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# ECONOMIC SCALABILITY OF 5G MOBILE NETWORK BY SDN AND MPLS

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**Abstract-** The evolution of 5G has become in two steps since it began with the 4G evolved packet core. The first step was the separation of the user and control planes of the 4G EPC. Programmable networks, such as software-defined networks (SDN), bring standardized and programmatic interfaces to the table. These interfaces, such as Open Flow, enable network operations to be automated. These operations consist of arranging a variety of heterogeneous items as well as flow management in order to make effective use of available resources. In currently not-programmable of networks such as MPLS, there are many of them that can be call for many skills which sets, such as different methods, different programmers, as end user personnel. Conduct an analysis of costs for network and give many metrics: the device Service Scalability of cast metric, which evaluates the work of a network unit cost for work requests in which to an high work workload; and the Cost-to work metric, which cheap quantifies the cost of modern service into a networking model. Both of these metrics can be found in the following. The following provides both of these metrics for your perusal: The metric for the Scalability of the USC both the USC Scalability metric and the CSS metric Within the context of this part of the article, both of these measurements are discussed. carried out a quantitative investigation employing an activity-based methodology to compute the CAPEX and OPEX costs associated with a network. Second, for checking the aforementioned architectures of their economic performances, utilized the metric for measuring the scalability of the unit service cost as well as the Cost-to-Service metric. The findings are summarized in the table that can be found below. In addition to this, we have made available mathematical models that can be put to work in order to determine specific cost components of a network. have compared and contrasted the various current SDN plane design, such as CCP, DCP, and HCP, with one another to have best understanding of the economic impact of these models. This is the case despite the fact that the total cost of ownership (TCO) when cheek to SDN models, give MPLS displays less No. of good requests and a huge total cost of ownership. This is the case despite the fact that the total cost of ownership (TCO) MPLS has been shown to have bigger USC than SDN design, as a direct consequence of the findings of the aforementioned research. As a result of this, the cost of providing a unit of service for MPLS networks is typically more expensive.

**Keywords:** Economic Scalability, Mobile Communication, 5G, SDN, MPLS.

## 1. INTRODUCTION

As a result of the invention of mobile communication systems, these networks are continuously undergoing development and are rapidly expanding across the world. Use cases for mobile communications systems encompass almost every potential application domain, such as those found in area of work, health care, learn, and the military. As a result, there has been a discernible increase in the number of connected devices. According to the information presented in reference [1].

There are approximately 30 billion devices around the world that are connected to the 5G core network. The modernization of the technology that lies beneath mobile core networks is the primary force driving the evolution of these networks. In a hybrid model, the virtual and physical features of the core network work together to provide functionality. Recent developments in 3GPP have resulted in the release of new capabilities, including user plane separation and network slicing at multiple stages figure.2. These new capabilities were developed. Both of this capacity is considered as being essential for the development of 5G. In addition to adding features, the priorities of the business are shifting away from a focus on hardware and toward virtualized network functions and open-source platforms. Increasing adaptability and dependability while simultaneously decreasing reliance on OPEX are the goals of modern end-eavors. During this time, 5G has also been released, and users have shown enthusiasm for a newly developed core network architecture.

According to [3], the evolution of 5G has become in two steps since it began with the 4G evolved packet core. The first step was the separation of the user and control planes of the 4G evolved packet core. The second step was the rearrangement of the functions of the separated users and control planes into services. Consequently, the introduction of user and control plane segregation was the first step taken toward the development of 5G.

The components of the 4G EPC, also known as the Evolved Packet Core, have been reorganized in service-oriented jobs, as shown in Figure 1. The increase in the modularity of the software industry's products can be directly attributed to the widespread adoption of service-based architectures in this sector. As a result of this inventiveness, software products could be divided into numerous communicating services, and software developers could incorporate the services of more than one vendor into a single product. A type of software design known as service-oriented architecture (also referred to as SOA) is one in which various application features, such as utilizing a communication protocol over a concerned network, are used to deliver services to the components of the software. Service-oriented architecture is also known as SOA. The independency of this service-oriented architecture's components, including vendors, products, and technologies, is one of its defining characteristics. These services constitute distinct operational units, each of which is capable of being accessed and updated in its own right.

