CALL ADMISSION CONTROL ALGORITHM WITH EFFICIENT HANDOFF FOR BOTH 4G AND 5G NETWORKS

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ABSTRACT

Recently, many generations of mobile networks have changed from one transition to another transition. The mode of transition from the first generation (1G) to the fifth generation (5G) is characterized by a lot of performance challenges such as delay, speed of the users, mobility, and variety of services. Currently, different from prior generations, 5G is not only concerned with the mobile networks but also, with various applications and different services such as health sector, transportation, energy consumption, safety well as Smart City. All these services are incorporated by 5G. In this paper, we proposed a call admission control (CAC) algorithm with an efficient handoff for both 4G and 5G networks. Simulation is used to evaluate the effectiveness of the proposed algorithm, and the obtained results indicate it considerably performs better than do other algorithms based on valuable metrics such as data throughput, call blocking probability (CBP), and call dropping probability (CDP).

KEYWORDS

Long Term Evolution, 4G, 5G, Networks, Call admission control

1. INTRODUCTION

The communication industry commenced with Advanced Mobile Phone System (AMPS) also known as 1G in form of analog mode. The next advancement was the Global System for Mobile (GSM) the first digital communication method referred to as 2G. An improvement of 2G in terms of data rate yield to the development of the Universal Mobile Telecommunication System (UMTS) is a 3G technology. With the improvement in data rates and high need for bandwidth Mobile Wimax and LTE (4G) evolved to overcome the limitations of 3G. Nowadays, sophisticated communication technology is 5G [1]. The architecture of the 4G network consisted of three key sub-networks via Evolved Universal Terrestrial Radio Access Network, evolved packet network, and broadband network. Similarly, the 5G networks consist of all Internet Protocol (IP) for mobile and wireless network interoperability which comprises user terminals and an autonomous radio access technology. Radio resource management is one of the key research trends in both 4G and 5G. The CAC is one of the fundamental strategies for radio resource management.

Although the LTE 4G network is good, yet it has some defects associated with it, for example, its environment and set back of transmission order as in the cases of 1G, 2G, and 3G. Several isolated rural areas and many structures in the urban cities have network access because of the present transmission orders and equipment. This has to be improved to satisfy the predicted 5G network that has a variety of different skills that are proficient in providing transmission order and may

DOI: 10.5121/ijwmn.2021.13201

other purposes [2]. The present anticipated wireless communication for 5G will help the liberated implication of several information open which a well-known CAC in the smart city relies on. The CAC in the smart city and 5G are carefully correlated because the amazing large data created by the CAC will want the flexibility that 5G is capable to quarter and hence CAC in the smart city will drive the advanced form of the 5G network.

In this paper, a novel CAC algorithm with efficient handoff for both the 4G and 5G networks is proposed. It is an extension of our previous work on the efficient dynamic CAC for 4G and 5G networks[3]. First of all, the algorithm classifies calls based on the arrival of traffic type. There are two different types of traffic types, handoff call with the best example of real-time (RT) traffic which has a high priority for instant live streaming and new call comprises of non-real-time (NRT) and best-effort traffic with low priority, for example, YouTube and an email. Afterward, to adjust the handoff calls a threshold value is used by looking at the traffic intensity.

The main contributions of this paper are twofold. Firstly, the throughput of the best-effort traffic is increased as a result of the proffer utilization of network resources. Secondly, minimizing the CBP and CDP using the threshold value that adjusts the network conditions.

The organization of this paper is as follows. Section 2 provides several related works. Section 3 presented the proposed algorithm and its details. Simulation results are illustrated in Section 4, while conclusions and future work are given in Section 5.

2. RELATED WORKS

A lot of investigations have been done on CAC in 4G and 5G both at academia and industries, hereafter researchers have presented many proposals towards such directions. The authors in [4] proposed the CAC algorithm for Energy Saving in 5G H-CRAN Networks intending to minimize the total power consumption in the H-CRAN using switch sleep mode strategy. However, call blocking probability (CBP) and call dropping probability (CDP) are completely ignored which are the building blocks in CAC. In [5], Fuzzy logic-based CAC in 5G cloud radio access networks with preemption was presented. The algorithm used a cloud bursting method during the congestion period to preempt delay-tolerant low-priority and outsourced penalty charges for the public cloud. It achieved a low CBP 5% but an increase in CDP. CAC for Real-Time and Non-real-time Traffic for Vehicular LTE Downlink Networks was proposed in [6]. The algorithm aims to accept or reject calls based on user priority. Besides, it classified calls into handoff and new calls while the traffic requests are categorized into real-time and non-real-time.

