

A Dynamic Pre-Emptive Call Admission Control Scheme for Emergency Communications in LTE-Based Public Safety Networks



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ABSTRACT: Historically, wireless networks have experienced difficulties caused by network congestion because of inadequate resources. Network providers and subscribers are affected by congestion through degraded Quality of Service (QoS). Network congestion becomes even more worrisome for emergency calls especially during emergencies. To manage this challenge, a pre-emptive call admission control (Pre-CAC) scheme that prioritizes public safety calls amidst emergency conditions, is proposed. This technique focuses on minimizing the inconveniences faced by Emergency First Responders (EFR) and the public by prioritizing public safety calls above commercial calls during emergencies. The Pre-CAC scheme explores probability methods to vary certain network conditions in-line with dynamic call behaviours. Network Simulator 3 was used for the simulations to measure the performance of the Pre-CAC scheme using throughput, call rejection rate and resource utilization as performance metrics. Comparing the Pre-CAC scheme with its reference model (ECACS), Pre-CAC scheme displayed improved results for public safety voice calls; throughput was enhanced by 3.06%, percentage resource utilization improved by 0.12% and call rejection rate decreased by 6.38%. The results show that during emergencies, Pre-CAC scheme can efficiently manage congestion and enhance communication of critical calls in long term evolution (LTE)-based Public Safety Networks (PSN).

KEYWORDS: Call Admission Control, LTE, Public Safety Network, Resource utilization, Throughput.

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I. INTRODUCTION

The conventional Public Safety Communications began with the police department, Detroit city in the United States on 7th April 1928, utilizing Long-Range Mobile Radio (LMR) technology (Alcatel-Lucent, 2023). It is the beginning of secure and dependable communications networks for public safety ministries globally. Public safety network (PSN) is a radio network built with sufficient resilience to enable communication during emergency conditions (El-Keyi *et al.*, 2017). It is a network of choice particularly in a case of emergency but is vulnerable to network congestion. Emergency situations are inevitable, and Emergency First Responders (EFRs) are under obligation to reduce the impacts of such situations on the general public. Call admission control (CAC) algorithms have always been a force to reckon with in terms of network management especially for managing congestion (Ani and Ani, 2020). LTE, being a broadband network, supports real time communications among the EFRs as it minimizes the impacts of emergency situations through uninterrupted call connections. The major direction of the studies in (AlQahtani, 2017; Ani and Ani, 2020; Yese *et al.*, 2019) is on theoretical part of CAC schemes. Their respective methodologies are classifying users & service types, adoption of analytical approach in the comparison of CAC schemes and a survey that categorizes schemes into different classes.

These research papers perform excellently well in theoretical evaluation of CAC algorithms and comparative analysis of various algorithms based on certain key performance indicators (KPI). Despite that, the papers are lagging in practical applications, falling short of discussions on trade-offs between KPIs. The studies equally oversimplify the complexity of network behaviours. The papers in (Ahmad and Chang, 2020; Belghith *et al.*, 2016; Vanitha and Amudha, 2023; Shen, *et al.* 2020) aim to enhance CAC algorithms and some propose for new ones using different methodologies. Such methodologies include the use of coordinated scheduling, classification of calls into real time and non-real time, proficient rate control & fair bandwidth allocation and efficient base station placement algorithm respectively. Significant improvements are made by these studies in proposing tangible enhancement methods for CAC algorithms and in uncovering new methods to enhance network performance. However, these studies fail to show practical implementation strategies, depending solely on simulations. Again, they are limited in comparative analysis with other existing algorithms or schemes. The studies in (Sun *et al.*, 2017; Khedhir *et al.*, 2016) are all focused on emergency conditions and public safety. Their approaches are selective admission control mechanism and classification & prioritization method, in that order.

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The strengths of these studies lie in their clear relevance to critical emergency scenarios, with the aim of enhancing network performance for critical communications. But their overwhelming weaknesses include lack of consideration of any emergency situations, oversimplifying emergency response requirements and limited analysis of implementation difficulties. According to (Mohammed and Suleman, 2021; Younes *et al.*, 2023), the issue of delivering guaranteed QoS in LTE networks has been handled.

Their respective methodologies are dynamic degradation algorithm and probabilistic model checking. The studies are rich in handling important QoS issues in LTE networks and in suggesting novel approaches for allotment of resources. In spite of these gains, the papers are lacking in validation of their individual schemes and also falling short in analysis call behaviours under changing network conditions. The complexities involved in practical implementation of the approaches are largely overlooked by the studies.

In (Saha and Cioffi, 2024; Senapati, 2021; Khan *et al.*, 2023; Khan *et al.*, 2024; Nasralla and Rehman, 2018), modern technologies and how to incorporate various systems into LTE networks are investigated. Their individual approaches involve; “dynamic spectrum sharing, system capacity estimation & parameters optimization, analysis of challenges, optimizing the positions of the observational & relay and analysis of downlink scheduling schemes respectively”. The papers perform well in the aspect of investigating state-of-art technologies and incorporation concepts, thereby giving perception into modern directions for CAC algorithms. However, they fall short in providing current real-world applications of their respective algorithms.

