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# Cross-Slice Radio Resource Optimization In An LTE-A Network Based On Owl Search Algorithm

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***Abstract. The phenomenal development of mobile networks and the intelligence of smart mobile devices push resource providers to gaze for more efficient management mechanisms for radio and core network resource so as to improve the clients QoS and the efficiency of traffic management. Network slicing is a technology with the built in concepts of software-defined network (SDN) and network function virtualization (NFV), which enables service providers to set up multiple independent virtual networks to support a wide range of services and applications on a single physical network. An efficientnetwork slicing resource allocation system on LTE network is proposed in this work which helps the network to manage resources allocation individually based on their desires and physiognomies. We formulated the optimal allocation of resources as a convex problem with the goal of optimizing the overall data rate function of the system. We implemented an owl-based search approach to solve the problem of process optimization and theoretically demonstrated that the approach is special and also converges to the optimal solution of the global system. The proposed solution is implemented in MATLAB and simulation results have been given to test the bandwidth and resource allocation efficiency of the distributed scheme for different users based on demand. We also contrasted their success with our proposed metaheuristic approach and without it and the results describes the increased efficiency for network slicing.***
***Keywords: software-defined network, network function virtualization, convex problem, optimal allocation, metaheuristic approach***.

## 1. INTRODUCTION

The concept of network slicing can be applied based on two types: vertical and horizontal network. Vertical slicing target supports with vertical industry and markets. It allows sharing of resources between services as well as applications to avoid and clarify an impact of traditional engineering of QoS. Horizontal slicing is a goal of progress, to expand the ability of mobile devices as well as enhance experiences of user. Horizontal slicing passes beyond the platforms as physical limits. It allows you to share resources between nodes as well as network devices, i.e., nodes / high capacity network devices divide their resources (for example, computing, communication, storage) to improve the ability of less capable network nodes / devices. A final outcome of horizontal slice is a novel generation that underlies the mobile network groups; here the terminals become nodes of mobile networks. Horizontal slicing needs the exchange of resources by air at nodes of network.

The vertical and horizontal slicing shapes can be measured as autonomous slices. The flow of end-to-end traffic at vertical segment is normally conveyed among central network as well as terminal devices. Horizontal segment denotes end-to-end traffic flow; it is generally local and travels among two ends of horizontal segment.

In Vertical slicing, every nodes of network are generally provided as equal functions between slices. Dynamic performance of network node is provided by the dynamic allocation of resources to every segment. For instance, portable device can require various functions to help various types of portable devices. Dynamic part can be the network function and partition of resources.

Cross-layer is the sharing of information between the layers for effective purpose of network resources and reach maximum adaptively. Based on the framework of cross-layer, every layer is functioned to control knobs and some key parameters. To provide the parameters with different layers to assist and choose the better rules of adaptation for control knobs concerning the accessible network status. Cross-Layer framework is typically described as issue of optimization, to variables optimization as well as multiple layer restrictions. Tackling the impact of optimization gives value of optimal with knobs of control at layers.

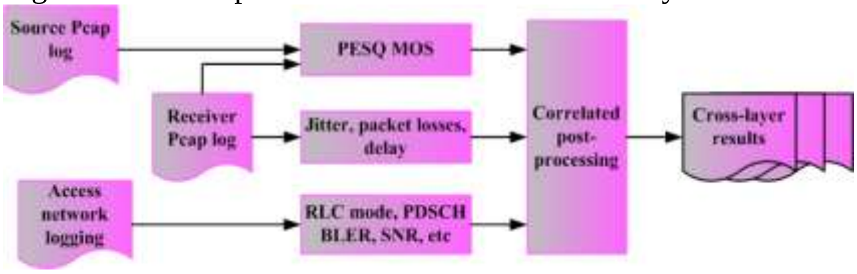


Figure.1 Design of cross-layer in networking

Network between two nodes to a great extent relies upon the separation among them as well as power transmission. Attributes kind of LTE networks required joint parameters recently situated at various layers. The parameter design that placed at various layers, are now more firmly coupled to those networks of LTE. It is trying to build up an obvious "Division principle" for remote networks. It consists of noteworthy advances at summarize and stretching out these endeavors to recover progressively broad multiuser communication situations LTE, consolidate traffic dynamics, represent assortment of requirements QoS, as well as permit increasingly broad class of functions objective (additionally known utility behavior). Specifically, it has developed a design of cross-layer structure which gives an efficient approach to network algorithm plan which envelops multi-layer functionalities of the customary system layer chain of importance, consists of power control, classification rate, congestion control, programming, multichip routing, and so on.

