e-ISSN 3050-9661

10.5281/zenodo.15202001 Volume 8, Issue 1 (Jan-Jun 2025) Manuscript ID: #1843

Analysis and Modeling of Intelligent Channel Allocation Techniques in Mobile Communication Systems

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Abstract

This study is on the analysis and modeling of intelligent channel allocation techniques in mobile communication systems where different channel allocation techniques were considered in mobile communication systems. Also, the different channels which are used in the cellular networks were sufficiently described. Various parameters in mobile communication system that are related to channel allocation techniques and blocked calls were identified and discussed. Data collection was carried out from the Network Switching Center of a highly established and reputable Telecommunication Operator. Data were collected both from the Base Transceiver Stations (BTS), the Base Station Controller (BSC) and the Mobile Switching Centre (MSC), at different locations in Nigeria. These data were collected at different times on monthly basis for a period of thirty six (36) months in the course of this study. Proteus software was used to analyze data collected to enhance the simulation set up. A model (GRACE MODEL) of intelligent channel allocation technique algorithm was developed to reduce the call blocking and also call dropping probability. To authenticate the effectiveness of the proposed algorithm, the simulation result was demonstrated respectively showing normal capacity; over capacity; rerouting to neighbouring sector, e.t.c. It was observed that with the use of the proposed channel re-assignment strategies algorithm, the radio coverage at large distances had more increase in the system channel capacity. It was also observed that the blocked calls (the chance that a call will have no service) were highly reduced due to intelligent philosophy in the developed model. Additionally, the model helped to scale up performance and provided great improvement in network spectral and energy efficiency.

Keywords:

Intelligent Channel Allocation, Mobile Communication Systems, Call Blocking Probability, Network Performance Optimization, Spectral and Energy Efficiency.

How to cite: Charles, U., & Rex, U. (2025). Analysis and Modeling of Intelligent Channel Allocation Techniques in Mobile Communication Systems. *GPH-International Journal of Computer Science and Engineering*, 8(01), 13-25. https://doi.org/10.5281/zenodo.15202001

1.0 Introduction

Channel allocation is a strategic enhancer of the Fifth Generation (5G) operation in cellular networks. A convenient frequency range is usually assigned to base stations. The assignment of channels as well as the location of base stations plays a lead role in the characteristics and performance of cellular networks.

In channel allocation techniques, an individual channel is sub-divided and assigned to a number of users. This operation is to ensure that multiple operations can be carried out as long as there is demand on each of these sub-divisions in the channel by end users. Channel allocation techniques handle the allocation of channels in cellular networks which comprise cells. As soon as these channels are allocated, cells within the cellular networks will then allow users to access channels more effectively and efficiently. This is implemented by deploying frequency reuse by re-assigning frequency in a manner to avoid crosstalk (Huynh, 2015).

There are two prominent channel allocation techniques. These are: fixed channel and intelligent channel. In Fixed Channel Allocation (FCA) scheme, channels are permanently assigned. This strategy allocates channels to each cell in advance according to estimated traffic intensity in the cell. In intelligent channel allocation (ICA) scheme, channels are only allotted as needed. The ICA strategy foresees the assignment of radio resources to various cells dynamically in real time, to meet rapidly changing demand for communication channels.

This results in maximum utilization of network resources with less chances of call blocking in voice transmission. Intelligent channel allocation technique essentially explores the gains of cellular network resources by proactively engaging frequency reuse while ensuring smart and effective allocation of channels to mitigate network undesirable effects such as blocked calls and to attain system efficiency. To allow frequency reuse, the network cells can be split into smaller cells or microcells. This results in better frequency utilization through the use of identical frequencies which are separated to limit interference (Yang, 2016).

Also to maintain un-interruption of on-going communications, a current communication link is handed off to the next cell and with respect to the existing state of traffic, an optimal number of control channel is dynamically adapted in accordance with the user position information. Today, as 4G goes on full swing globally, 5G has become the current game changer to exploit. In this 5G era, the build-up towards the network spectrum deployment and global connectivity will translate into a monumental increase in cellular network technology development with the avalanche launch of premium electronic services such as e-money transfer, e-learning, e-commerce, e-voting, e-conferences, e-product launch, e-media, e-medical services, e-content development, e-media advertisement, etc.

