

DATA TRAFFIC CONTROL OVER 5G NETWORKS USING SOFTWARE-DEFINED MULTIPLE ACCESS

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ABSTRACT

Recently, user requirements have been increased in different networks environments. However, massive users have been promised to be served at the minimum range of latency. For that, researchers have investigated the effects of the gradual increase. Traffic control has been considered as one of the most sensitive issues in 5G environments. In this paper, the data traffic control has been addressed to serve wireless network users at best over 5G applications. Thus, it has proposed Data Traffic Control Over 5G Networks (DTC5GN) model for managing traffic in wireless networks with a massive number of users. It has followed classifying any received request and based on that direct the request to the best routing map. Furthermore, this work would enhance traffic management in massive networks to get user's satisfaction. Additionally, this model has discussed the traffic issues, starting from the access step till the service delivery.

Keywords: *Traffic control; Software Defined Multiple Access; Wireless traffic models; Traffic Predictions; Dynamic Spectrum Sharing; 5G networks*

1. INTRODUCTION

Recently, 5G requirements have rapidly increased at various levels. Thus, researchers are required to provide proactive solutions to meet different user's requirements. In fact, diverse solutions have been proposed in limited simulation environments. However, an estimated increase of coming networks is faced by more needs of different 5G applications. Furthermore, latency reduction promises are more significant due to an enhanced capacity. On the other hand, more services are required for a massive number of users. Also, the number of users is gradually increasing based on the global statistics. Furthermore, applications have been increased, providing services to serve an unlimited number of end users. Here, the importance of managing traffic has been shown for the network when achieving massive tasks. Then again, users are keen to facilitate the best possible of quality at different services.

In fact, traffic control is a technically sensitive task to manage between both user's needs and system's limitations. This task is thoroughly needed when we implement heterogeneous systems for massive users. Thus, it helps to manage different resources of systems. This can be achieved by providing a proactive solution in terms of routing

and quality of services. Then after, it will increase the resource allocation at the peak times. Finally, a successful traffic managing approach will gain the user's satisfaction. In fact, the importance of managing traffic is clear when balancing between system's capacities and user's requirements. Moreover, it is thoroughly needed for large systems and massive users.

In fact, 5G networks have announced for providing services at best possible. Thus, it was very important to reduce delay time to the minimum range. For that, this paper has focused on traffic control for wireless networks. however, the difference of the proposed work is that it can be applied to 5G environments. Thus, this work balances between the massive number of users and an increasing number of provided services. Therefore, providing efficient techniques of traffic controlling would improve the user's experience of a wireless network in 5G applications. However, research to date has not yet generalized a one solution for traffic controlling in 5G networks. thus, we have studied this issue and propose the model of Data Traffic Control Over 5G Networks (DTC5GN).

Initially, this work has focused on traffic management techniques in 5G environments. Thus,

we have studied the latest techniques and previous attempts. However, we have proposed a model of managing traffic, specifically for wireless networks. This model contains adding more steps to manage overload traffic. Basically, it leverages using the Software Defined Multiple Access technique for handling data traffic issues of 5G networks. In fact, this model will result in reducing latency for massive requests. Also, it would enable applications to get user's satisfaction in terms of traffic managing approach. Thus, future networks will be prepared for managing massive traffic causes.

Mainly, this work focuses on the traffic control by leveraging the recent technologies. Also, it was specifically targeted 5G application when using wireless networks. thus, it classifies the received requests based on clear criteria. Also, this model considers the best possible of delivered service to the end users. Thus, section 2 discusses the state of the art, including the recent technologies of traffic control. Furthermore, section 3 shows the proposed Data Traffic Control Over 5G Networks model with more descriptions. However, section 4 contains both operational scenarios and indicative results. After that, section 5 analyzes the proposed model based on different factors. Then, traffic challenges are presented in section 6 in terms of intelligent SoDeMa. Finally, section 7 has concluded this paper with a final focus on the further directions.

2. STATE OF THE ART

This section considers the different approaches to managing traffic within 5G networks. Furthermore, it will present an overview of SDN and SoDeMa in terms of traffic managing. Additionally, it covers the concept of data traffic for enormous networks. Thus, front and backhaul are significant factors for studying the traffic causes. Also, it would help in to design appropriate solutions.

