assigns more RBs to the UE with high SNR. To perform packet scheduling, UEs send the channel condition to the BS. Basically, in the downlink, the BS transmits a reference signal (RS) to the UEs. These RSs are utilized by UEs for the mapping SNR to the channel quality indicator (CQI). BCQI scheme can increase the UE throughput and system capacity sacrificing the fairness. In this strategy, UEs moving at the cell boundary UEs are improbable to be scheduled [64], as shown in Figure (4.2). The following code is used to depict the work of BCQI scheduling scheme.

```
function [selectedUE,mcsIndex]=hNRSchedulingStrategyBestCQI(schedulerInput)
selectedUE = -1;
mcsIndex = -1;
bestAvgCQI = 0;
for i = 1:length(schedulerInput.eligibleUEs)
    bufferStatus = schedulerInput.bufferStatus(i);
    if(bufferStatus > 0)
        cqiRBG = schedulerInput.cqiRBG(i, :);
        cqiAvg = floor(mean(cqiRBG));
        if(cqiAvg > bestAvgCQI)
            bestAvgCQI = cqiAvg;
            selectedUE = schedulerInput.eligibleUEs(i);
            mcsIndex = schedulerInput.mcsRBG(i, 1);
        end
    end
end
end
```

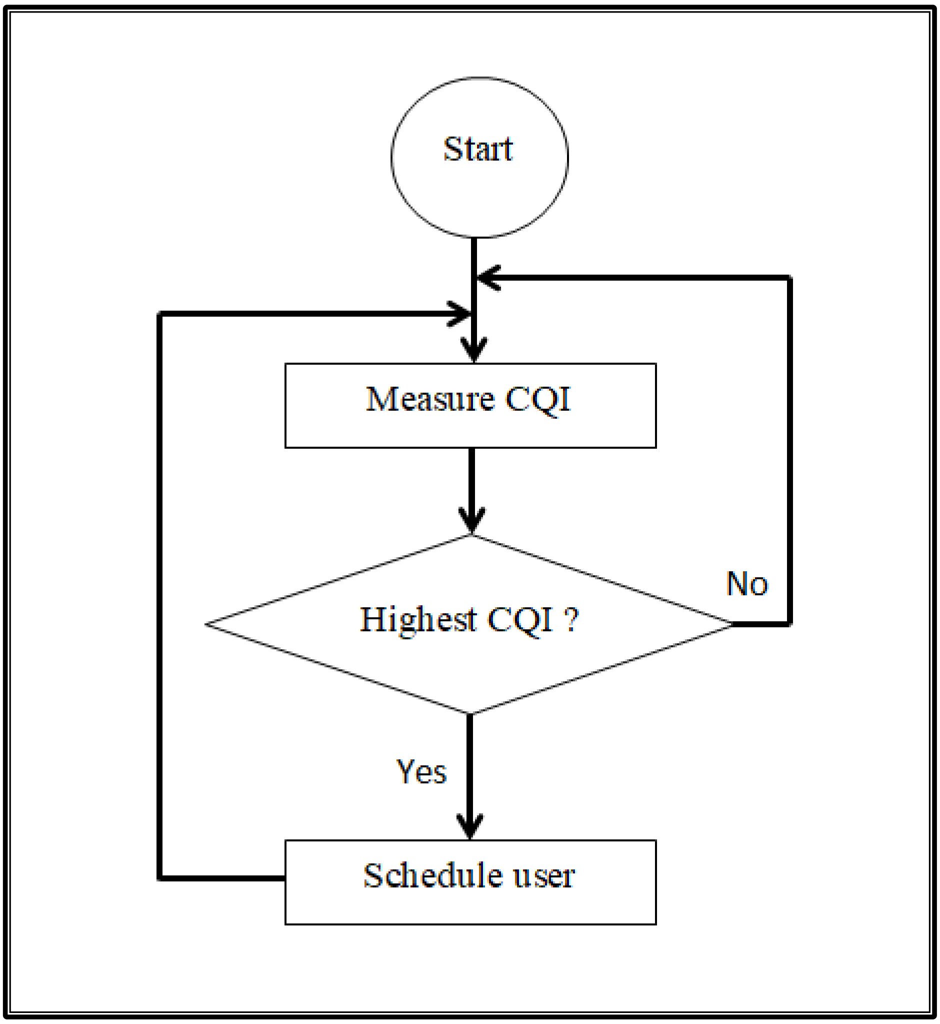


Fig (4.2) Flow chart of best CQI Scheduling [63].

4.2.3 Proportional Fair (PF) Algorithm:

PF improves spectral efficiency and provides higher fairness to the system by using the channel variations. This scheduler allocates the resource blocks to the cellular users with the best link quality by combining CQI & level of fairness. It also allows the mobile users to achieve a maximum QoS because it maintains a balance between fairness and maximum cell throughput . It allocates the RB by considering the throughput at a specific TTI and the average throughput of the cellular user. This is achieved by means of a weighted fair queueing algorithm (WFQ) that sets scheduling weights for data flow [65]. Figure 4.3 depicts the decision-making process of this scheduler . The following code is used to depict the work of PF scheduling scheme.

```
function [selectedUE, mcsIndex] = hNRSchedulingStrategyPF(schedulerInput)
selectedUE = -1;
maxPFWeightage = 0;
mcsIndex = -1;
for i = 1:length(schedulerInput.eligibleUEs)
    bufferStatus = schedulerInput.bufferStatus(i);
    pastDataRate = schedulerInput.pastDataRate(i);
    if(bufferStatus > 0)
        bitsPerSym = schedulerInput.mcsRBG(i, 2);
        achievableDataRate = ((schedulerInput.RBGSize * bitsPerSym *
        14 * 12)*1000)/(schedulerInput.ttiDur);
        pfWeightage = achievableDataRate/pastDataRate;
        if(pfWeightage > maxPFWeightage)
            maxPFWeightage = pfWeightage;
            selectedUE = schedulerInput.eligibleUEs(i);
            mcsIndex = schedulerInput.mcsRBG(i, 1);
        end
    end
end
end
```

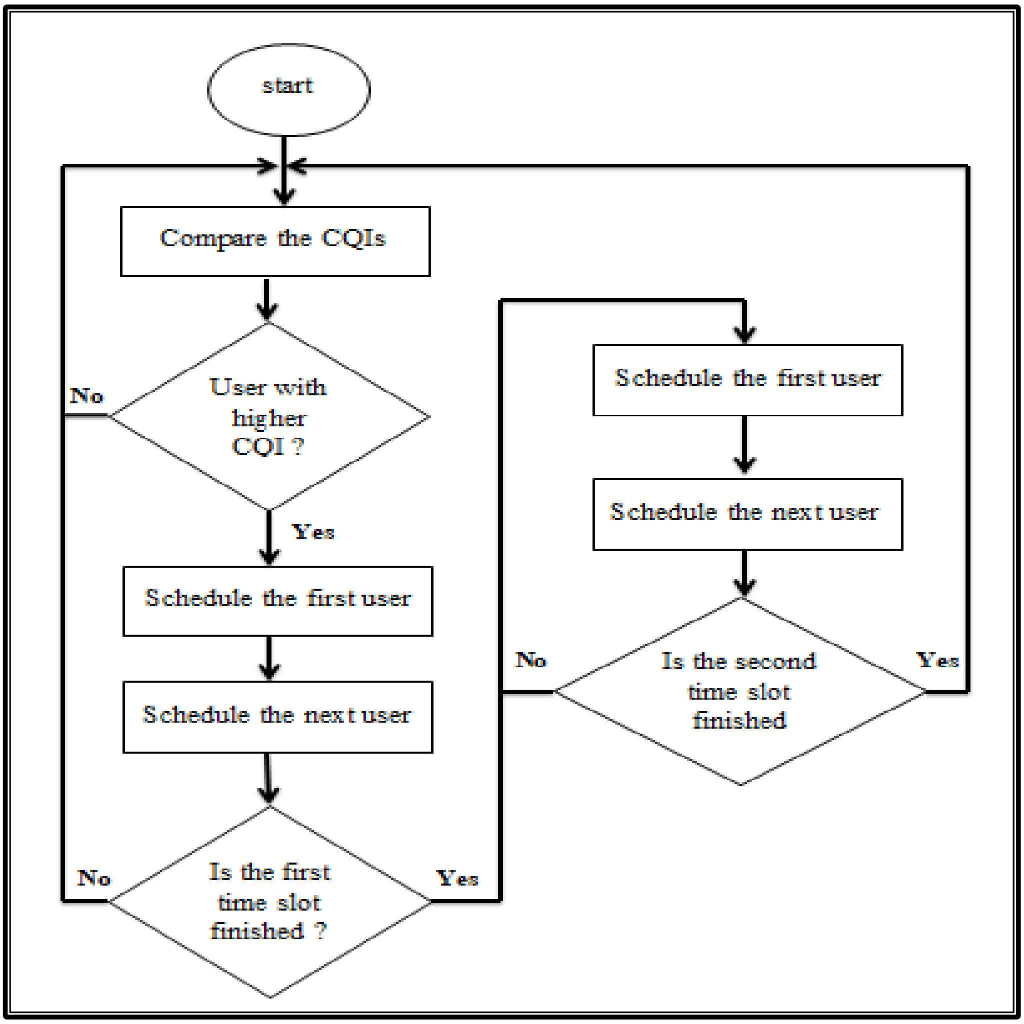


Fig (4.3): Flow chart of PF Scheduler [65].

4.3 System Model and Configuration:

In this model, we consider the 5G system having many small base station cells in the same network, each operating with a carrier frequency 28 GHz. To evaluate the effects with three schemes in the downlink and uplink.

The MATLAB R2020a software simulator is utilized . Its setup involves a single cell massive MIMO system covered by the massive number of antenna elements having 3UEs. The distant locations of the three UEs from gNB are 100m, 400m and 700m. The scheduling strategy comparison is between RR, BCQI, and PF. The subcarrier spacing is 15 kHz. The packet size of the uplink is 2000 bytes generated by each UE. The main parameters of the simulation are summarized in Table (4.1).

The simulation shows how a scheduling strategy (controlled by the gNB) assigns UL and DL resources among the UEs. Considers the following operations at gNB and UEs that facilitate UL and DL transmissions.

TABLE 4.1. Parameters used in the simulation

Parameters	Settings
Configurable	TDD pattern
Number of UEs	3
Distance of UEs from gNB	UE1:100m, UE2:400m, UE3:700m
Simulation time	10000 ms
Scheduling	symbol based
Scheduling strategy comparison between :	RR, BCQI, PF
HARQ	16
Subcarrier spacing	15 kHz
Duration of the uplink pattern	5 ms
Periodicity at which the UL and DL packets are Generated by UEs	30
Size of the UL and DL packets (in bytes) generated by UEs	2000
Sequence number field length (in bits) of the logical channel for each UE	6
Reassembly timer of the logical channel for each UE	5 ms
Max buffer length of the logical channel for each UE (to model Tx buffer overflow)	20000
Channel Update Periodicity	200 ms

4.4 Simulation Evaluation and Results Assessment:

The simulation runs using the MATLAB codes to evaluate the performance of the 5G system. The simulation model runs according to the system model parameters model.

4.4.1 Throughput Resolution Simulation Evaluation:

One of the networks slicing performance schemes evaluations is the throughput resolution.

1. **MAC throughput evaluation:**

The uplink and downlink MAC throughput results for 3 UEs is depicted in Figure 4.4(a, b) for the Round Robin Scheduler. The evaluation depicts that the system distributes the available resources in fair manner according to the user's distance and priority.

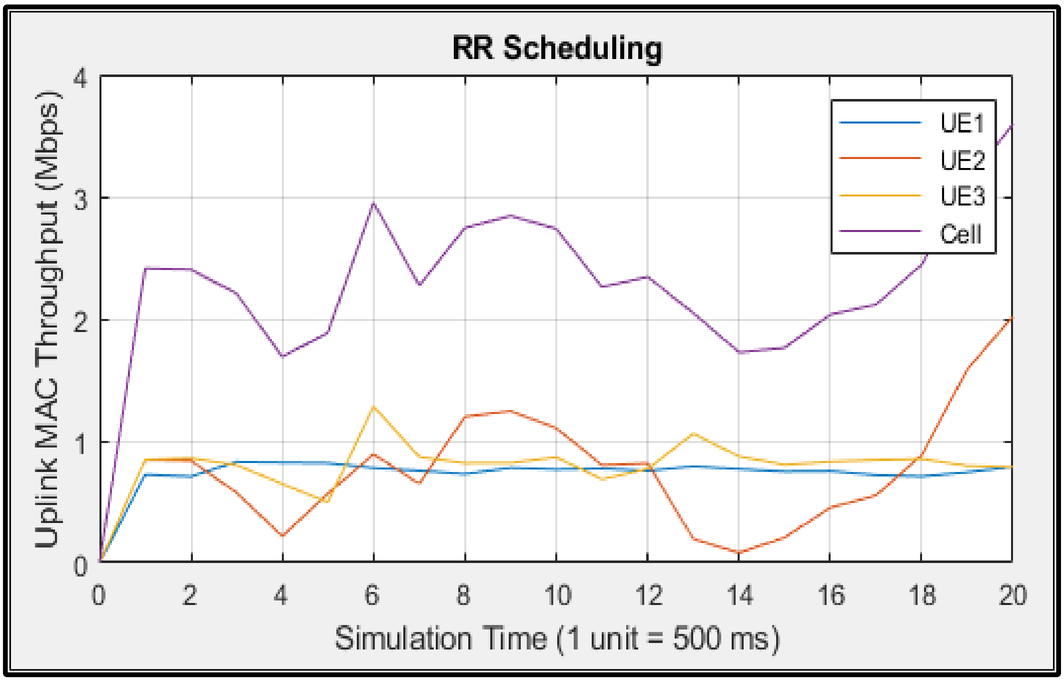


Fig 4.4 (a) Uplink MAC throughput with time for (RR) Scheduler.