At this stage in their development, EPC and 5G face primarily a few challenges, the most significant of which is the implementation of a wide variety of crucial network functions. The following are major building blocks that are considered when attempting to define evolution: The user plane and the control plane are kept separate to facilitate independent scaling and management of the user plane and control plane traffic lifecycles. Network slicing is the process of creating multiple logical networks out of a single unit of physical infrastructure. The process of installing core network features in close proximity to radio networks and customers. The gathering together of data traffic emanating from mobile and fixed wireless access points into a single stream. A number of prominent workers in area [4-5]. By means of their paper titled "Constructing a New World", Ericsson published "A guide to evolving from EPC to 5G Core," in which the company defined work evolving the core network to 5G. It has good results and mapped later than area of work that are posed by the process of 5G network evolution.

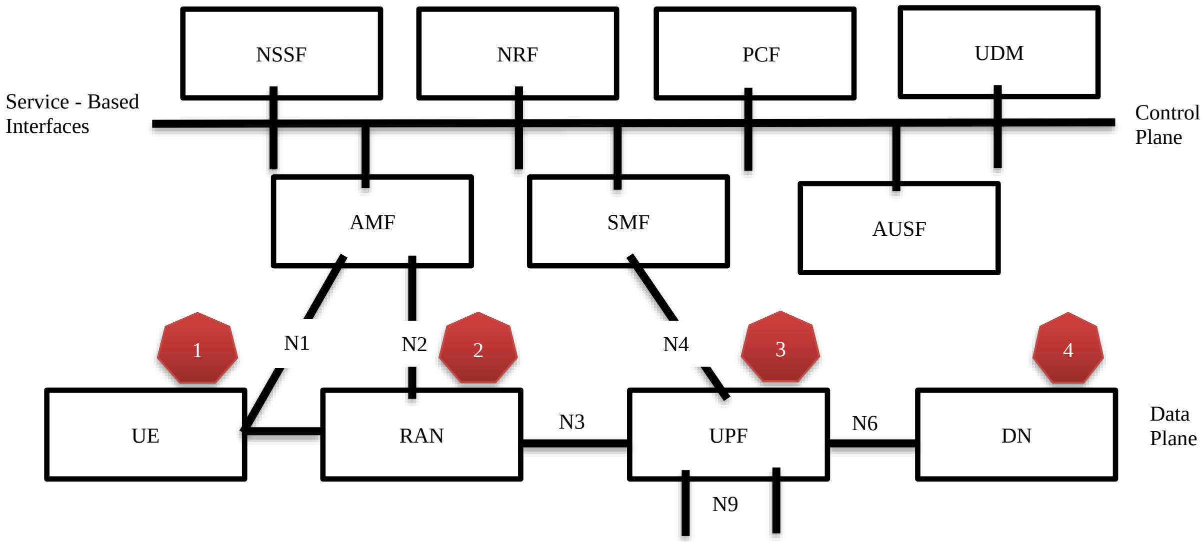


Figure 1. 4G EPC items functions [1]

