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Assessing The Role of Guard Bands in Optimizing Call Management in Cellular Networks

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ABSTRACT

Prioritization of new and handover calls is accomplished using the suggested model. It is presumed that the system follows a queuing strategy and reservation channel scheme to preserve the HO priority. This research looked at how guard bands affected the likelihood of new calls being blocked, the likelihood of HO calls being dropped, and the average waiting periods for new and HO real-time connections. Increasing arrival rates had a substantial influence on dropping and blocking probabilities, according to the findings. The guard band substantially reduced HO call drops by a factor of two to twenty compared to the scenarios without the band. Also, the data showed that a guard band reservation method did help with HO call handling, but it made new connections take longer to establish.

Keywords: *Guard Bands, Blocking, Real Time, Probability, Call Management.*

I. INTRODUCTION

The backbone of communication in today's hyper-connected world are cellular networks, which provide key services across many sectors, from personal communication to crucial corporate activities, and enable seamless interactions. An effective system for managing cellular calls is more important than ever before due to the explosion of data-intensive apps and the ever-increasing number of mobile devices. Improving call management entails fixing problems like call blocking and dropping rates while maintaining a good QoS for incoming and outgoing calls. Advanced algorithms, techniques for allocating resources, and cutting-edge technology are crucial in this setting.

Managing call resources, especially during high demand periods, is one of the core difficulties of cellular networks. In order to decrease the blocking probability, which occurs when a user tries to begin a call but the system does not have enough resources, the system must utilize existing resources effectively. Users may become dissatisfied, churn rates may rise, and service reputation may suffer if blocking probabilities are high. Similarly, there are special difficulties with handover calls, which involve switching cells as users move around. Dropped connections during handover

IJAMSR

International Journal of
Advanced Multidisciplinary Scientific Research (IJAMSR) ISSN:2581-4281

conversations may drastically diminish the customer experience if not handled correctly. If you want to keep your customers happy and stay competitive in the market, you need to make sure your call management systems can handle both new and handover calls.

Call management is affected by a lot of things, such how the network is designed, how much traffic there is, and how users respond. With smart resource allocation in response to real-time demand, a well-designed network can provide enough bandwidth for both new calls and continuing sessions. When users in a network have different expectations for the quality of service they get, dynamic resource allocation methods like priority-based queuing and reservation schemes come in handy for keeping everyone's needs met. One method that has been shown to drastically cut down on lost calls is the use of guard bands, which provide a certain amount of bandwidth just for handover calls. Nevertheless, it is important to consider the potential drawbacks of this strategy, such as longer wait times for incoming callers, while developing call management techniques.

Many network operators are looking at new technologies like AI and machine learning to improve call handling. In order to improve the overall efficiency of the network and allocate resources proactively, these technologies may examine past data in order to forecast traffic patterns. Networks may improve their reaction to changing traffic loads and, in turn, call management performance, by using algorithms that learn from previous actions. On top of that, analytics powered by AI can help with decision-making in real-time, so you can quickly change how resources are allocated according to user requests.

There are new possibilities and threats to call management brought about by the advent of 5G networks. The next 5G network is expected to completely transform the way we communicate by offering more faster data speeds, less latency, and more capacity. But, current call management procedures also need to be reevaluated in order to make the switch to 5G. Modern methods of call optimization are insufficient due to the complexity of 5G architecture, which includes support for mMTC and URLLC. An integral part of 5G, network slicing lets operators build several virtual networks on top of a single physical infrastructure, letting them allocate resources according to user needs. Network slicing allows operators to optimize call handling for various use cases, allowing for the optimal coexistence of both conventional voice services and developing apps.

II. REVIEW OF LITERATURE

Subramanian, Kanaga Suba Raja & Virgin Louis, Bamila. (2021) This literature review provides an overview of CAC methods in cellular wireless networks; more specifically, we highlight the relevance of CAC in the present day of communication and categorize it according to the research. This article presents a number of CAC scheme design considerations, investigates several CAC implementation approaches, and concludes by mentioning some research topics and difficulties related to next-generation wireless networks.