*1.1 LTE network slice Architecture*

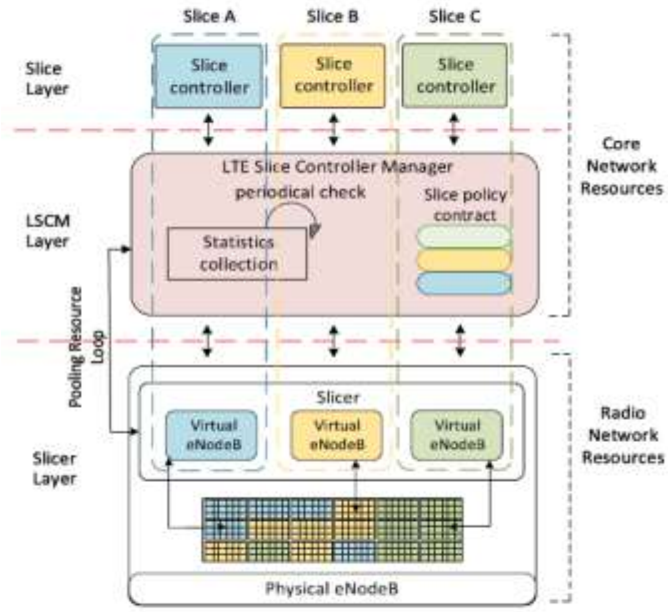


Figure. 2 LTE network slice Architecture

To introduce our framework model, we consider that in a LTE network there are three slices (slice A, slice B and slice C), as displayed in Fig. 2. We consider that each cut has a place with an administrator and it is overseen by its regulator. The regulator is accountable for augmenting use of the slice assets. For the most part, a client may have at least one streams. These streams may have a place with similar cut or various slice. In the event that when the streams have a place with a similar cut, the regulator needs to oversee intra cut assets to apportion expected assets to each stream. Furthermore, it ought to guarantee the disengagement between the streams in a cut. To ensure that every one of the cuts can have trimmed portion, we need to have entomb cuts seclusion. The cut asset separation can be ordered into three general classifications relying upon gathering of clients with a similar sort of use, start to finish systems administration and assets allotted across various slices.

*Related Work*

A network slicing from a start to finish viewpoint specifying its authentic legacy, head ideas, empowering innovations and arrangements just as the current standardization endeavors is specified in [1]. Multi-access Edge Processing (MEC) is an empowering advances use in network cutting technique. Organization cutting is a key innovation and business empowering influence for 4G, working with multi-tenure and upgraded network inclusion for outsiders in an adaptable manner, guaranteeing an additional income implies for administrators, foundation and cloud suppliers. Organization cutting remembers various legitimate independent organizations for top of a typical actual framework stage empowering an adaptable partner eco sys-tem.

A 4G networks design based on network slicing has been proposed in [2]. The adaptable radio access network with center around network cutting and their effect on the plan of 4G portable organizations is figured it out. Radio Access Innovation Material Between net may require cautious situating of assets to limit idleness. Organization Function Virtualization Framework (NFVI) started up in a redid way for each organization cut. The primary benefit of the normal PDCP approach is the adaptability it offers as far as the actual area of the convention stack layers. Macintosh approach promotion vantage is quick data trade between the distinctive multi-network legs.

The malleable radio access network based network slicing is realized in [3]. On the off chance that few cuts are arranged in Radio asset the executives and control in the base station, and correspondingly in the UE it is answerable for designing the RAN convention stack and QoS as indicated by the cut prerequisites. 3GPP LTE, where radio cuts are addressed by new variations of 3GPP, for example, Narrowband-IoT (NB-IoT), 4G requires the innate conjunction of different administrations. PDCP approach utilized that of double availability in 3GPP LTE, and offers the upside of adaptability as far as the actual area of the convention stack layers.

