Adaptive Bandwidth Allocation Schemes for Call Admission Control using Fuzzy Logic in Cellular Networks

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Abstract- In recent years, consumers of 4G cellular networks have increased exponentially as they discover that the service is user-friendly. Due to the large users and their frequent demands, it is necessary to use the limited network resources that guarantee the eminent standard quality of service (QoS). Call admission control (CAC) scheme has a major impact in assuring QoS for different users with various QoS requirements in 4G networks.
The time-varying nature of the parameters influencing the Quality of service (QoS) of real-time applications means the Call Admission Control (CAC) in LTE networks has to deal with some degree of uncertainty. The existing approaches fail to properly manage this uncertainty. A model is proposed to effectively manage real-time traffic via the deployment of a Fuzzy Logic Controllers (FLCs). Simulation results show that the proposed scheme significantly outperforms the reservation-based scheme and bandwidth degradation schemes in terms of admitting many calls and guaranteeing QoS to all the traffic types in the network.

Keywords- CAC, CBP, CDP, Handoff, Fuzzy Logic

I. INTRODUCTION

The network operators in the Next Generation Wireless Networks (NGWN) come up with wide array of services to their users thus increasing the customer base of the network operators. Users in the NGWN demand for Quality of Service (QoS) requirements of varied types as they may not be willing to use all the services provided by the network operator. Hence user differentiation plays vital role in NGWN and providing QoS guarantee to users in NGWN will become a challenging problem [1]. In this paper, we categorize the users into three classes viz. ClassP, ClassG and ClassS representing platinum class users, gold class users and silver class users respectively [2].

Call Admission Control (CAC) is one of the fundamental techniques for RRM. CAC scheme is the process of accepting a new call or handoff call in the network while regulating QoS of the existing calls without degrading any call drops. Handoff call refers to the method of transferring an ongoing call or data session from one channel to another

in a cellular network without compromising QoS requirements [3]. To satisfy user QoS requirements the CAC scheme arranges handoff call to the network by considering the available bandwidth. Hence, some amounts of bandwidth are reserved for incoming handoff call and assign the outstanding to new calls. An effective CAC scheme must concurrently provide efficient network resources utilization and an excellent QoS to the admitted users.

The work in [4] proposed a channel-borrowing scheme in which the best effort (BE) traffic borrows the bandwidth reserved for high-priority calls. Henceforth for the purpose of this paper, we call [5] as the Reservation-Based scheme. The Reservation-Based scheme used modeling and approximation processes for its CAC scheme. However, modeling of individuals and approximation of key system parameters is inefficient for the wireless network, due to the starvation of user traffic. Additionally, the scheme dynamically reserved some amount network bandwidth for handoff call using time varying status. However when some bandwidth is borrowed and reserved for handoff call, it may happen that the network has only a few or no handoff calls, then those network resources may be underutilized or wasted; consequently, this results in ineffective use of network resources.

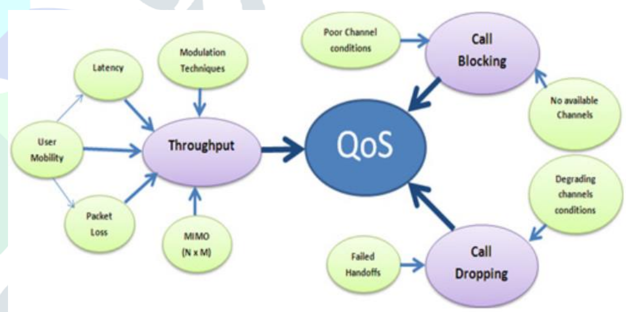

Figure 1: Factors influencing QoS

In the new CAC criteria, to create opportunities for the new calls, bandwidth degradation approach is introduced when the networks have scarce resources under heavy load scenario. Subsequently, an adaptive threshold value is applied to reserves available bandwidth for handoff calls by considering its traffic strength intensity. The major contributions of this paper are threefold. First, is maximizing the throughput of the BE traffic which is blocked because of lack of efficient utilization of network resources. The second contribution is the reducing of call blocking probability (CBP) and call dropping probability (CDP) by using an adaptive threshold value which adjusts the network status. Lastly, an analytical model using two levels Markov chain was developed to measure the performance of the proposed scheme [6].