The technical challenges associated with incorporating both existing infrastructure and modern technologies are not considered. Authors in (Alcatel-Lucent, 2023; Seeman *et al.*, 2018; Uchenna *et al.*, 2020; Martin *et al.*, 2021; Santiago *et al.*, 2024) use different methods to address the network challenges. Their respective methods involve, investigating the transition of LTE to packet-switched models, examining Next Generation 911 (NG911) issues, prioritized CAC schemes, disaster relief Device-to-Device (D2D) communication and Mission Critical Services (MCX) voice service limitations. The studies give insight into network advancement, policy gaps and performance improvements. Unfortunately, the papers focus on few specific areas, not considering in-depth implications and possible shortfalls. They are also lacking in detailed analysis of real-world advancements and challenges that cut across their individual areas.

Creative approaches for improving mobile network quality and enhancing timing synchronization in LTE systems are examined in (Alimi *et al.*, 2015; El-Keyi *et al.*, 2017; Cicalò and Tralli, 2018). Their respective methodologies involve, overview of attributes & benefits of congestion control schemes, computation of timing detection metric & adaptive filtering, and a combination of admission control & radio resource allocation strategies. The strength of the papers rests on their promising techniques in handling

signal degradation, network congestion and ease of interference. However, they depend largely on simulations for validation and are also lacking in detailed evaluation of the limitations of their individual approaches.

Irrespective of the research gains made by some of the studies that are closely related to this research paper, there still exists a noticeable gap. The study (Khdhir *et al.*, 2016), an Efficient Call Admission Control Scheme for LTE and LTE-A Networks (ECACS) is otherwise referred to as the reference model. ECACS falls short in appreciating the evolving and dynamic nature of networks in real-world settings, unintentionally ignoring new calls. In the same vein, the scheme presented in (Sun *et al.*, 2017) referred to as reference model-2 - selective admission control (SAC), is lagging by being static. It lacks the variability to show the dynamic nature of network conditions. Having recognized this basic limitation, this paper aims to bridge the gap by proposing a scheme that addresses the dynamic evolution of networks. It proposes a dynamic pre-emptive CAC (Pre-CAC) algorithm that considers the network conditions and degree of importance of each call before allowing such a call to access the network resources, particularly during congestion.

In this study, strategies like public safety voice (PSVo) calls and the dynamic Pre-CAC scheme are identified to improve emergency communications amidst network congestions. It opens up opportunities for efficient and reliable emergency communication systems via designed configurations and resource management technique. It provides valuable direction to network administrators and policy makers who are in want of reliable emergency communication. The remaining parts of this paper are organized as follows. Section II presents the research methodology. Results and their accompanying discussions are presented in Section III. In Section IV, the research conclusions are presented.

II. METHODOLOGY

A. Description of the Physical Architecture

The physical architecture of a typical LTE network that shows how it implements CAC schemes using isolated eNodeB and user equipment (UE) is shown in Figure 1. The architecture ensures effective resource control, random distribution of UEs and dependable connections between eNodeBs and UEs. The ability of LTE to guarantee high-speed and low-latency mobile broadband services to different applications is based on the combination of these components.

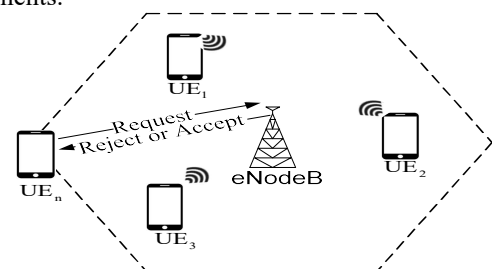


Figure 1 eNodeB with Distributed UE

B. Development of the Proposed Dynamic Pre-CAC Scheme

The proposed scheme is presented in Figure 2. The figure explains the flow of calls when they arrive at the enodeB.

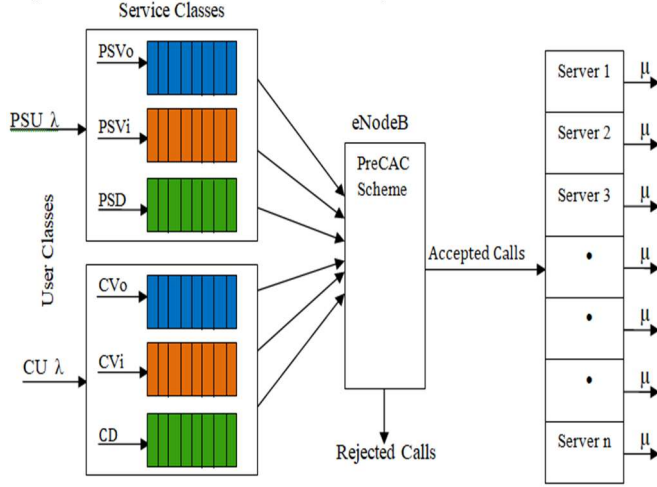


Figure 2 The Proposed Pre-CAC Model

In this work, users are grouped into public safety users (PSU) and commercial users (CU). Both groups share the same network resources. The proposed scheme gives higher priority to PSU over CU in LTE network. The following assumptions are made in this paper.

