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SDN Based Data Offloading and Load Balancing Techniques for Applications in 5G

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Abstract*: a huge development of wireless users traffic and the deficiency of accessible resources has led to new difficulties for future cell systems. Nowadays our network needs to deal with extensive measure of traffic and serve a large number of customers. It is exceptionally difficult for a solitary server to deal with such tremendous burden. Since, the architecture of 5G is highly advanced by using SDN and NFV, its network elements and various terminals are characteristically upgraded to afford a new solution for these traffic issue. In this paper we proposes a data offloading algorithm by forwarding the traffic between cellular network, femtocell and Wi-Fi network in order to reduce the overall burden on cellular network. We also proposes a load balancing technique which will manages the available network resources between the incoming user requests and existing users. The proposed traffic offloading algorithm uses an SDN controller for i) making the decisions of forwarding data between femtocell network, Wi-Fi and cellular network. ii) it also uses controller for taking the decisions in balancing the load of users with the existing the resources.

Index Terms*: Data Offloading; femtocell network; Load balancing; SDN controller; Wi-Fi network; cellular network.

I. INTRODUCTION

The entry of the upcoming portable networks has rendered the requests of novel, more advanced and adaptable innovations as its basic necessity. Mobile clients are very increasing not just due to the way that the number of individual gadgets are increasing, but also for the reason of machine to machine (M2M) specialized strategies. These gadgets empower universal access to different general applications and storage based applications [1]. As per the survey done by Cisco's networking agency and from its report [2], it is estimated that the data traffic is going to develop yearly rate at the rate of 57 % in the year 2019. Existing cellular systems are not sufficient enough for supporting those increased traffic rates. Thus, fifth era (5G) is expected to be as the cutting edge cell technology. These 5G systems are imagined to have a densified heterogeneous system design, consolidating numerous radio access advances (multi-RATs) into a solitary comprehensive system [3]. In spite of the fact that now a days there are numerous procedures proposed for resource management in a network, the issue stays unsolved because of the expanding number of portable clients. Hence some technology like 5G is required to overcome all these issues and to handle more number of devices.

For providing high speed communication for devices, 5G is the emerging technology. Implementation of 5G technology requires two main technologies that is SDN and NFV. Software defined networking (SDN) and network functions virtualization (NFV) are two firmly related advancements that are towards network virtualization and automation. The event of these two innovations are for the most part determined by the necessities for robust data management systems and access to data transfer capacity by servers situated at various locales and associated over long separations through open and private clouds. These can provide the high speed data transmission by converting the hardware into software and allowing the users to use the function of hardware as VM. SDN and NFV technologies are implemented in 5G where that can implement a heterogeneous network for data offloading and load balancing in that network. Data offloading technique provides the solution for overcoming the shortage of spectrum availability. Data offloading refers to dividing of incoming user requests targeted for cellular network into number of requests and forwarding it to different networks like Wi-Fi, femtocell network etc and finally combining all the responses and sending over the cellular network [4]. As given in paper [5], the overall network usage is divided into home users and office users. Home users are using 55% and office users are using 26% of hotspot. Hence, one of the existing solution to overcome the shortage of bandwidth over cellular network is by using Wi-Fi. But using Wi-Fi for more number of devices causes network congestion in that Wi-Fi network. In order to overcome congestion problem, resources available in the network must be managed so that the resources are equally served between all the data requests during the requests from users. This is referred as load balancing. In paper [6] multiple macrocell is one of the solution suggested for load balancing in a network. By using the existing Wi-Fi cards, the smartphones can use the unlicensed band for data usage. Wi-Fi is an efficient technique for data traffic offloading. Many papers has been published on the data offloading techniques. A more flexible Wi-Fi data offloading model is proposed in [7] which is based on the mobile internet protocol which has been introduced in a core cellular network. As on the research on load balancing, conventional plans have taken the received signal quality or resource utilization ratio to settle on load adjusting decisions for instance as given in [6] that is basic distributed mobility load balancing algorithm. But in paper [8],

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the author has even considered maintaining QoS and proposed a load balancing algorithm that improves the efficiency of resource allocation method and which proportionally increases the performance.