A Hybrid Approach to CAC in 5G Networks was proposed in [7] using neurofuzzy controller as one of the strategies of artificial intelligence. The algorithm increases the quality of service (QoS) by minimizing the CBP of the new incoming calls in a network. However, the CDP was significantly increased. In [8], a comprehensive survey has been presented that described the current research state-of-the-art of 5G Internet of Things (IoT), key enabling technologies, and main research trends as well as challenges in 5G IoT.

Similarly, Simulation analysis of key technology optimization of 5G mobile communication based on IoT technology was proposed in [9]. The algorithm aimed to minimize the base station energy power consumption and improve network energy efficiency to achieved good communication quality. The base station was tested based on four working loads: zero, light, normal, and heavy. In [10], Energy Efficient Proposal for IoT CAC in 5G Network was presented. The algorithm aimed to minimize energy consumption using CAC modeling for IoT in new radio access 5G networks. However, the CBP and CDP are ignored which resulted in network performance degradation.

An Efficient admission control and resource allocation mechanisms for public safety communication over 5G network slice was proposed in [11]. The authors provide an overview of how CAC and resource allocation can be deployed efficiently in the 5G network. In [12], An Adaptive CAC with Bandwidth Reservation for Downlink LTE Networks was presented. The algorithm uses an adaptive threshold value to adjust the network environment under heavy traffic load. It achieved maximum throughput for Best-effort traffic (BE), decreased CBP and CDP. However, the algorithm was implemented in LTE 4G networks. Therefore, in this paper, a Dynamic efficient CAC for both 4G and 5G networks is proposed which is an improvement of [12], therein provides better throughput for BE traffic, a significant decrease in CBP and CDP.

The authors in [13] suggested an algorithm which was model in CAC environment served by three classes of services in a 5G access network with the aim to decrease energy consumption which provide adequate QoS and permit the development of the IoT. However, this algorithm ignored to evaluates its performance based on the valuable metrics in CAC for instant CBP and CDP. In [2], a framework of 5G networks as the base for IoTs was presented as a survey which described how integration of 5G and IoT will be used use in communication millions mobile users at different smart cities.

A Dynamic Handover Control Parameters for LTE-A/5G Mobile Communications was presented in [14], the work proposed dynamic handover control parameters in heterogeneous works with dense small cells. It aims to minimize the probability of ping pong handovers, radio link, thus enhancing network performance. However, it increases CBP and CDP at the network environment. In [15], a novel and optimized handover failure and message mapping was presented. The algorithm prepares of handover failure and provides ways it can be overcomes in 4G/5G networks. However, the performance of networks was deteriorated due the increases of both CBP and CDP. Improving CAC in 5G for Smart Cities applications was proposed in [16], aimed at enhancing of CAC at minimal energy using one base station in ultra-dense networks. However, details of results are missing from the proposed work. The proposed work in [17], propose new vertical handover prediction strategies with aim to provide efficient prediction method without putting stresses on the mobile station and entire network. The prediction strategies use two independent thresholds. Firstly, the strength of the signal by the current base station is defined, while the second is gotten by the strength signal of user measured by mobile station. However, the scheme ignored to test for CBP and CDP which are important metrics for handover prediction.

In [18], details are provided for the readers as a new innovation in Smart cities Applications. In [19], a novel handover algorithm using multi-attribute and neutral network for heterogeneous integrated network is presented. The algorithm was designed by using interchanged network resources among 4G, 5G, wireless local area network etc. However, the algorithm causes an increased in CBP and CDP in 4G and 5G networks.