II. FUZZY LOGIC

The Fuzzy Logic Algorithm is lit up by the intense capacity of fluffy rationale framework to deal with vulnerability and uncertainty. Fluffy rationale framework is notable as model free. Their enrollment capacities are not founded on factual dispersions. In this paper, we apply fluffy rationale framework to streamline the directing procedure by some foundation. The principle objective is planning the calculation to utilize Fuzzy Logic Systems to extend the lifetime of the sensor systems [7].

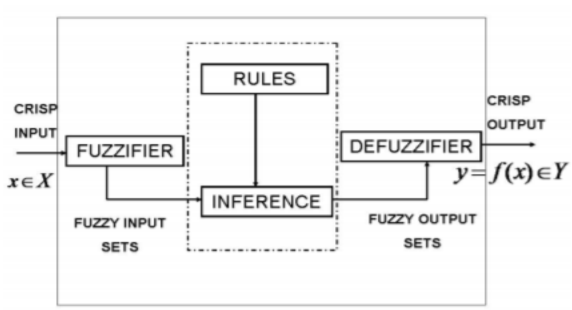

Figure 2: The structure of a fuzzy logic system

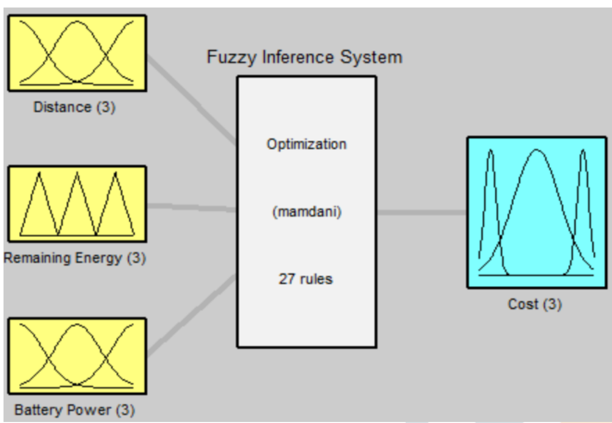

Figure 3: Optimization 27 rules with 3 inputs, 1 outputs

The throughput in the correspondence in work spine of remote work organize can be expanded by the expansion of new portals as the expansion of new doors effectively lessens the ordinary transitional hubs expected to get to the doors and furthermore it lessens the traffic load from the current entryways.