The multiplier effect of this is that data rates will be more enhanced multiple times in the 2020s than it was in the 2010s era. What this implies is that during the 4G exploration, if a number of items are interfaced via the cellular network globally, then as much as over 20 times enhancement of the value of such items is achievable on the 5G technology. A number of local items, home smart items, retail products, industrial products, logistics and peripheral digital devices are linked to the network globally through the cellular technology (Vrbrski, 2017).

Going forward, 5G Internet of Things is fast becoming a global phenomenon in which the information super highway and macro level new age techniques are activated to ensure that the entire world becomes functionally integrated and activated to enhance the carrying capacity of such technology. While the unfolding cellular network technology continues to evolve and develop, the emerging networks remain a dynamic system with multiple and diverse career opportunities for continuous expansion, growth and development (Abbas, 2020).

2.0 Historical Review

Previous studies have explored the existing technologies at various levels to optimize channel allocation gains and overall system performance. The improvements on analogue and the earlier generation mobile communication systems have led to several algorithms and approaches being proposed to maximize channel utilization. Subsequently, the increasing applications of wireless communications have engendered more research in a manner to utilize available spectrum for robust commercial use in the midst of apparent limitations of wireless communication resources. The continuous and exponentially increasing rate of subscription in the internet and expectations from the wireless communication services providers in our modern world today, have continued to place a herculean burden on wireless network designers to fashion out ways of expanding the channel allocation capabilities. This is achievable by a way of spectrum reuse without demand for more bandwidth, while keeping the probability of blocked calls occurrence at barest minimal level.

A careful review of the works of previous authors reveal that, Huynh *et al*.(2015) used a Hungarian algorithm (HA) based power allocation and channel selection method to maximize the channel capacity under minimum blocking probability. This was achieved by defining the optimization tasks with maximum channel capacity for transmission and minimum interference in order to increase the transmission performance. The drawback associated with this model was the difficulty in realizing accuracy.

Miao *et al*. (2015) proposed a heuristic approach to address the problem of finding location and minimum number of central nodes to fulfill connectivity of the clustered smart network. They approached this model by incorporating advanced two-way communication and pervasive computing capabilities for improved control, efficiency, reliability and safety to upgrade the electricity distribution and management. However, the efficiency of the system was only restricted to location resources limitations.

Khan *et al*.(2016) proposed a channel allocation scheme by allowing distributed wireless networks equilibrium solutions for the analysis and prediction of convergent networks resources for the realization of high throughput. This was implemented by ensuring that the transmitter of a link was directly connected to the receiver of the link. The limitation of the model was that the overlap in the links led to dense networks with high level of interference especially for channels that share links.

Yang *et al.* (2016) proposed a dynamic spectrum allocation (DSA) based on fairness using binary particle swam optimization. They applied cognitive radio technology to communication infrastructure of smart grid by using dynamic programming to determine the optimal placement of base stations in an urban setting. However, the drawback associated with this model was the limitation of spectrum and the inefficiency of resource utilization especially in remote locations.

Kosta *et al*. (2017) developed a new concept in channel allocation based on metric and tool. They presented the description of the fundamentals of performance metrics and demonstrated how the approach can be used as a tool in improving metrics. However, its drawback was the difficulty in ascertaining the certainty of the freshness of information on remote systems.

Alam *et al*. (2017) used the general scenario and metaheuristic technique such as Genetic algorithm (GA) and cat swam optimization (CSO) to solve the channel allocation problem using the fairness and maximum sum reward (MSR). They supported a two-way flow of information through enabling self-monitoring remote testing and active control thereby increasing efficiency. However, the efficiency was limited to the two-way scope of the scheme while actualizing the optimization was somewhat complex.

Vrbsky *et al.* (2017) researched on clustering in smart grid with respect to load profiling and data analysis where Affinity propagation and Binary Firefly Algorithm were used as hybrid model to significantly increase the system efficiency. However, the drawback was non-linearity, difficulty in mapping the scenario and complex operation to ease the spectrum congestion.