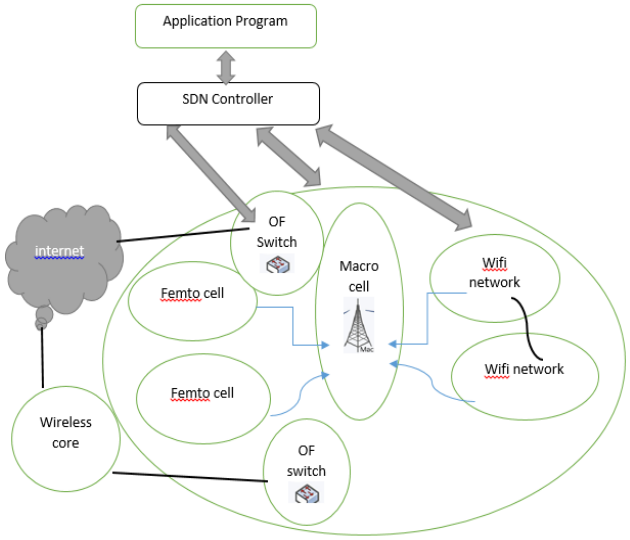

Fig.1: Wireless heterogeneous network structure based on SDN

Maybe a couple of the previously mentioned research shows performance improvements for managing the resources, however, there yet exist technical difficulties that should be consider for efficient resource management, particularly when the 5G Heterogeneous Network design is contemplated. Firstly, whenever the uncoordinated Wi-Fi cells and femtocells are employed in a heterogeneous network, resources management between these three networks is a main challenge in this three tier architecture. Secondly, after offloading the data from user, it will be directly routed into the internet by Wi-Fi backbone architecture which is owned by third party. There comes the issue of security and privacy of the user information. The existing protocols are designed to handle current network density level. If it is deployed under high density level then the overall performance will be degraded. For instance, existing load balancing calculations are for the most part conveyed, which causes ping - pong handovers because of the absence of global information [9].

In our paper, we use SDN [10] a programmable network framework, as an empowering solution for applying insight and control in 5G Heterogeneous Networks [11]. The likelihood of programmable systems has been around for a long time. Later, the methodology of the Openflow interface has suggested another life to SDN [12]. OpenFlow switch technique was first exhibited in [13], where the creators give a uniform interface to examiners to program stream passages and to execute preliminaries on Ethernet switches, without any finding out about the internal functions of the switch. With respect to remote interchanges, the authors in [14] present OpenRoads—an open SDN arrange which enhances the managing portability of devices in Heterogeneous network. Similar work in [15] gives SDN as a way to deal with handover the board in heterogeneous networks and the ongoing proving ground indicates huge execution enhancement in the QoS of the constant video recordings.

We propose a SDN-based incomplete information offloading and load balancing algorithms to overcome the drawback of shortage of spectrum availability concerns and to address the traffic congestion issue in a network. The proposed data offloading method exploits a SDN controller's worldwide perspective on the system to accomplish the previously mentioned goals, while considering system constraints and the end customer QoS necessities into thought. With a general point of view on the system, the SDN controller has detectable quality over the offloaded data and can deliver to the end user [4]. This paper proposes a technique for data offloading and load balancing by dividing the incoming traffic over Wi-Fi and femtocell network. Section II gives the details of network architecture and model. Section III describes about the data offloading technique for reducing the load on cellular network. Section IV provides the information of balancing the load over the primary and secondary network. Section V depicts the experimental results obtained from proposed technique and Section VI details the conclusion of both the techniques.