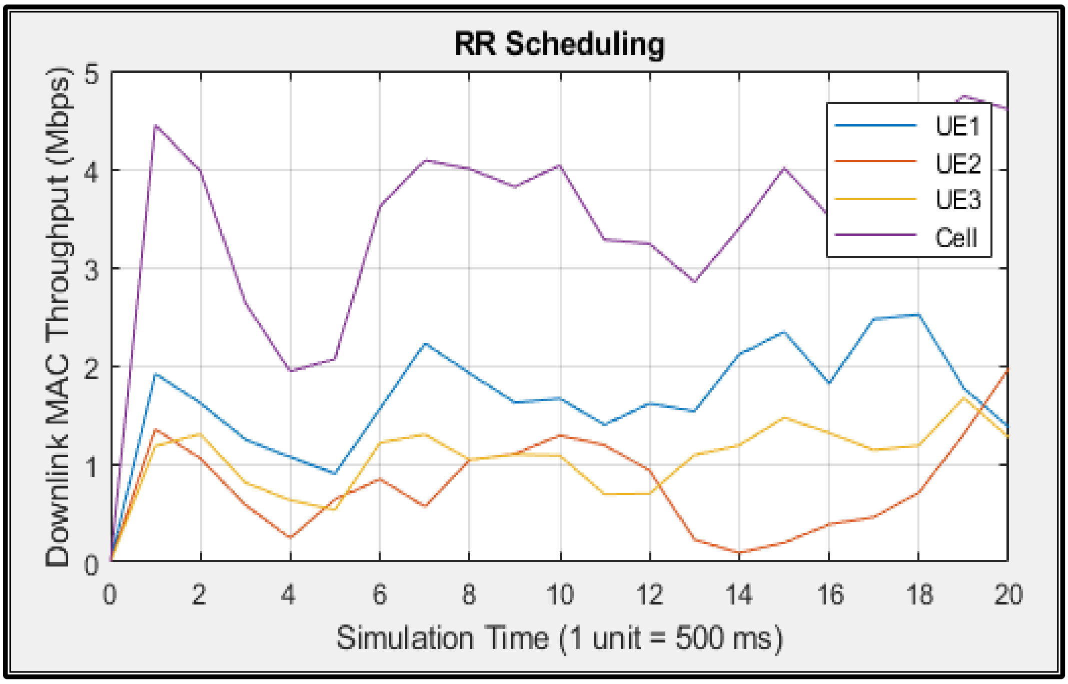


Fig 4.4 (b) Downlink MAC throughput with time for (RR) Scheduler.

According to evaluation in Figure 4.4(a, b), it is found that the user throughputs are always different according to diverse slices applications not taking into consideration neglecting UE's SNR and distances.

Now, the next Figure 4.5 (a: for the uplink and b: for the downlink), is a Best CQI scheduler, which depicts the MAC throughput for this algorithm. The figure (4.5 (a and b)) shows that the distribution is unfair and the priority is given for the UE with best channel quality.

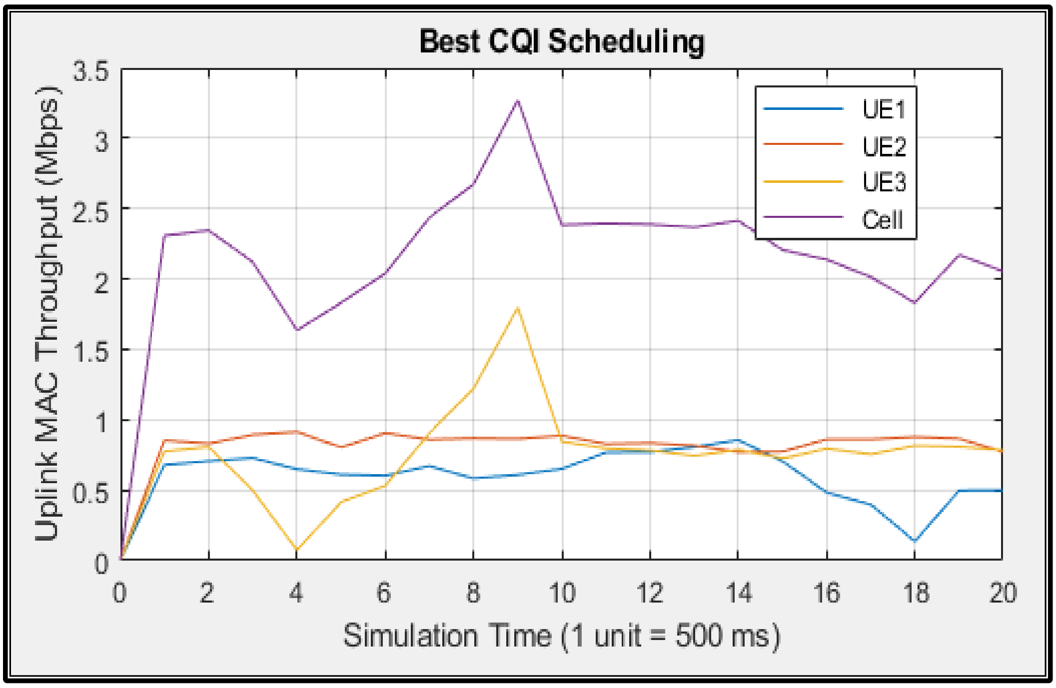


Fig 4.5: (a) Uplink MAC throughput with time for (BCQI) Scheduler.

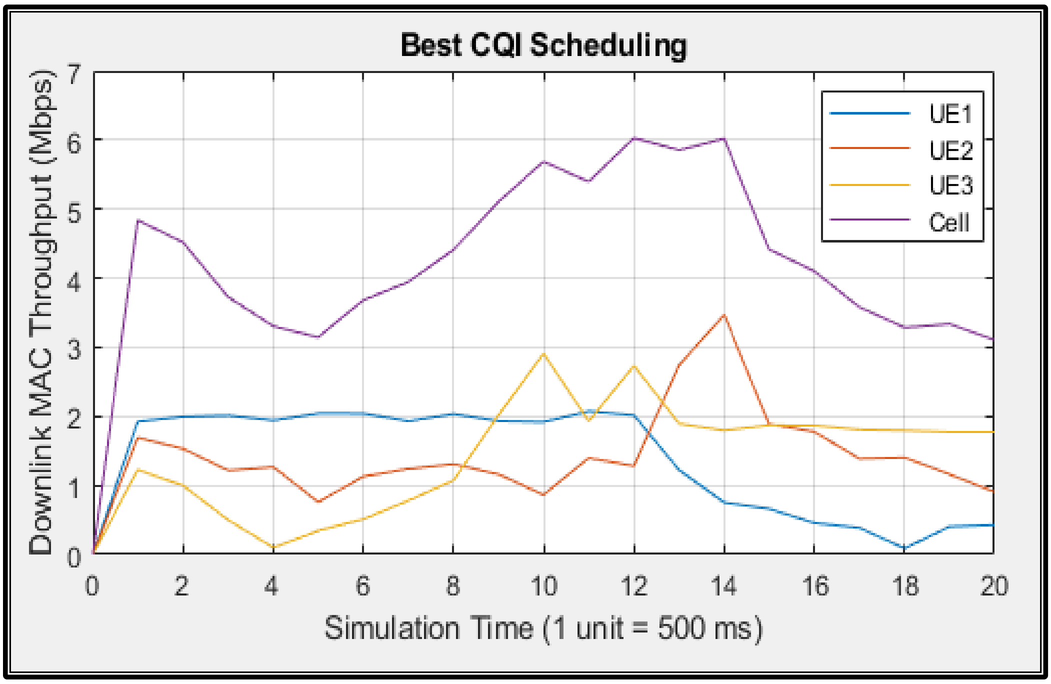


Fig 4.5:(b) Downlink MAC throughput with time for (BCQI) Scheduler.

From Figure (4.4), we can notice that all UEs get equal throughput, which can be provided by RR scheduler. While, for Figure 4.5, we can notice that the UE with high SNR and good channel quality, the cell assigns higher throughput. This is very clear for UE 1, which has higher throughput than others.

Then, The result for MAC throughput PF scheduler is shown in Figure 4.6 (a for the uplink and b for the downlink), which depicts good balance between the objective of maximizing cell throughput for all UEs.

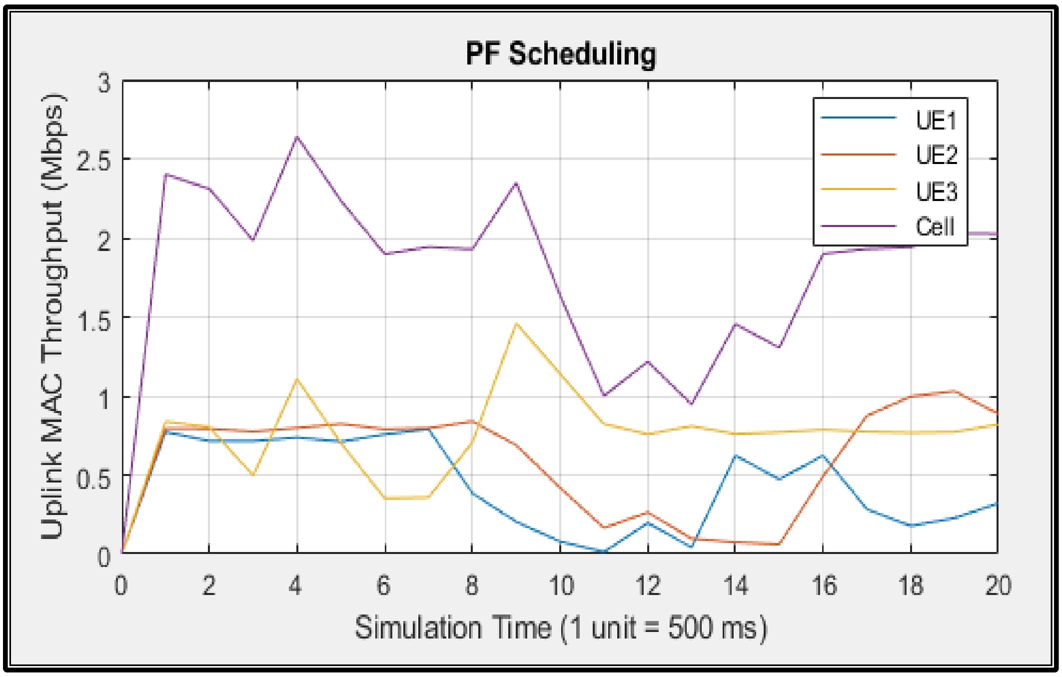


Fig 4. 6 (a): Uplink MAC throughput with time for (PF) Scheduler.

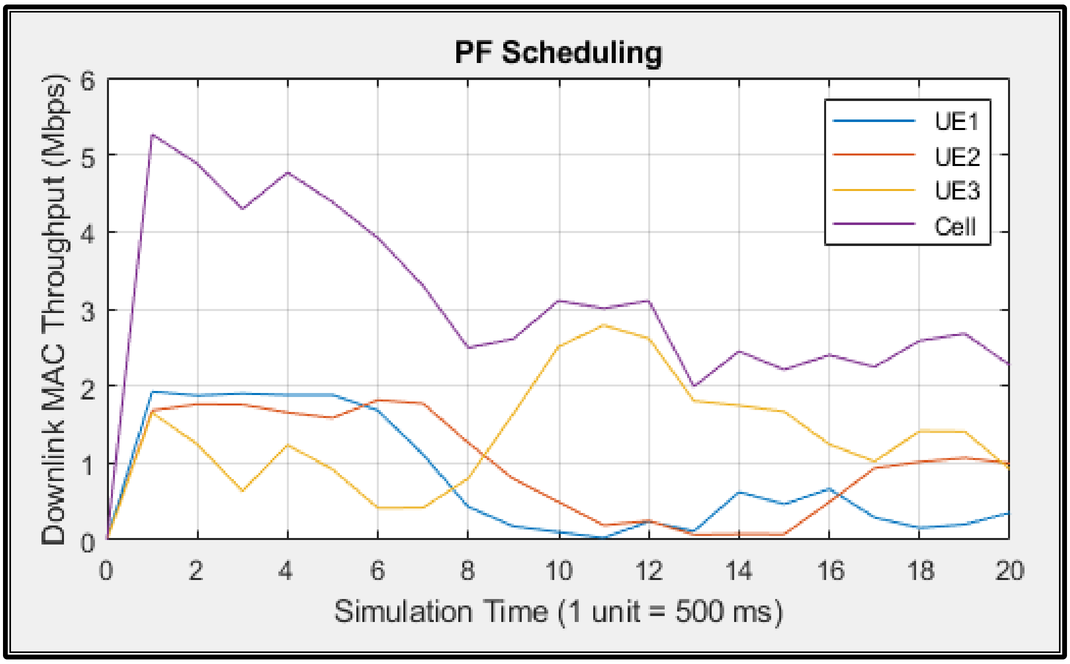


Fig 4. 6 (b): Downlink MAC throughput with time for (PF) Scheduler.

According to Figure 4.6 (a, b), it is noticed that a balanced distribution among the users because PF scheduler doesn’t rely on interval and priority.

Finally , comparison total throughput for 3 user between types of scheduling show in Figure 4.7 (a for the uplink and b for the downlink)

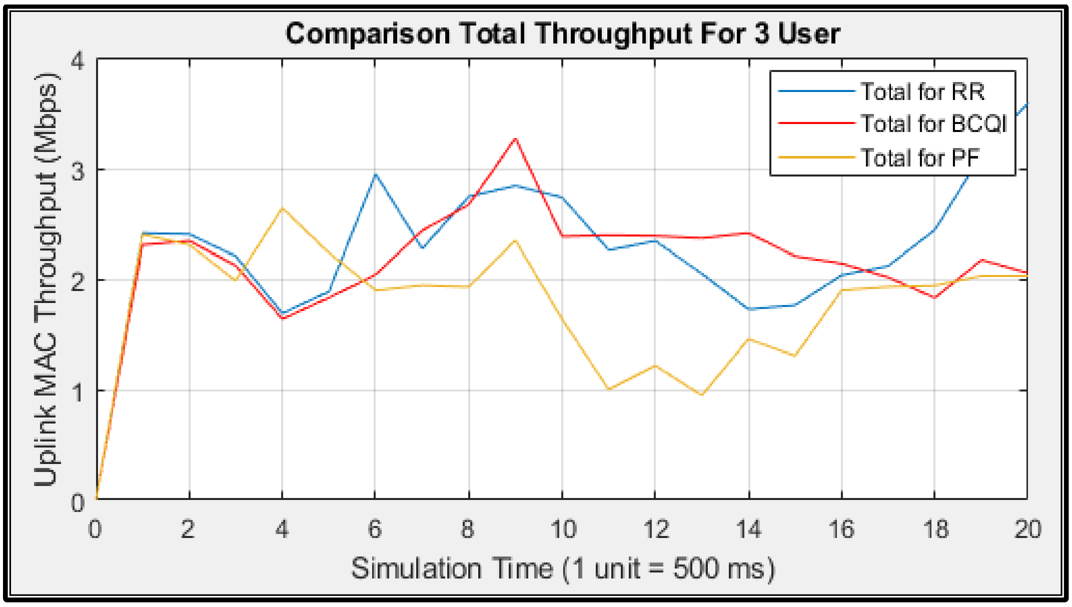


Fig 4. 7 (a): Comparison total Uplink MAC throughput with time for 3 Scheduler.