Singh, Avinash et al., (2018) The sudden increase in the demand from customers to make connections in a certain cell at the same time causes congestion, which is a common occurrence in wireless media. Cellular network traffic congestion is a common issue that has persisted through almost every generation. This is a daily challenge for all mobile network providers, and they haven't

IJAMSR
International Journal of
Advanced Multidisciplinary Scientific Research (IJAMSR) ISSN:2581-4281

been able to find a solution yet. The growing number of people using cellular devices is driving up the need for more advanced gadgets, which in turn increases the bandwidth requirements of cellular subscribers.

Safwat, Mahammad et al., (2014) Optimizing the usage of assigned channels versus provided traffic while preserving the needed quality of service (QoS) is the job of the call admission control (CAC). It is difficult to provide quality of service to users at the cell edge when cell resources are limited because of inter-cell interference (ICI). Soft Frequency Reuse regulates how users share resources, which is one way to lessen the impact of ICI.

Senouci, Sidi-Mohammed et al., (2004) This article discusses the call admission control (CAC) issue in cellular networks that deal with various types of traffic that have varying resource needs. A semi-Markov decision process (SMDP) issue formulation is used for the problem.

III. EXPERIMENTAL SETUP

Simulation Environment

We used Matlab, version 7.0.1, to construct our method. This program is selected because to its pre-installed foundation of features that are essential for simulating various traffic rules and queues. To generate traffic models based on random processes, functions like poissond and expond were invaluable (poissoniens, exponential, etc.).

For the purpose of representing the findings in curve form, other functions such as plot were also quite helpful.

Simulation Parameters

The following assumptions and parameters were included into the simulation design:

- A homogeneous network has several cells, whereas this network only has one cell.
- Both the uplink and the downlink may use the full 10 Mbps of available bandwidth in the BS.
- Frame duration: 5ms.
- New and HO calls' arrival processes are poissonniens, with λ and μ being the corresponding parameters, and $\lambda = \mu * 5$.
- A duration of 200 frames is used for the observation.
- Two kinds of traffic are taken into account here: video traffic encoded using MPEG-4 and file transfer protocol traffic whose flow ranges from 16 to 256 kbps. 5Kbps is the allotted minimum flow.

IV. RESULTS AND DISCUSSION

Impact of Guard Band on New Call Blocking Probability

We have recreated the BS's actions in relation to the new call arrival rates λ. Rates range from 25 to 45 calls per second (with HO call arrival rate: $\mu=\lambda/5$) in both the G=0 and G=B/10 scenarios, where B=5Mbps. The two curves shown in Figure 1 are the results of the computation of the likelihood of new calls blocking:

International Journal of
Advanced Multidisciplinary Scientific Research (IJAMSR) ISSN:2581-4281