II. NETWORK MODEL

We consider a Heterogeneous system condition involving cell Base Stations and Wi-Fi Access Points and femtocells as showed up in given diagram Fig. 1. BSs convey on approved band while Wi-Fi APs and femtocells communicates using the unlicensed band. The Wi-Fi APs and femtocells are found self-assertively inside each cell. OpenFlow tradition is executed on BSs, APs, and switches so as to engage the SDN controller to easily control these system segments through a secure channel of OpenFlow. It is normal that most of BSs, Wi-Fi APs and femtocell will be associated with the OpenFlow switches, as depicted in Fig. 1. Switches must be associated with the base station in any cellular network. Given that controller is a program running on a server, it might be set wherever inside system, even on remote server centre [16]. The controller application contains three main segments, specifically, validation and charging (AC) module, then the offload administrator/manager (OM), and load balancing (LB) module. The first module takes care of managing identification of users and charging functionalities, that are useful to implement affirmation control and membership-based charging, specifically. Once authenticated by AC, a portable client can get to the majority of the accessible system assets. These assets are either claimed by the system administrator or they are rented from the accessible Wi-Fi networks. Next, for the OM module, the administration level principles portray the traffic highlights and functionalities which are required by the offload administrator. These highlights and qualities depend on the traffic flow template (TFT) filter [17] and the related QoS portrayals. Lastly, the LB module incorporates the load estimation and portability management functionalities, which gathers cell load proportion and execute the load adjusting calculations. The total SDN structure is introduced in Fig. 2, where it tends to be seen that the SDN applications (AC, OM, and LB) use the global perspective on the APs to enhance network management.This proposed algorithm is applied when both primary network (cellular network) and secondary network (femtocell network and Wi-Fi network) has mutual agreement in order to maintain security and privacy aspects of users. Hence the burden on cellular network can be reduces in order to serve more number of devices.

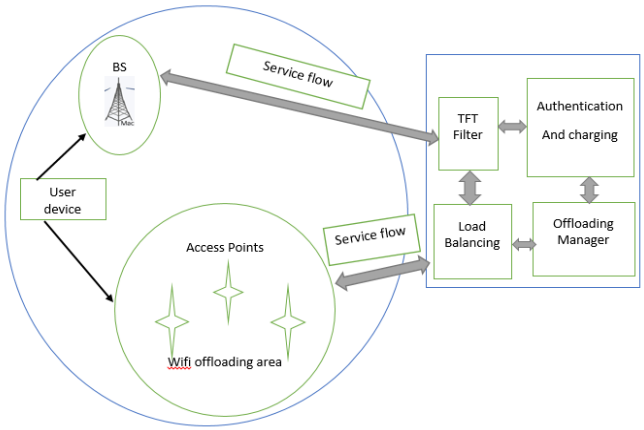

Fig.2: SDN-based Data offloading examples with modules

III. PARTIAL DATA OFFLOADING IN SDN NETWORK

Fig. 1 shows the SDN used resource management algorithm for heterogeneous network. The central SDN controller controls the working of data offloading from incoming application program which is a mobile user. SDN controller controls openflow switch for connecting the core internet with the femtocell network and Wi-Fi network. All the decisions of data offloading and load balancing will be taken care by controller device. In this section we present a data offloading technique which partially offloads the cellular data. Here, a piece of client data is offloaded on to the femtocell and Wi-Fi network then rest of the will be prepared by cellular network itself. Here a part of burden on cellular network is diverted to Wi-Fi network and femtocell network. The idea of data offloading proceeds as follows: when a user moves into the coverage area of Wi-Fi network and starts transmission of data, a part of data will be put in the queue of openflow switch so that it will wait in queue for next processing. Then the offload manager executes a delay threshold based choice algorithm [7] that chooses the suitable traffic from cellular to offload it on to femtocell and Wi-Fi.