3. PROPOSED ALGORITHM

In this paper, we proposed a new CAC algorithm named "Call Admission Control Algorithm with Efficient Handoff for both 4G and 5G Networks" which is an improvement of Adaptive CAC with Bandwidth Reservation for Downlink LTE Networks. Firstly, the limitations of the Adaptive CAC algorithm are outlined. The algorithm uses an adaptive threshold hold value to achieve maximum utilization of resources. But this causes an increase of CBP and CDP which deteriorates the network performance. To eradicate the shortcoming of Adaptive CAC, the proposed algorithm uses a dynamic threshold value that can be applied in both 4G and 5G networks thus increase the effective network performance, reduce CBP and CDP. The dynamic threshold value is calculated based on Equation 1. If the threshold value is less than the total bandwidth, then handoff calls or new calls are accepted, otherwise, the calls are rejected. The θ value is set 20 [20] to enable much traffic for handoff calls to be admitted into the network, while new calls are blocked when the number of calls is above the θ value. Figure 1 illustrates a flow diagram of how the proposed algorithm works.

$$Threshold_{Dynamic} = \theta \times Handoff\_call_{prob} + New\_call_{prob} \quad (1)$$

where θ is equal 20, $Handoff_call_{prob}$represents the handoff call probability and New_call_{prob}denotes the new call probability respectively.

The $Handoff\_call_{prob}$ and New_call_{prob} are defined as indicated in Equation 2 -3 respectively.

$$Handoff\_call_{prob} = \left(Handoff_{BW} + \alpha_{Handoff}\right) \leq Total_{BW} \quad (2)$$

where $Handoff_{BW}$ represent the criteria for a call to be admitted into the network, $\alpha_{Handoff}$

denote the call admission criteria of user call, and $Total_{BW}$ represent the total network bandwidth.

Similarly, the New_call_{prob} is granted into the network environment using the given equation below:

$$New\_call_{prob} = (NewCall_{BW} - \theta) \leq Total_{BW} \quad (3)$$

where $NewCall_{BW}$ denote the criteria for a call to be blocked from the network, θ is the adjusted threshold value, and $Total_{BW}$ represent the total network bandwidth.

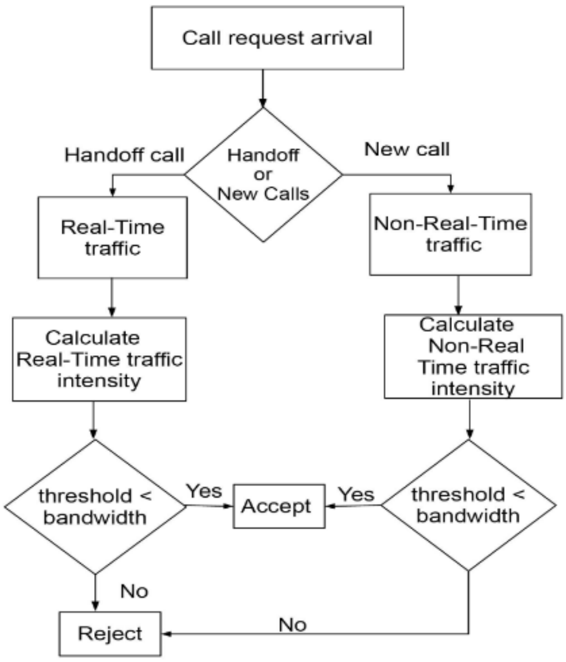

Figure 1. Proposal Algorithm

In this work, we have a single evolved NodeB (eNodeB) also called the base station, and many mobile nodes as shown in Figure 2. Various mobile nodes are within the network environment demanding new calls, whereas others are outside the network environment hereafter demanding for handoff call. The eNodeB handles the incoming demands from both the handoff and new calls.

If there is unused bandwidth the proposed algorithm granted access to the new calls and some bandwidth is kept for handoff calls. Else, both calls aborted.

