Multi-Knowledge Electronic Comprehensive Journal For Education And Science Publications (MECSJ)
Issue (36),2020
ISSN: 2617-9563
www.mecsj.com/

ENHANCED VERSION OF NETWORK SLICE ISOLATION ARCHITECTURE

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Abstract

5G technology is the future of mobile networks, and in different countries, 5G mobile networks are launched. Different use cases have different requirements for the function and the performance of 5G network. They would require different types of factors and networks which include data rate, delay and scalability. Those requirements will be met in 5G by using network slice architecture, which uses network virtualization technology. In this paper, we present network slice architecture for 5G network, analyze the state-of-the-art 5G network slice, address several network slicing architecture issues, and evaluate the proposed architecture by comparing the result with recent methods.

Keywords: network slice, isolation, 5G network.

ملخص الدراسة:

تكنولوجيا الجيل الخامس هي مستقبل شبكات الهاتف المحمول.وفي بلدان مختلفة، يتم إطلاق شبكة الجيل الخامس المتنقلة. حالات الاستخدام المختلفة لها متطلبات مختلفة لوظيفة وأداء شبكة الجيل الخامس. وهي تتطلب أنواع مختلفة من العوامل والشبكات التي تشمل معدل البيانات والتأخير وقابلية التوسع. وسيتم الوفاء بهذه المتطلبات في الجيل الخامس باستخدام بنية شريحة الشبكة التي تستخدم تكنولوجيا المحاكاة الافتراضية الشبكية. في هذه الورقة، نقدم بنية شريحة الشبكة لشبكة الجيل الخامس ونحلل شريحة شبكة الجيل الخامس المتطورة ونعالج العديد من قضايا بنية تقطيع الشبكة ونقيم البنية المقترحة من خلال مقارنة النتيجة بالأساليب الحديثة.

الكلمات المفتاحية. شريحة الشبكة ، عزل الشبكة ، شبكة الجيل الخامس

1. Introduction

The demand and scene of 5G network are diverse, and different scenes have different requirements for the function and performance of the network.

The 5G technology is providing high-speed communication services because it is using millimeter waves to transfer data from one location to another location. 5G is also supporting many devices because the network speed is remarkably high. It can be improved by introducing a new architecture, and this architecture is known as network slicing. Network slicing is an important architectural technology for 5G [1], [2].

Network slicing is the most important concept to realize personalization of mobile networks for users [3].

Basically, logical networks will be virtually representing the 5G single physical network, and each one called network slice. Every network slice will have specific network functions to provide different services for different requirements. Network slicing offers better business agility, flexibility, and cost-efficiency. 5 G network slice consists of a collection of network functions, resources running these network functions, and network software that has a particular configuration. Such network functions and their corresponding configuration form a full logical network that contains the network characteristics required for a particular business and provides the corresponding network services for a particular business [4].

It is challenging to design a robust network slice architecture. Currently, it is found that the full network slice isolation is not met yet. Full isolation means that each network slice instance has its own function without sharing with the other slices. Each slice should have its own path for its data traffic and store its data in separate storage or memory without sharing that with network slice instances.

Currently, the 5G networks are supporting high speed with many numbers of connections. But this speed can be affected because 5G is going to support IoT devices and these devices are increasing day by day [5]. Thus, the main issue is to enable 5G networks to behave like multiple slices, and each slice must be working independently.

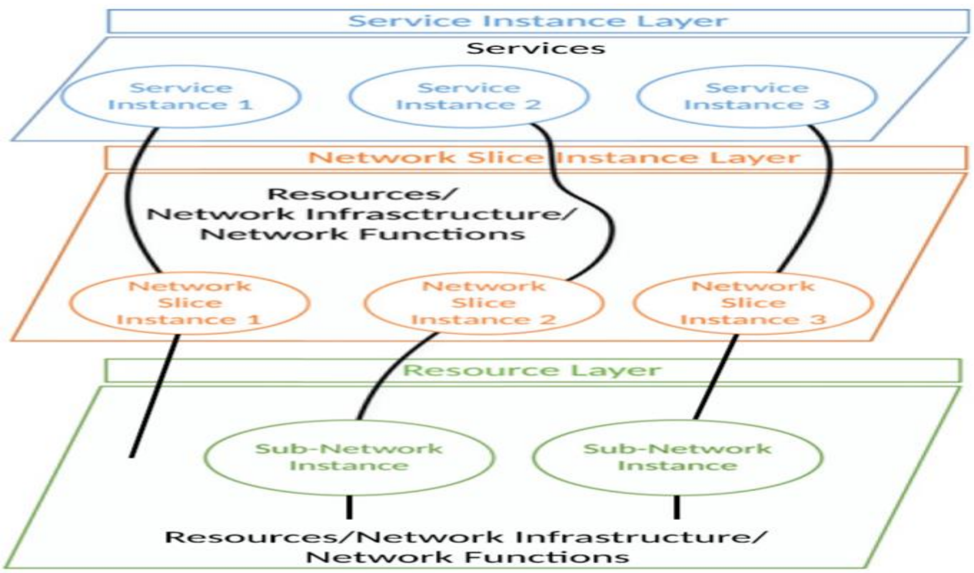

Fig.1 network slicing layers

As shown in Fig.1, in recent studies and designs the network slicing idea is based on the three-layer model [6]:

• Service Instance Layer,

• Network Slice Instance Layer,

• Resource Layer.

The goal of this research is to examine the isolation capabilities and selected approaches for its realization in network slicing context and to concentrate on the second layer (Network slice instance) by providing an isolation management for each slice to control each slice data flow and provide high quality of services for connected users.

Isolation among Network Slices Different services in 5G networks have unique requirements. Consequently, dedicated virtual network resources are needed to guarantee the service quality at each slice. This requires slices to be highly isolated from each other. The isolation among network slices can be achieved via data plane isolation and control plane isolation. In general, the slice control function can be shared among slices, while for some services such as mission-critical communications; the slice needs its own control function. Further, the effective isolation of network slices can ensure that the failure or security attack on one slice does not affect other slices' operation. The consumption of multimedia services and the demand from consumers for high-quality services have triggered a fundamental shift in how we manage networks in terms of the abstraction, separation, and visualization of service aspects of transmission, control and management. In 5G networks, the physical network has to be divided into multiple isolated logical networks with different size. Those logical networks are dedicated to different types of services with different characteristics and requirements based on their requirements (e.g., a slice for massive IoT devices, smartphones, or autonomous cars, etc.).

Hence, the slice isolation mechanism is a key challenge of implementing network slicing lately and we will concentrate on design an isolation architecture for an isolated network slice and implement it using Python simulation tool. Each isolated slice network will have its own management and control over their services to connected users. This will assist organizing the dedicated customized various network slices for providing services to heterogenous users' requirements. As the current vision is managing the whole slices with a centralized management and that has some drawbacks that will be covered in the second chapter.

1.1 Research motivation

Network slicing in 5G networks has many advantages for the performance of the whole network. By using 5G, it is expected that the number of connected users will be higher and heterogeneous use cases have different requirements. Therefore, slicing technology is described as one of future 5G enablers for handling the anticipated heterogeneous requirements. Slices for different applications may also be specified which can require tailored network capabilities. It is possible to have customized slices for specific use case requirement and for specific connected users. By offering the isolation on the 5g network slices, each network slice, configured with specific network functions to provide various services for different requirements. Each end user requires different types of features and networks in terms of data rate, delay and connection numbers. Depending on the requirement of the specific end user, there are different 5G network slices offering different services to connected end users. Each slice offers services for specific devices or end users For example, a network slice offers a high-throughput service for smart phones, a slice offers a low-rate non-critical service for Internet of Things (IoT), and a low-latency service for critical real-time communications or slices by the kind of application. Network slicing would also allow for the creation of new business models in the mobile market. In addition, compared to the traditional networks, slicing technology has more significant advantages. First, Network slicing can provide better performance to logical networks than to single-size networks. Second, A slice of network will increase or decrease as service requirements and as the number of user changes. finally, A slice of the network is customized to service requirements and can automate the allocation and usage of physical network resources.

