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Policy Model for Sharing Network Slices in 5G Core Network

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Abstract

As mobile data traffic increases, and the number of services provided by the mobile network increases, service load flows as well, which requires changing in the principles, models, and strategies for media transmission streams serving to guarantee the given nature of giving a wide scope of services in Flexible and cost-effective. Right now, the fundamental question remains what number of network slices will be cost effective for slice managing and giving the required functionality. So, the aim is to improve the efficiency of mobile network by forming an ideal slice in a multi-service communication network. In this paper, we propose a model to demonstrate network resource allocation system that forms devoted network slices to serve particular types of services independently on shared infrastructure. This model solves the problem of creating a strategy to form multi-service core mobile communication network slices, which allow the providing of a wide scope of services with certain quality indicators according to the effective dynamic configuration of the system. A resource management system model is created, to provide a method that considers costs related with excessive resource allocation, and also reduces the number of network recalculations, allowing for a reasonable proportion of management costs and Qualities of Service.

Keywords: Network functions virtualization, Network slicing, 5G, Evolved packet core.

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Introduction

There is a critical increment in traffic in mobile networks, which is related to the expanded utilization of smartphones, various services, and different other factors. Current communication systems are constructed as complex networks that spread different sorts of devices consolidated combined in a single complex, and work in conditions of enormous burden flows, and many connections (Narang, *et al.*, 2018). Besides the average signaling requirement per supporter is up to 42% higher for Long-Term Evolution (LTE) compared with the High-Speed Packet Access (HSPA) communication standard (Hashim & Abido, 2019).

As appeared in Fig. 1, an assortment of services will be given by wireless networks (Bera, *et al.*, 2017). Lately advancements in mobile communications innovations and mobile terminals stimulate the spread of different services with a wide scope of latency, mobility, and reliability among others (Foukas, et al., 2017). Recently, mobile networks give basically voice and data services through the Evolved Packet Core (EPC) design.

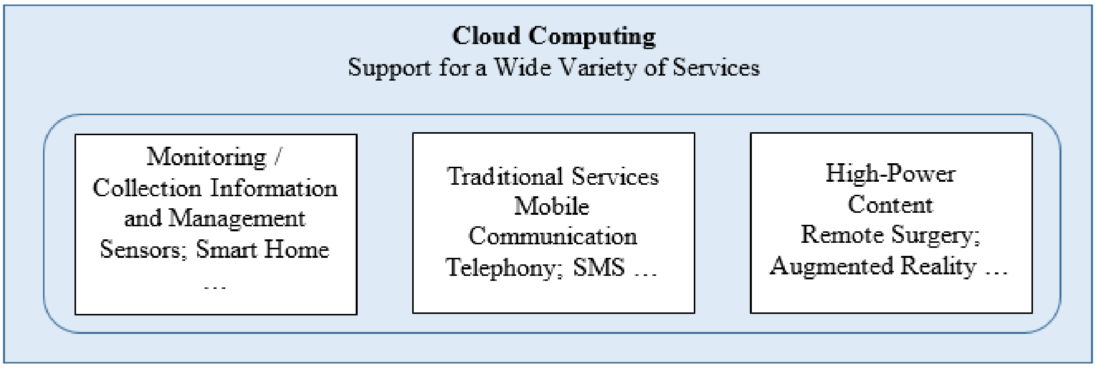

Figure 1. The Services of the Next Generation Networks

EPC is a completely IP network architecture that serves all services and different kinds of User Equipment (UE), for example, smartphones and Machine-to-Machine (M2M) machine interface devices. Today, there is a need to adopt new ways to deal with sorting out the arrangement of services that will provide software as per the necessities of end clients, and the kinds of services. The purpose of this work is to improve the efficiency of the mobile network by forming ideal slices of the multiservice communication network. The problem statement that EPC is created utilizing a structural methodology a "case-by-case" way to deal with a wide range of traffic that is taken care of comparatively by the components of the underlying network, for example, Serving Gateway (SGW) and Public data network Gateway (PGW) (Foukas, et al., 2017).