- The call arrival requests follow a Poisson process with mean arrival rate $\lambda_{i,j}$, as call arrivals are independent of each other.
- Every call class ij has its own buffer (Buf_{ij}) and the maximum buffer delay for each call is defined based on its QoS requirements. This prevents resource starvation among different call types.
- Low priority calls can borrow the resource blocks (RBs) meant for high priority calls but can be pre-empted without prior notice. This is to ensure optimal resource utilization.
- Calls are classified into voice, video and data calls to ensure precision.
- Emergency happenings usually occur at specific places; hence this paper has no consideration for handover calls.

1) The dynamic pre-cac scheme formulation

The approach involves applying a probability concept to match different calls during emergency situations. This entails modelling each call using queuing concept.

The classification of users is denoted by i , so for Public Safety users, $i = 1$ and for Commercial users, $i = 2$. Similarly, the classification of call types is denoted by j and for voice calls, $j = 1$, for video calls, $j = 2$ and for data calls, $j = 3$.

In general, the classifications are public safety voice call (PSVo), public safety video call (PSVi), public safety data call (PSD), commercial voice call (CVo), commercial

video call (CVi) and commercial data call (CD). The priority of user and call classes with their attached numerical index is in descending order as follows: PSVo (0), CVo (1-2), PSVi (3-4), CVi (5-6), PSD (7-8) and CD (9). The priority factor for each call is proportional to the QoS required by the call and such determines the call's access to the network. In order to evaluate the priority levels for Public Safety users and commercial users, two factors are adopted and they are; delta (δ) and theta (θ), respectively. For call priority levels, the factors adopted for voice, video and data calls are as follows: alpha (α), beta (β) and gamma (γ), respectively. The user priority factors are related as shown in Equation (1).

$$P(\delta \cup \theta) = P(\delta) + P(\theta) = 1 \quad (1)$$

Also, the priority levels for calls are related as expressed in Equation (2).

$$P(\alpha \cup \beta \cup \gamma) = P(\alpha) + P(\beta) + P(\gamma) = 1 \quad (2)$$

where $\alpha > \beta > \gamma$ while, $0 < \alpha < 1$, $0 < \beta < 1$ and $0 < \gamma < 1$.

In Equation (2), $P(\alpha) = 1 - [P(\beta) + P(\gamma)]$,

$$P(\beta) = 1 - [P(\alpha) + P(\gamma)], \text{ and}$$

$$P(\gamma) = 1 - [P(\alpha) + P(\beta)]$$

The product of the user priority and the call priority factors determine the pre-emption capability or vulnerability of a call ij and is represented as the Pre-emption Level, PL_{ij} . It

is the overall priority level for any ij call request. Note that higher priority level leads to higher access to the network resources and vice versa. In this research, the RBs dedicated to user connection plane N_u are segmented into six parts

for the six different call types as follows: $N_{11}, N_{12}, N_{13}, N_{21}, N_{22}$, and N_{23} . Consequently, the RBs needed to guarantee the QoS required by a call ij is denoted by N_{ij} .

Therefore, the sum of RBs required by the individual connections in a network is given in Equation (3)

$$\sum N_{ij} \leq N_u \quad (3)$$

Hence, the bandwidths required by each individual call requests are as given in the following equations:

For a PSN voice call, the bandwidth required is determined using Equation (4).

$$N_{11} = P(\delta) \cap [1 - (P(\beta) \cup P(\gamma))] \times N_u \quad (4)$$

The bandwidth required by a PSN video call is evaluated as in Equation (5).

$$N_{12} = P(\delta) \cap [1 - (P(\alpha) \cup P(\gamma))] \times N_u \quad (5)$$

For a PSN data call, the required bandwidth is calculated using Equation (6).

$$N_{13} = P(\delta) \cap [1 - (P(\alpha) \cup P(\beta))] \times N_u \quad (6)$$

The bandwidth required by a commercial voice call is computed as in Equation (7).

$$N_{21} = P(\theta) \cap [1 - (P(\beta) \cup P(\gamma))] \times N_u \quad (7)$$

For a commercial video call, the bandwidth required is defined in Equation (8).

$$N_{22} = P(\theta) \cap [1 - (P(\alpha) \cup P(\gamma))] \times N_u \quad (8)$$

The bandwidth required by a commercial data call is determined using Equation (9).

$$N_{23} = P(\theta) \cap [1 - (P(\alpha) \cup P(\beta))] \times N_u \quad (9)$$

For the proposed dynamic Pre-CAC scheme, before a call request is accepted or rejected, the total RBs currently in use

N_c and the potential load increment in terms of RBs ΔN_{ij} , are considered. The increment in load is defined as expressed in Equation (10).

$$\Delta N_{ij} = S \times \left[\frac{N_{ij}}{W_{RB}} \right] \quad (10)$$

where, S = number of sub-frames, W_{RB} is bandwidth of one RB, N_{ij} is the bandwidth required by the new call request.