Furthermore, slicing offers flexibility and cost efficiency. Management of a wide verity of slices with heterogenous requirements would be complex.

However, by offering Isolation, each slice will have self-management. This helps reducing complexity and avoiding higher cost.

Further. With isolation in network slices, it can be insured that failure or vulnerability of one slice does not affect the function of the other slices.

In this research, there will be a proposed network slice isolation architecture. This new concept has not been proposed recently and is a research area that is need to further study and investigation. That is the reason why I am motivated to study this topic Hence, we will propose the architecture to enforce isolation among slices. Each slice will work as an entire network. Implementing this architecture is the main contribution as we will measure the performance requirements and evaluate the proposed model to find whether it will be useful or not.

1.2 Problem statement:

Strong isolation among network slices is a major requirement that must be fulfilled for parallel slices to be worked on a single shared physical infrastructure. According to [٦], the research should be conducted in the isolation domain.

A common or shared network services and functions such as mobility management is an unsolved challenge that is needed to be addressed. To illustrate, every UE should have an exclusive access to network in order to have a satisfactory service, rather than waiting in a long queue or getting rejected when the queue is full.

We have designed isolation architecture for network slicing in 5G, where each slice has its own Slice Manger and a virtualized SDN. Each UE will have a sperate path for the data flow that does not move to another slices' flow, and that will be managed through the slice manager. We will simulate this architecture using Python simulation and collect the result. Finally, we will evaluate the performance by comparing the proposed model to recent existing algorithms used.

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Issue (36),2020
ISSN: 2617-9563
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This would Provide more flexibility and scalability for each isolated slice network and reduce the end-to-end delay.

1.3 Contributions of Thesis

The objectives and contributions of this research can be summarized as follows:

The contribution is to provide a completed isolated 5G slice architecture where all slices must work independently. Also, Provide SDN technology for each slice, because the software-defined network can be helpful to manage all the operations of each slice. If each slice is equipped with the latest SDN, then each slice must work as an entire network. Therefore, the contribution of this research based on the objectives is summarized as follows:

1- propose a network slice architecture: adding a slice manager to each slice. This slice manager has the management properties of the slice.

2- Implementation: there will be an implementation of the proposed architecture using a simulation program written in (Python) to simulate two different slices to measure the performance requirements of each independent network slice instance

4- Result and discussion: analysis and evaluation of the proposed approach, discuss and compare the result with the recent related work. Also, discuss the challenges of network slicing and future research direction.

2- Related Work

2..1 5GNetwork slice challenges:

Despite some significant advantages that network slicing brings to 5G system, there are many challenges that need to be resolved. In this section, we will define key research problems and potential directions in the area of network slicing which need to be investigated [7] [8] [9] [10].

1- Performance: as there will be different virtual network slices serving different user equipment with various quality of service (QoS) sharing the same physical infrastructure, it would be a challenging task to measure the performance of network and measure the QoS as well. Hence, there is need to further research to measure the performance of different network slices with specific requirements as each service has some specific properties (Key Performance Indicators, QoS/QoE parameters, etc.). in our research, we will measure the performance requirements deeply in section4.

2- Security: By enforcing isolation to the network slice, there would be a security concern of the whole network. There might be new methods to attack one weak isolated network slice in order to reach another strong slice resource that has better parameters. The security and privacy concerns in 5G slicing are a significant challenge to adopting multi-tenancy approaches [11]. n our proposed model, each slice will have a slice manager element to manage the isolated slice and that will be further explained in section 4. As for slice security, it will be reviewed in chapter 6 and 7

3- Management: one of the main focused challenge in network slice life cycle management, that includes creating slices ،changing slices' properties ، reconfiguration of slice's network, etc.

is lifecycle management and orchestration among slices. This is the huge challenge of essential flexible slice end to end orchestration. Our research proposes a model to isolate the 5G slice and with self-management and orchestration workflows across the heterogeneous virtualized connected users. (section 4) [12].

4- Isolation among network slices: Isolated network slices are a significant factor for service realization in the future network [13]. however, one of the key challenges of implementing network slicing is the slice isolation. There are some levels and types of isolation and that are deeply discussed in section 3. Also, our proposed model concentrates on enforcing the isolation in network slicing in terms of management (section 4).

2.2 Network slice isolation:

The aforementioned logical networks form the basis of the network slicing theory. The network and resources will be partitioned into numerous virtual slices and each will be considered a logical network. Network slices all together form an orchestration concept which provides slice

management of the life cycle (creating slices, changing properties of slices, etc.). This function aims to make services and networks more flexible and adaptable to business and user needs

One of the key challenges in the concept of network slicing is isolation. According to [14], there are different factors of describing the isolation concept. This includes:

1- Performance: Each slice is specified to satisfy unique service needs. This means each slice has to meet the required performance to the desired service. Each slice may differ in the level of the required performance.

2- Security and privacy: the advantage of having isolation in different slices is that if there is an attack occur in one weak slice, this would not affect the other slices and the overall network performance will not be affected as well.
3- Management: Each slice shall be operated as an independent network to monitor and contol its data flow.

In addition, according to [15], there are different levels of isolation in network slicing. This includes:

1. traffic isolation: All slices use the same network services, and slices of the network will ensure that data flows from one slice do not transfer to another.
2. bandwidth isolation: all slices assigned certain bandwidth and one slice should not use any other slices bandwidth.
3. processing isolation: Each slice should have an isolated processing packet that is unique and without interfering with other slices, while they all use the same physical resources.
4. storage isolation: each slice should have a separate storage for its data.

one of the main challenges in the future 5G networks is isolation among network slices and end-to-end slice orchestration and management issues [16], [17].

3: Research design

In this section, we will talk about how the proposed network isolation architecture that is implemented with a NetSlicer simulation program that is written in python.

3.1 The proposed network slice isolation architecture in 5G networks

In NetSlicer, each slice is simulated as a separate slice simultaneously, then the result

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Issue (36),2020
ISSN: 2617-9563
www.mecsj.com/

will be combined at the end of simulation. We propose an architecture for the isolated slice, and this applies for each slice as shown in Fig.10.