A. The algorithm for data offloading works as follows:

1. Whenever the user is in the coverage area of Wi-Fi network and the user starts data transmission, the user is first authenticated by using authentication module in order to maintain the security inside the network.
2. Then the offload manager collects information on already existing traffic in the Wi-Fi network and calculates the existing resources to serve the traffic flow. As given in [18], suppose if each existing user requires Ri resources and link rate of the femtocell and Wi-Fi access point is Lr then the resource requirement for the users is given as

$$\theta i = Ri/Lr \qquad (1)$$

3. Now the remaining and available resources is then calculated for offloading data for incoming user requirement.
4. The offload manager calculates the number of data transmissions that can be offloaded for the available resources in the network. If the number of user data is more than the threshold then the only partial data is offloaded else all the user data is forwarded to femtocell and Wi-Fi network.

The delay tolerance threshold Ts for each application is calculated and also the amount of data Ds that is transferred with the time period Ts. For this, consider that the user is entering offloading area at tin and leaving that area at the time tout. Then the time the user stays in femtocell and Wi-Fi network is $t_c = t_{in} - t_{out}$. In the above mentioned scenario, delay tolerance threshold Ts is equivalent to the contrast between the application explicit deadline Td, which is gotten from the TFT filter in the system model and waiting time from SDN controller.Vs is given as the amount of data that will be transmitted. If b1, b2 and b3 is bandwidth that is reserved for transferring the data by cellular network, femtocell network and Wi-Fi network then according to [7] Vs can be written as Vs = b1Ts+ b2 min (Ts)+ b3 min (Ts). Depending on the value of this Vs, the offload manager decides whether the incoming traffic flow must be partially offloaded or fully offloaded on to the Wi-Fi network.

B. Data offloading Algorithm:

1. Start // Procedure of data offloading algorithm
2. d: size of file in bytes
3. Vs2 = b2 min(Ts) which is size of data that to be transferred on Wi-Fi network
4. Vs3 = b3 min (Ts) which is size of data that to be transferred on femtocell network
5. If d< Vs2 && d< Vs3
6. Divide Incoming d: d=d1+d2
   Offload data to femtocell and Wi-Fi network; update d
7. Else if d<= Vs2 && d<= Vs3
   Divide Incoming d: d=d1+d2+d3
8. Send d1 on femtocell, d2 on Wi-Fi and d3 on cellular network respectively and update d
9. end if
10. end if
11. end procedure

In the above given algorithm, d represents the file size from user. The amount of data in bytes is represented as Vs in that the Vs2 and Vs3 represents the size of data that is divided between the networks femtocell and Wi-Fi. The incoming data size is compared with the data size allowed inside the secondary network. If it is less than the Vs 2 and Vs 3 then the file is divided into d1, d2 and the all the incoming data is offloaded into the secondary networks femtocell and Wi-Fi. Else if the incoming data is less than or equal to Vs 2 and 3 then the data is divided into d1 , d2 and d3 and forwarded into cellular, femtocell and Wi-Fi network respectively in order to overcome the problem of spectrum shortage. Updating d empowers the system to monitor the volume that has been transmitted in three ways. Here, delay influenced in recollecting the packets in the application layer is considered as immaterial. Because during execution, the data isn't spread on the basis of separate packet premise, rather,
it's appropriated in bursts between the primary and secondary networks. With synchronous transmission, these bursts will be gotten at the receiver in general at a comparable time, as such diminishes the waiting period incurred for all packets to reach the receiver device. In this way, the partial offloading strategy decreases the overall delay incurred during the process of packet arrival at the destination.

5. Finally the offload manager will record the available resources for accepting the next data for offloading over the secondary network. This information is maintained for short period of time so that it helps in taking decision about the incoming traffic.

Fig. 3 describes the flow charts which depicts the flow of operations in the technique. The algorithm calculated the d, then divides the traffic over the primary and secondary network.