Aradicalhallucination of 4G networks, in which SDN programs wireless network functions, and where Mobile Network Operators (MNO), Enterprises, and Over-The-Top (OTT) third parties are provided with NFV-ready Network store is proposed in [4]. In comprehensive methodology serves the virtualization innovations for end-client Nature of Involvement with an exceptionally heterogeneous climate. Organization Capacities and Organization Applications will permit the cloud to be re-customized, assembled, and scaled as an element of specific business application situations, and bring about the idea of organization cuts for 4G frameworks [5]. The Organization Store innovation utilized in administrations that are impromptu accessible to each cut proprietor virtual assets, virtual administrations, administration pack, and administration chains, cloud just as NFV and SDN advances are utilized for this strategy.

A Cut Enhancer segment as an augmentation to LTE's advanced NodeB to understand the idea of organization cutting on LTE Radio Access Organizations. In this technique n SDN Regulator to get data in regards to the organization cuts and adjusts the cuts as per the organization state [6]. Administrator Application is utilized by the organization administrators to characterize strategies. The prioritization of ongoing administrations like far off a medical procedure throughout non-continuous administrations is an illustration of such arrangements. The combination of numerous technologies, like SDN and NFV, gives all the versatility, programmability and seclusion important to oversee network cuts. Programming Characterized Organizations techniques offer administrations to more significant level parts, for example, network applications through its Northward Programming interface. The allotting radio assets to the client hardware dependent on some data like Radio Connection Control (RLC) cradle status, QoS got by upper layers and the CQI announced by the UE[7]. In life cycle the board and control of the cuts just the SDN Regulator is dependable. While the SO and the Regulator utilize the IMSI the PF utilizes the Radio Organization Transitory Identifier (RNTI) to distinguish UEs.

SDN and NFV advances with the accessible organization cuts can be rapidly deployed and halfway oversaw, prompting improved on administration, better asset use, and cost proficiency by commoditization of assets. [8] zeroed in on the algorithmic difficulties that arise in effective organization cutting, necessitating novel procedures from the networks of activity research, systems administration, and software engineering. Virtual hubs can be utilized as Virtual Organization Capacities (VNF) running on broadly useful equipment shaping a cloud foundation. The Organization Cutting issue is a consolidated advancement issue of putting network capacities over a bunch of up-and-comer areas and choosing their interconnections. Virtual Organization Implanting technique is utilized to tackle the multi-way separator issues. Dynamic Organization Cutting [9] system makes a field of online enhancement issues. The online Organization Cutting issue incorporates the online least expense multi product issue, the online organization inserting issue and the online VNF position issue. Worldwide advancement approach invests impressive measure of energy in problematic setups. The online

enhancement issues can be settled straight by online calculations. One of the drawbacks is the VNE issue is characterized as tracking down the plausible installing with the most minimal expense [10].
The mathematical model is formalized as a structured Mixed Integer Linear System to solve the offline Network Slice Embedding Problem [11]. A latency-sensitive purpose feature ensures maximum use of the network and low latency in network slice interaction. [12] suggested a slice-based scheduling of digital assets with NOMA software to increase the system's quality of service (QoS). They formulate the allocation of power granularity and subcarrier allocation strategies into a question of the Constrained Markov Decision Process (CMDP), aimed at optimizing the overall user frequency. They developed an adaptive resource allocation algorithm based on Approximate Dynamic Programming (ADP) to solve the problem in order to further escape the dimensionality curse and the expectation estimation in the optimal value function.

## 1 *Network Slicing Resource Allocation Mechanism*

Depending on the slice's preference, the admission control mechanism chooses to serve the slice [13]. Finally, the virtual network classifies resources with UEs / user accepted slices due to inter and intra slice priorities. As per the admission control decision, and the resource allocation function is carried out with goal of optimizing the user quality of experience (QoE) within each slice, taking into the account of inter-slice priority.