At any given moment, there would be k_{ij} active connections in the network. Therefore, the number of RBs in use at any moment is calculated using Equation (11).

$$N_c = \sum_{i,j=1,1}^{2,3} k_{ij} \times \Delta N_{ij} \quad (11)$$

For the network to operate free of congestion, the condition given in Equation (12) needs to be met.

$$N_c + \Delta N_{ij} \leq N_u \quad (12)$$

The procedure for the scheme is as follows:

- i. A call request ij is served if the condition given in Equation (12) is met.
- ii. When a request arrives and there are no RBs to serve it with, the priority policy is followed strictly. It either pre-empts low priority calls or goes to the buffer. Again, if there is no space in the buffer, the call will be rejected.
- iii. A call request ij can be dropped from the buffer, if it stays beyond its maximum buffer delay limit.
- iv. When one or more RBs become available, the value of the pre-emption level PL_{ij} is re-evaluated for each buffered request ij . The request with the highest PL_{ij} value is given the highest priority to access the network resources.

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The buffer serves as intermediate call storage location where a call waits until it can be processed if the network is congested. When a call arrives, the developed scheme checks if there is congestion in the system, if yes, it checks for available buffer space and if space exists, a buffer is allocated, and the call is stored. If no space is available, the call is rejected. A stored call waits in queue until processing is completed. If the buffer delay limit is reached without the call being served, then the call will be dropped from the buffer (rejected).

The value of the pre-emption level PL is determined as in Equation (13).

$$PL_{ij} = \frac{N_{ij}}{N_u} \quad (13)$$

The flowchart of the proposed CAC scheme is shown in Figure 3, depicting the scheme analyses a call on its arrival.

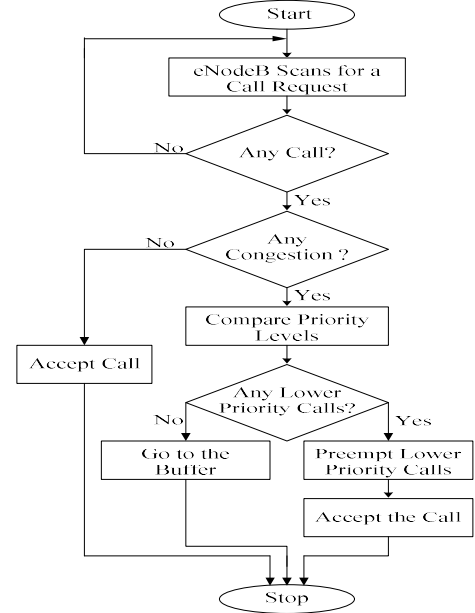


Figure 3 The Pre-CAC Scheme Flowchart

The pseudo code for the developed scheme is as follows:

1. **Begin**
2. eNodeB scans the network for a call request
3. **if** equation (1) holds:
4. then compute Equation (2)
5. **if** any congestion:
6. Compare priority level as in Equations (4-9)
7. **if** any lower priority call:
8. Pre-empt lower priority calls
12. **else:**
13. Accept call request - Equation (12) holds
14. **else:**
15. return to step 2 - Equation (1) fails
16. **End**

C. The Dynamic Pre-CAC Model Simulation Approach

Network Simulator 3 version 3.39 (NS3 v3.39) was used for the simulations to evaluate the effectiveness of the developed dynamic Pre-CAC model. The choice of NS3 was based on its improved capabilities and rich features as a discrete network simulator. This simulation tool served two purposes: it helped in collection of data through a testing process and examined the performance of the developed scheme across various call volumes. The implementation of the whole simulation setup was performed using the C++ programming language. The simulation data was generated by keeping the total number of RBs & channel bandwidth constant while the number of UEs was varied with

increment of 20 UEs at each interval. A command-line tool called *tshark* was used to capture and analyze the generated network traffic in packet capture (*pcap*) format. See appendix B. The simulation parameters used for the evaluation are given in Table 1 (Nasralla and Rehman, 2018).

Table 1: Simulation parameters (Nasralla and Rehman, 2018)

Parameter	Value
Channel bandwidth	20MHz
Total number of RBs	100
Number of subcarriers	1200
Subcarriers Spacing	15KHz
Number of subcarriers	12
Transmission Time	1ms
Number of users	120
Frame duration	10ms
Modulation scheme	QPSK, 16QAM, 64QAM
User priority factors	$\delta = 0.6$ and $\theta = 0.4$
Call priority factors	$\alpha = 0.7, \beta = 0.2, \text{ and } \gamma = 0.1$

This study used certain performance metrics such as: throughput, packet loss and percentage resource utilization due to preemption. The validation process involved a comparative analysis of the developed scheme with a reference model.

III. RESULTS AND DISCUSSION

A. Presentation of Results

The findings from the simulation of the developed model and the accompanying discussion are presented in this section. The goal of the discussion is to validate how effective the developed dynamic Pre-CAC scheme is, via comprehensive analysis. The analysis is used to measure how efficient the dynamic pre-CAC scheme is in controlling network congestion. Figure 4 presents the throughput graphs for three different call types during emergency. The call types are; the reference model (ECACS), PSVo and CVo calls.