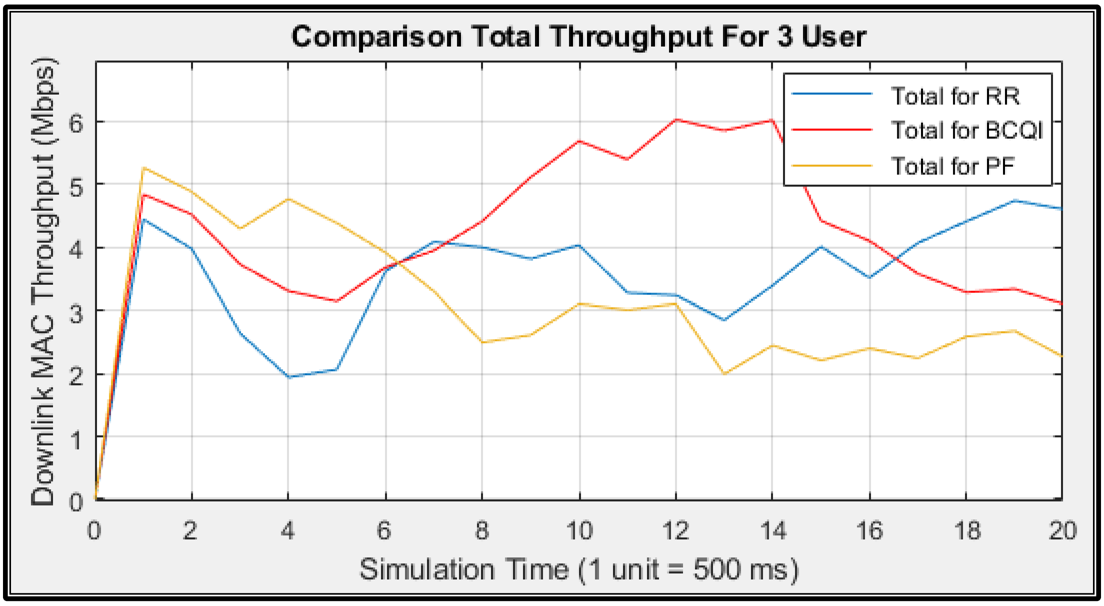


Fig 4. 7 (b):Comparison total Downlink MAC throughput with time for 3 Scheduler.

From the above figures 4.7 (a ,b), it can be shown that the BCQI scheduler achieve more throughput according to the SNR for each UE, while the RR scheduler achieve better throughput as it does not depends in the SNR. but PF scheduler depicts a good balance between the objective of maximizing cell throughput for all UEs

2. **RLC throughput evaluation:**

The uplink and downlink RLC throughput results for 3 UEs is depicted in Figure 4.8 (a, b) for the Round Robin scheduler.

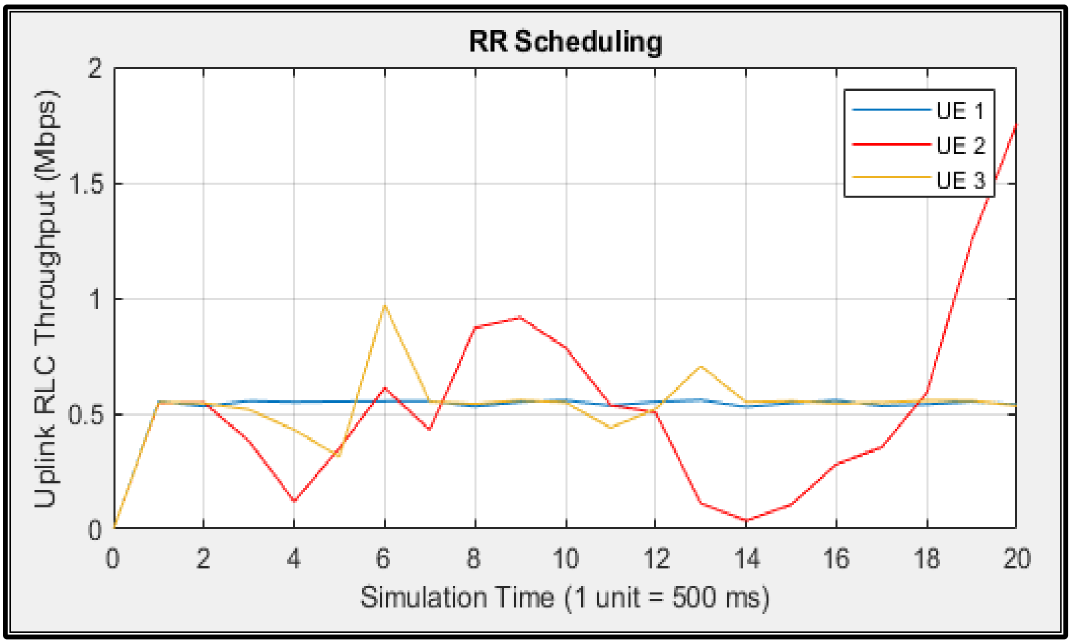


Fig 4.8 (a): Uplink RLC throughput with time for (RR) Scheduler.

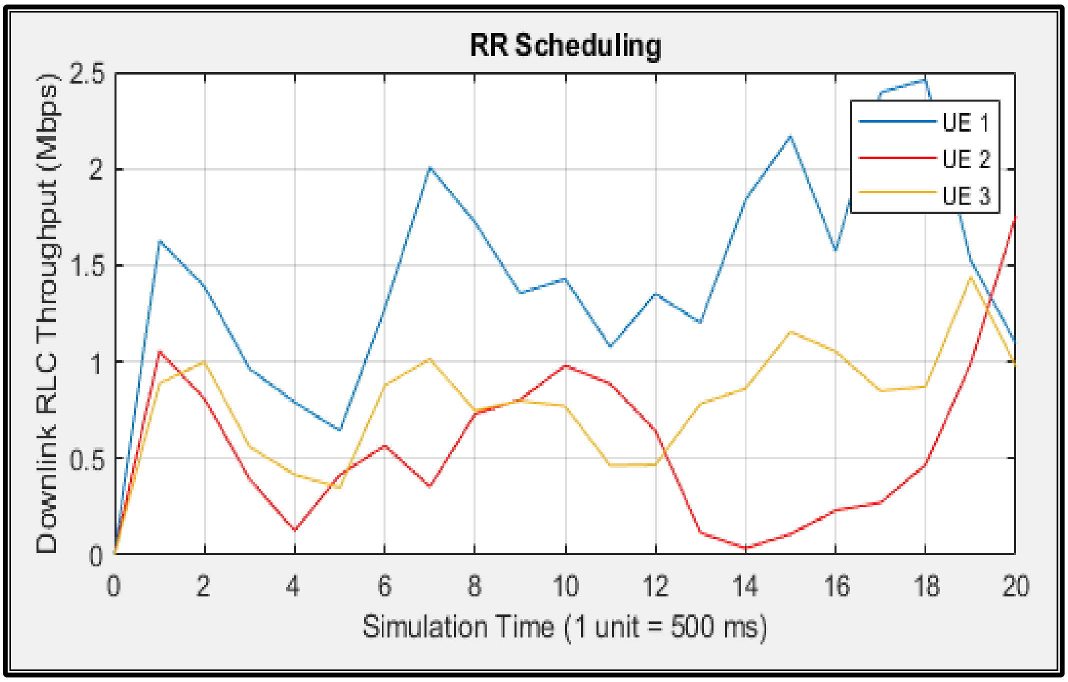


Fig 4.8 (b): Downlink RLC throughput with time for (RR) Scheduler.

According to the RLC throughput shown in the Figure 4.8 (a, b), it is found that the nearest UE to the BS, at the uplink, is stable and constant with time interval while, for downlink the nearest user has a more RLC throughput.

For Best CQI RLC throughput show in Figure 4.9 (a, b) which depicts the higher throughput provided for the UE with best channel quality.

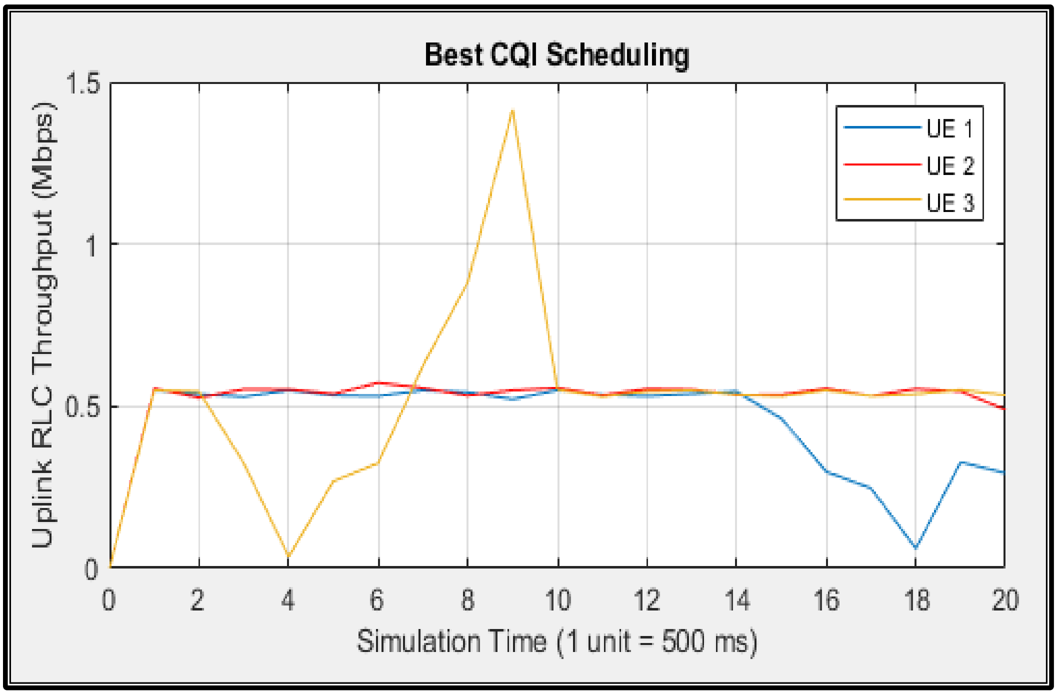


Fig 4.9 (a): Uplink RLC throughput with time for (BCQI) Scheduler.

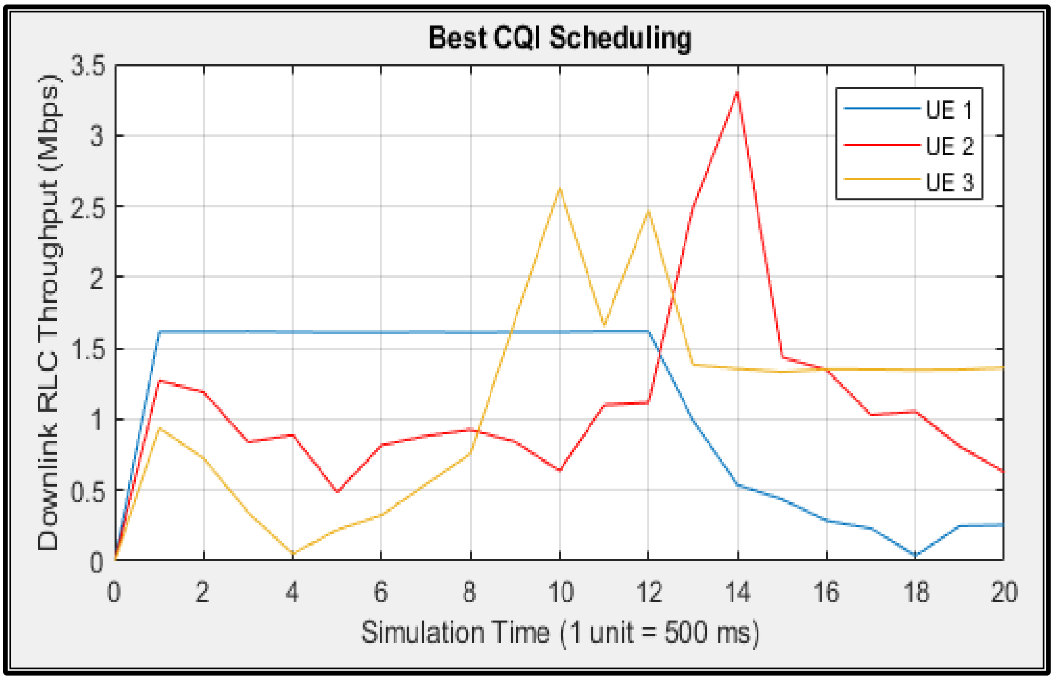


Fig 4.9 (b) Downlink RLC throughput with time for (BCQI) Scheduler.

Thus, the evaluation from Figure 4.9 (a, b), for BCQI, it is noticed that the UE has a higher throughput with the high SNR, as mentioned in the specifications of this scheduler.

Then, for this comparison, the system uses the PF scheduler to schedule the slices. The result for RLC throughput is shown in Figure 4.10 (a for the uplink and b for the downlink).