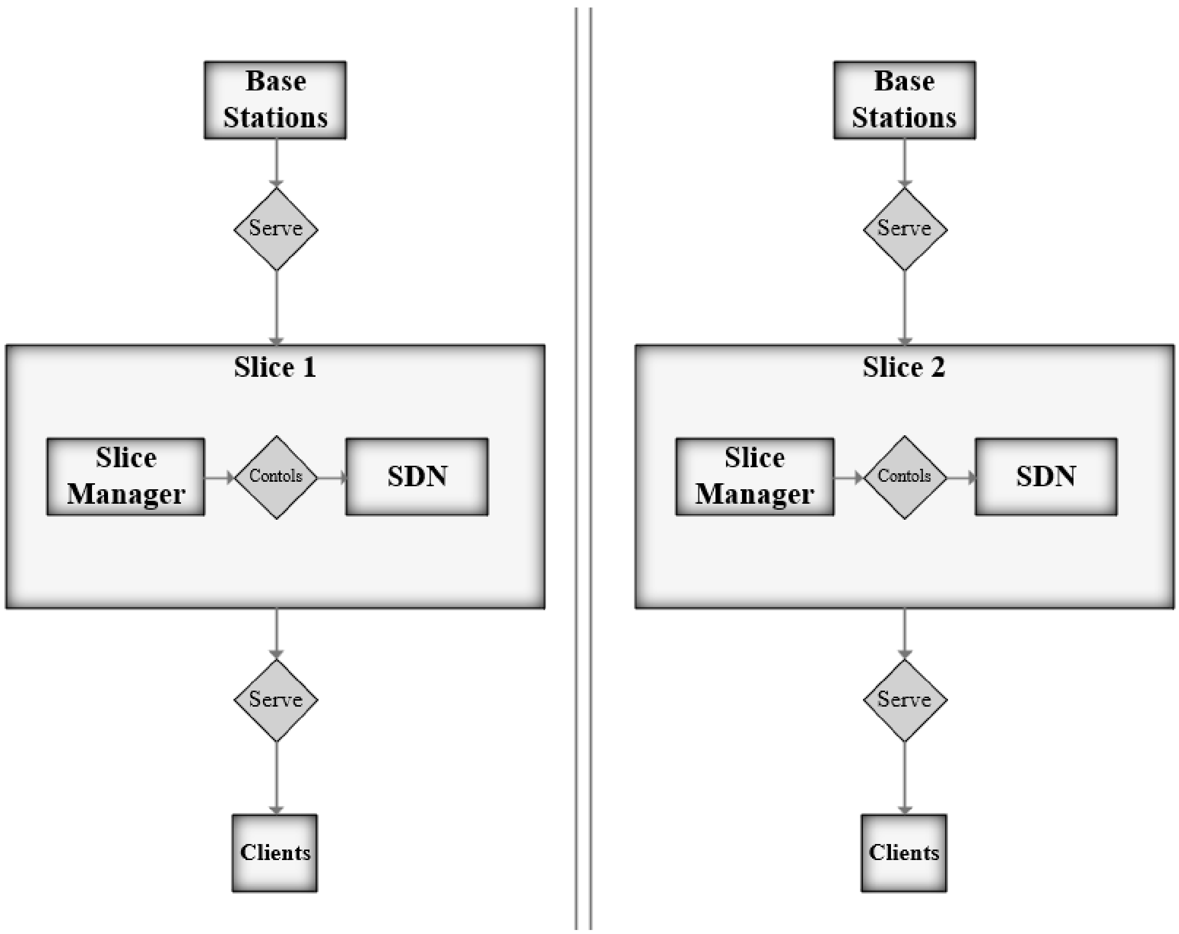

Figure 10 the network slice isolation architecture

The network slice isolation platform aims to provide self-management of the network slices and provide a wide variety of services to heterogeneous connected users as ach slice is customized to provide specific requirements. The proposed architecture is illustrated in Fig.1.

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Issue (36),2020
ISSN: 2617-9563
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- ***Slice Manager (SM):*** in the proposed model, each virtualized network slice has its own slice manger. SM has many responsibilities inside the slice. First, SM has configured NFV specially to meet the required service. Second, it is responsible for managing and controlling the relationship between slice/service users and slice/service providers to ensure and maintain an acceptable Quality of Service (QoS) level in an efficient manner. Furthermore, SM is also responsible for managing the slice resources as each slice has its own chunks of compute and network resources that match the network services it provides. Finally, SM is responsible for managing slice network resource Like NFV in order to assure operation within expected parameters needed.
- ***Software- Defined-Network (SDN):*** SDN is basically a Physical separation of the network control plane from the forwarding plane and where many nodes are operated by a control plane. This separation assists controlling the data flaw of the entire network slice. Also, SDN provides a virtualized control plane that can implement smart network management decisions, interacting with SM to assure service delivery and network managers. SDN-based in an isolated network slices offers slice control flexibility and is considered one of the primary enablers of 5 G slicing [18,]

3.2 Use cases:

In this simulation, we assign slice 1 to support IOT device that requires a high-throughput and low latency, while slice 2 provide service for mobile broadband that require high performance simultaneously. The two slices will be implemented simultaneously to perform all functions on them separately then combine the results and compare them in a single page view.

NetSlicer simply builds an environment of simulation for each slice to calculate all slice performance requirements like throughput, latency, block ratio and bandwidth.

4.Implementation:

In this section we will focus on how the simulation program works to collect the network performance result. results will be discussed in detail in the next chapter (chapter 4).

4.1Simulation slices:

Depending on the requirement of the specific end user, there are different 5G network slices offering different services to connected end users. Each slice offers services for specific devices or end users. In our proposed model, two slice were simulated simultnously to maintain the isolation for each slice and measure the performance requirements for both.

Slice 1: eMBB

slice 2 provides service for e-Mobile BroadBand that requires high performance in throughput and low latency.

Slice2: IOT

slice 2 supports IOT device that requires a high-throughput and low latency

4.2 Simulation setup

NetSlicer is based in modular objects to build a full simulation environment with predefined parameters. In this simulation program we used a very common python library for simulation, it's called SimPy.

SimPy is a process-based discrete-event simulation framework based on standard Python. Processes in SimPy are defined by Python generator functions and may, for example, be used to model active components like customers, vehicles or agents. SimPy also provides various types of shared resources to model limited capacity congestion points (like servers, checkout counters and tunnels).

Simulations can be performed "as fast as possible", in real time (wall clock time) or by manually stepping through the events. Though it is theoretically possible to do continuous simulations with SimPy, it has no features that help you with that. On the other hand, SimPy is overkill for simulations with a fixed step size where your processes don't interact with each other or with shared resources.

Fig.23 demonstrates the generic experimental setup used for the implementation of network slice isolation in 5G for the two isolated slice that were simulated. The simulation is described step-by-step as follows:

- *Step one*: The end user requests a specific service.
- *Step two*: Radio Access Network (RAN) forwards the request for service to Slice Manger of slice 1.
- *Step three*: SM prepares all the NFV required and interact with slice SDN.
- *Step four*: the slice manager accepts connecting to the EU and monitor and control the service provided throughout connection.

The same steps are taken in the second slice simultaneously when connecting with different end user to provide the required service. Each slice performance will be measured simultaneously in terms of delay, throughput, bandwidth, and the result will be presented at the end for both slices. Result will be discussed in detail in chapter 5.

The program runs with a specified sequence that it adds the collect methods of stats object to simulation environment in order to collect simulation data during simulation time. Then it runs the simulation environment, graph the result then show the result as Fig.24 shows. NetSlicer mainly has three steps to do the entire work:

- Calculate stats for first slice.
- Calculate stats for second slice.
- Merge two results to compare them

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ISSN: 2617-9563

Figure.23 Schematic of the generic experimental setup used for the implementation of network slice isolation in 5G.

5. Results and comparison:

This chapter reviews all the results, analyze each result, and compare it with recent existing algorithms.

5.1 Result of one slice simulation:

Firstly, we have implemented only one slice to assure that the performance will not be largely changed if we add another isolated slice in the same area. As shown in Fig.26, the performance of the slice is enhanced. The measurement of the performance requirements proves that as the latency is remained reduced over the time and increased the throughput of around 6Gbps.