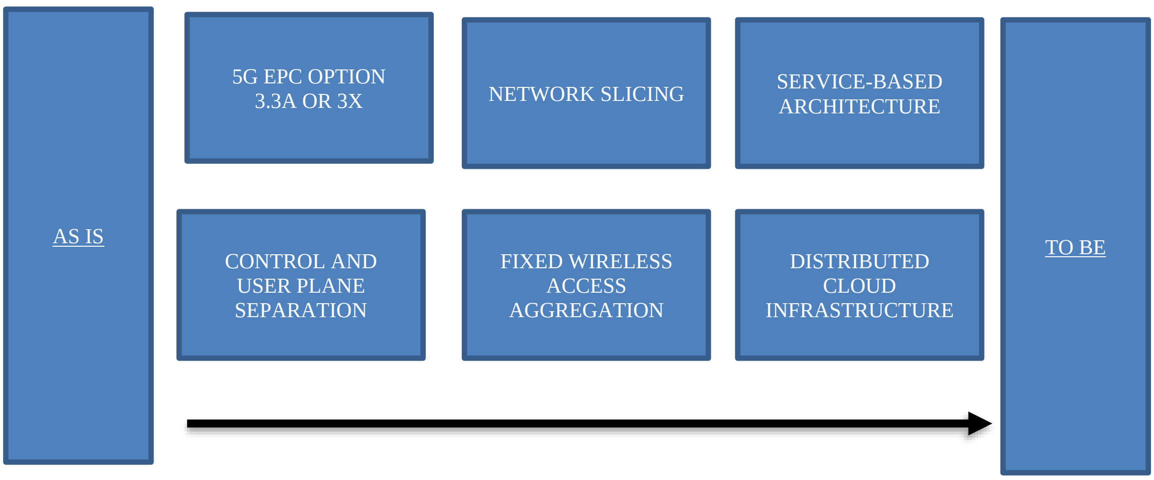


Figure 2. 5G developments [4]

## 2. NETWORK ECONOMIC PERFORMANCE INDICATORS

The item cost is charged by the system is the primary factor that is used to determine price to customer must give use of services that are provided by networks. This is because the overall cost of the service that is provided by the network is proportional to the cost of the service that is provided per unit. This is due to the fact that the item cost of the service represents the amount that the network must pay to give the service to the end user.

On the other hand, these kinds of calculations of internal costs are kept extremely confidential because, according to the practices that are currently in place, networks typically do not disclose the internal cost structures that they make use of. Moreover, these kinds of calculations of internal costs are kept extremely confidential because they are used to determine whether or not a network is profitable. On the other hand, having a solid grasp of these internal price calculations is of the utmost significance. Essential in the process by which researchers are attempting to develop a pricing structure that is optimal for users as well as service providers. Network operators have a difficult task ahead of them when it comes to figuring out how much it will cost to provide a quality-of-service based service within a network. If the price of work in a network is not calculated accurately, there are two possible outcomes that may take place for the network in either the middle or long term, depending on which one is chosen. If the end user is a small percentage of the overall real cost for the work that they use, the price that they spend via the network will be lower, one of the consequences is network began reduce. This is because the actual cost of providing those services to customers is less than what customers pay. This is one of the outcomes that could take place.

Another potential consequence may take place if a network determines that it will lose customers over the long term, which will lead to a reduction in revenue; this is one of the potential outcomes that could take place. A cost that is added to the service that is in excess of what it actually costs to provide it. In this hypothetical situation, the network might have the appearance of advance in a privation, but if the situation were to continue on for an extended period of time. As a direct result of this, the process of calculating costs is an essential step for a network in order to accurately reflect actual price for the provision of services. This is done in order to give customers and networks the best possible chance of benefiting from an optimal solution. Relationship between the cost of their services and the businesses they will continue to operate in the future. It has come to our attention that the method that we use to calculate costs is indicative of the bare minimum fee that network ought to demand for the service. This information was brought to our attention by a member of our staff. It does not produce or lead to either a loss or a profit for a network. It does not produce either outcome, nor does it lead to either outcome. Whether or not a network decides to maintain its costs at a big level or a small level is dependent on the market strategies that the network decides to implement., which evaluates work of a design unit cost for end user requests in relation to higher service workload; and the CS metric. Both of these metrics can be found in the following: The following provides both of these metrics for your perusal:

Please present the calculations for CAPEX and OPEX, which are utilized in the process of determining the unit CS in a network that has QoS parameters, in addition to this, please present the unit CS calculations. These calculations are presented in addition to our presentation. In addition to multiple numerical service tiers, the only quality of service parameter that is taken into consideration when handling service requests is the bandwidth quality of service parameter. It the method of calculating unit costs that has been suggested in this paper reflects the least amount of money that a network ought to pay for the work in order to compensate itself for the costs that it has incurred. This is something that should be brought to the attention of the reader as soon as possible. As a consequence of this, it does not bring about a financial loss for a network, nor does it bring about a financial gain for a network. The cost can be kept at bigger or lower amount depending on the market system of the network; however, that subject is outside the scope of this paper and will not be discussed further here.

