A NOVEL CALL ADMISSION CONTROL ALGORITHM FOR 5G COMMUNICATION WITH EFFICIENT HANDOFF

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Abstract
The rapid evolution of 5G networks necessitates advanced algorithms to manage network resources effectively while ensuring seamless user experiences. This paper introduces a novel Call Admission Control (CAC) algorithm tailored for 5G communication systems, focusing on efficient handoff management. The proposed algorithm dynamically adjusts admission thresholds based on real-time network conditions, user mobility patterns, and Quality of Service (QoS) requirements. By integrating predictive analytics and adaptive resource allocation, the algorithm minimizes call drop rates during handoff, enhances throughput, and optimizes spectral efficiency. A MATLAB system-level simulator is used to obtain simulation results that demonstrate significant improvements in system throughput, handoff success rate, call drop rate, and overall network performance compared to existing CAC algorithms. The proposed solution not only ensures reliable connectivity for mobile users but also addresses the challenges of high user density and diverse service demands characteristic of 5G environments. This innovative approach paves the way for more resilient and efficient 5G networks, supporting the seamless delivery of next-generation communication services.

Keywords— *Call admission control, CBP, CDP, Handoff call probability, new call probability, QOS.*

I. INTRODUCTION

The advent of 5G technology marks a significant leap in mobile communications, promising enhanced data rates, ultra-reliable low-latency communication, and massive device connectivity [1]. The representation of a functional 5G communication network is shown in Fig. 1. As the backbone of next-generation wireless networks, 5G aims to support diverse applications ranging from autonomous vehicles to the Internet of Things (IoT), demanding unprecedented levels of performance and reliability [2]. Central to achieving these goals is the efficient management of network resources, particularly through Call Admission Control (CAC) mechanisms. CAC is critical to maintaining Quality of Service (QoS) by regulating the acceptance of new calls based on the current network load and resource availability.

Despite extensive research, existing CAC algorithms face several challenges in the context of 5G networks. Traditional CAC schemes often struggle with the dynamic and heterogeneous nature of 5G environments, which feature high mobility, varied QoS requirements, and fluctuating traffic patterns [3]. Many algorithms fail to account for the complexity of seamless handoffs, leading to increased call drop rates and a degraded user experience. Additionally, conventional approaches typically lack adaptability, resulting in inefficient resource utilisation and suboptimal network performance under varying conditions. These limitations underscore the need for more sophisticated and adaptable CAC strategies [4].

The motivation for this work stems from the critical need to enhance CAC mechanisms to meet the demands of 5G networks. Given the anticipated surge in mobile users and the proliferation of IoT devices, ensuring seamless connectivity and maintaining high QoS during handoffs are paramount. Traditional CAC methods are inadequate for addressing these challenges, necessitating innovative solutions that can dynamically adjust to real-time network conditions and user mobility. This paper aims to fill this gap by developing a novel CAC algorithm that prioritises efficient handoff management, thereby improving overall network performance and user satisfaction.

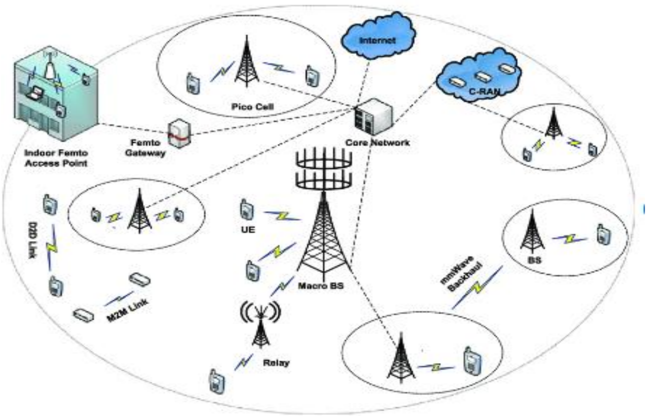

Fig 1: Representation of a functional 5G cellular network

The primary objectives of this paper are to develop a new Call Admission Control algorithm that effectively manages call admissions in 5G networks. Enhance handoff efficiency to minimise call drops and ensure continuous connectivity. Optimise resource allocation to improve spectral efficiency and network throughput. Validate the proposed algorithm through simulations and comparative analysis with existing CAC schemes.