2.1 Data Traffic in 5G networks

5G networks have promised to offer enormous services to various users. However, this promise results in more networks requirements. Since network traffic will be expected to increase every nine months [1]. Thus, it is highly required to maintain the resources of the network for satisfying unlimited growth of 5G networks. However, there is no complete standardized definition of the 5G requirements, but there are valuable efforts that have been considering 5G issues such as [2]. However, this has led many researchers to discuss the significance of traffic managing schemas. Thus, some have studied the use of SDNs such as [3], for

traffic issues. Thus, they have used different controllers for managing traffic, especially for WiFi networks. However, as shown in [4] since 5G standardization is expected to be ready by 2020. Thus, more issues including delay, reliability and traffic issues will be discussed after the initial applications. On the other hand, the virtual traffic management system that incorporates all the key technologies has to be designed and implemented for managing heavy loads of coming networks such as video delivery [5]. Thus, the requirements of 5G services have thoroughly increased to satisfy higher data rate (10 to 100x higher data rate), reduced latency (1 ms end-to-end round-trip latency) and massive connectivity (10 to 100x number of connected devices) [6]. Previous promises require efficient techniques to deal with them. Also, there are many other promises that should be met to enable efficient future networks. Therefore, efficient approaches should satisfy the vast growth at different aspects of coming networks.

2.2 Software Defined Networks

In the massive applications' growth, new approaches to management have appeared to overcome the centralization of network control. An example of these approaches is using Software-Defined-Networks (SDNs) which have been used for enabling decentralized management of massive networks. An example can be seen in [7] where they have focused on the mechanism approach of SDN on 5G networks. Also, they have studied the currently proposed systems and then exploring high demand for the future. However, it is clearly seen that they focused on the results of SDN in the network security. However, authors of [8] have discussed different challenges when performing intelligent content delivery in LTE and Wi-Fi networks. Thus, they have considered these challenges by using a prototyping model of SDN. Finally, they have applied the network condition changes based on the needed quality of service.

Furthermore, more works have been using SDN to enable for lightweight systems in terms of traffic managing. Thus, they have classified the levels of quality based on the service requirements. Also, another work has been proposed as a QoE by using the SDN-Controlled framework as shown in [10]. However, authors of [11] have studied SDN-Traffic control by another approach. In fact, they have studied Traffic Engineering TE in terms of, firstly TE management: that is applied by traffic load balancing, QoS, EE scheduling and traffic management in IP/SDN network. Secondly, TE measurement: that is focused on the application and

network layers. Nevertheless, authors of [12] have proposed a new architecture for supporting spectrum management in heterogeneous wireless networks in 5G environments. This approach is mainly proposed to improve the QoE on heterogeneous networks. Moreover, authors of [13] have analyzed the deployment architecture for each component layer. Then they have proposed a software-defined Industrial IIoT architecture that is considering the prominent problems of IIoT. However, authors of [14] have studied the traffic by another model. Therefore, they have considered the traffic prediction in resource allocation. Also, they have studied end-to-end delay and bandwidth with packet loss decreasing. However, authors of [15] have focused on adjusting the weight settings, for balancing purposes. Then, they have proposed an algorithm for minimizing the maximum link utilization. Also, authors of [16] have analyzed the deficiency of current solutions at data centers in terms of multipath and multi-homing. Furthermore, they have used SDN for enabling flexible programmability.

2.3 Non-Orthogonal Multiple Access

In fact, Non-orthogonal Multiple access NOMA has enabled for many features that include overcoming the orthogonality in access schemas for enormous systems. Thus, it was precisely focused on investigating the traffic issue within the increasing environment of the small cell networks by enabling the dual connectivity as shown in [17]. However, another approach has focused on the cognitive radio by using NOMA, signal model and implementation of NOMA. However, they targeted maximizing the energy efficiency in terms of transmitting power constraints and QoS. They have compared the energy efficiency max in both OMA and NOMA in three different scenarios as in [18]. On the other hands, more efforts have investigated the network throughput through designing a scheduling downlink traffic especially for LTE small networks enabling the dual connectivity as seen in [19].