### 2.1. Unit SCS Metric

Scalability is a property that a wide variety of different types of computer systems assert they possess. It is a difficult problem with many facets to consider. Despite the fact that the core concept is pretty self-explanatory, not everyone's first thought when they hear the word "scalability" is the same thing, even though it is a fairly fundamental concept. Others may refer to scalability as a measurement of the many multiple machines, while others may define scalability as the improve of procedure power to central processing units (CPUs). The optimization of processing power to CPUs is one definition that some people use to describe scalability.

As a direct result of this, there is not a widespread and all-encompassing consensus on either the definition of it or the content of it. Despite this, it is a desirable property that indicates the case regardless of the meaning that it may have for an individual. Some of the research that has been done to propose a metric design can be found in [6-12]. Another research can be found in [6-11]. The vast majority of these metrics are intended for application in settings that are comparable to one another. Iso-speed scalability and Iso-efficiency scalability are the two types of scalability metrics that are generally agreed upon as being of the utmost importance. The majority of these suggestions center on these two types of scalability metrics. It is possible for the machine's average unit speed of an algorithm to remain unaffected by changes in the number of processors or in the size of the problem that is being solved on a particular machine.

The value [6] exemplifies the defining quality of the scalability, which is referred to as the Iso-speed. In the piece of research that was referred to in the previous sentence (7), The function of scalability $\psi(p, p_0) = p'W/pW'$, where, $p$ and $p'$, respectively, the initial and scaled number of processors in the systems, and $W$ and $W'$, respectively, to the initial problem size and scaled problem size (workload). where $W$ represents the problem limit. Their scalability function enables users to adjust the total number of processors in a system by either adding or removing processors.

This can be done in either direction. The ability of a parallel machine to maintain the same level of parallel efficiency despite an increase in the size of the system or the problem is known as iso efficiency scalability [12]. the same level of parallel value of quality. Multiplying the speedup by the total number of processors that are being utilized is the method that is used in order to calculate the parallel efficiency, which is represented by the equation $E = S/p$. The ratio of the size of the problem to the amount of time it takes to execute the problem in parallel, which is represented by the letter "$T_p$", is another indicator of speedup in the problem-solving process. The $W$ plus $T_0(W, p)$ multiplied by p is equal to "$T_p$", where, $T_0(W, p)$ is an additional communication overhead [9]. The $T_p$ equals $W$ plus $T_0(W, p)$ times $p$.

The $S$ is equal to $W$ multiplied by $T_p$, where $T_p$ is equal to $W$ multiplied by the product of $W$ and $T_0(W, p)$. In Pastor and Orero's [10] explanation of heterogeneous scalability, a heterogeneous efficiency function is presented as a part of the heterogeneous scalability definition. Which requires the calculate of successfully resolving the large-scale problem on a single node. This is because they make an effort to largest the homogeneous Iso efficiency scalability heterogeneous model calculated. Iso-speed-efficiency is the name of a scalability metric that Sun and colleagues [11] propose for use with general heterogeneous computing systems. Iso-speed-efficiency measures how well one system performs relative to another.

The model describes using a concept that is known as "Marked Speed." The scalability metrics known as Iso-speed and Iso-efficiency, which form the roots of this metric, are combined to form this metric. Scalability is not only can work, but also the ability to operate effectively while maintaining an adequate level of service quality across a specified range of configurations. Scalability refers to not only the can work also the ability to operate effectively. they need to provide those answers. The question of whether or price of the model to give service has an effect on the scalability of design is an example of this type of question that is both interesting and relevant.