Concentrated fixed architecture, complexity, and statics are factors that ruin the improvement of mobile networks. Also, the circumstance is convoluted by the excess of functionality. For instance, Mobility Management Entity (MME) is utilized in the system to oversee user mobility in the EPC, however, not all user equipment (UE) needs mobility support (for instance, M2M machine collaboration sensors have a fixed geographical area during the operational period). Simultaneously, advancement requirements direct the need for fast and adaptable sending of new various services. Furthermore, the system load changes during the day. Thus, as (Liu, *et al.*, 2018) up to 80% of the computing power of base stations and up to half of the power of the base network are unused. These outcomes in low resource utilization, just as high energy consumption, which decreases the cost-effectiveness of the network for Telecom operators.

Thus, there is a problem of building a mobile network with the ability to support various services with the specified service requirements, effectively using the technical resources of the Telecom operator. The initial data will be the performance requirements of the service j, which are set as, where l is the number of system performance parameters. As a result, you need to get the number of dedicated networks |k| and l parameters for each of them to minimize the operator's resource costs and operating costs.

So, there is a problem of building a mobile network with the ability to help different services with the predefined service requirements, efficiently utilizing the specialized resources of the Telecom operator. The underlying information will be the performance requirements of the service j, which are set as, where l is the quantity of system performance parameters. Subsequently, you have to get the number of committed networks |k| and l parameters for every one of them to limit the operator's resource costs and working expenses.

Literature Review

The burdens of the current EPC can be condensed as follows (Foukas, et al., 2017):

1) **The Architecture of the system:** It is neither capable nor effective for keeping up an enormous assortment of services (particularly with strict requirements) because of inflexibility.

2) **Processing bundles:** Data packets are unreasonably prepared by many network components that stretch out in the mobile network (from: Evolved Node B - eNB, Serving Gateway - SGW to Public data network Gateway - PGW). Many of these procedures are duplicated in different functional elements.

3) **The status of the subscriber:** A similar client States are bolstered in different network components.

4) **Time to enter the market:** A traditional EPC network sets aside a long effort to deploy through the hardware deployment cycle.

5) **Cost:** High capital and operating costs Capital Expenditure (CAPEX) and Operating Expense (OPEX).

To solve these problems, it is proposed to utilize the virtualization technologies (Shimojo, *et al.,* 2017). The virtualization of Network Functions Virtualization (NFV) Network Functions is portrayed inside the details of the European telecommunications standards Institute (ETSI). The NFV rule (Shatzkamer, *et al.*, 2018), planned for transforming network architectures by implementing network functions in software that can work on a standard hardware platform. A network function is a functional block inside a network infrastructure that has all-around characterized outer interfaces, and very much characterized functional behaviour. As examples of network functions there are components in the LTE EPC core network, for example, MME, Home Subscriber Server (HSS), and so on hence, a virtualized network function is a usage of a network function on virtual resources, as a virtual processor and virtual machine memory.

NFV is closely identified with other new technologies, for example, Software-Defined Networking (SDN) (Mijumbi, *et al.*, 2015). SDN is a network technology that isolates the control plane from the lower-level data plane and join control functions in a sensibly centralized controller.

To meet a wide scope of requirements in the 5G period, different communications associations are dealing with the above issues. For instance, Next Generation Mobile Networks Alliance (NGMN) utilizes the idea of "network slice", which set up committed virtual network dependent on services, utilizing strategies for virtualization of NFV network capacities functions using slices, and SDN (Fig. 2) (Shimojo, et al., 2017), (Yi, et al., 2018).

Network slicing permits you to construct future 5G networks that spread the necessary versatility and adaptability attributes, in this way supporting different help situations and services. A network slice can be characterized as a logically isolated network that incorporates 5G devices, just as network access, transport, and core functions (Yi, *et al.*, 2018).

The slicing idea might be one of the key attributes of the 5G network; in any case, the resources of functional entities allocated to each slice are restrictive and separated. In this way, a "slice-to-service" architecture that distributes cut slice-to-service resources to meet an execution necessities will bring about lost multiplexing gain. What's more, administrators must make and deal with countless cuts for different services, so working costs will increment.

