Optimization of Adaptive Call Admission Control Schemes for LTE Networks with Bandwidth Reservation

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Abstract - *Consumers of 4G wireless networks have grown exponentially in recent years as they discover how user-friendly the service is. Due to the large number of users and their regular requests, it is important to make use of the limited network resources available to ensure the highest level of service quality (QoS). In 4G networks, the call admission control (CAC) scheme has a significant effect on ensuring QoS for different users with different QoS specifications. Reservation-based schemes and bandwidth degradation schemes have recently been proposed with the aim of making efficient use of network resources and ensuring that admitted calls meet QoS requirements.*

In this paper, we propose a novel CAC scheme that makes efficient use of network resources while avoiding traffic starvation. The scheme has an adaptive threshold value that changes network capacity when there is a lot of traffic. In terms of admitting several calls and guaranteeing QoS to all traffic types in the network, simulation results show that the proposed scheme greatly outperforms the reservation-based scheme and bandwidth degradation schemes.

Key Words: *Call admission control, call blocking probability, calls dropping probability, Handoff, Quality of service.*

1. INTRODUCTION

The implementation of promising technology by the 3rd Generation Partnership Project (3GPP) Long Term Evolution was necessitated by the rapid growth of cellular networks across various technologies (LTE). To increase user data rates, provide wide area coverage, and boost spectral performance, LTE uses Orthogonal Frequency Multiple Access (OFDMA) and Multi-user Multiple-Input Multiple-Output (MU-MIMO) technologies [1]. There are significant challenges in meeting Quality of Service (QoS) standards and reducing network congestion in order to achieve these goals. It is essential to have an efficient radio resource management system in order to solve the problems listed above (RRM). One of the most basic RRM techniques is Call Admission Control (CAC). The CAC scheme is a method of accepting a new call or handoff call into the network while maintaining the QoS of current calls without causing any call drops. The process of moving an ongoing call or data session from one channel to another in a cellular network without violating QoS specifications is referred to as a handoff call [2]. The CAC scheme arranges handoff calls to the network based on available bandwidth to meet consumer QoS requirements. As a result, some bandwidth is set aside for incoming handoff calls, and the remaining bandwidth is assigned to new calls. An successful CAC scheme must provide efficient network resource usage as well as excellent QoS to admitted users at the same time.

The work in [3] suggested a channel-borrowing scheme in which best effort (BE) traffic borrows bandwidth from high-priority calls. For the rest of this article, we'll refer to [3] as the Reservation Based scheme. For its CAC scheme, the Reservation Based scheme used modeling and approximation methods. However, due to the lack of user traffic, individual modeling and approximation of key device parameters is inefficient for the wireless network. Additionally, the scheme used time-varying status to dynamically reserve some network bandwidth for handoff calls. However, if some bandwidth is borrowed and reserved for handoff calls, but the network only receives a few or no handoff calls, those network resources can be underutilized or wasted, resulting in inefficient network resource utilization. To address the inefficiency of Reservation Based CAC, we propose An Adaptive Call Admission Control with Bandwidth Reservation for Downlink LTE Networks in this paper. To begin, the mechanism establishes new CAC requirements based on the types of traffic. When networks have insufficient resources under a heavy load situation, the latest CAC criteria incorporate a bandwidth loss strategy to generate opportunities for new calls. Following that, based on the traffic strength intensity, an adaptive threshold value is used to reserve sufficient bandwidth for handoff calls. This paper makes three significant contributions. The first goal is to increase the throughput of BE traffic, which is currently being slowed due to inefficient network resource use. The second contribution is the use of an adaptive threshold value that changes the network status to reduce call blocking probability (CBP) and call dropping probability (CDP). Finally, an analytical model based on a two-level Markov chain was created to evaluate the proposed scheme's results.

The following is a breakdown of the paper's structure. The following section gives a summary of the relevant works. In section III, the proposed algorithm is introduced. In section IV, you'll see an example of an empirical analysis. Section V contains the results and debate, while Section VI contains the findings and possible directions.