Furthermore, other works have explored the performance of NOMA in two cases including QoS based user data rate and rates allocated opportunistically according to channel conditions such as [20]. Furthermore, multicasting techniques have been explored in NOMA by [21] to enable for a spectral efficiency of different NOMA scenarios. Additionally, there were more attempts to shift the theoretical models into practical life such as [22]. Since they have Studying the achievable rate tuples through Monte Carlo for more input on the downlink capacity. Again, the performance of

NOMA is thoroughly needed to be more investigated alongside different techniques. An example can be seen in [23] that have examined the performance through the average of user throughput of NOMA scheme using code division multiplexing. However, more works have focused on the performance gained of downlink NOMA when considering different practical assumptions such as [24]. Thus, they have investigated the different cases of NOMA and OMA, with Full and Non-Full buffered scenarios.

2.4 Software-Defined Multiple Access

In fact, Software-Defined Multiple Access (SoDeMa) was proposed to leverage different multiple access schemes including both conventional OMA and new NOMA as seen in [25]. Thus, using this technology enables for flexible usage and an easier decision making for different services. However, it was proposed for providing higher resource allocations in large applications. Also, it enables for choosing the suitable transmitting schema depends on the needs and current resources. As seen in Figure 1, SoDeMa can choose the suitable schema depends on the request type. Thus, it leverages various features from both NOMA and OMA based on the request needs. Furthermore, it enables for an easier mechanism of quality of service for large applications through 5G networks.

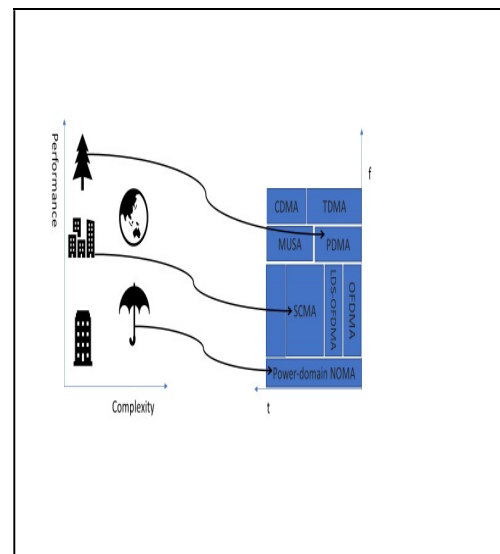


Figure 1 SoDeMa design [1]

Thus, many techniques have been proposed for enabling reliable control of traffic for wireless networks on 5G applications. But then, each proposal has studied this issue from a different

perspective. Thus, we have concluded the main differences between previous techniques in terms of different criteria. However, each technique has different usability scenarios. But we have compared between most of them in term of several parameters. The classification approach has followed the conclusions of previous works.

Table 1 : Comparison of current traffic techniques

Criteria	SDN	NOMA	OMA	SoDeMa
Flexibility	High	High	Low	High
management	Easy	Medium	easy	Advanced
programmability	High	High	Low	High
Applications	Massive	Massive	Medium	Massive
Centralization	No	No	Yes	Yes/NO
Resource Allocation	Medium	High	Low	High
Energy Efficiency	High	High	Low	Medium

3. TRAFFIC CONTROL MODEL FOR WIRELESS NETWORK IN 5G ENVIRONMENTS (DTC5GN)

In fact, dealing with an incredible number of users is thoroughly a sensitive task. However, earlier 5G proposals have promised for enabling similar features for different users. Thus, different proposals have been published during the last two years. However, some attempts lack the possibility to be a practical existence. The reason behind that is the late standardization of 5G applications. However, in our model, we have considered technology developments as well as increasing user's requirements. Accordingly, we have maintained the priority needs for applications with massive users. Since increasing services would result in more traffic among wireless networks. Therefore, we have divided our model to deal with every single request. Also, this model considers the

time taken from the accessing step till the service is provided. Moreover, we have considered the resources of wireless networks to reduce the cost of each request. Consequently, this model deals with the request at a specific time for analytical purposes. Also, we leverage from the previous requests for future estimations. The main idea is that classify coming request. then, we can improve the quality of service of our model. So, we divide our model into several steps to traffic consideration at different levels. As shown below Figure 2, explains the hierarchical architecture of our model from the request type till decision making step.