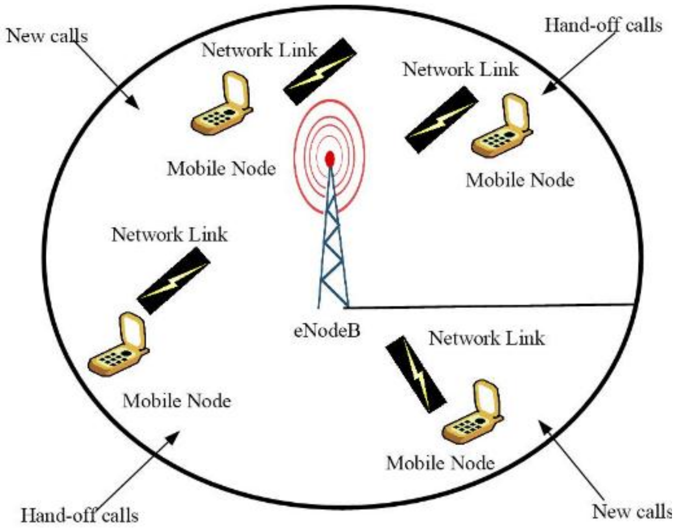

Figure 2. Simulation Topology

4. Simulation Results

This section evaluates the performance of the proposed algorithm. The proposed algorithm is compared with the Adaptive CAC algorithm and simulation results are obtained using MATLAB system-level simulator. Three valuable metrics are used to measure the performance of the proposed algorithm which includes throughput, call blocking probability, and call dropping probability. The simulation scenario consists of one hexagonal cell with a 500 m radius. The total bandwidth used is 5 MHz with 25 resource block per slot of 12 subcarriers spacing. The calls that arrived at the network environment are classified as handoff calls which includes real-time traffic that has the highest priority for instance live streaming and new call consist of non-real-time traffic which has low priority example YouTube and best-effort traffic for example email. The arrival rate for both real-time and non-real-time is Poisson distribution, while the service time is exponentially distributed. The simulation time is 500s, while an average of 20 times is used to obtain the simulation results. The simulation parameters are listed in Table 1.

Table 1. Simulation Parameters

Parameter	**Description**
Bandwidth	5 MHZ
Number of Resource Blocks	25
Total Transmission Time	1 ms
Simulation Time	500 s
Mobile Distribution	Uniform
Traffic arrival rate	1

Figure 3 shows the throughput of the proposed algorithm against the Adaptive CAC algorithm for the BE traffic. From the figure, it can be observed that the proposed algorithm has shown significant improvement in the 5G environment thus, prevent starvation of Best-effort traffic. The prevention of starvation for the best-effort traffic is achieved when there is sufficient bandwidth; several of them are assigns to best-effort traffic so that they can be admitted into the network area since they have the highest priority

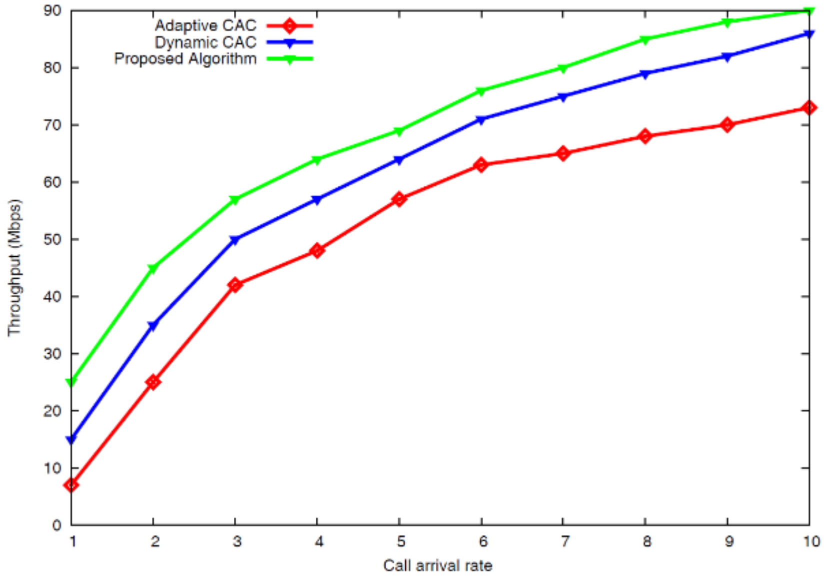

Figure 3. Throughput Best-effort traffic

Figures 4 and 5 illustrate the results of CBP and CDP. The proposed algorithm has the minimum probabilities due to the nature the threshold value is adjusted whereby user-requested are granted based on Equation 1. Figure 4 illustrates the New call CBP for both the proposed algorithm compared with Adaptive CAC and Dynamic CAC algorithms. When the traffic arrival is increased the proposed algorithm performs better than both algorithms by decreasing the new call CBP. This was caused because of the introduction of new call criteria to prevent starvation of Best-effort traffic as well as the waste of resources of handoff calls. To this end, several new calls will be admitted into the network. Figure 5 shows the Handoff call CDP of the proposed algorithm is compared with both the Adaptive CAC algorithm and Dynamic CAC algorithm. When the numbers of calls are increased the proposed algorithm significantly outperforms both algorithms by minimizing the new call CDP this was attributed due to how the threshold value was adjusted. Consequently, the proposed algorithm guarantees the QoS of much traffic.