The findings of the research conducted by Jogalekar and Woodside [12] indicate that make big capacity must not be unreasonable in relation to the total price of the model, and it is imperative that the efficiency. also, when have the scalability of a system, a big number of effects that influence the subject matter must be taken into consideration in order to arrive at a complete picture of the situation. This is necessary in order to arrive at a conclusion that is accurate. According to Behringer et al. [14, 15], one example of such a factor is the total cost of ownership, which is also abbreviated as TCO. Multiple pieces of research have been done in an effort to develop a metric to calculate the systems. A scalability metric that takes into calculate price in distributed environments is proposed by [15-17]. P-Scalability is the name that has been given to this metric. It does this by utilizing a measurement that is known as "power" and the cost of the system in order to fulfill the requirement of providing process at a point factor $k$.

It is possible to characterize it as [13]:

$$P - Scalability(k_1, k_2) - P(k_2)Cost(k_1) / P(k_1)Cost(k_2) \quad (1)$$

The term $P(k)$ = Throughput/ Response Time, and it is used here. In addition to the capacity and response time, the cost of the system is factored into the calculation of this metric as well (both of which are included in the power $P$). Scalability is defined in [12] with reference to the "productivity" of model environments. Scalability refers to design which can to grow. To determine productivity, which is represented by the symbol $F(k)$, divide the value that is get each second via the cost that is incurred per second [13].

$$F(k) = l(k) f(k) / C(k) \quad (2)$$

where, $l(k)$ is throughput expressed in responses per second at scale $k$, the value of quality of service at scale $k$ is represented by the symbol $f(k)$, also calculate point $k$ is represented by the symbol $C(k)$.

According to the findings of the studies that were discussed previously, one method for determining whether or not a system is capable of scaling to meet increasing demand is to calculate the cost of providing service while maintaining quality of service (QoS) for each individual service request. This method was found to be one of the ways to determine whether or not a system is able to scale to meet increasing demand. refer to the work of a network's unit cost for work requests as the Unit SCS Metric for the purposes of this discussion because it is relevant to the topic at hand. Because of this, will be able to assess how well a network deals with an increasing workload for service requests. This metric takes into account both the workload of the network and the various costs incurred in order to keep the Quality of Service (QoS) at level that are processed through the network. can believe that architectures that are more scalable will ultimately lead to lower costs per unit of service in networking environments. This is because networks with such architectures are able to handle a greater workload while keeping their network expenses at the same level as those of other networks.

The cost of this is established by the service tier on its own. Workload is a term that refers to service requests that are being processed by the network. These service requests can come from any and all service tiers. Users and customers are the ones who make these service requests, and it is the responsibility of the network to ful fill those requirements. The equation gives an overview of total price cost quality of service items (bandwidth) coming from a service tier. One way to interpret this is as a request for more bandwidth. 8. According to this formula, cost can be calculate coming from a particular service tier is calculated by dividing the total cost of ownership (CAPEX + OPEX) by the amount of work that is completed within a given time period. By using this ratio, one is able to calculate the total cost of ownership that is associated with the request.

$$\begin{aligned} C_{bwj} &= f(C,O,W) = C + O / S_j = l(w_j)\left|bw_j\right|\left|bw_j\right| \quad \text{before}\,\Delta \\ C_{bwj} &= C + CD + O + OD / S_j = l(w_j + wD_j)\left|bw_j\right| \quad \text{after}\,\Delta \end{aligned} \tag{3}$$

where, $bw_j$, | $bw_j$ |, $Cbw_j$, $C$, and $O$ can be type of (i.e., bandwidth) work with tier $j$, the analysis value of the work tier $bw_j$, the cost of the work $bw_j$, CAPEX, and OPEX in a time frequently (for example, month or year), respectively $bw_j$ also represents the analysis point of the work tier $bw_j$. $w_j$ and $w\Delta_j$ are symbolic representations of the workload and any potential additional workload associated with service $bw_j$ and $W = \Sigma_{j=1} w_j$ and $W\Delta = \Sigma_{j=1} w\Delta_j.w_j$ and $w_j$ are calculated using the formula $W = P_j = l(w_j)$. In a manner that is analogous, the letters $C\Delta$, $O\Delta$, and $W\Delta$ stand for the potential additional capital expenditures (CAPEX), operational expenditures (OPEX), and workload, respectively, that will be incurred in the network as a direct result of the implementation of a wide variety of many types of changes (represented $\Delta$).