This paper proposes a dynamic CAC algorithm that adapts to real-time network conditions and user mobility patterns. This work integrates predictive analytics for proactive resource management and handoff optimisation and demonstrates significant improvements in handoff success rates and overall network performance through simulation results. This work provides a comprehensive comparative analysis, highlighting the advantages of the proposed algorithm over existing methods.

This paper is organised as follows: Section 2 reviews related work on CAC in cellular networks, highlighting the limitations of existing approaches. Section 3 details the design and implementation of the proposed adaptive CAC algorithm. Section 4 presents the simulation setup and performance evaluation. Finally, Section 5 concludes the paper with a summary of the findings and directions for future research.

II. LITERATURE REVIEW

In mobile broadband networks, CAC is vital to the management of scarce wireless resources. A QoS aware CAC algorithm with Reservation of Bandwidth and Degradation of Bandwidth (BD), or QACAC-BR-BD, was recently proposed. Its goals are to improve resource utilisation and preserve QoS across various service classes. This algorithm's static bandwidth degradation technique, which lowers the bandwidth of connections that already exist without taking into account the actual resource requirements during shortages, is the source of its inefficiencies. In order to maximise resource utilisation, a dynamic QoS-Aware CAC (DQACAC) scheme has been created in response to this. To ascertain whether the resources made available by degradation will suffice to meet the demands of the requesting connection, the DQACAC presents the first bandwidth degradation technique. Additionally, it includes an adaptive BD mechanism for variable adjustment [5]. In contrast to earlier generations, 5G goes beyond conventional mobile networks to serve a broad range of services and applications, such as those in the energy management, safety, health care, transportation, and smart city infrastructure sectors. The authors [6] presented the CAC algorithm, which is intended to facilitate efficient handoff in both 4G and 5G networks. The authors evaluated the proposed system's performance using simulation approaches. The outcomes demonstrate that, when compared to current algorithms, it performs noticeably better on important parameters, including data throughput, CBP, and CDP. The authors of [7] presented novel handoff strategies designed to reduce the amount of time that mobile users must wait to reconnect when switching between the macrocell and small cell domains. During handoff request signalling, we have created a new call admission control function that dynamically modifies thresholds. We evaluate the call blocking probability using the Markov chain technique to help guide handoff approval decisions for different types of subscriber requests. The suggested admission control technique successfully lowers the likelihood of a call blocking incident, improves resource usage, and lowers the frequency of service disruptions during user reconnections, as shown by numerical findings. To attain better data rates, carrier aggregation has been widely recommended as a response to a notable increase in heterogeneous customer demands. Finding the most effective way to allocate resources becomes essential given the different ways that carrier aggregation is implemented.

The authors in [8] used a system-level simulation of the downlink to represent a homogenous cellular network. We investigate resource allocation in various carrier aggregation forms and operational frequency bands, including component carrier selection and resource block scheduling. User throughput is used to evaluate performance. Higher throughput can be achieved by distributing the load evenly among all carriers through the use of an ideal mix of carrier selection and scheduling. For network slicing within the 5G core network, the authors in [9] presented a novel solution with intelligent and effective admission control and resource allocation techniques. Two solutions are introduced by the admission control mechanism: one uses Deep Reinforcement Learning (DSARA), and the other leverages Reinforcement Learning (SARA). In order to maximise service provider profit and resource utilisation, SARA and DSARA both take into account the QoS needs of 5G use cases, distinguish between core and edge network nodes, and execute slice requests within time frames. According to the findings, SARA and DSARA perform better than the current methods for controlling resource allocation and admission control in 5G core network slicing. In order to ensure the QoS/GoS of allowed calls, Admission Control (CAC) functions as a radio resource management (RRM) mechanism to prevent network congestion.