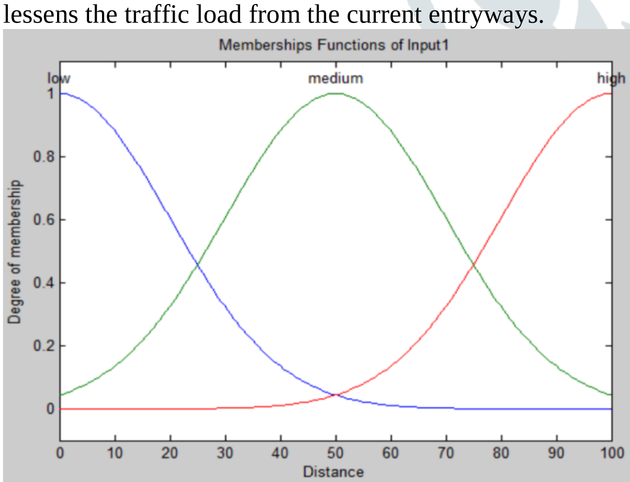

Figure 4: Members Functions of Input1

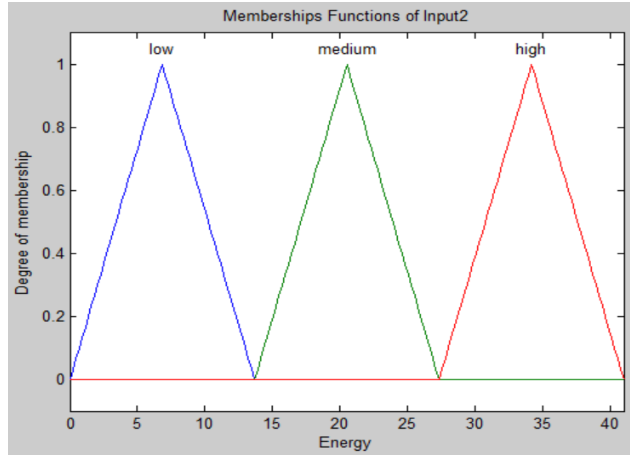

Figure 5: Members Functions of Input2

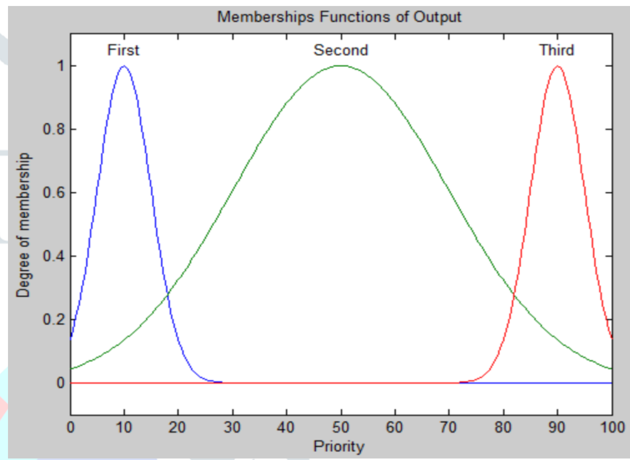

Figure 6: Members Functions of Output1

The above preferences can be decreased as a result of the unsatisfactory task of the area to the portals; wrong situation of the new passages may likewise meddle with the current doors. Subsequently the privilege position of the door discharging traffic stacks in the system just as limit the obstruction.

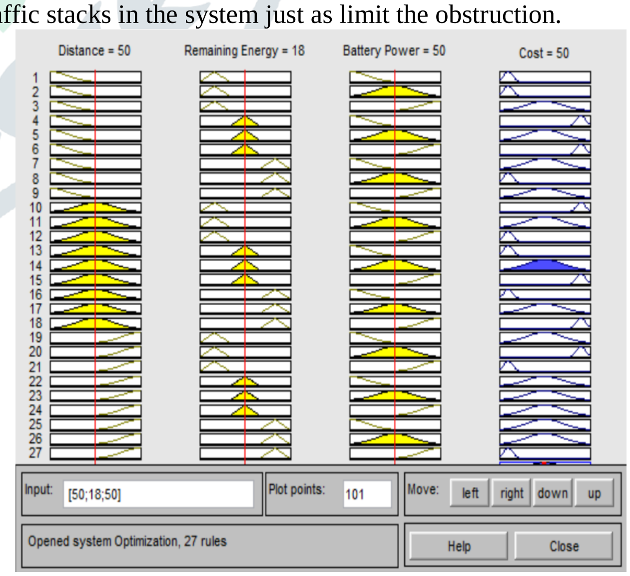

Figure 7: Rule Viewer Optimization

A creative plan is proposed in [8] to choose the passage for introducing a WMN if there should arise an occurrence of debacle recuperation which is utilized to accomplish the most extreme throughput of the framework. As indicated by [8] the base station is at the focal point of the system and various work switch it can choose as entryways and sets up the association with every one of them.

Especially, because of the base station bolsters one channel, it is expected here that a solitary channel is utilized for the correspondence between the work switches. Here a system topology has been intended for the examination of the framework limit throughput. In this the remote work switches are composed discretionarily in certain zone. So as to keep up a one of a kind steering way by expelling the excess way least spreading over tree has been utilized.