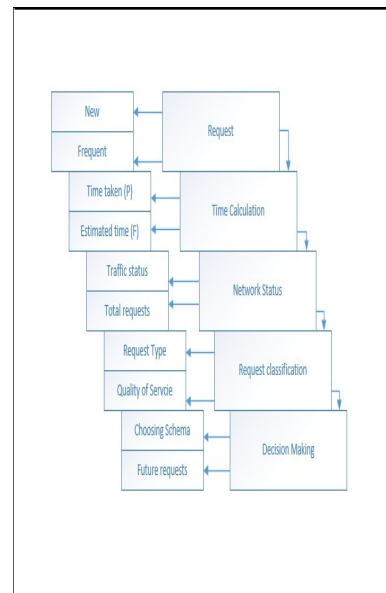


Figure 2: Hierarchical Architecture of the Model

Truly, our model considers the traffic control of the wireless network in the environments of the 5th generation. Thus, we have applied two main scenarios. Firstly, scenario one is responsible for the request's requirements. Whereas, scenario two is responsible for analyzing the status of the network. We have applied several factors to deal with the most frequent requests. As shown in Figure 3, it describes the process of dealing with a new request that is never served over the network.

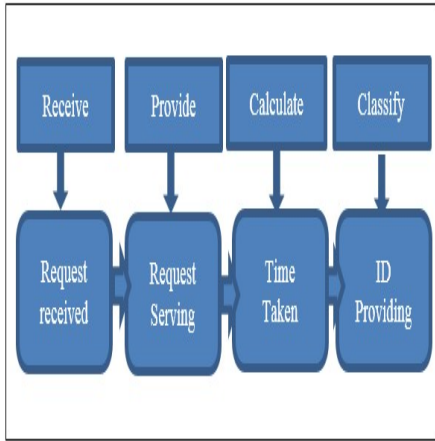


Figure 3: First experience of request

In the beginning, the request is received at a random status of the network with no consideration of the request type. However, then after serving the request, the calculation starts as a car joining the crowded roundabout. after that, it will be served with more consideration to the request type and the network status. Then, our model starts collecting data for future traffic. In this step, we calculate the time taken for this request compared to the current network status. Network status can be given a range to announce the status for coming requests. Then, the calculation step can be achieved through different factors. Initially, it starts with calculating the taken time for the current request. Then, the calculation of the status of the wireless network. At this stage, it compares the system’s capacity with the specific time. As shown in Figure 4, it shows the main tasks of calculation control.

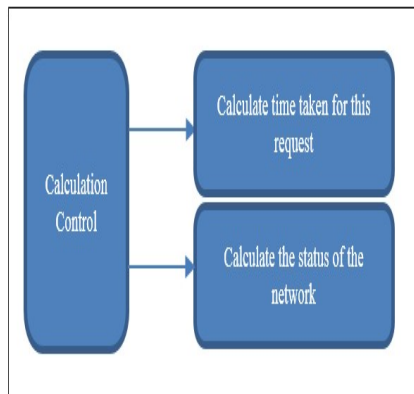


Figure 4: Calculation Control

Furthermore, request classification can be another important task to maintain the Quality of Service. Thus, the user is initially classified based on the previous requests. First request can be considered as a new experience. If the request is a frequent one, it will check the time needed based on the stored times in the data base. Then, the suitable schema will be chosen for better traffic management. However, if this request is a new, the time calculations will be considered. Then, it will be moved to the circle of previous request. This will help in future traffic management.

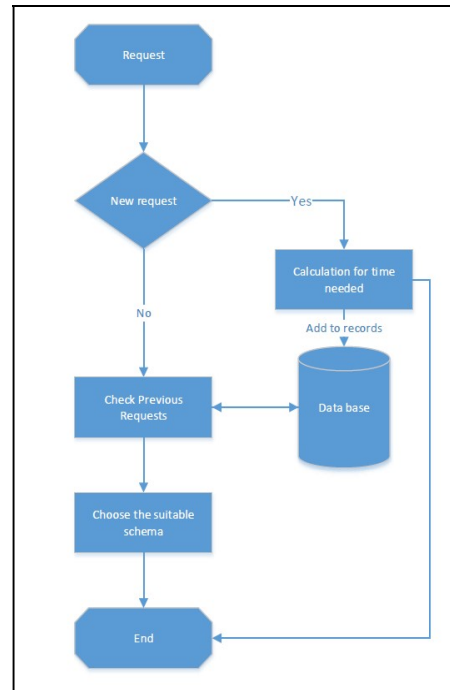


Figure 5: Request classification based on the number of experiences

4. OPERATIONAL SCENARIOS AND INDICATIVE RESULTS

Initially, this model deals with every received request. Thus, we had to classify every request based on three different factors. The first factor is the previous experiences. Thus, the new request will be expecting the time needed for achieving this request. However, if it was a frequent request, it will be saving the same request and then to be added an array of previous services. Moreover, the second factor is considered as the latency time of previous time. Thus, it compares the status of the network at both experiences. Then it will be deciding whether the current decision is made successfully to the suitable schema. Moving to the third factor, that considers making the best possible