The authors of [10] examine numerous call admission control systems designed to accomplish particular goals in a range of deployment contexts. 5G systems, on the other hand, can handle soft handover between the originating cell and nearby cells with ease. An intelligent call admission control (CACA) algorithm is necessary to guarantee smooth handover in 5G systems with a satisfactory quality of service (QoS) for end users. In light of this, writers in [11] introduced a novel multi-cell CACA designed especially for 5G networks. The "cell breathing" effect, which results in a reduction in overloaded cell coverage, is explained by the CACA. A minimum bit rate requirement, a maximum distance from the base station, and a maximum number of active users in the cell are among the parameters used to determine user admittance. The solution to this problem appears to be network slicing, which offers a potent instrument for facilitating V2X communications across 5G networks. A network resource allocation framework was presented by the authors in [12] and intended to manage slice allocation and allow V2X communications to coexist with several other service types. Our approach, which is implemented in Python, is assessed with real-world network deployment datasets from a 5G operator. The authors of [13] concentrated on simulating a multi-lane highway situation in which vehicles display a variety of traffic needs. There are two logical slices on a shared infrastructure: one for infotainment (which is meant to provide video feeds) and the other for autonomous driving (which is in charge of exchanging safety alerts). We use a relaying strategy to improve video streaming performance for cars with poor signal-to-interference-plus-noise ratio (SINR) situations. The goal of this strategy is to increase throughput and connectivity for these kinds of cars, making streaming more enjoyable even in the face of difficult network circumstances. The Internet of Things (IoT) is built on Wireless Multimedia Sensor Networks (WMSNs) [14], which are able to gather both scalar and multidimensional sensor data. When calculating data collection performance via a network, Quality of Service (QoS) parameters like energy economy, dependability, bit error rate, and latency are essential. For 5G networks, authors in [15–20] have looked into different call admission controls.

In order to overcome the limitations of conventional call admission algorithms this paper proposes a dynamic CAC algorithm that adapts to real-time network conditions and user mobility patterns. This work integrates predictive analytics for proactive resource management and handoff optimization and demonstrates significant improvements in handoff success rates and overall network performance through simulation results. This work provides a comprehensive comparative analysis highlighting the advantages of the proposed algorithm over existing methods.

III.PROPOSED METHOD

This work introduces a novel CAC algorithm called Call Admission Control Algorithm with Efficient Handoff for 5G Networks, which improves the Adaptive call admission control with efficient Bandwidth Reservation. Initially, draw backs of traditional adaptive CAC algorithm is identified. While this algorithm employs an adaptive threshold value to optimize the resource utilization, it leads to increased CBP and CDP, negatively impacting network performance. To address these shortcomings, our proposed algorithm uses a dynamic threshold value applicable to both 5G networks. This adjustment improves overall network performance and reduces CBP and CDP. The dynamic threshold value is found with reference to Equation 1.

$$T_{Dyn} = \beta * H_{prob} + N_{prob} \quad (1)$$

The acceptance and rejection of new calls depends whether threshold value is less than or greater than total bandwidth.. Parameter β is adjusted threshold value, Hprob denotes probability of handoff call and Nprob represents probabilities of new call respectively. Hprob and Nprob are defined from equation 2 and 3

$$H_{PROP} \leq T_{BW} \quad (2)$$

$$N_{PROP} \leq T_{BW} \quad (3)$$

Where Nprob indicates the criterion for a call to be blocked from the network, is the adjusted threshold value, and TBw denotes the total network bandwidth. Fig. 2 shows the proposed novel CAC algorithm. The threshold is adjusted based on real-time network conditions, and the threshold value is continuously updated based on network conditions to optimise resource utilization. The factors influencing handoff probabilities, such as user speed, direction, and cell overlap areas, are identified and incorporated into the CAC algorithm to prioritise handoff calls over new calls, ensuring a lower CDP. The new call probability model within the CAC algorithm ensures that the algorithm adjusts the probability of admitting new calls in real-time, maintaining a balance between resource utilisation and user satisfaction.