2. RELATED WORK

Reservations are needed. CAC has gained a lot of traction in LTE networks, so researchers have suggested a number of projects in this direction. [4] proposes a CAC scheme for non-real-time (NRT) calls that is based on adaptive multilevel bandwidth allocation. To provide QoS, the algorithm makes use of the available radio tools. However, channel control distribution is disregarded, resulting in a high CBP and inefficient use of resources. The authors of [5] suggested a cognitive radio network interference award spectrum handover system. The scheme aims to optimise network power while reducing spectrum use. To solve the spectrum handover problem, the heuristic algorithm was created using the Branch and Bound method. [6] presents a channel reservation and preemption (CRP) model in a cellular network with multiple sectors that uses overlapping regions. On enodeB, directional antennas are mounted, dividing the coverage into equal-sized sectors. The scheme aims to reduce the chance of a handoff call being dropped by making effective use of available channels in the field. The effect of group vertical handoff in heterogeneous networks was investigated in [7]. To solve the problem of network congestion in community mobility scenarios, the congestion game approach was developed. In a stochastic scenario, the method employs two learning algorithms to reach the Nash equilibrium stage. [8] Proposes a CAC algorithm for cellular networks with direct and dynamic monitoring of QoS efficiency. The algorithm aims to meet QoS requirements by estimating device delay details and calculating residual throughput based on total achieved throughput. It achieves resource utilization efficiency. The paper [9] presents an opportunistic CAC for wireless broadband cognitive networks. The scheme created a structure and optimization technique that takes into account the demand for each service provider and cognitive subscribers. [10] Suggested a CAC reservation algorithm that takes into account resource variations and assigns resources to users based on QoS and channel efficiency. The algorithm takes into account two types of applications: wide-band and narrow-band. To avoid QoS degradation for the incoming call, extra resources are predicted and reserved. However, different call sizes exist in the LTE environment, and reserving resources in such a situation results in low resource utilization. [11] Suggested a Quality of Experience system that reserves network resources statically or dynamically. The scheme dynamically reserves capital based on prior information to maintain undetectable quality fluctuation during the handover for LTE networks. However, because of the mobility prediction, this scheme resulted in increased system complexity and inefficient resource utilization. Several CAC schemes [12], [13] have been proposed that consider bandwidth reservation from the perspective of mobility prediction. In [12], a cellular network mobility prediction scheme was created. The Hidden Markov Model (HMM) is used to explore user mobility in broad spatial and temporal scales. To improve device efficiency, the proposed scheme was combined with a threshold-based statistical bandwidth multiplexing strategy. The mobile reservation protocol begins the session by sending a service request to the active cell by the mobile host. The active cell checks if the available channels are free before granting the request; otherwise, it is denied. [14] Suggested a structure and scheme for bandwidth reservation. To predict paths to destinations, times when users enter/exit cells along predicted paths, and usable bandwidth in cells on predicted paths, the scheme incorporates a user mobility and available bandwidth model. The scheme has a low level of complexity, making the proposed system feasible for use in mobile networks.

3. SYSTEM MODEL

As an upgrade to the Reservation Based system, a novel CAC scheme is proposed in this paper. In addition, the drawbacks of the Reservation-Based system are discussed. Modeling, an approximation technique, and BE traffic, which reserved bandwidth for high-level priority calls, were used to establish the scheme's CAC benchmark. The BE traffic, on the other hand, was not allowed into the network during the borrowing time, resulting in traffic starvation. As a result of the traffic starvation, the number of handoff CBP and CDP rises. Furthermore, the scheme uses time-varying conditions to dynamically assign channels for an individual cell or allocate a certain number of channels from the total channels in the cell for handoff calls. When new calls and handoff calls occur frequently, however, some network resources can go unused, resulting in inefficient network resource utilization. As a result, a new CAC strategy is proposed to overcome the aforementioned challenges. To maximize bandwidth usage, the proposed scheme uses different traffic loads to accept new users and employs a threshold QoS provisioning strategy. User traffic has various adaptive threshold QoS specifications, which is taken into account in the basic definition of our proposed scheme. As a result, with adaptive QoS, a CAC criterion is modified by using available bandwidth to maximize the amount of admitted calls. Furthermore, since RT traffic has a high priority, their handoff or new call bandwidth requirements are as follows:

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

Where a_i denote the call admission criteria for call i while
W^{max} represents 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} denotes the minimum bandwidth requirement for call i