of the status of our network for higher resource allocation. In fact, this would enable for using the best technique of serving request based on the current circumstances. This would enable for an improved experience for this request at this time. Also, it would handle the best application with the quality of service. In fact, this model consists of four main scenarios.

4.1 Scenario 1: New Requests

New requests are received in different circumstances of the network. However, they will enter the chain of the previous request as they have been served. In this case, each new request will be dealt with at four main steps. As mentioned before, requests will be received then it will be served for providing the best possible at this time. Then, the request time and the service provided will be calculated for future needs. The taken time will be also be stored compared to the current resource's capacities. Finally, there will a significant step of providing this request of a unique ID to ease the future experiences. This ID will be stored in the database with more descriptive information. The request description will have three main parts. Namely, they are requesting type, taken time and chosen schema for serving.

4.2 Scenario 2: Frequent Requests

Dealing with frequent requests is a significant step in this model. Since it can provide indicative results to our model. However, after the first experience of any request, it will be added to the frequent ones with consideration to the frequency-time of the service request. Thus, the frequency is calculated through the number of previous requests as well as the taken time. So, we can estimate the time best schema to be given to a specific request. It will be adding another number to the counter with the descriptive information. this step also helps in classifying the request after analyzing them to maintain our system. Thus, it would identify the frequent request based on the ID shown in each request.

4.3 Scenario 3: Applying Suitable Schema

After classifying the frequent request, we consider applying the suitable schema for an improved quality of service. This step can reduce the consumption of network resources as well as reduce the taken time when serving requests. Also, this would enable users to use the best possible of the network's resources at the specific time. The

shown ID will be counted to the suitable schema. However, the number of choices the same schema will be added to previous times of the same request. Also, the number of each chosen schema will be stored to analyze the most and least chosen schema between all others.

4.4 Scenario 4: Comparing the Experiences of Different Requests

At this level, we focus on comparing random request based on the different network status. through this step, we can also estimate the maximum that we can serve at the specific time. Thus, it can be initially calculating the previous request by different factors, including:

$$eX = \frac{Tt * Pr}{Np - 1} \quad (1)$$

Where eX is the average of previous experiences for a request. However, Tt means the total time that has been taken when requesting any service. The Pr stands for the previous request at a specific time. Also, Np is very important since it stands for the number of previous requests. We can also calculate the average aTt for a specific request.

$$aTt = \frac{Tt}{Nr} \quad (2)$$

Where aTt is the average of the taken timer of similar request that served for the same user. Also, Nr is the number of previous requests including the first experience.

As shown in Figure 6, each request is received at a certain time. Then, the request will be classified into a frequent or as a new request. This will be achieved by the control unit. If the network is ideal, it will direct the new request to the nearest route after estimating the needed time for the requested service. Otherwise, it will retrieve the previous requests from the same users. Then, it will suggest the best routing schema for decreasing traffic over the network. For new requests, it will be directly stored after serving to retrieve this experience in the future. However, it will be added to previous request consideration to provide an improved service. Also, this control will help to determine the peak times of the network to support new request in similar cases. In the classification step, we had used the best of ID to apply our model.