QoE (Quality of experience) is calculated in this work by considering the user's effective throughput, standardized according to their total required data rate. To end, of the resource allocated to a minimum-priority slice must decreased, if required, with low number of capacity to meet fundamental criteria of QoS used to allow the higher priority for new slices [14]. Our concept adjusts the sum of network resources assigned with slices of network dynamically. Suggested access control mechanism progressively establishes the assigned assets consist of slices based on load of current traffic. Consideration was provided to inter-slice as well as intra-slice priority order to model the classification of resource task's QoE maximization problem. Due to the view of order of priority of QoE work, the use of the network can improve the adequate rate of UEs.

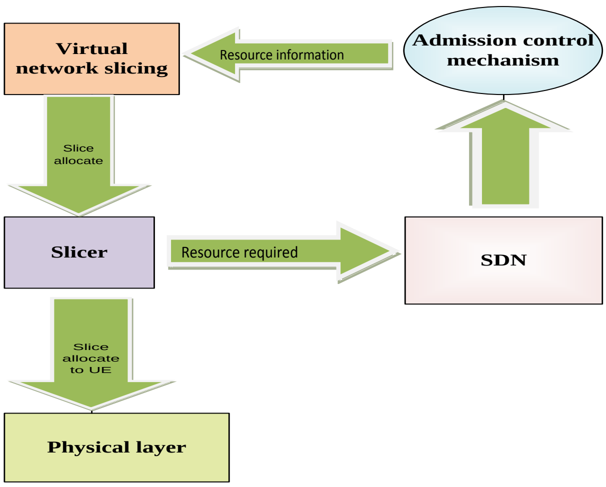


Figure. 3 Proposed Resource Allocation Scheme

The design consists of four major elements: system slice layer, virtual network layer, physical resources as well as manager of admission control. Service slices provide various services that resources demanded to be served.

We show in virtual network with the collection of slices $S = \{1,2,3,......., S\}$. The slice consists of set of UEs, set denoted by $Z_s = \{1,2,3,......., Z_s\}$. In terms of QoS restrictions, the slice executes an application for admission control. An objective model in this paper with $F_s^{\min}$ and $F_s^{\max}$ that indicates data rate as low and high related to slice. Every slice prioritized $\rho_s$, here some priorities specified to restriction which $\sum_{s\in S} \rho_s = 1$. Likewise, every client $u$ that belongs with slice $S$, i.e., where $\sum_{\mu_s \in \# z_s,} \mu_{zs} = 1$ the virtual network layer implements the abstraction of physical resources of network, $Z_s$ is defined to priority $\mu_{z_s}$.Virtual network cuts the infrastructure network to accommodate different slices according to the admission control / control manager's decisions [15]. The digital network receives requests from various slices based on UEs that will be addressed for every slice as well as carried out classification result of physical resources due to inter-as well as intra-slice priorities though taking into account UEs ' QoE, with this goal, we may denote

$$q_{z_s} = (\frac{r_{z_s}}{F_s^{\max}}) \quad (1)$$

Based on UE's, QoE at slice s; if UE's $z$ slicing $s$, data rate $r_{z_s}$. The total slice client QoE can be estimated as:

$$q_s = \sum_{Z_s \in Z_s} (q_{z_s})^{\mu_{Z_s}} \quad (2)$$

We can clearly describe that,

$$Q = \sum_{s\in S} (q_s)^{\rho_s} \quad (3)$$

The total QoE of all UEs slices are encountered, on a scheduling basis, the virtual network provides services. Based on the standard scheduling frame t, we define with, $q_{zs}^t, q_s^t$ and $Q^t$ then QoE. The average time QoE values can be defined as follows:

$$E[q_{zs}] = \frac{1}{T} q_{zs}^t \quad (4)$$

$$E[q_s] = \frac{1}{T} q_s^t \quad (5)$$

$$E[Q] = \frac{1}{N} Q^t \quad (6)$$

Here $N$ represent total number of programming frames consider, the physical resources corresponds virtual network's radio infrastructure. For convenience's purpose, we refer to one vector-cell's backhaul network. B MHz represents the total available bandwidth. Set M= {1, 2... M} specifies sub-channels available in which standard sub-channel m bandwidth denotes $b_m$= B / M. Maximum transmission power PTOT [16] distributed uniformly with every sub-channel, i.e. $p_m$= P / M. The essential problem is concern during the resource allocation stage is to optimize the UEs ' QoE, simultaneously taking into account the inter- and intra-slice priorities. This problem can be formulated as shown in the equation below.