Zhang *et al. (*2019) made an excellent review of the literatures on these emerging techniques, citing among them large intelligent surfaces and the advent of quantum computing which is increasingly present in large technological companies such as Google for quantum communication systems. They deployed large-dimensional and autonomous network architecture that integrates space, air, ground and underwater networks to provide unlimited wireless connectivity. However, call blocking probabilities was not properly addressed by the model.

Azarhava *et al. (*2020) proposed a new protocol based on non-orthogonal multiple - access in a wireless IOT network with energy harvesting sensors and limited battery cells. A closed form defining equation for the entire system is obtained and it is optimized by power scheduling parameters. However, achieving maximum throughput through minimum power requirement is still undergoing research efforts.

3.0 Materials and Methods

Data were collected on the following parameters which are related to channel allocation and blocked calls. They are:

(i) Cell Availability

(ii) High-Speed Packet Access (HSPA) Congestion Rate

(iii) Call Set up Success Rate (CSSR) -

(iv) Hand Over Success Rate

(v) Data Traffic.

(vi) Cell Location Area Code (LAC)- Unique number usually given to each location area within the network.

(vii) Cell CL

(viii) Number of Sites

(ix) Number of Cells

Adaptive Multi-Rate (AMR) Drop Calls Rate –Advanced voice codec rate at which voice is translated into digital data.

4.0 Presentation of Data

Table 3.1: Call Success /Call Blocking Benchmark

S/N	Parameter	Benchmark Value
1.	Call Setup Success Rate	Greater than or equal to 98%
2.	Call Blocking Rate	Lesser than or equal to 2%

Source – NCC key performance indicators benchmark.

Table 3.2 Channel allocation parameters in cell locations within in a region, in a certain cell cluster

S/N	CELL LAC	AMR BLOCK	PS BLOCK	HSPA	CSSR	RAB	SHO	DT
1.	3074	0	0.413264	0.032523	98.86525	98.86525	99.695.15	1172.864
2	3074	0	0.2411278	0.020165	95.59173	98.34254	99.57031	3052.584
3	3074	0.569653	1.105484	0.020829	96.04486	98.73992	99.57578	10010.77
4	3074	0	0.530455	0.027145	94.83367	98.87218	98.63074	1756.278
5	3074	1.886792	2.213357	0.016447	95.47678	98.0315	99.40835	3684.032
6	3074	0.47099	1.242067	0.023332	93.93164	97.98729	99.44756	10685.13
7	3074	0.411039	1.192131	0.020695	97.87263	98.55383	99.37516	15615.55
8	3074	1.745201	2.2966	0.029069	94.09199	98.23609	98.84393	4190.987
9	3074	0.807382	2.317934	0.027814	97.07897	98.85932	99.18867	7891.73
10	3074	0.484966	1.226677	0.024499	97.2934	97.8903	99.27965	14380.45

Source: Field survey.

5.0 The development of the Algorithm Simulation Model

For this method of intelligent channel allocation, the algorithm simulation model is presented which utilizes the intelligent wireless channel assignment algorithm on the basis of intelligent channel allocation principle where a number of channels are placed in the pool and assignment is only implemented on demands based on least congested channel. The intelligent component part of the scheme is such that the dynamic system perceives information from open and neighbouring stations and authenticate signal and seeks to enhance its operation by specifying behaviour, which leads to the options of its interfaced mode of operation.

From the foregoing therefore, the intelligent channel allocation model is hereby proposed and developed in order to solve the problem of blocked calls, realize effective service delivery and exceed the benchmark as set by the appropriate communication regulatory authorities in various countries such as the Nigerian Communication Commission.

Individual operation and inter-faced operations ensure the system automation to make decisions to decide a specific operation which also cascades its effect in its larger pool in the operational environment. The intelligent channel assignment employs an intelligent approach in channel related network problems and resolves them on the basis of knowledge and adaptive algorithms.

In achieving this channel allocation operation and subsequent analysis, the following principles are ascertained in intelligent assignment of channels:

(a) For channel resource components in existence, all the channels are assigned and equity mode of operation is upheld.

(b) The channel assignment upholds the out of service rate and the least Grade of service philosophy.