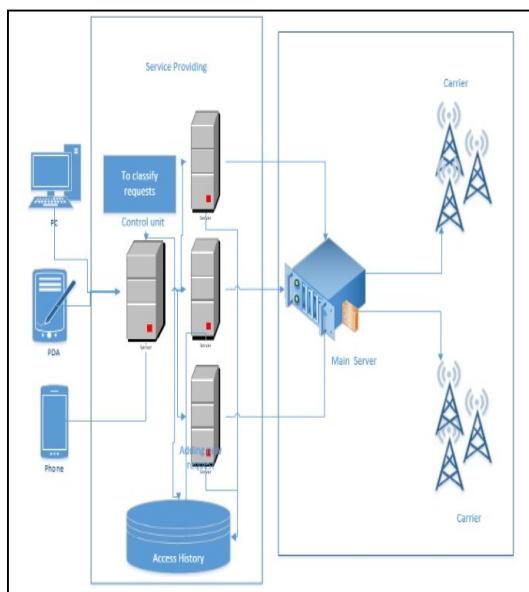


Figure 6: Overall Scenario of DTC5G

5. ANALYSIS

Traffic management is a sensitive task in 5G networks. Thus, the DTC5GN model has considered different factors to be thoroughly studied. However, applying this model helps in future networks for easier traffic control. Thus, it will reduce the latency by classifying each received request. It was needed to apply SoDeMa for classified services. Also, it was needed for improving quality of service for each received request. There are different factors have been considered in this model, including frequent request, classification types and time management consideration. This model is mainly attempting to move the network concept from reactivities to proactivity-based solutions. Thus, it will deal with the increasing number of requests at future networks. Also, it can estimate the future traffic by the frequent requests-based on the mentioned factors. In fact, the following considerations are very important for successful traffic managing models. Thus, we have focused on them as an initial part of this model.

5.1 Frequent Request Considerations

Frequent requests are thoroughly considered in this model. Due to the Thus, they were given different level of serving. Also, they have been classified to different levels to provide them with the preferred service at the nearest time. Then, the future coming request will be added to this request after the identification process. The identification process includes the request type, taken time and

the previously chosen schema. This will reduce the time taken by overcoming the first request procedures.

5.2 Classification Types

Requests types have been considered for managing the network resources. Also, it can assist in predicting the time needed for new requests. Thus, we have classified coming requests based on their taken time. Also, we have considered the resource consumption for each request. However, the classification step can be computationally intensive at the beginning. Then after, it will be reduced after the first time for an improved resource saving. Again, this step can assist in announcing the heavy requests such as multimedia transmission and real-time applications. Moreover, this will improve the quality of service for a massive number of users. In fact, classifying step is a key point to enable for an improved quality of service for massive users. Correspondingly, it can be stored in the data based as a record for future uses. This can help in decision making when managing traffic for massive applications with enormous users.

5.3 Time Management

Time management is considered in this model due to the significance of traffic models. Also, it was important with massive requests in 5G environments. In this scenario, we consider the management of time, especially after the first request, is received by a specific user. Thus, suggesting the best schema for a request can reduce the taken time. But at the beginning, it may take more time when classifying the request. However, it will not be repeated after serving request with first time experience. For frequent request, we have managed time wisely since they will be directed to the suitable schema after identifying their ID at the control unit. Hence, control unit is responsible for differentiating between massive request to enable the systems calculating the needed time for each request.

5.4 Model's Limitations

This model investigates the traffic management of 5G network. However, several environmental practices can not be applied when designing the initial phases of this model. Thus, it needs support the changeability for future improvements. This issue should be resolved to enable this model adopting different needs of future networks. furthermore, the massive requirements for Quality of Service users, especially at the same time. This

issue may result of different QoS practices for massive users. Also, Quality of experience may be decreased for unpredicted quality of service demands. Moreover, classifications methods must be improved to support artificial intelligence needs for different requirements of future users. For implementing this approach, the User Equipment (UE) must support such service by both in terms of software and hardware sides.

6. TRAFFIC CHALLENGES WITH INTELLIGENT SODEMA

Increasing number of smart devices face heavy data traffic problems such as speed of the receiving and sending emails [26]. Most of the smart devices are usable in different locations whenever users need and wherever they go. These mobile devices can get the support from 5G networks which influence with Machine-to-Machine communication (M2M). Traffic challenges of mobile data between the smart mobile devices need an intelligent traffic management system. Despite many benefits, maximizing coverage and reducing overall cost are still major challenges in the future 5G systems.

Using multiple controllers in the 5G networks communication systems simplifies the data traffic challenges such as minimizing delays and latency. With the efficient optimization algorithm and SoDeMa, optimizing path of the data traffic between the controllers and switches minimizes the delays [27]. Although SDN was employed to control the data path in 5G systems, SoDeMa enhances the controllability as well as the reliability of the data path when the delay is exceeding the limit.