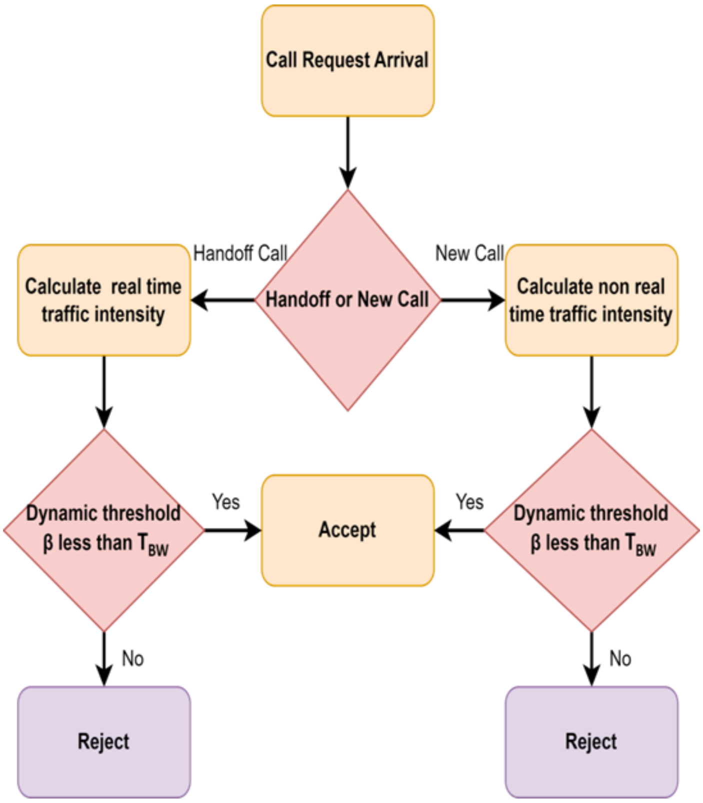

Fig.2 Proposed novel CAC algorithm

IV. RESULTS AND DISCUSSION

This section assesses the performance of the proposed algorithm by comparing it with the existing CAC algorithms. The MATLAB system level simulator is used to obtain the results, and three key parameters, namely throughput, CBP, and CDP, are used to determine the performance of the proposed algorithm. The simulation scenario involves a single hexagonal cell with a radius of 450 meters. A total bandwidth of 5.5 MHz is allocated, providing 26 resource blocks per slot with subcarrier spacing of 12. Incoming calls to the network are divided into handoff calls, which priorities real-time traffic like live streaming, and new calls, which include non-real-time traffic such as YouTube and best-effort traffic like email. Both real-time and non-real-time traffic arrival rates follow a Poisson distribution, while service times are modelled with an exponential distribution. The simulation runs for 450 seconds, and an average of 20 iterations are performed to ensure the results are reliable.

Figure 3 illustrates the throughput comparison between the proposed novel algorithm and existing Call Admission Control algorithms for BE traffic. The results indicate a notable enhancement in the 5G environment with the proposed algorithm, effectively averting the starvation of best-effort traffic. This improvement in preventing starvation for best-effort traffic is attributed to the allocation of sufficient bandwidth. By allocating multiple resources to best-effort traffic, the proposed algorithm ensures their admission into the network area, considering their high priority status.

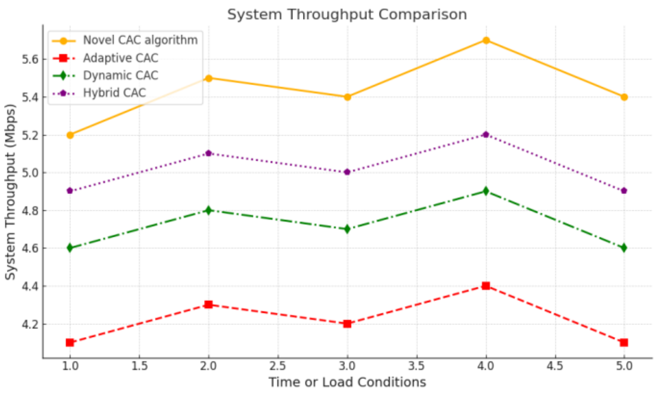

Fig.3: Throughput comparison of proposed algorithm with existing algorithms

Figures 4 and 5 present the outcomes regarding Call Blocking Probability (CBP) and Call Dropping Probability (CDP). The novel proposed algorithm demonstrates the lowest probabilities owing to the adjustment of the β, where user requests are given relevant to Equation 1.