(c) The channel allocation upholds the least 'no service' philosophy.

(d) The channel is selected at random within the confines of the available channels.

(e) The first available channel is then selected from a linear search among the channels counting from the first channel.

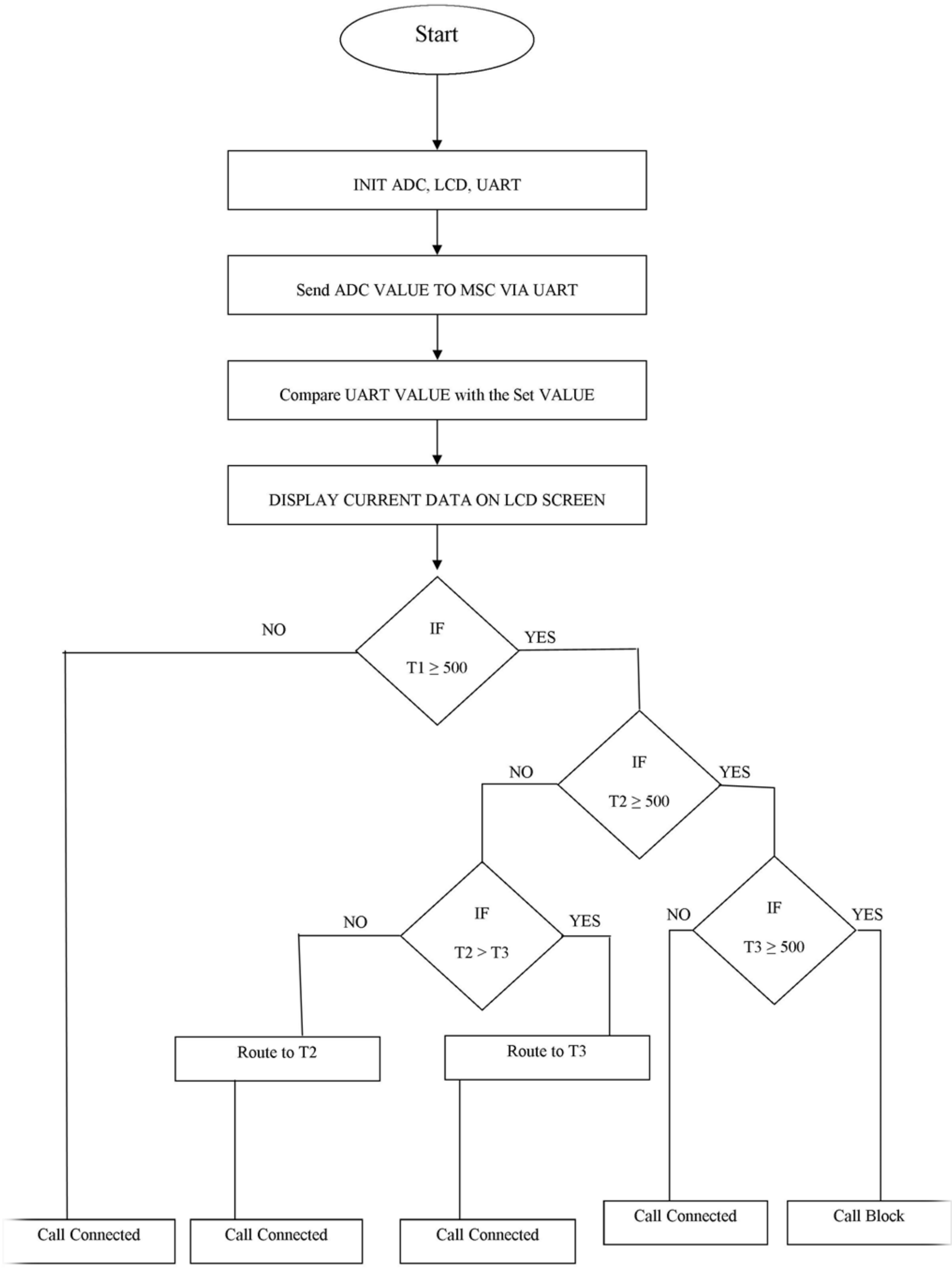
(f) The available channel is selected for maximal outcome.