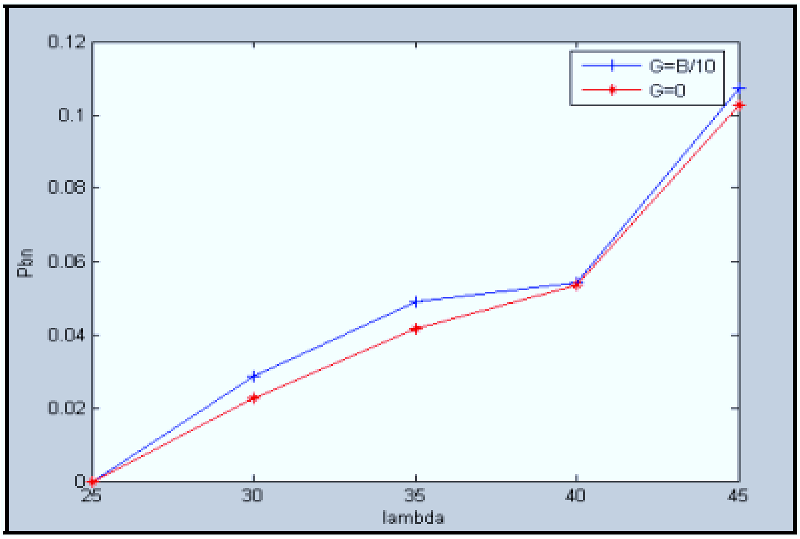

Figure 1: Impact of Guard Band on New Call Blocking Probability

The likelihood of new connections being blocked increases as λ (and by extension, μ) increases, as seen in Figure 1. The blocking rate is considered acceptable while κ is between 25 and 35 calls/s, ranging from 0 to 4%. However, when κ goes above these values, the blockage rate becomes too high, reaching over 10% when κ goes over 45 calls/s. In the first scenario, when G=0, the blocking rate is the lowest. This is understandable given that in this instance, both new and HO calls are handled equally: they are accepted if the bandwidth is available. As a result of allocating some bandwidth specifically for HO calls, the likelihood of new calls being accepted decreases, leading to an increase in the likelihood of calls being blocked, in the second scenario when G=B/10=500 kbps.

Impact Of Guard Band on HO Calls Dropping Probability

Using the same settings as the previous paragraph, we have simulated the BS behavior to explore how the guard band affects the dropping likelihood of HO calls. Figure 2 displays the outcomes of the simulation.

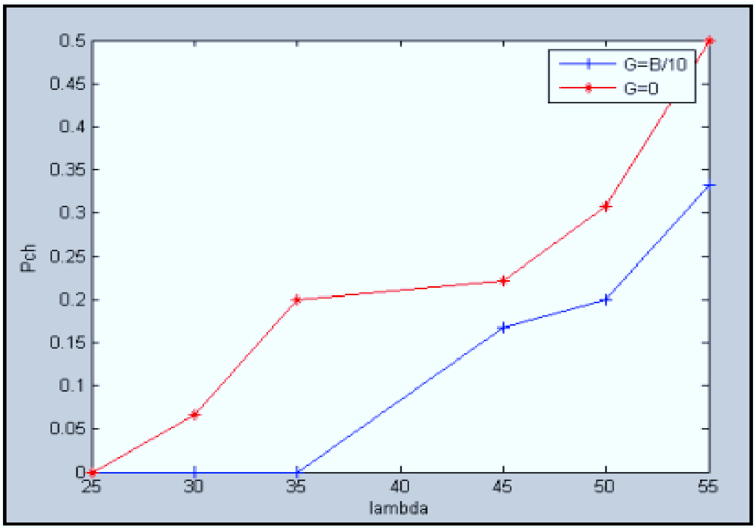

Figure 2: Effect of The Guard Band on The Decrease in The Likelihood of HO Calls

IJAMSR
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As contrast to the policy without the band, which leads in a HO call dropping rate ranging from 2 to 20 times for an arrival rate Λ of 30 to 55 calls/s, we find that the admission control policy with the band significantly reduces this rate. The user has it bad when the Pch goes above 10% after 45 calls/s, which is terrible since losing calls is far worse than blocking them initially, and all HO calls are accepted up to 35 calls/s. We may experiment with parameter G to see what happens if we maintain this probability below a certain threshold for a high call arrival rate.

Protective Band's Effect on Typical Lag Time for New Real-Time Connections

Here, we suggest figuring out how long it typically takes for fresh real-time calls to be serviced in the queue. The following assumptions were made by us: There is a 40-millisecond limit on how long a real-time call may wait in the queue before being refused. This time is 10 milliseconds for HO calls. We got the following results (see Figure 3) by changing λ between 25 and 55 calls/s.