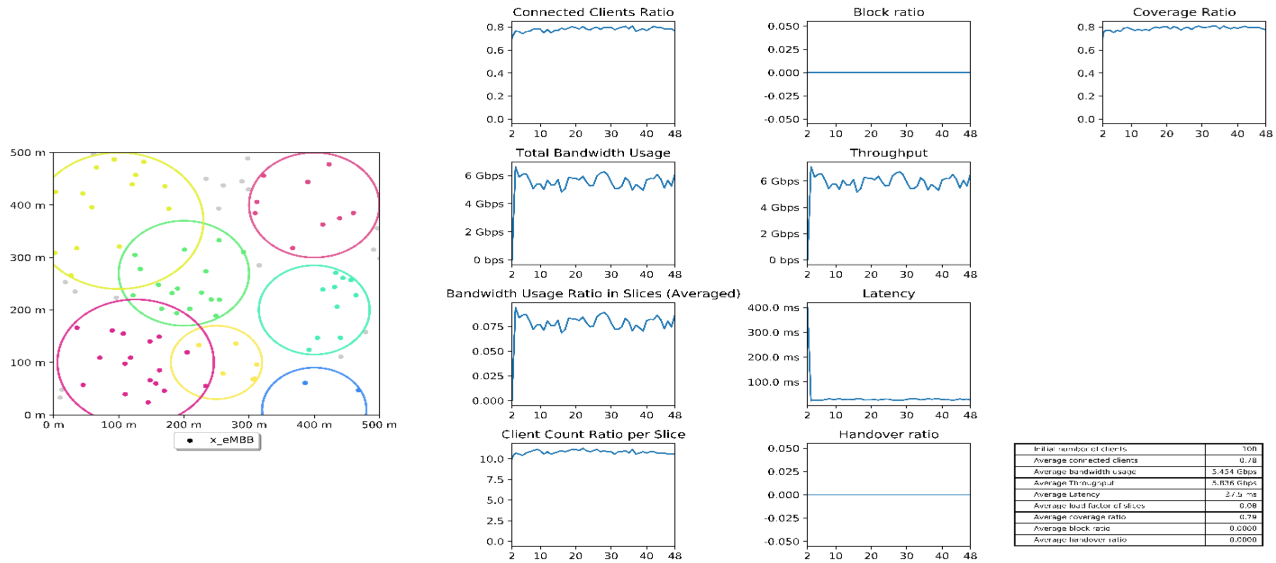

Figure.26 the result of one isolated slice

5.2 Result of two slices simulation:

As shown in Fig.27, we have simulated to isolated slices simultaneously and there is no big difference when we added another slice as each slice works in an isolated manner without interfering with the other slice

it is clear that how the isolation of the slices makes the slice free of occupancy and out of congestion in the mixed slices manner, we notice that the average latency for the two isolated slices is 37.5 ms since each slice has a separate path for its data flaw and this path is monitored by the slice manager. In addition, low latency obtained here is very suitable one for 5G and will be decreased if we increase the number of base stations and wide the coverage of each one.

Furthermore, the throughput almost equal to the bandwidth which indicates that there is approximately no packet loss in the network.

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ISSN: 2617-9563
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The overall performance of two slices assures that each slice has satisfied specific types of QoS requirements within specific slice.

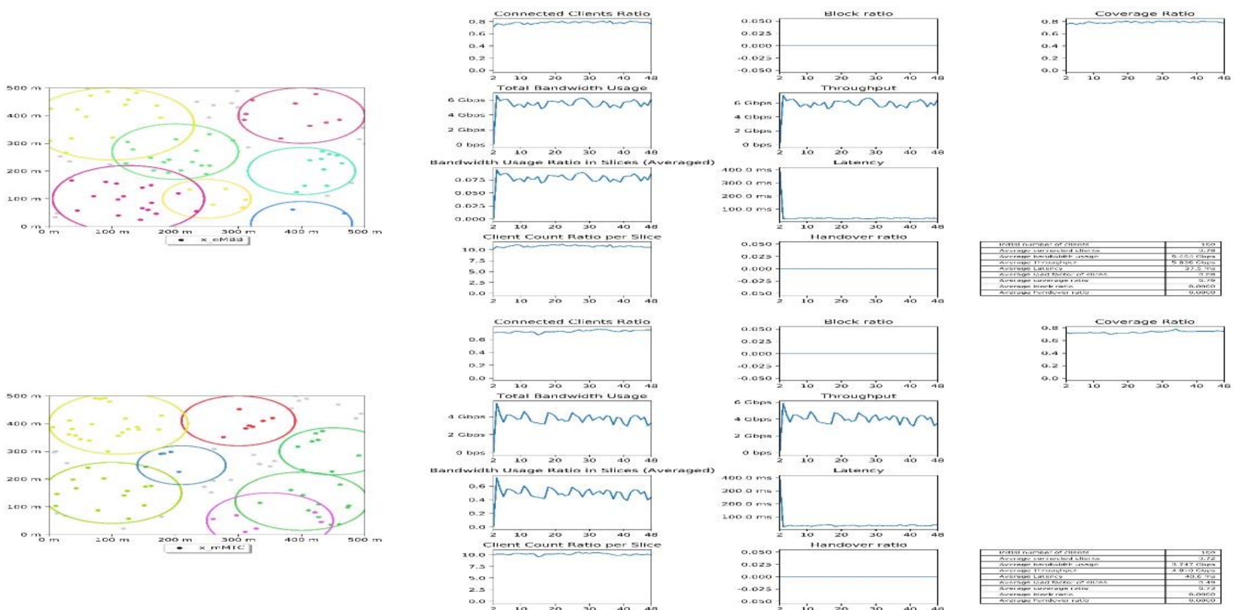

Figure.27 Result of two isolated slices

5.3 Recent comparisons

In this section, there will be a comparison between the proposed model of slice isolation to the algorithms used recently to evaluate the performance requirements parameters in terms of latency, throughput that have a significant influence on the overall network performance.

5.3.1 Comparison 1

In [19], the author presents that resource isolation of network slices can be a challenging task in wireless networks because interference between links affects the actual slice bandwidth and reduces their QoS. Hence, the author proposes Slice management scheme that mitigates the intrusion put on each slice by identifying flow routes with a different routing policy according to its priorities

The main goal of the proposal is to prioritize slice management scheme that differentiates QoS of wireless network slices by priorities by using a greedy routing algorithm that sequentially determines routes of flows belonging to each slice as the QoS of slices is differentiated by their priorities.

5.3.2 NetSlicer and MDPI slicer with the same parameters:

- ***Parameter used:***

In this experiment, we simulated the same parameters of the selected paper in the proposed simulation program to compare the result and prove that our NetSlicer is more efficient than the selected one.

Fig.28 shows the parameters used in [19], while Fig.29 shows a snapchat of the same parameters used in the proposed simulation program.

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Parameter	Value
Carrier sensing threshold	3.65262×10^{-10} W
Transmission power	0.281838 W
Frequency band	2.4 GHz
Loss factor	1
Minimum contention window	15
Maximum contention window	1023
Slot time	9 µs
Short interframe space	16 µs
Preamble length	144 bits
Length of PLCP header	48 bits
Data rate of PLCP	6 Mb/s
Basic rate	6 Mb/s
Data rate	9 Mb/s
RTS/CTS threshold	1 byte
Limit of short retry	7
Limit of maximum short retry	7
Limit of long retry	4

Fig.28 parameters for selected method

```
parameters:
    Carrier_sensing_threshold: 3.65262e-10
    Transmission_power: 0.281838
    Frequency_band: 2.4
    Loss_factor: 1
    Minimum_contention window: 15
    Maximum_contention_window: 1023
    Slot_time: 9
    Short_interframe_space: 16
    Preamble_length: 144
    Length_of_PLCP_header: 48
    Data_rate_of_PLCP: 6
    Basic_rate: 6
    Data_rate: 9
    RTS_CTS_threshold: 1
    Limit_of_short_retry: 7
    Limit_of_maximum_short_retry: 7
    Limit_of_long_retry: 4
```

Figure.29 a snapshot of the parameters for our slicer

The simulation conducted in the same simulation area used in our proposed method as shown in Fig.30. In addition, Fig.31 presents the result of the simulation of the parameters used in [19].