(g) When an incoming call or handoff is requested, the system will recognize both as new calls and further ascertains the originating cell.

(h) The system ascertains the originating cell identity through the synchronizing channel and checks the schedule of channels in that specific cell.

(i) Whereby channels are unavailable in the confirmed cell, then the system will select a new channel to assign for the incoming call.

(j) When the proposed algorithm philosophy will search for a new channel, it will check if there is any channel available in the central pool within the set value to allocate for the call. If yes, the call will pull through. If no, then the call is routed to a neighbouring base station with the least number of engaged channels. By this process therefore, call blocking occurrence is mitigated and the call is connected.



In plate 3.1, the Simulation Model Environment is presented showing three base stations serving the calls within the base station subsystem and also showing the Mobile Switching Center which is responsible for switching the calls between the respective base stations.

In plate 3.2, the Simulation Model Environment is Initializing, Showing NORMAL CAPACITY for sector1, NORMAL CAPACITY for sector2 and NORMAL CAPACITY for sector 3. It is observed that the calls routing through BTS1, BTS2 and BTS3 respectively, are all less than the set 500 threshold channels allocated to each of the BTS hence each of the BTS is showing Normal Capacity hence there is no blocked call occurrence.

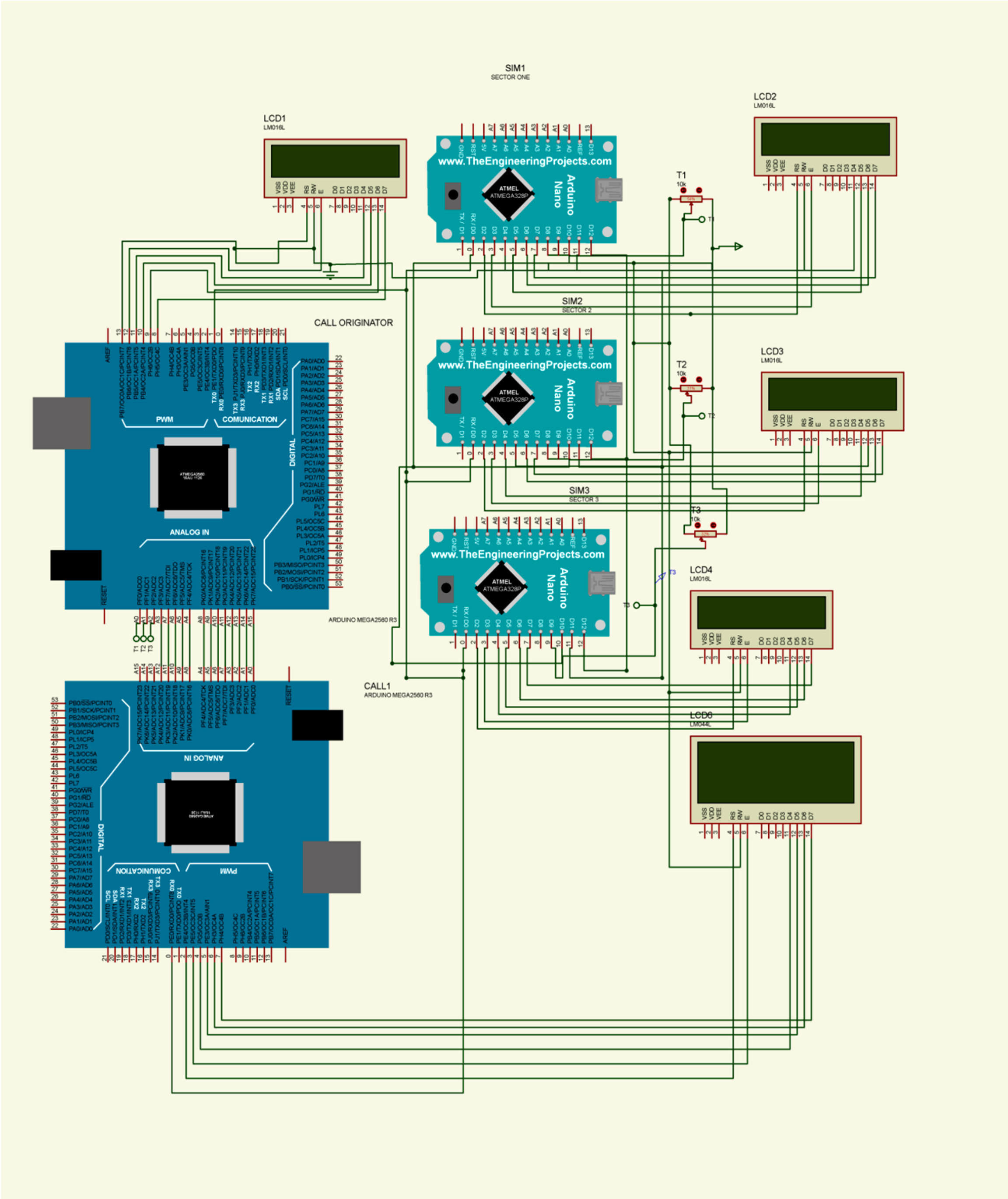


Plate 3.1 The Simulation Model Environment.