$$\text{Max} \sum_{s\in S} \left[ \sum_{z_s \in Z_s} \left( \frac{r_{z_s}}{R_s^{\max}} \right)^{\mu_{zs}} \right]^{\rho_s} \quad (7)$$

Subject to $\sum_{m\in M}\sum_{s\in S}\sum_{z_s\in Z_s}\alpha_{m,}z_s b_m \le B$ 7(a)

$R_s^{\min} \le r_{zs} \le R_s^{\max}$ 7(b)

In which limit (7a) specifies that the sum of sub-channels may not exceed the bandwidth maximum included; restrictions often explicitly applies with orthogonal of delegated services. Framework (7b) indicates the data rate obtained with UE is constrained to corresponding slice s requirements. It should be noted at Equation (6), QoE represents amount as lower than or similar to 1. Resource allocation process is achieved by optimizing the data rate using Owl search optimization algorithm as well as the UEs channel conditions.

### *3.1 Owl Search Algorithm*

Owl search algorithm launches the optimization process by an initial set of random data rate solutions that reflects the forest owl's initial position (dimensional search space [16]. Therefore, to assign the first location of every owl at forest, a uniform distribution is used.

$$U_i = U_L + V(0,1) * (U_z - U_L) \qquad (8)$$

Where i$^{th}$ owl $U_i$ in the j$^{th}$ dimension and V (0, 1) are lower and upper limits of $U_L$ and $U_z$, respectively, denotes random number uniformly distributed at range [0, 1]. Fitness of every owl's location at forest is evaluated and stored as an objective function in equation 8.

It is presumed that the present work of the fitness value based on the location of each owl directly relates the frequency information received through the ears. Therefore, the strongest owl achieves maximum intensity (for problems with maximization) as it is closer to the vole. The i$^{th}$ owls structured strength data is used to modify the location and can be measured as:

$$J_i = \frac{f_i - w}{b - w} \qquad (9)$$

Where $b = \max_{k\in 1,\dots n} f_k$

$$w = \min_{k\in 1,\dots n} f_k$$

Every single owl and prey's distance information is measured with the following equation:

$$F_i = \| U_i, P \|_2 \qquad (10)$$

Where P is the prey position obtained by the fittest owl, it stated that the forest there is only one vole (global optimum). As they pass towards the prey, the Owls undertake flight is silence. Therefore, they obtain the modified frequency, obeying the sound intensity inverse square law. You can obtain the shift in frequency for i$^{th}$ owl as follows:

$$J_{ci} = \frac{J_i}{F_i^2} + Random\,noise \qquad (11)$$

Voles are present in the real world but the movement causes the owls quietly change their approach location. By using this chance the prey movement is planned and thus the new owl positions can be obtained through the following position updating function:

$$U_i^{t+1} = \begin{cases} U_i^t + \beta * J_{ci} * |\alpha P - U_i^t|, if\ p_{vm} < 0.5 \\ U_i^t - \beta * J_{ci} * |\alpha P - U_i^t|, if\ p_{vm} \ge 0.5 \end{cases} \qquad (12)$$

In the above equation $p_{vm}$ seems the possibility of optimal global progression i.e. data rate, α represent random number uniformly distributed at range [0, 0.5] β represent stable that reduces linearly as 1.9 to 0 makes major changes and encourage the searching space exploration.

## 2. RESULTS AND DISCUSSIONS

This section offers an analysis of the quality of our proposed mechanism for allocating the resource. Thus, we introduced a resource allocation algorithm that allocates the network resources to optimize users overall QoE by taking into account their QoS criteria (minimum and maximum data rate) as well as each user's priority. This manuscript, utilize MATLAB; by analyzing various scheme test presented models. Thus by considering the admission control process, we implement the resource allocation scheme that is carried out at the first step before the allocation of resources. The explanation behind this selection is to highlight the effect of admission control on network resource management. Therefore, we assume that the user equipments (UEs) arrival data rate is distributed uniformly over the entire simulation period. Thus the total number of UEs is distributed evenly among the slices are considered. The values of UEs within the same slice are generated randomly with the restriction of sum is equal to 1. In case, the priorities of UEs are much same as our proposed solution is considered, with the exception, that the restriction have a number of priorities is equal to 1 is applied to all users in the system. The parameters used by the core network is about 5 MHz LTE bandwidth, 200 overall UEs, 10s overall interval and 174dBm / Hz overall Noise Spectral Density.