### 2.2. Cost-to-Service Metric

Programmable system, such as software-defined networks (SDN), give quality and programmatic both to the table. These interfaces, such as Open Flow, enable network operations to be automated. These operations consist of configuration can pass a variety of heterogeneous items as well as flow management in order to make effective use of available resources. An example of a programmable interface is something called Open Flow. Programmable networks are an example of a type of networking known as software-defined networking. They also reduce the amount of human intervention that is required for the operations of the network, which helps to bring down the operational expenses associated with the network (OPEX). Because of this automation, the rate at which services are provided increases, which, in turn, makes the introduction of new services easier and encourages the development of innovative applications and services. In addition to this, when it is work with NFV, the creation of extremely agile service is possible.

The capabilities of the two different technologies can be combined in order to achieve this goal. These roles are all required for the device to function properly. The reason for this is that traditional non-programmable networks do not come equipped with programmable together. They do not provide the necessary flexibility to develop new service offerings or make dynamic changes to the network. Introducing any kind of change into these networks is not only difficult but also time-consuming and fraught with the possibility of harm. Programmable networking is advantageous because it helps cut down on the total cost of system and the amount of time that is required to launch a new service.

Both of these factors contribute to an increase in overall network costs. It is possible for the operators of networks to make the decision to provide new services to their users for a variety of reasons, one of which may include the creation of new opportunities for the generation of revenue. This procedure needs to finish all of its steps before the service can be used in its entirety before it can be used at all. Within the context of this particular research project, these stages are referred to as the work Design/Implementation (I), Service Testing (E), and Service Tuning Up (T) steps, respectively. The majority of time spent during the Service Design and Implementation phase is devoted to planning the arrange particulars for each system entity and site. VLAN addressing, and a great deal of other information.

It is absolutely necessary to have a detailed process of design in order to ensure the accuracy, timeliness, and continuity of the entire process of introducing the service. This is because having a thorough design process is absolutely necessary. In addition, the implementation of the design so many require the use of benefit coding across a variety of network entities, such as but not limited to systems. This is because the technique, set up, and system arrange of the items and files all play a role in determining whether or not this is required. In the case of SDN, these work process and Behaviors can be smallest due to it is not necessary to perform such actions for all network entities. This frees up resources that can be put to better use.

This indicates that there is potential for a reduction in the total amount of work that must be completed. Instead, the necessary actions can be applied centrally just once, and then they can be distributed to the appropriate network devices. This is a much more efficient method. This results in fewer employees needing to be hired, as well as a reduction in the amount of time required to launch the service. During the Service Testing phase, the objective is to identify network configuration issues that are causing improper service functioning as well as a degradation in service quality, both of which may lead to revenue losses. In addition, the phase seeks to identify issues that are causing an increase in the likelihood of a security breach. Depending on the capabilities of the available technology, this testing procedure can either be carried out automatically through the utilization of network programming or it can be carried out manually.

Programmable networking, in contrast to traditional networking, makes it possible to remotely program and test each and every component of the network in a significantly shorter amount of time. This is an advantage over traditional networking. This outcome results in a minimize in the many numbers of work employees that are needed, as well as a reduction in the amount of time spent on testing in order to facilitate a rapid introduction of the service. In the final stage of the process, which is referred to as "Service Tuning Up", any final touches that are required to be made to the service in order to maximize its quality, fix any problems that were discovered during the testing phase, and generate or keep the revenue that the service generates are made. The automation of programmable networks, which is provided by the step that is performed before this one, leads to cost savings for this phase as well, just as it did for the step that was performed before this one. The costs that are associated with each step of the service introduction process, which were detailed earlier, contribute to an increase in the overall cost of the process. This brings the total cost of the process to a higher level. The refer to a metric that is known as Cost-to-Service. This metric is discussed within this context.