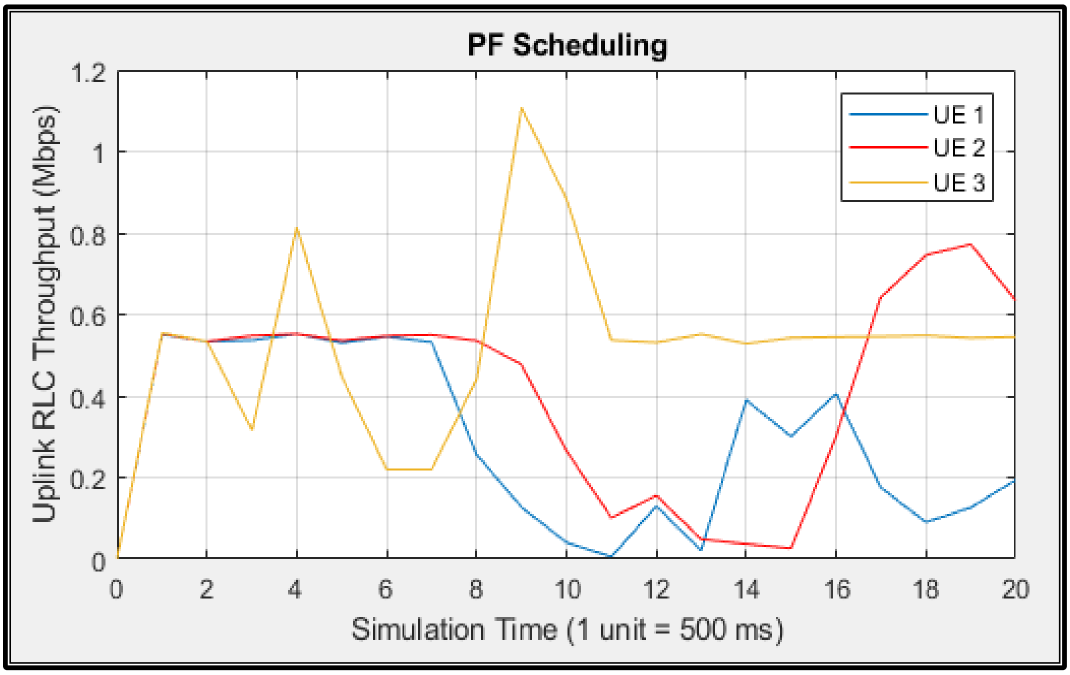


Fig 4.10 (a): Uplink RLC throughput with time for (PF) Scheduler.

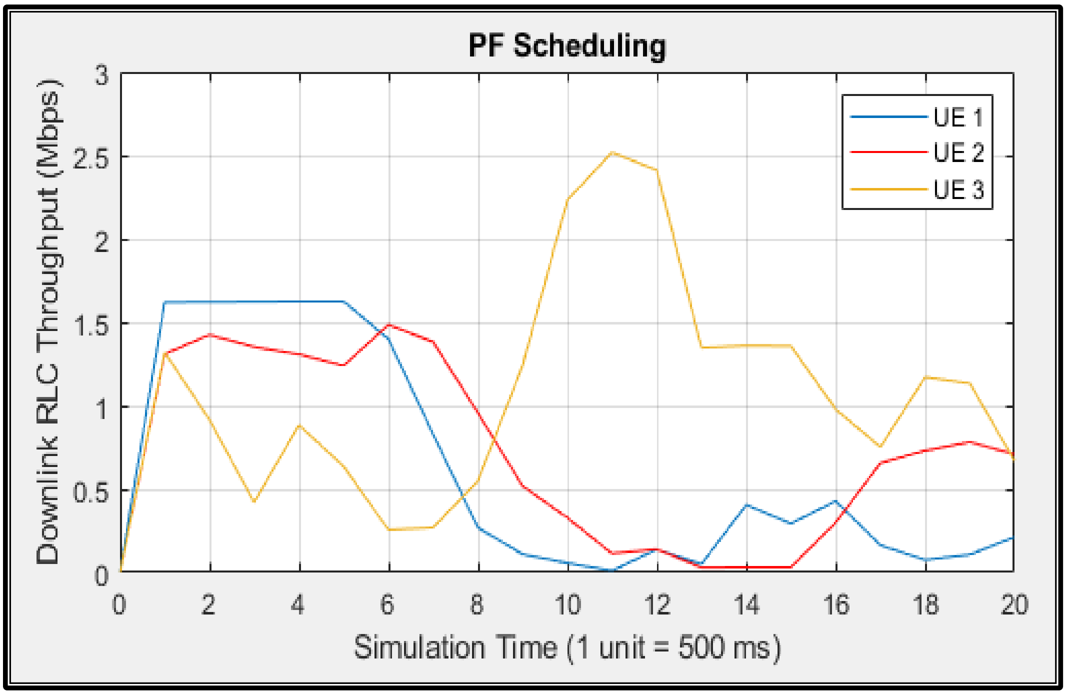


Fig 4.10 (b): Downlink RLC throughput with time for (PF) Scheduler.

Throughout the previous evaluations of the comparisons presented before, it is noticed that the RR achieves equal throughput while the other schemes depend on the priority of the slices. The priority is for those who have higher CQI, PF all UE has the same opportunity.

4.4.2. Resource share resolution Simulation Evaluation:

In order to know the distribution of shared resources over time for the 3 type Scheduler, we can observe the Figures 4.11 , 4.12 and 4.13.

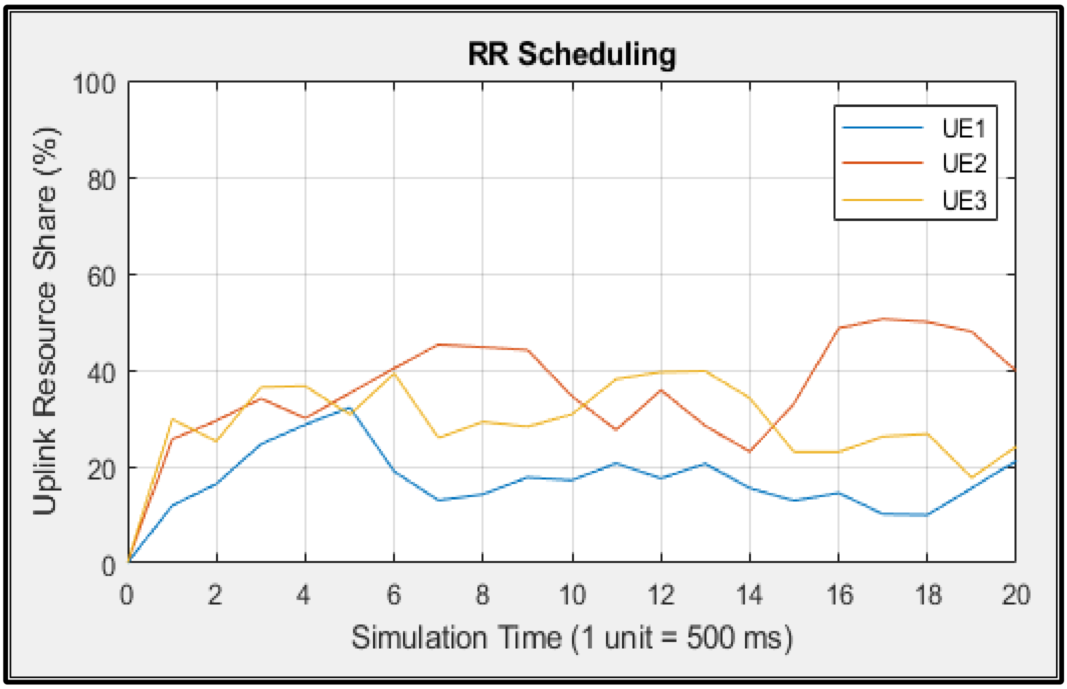


Fig 4.11 (a): Uplink Resources share with time for RR scheduling.

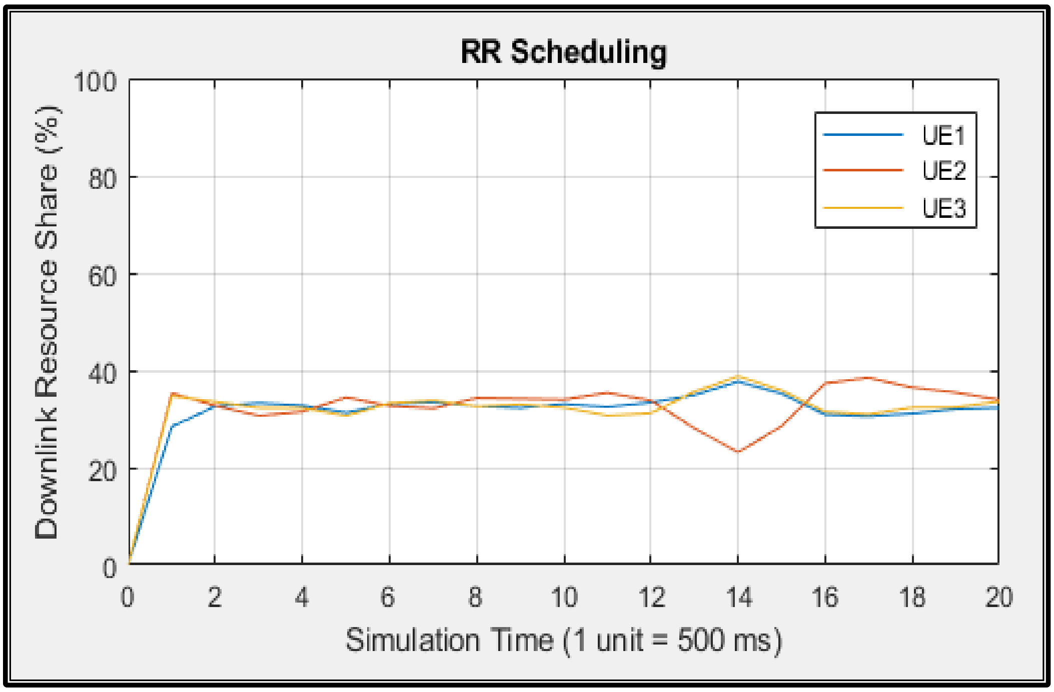


Fig 4.11 (b): Downlink Resources share with time for RR scheduling.

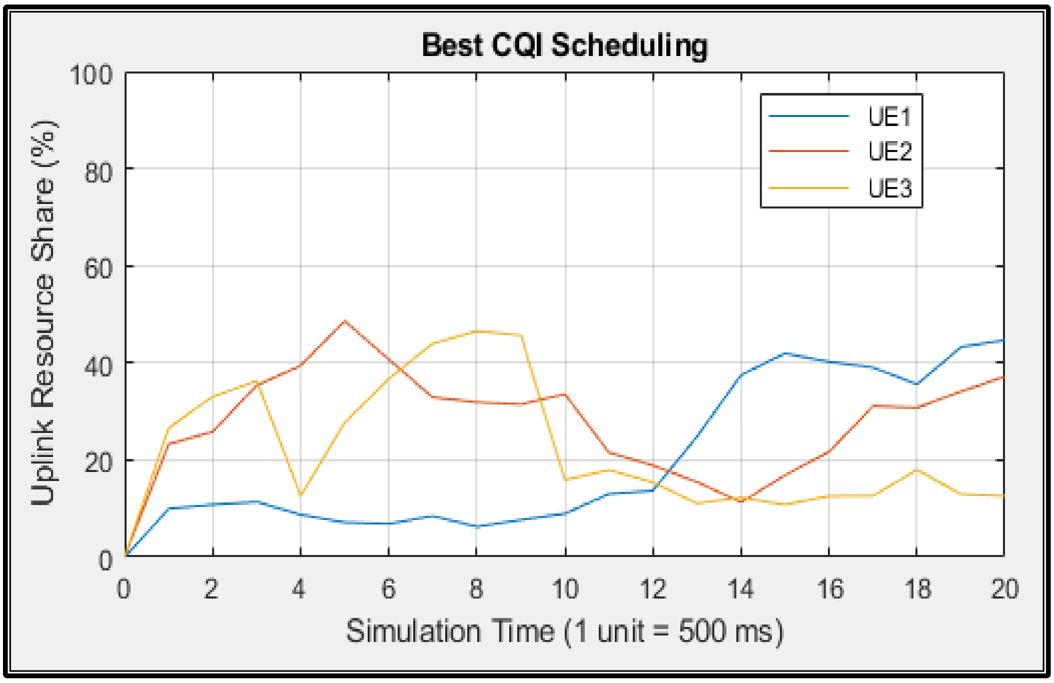


Fig 4.12 (a): Uplink Resources share with time for BCQI scheduling.

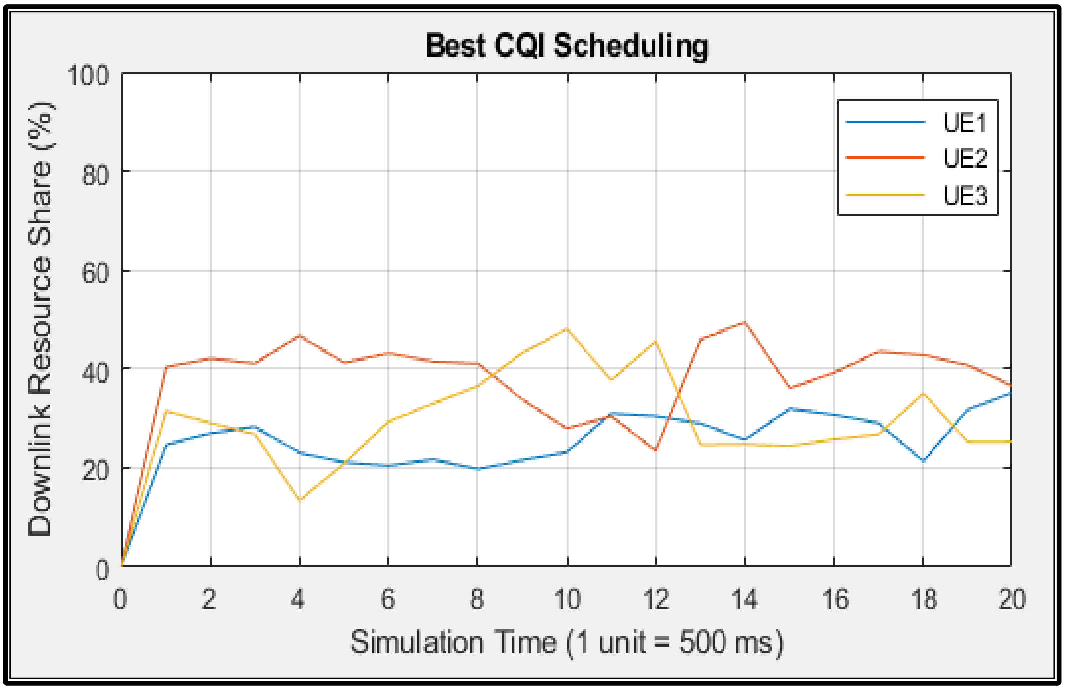


Fig 4.12 (b): Downlink Resources share with time for BCQI scheduling.