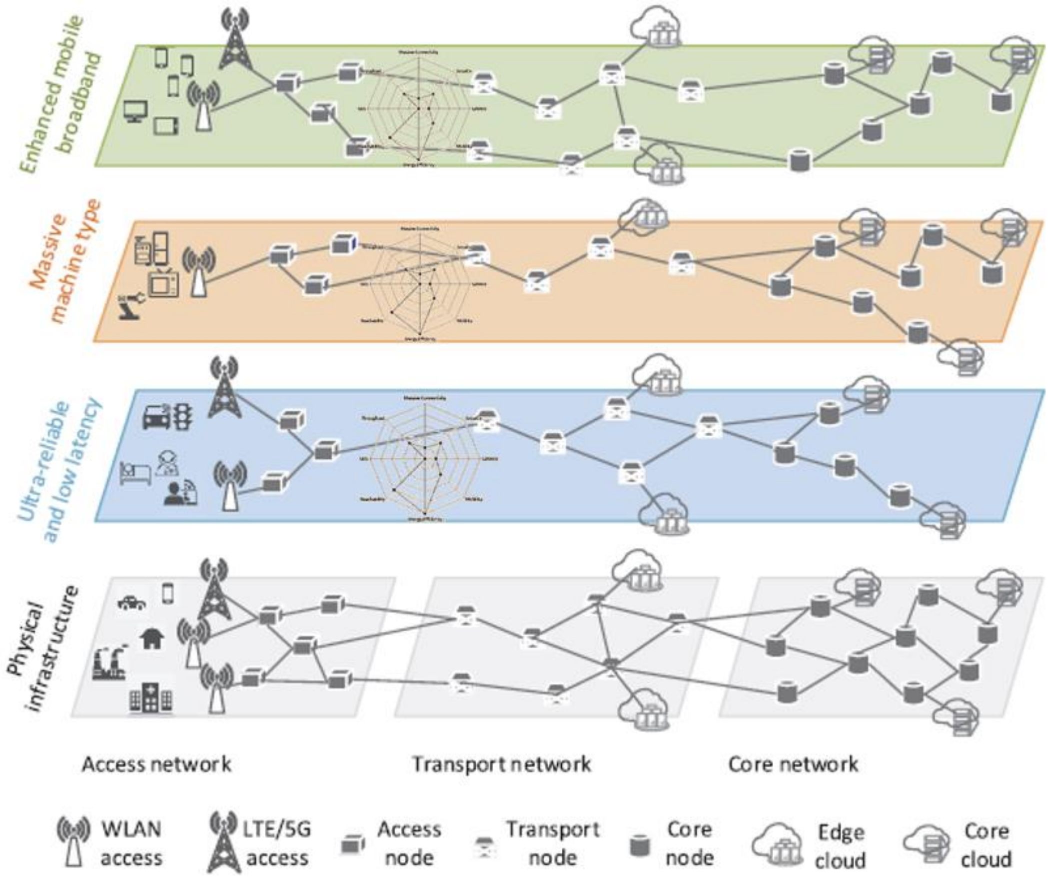

Figure 2. 5G network Slicing Architecture with Distinct Key Performance Indicators (DKPIs) (Guan, et al., 2018)

A successful method to decrease these working expenses is to make cuts where each cut has a gathering with comparable system prerequisites, consequently, decreasing the total number of slices (Shimojo, et al., 2017). In this manner, the principle question remains what will be the keen or ideal number of network slices. While a greater amount of them can prompt tremendous expenses for overseeing and looking after cuts, then again, constraining the number can likewise make a bottleneck regarding functionality (Foukas, et al., 2017).

Right now, the "slice-to-group" approach and the technique for shaping services in a slice is improved. The model of the proposed strategy are the standards portrayed in (Shimojo, et al., 2017). The improved system for representing performance costs has decreased the number of recalculations of the ideal number of network slices and reduced resource cost.