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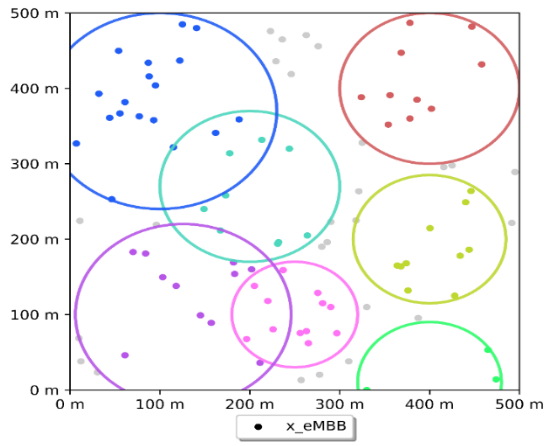

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Figure.30 the simulation area

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Issue (36),2020
ISSN: 2617-9563
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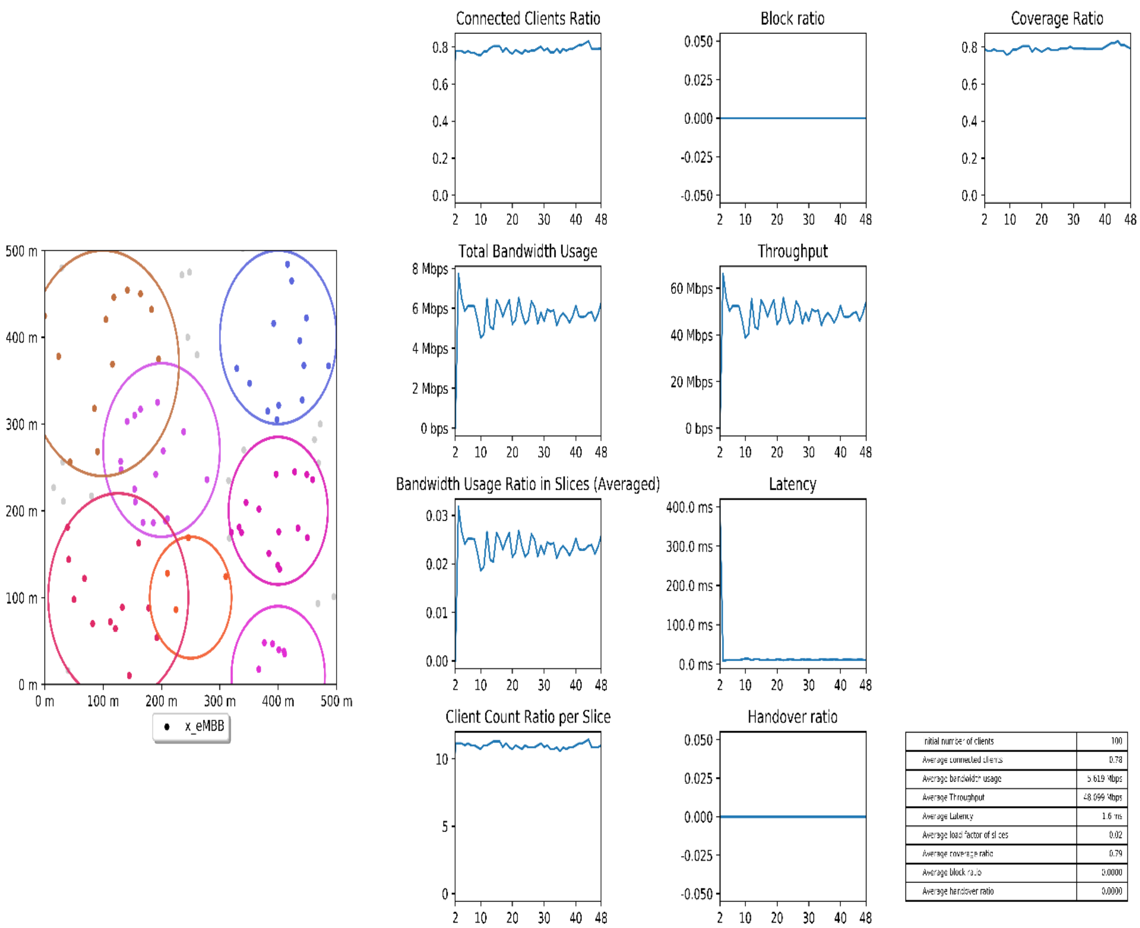

Figure.31 the simulation model result

It is obvious that by simulating the parameters used in [19] in our proposed simulation program (NetSlicer), the result shows better performance in terms of all the performance requirements parameters used in NetSlicer as each slice has an isolated path and there is no interference between the data flaw, whereas in the existing method used in [19], the author attempted to minimize the interference by prioritize the data flaw among the slices.

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ISSN: 2617-9563

The next section will be concentrating on the difference between our slicer simulator and other one used by selected paper in two parameters throughput and latency (delay) as they are the main parameters in the two simulation aspects.

Delay

This section will compare our model to the recent model in terms of delay. We use the same parameters used in [19] and simulated into the proposed model to compare both results in order to evaluate our proposed model performance.

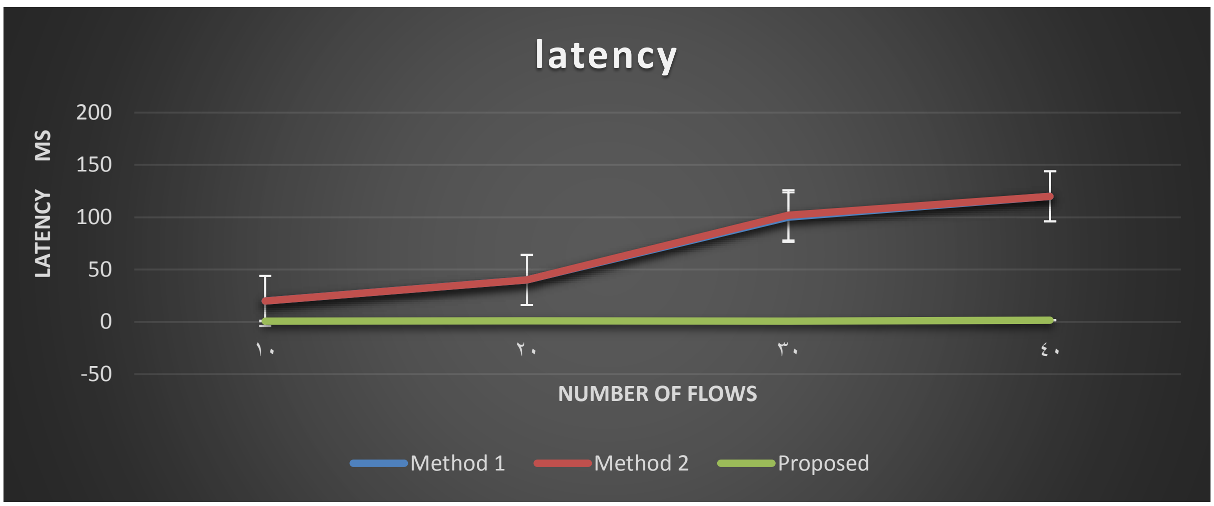

Figure.32. delay of the high-low-priority slice [19] and the proposed

As it is showed in Fig.32. the latency in high priority slice in [1] and the latency in the proposed model with the same parameters. It is clear that the delay in [19] is increased in this simulation as the number of flows increased and that applies on the delay in the low-priority slice using the same algorithms. In comparison, however, the latency with the same parameters used in the proposed model shows that our slicer approach is more efficient to be low at 1.6 ms .