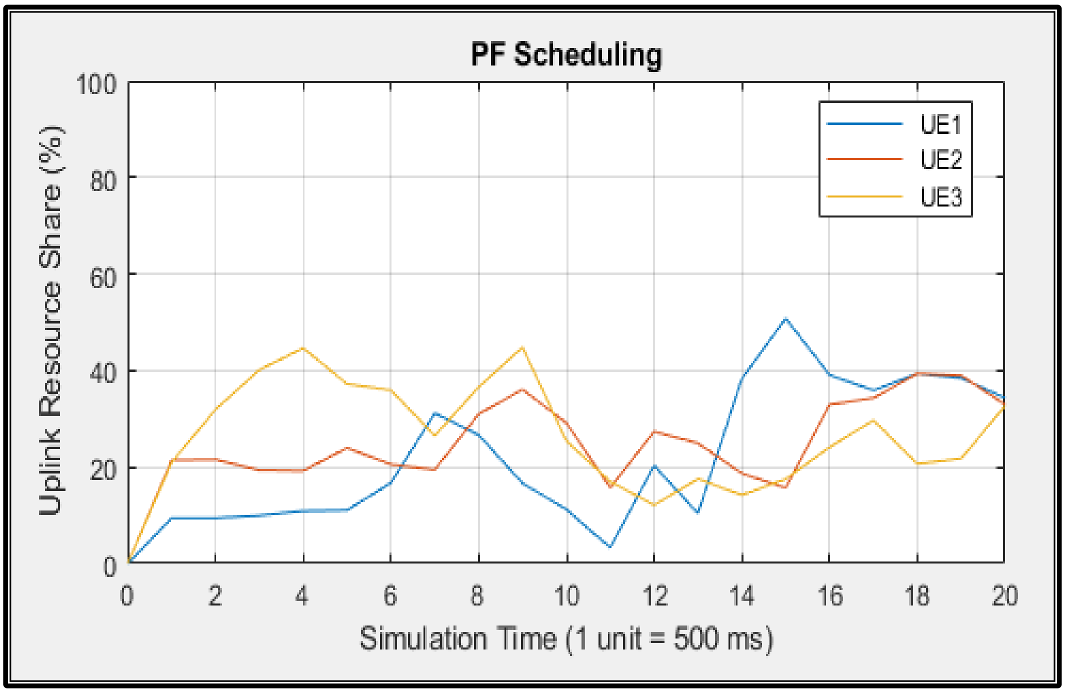


Fig 4.13 (a): Uplink Resources share with time for PF scheduling.

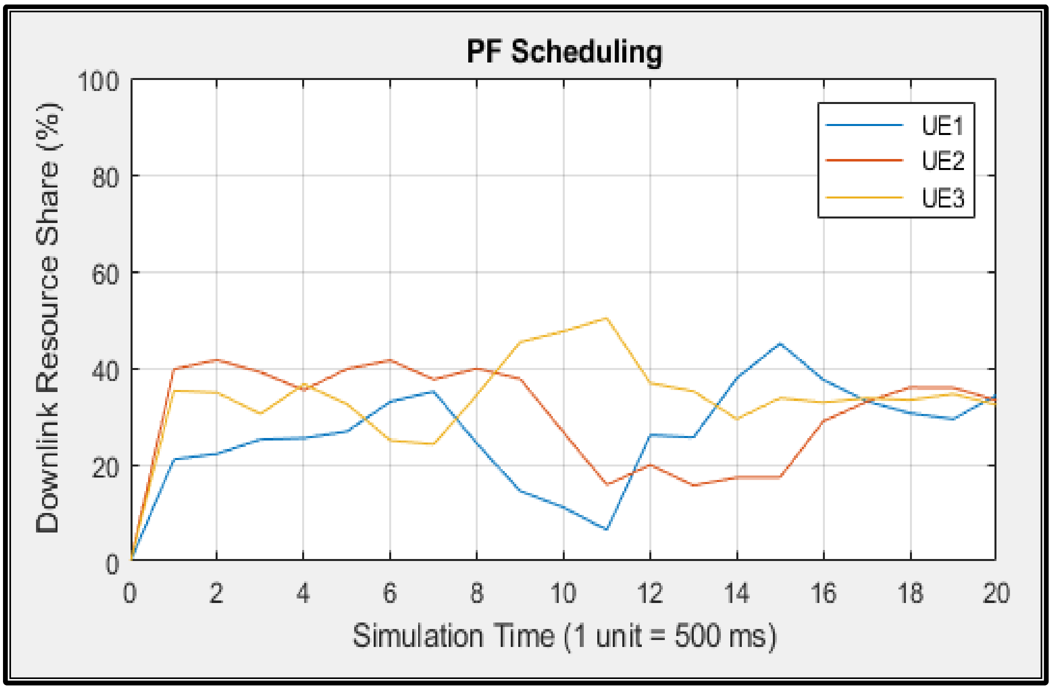


Fig 4.13 (b): Downlink Resources share with time for PF scheduling.

It is can be noticed from Figures (10, 11, and 12) that the RR scheme gives UEs equal distribution while for BCQI the system distributes the resources according to each UE's CQI. Finally, in PF scheduling the distribution is more equitable.

4.5 New Proposed Dynamic Scheduling Scheme:

The comparison between the three resource allocation schemes (RR, BCQI, PF) as well as the evaluation which depicted a clear difference in performances call for proposing a new scheduling scheme type that adapts to switch among the three schemes to explore the best performance of each algorithm. The proposed dynamic switching schedules algorithm for UL and the DL System to evaluate the performance of the system.

4.5.1 The New Adaptive Scheduling Scheme:

According to the channel state for each user, adaptive scheduling can be made according to the users' conditions, for example, if the distance is close between them and the bit you see is close, RR scheduling can be used, but if there is a miss with CQI and there is nothing emergency, best CQI scheduling can be used, and if there are lapses between users in terms of throughput and fairness and need a fair procedure, we use PF scheduling.

Any scheduler can be regarded efficient due to the QoS, desired throughput in resource allocation among UEs. The BCQI scheme can increase the overall system throughput but sacrificing the fairness. It was proved that the BCQI and RR, as well as all scheduling algorithms, cannot realize good fairness and high throughput at a time. The proposed uplink and downlink 5G system scheduler is found in a method that the system can provide high throughput every TTI. The proposed scheme can switch among RR, BCQI and PF schemes since it syndicates features of all schemes in an adaptive way on the operating SNR, the appropriate scheduler for each slice selected according 5G characteristics shown in Figure 4.14 (a, b).

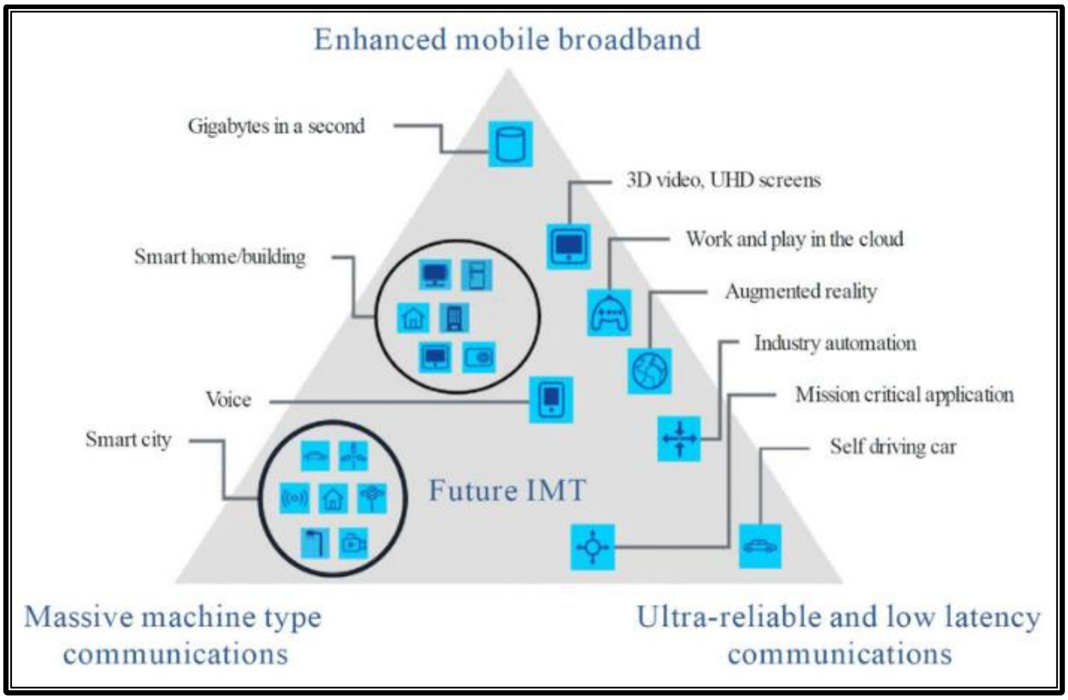


Fig 4.14 (a): 5G key (eMBB, mMTC, uRLLC) [66].

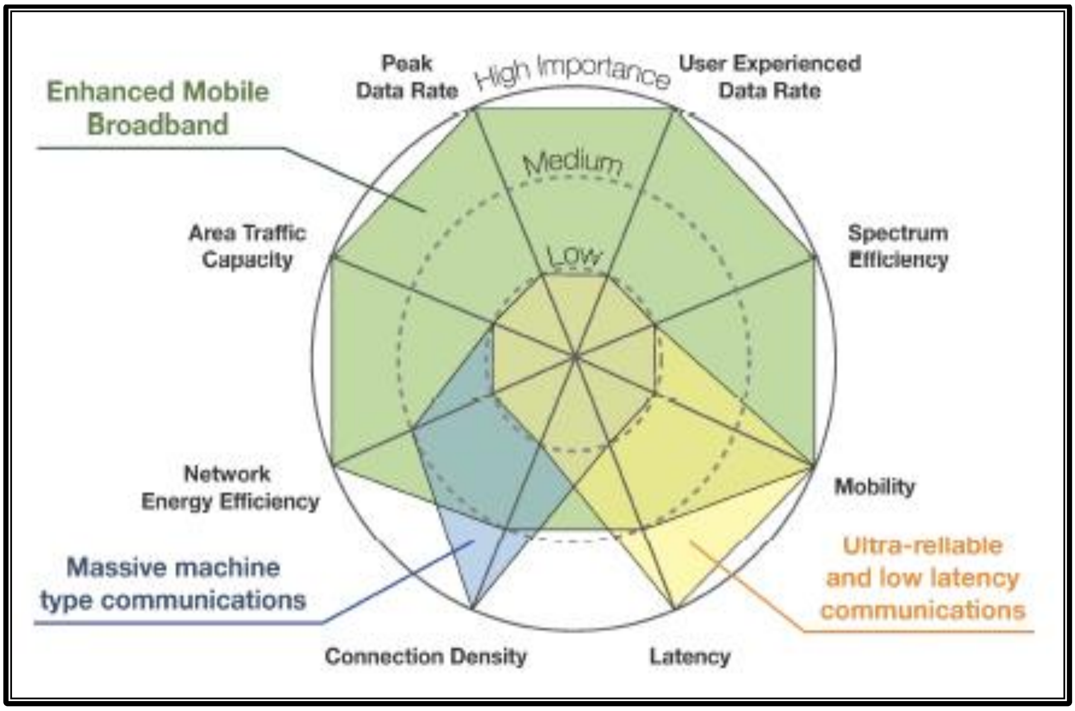


Fig 4.14 (b): 5G Usage Scenarios (eMBB, mMTC, uRLLC) [67].

4.5.2 The Adaptive Proposed Scheme Steps:

The proposed adaptive scheme, as indicated in Figure 4.15, is presented as the following:

At each TTI cycle, the received SNRs for active UEs can be determined , in order to know the relationship of the SNR with the CQI , you can see Table (4.2) . The proposed adaptive scheme inserts new process; the process is that to investigate whether the user application or service is traffic type.

The investigation is to choose between traffic types; eMBB, and mMTC. Then, the system assigns the traffic type, a scheduler is adopted according to the following steps;

Step 1: Insert UE's packet into system's queue.

Step 2: For each UE, the system finds out CQI, PMI, and RI while taking into consideration the traffic type, channel condition (SNR), and the quality of service (QoS) requirement.

Step 3: The scheduling starts at each TTI.

Step 4: System chooses the traffic model.

Step 5: Each UE assigns its own slice.

Step 6: For eMBB slice use Best CQI scheduling for URLLC use PF scheduling for mMTC using RR scheduling.

Step 7: System waits for packet acknowledgment, ACK.

Step 8: if ACK fails, use hybrid automatic repeat request (HARQ).

TABLE 4.2. SNR and CQI mapping table.

SNR	CQI	Modulation	Code rate (x 1024)	Efficiency (information bits per symbol)
-6.9360	1	QPSK	78	0.1523
-5.1470	2	QPSK	120	0.2344
-3.1800	3	QPSK	193	0.3770
-1.2530	4	QPSK	308	0.6016
0.7610	5	QPSK	449	0.8770
2.6990	6	QPSK	602	1.1758
4.6940	7	16QAM	378	1.4766
6.5250	8	16QAM	490	1.9141
8.5730	9	16QAM	616	2.4063
10.3660	10	64QAM	466	2.7305
12.2890	11	64QAM	567	3.3223
14.1730	12	64QAM	666	3.9023
15.8880	13	64QAM	772	4.5234
17.8140	14	64QAM	873	5.1152
19.8290	15	64QAM	948	5.5547