Results and Discussion

The proposed algorithm for showing services on a slice was demonstrated and assessed in the MATLAB software, and the connection between threshold values, and functional losses for 24 services with four parameters of framework performance requirements was defined. The qualities of services were created at random consistently distributed numbers. Three thresholds were utilized: one, two, and three. To analyze the proposed strategy for showing services on a slice, we assessed the typical EPC method (on account of an infinite threshold, that is, any sort of service can be put in an EPC slice) and the service on-slice architecture (on account of a threshold equivalent to zero, that is, just one kind of service can be set in a single slice), the model (Shimojo, et al., 2017) as well.

Materials and Methods

The proposed model for forming services on a slice, shown in Fig. 4. In this section we have used four formulas (1), (2), (3) and (4) as mentioned in (Shimojo, et al., 2017). The method consists of the following steps.

1) The Optimizer Manager (OM) waits for a request.
2) Once the slice request is received. It interacts with the OM to define the allocation.
3) The OM starts the optimization model, and pass the slice request to balancing step.
4) Balancing level is responsible for matching the slice types to be passed to the next step.

The network slice record including the ability of network slice service-level agreement (SLA). Each network slice needs to feed the information needed in the matching field to the network slice record every time. Where the network slice record, the ability of network slices is described by service performance requirements (level reliability, latency …etc.). The priority in the network slice record is the match order for slice selection, and the priority order is the ability of Network Slice > Network Services > Slice Load. As shown in Fig. 3.

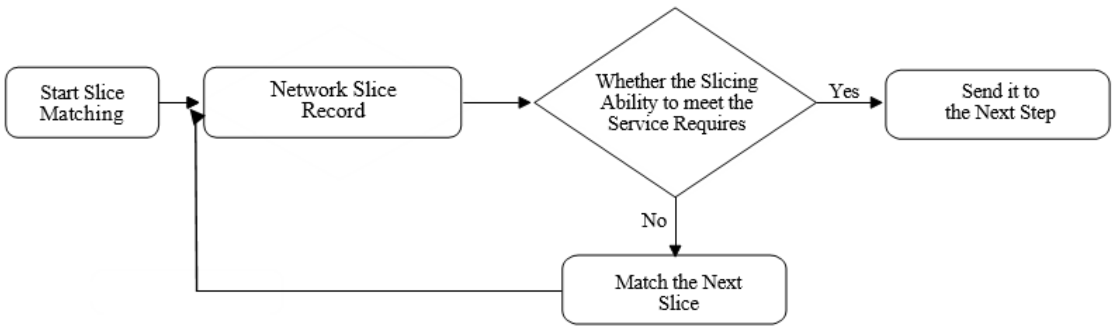

Figure 3. Balancing Matching Process

1. This service requires an isolated slice. If so, the selected slice is ready then the slice information send to the allocation storage.

2. When the service permits converging with different services, the "functional loss" (w_k) of each slice is calculated. Each slice is modeled as $N_k(s_{k,}p^{NS}{}_k)(k=1,2...n), s_k$ is a set of

$m_k \subset M$ services hosted in slice k (for example, M= {ubiquitous video, E-health...}). $p^{NS}{}_k$ is the system performance of a slice, which involves of many parameters (for example, latency, bandwidth, AND UE density). So, $P^{NS}{}_k = [P^{NS}{}_{k,1}, P^{NS}{}_{k,2}, ..., P^{NS}{}_{k,l}]$ and l represents the number of system performance parameters. In the slice, the j service performance requirements are set as $P^S{}_j = [P^S{}_{j,1}, P^S{}_{j,2}, ..., P^S{}_{j,l}]$.

Algorithm for showing services on a slice Service-slice Mapping Function (SMF) calculates w_k on each slice as:

$$w_k = \sum_{i=1}^{l} w_{k,i} \tag{1}$$

$$w_{k,i} = \left|p_{k,i}^{NS} - p_{k,j}^{S}\right| \tag{2}$$

If the slice performance varies from the service performance requirements, SMF calculates the difference between each parameter as a "sub-functional loss of $w_{k,i}$ ".