III. SYSTEM MODEL

In this work, a novel CAC scheme is proposed as an improvement of Reservation-Based scheme. Moreover, the shortcomings of Reservation-Based scheme are described. The scheme defined its CAC benchmark based on modelling, approximation method, and the BE traffic which reserved bandwidth for the high-level priority call. However, the BE traffic are not admitted into the network throughout the borrowing period which resulted in the starvation of this traffic. Therefore, the starvation of this traffic leads to increases of handoff CBP and CDP. Furthermore, the scheme dynamically distributes channels for an individual cell or reserved certain quantity of channels from the overall channels in the cell for handoff call using time-varying condition. However, when new calls and handoff calls occur repeatedly then some network resources may be left unutilized and this results in ineffective usage of network resources. Therefore, to solve the aforesaid obstacles a new CAC approach is proposed. The proposed scheme uses different traffic loads to admit new users and employs a threshold QoS provisioning approach to increase the efficient bandwidth utilization. The basic concept of our proposed scheme is taken into consideration that user traffic has different adaptive threshold QoS requirements. Thus a CAC criterion is adjusted by using the available bandwidth to increase the number of admitted calls with adaptive QoS. Moreover, RT traffic has high priority hence their handoff or new call bandwidth requirements can be described as:

$$a_i = BW_i^{\max} \qquad (1)$$

Where a_i denote the call admission criteria for call i while $BW_i^{\max}$ represent the maximum bandwidth for call i. If handoff or new call belongs to NRT or BE traffic, their bandwidth requirement is calculated as follows:

$$a_i = BW_i^{\min} \qquad (2)$$

While $BW_i^{\min}$ denote the minimum bandwidth requirement for call i.

Furthermore, when the available bandwidth cannot be enough to admit new call, bandwidth degradation approach is applied to RT traffic since they were assigned enough; this will save the BE traffic from starvation. Therefore, to compute bandwidth degradation for each class j considers the given equation below:

$$BW_j^{\deg raded} = BW_j^{\max} - D_j^{level} \qquad (3)$$

Where $BW_j^{\deg raded}$ denote degraded bandwidth for class j, $BW_j^{\max}$ represents available bandwidth and D_j^{level} is the present degradation level. However, Equation (3) must satisfy Equation (4) as given below:

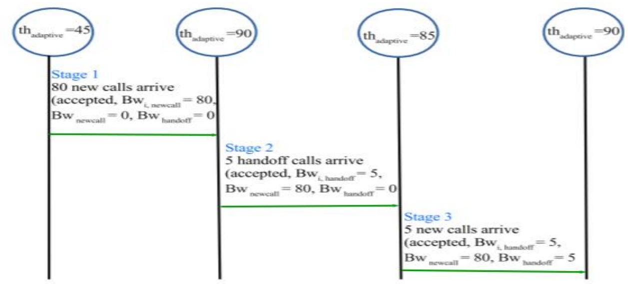

Figure 8: Proposed scheme case study scenario with Adaptive threshold

A simplified case study scenario is illustrated in Fig. 8 where we assume the total bandwidth of the network is 100 ($BW_{total} = 100$) and at the initial stage, the network is empty. Suppose that 80 new calls, 5 handoff calls, and 5 new calls arrive consecutively. Both schemes are assumed to have between 0 and 90 threshold values respectively with an initial threshold value of 45 units.

For the Reservation-Based scheme 5 new call ($BW_{i,new}$) and 5 handoff calls ($BW_{handoffcall}$) are rejected, resulting in 10 units of networks resources left unused and cannot be used again for new call admission. Therefore, ineffective bandwidth resource utilization occurred. But, our scheme significantly improves such situation by admitting new calls to the network resulting in efficient bandwidth resource utilization. Algorithm 1 represents the pseudocode for the proposed An Adaptive Call Admission Control with Bandwidth Reservation for Downlink LTE Networks.

This section described the analytical model for our proposed CAC scheme. Using this model we derive CDP and CBP for the different traffic classes and extensive experimental simulation is carried out to verify its accuracy. In this model, we have one base station called evolved NodeB (eNodeB) and several UEs, as illustrated in Fig. 9 some UEs are within the cell and are requesting for the new call, while others are outside the cell hence requesting for handoff call. When there is an incoming handoff or new call the UEs request for the available bandwidth from the eNodeB.