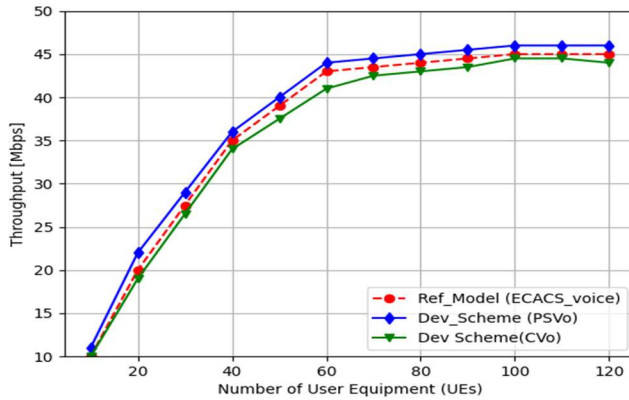


Figure 4 Throughput (Mbps)

In Figure 4, the graphs for the three call types show a gradual but continuous rise as the number of UEs increases. In Figure 5, the Call Rejection rates for PSVo, PSVi and

PSD Calls and those of the reference model (SAC) are presented.

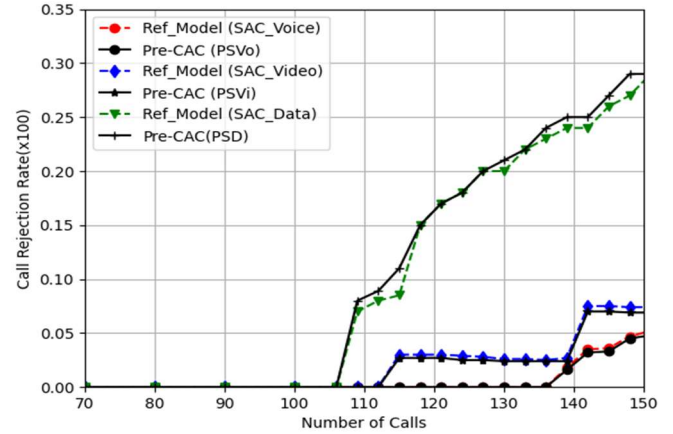


Figure 5 Call Rejection Rates for Ref Model (SAC), PSVo, PSVi and PSD

Figure 5 shows an inclination where the call rejection rate for both the reference model and the developed dynamic Pre-CAC scheme grows as the number of calls increases. In Figure 6, the graphs of the network resource utilization are presented.

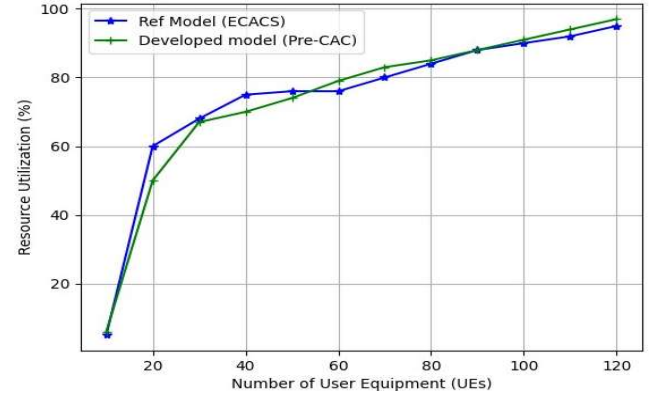


Figure 6 Resource Utilization (%)

Figure 6 presents graphs of resource utilization plotted against number of UE for the dynamic Pre-CAC and the reference model (ECACS).

B. Discussion of Results

The theoretical framework of the dynamic Pre-CAC scheme involves prioritization of high-profile calls, resource efficiency and congestion control. The framework is closely followed while implementing the scheme. Simulation results in Figures 4 to 6 validate these theoretical frameworks using key performance metrics.

Figure 4 presents the graphs of throughput performance for three different call types (PSVo, CVo, and ECACS), against the number of UEs. The graphs show that with increasing number of UEs, the throughput for each call type witnessed a continuous rising trend. The trend indicates that the network system can manage increased load without experiencing network congestion. As the number of UEs gets to a certain threshold, the throughput becomes stable for all call types. This stability implies that the developed model

supports consistent performance even as it draws nearer to its full capacity. The difference in values of the throughput of CVo and PSVo calls, with PSVo calls indicating superior performance, is a pointer that the developed scheme naturally favours high-priority calls. This supports the theoretical principle that focuses on QoS for critical calls. Figure 5 shows the graphs of call rejection rate for ECACS and the developed dynamic Pre-CAC scheme against number of calls.

The rejection rate for both schemes increases with increase in the number of calls. This rising trend is in line with the usual pattern of network congestion. It suggests that as more calls get connected to the network, the tendencies of rejecting incoming calls during admission also increases. It is a pointer that there is network congestion. The graph of dynamic Pre-CAC PSVo has the least rejection rate, compared to the ECACS model. It supports the theoretical design of this dynamic admission control and improves connections for critical calls during congestion. Figure 6 presents graphs of resource utilization for the developed scheme and its reference model plotted against different numbers of UEs. As the number of UEs increases, resource utilization also increases. The common increasing trend shows an efficient and balanced resource allocation scheme. It indicates that increased network congestion can lead to increase in demand for network resources. The near-linear increase in resource usage shows scalable and balanced resource allocation, matching theoretical expectations for efficient congestion-aware network design.