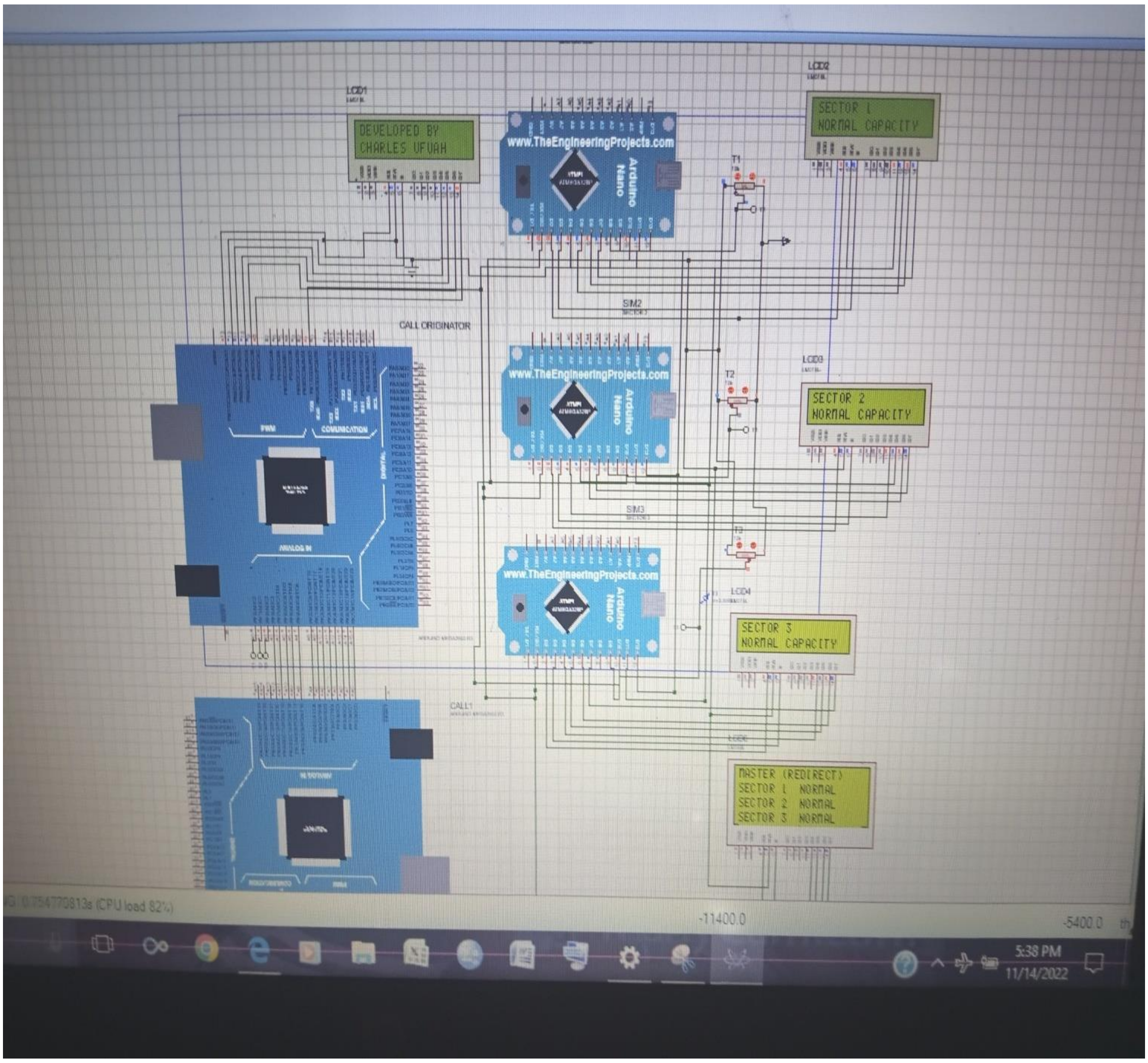


Plate 3.2, the Simulation Model Environment is Initializing, Showing NORMAL CAPACITY for sector1, NORMAL CAPACITY for sector2 and NORMAL CAPACITY for sector 3