In this approach, various evaluation parameters are used to validate the performance of the proposed approach. Bandwidth represent significant factor to determine speed as well as quality of network. It is defined as number of data which may passed as one point to other include network at time specified. Usually, bandwidth denotes as bit rate, it is scaled at bits/sec (bps). Energy consumption denotes total energy consumed by the network. It is normally measured in Joules (J). Average packet delay denotes additional time considered by packet to reach destination. It is also referred to as latency and it is normally measured in milliseconds (ms).Average packet jitter is defined as a variation of delay in received packets. It is also expressed in milliseconds (ms) like that of Average packet delay. Throughput is a measure of how many units of information system can process in a given amount of time. It is usually scaled at kilobits per second (kbps) or megabits per second (mbps).

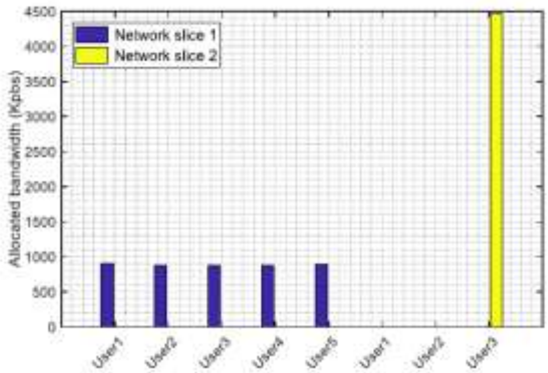


Figure. 4Average bandwidth for UEs

Figure 4 shows that the average bandwidth of same slices for UEs. It can be remembered that, these services belong to two different slices with different priorities; the proposed mechanism experiences the same throughput and bandwidth for each slices. This illustrates strongly that the proposed solution is not only capable of ensuring slice-based resource allocation, but also based on utility.

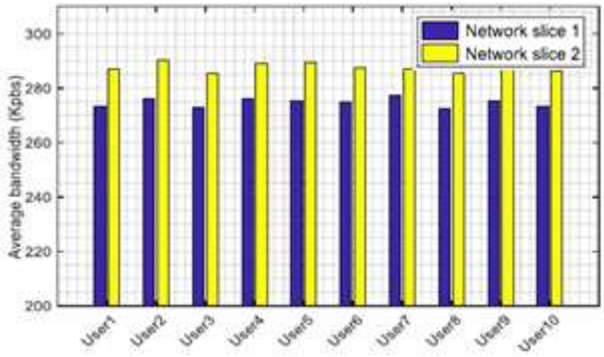


Figure.5Bandwidth comparison for system with and without optimization

In Figure 5, our proposed solutions can significantly increase the data rate for all service slices in contrast to the management of resource allocation without optimization. We may note that the proposed approach ensures that the higher bandwidth efficiency compared to the management approach without optimization, thereby emphasizing the importance of the proposed admission control which achieve better resource utilization. From this estimate, the number of UEs rises, we can note that the total QoE decreases. This is because that the algorithm helps to maximize general data rate of network by allocating resource with services when the number of UEs increases.

Figures 6 depicts the resource allocation before optimization and after optimization based on owl search algorithm. The sharing of resources differs for both optimizations are shown in Fig. The resources are fairly dependent on the requirements after owl search-based optimization. Therefore, it is noted that there is sample use of the limited resources across network slices. From the same Figure, we can also realize that, under each slice all the users are provided almost the same amount of bandwidth. These results clearly highlight that NSRM with optimization can successfully isolate not only the inter slice bandwidth but also it can isolate users' bandwidth within a slice.