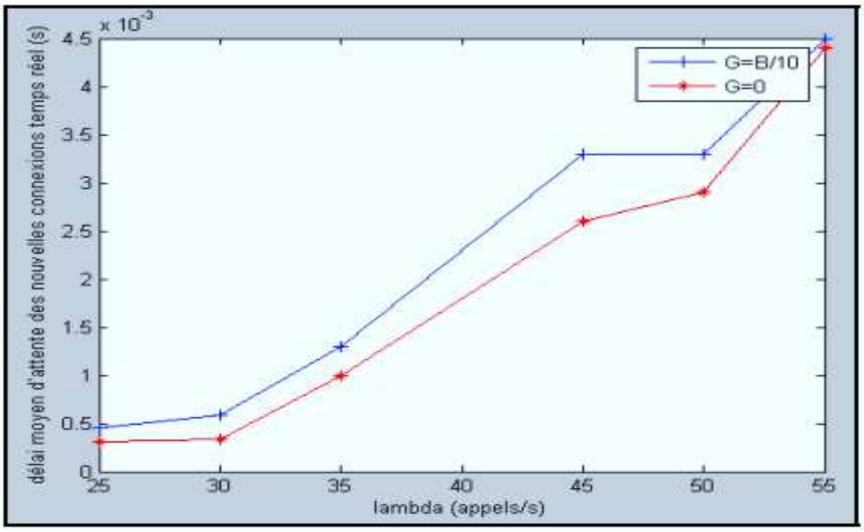

Figure 3: Impact of Guard Band on Average Waiting Time of New Real-Time Connections

The average waiting time for new real-time connections grows when the arrival rate of new calls and the guard band G both rise, as can be shown in Figure 9. New calls are more likely to be utilized with G=0 because they can take use of the available bandwidth. After that, they will wait in line, if not directly. If G is not equal to zero, means that some bandwidth is set aside for HO calls only, there might be available bandwidth that new calls can't use because it's reserved for HO calls only. This causes the call to wait in the queue and, if it goes over the maximum for the affected period, it might be rejected.

Impact Of Guard Band on Average Waiting Time of Real-Time HO Calls

This section will analyze the influence of guard bands on the average waiting time of real-time HO calls, using the identical assumptions as the previous paragraph. Two curves in Figure 4 were produced by the two scenarios when G=0 and G=B/10.

IJAMSR
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Advanced Multidisciplinary Scientific Research (IJAMSR) ISSN:2581-4281

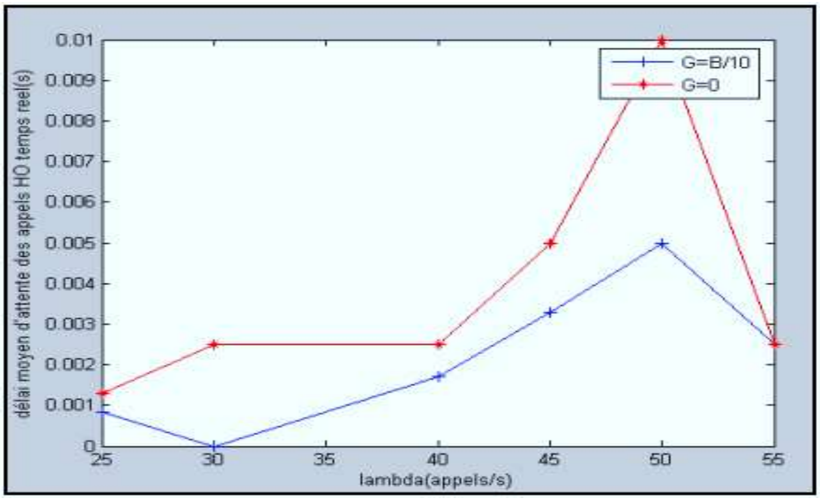

Figure 4: Impact of Guard Bands on Average HO Call Wait Times in Real-Time

When comparing two entry control policies, one with and one without guard bands, in terms of real-time HO call handling, the former yields superior results (Figure 4). Due to the high time demand of these calls, it is critical to maintain the call waiting time before being given below a particular threshold whenever a request is made to migrate from one cell to another. Based on the statistics given in this image, our solution saves us about half the time compared to a policy without a guard band.

V. CONCLUSION

When compared to situations without a guard band, the testing findings show that HO call dropouts are reduced by a factor of two to twenty when a guard band reservation method is used. Results also show that waiting times for real-time connections and the likelihood of new calls being blocked both increase with increasing call arrival rates. While a guard band does improve HO call management, it unintentionally makes new call wait times longer, especially when bandwidth is set aside just for HO connections. The research concludes that in order to maximize the network performance, minimize user discomfort, and provide excellent service quality for both new and HO calls, a balanced approach is necessary when implementing guard band regulations. Improving the efficiency of call management in dynamic network settings might be the focus of future study, which aims to refine the guard band parameters to improve the trade-off between call admission rates and waiting times.

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