3. The w_k value of all slices is sorted. Then the minimum w_k is compared with the specified (functional cost threshold) *th*. If it exceeds *th*, the SMF creates a new slice for the service; otherwise, the relative loss of the rw_k is calculated, assuming that the SMF places the service in the k.

$$rw_k = \sum_{i=1}^{l} rw_{k,i} \tag{3}$$

$$rw_{k,i} = \max_{g}\left|p_{k,i}^{NS} - p_{g,i}^{S}\right| \tag{4}$$

4. The (relative functional costs of slice k) rw_k is compared to a predefined (threshold of relative functional costs) *rth* threshold. If it exceeds *rth*, the SMF repeats Step 7 for the next slice in the sorted set; otherwise, the SMF places the service in slice K. If none of the slices meets the *th* or *rth* boundary, a new slice is created.

If the SMF doesn't create a new slice for the service, after selecting the appropriate slice for the service, the SMF calculates the required number of additional resources based on information about the service traffic, the number of subscribers, the service traffic patterns, and the statistical multiplexing gain of the slice. The SMF then orders the control and orchestration system to increase the slice resources according to the calculation result.

If the EPC has *th* equal to infinity, then all services are multiplexed into one slice and functional losses increase, whereas the slice-per-service architecture that allocates a separate slice for each service has *th* equal to zero.

This method ensures that if the performance of the slice increases, the functional losses of the services will not exceed the threshold values.

To find the optimal organization of slices, it is advisable to perform calculations of the algorithm for different thresholds of functional losses, and compare it with the maximum gain for combining services into groups and operating costs. After that, compare the possible options for forming slices and choose the most effective one.

The multiplexing win function $f_1(m_k)$ is used to quantify the grouping of services. Operating costs is a function of $f_2(n)$ capital and operating costs. Thus, for different *th*, a convolution is calculated, for example, an additive one with the weight coefficients u_1, u_2, u_3 $U = u_l w_k + u_2 f_1(m_k) + u_3 f_2(n)$. And the best option for organizing the slice system is selected, then the slice information sends to allocation storage. If no solution is found, the request is denied, and the response is sent to the OM.

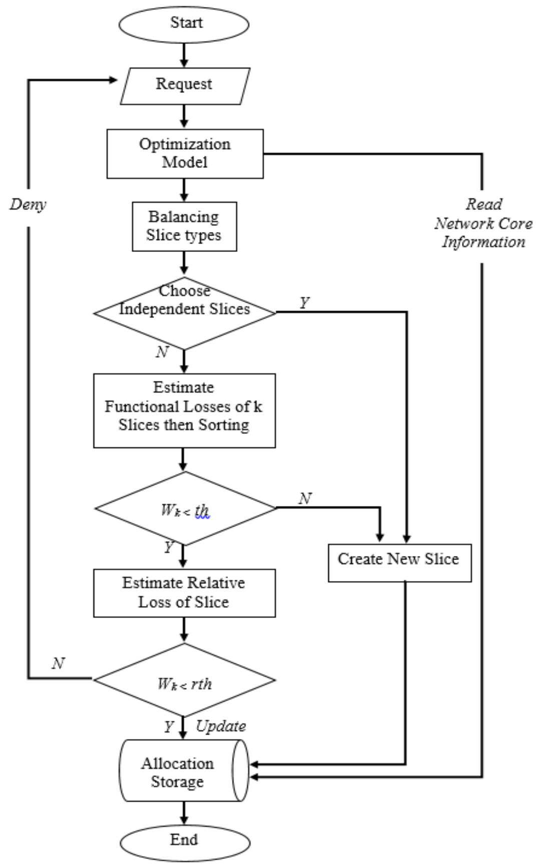

Figure 4. Displaying Optimize Service-Slice Mapping

After the slices are formed, the stage of optimal construction and mapping of virtualized network slices to the lower-level physical infrastructure takes place, taking into account resource availability, load intensity, and quality requirements.