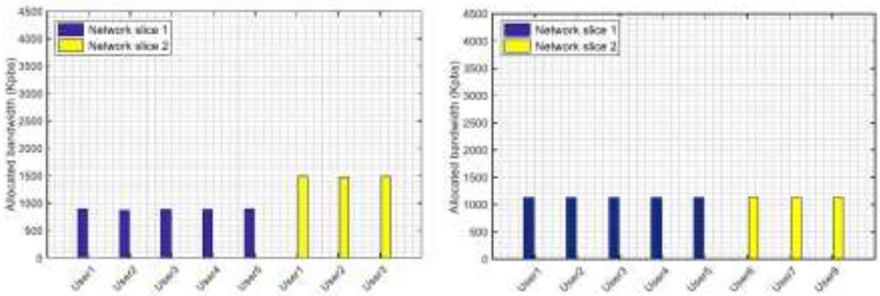


Figure. 6 Resource allocation without and with optimization

Figure 7 shows the energy consumed by various users in slice. The total energy consumption increases when the number of users increases. First, observe that jointly optimizing bandwidth and power results in a significantly larger performance region than the other sets. It can be seen that the performance gain is higher than in the TP domain which indicates that fixing the power is much more constraining than fixing the bandwidth. Moreover, optimizing both variables jointly results in a much higher performance gain than can be obtained by just optimizing one variable.

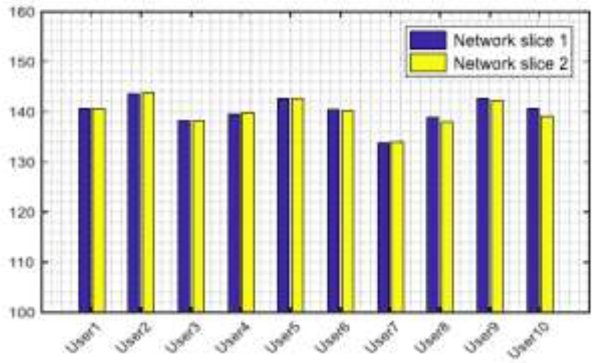

Figure.7Energy consumed by various users in a slice

Figure 8 represents the bandwidth utilized and average packet jitter by the proposed Owl-search based resource allocation approach to that of existing Network slicing resource management mechanism (NSRM) approach. Here, the average packet jitter reaches to a high extent of 0.48 ms, when there are ten users in a slice. Thus from the figure, it is clearly understood that the average packet jitter increases rapidly when the number of users increases. The average packet delay is nearly similar to that of average packet jitter exhibited by the proposed approach.The owl-search based resource allocation framework performs the existing resource allocation schemes.

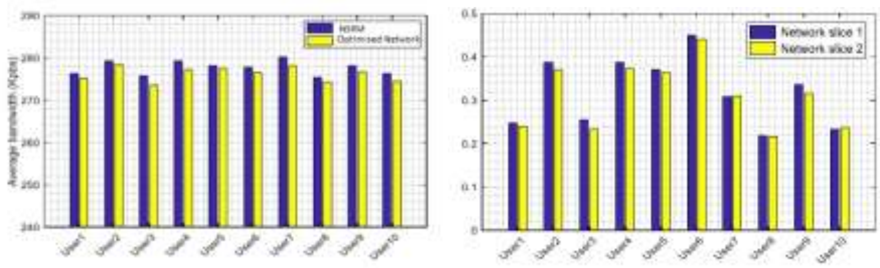


Figure.8Bandwidth comparison &Average packet jitter among various users in a slice

Thus from the obtained results, is observed that the presentation method achieves better throughput, bandwidth, delay and jitter when compared to the other network slicing approaches.

## 3. CONCLUSION

Network slicing is a process which allows the development of several logical networks on behalf of a common physical infrastructure shared. In this work, we address the issue of sharing resources equally between slices based on demands and so we implement a novel resource allocation system for network slicing in an LTE network that allows us to provide real-time slices and self-scale slices optimally. We formulated the optimal allocation of resources as a convex problem with the goal of optimizing the overall data rate function of the system. We implemented an owl-based search approach to solve the problem of process optimization and theoretically demonstrated that the approach is special and also converges to the optimal solution of the global system. The proposed solution is implemented in MATLAB and simulation results have been given to test the bandwidth and resource allocation efficiency of the distributed scheme for different users based on demand. We also contrasted their success with our proposed metaheuristic approach and without it.

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