Additionally, according to Fig.19, it can be seen that the simulation results of the recent algorithms used in [19] and our proposed model to isolate the slices traffic shows that the proposed model significantly reduces the latency of the network performance and outperformed the recent algorithms used in [19] and the low-latency obtained definitely satisfies the use cases requirements connected to each slice. The average latency in [19] is 3.5 ms , whereas in our simulation model, the average latency is 1.6 ms as shown in Fig.27. Hence, it is proven that our proposed model is better than the existing approach used in [19].

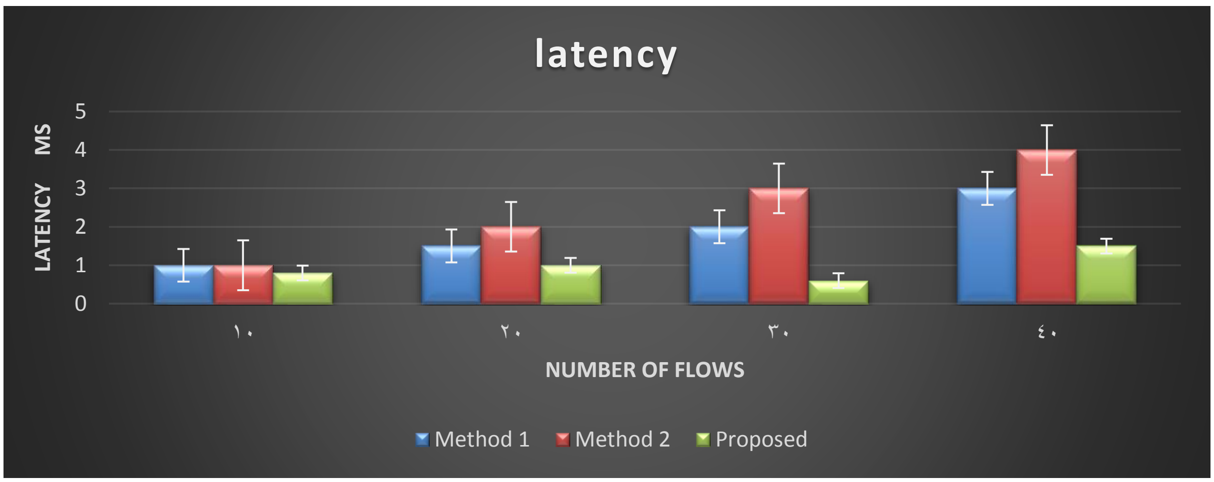

Figure 33. the average latency comparison

Throughput

This section will also continue to compare our proposed model to the recent algorithms used in [19] in terms of the throughput. Two slices were simulated in both simulations. Fig.28 shows the throughput of high and low priority slices in [19] and in the proposed model using the same parameters.

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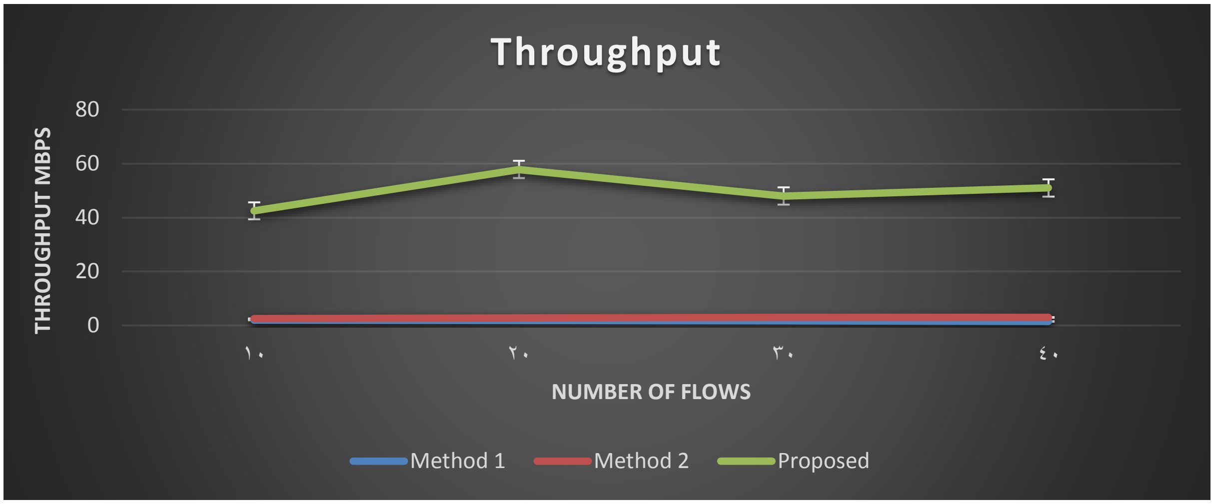

Fig.28 throughput in high&low priority slices [1] and in proposed model

It is clear that the throughput of high-priority slice declined from 1.8 Mb/s to reach 1.5 Mb/s, while the low-priority slice increased from 0.5 Mbps to be 1.5 Mbps.

In comparison to that, the throughput in our proposed model is much higher than in [19]. Fig.28 shows the throughput for the same parameters of slices in our simulation approach.

It is obvious that the proposed model increases the throughput ranging from 40 Mbps to almost 60 Mbps. Therefore, our proposed mode of isolation the slice network outperformed the existing algorithms in [19]. Since the latency in our model is amazingly reduced, the throughput will be increased in order to satisfy the required service that the slice offers for connected users. This will absolutely enhance the overall network performance. The average throughput in our proposed mode is much higher than in [19]. It is about 48 Mbps in the proposed model, while in [19], the average throughput was around 1.5 Mbps. Hence, there is a huge difference in both results and they also prove that using the proposed model will absolutely be great for the network performance based on the result as the latency was low and the throughput is reasonably higher.

Tabl.1 summarize the comparison of the existing and proposed model using the same parameters. It is clear that our proposed model outperform the existing method in [19] and provide better performance measurements.

6.Analysis and discussion

In this chapter, there will be analysis of the results in previous chapter and discuss open issues that are in need for further study.

6.1 ANALYSIS OF SELECTED PAPER RESULTS AND DISCUSSION

First of all, Diverse user applications with different quality of service (QoS) specifications are

needed in 5G networks to be served simultaneously by different virtualized network slices. The author in [19] believes that a transmission of a slice interferes with other transmissions of other slices because of the omnidirectional signal propagation feature of wireless channels. They propose a slice management scheme that mitigates the wireless interference among slices by the prioritized interference-aware routing and admission control. Determination of flow routes

under a common routing scheme. Traffic flows are routed into shortest paths in the slice with highest priority. The routing of traffic flows is performed in each lower priority slice, while minimizing a weighted summation of interference to other slices. Basically, a slice with the highest weight is the highest priority. Therefore, A better QoS is given for higher priority slice applications as the manage priority routing flow of slices to differentiate their QoS by their priorities. The main pint is that they Allow to operate multiple slices in a single channel network while minimizing interference between them. Fig.5 shows the system mode proposed in [1].