This is accomplished by contrasting the currently available service with the one that the new service will eventually take the place of. This metric was developed by Cisco, the company that you may be familiar with. Specifically, the purpose of this definition is to arrive at a monetary value that can be assigned to the costs that were incurred in the process of launching the service. The equation that is used to describe this metric can be written as follows as a direct consequence of this, which is as follows [13, 16, 18]:

$$SC = f(e,p,t) = C^I + C^E + C^T = \\ = S_{i=1} e_i^I p_i^I t_i^I + S_{j=1} e_j^E p_j^E t_j^E + S_{k=1} e_k^T p_k^T t_k^T \quad (4)$$

where, subscripts $I_j$, and $k$ represent the corresponding work involved in and where $C^I$, $C^E$, and $C^T$ are the costs of the corresponding step that are currently in use.

## 3. RESULTS AND DISCUSSIONS

Create a structure for the results analysis of the many different system architectures that have developed in this article, and present it to the audience. In particular, to have a best understanding of the effects that programmable networking has, carried out a low-cost analysis of both SDN system and MPLS system, also known as SDN technology, has on the economics of a network in comparison to traditional networking, also known as MPLS technology. This is so that can gain a better understanding of the effects that programmable networking, also known as SDN technology, has on the economics of a network.

To begin working toward this objective, carried out a quantitative investigation employing an activity-based methodology to compute the CAPEX and OPEX costs associated with a network. Second, to cheek the aforementioned architectures in terms of their economic performances, utilized the Unit Service Cost Scalability metric as well as the Cost-to-Service metric. The findings are summarized in the table that can be found below. In addition to this, we have made available mathematical models that can be put to work in order to determine specific cost components of a network have compared and contrasted the various popular SDN control plane models with one another in order to get the best understanding possible of the economic impact that these models have.

These models include CCP, DCP, and HCP. This was done to get best understanding of the various currently SDN plane system. Software-defined networking (SDN) makes network programmability possible because its loss the plane from the plane of data. As a result of this separation, network operators and administrators are able to make more efficient use of the network's resources and have an easier time provisioning those resources when compared to before. By bringing programmability to the table, it simplifies the process of altering the properties of the entire network. The software-defined networking (SDN) paradigm possesses a number of significant characteristics that, when combined, have an impact on the equations describing CAPEX and OPEX in the system.

These characteristics include: Researchers from academia and industry have taken an interest in it because of the networking features it promises. They see it as a potential avenue that could be exploited to bring about a reduction in the costs of maintaining networks and the generation of revenue for service providers. In spite of the fact that the total cost of ownership (TCO) of SDN system and MPLS give a decrease due to a decrease in OPEX in the case of 100 Gbps data link frequency bandwidth, the findings of the simulation indicate that these two models give a large amount of information as the switch analysis increases due to an increase in the total number of connections. This causes more OPEX to be incurred in the network for each switch case when the link bandwidth is 1 Gbps. This is the case despite the fact that the total cost of ownership (TCO) when compared to SDN system, the MPLS displays a smaller number of acceptable requests and a higher total cost of ownership. This is the case despite the fact that the total cost of ownership (TCO) MPLS has been shown to have a larger unit work cost than SDN system, as a direct consequence of the findings of the aforementioned research. As a result of this, the cost of providing a unit of service for MPLS networks is typically more expensive. In addition, it demonstrated that MPLS incurs large r service can give of costs when compared to SDN system as a result of a lack of automation and programmability. This is the case because MPLS does not allow for as much customization of its network. Because MPLS cannot be easily automated or programmed, this is the situation that has arisen. The amount of time needed to introduce a service is reduced, and this reduction is independent of the number of devices that are currently in use. This reduction is made possible by the automation and programmability of SDN.

## 4. CONCLUSIONS

In a position to reach the self-evident conclusion that the utilization of an SDN controller does not result in the establishment of a consequent delay for UEs' data plane, able to draw this conclusion. It is essential to emphasize the fact that incorporating the SDN paradigm into mobile networks makes it possible to introduce new services with increased agility. This is especially true when taking into account the programmability that is made available by NFV. Additionally, increasing the system's scalability and flexibility can be accomplished by physically separating the plane from the plane of data.

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