C. Validation of Results

In Figure 4, the throughput of the developed dynamic Pre-CAC model particularly PSVo call, shows a 3.06% enhancement compared to that of the reference model (ECACS). This is statistically significant with probability value (p-value) of 7.39×10^{-8} ($P < 0.05$). However, the throughput of the reference model slightly outperformed that of CVo by 2.15% but with p-value ($p < 0.05$), meaning that CVo is not the most prioritized call in the family of dynamic Pre-CAC scheme. The 3.06% throughput improvement in PSVo call indicates the effectiveness of the developed scheme (dynamic Pre-CAC) in prioritizing critical communications, ensuring enhanced call quality under heavy loads. This improvement in throughput can allow a typical urban cell to support approximately 30 additional high-priority voice calls during emergency periods. In Figure 5, the developed scheme, dynamic Pre-CAC-PSVo and Pre-CAC-PSVi calls show a decrease in call rejection rate with 6.38% and 8.01% respectively relative to reference model- selective admission control (SAC). Pre-CAC-PSVo is statistically significant with p-value of 0.00617 ($p < 0.05$) relative to SAC model. The disparity in call rejection rate for Pre-CAC-PSVo and Pre-CAC-PSVi shows the dynamic nature of network conditions in real-world scenarios. The reduced call rejection rates, 6.38% (PSVo) and 8.01% (PSVi) show enhanced capacity to manage high demands on resources, reducing user disruption and minimizing revenue loss from failed calls. The 6.38% reduction in call rejection rate, means 638 fewer dropped calls per 10,000 attempts.

Figure 6 shows that the developed scheme performs better than the reference model (ECACS) in the aspect of resource usage. Precisely, it uses resources more effectively than ECACS model by approximately 0.12%. For resource utilization, Pre-CAC shows no statistically significant difference from its reference model ECACS ($p > 0.05$). The 0.12% increase in resource utilization efficiency, translates into modest significant operational savings in resource usage. Resource utilization efficiency (0.12%) can cause reduction in resource overhead across 1,000 enodeBs. From a business viewpoint, prioritizing PSVo calls supports premium service offerings, protects revenue through reliable service delivery and separates providers in competitive markets. Again, the model's scalable and cost-efficient resource management supports sustainable network growth. These improvements support user satisfaction, operational reliability and business sustainability in real-world deployment settings.

IV. CONCLUSION

This research work developed a Pre-CAC scheme with the aim of reducing the effects of network congestion on critical calls in LTE-based PSNs. It started by prioritizing PS calls over commercial calls amidst emergencies. To achieve the aim, it used probability theory to represent different types of calls during emergency times. The dynamic network conditions are simulated using NS3 version 3.39. The validation of the developed scheme was performed by comparing the simulation results with those of the reference models. Generally, the developed scheme showed a significant improvement in network performance, managing major issues in present-day telecommunications networks. The improvements include guaranteeing enhanced throughput, minimizing call rejection rate and improving resource utilization under changing network scenarios. The results indicated that adjusted configurations (like PSVo calls) and resource management strategy (like the dynamic Pre-CAC scheme) can efficiently reduce the unfriendly effects of network congestion on emergency calls. Future research work would evaluate the application of the identified approaches across different network types and sizes in both rural and urban settings.

AUTHOR CONTRIBUTIONS

M. A. Ani: Conceptualization, Methodology, Validation, Writing – original draft, Writing – review & editing. **U. N. Nwawelu:** Software, Data curation, Visualization, Writing – review & editing. **D. A. Amoke:** Formal analysis, Validation, Writing – review & editing. **M. A. Ahaneke:** Supervision, Project administration, Writing – review & editing. **V. C. Chijindu:** Writing – original draft, Literature review, Writing – review & editing. **J. N. Eneh:** Supervision, Funding acquisition, Writing – review & editing.

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215–253.