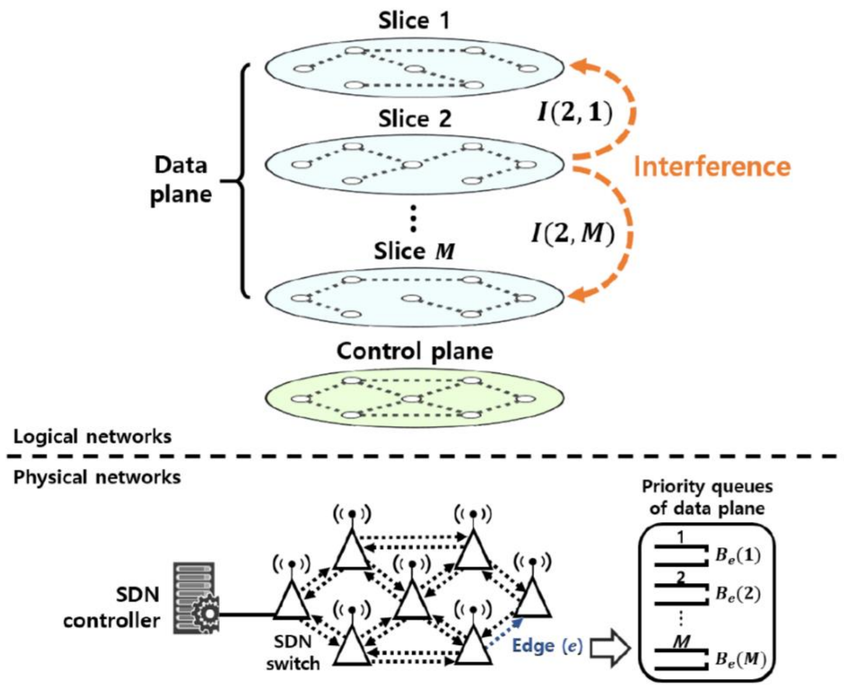

Figure 2 system model in [19]

As shown in fig.5, the proposed system model in [19] uses a centralized software-defined networking (SDN) technology that is known for separating the control plane from the data plane. The SDN controller connected to the data plane switches will handle the slices' traffic flows in a centralized view while the data plane is virtualized into multiple slices. To illustrate their concept, by looking at Fig.6 that shows an example of prioritized multiple routing, there are three different slices. Slice 1,2, and 3 respectively. Based on the weight, they assign a higher weight to slice 1, therefore, flows in slice 1 are routed in the shortest path, while Slice 3 flow routes are calculated when reducing the weighted summation of slice 1 and 2 intervention. Hence, slice 1 is the highest priority slice and that make it receive the lower interference from other slices. This means the QoS of slices is differentiated by their priorities.

Multi-Knowledge Electronic Comprehensive Journal For Education And Science Publications (MECSJ)
Issue (36),2020
ISSN: 2617-9563
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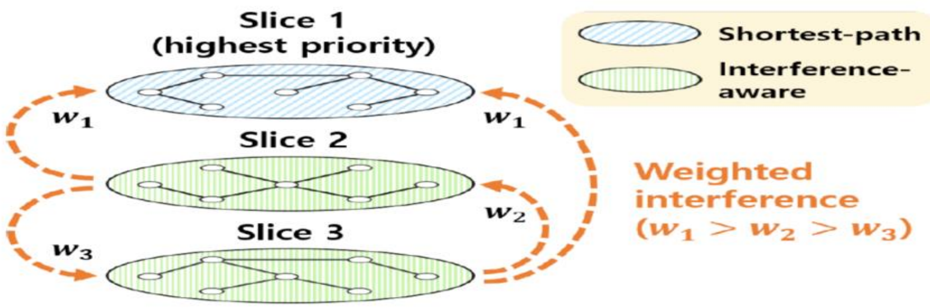

Figure 3 example of the proposed model in [1]

The author of [19] simulated the system using the NS-2 simulator where the nodes were using the same wireless channel for communication and the queues were scheduled based on their priorities. The simulation was performed in three different scenario and two topologies. Two scenarios were simulated in small/large sized Grid Topologies with 16 and 100 nodes respectively. The third scenario performed in a large-sized random topology with 200 nodes.

As for the result of the above simulation, the author compared the two proposed routing methods, k-hop greedy routing and brute-force search methods applied to route flows. In small and large-sized Grid topology, we can see that the average throughout of flows in high-low priority slices declined and the delay become higher in both scenarios. The throughputs were about 1.5 Mbps in both high and low priority slices and the delays were over 3 ms in both respectively in small- sized Grid. Also, in large-sized Grid topology, the average throughput also declined to reach around 0.1 Mbps in high and low priority slices, and the delay increased to reach 140 ms in both slices. To analyze, we can see that as the amount of flows increased, the interference among slices increased and the possibility of loosing packets at each edge became higher.

This causes the gradual increase in delay and gradual decrease in throughput respectively as the number enlarged. That caused rejection of more flows to meet the interference constraints.

As for the large-sized Random topology, here the author increased the number of slices to be 5 slices. This shows a better performance in terms of the QoS of the proposed slice management according to their priorities. The average throughputs increased, and the delays declined. However, we can see that the average delay of five slices was about 38 ms, and the average throughput was 7 Mbps.

Needless to say, as the number of slices increased, the granularity of paths for routing the traffics enhanced, and the interference imposed on the high priority slices reduced. To summarize, the queues here were managed and scheduled according to their priorities by centralized SDN to reduce the interference among slices and especially that imposed on high priority slices to be routed first. In addition, nodes were communicated with one another through the same wireless channel.

6.2 ANALYSIS OF THE PROPOSED MODEL RESULTS AND DISCUSSION

We simulated the previous model in our proposed simulation tool and showed a better result, however, first let us look at how the proposed model works. To begin with, explaining how to connect the user equipment with the right network slice. There are few steps taken include:

1- Network slice (NS) assignment based on the UE's QoS requirements.
2- Determining the isolated path.
3- Routing flows through an isolated service path.

To illustrate, basically, when a network receives a request from the UE through the Radio Access Network (RAN).

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Multi-Knowledge Electronic Comprehensive Journal For Education And Science Publications (MECSJ)
Issue (36),2020
ISSN: 2617-9563

This request contains a description of the services and its QoS requirements (for example, latency, throughput, etc.) to be served by a NS. RAN attempts to match this request with the particular NS provide that service. The slice selection can be more explained in the following steps:

1- A request message containing a description of the services and its QoS requirements (for example, latency, throughput, etc.) to be served by a NS
2- Radio Access Network (RAN) forwards the request for service to Slice Manger of slice 1.
3- SM prepares all the NFV required and interact with slice SDN as there is a virtualized SDN in each NS.
4- the slice manager accepts connecting to the EU and monitor and control the service provided throughout connection
5- The NS is assigned to the UE/application.

The significant difference between the proposed model and the one in in [1] is that in our proposed model, there is no centralized SDN. Instead, each independent slice has a slice manager

(SM) and a Software-Defined-Network (SDN). SM has many responsibilities inside the slice. First, SM has configured NFV specially to meet the required service. Second, it is responsible for managing and controlling the relationship between slice/service users and slice/service providers to ensure and maintain an acceptable Quality of Service (QoS) level in an efficient manner. Furthermore, SM is also responsible for managing the slice resources as each slice has its own chunks of compute and network resources that match the network services it provides.

In addition, SDN is basically a physical separation of the network control plane from the forwarding plane and where many nodes are operated by a control plane.

This separation assists controlling the data flaw of the entire network slice. Also, SDN provides a virtualized control plane that can implement smart network management decisions, interacting with SM to assure service delivery and network managers. More importantly, SDN makes the best route and

pushes more traffic processing on the related switches.