Dynamic network conditions influence with the autonomous and intelligent systems which depend on the efficient architecture of Heterogeneous Cloud Radio Access Network (H-CRAN) [28]. Potential 5G telecommunication infrastructure will be leading to handling the data traffic during the data transmission. Although data traffic decreases the QoS in the 5G based applications, QoS is still one of the important challenges in the 5G systems. To improve the QoS and overcome the limitations of the dynamic network conditions, the H-CRAN may be considered as a promising architecture.

5G research has been looking for managing all requirements which improve the availability, reliability, flexibility, etc. to potential users and future users who hold the multiple devices. Challenge is with growing number of users as well as the increasing numbers of multiple devices

which communicate each other whenever they need. Dynamic and low-latency network architectures of the future the 5G applications need efficient traffic management [29]. In this regard, SDN and SoDeMa will be taking important functions which not only manage the challenges but also improve the EE in the next generation networks such as 5G+. Although SDN was originally designed for improving flexibility and programmability, an enhanced version of SoDeMa based on SDN allows the users and service providers to handle above mentioned challenges intelligently.

According to [30], innovation of named data networking (NDN) is applied efficiently to handle the content-based services in future 5G networks. Although it improves the 5G networks, changing legacy networks will be the major step for disseminating contents in more flexible and feasible way. Regarding the implementation of NDN, the existing network infrastructure of the legacy systems needs to be modified according to the 5G requirements. Again, SDN and SoDeMa will be applicable to manage the network traffics with minimum energy consumption.

Data traffic increasing with many users and devices needs an intelligent traffic management system which provides data traffic according to the priority through the SoDeMa. According to [31], efficient software can handle the data traffic in programmable approach which allows users to manage their data whenever they want. In addition to this, flexibility and reliability of the system operation simplify the users' potential challenges such as speed of browsing during the peak time. Network data management and softwarization increase the end-to-end reliability which is improving the traffic performance such as speed. Emerging 5G systems and applications is able to handle maximum data traffic when multiple radio access technologies are integrated with the SoDeMa.

Previous works have been focusing on the traffic management using Software-Defined Networks (SDNs). Thus, traffic issues require more techniques to deal with unpredicted future networks. also, the user's satisfaction is a key point of coming generations. Accordingly, this model has focused on obtaining the user's considerations. Moreover, it has considered dealing with traffic from another perspective. This model transfers the concept of network from the reactivity side to proactivity side. Thus, it can predict the future traffic by leveraging from the current situation of any network. Then, it can predict the traffic

volumes. Again, this can result on choosing suitable schemas when managing traffic at enormous networks. also, massive users can be served according to their previous requests. Also, time management considerations are another key point of this model. It plays important role in comparing the request needed time and the current status of networks.

In fact, challenges of traffic volumes have been considered to enable for an improved Quality of Service for coming generations. However, at the other side, 5G networks have promised for reducing the latency to the minimum rates. Thus, current techniques should fulfil both requirements to obtain the user's satisfactions as well as reducing the time taken for each request. Correspondingly, there is no fitting technique that can achieve all the requirements. However, we have attempted to classify the requests based on their importance and based on the current status of the network. In this case, this model can improve the massive applications since it applies the SoDeMa in managing traffic volumes. However, it can shift the concept of traffic management from the reactivity to proactivity approach.

7. CONCLUSION AND FURTHER DIRECTIONS

In conclusion, this work has investigated the traffic control of the wireless network in 5G environments. Then, it has proposed DTC5GN for managing a wireless network in 5G applications. Despite many data traffic models, DTC5GN was using the recent technology for classifying massive request over the network. Moreover, this model has studied the traffic from the accessing step of the wireless network to serve users. Also, it has considered applying several factors for enabling users with the best possible of network's capacities. Thus, following this approach would enable more flexibility and improved allocation of current resources. Flexible, it can achieve more request at a specific time under the rational network status.

However, new directions of traffic models are needed for maximizing the network throughput. Practically, traffic models can improve the experiences of massive users. Also, it will reduce the latency for different request on massive network environments. However, more identifications are needed about the limitations of coming networks. Also, several tradeoffs are needed to balance the different priorities of different services. Furthermore, the lack of practicing future network

environments can be considered as the key problem with this model.

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