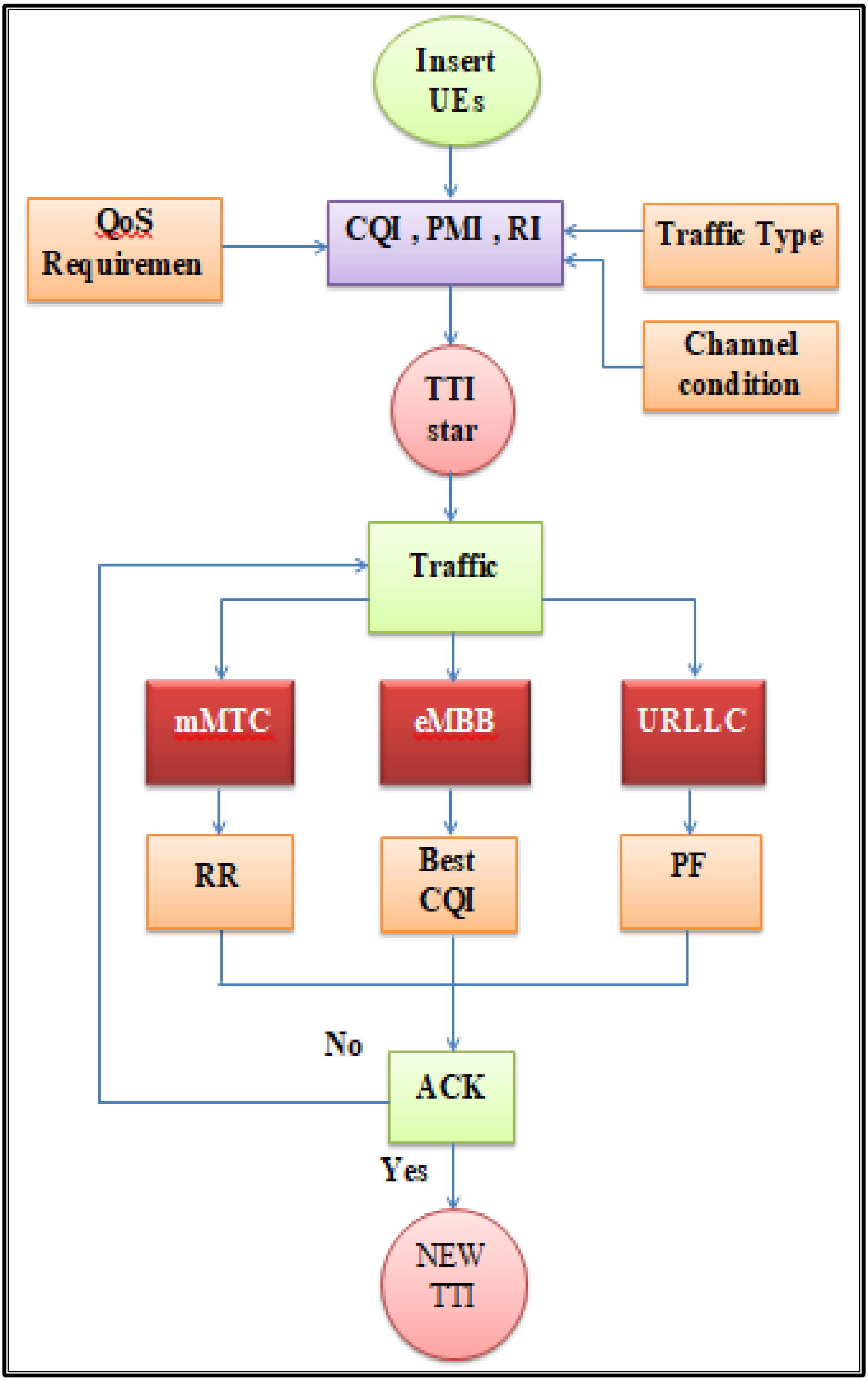


Fig 4.15: Flow chart of the proposed scheduling.

4.5.3 The Proposed Adaptive Scheme Results:

The proposed dynamic scheme is based on traffic slicing technique to schedule the traffic user's applications. The proposed scheme can be simulated, to be implemented and tested efficiently. It can be a real-time to evaluate the 5G system performance at uplink utilizing network slicing.

We apply the scheme with two different models, first when the users are at the same distance from the base, and secondly when they are at different distances.

A - The results obtained when using 3 users with equal distances between the user's equipment and the gNB. For example, the distance is 200 m.

For the proposed adaptive scheme, in Figure 4.15, the evaluation is depicted in Figure 4.16(a, b), which indicates that the UE used the slice 2 gets the highest throughput with more stable than the other UEs.

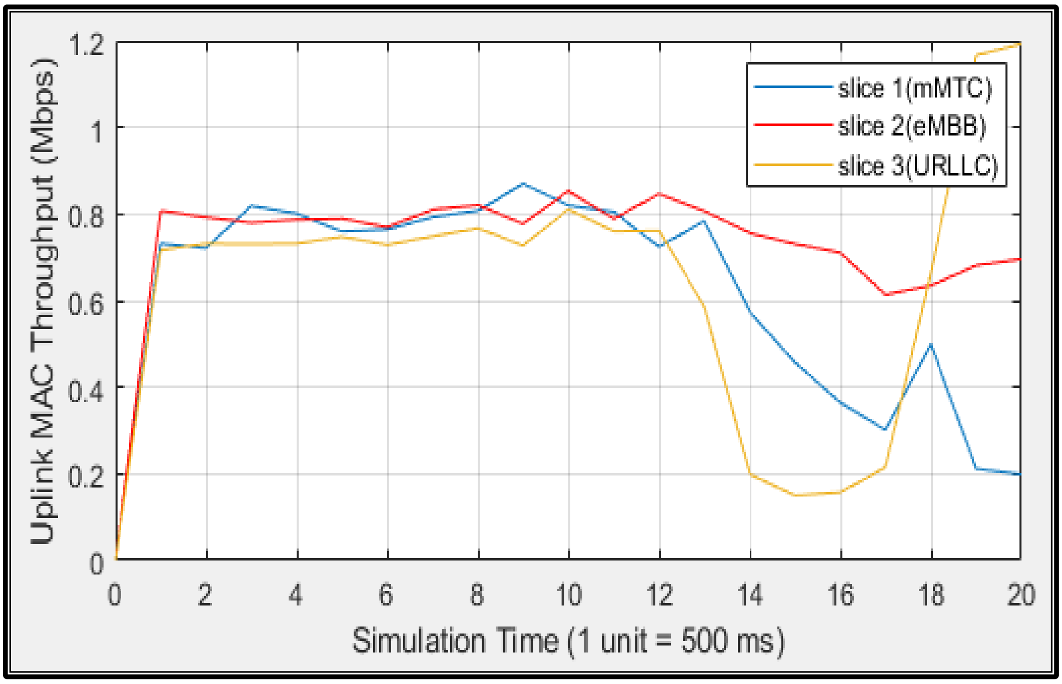


Fig 4.16 (a): Uplink MAC throughput for 3 user's with time.

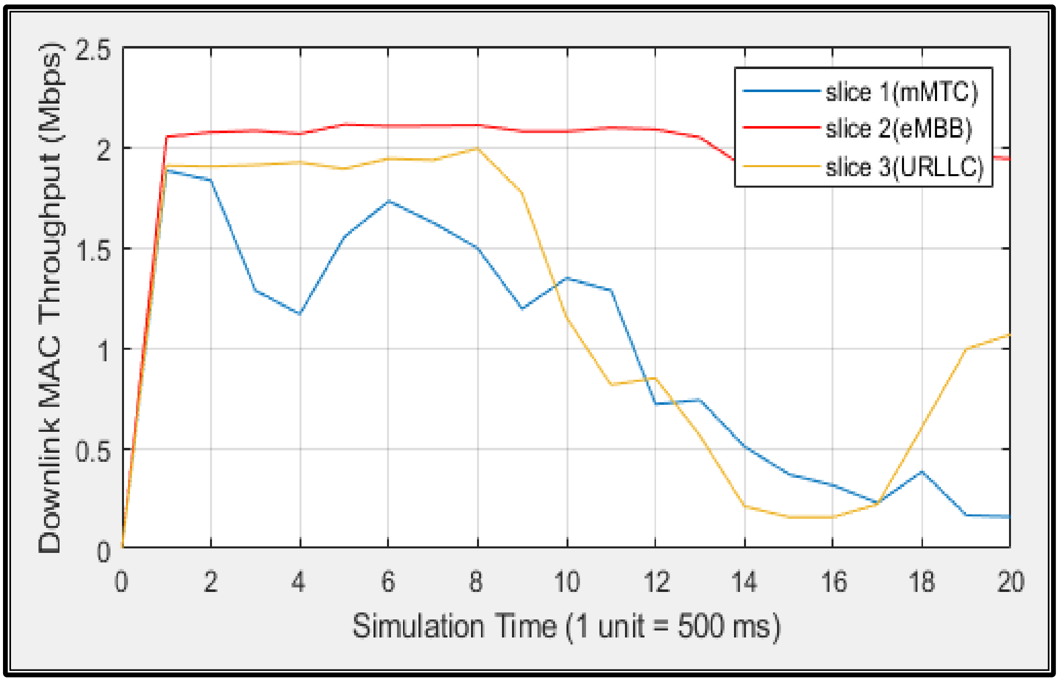


Fig 4.16 (b): Downlink MAC throughput for 3 user's with time.

While for the uplink, figure 4.15 a, for the MAC throughput it is clear that the results are similar for the three slices. For the RLC throughput, the curves in Figure 4.16 (a, b) show the slice's throughput.

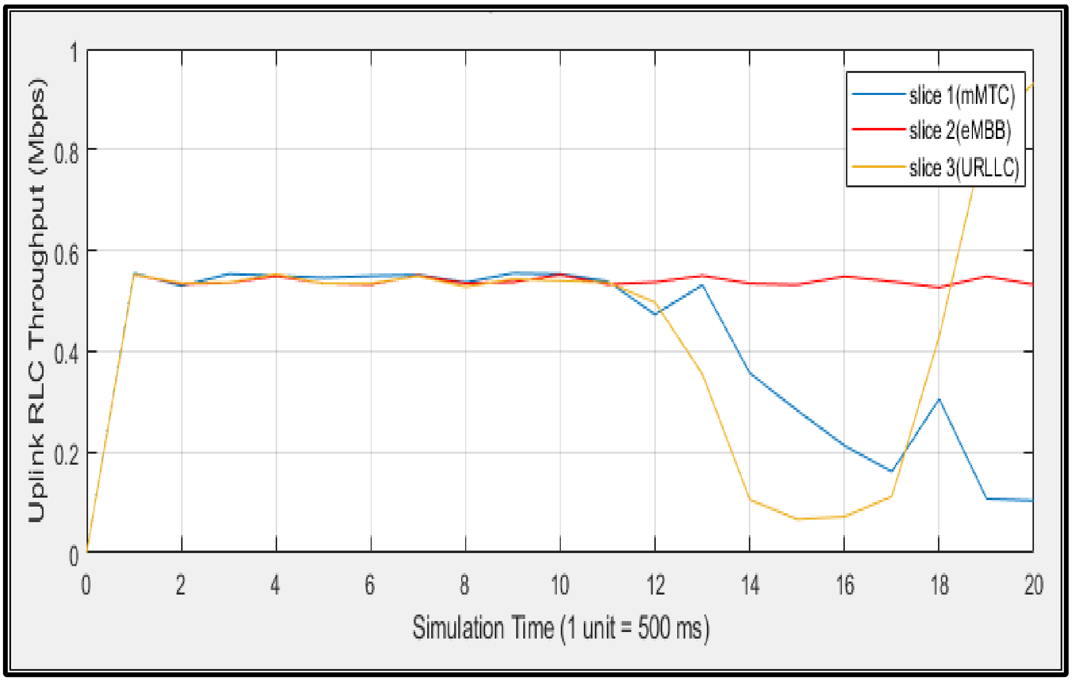


Fig 4.17(a): Uplink RLC throughput for 3 user's with time.

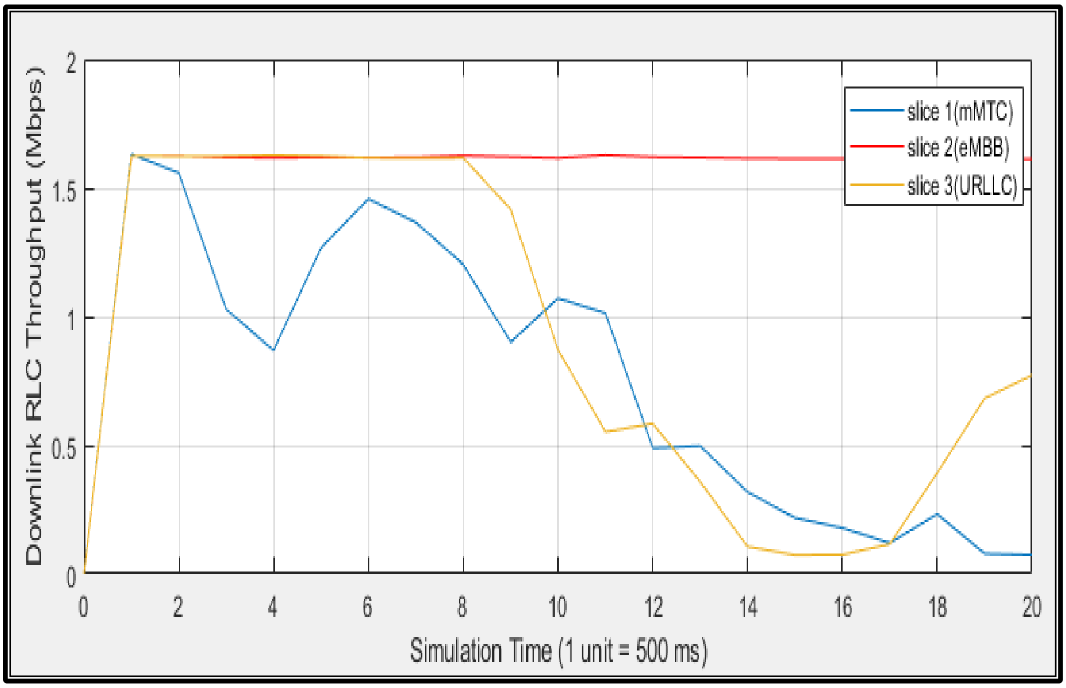


Fig 4.17(b): Downlink RLC throughput for 3 user's with time.

Figure 4.17, shows that the UE used the slice 2 gets highest downlink throughput with more stable than the other UEs. While for the uplink, for the MAC throughput it is clear that the results are almost similar in starting for the three slices.

Now we can see the resource share for three scheme in figure 4.18 (a ,b) , through the results in the uplink it is a priority for eMBB slice , but in downlink there is evenness.