Appendix A

```
vagrant@ubuntu-focal: ~/ns3/bake/source/ns-3.39
UE 37 is assigned a COMMERCIAL Video call with a final priority of 0.08
UE 38 is assigned a COMMERCIAL Voice call with a final priority of 0.28
UE 39 is assigned a COMMERCIAL Voice call with a final priority of 0.28
UE 40 is assigned a PUBLIC_SAFETY Video call with a final priority of 0.12
UE 41 is assigned a PUBLIC_SAFETY Voice call with a final priority of 0.42
UE 42 is assigned a COMMERCIAL Video call with a final priority of 0.08
UE 43 is assigned a COMMERCIAL Video call with a final priority of 0.08
UE 44 is assigned a COMMERCIAL Data call with a final priority of 0.04
UE 45 is assigned a COMMERCIAL Voice call with a final priority of 0.28
UE 46 is assigned a COMMERCIAL Voice call with a final priority of 0.28
UE 47 is assigned a COMMERCIAL Voice call with a final priority of 0.28
UE 48 is assigned a PUBLIC_SAFETY Video call with a final priority of 0.12
UE 49 is assigned a PUBLIC_SAFETY Data call with a final priority of 0.06
UE 50 is assigned a PUBLIC_SAFETY Video call with a final priority of 0.12
UE 51 is assigned a COMMERCIAL Video call with a final priority of 0.08
UE 52 is assigned a PUBLIC_SAFETY Voice call with a final priority of 0.42
UE 53 is assigned a COMMERCIAL Video call with a final priority of 0.08
UE 54 is assigned a PUBLIC_SAFETY Data call with a final priority of 0.06
UE 55 is assigned a PUBLIC_SAFETY Voice call with a final priority of 0.42
UE 56 is assigned a COMMERCIAL Voice call with a final priority of 0.28
UE 57 is assigned a PUBLIC_SAFETY Data call with a final priority of 0.06
UE 58 is assigned a COMMERCIAL Video call with a final priority of 0.08
UE 59 is assigned a COMMERCIAL Voice call with a final priority of 0.28
UE 60 is assigned a COMMERCIAL Data call with a final priority of 0.04
UE 61 is assigned a COMMERCIAL Data call with a final priority of 0.04
UE 62 is assigned a COMMERCIAL Data call with a final priority of 0.04
UE 63 is assigned a COMMERCIAL Voice call with a final priority of 0.28
UE 64 is assigned a COMMERCIAL Video call with a final priority of 0.08
UE 65 is assigned a COMMERCIAL Voice call with a final priority of 0.28
UE 66 is assigned a PUBLIC_SAFETY Data call with a final priority of 0.06
UE 67 is assigned a PUBLIC_SAFETY Data call with a final priority of 0.06
UE 68 is assigned a COMMERCIAL Data call with a final priority of 0.04
UE 69 is assigned a COMMERCIAL Video call with a final priority of 0.08
UE 70 is assigned a PUBLIC_SAFETY Video call with a final priority of 0.12
UE 71 is assigned a PUBLIC_SAFETY Data call with a final priority of 0.06
UE 72 is assigned a PUBLIC_SAFETY Voice call with a final priority of 0.42
vagrant@ubuntu-focal:~/ns3/bake/source/ns-3.39$
```