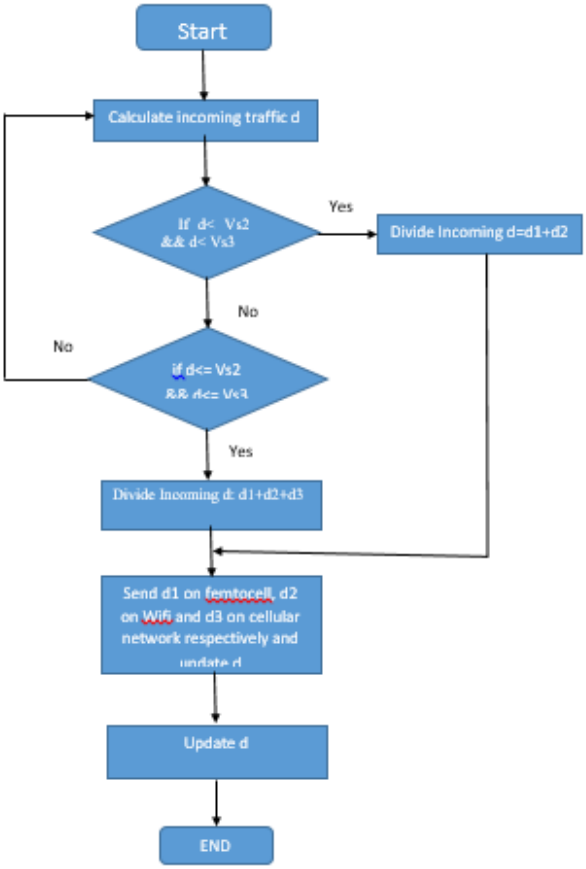

Fig. 3: Flow chart of data offloading technique.

IV. LOAD BALANCING IN SDN BASED NETWORK

Load balancing method has very greater impact on congestion problem in cellular networks. Load balancing refers to reducing congestion in a network caused due to the increased number of users in a given network. During congestion, it is very difficult to distribute available resources efficiently in the network. For that there are many resource allocation and management techniques are proposed, still there exist resources scarcity in a network because of very increased number of devices. With SDN Load balancing methods, it distributes the incoming traffic efficiently between the available resources so that the network performance will be improved. And it is easier to find out the next neighbouring AP or BS's for minimum number of handovers so that the QoS will be achieved.

A. Load balancing system

In a SDN network, whenever there is an incoming traffic, the source cell checks its load. If the source cell is overloaded, it will find the nearest neighbouring cell by sending request to the controller for load balancing. The overload on the cell is determined by checking the threshold value. A cell i is distinguished as over-burden when its load ratio LRi surpasses a specific threshold. The load ratio LRi is defined as in [6]:

$$LRi = w1 * Ui + w2 * Ri \quad (2)$$

where Ui is the proportion of the number of clients equipments (UEs) to cell i's most extreme UE limit, Ri is the proportion of the utilized resource blocks to all available resources blocks in a cell i, while w1 and w2 specifies to the weight parameters which give the administrators the choice to give higher inclination to either Ui or Ri.The controller computes the load of each cells except the source cell and finds the cell with the lesser load so that it can be selected as a target cell for distributing the incoming traffic. So as to keep up radio link quality after handover, the decision of edge clients continues as before as that with the current algorithm [6]. In other words, just the source cell edge clients, which are near to this chosen target cell with adequate connection quality will be given over to the target cell. In the customary distributed load balancing situations, there is a plausibility that different overloaded cells pick a similar target cell for load balancing, causing another over-load circumstance or ping-pong handovers [6, 9]. In any case, SDN-based load adjusting technique utilizes a general network view while choosing the target cell, which diminishes handover times and improves the overall system performance.

V. EXPERIMENTAL RESULTS

The model describes the technique of data offloading and balancing the network load by distributing over Wi-Fi and femtocell network. OpenFlow as a SDN enabler not only provides enough flexibility, but also aggregates network statistics required for load balancing. This will result in achieving increased throughput and performance of the 5G network. The simulation results in Fig.4 shows the increase in throughput for the number of data users offloaded on to the secondary network with time. As the incoming number of user data varies, the throughput will vary.