Results

The number of slices and functional losses comparable to various thresholds has appeared in Fig. 5 as appeared in the figure, when the thresholds value is increased, the proposed algorithm decreases the number of slices. Then again, the measure of functional loss increments with the threshold value.

The strategy was assessed in comparison to the model (Shimojo, et al., 2017), the results of the analyses have appeared in the table. 1.

Figure 5. Results of Modeling the Slice Formation System. Number of Slices and Functional Costs Depending on the th

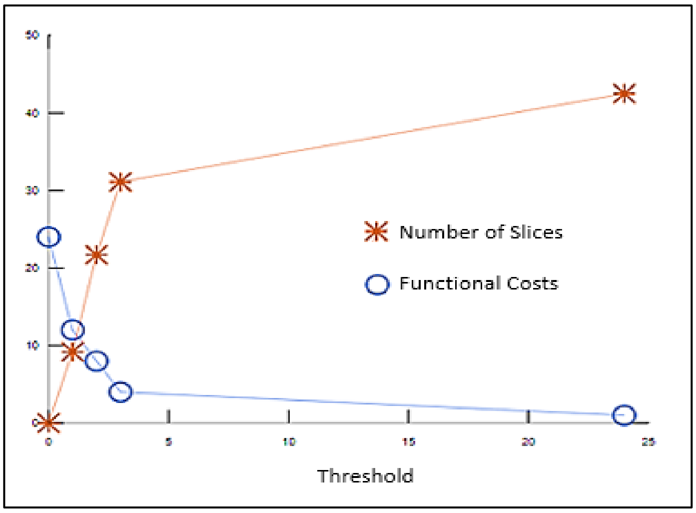

Table 1. Results of Experiments

	Method (Shimojo, et al., 2017)		Proposed Method	
Threshold	**Number of Slices**	**Functional Costs**	**Number of Slices**	**Functional Costs**
0	24	0	24	0
1	8	12.2	12	9.2
2	4	24.2	8	21.7
3	1	42.5	4	31.1
24	1	42.5	1	42.5

Discussion

The simulation results show there is an exchange off between the number of slices and functional losses. Based on, the proposed algorithm gives the network operator a way to choose the proper threshold that adjusts the number of slices (specifically, meets the performance requirements of services) and resource costs.

The model was contrasted with the comparable technique proposed in (Shimojo, et al., 2017), which demonstrated the ability to decrease functional losses by an average of 15%, and accelerate the process toward finding a solution by up to 10%.

Experimental Study

In this research, we proposed a model to validate network resource allocation system that forms devoted network slices to serve particular types of services independently on shared infrastructure. As illustrated earlier, the proposed study to create a strategy for forming multi-service core mobile communication network slices, which allow the providing of a wide scope of services with certain quality indicators according to the effective dynamic configuration of the system.

Conclusion

The investigation of the standards of building mobile networks permitted us to distinguish the fundamental patterns in the advancement of communications systems, and the issues that hold them up. It demonstrated that the key advances will build devoted virtual networks that will be able to serve the dynamic traffic of different services, keeping up the predetermined indicators of services requirements in a cost-effective way.

Guaranteeing the activity of such systems, you ought to deliberately arrange the configuration of the communication and computing environment. The paper examined the need for strategies of creating, "network slices” that will be set up committed virtual networks dependent on services that are assembled by their functional proximity. To solve the issue of forming a slice base multi service mobile network introduces an improved strategy, which depends on the model of the system organization of resources incorporate costs related with overabundance resources and furthermore decreases the number of allocations network configuration that permits to accomplish the efficient ratio of the board costs and the complete estimation of service the quality of network services.

The model was assessed by simulation in the MATLAB system. The outcomes demonstrated that it is conceivable to reasonably allocate system resources, particularly when contrasted and compared with similar methodology; functional losses were decreased by an average of 15%. This model can be utilized to deal with the arrangement of virtual multi-services networks on a lower-level physical network to limit operator costs and improve the nature of client service. Our future research is aimed at building up a technique to show the created slices on the physical structure.

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