Routing process:

Once the UE assigned to the particular NS, the entire paths of the NS is reserved to process and serve the UE's service requirements in an isolated independent manner without interference with other slices' flows.

The steps involved in routing as shown in Fig. 66 are as follows:

1) The user equipment's packet arrives at slice manager.
2) SM has configured NFV
3) the network path determined and set up by SDN control plan
4) SDN forwards the packet back to SM to process the it
5) SM process the packet. The packet processing involves the performance of any necessary protection, session management operations, etc., depending on the data contained within the packet and the type of network function the NS Manager performs.
6) process is repeated till the SFP is traversed.

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Issue (36),2020
ISSN: 2617-9563
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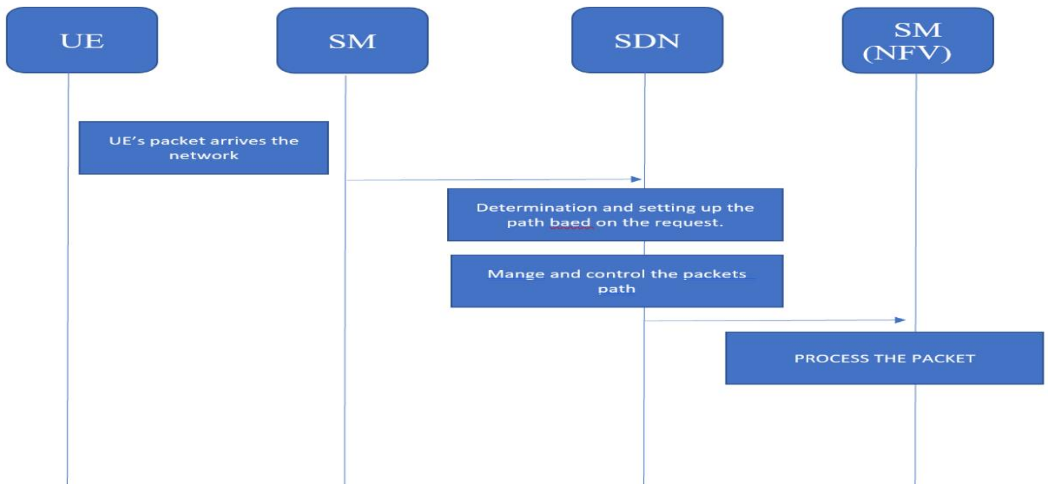

Figure 4 routing packets in the proposed model

So, we have simulated the parameters used in [19] into the proposed model. The simulation turns to get a better result. The average throughput was 48Mbps, while the average latency was 1.6 ms.

The throughput is higher here. This means more packets were successfully transmitted from source to destination with lower and reduced delay that occurs in transmitting packets. This due to using an isolated data palne of the slice's SDN with zero interference with other slice's data flows. As each slice has a separate data plane according to each slice SDN. The data plane of each slice is managed and controlled through SDN controllers and the slice manager as well.

This proves that the proposed isolation network slice architecture outperformed the algorithms used in [19].

Although, adding a slice manager and SDN to each slice will increase the complexity, Network slicing would allow dedicated networks to be deployed more cost effective. In addition, providing flexibility, network scalability and resource efficiency.

Also, using the isolation technique, Network slicing will enable operators to independently evaluate the operating expenses (OPEX) and revenues generated on each slice.

6. Conclusion and Future Work

This chapter reviews the conclusion and presents future steps that can be studied in future work.

6.1 Conclusion

In conclusion, network slices are one of the main technology enablers in 5G mobile networks. A wide variety of users and business requirements will be met in 5G by using network slice architecture. It offers better business agility, flexibility, and cost-efficiency. This research provides increasingly comprehensive research on the isolation of virtual network slices. Additionally, proposing a network slice isolation architecture in 5G networks that isolate each slice from another. The isolation technique provides many advantages for the entire network as there will be no interference among slices data flaw. We have simulated the architecture proposed using Python.

In the simulation, first, we simulated one slice and then adding another slice. Each slice has a slice manager to manage it. Also, we evaluated the performance of the proposed slice isolation management according to the result of the performance requirements of each slice, the performance requirements include latency, bandwidth, and throughput. Additionally, to evaluate, we compared the result with recent algorithms used to differentiate the QoS of wireless network slices according to their priorities. The simulation results show that the proposed isolation slice management method outperformed the existing algorithms in terms of the throughput and delay performance.

Therefore, the idea of fully isolated the virtual network slices enhanced the performance of the whole network in an efficient, cost effective and scalable manner.

6.2 Open issues

By using the proposed isolation slice networking architecture, services provided by the slices will be delivered in a high Quality of Service (QoS). As in 5G networks, it is expected to handle UE's requests based on their individual requirements by different dedicated network slices.

Hence, every UE will be connected to sperate isolated dedicated slice to provide the requires service rather than single size-fits-all network where the network the network treats them in the same way. That slice is particularly created to meet that required type of service of UE. For instance, when enhanced mobile broadband (eMBB) device requests a service for live video and obviously to deliver a best live video streaming requires a high throughput and high traffic volume. RAN will forward the request to the slice to provide that service. This slice will be delivering the service in an isolate manner and provide the best QoS as it has been proven that it will deliver services in high throughput and lower latency. Therefore, the proposed model is considered both helpful and beneficial for the next generation use case.

In addition, one of the advantages of being network slices completely isolated from each other is to obtain safer and more general network protection.

Where if the slices are shared, then exposing any of them to the danger of attack also exposes others to the same danger, and thus the data for each slice is at risk.

Moreover. If the management of network slices is centralized and endangered, this exposes the entire network to the same risk. However, with the isolation between the slices, the exposure of any part of them to danger may not expose other slices to the same danger, and thus the system and other slices continue to provide the service as the

Multi-Knowledge Electronic Comprehensive Journal For Education And Science Publications (MECSJ)
Issue (36),2020
ISSN: 2617-9563
www.mecsj.com/

endangered slice does not disrupt the entire system. This is known as a Security isolation, which means that data in one slice cannot be accessed or modified by other slices sharing the same infrastructure.

While demonstrated and proven to be extremely useful, the challenge of the isolation of 5G network slicing services lies in user security, and the effectiveness of delivering the UEs services in a secured way to meet user requirements.

Since network slices are completely different in the services, they provide to UEs and are completely independent from each other(isolated). Its users are also completely different

It is difficult to find a single, uniform security mechanism suits for all slices. Therefore, each slice needs a different method of protection than the other, which is a major challenge that these slices encounter considering the evolution of dangers and organized viruses to target them. For example, an IoT slice may provide a different authentication and/or encryption method than an eMBB slice.

This adds to the complexity of the overall slice security architecture requiring early attention in the overall design process.

In the future. Each network slice may have special users as well as a special security method that ensures complete protection of user data. For example, a slice might require very low latency. Applicable security mechanisms need to be compatible with the primary slice service requirements (for example, low latency)

As the confidentiality of user data is one of the current challenges these slices face, network slices requests submitted by users must not only be served in a high QoS, but also ensure confidentiality, which often leads to security problems.

Ensuring confidentiality means that packets are not made available outside of the slice that generated them, or the slices which are allowed to interconnect.

Additionally, the data carried in those packets or held within the Slice Manger (SM) that process them must not be available to anyone other than the authorized elements or end-users. Therefore, slices need to be maintaining a level of confidentiality acceptable to the user. For instance, an attacker may eavesdrop on the data transmitted and extract sensitive information to execute attacks of running network slice like Denial of Service (DOS) attacks.

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