Furthermore, when the available bandwidth is inadequate to receive new calls, RT traffic is subjected to a bandwidth depletion system because they have been allocated enough bandwidth; this prevents BE traffic from being starved. As a consequence, the following equation is used to calculate bandwidth loss for each class j:

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

Where $BW_j^{degraded}$ denotes 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:

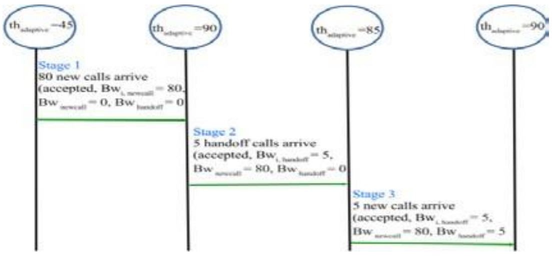

Fig -1: Proposed scheme case study scenario with Adaptive threshold

Figure 1 depicts a simplified case study scenario. 1 where we assume the network's total bandwidth is 100 (BWtotal = 100) and the network is empty at the start. Assume 80 new calls, 5 handoff calls, and 5 new calls all arrive at the same time. Both schemes are considered to have threshold values of 0 and 90 units, with a 45-unit initial threshold value. The Reservation Based scheme rejects 5 new calls (BWi,new) and 5 handoff calls (BWhandoffcall), leaving 10 units of network capacity unused and unavailable for new call entry. As a result, bandwidth resources were used inefficiently. However, by allowing new calls into the network, our scheme greatly enhances this situation, resulting in efficient bandwidth resource usage. The proposed An Adaptive Call Admission Control with Bandwidth Reservation for Downlink LTE Networks is represented by Algorithm 1.

4. PERFORMANCE EVALUATION

In this section, using the MATLAB simulation tool, the output results of the adaptive call admission control with bandwidth reservation technique scheme are obtained and compared to the conventional scheme. In Figure 1, the new call blocking probability, handoff call falling probability, and RB utilisation are plotted as a function of new call arrival rate. 2. As shown in Fig. 2. As the new call arrival rate increases, the new call blocking probability for adaptive call admission control with bandwidth reservation technique scheme increases. This is because more resources are used as the load (new call) in the MP increases. As a result, the likelihood of a new call coming and having a greater proportion of the RBs in the MH network occupied rises.

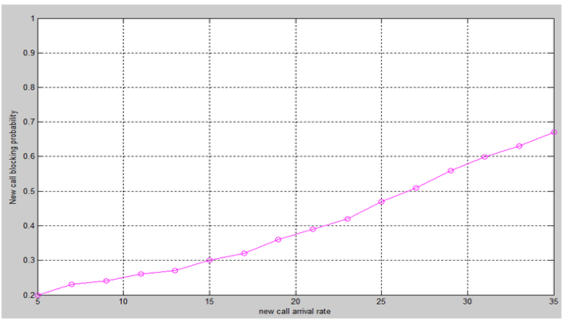

Fig -2: New call blocking probability as a function of new call arrival rate.

Figure 1 shows the handoff call falling probabilities for adaptive call admission control using the bandwidth reservation technique. 4. In general, the likelihood of a handoff call falling increases as the new call arrival rate rises. This is because, in comparison to the constant handoff call arrival rate, the arrival rate of new calls rises.

5. CONCLUSION

In this paper, we propose an Adaptive Call Admission Control with Bandwidth Reservation for user traffic in wireless cellular networks to increase the efficient use of network resources. To stop user traffic hunger, the new scheme implemented CAC requirements. If there are insufficient network resources to support new users, the criteria use bandwidth loss to accept a large number of users. In addition to bandwidth loss, the proposed scheme contained an adaptive threshold value that modified network conditions to allow optimal use of network resources. To assess the feasibility of the proposed scheme, extensive simulation experiments were carried out. To confirm the experimental results of the proposed scheme, a mathematical model was developed using CBP and CDP. The numerical and simulation results are almost identical, with only minor variations. In comparison to the Reservation Based scheme and other bandwidth depletion schemes, the proposed scheme was able to increase data throughput, minimize CBP, CDP, and degradation ratio.

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