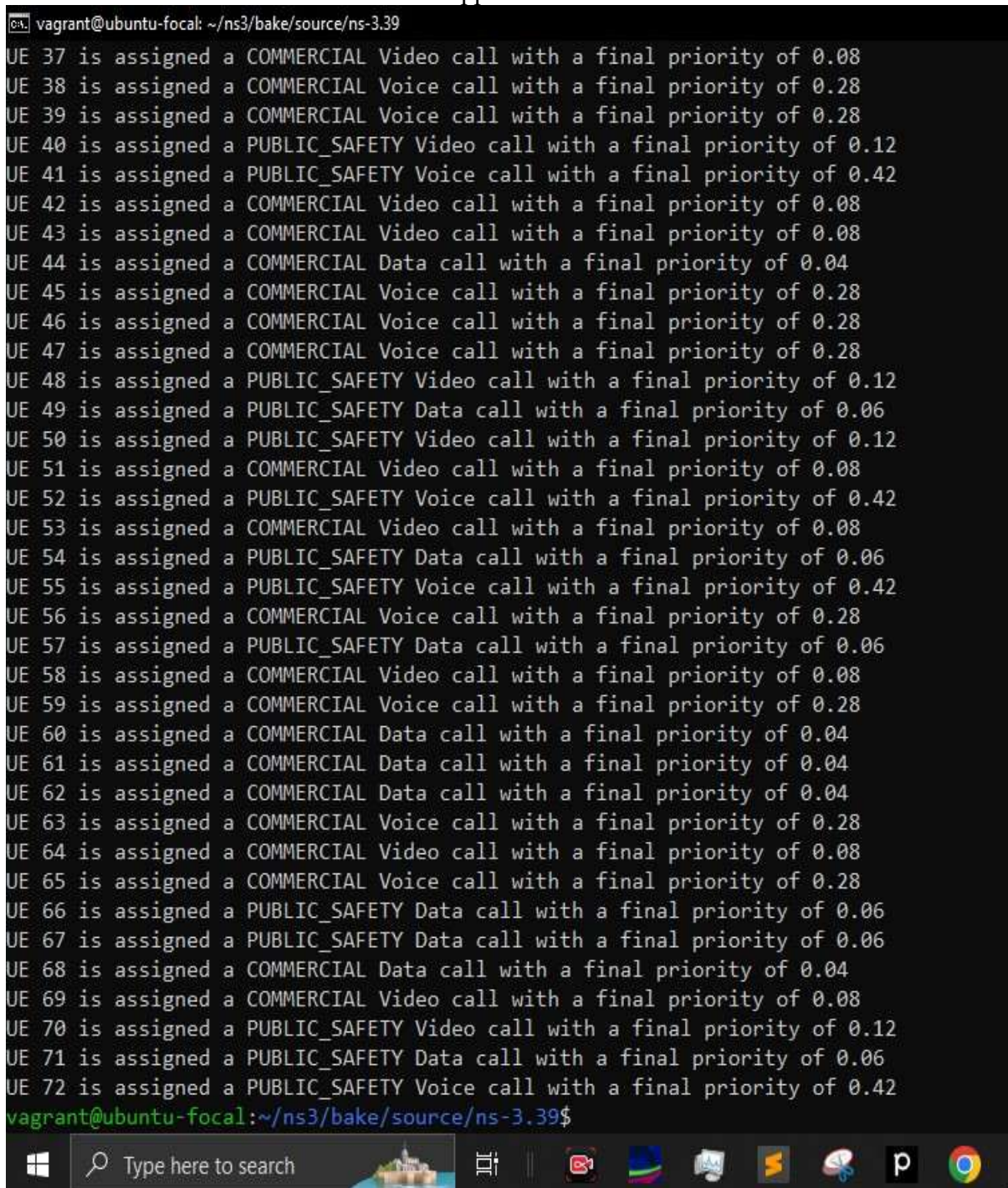


Figure A1: A Terminal Window of the Simulation Environment

Appendix B

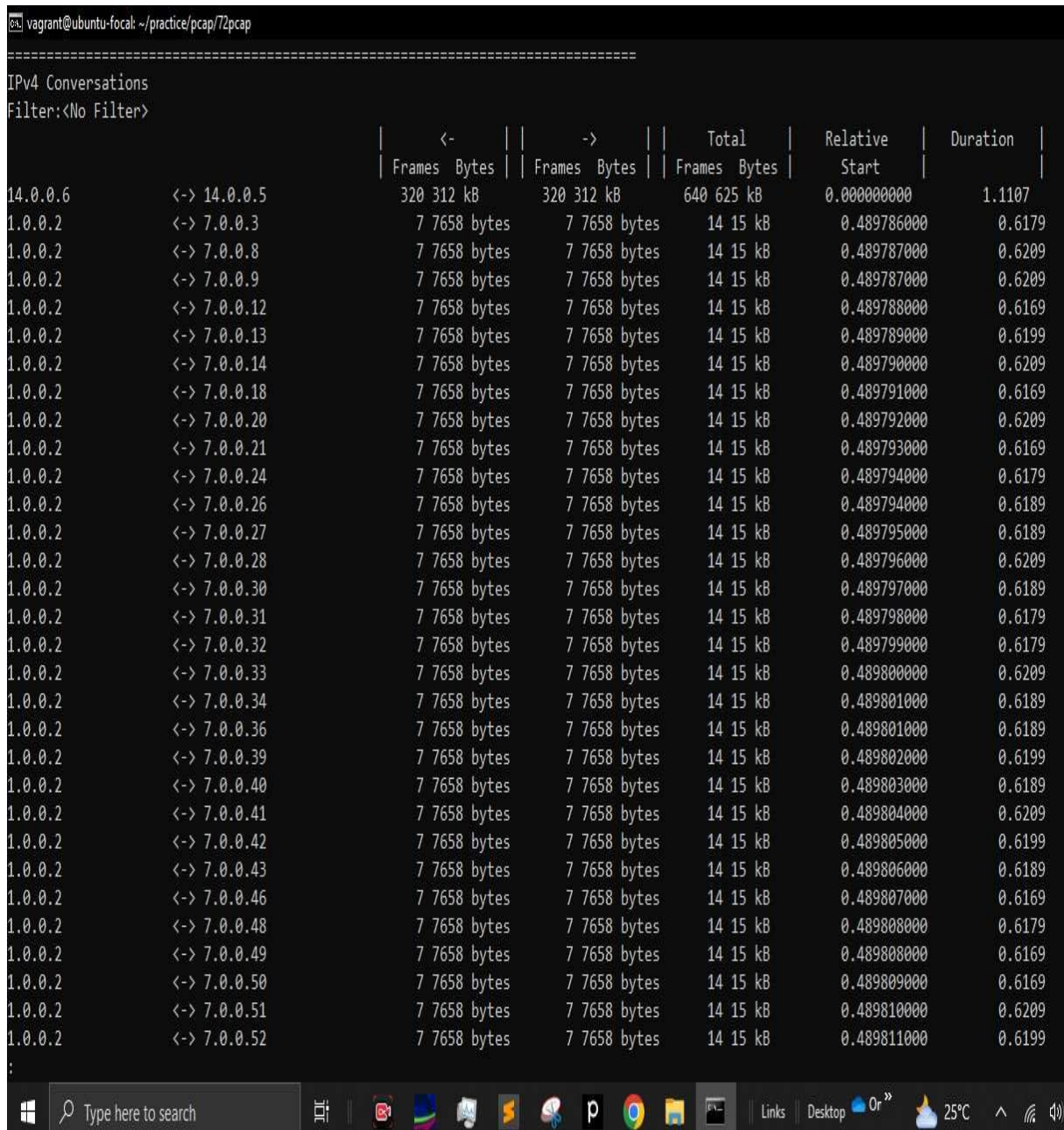


Figure B1: Extracted Simulation data