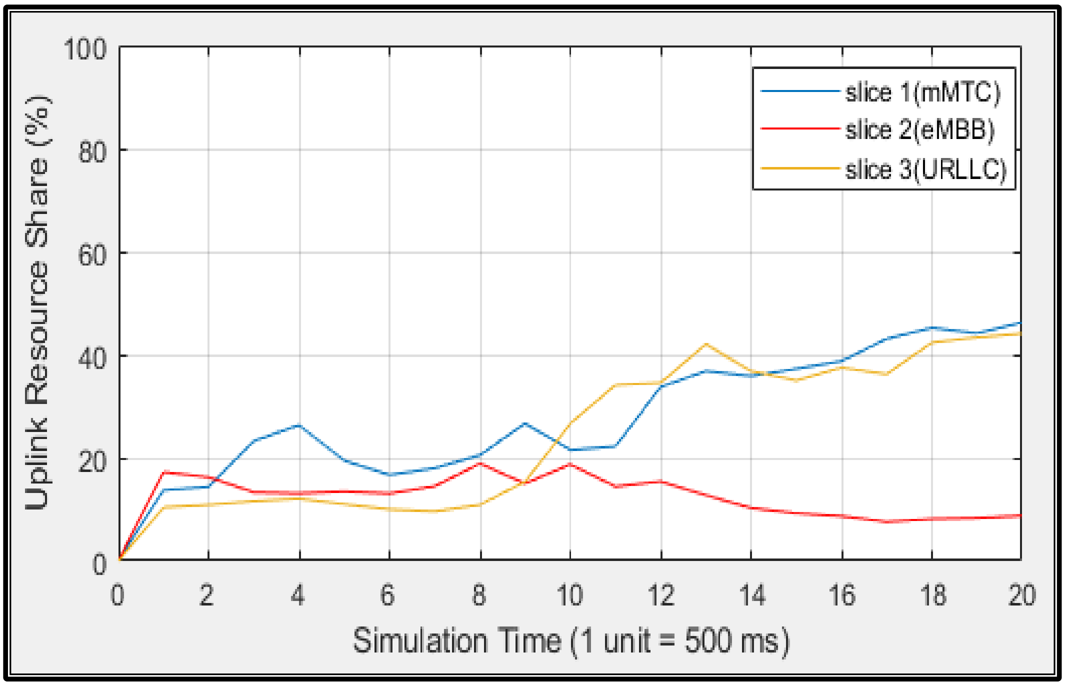


Fig 4.18(a): Uplink Resource share for 3UEs with time.

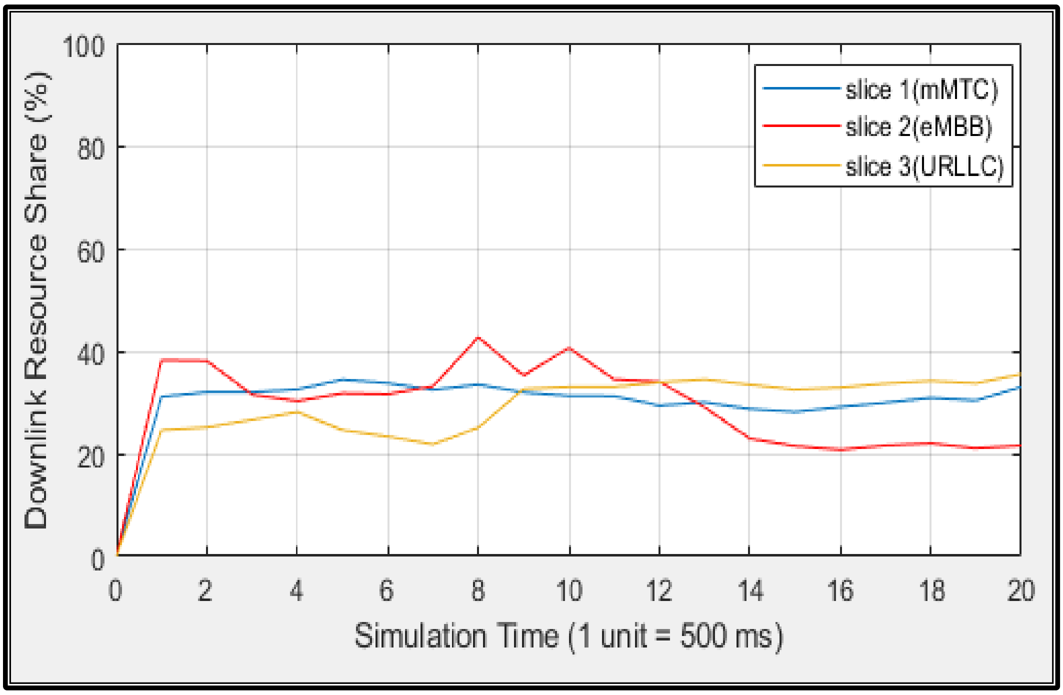


Fig 4.18(b): Downlink Resource share for 3UEs with time.

B - When using by users with a different distance, for example, the first user is at a distance of 100m from gNB ,second user at 400m from gNB and third user at 700m from gNB.

From the flow chart in figure 4.15 and 5G key in figure 4.14, user one goes to slice 2 (eMBB) because he has the highest throughput , user two goes to slice 3 because he need balance and user three to slice 1 because mMTC supports connection density.

It can be seen in the figure 4.19 and figure 4.20, that despite the difference in the distance between users, there is an equivalence resulting from an equitable distribution at slices.

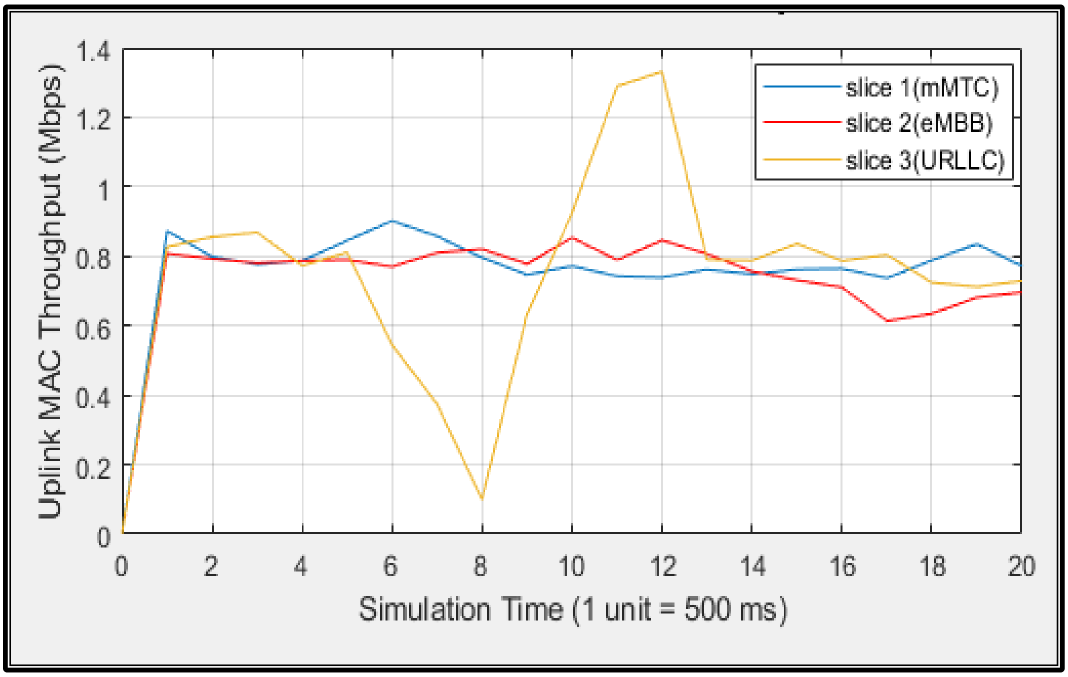


Fig 4.19(a): Uplink MAC throughput for 3UEs with different distance with time.

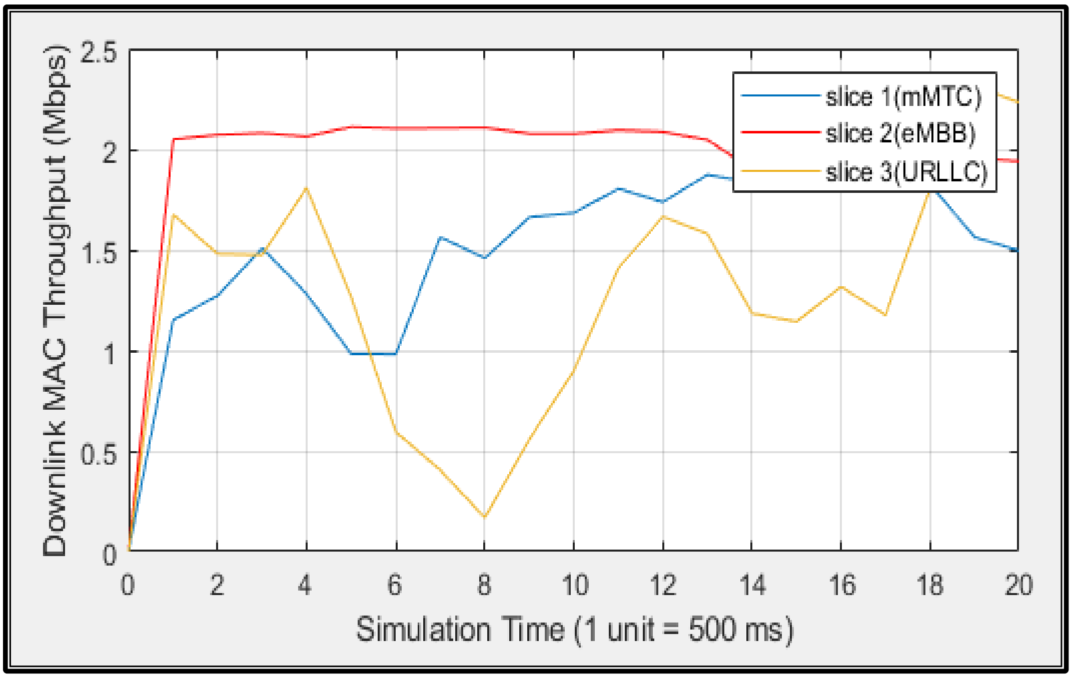


Fig 4.19(b): Downlink MAC throughput for 3UEs with different distance with time.

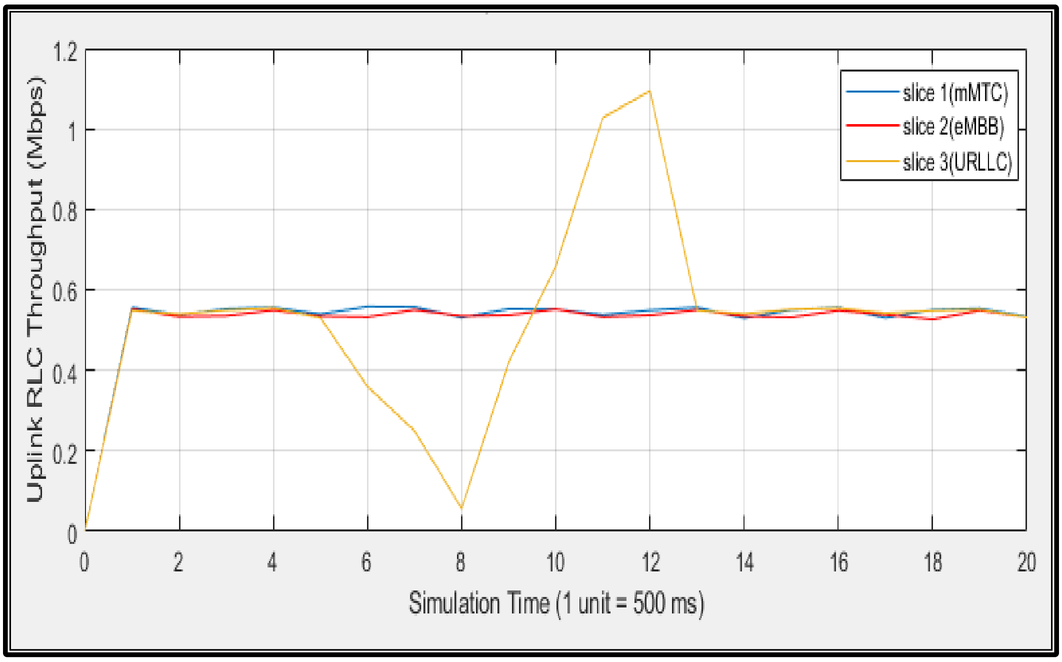


Fig 4.20(a): Uplink RLC throughput for 3UEs with different distance with time.

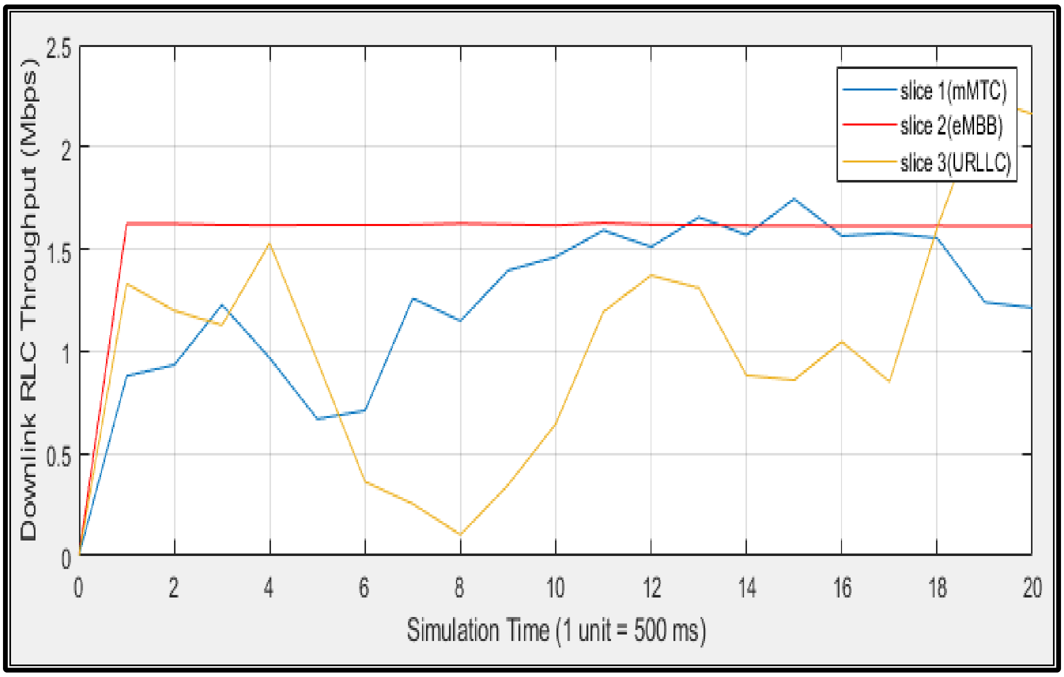


Fig 4.20(b): Downlink RLC throughput for 3UEs with different distance with time.

From the previous results, and after comparing them with the results obtained in the Chapter Four, we note the stability of throughput, and it is an approach for the three users, and the effect of the distance is small.

Finally, after comparing throughput for three scheme we can see the result of resource share for this scheme in figure 4.21 (a ,b).