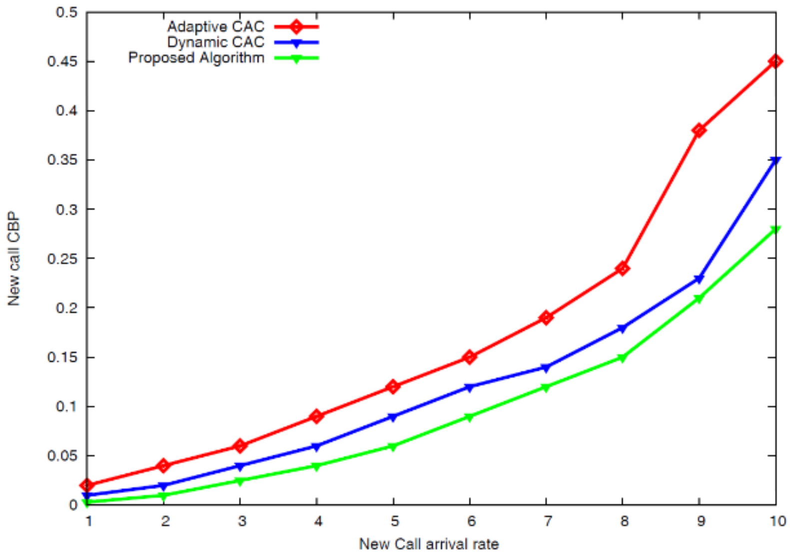

Figure 4. New call CBP

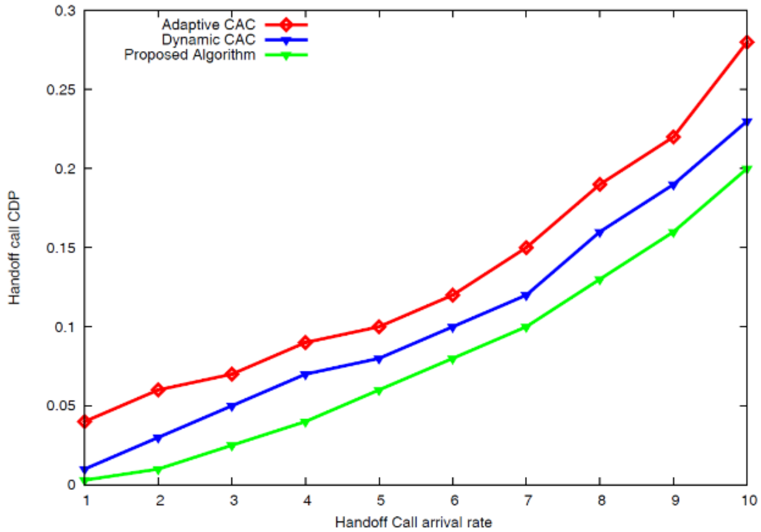

Figure 5. Handoff call CDP

5. Conclusions and Future Work

In this paper, we presented a Call Admission Control Algorithm with Efficient Handoff for both 4G and 5G Networks to prevent starvation best-effort traffic and improve the efficient use of resources in 5G networks. The algorithm uses admission criteria and a threshold value to admit may mobile nodes to the network environment, which results in the effective use of network resources. Extensive simulation results using MATLAB system-level simulator illustrates that the proposed algorithm significantly outperformed the Adaptive CAC by minimizing the CBP, CDP, and improved throughput. The obtained results show that the proposed algorithm is an effective candidate for 5G networks. In the future, we intend to test the algorithm using many load scenarios by a mathematical model.

Acknowledgements

This work is supported by Geran Putra Berimpak Universiti Putra Malaysia (9659400).

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