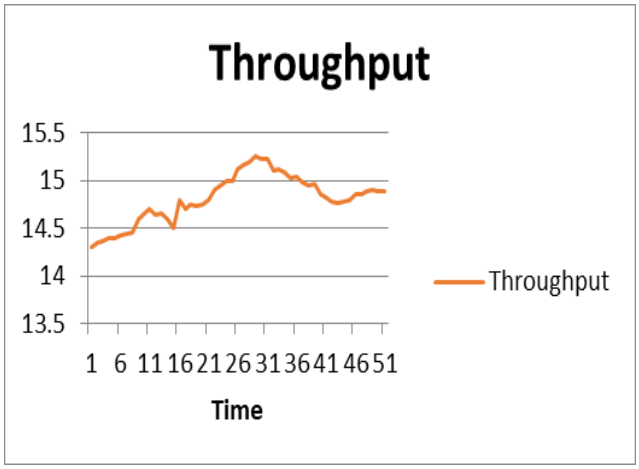

Fig.4: Throughput Analysis for the increased number of user with time.

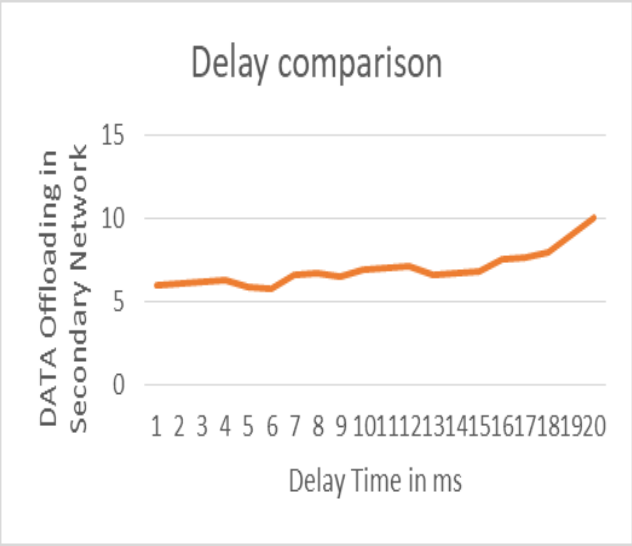

Fig.5: Delay comparison between cellular network and SDN based data offloading method network.

As the number of users increase over the network, the burden on the secondary network also increases. Hence this will result in delay occurrence. But the delay incurred in sending response back to the user from secondary network is considered to be negligible as suggested in [19].Hence the delay incurred in offloading data is considered to be less than in the cellular network. Fig.5 shows the graph that depicts the delay increase only after reaching the threshold value. The incoming data traffic will be sent on cellular network only when it reaches the threshold value. That time the incoming requests from users will be queued and forwarded to the available primary/secondary network. The time spent by the user in queue is very less compared to the traditional cellular network traffic. Only if the incoming traffic increases in huge number then the delay will be depicted to be more. Thus Fig 4 shows that the delay incurred in queue by incoming traffic is very less compared to the traditional cellular network.

VI. CONCLUSION

Due to the expanded number of mobile phone usage everywhere, it increases the data traffic and the concurrence of various radio access technologies, efficient way of managing resources is a key challenge in future 5G network. In this paper, we showed SDN-based femtocell and Wi-Fi information offloading algorithm among primary and secondary network and proposed load balancing algorithm for resource management in a network to serve all the incoming user requests. The new algorithm uses the controller's global perspective of the network to take progressively educated choices for effective resource management and lessens the burden on the cellular network by distributing the traffic flow on to two unique networks that is femtocell and Wi-Fi network. The load balancing is proposed by considering the handovers between the neighbouring cells. The closest cell is chosen for minimum handovers with the goal that the QoS is accomplished and the resources in a network are proficiently managed.

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