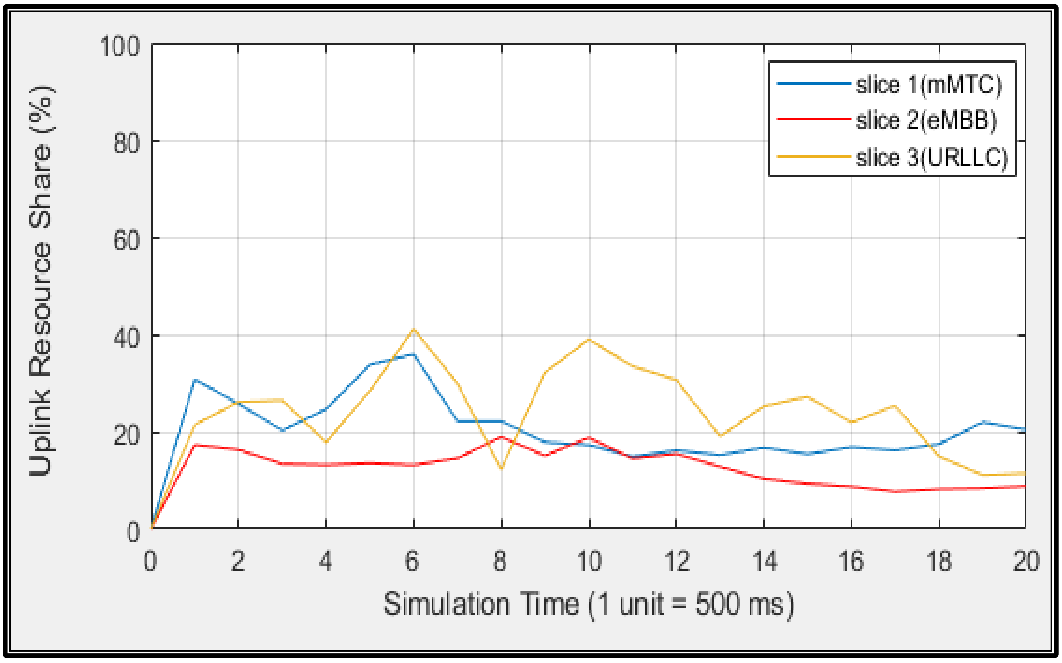


Fig 4.21(a): Uplink Resource share for 3UEs with different distance with time.

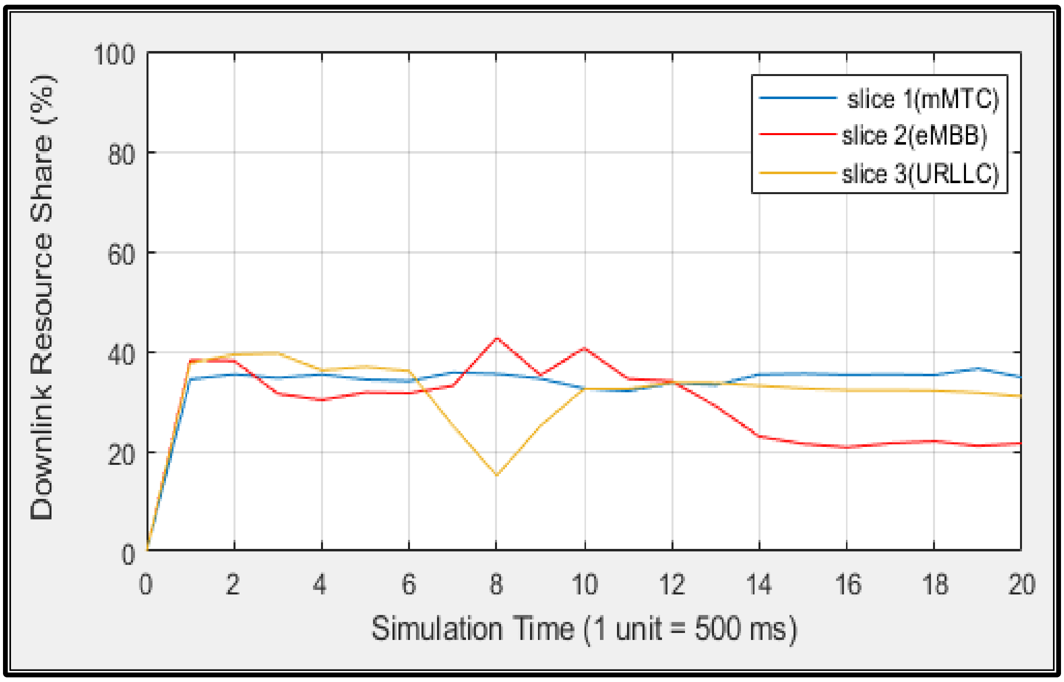


Fig 4.21(b): Downlink Resource share for 3UEs with different distance with time.

From figure 4.21 (a , b) we can observe that there is equal opportunity in uplink and downlink Comparing to previous results.

Chapter Five

Conclusions and Future Works Suggestions

This chapter concludes the main comparative evaluation for most famous scheduling schemes with network slicing as well as summarizes the main points of the proposed dynamic scheme work being achieved . Finally, the chapter presents some of the suggested future work.

5.1 Conclusions:

In this thesis, we investigated the network slicing in the wireless networks. In specific words, the network slicing with the fifth-generation.

The thesis also studied and presented a comparative resource scheduling algorithms evaluation for 5G system which deals with various scheduling algorithms and scenarios that were provided to evaluate the network slicing performance in 5G. The main issues were the principles and models of resource allocation algorithms in a 5G system with network slicing.

We first compare many resource scheduling algorithms to evaluate the performance of each scheme with network slicing. Then, we conclude the best resource allocation algorithm. Finally, the thesis proposes an adaptive switching among three scheduling schemes (BCQI, Round Robin, and PF) to enhance the performance, and throughput of the network.

The main conclusions that can be found from the study are:

1- For the MAC throughput, the simulations depict that the RR scheduling distributes the available resources in a fair manner according to the user's distance and priority, while for BCQI scheduling the distribution is unfair and the priority is given for the UE with the best channel quality, but PF scheduler depicts a good balance between the objective of maximizing cell throughput for all UEs.
2- The RLC was found that the PF scheduler is better when compared to the RR scheduler and the BCQI scheduler because it is noticed that the RR achieves equal throughput while the other schemes depend on the priority of the slices and the priority is for BCQI those who have higher CQI, but PF all UE has the same opportunity.
3- The comparison of the three scheduling schemes utilized by the network slicing distinguished a new adaptive scheme that switched adaptively among the three schemes to result in the enhanced system and user throughputs.
4- In the proposed scheme, a comparison among users was done when the UEs were moving at the same distance and when they are at different distances in order to enhance the results and when compared with the previous results.
5- Through the evaluations, it was noticed that there was a significant improvement in the results, as there was a balance between the three UE, even if there are different distances between one and the other.

5.2 Suggestions for Future Works: -

1. A more realistic modelling of eMBB traffic, e.g., finite buffer traffic, including the transmission control protocol (TCP) flow control mechanisms can be considered. Also, accounting for control channel errors and ACK/NACK misdetections is of relevance to further assess the URLLC latency and reliability performance.
2. Enhancements for unpredictable traffic and simulations considering non-ideal link adaptation can be accounted for.
3. Addressing the dynamic resource allocation problem in a multi-tier, multi-tenant network slicing by adopting the concept of generative adversarial network (GAN) can be made.
4. Multiuser Proactive Scheduling for Low Latency Communications by the increasing number of antennas to harden the wireless channel and thus, further enhanced URLLC performance can be contained. A detailed study on the robustness of the URLLC performance can be made.
5. Using network slicing to split each slice into a couple or more of the sub-slices for very low bit rate applications can be made.

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البحوث المنشورة

[1] Omar G Altaee , Youns M Abbosh and Ali O Aljanaby “5G UPLINK PERFORMANCE OF SYMBOL-BASED SCHEDULERS WITH NETWORK SLICING**”** at the 2021 International Multi-Disciplinary Conference ‘Integrated Sciences and Technologies’ **IMDC-IST 2021** ,7-9 September 2021.


IMDC-IST 2021

Certificate of Participation

EAI

EUDL

Scopus

This certificate is awarded to

Omar Altaee

for his/her valued participation at the

2021 International Multi-Disciplinary Conference “Integrated Sciences and Technologies”

IMDC-IST 2021, 7-9 September 2021

with the paper titled:

5G Uplink Performance of Symbol-Based Schedulers with Network Slicing

Prof. Rabee H. Alabbasi
Chancellor of Southern Technical University, Iraq
Chair of IMDC-IST 2021

Prof. Raed A. Abd-Alhameed
University of Bradford, UK
Chair of IMDC-IST 2021

الخلاصــة

تستخدم تكنولوجيا الاتصالات الرقمية واللاسلكية الحديثة في أنظمة الجيل الخامس لتعزيز وتحسين التصميم للشبكة لخدمة المستخدم المتنقل والأجهزة اللاسلكية لوحدها نحو الأنظمة التي تربط العديد من مختلف الأجهزة التي تعمل بتدفق بيانات عالية جدا. وتشمل السمات الرئيسية لنظام الجيل الخامس تحسين كفاءة الطيف ومعدل تدفق بيانات عالي جدا وتأخير وصول الحزم منخفض جدا وكثافة اتصال عالية جدا. وتدعم هذه الميزات توصيل الوسائط المتعددة والصوت والفيديو والانترنت وخدمات تطبيقات المستخدمين الحديثة ذات النطاق العريض. واحدة من اهم المعلمات الرئيسية لنظام الجيل الخامس هو تشريح الشبكة التي هي تقنية موهوبة لخلق مسار شبكة منطقية بين نهايتين يتم تكييفها بما في ذلك الموارد المشتركة. تظهر جدولة الموارد وتوزيع شرائح الشبكة تأثيرا أساسيا في أداء الشبكة وتوزيع الموارد وموازنة التحميل.

تقارن هذه الأطروحة العديد من مخططات جدولة الموارد في نظام الجيل الخامس مع تقطيع الشبكة. فتمت مقارنة العديد من خوارزميات جدولة الموارد:

(1) Round robin (RR) , (2) BestCQI , (3) Proportional Fair (PF)

علاوة على ذلك، تقترح هذه الأطروحة نظام جدولة متكيف يقوم جدول النظام بتبديله ديناميكيا إلى السلوك الأمثل لوغاريتم الجدولة بين المخططات الثلاثة المذكورة مع تقطيع الشبكة لتحسين حركة المرور وإنتاجية المستخدم وسعة الخلية.

<u>اقرار لجنة المناقشة</u>

نشهد بأننا اعضاء لجنة التقويم والمناقشة قد اطلعنا على هذه الرسالة الموسومة **(التحقق في مخططات تخصيص الموارد لشبكة الجيل الخامس مع تقطيع الشبكة)** وناقشنا الطالب (عمر غانم سالم) في محتوياتها وفيما له علاقة بيها بتاريخ / /2022 وقد وجدناه جدير بنيل شهادة الماجستير في اختصاص هندسة الاتصالات.

التوقيع:
رئيس اللجنة : أ. معن احمد شحاذة
التاريخ: / /2022

التوقيع:
عضو اللجنة: أ. م. د. محمد يونس ذنون
التاريخ: / /2022

التوقيع:
عضو اللجنة: م. د. صفوان حفيظ يونس
التاريخ: / /2022

التوقيع:
عضو اللجنة (المشرف): أ.م .د. يونس محمود عبوش
التاريخ: / /2022

التوقيع:
عضو اللجنة (المشرف): أ. م. د. علي عثمان محمد
التاريخ : / /2022

<u>قرار مجلس الكلية</u>

اجتمع مجلس كلية هندسة الالكترونيات بجلسته المنعقدة بتاريخ: / /2022 وقرر المجلس منح الطالب شهادة الماجستير في اختصاص هندسة الاتصالات.

التوقيع :
مقرر المجلس: أ.م.د. صدقي بكر ذنون
التاريخ : / /2022

التوقيع :
رئيس مجلس الكلية: أ.د. خالد خليل محمد
التاريخ : / /2022

إقرار المشرف

نشهد بان الرسالة الموسومة ب **" التحقق في مخططات تخصيص الموارد لشبكة الجيل الخامس مع تقطيع الشبكة "** تم اعدادها من قبل الطالب **(عمر غانم سالم)** تحت اشرافنا وهي جزء من متطلبات نيل شهادة الماجستير في علوم هندسة الاتصالات.

التوقيع :	التوقيع :
الاسم **:** أ.م .د. يونس محمود عبوش	الاسم : أ. م. د. علي عثمان محمد
التاريخ : / /2022	التاريخ : / /2022

إقرار المقيم اللغوي

اشهد باني قمت بمراجعة الرسالة الموسومة ب **" التحقق في مخططات تخصيص الموارد لشبكة الجيل الخامس مع تقطيع الشبكة "** من الناحية اللغوية وتصحيح ما ورد فيها من أخطاء لغوية وتعبيرية وبذلك أصبحت الرسالة مؤهلة للمناقشة بقدر تعلق الامر بسلامة الأسلوب وصحة التعبير.

التوقيع:

المقوم اللغوي: أ. د. باسم يحيى جاسم

التاريخ**:** / / 2022

إقرار رئيس لجنة الدراسات العليا

بناء على التوصيات المقدمة من قبل المشرف والمقوم اللغوي أرشح هذه الرسالة للمناقشة.

التوقيع:

الاسم: أ.م. د. محمود احمد محمود

التاريخ: / /2022

إقرار رئيس القسم

بناء على التوصيات المقدمة من قبل المشرف والمقوم اللغوي ورئيس لجنة الدراسات العليا أرشح هذه الرسالة للمناقشة.

التوقيع:

الاسم: أ.م. د. محمود احمد محمود

التاريخ: / / 2022

التحقق في مخططات تخصيص الموارد لشبكة الجيل الخامس مع تقطيع الشبكة

رسالة تقدم بها

عمر غانم سالم الطائي

إلى

مجلس كلية هندسة الالكترونيات

جامعة نينوى

كجزء من متطلبات نيل شهادة الماجستير

في

هندسة الاتصالات

بإشراف

أ.م.د. يونس محمود عبوش

أ.م.د. علي عثمان محمد الجنابي

1443 هـ

2022م

جامعة نينوى

كلية هندسة الالكترونيات

قسم هندسة الاتصالات

التحقق في مخططات تخصيص الموارد لشبكة الجيل الخامس مع تقطيع الشبكة

عمر غانم سالم الطائي

رسالة ماجستير علوم في هندسة الاتصالات

بإشراف

أ.م.د. يونس محمود عبوش

أ.م.د. علي عثمان محمد الجنابي

1443هـ   2022م