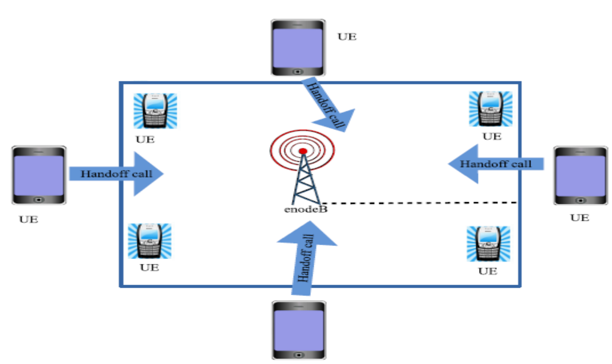

Figure 9: Simulation Topology

IV. PERFORMANCE EVALUATION

In this section, the performance results of the adaptive call admission control with bandwidth reservation technique scheme are obtained and compared against the traditional scheme using MATLAB simulation tool. The new call blocking probability, handoff call dropping probability and RB utilization, as a function of new call arrival rate, are presented in Fig. 10–Fig. 12.

In Fig. 10, it can be observed that the new call blocking probability for adaptive call admission control with bandwidth reservation technique scheme increases, as the new call arrival rate increases. This is due to the fact that as the load (new call) in the MP increases, more resource are consumed; while the probability of the arriving new call finding a larger percentage of the RBs in the MH network occupied, increases.

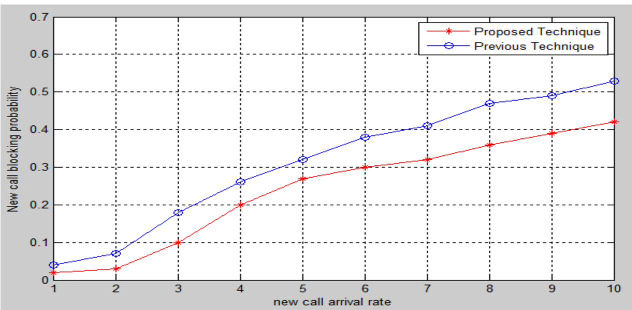

Figure 10: New call blocking probability as a function of new call arrival rate.

The handoff call dropping probabilities for adaptive call admission control with bandwidth reservation technique is shown in Fig. 11. Generally, the handoff calls dropping probability increases as the new call arrival rate increases. This is due to the fact that, as the arrival rates of new call increases relatively to the constant handoff call arrival rate.

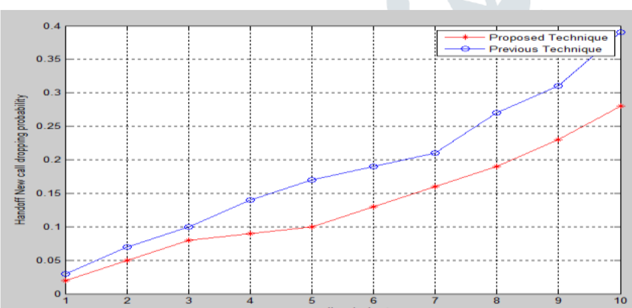

Figure 11: Handoff call dropping probability as a function of new call arrival rate.

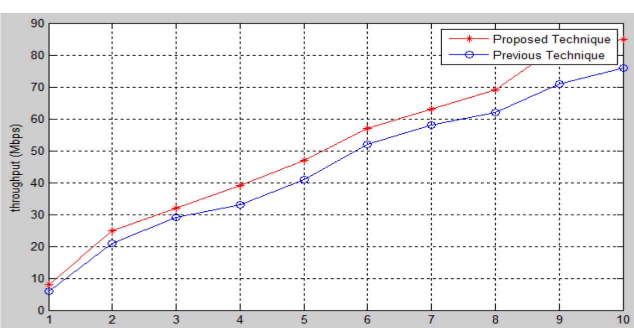

Figure 12: Resource throughput utilization as a function of new call arrival rate.

V. CONCLUSION

The criteria use bandwidth degradation to admit many users when there are insufficient network resources to accommodate new users. The proposed scheme in addition to its bandwidth degradation included an adaptive threshold value which adjusted the network conditions to enable efficient used of network resources. Extensive simulation experiments were conducted to evaluate the effectiveness of the proposed scheme. A mathematical model was introduced using CBP and CDP to validate the experimental results of the proposed scheme. Simulation results and numerical results are in total agreement with negligible differences. Results also show the outstanding performance of the proposed scheme as it was able to achieve an improvement of data throughput, reduces CBP, CDP and degradation ratio as compared to the Reservation-Based scheme and other bandwidth degradation schemes.

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