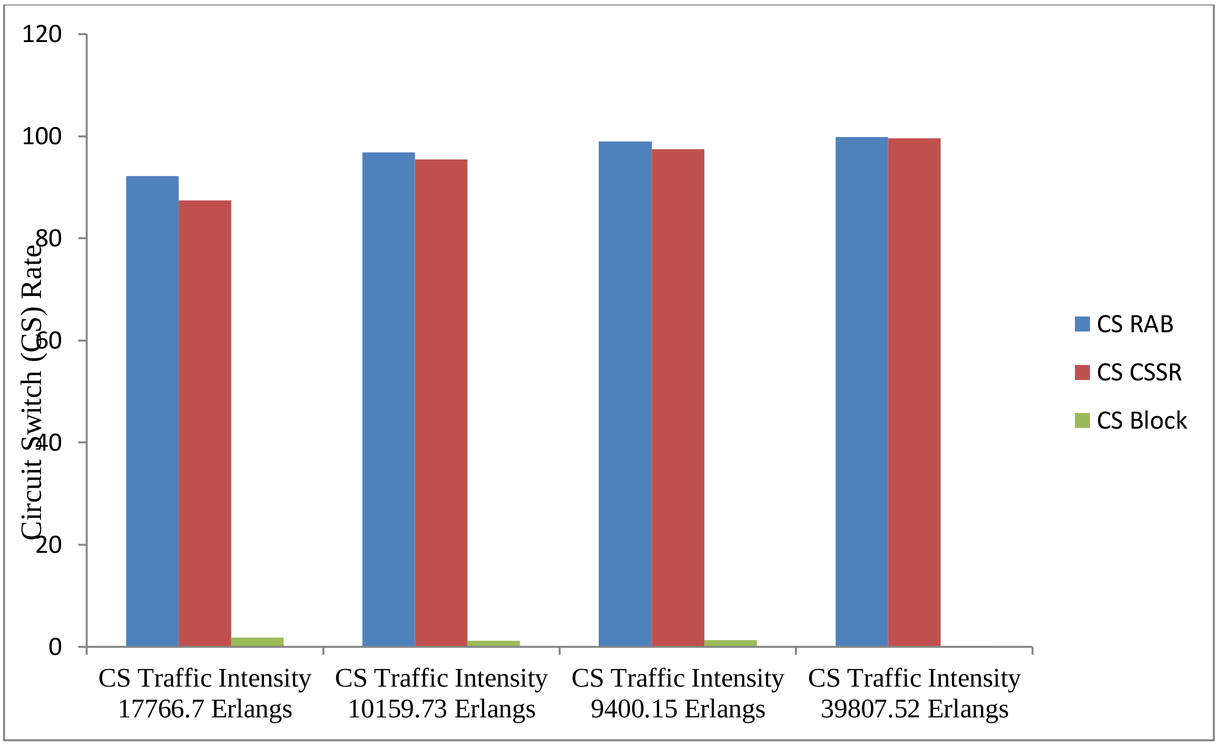


Fig. 4.1 Comparison between CS RAB rate, CS CSSR rate and CS Block rate in a typical Traffic Intensity Scenario in Blocked Calls Database.