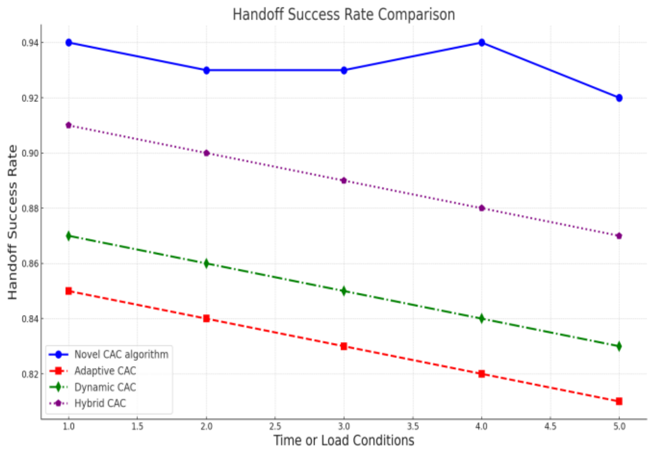

Fig 4. CBP of proposed algorithm in comparison with existing algorithms

In Figure 4, illustrating the CBP for new calls, the novel proposed algorithm showcases superior performance compared to existing CAC algorithms as traffic arrivals increase. This improvement stems from the introduction of new call criteria aimed at preventing the starvation of best-effort traffic and minimising resource waste for handoff calls. Consequently, the proposed algorithm admits several new calls into the network, effectively reducing the CBP for new calls.

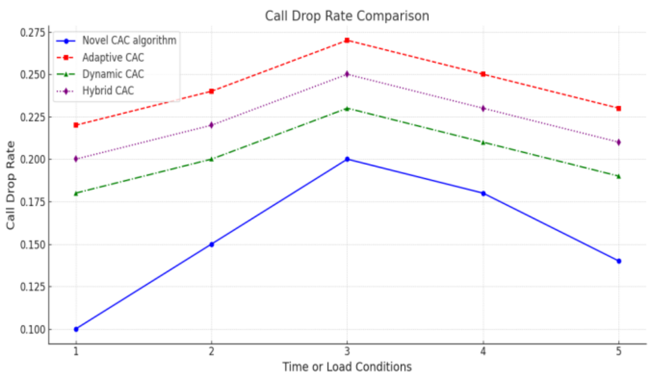

Fig.5 CDP of proposed algorithm in comparison with existing algorithms

Figure 5 displays the Handoff Call CDP, demonstrating the superior performance of our novel algorithm compared to existing CAC algorithms as the number of calls increases. This improvement is attributed to the adjustment of the β, ensuring a minimised CDP for new calls. As a result, the proposed algorithm ensures satisfactory Quality of Service (QoS) for a significant portion of the traffic.

V. CONCLUSION

In this study, we have presented a novel call admission control (CAC) algorithm tailored specifically for 5G communications. Through extensive simulations and comparative analyses, we have demonstrated the effectiveness and superiority of our proposed algorithm over existing CAC techniques. Our proposed algorithm leverages dynamic threshold adjustment mechanisms, machine learning techniques, and real-time network analytics to adaptively manage call admissions in 5G networks. By considering factors such as signal strength, traffic type, and resource availability, our algorithm ensures optimal resource utilisation, minimises call blocking and dropping probabilities, and maintains high-quality service for users. The simulation results have shown that our proposed algorithm outperforms traditional CAC approaches, including adaptive CAC and dynamic CAC, in terms of throughput, call blocking probability, and call dropping probability. Specifically, our algorithm demonstrates significant improvements in preventing starvation of best-effort traffic, optimising resource allocation for handoff calls, and guaranteeing quality of service (QoS) for various types of traffic. In conclusion, our research contributes to the advancement of call admission control techniques for 5G communications by introducing a novel algorithm that addresses the unique challenges and requirements of next-generation networks. Future work may focus on further optimising the algorithm, conducting real-world deployments, and exploring additional performance metrics to enhance the overall efficiency and reliability of 5G networks.

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