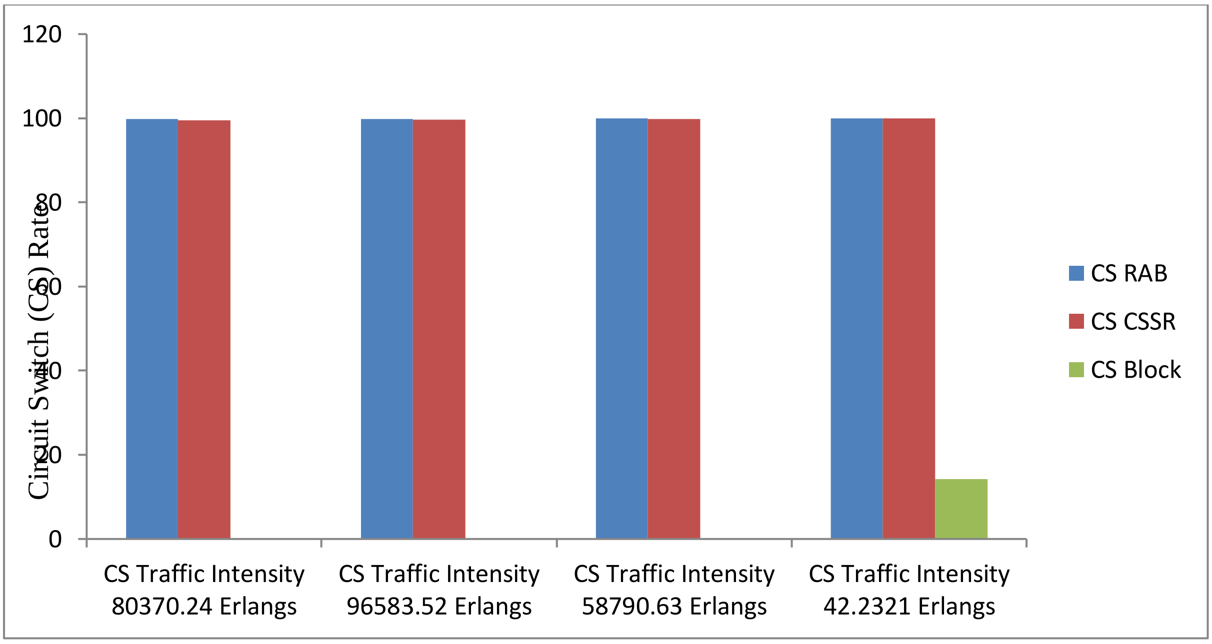


Fig. 4.2 Comparison between CS RAB rate, CS CSSR rate and CS Block rate in a typical Traffic Intensity Scenario in Blocked Calls Database.

Conclusion

In the course of this study, the fundamental concept, techniques and implementation of the channel allocation schemes in cellular network operations have been extensively presented. The overwhelming advantages of the Intelligent channel allocation leveraging the developed simulation model, over some other channel allocation schemes have also been discussed.

In this work, channel allocation schemes and strategies with mechanisms to mitigate against blocked calls and improve data rates have been presented and discussed. Also, various parameters associated with blocked calls and data rates have been identified and analyzed.

The investigations and results indicate overall good performances as a result of the approach for the downlink channel such as sectored feedback mechanisms configured for users. Furthermore, deployment and polarization of antenna network demonstrates upward records in throughput and therefore enhanced channel capacity.

Typically also, it is shown that for the various parameters both the proactive and reactive schemes have the same performances.

5.1 Recommendations

As the rollout of 5G technology gains wide applicability, analysis, implementation of numerical models, field measurement and studies have shown that new challenges arising from the massive exploitation of this emerging technology will include the utilization of new spectrum bands and large-scale use of technological advancements also are expected to be explored.

Furthermore, other new age and emerging radio access technologies such as pre-coding and coding techniques associated with channel allocation, hardware impairments, signal detection have new deployment challenges and complexity which need research and exploration to access the attendant and inherent advantages in these various technologies.

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