Comparison Of Uniform Fractional Band Cac And Uniform Fractional Channel Schemes In Wireless Cellular Networks

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Abstract: In wireless cellular networks, there are two major types of calls: new calls and handover calls. As losing an ongoing call during the handover process will affect the quality of service, handover calls are generally considered to have higher priority than new calls. To overcome this problem, various Call Admission Control (CAC) strategies have been developed. For this project, two existing CAC strategies are examined and implemented to ensure that ongoing calls are maintained and network resources are used efficiently. The first strategy is called the "Uniform Fractional Bandwidth (UFB) CAC scheme''. This strategy allocates a fixed portion of the total bandwidth to handover calls. The other strategy is called the "Uniform Fractional Channel (UFC) scheme". This strategy allocates a fixed portion of the total channels to handover calls. A comparison between the two strategies is made to identify the best CAC strategy.

Keywords: Bandwidth Management, Call Admission Control, Cellular Networks, Handoff Calls, Resource Utilization.

I. INTRODUCTION

The growing call for cell communication offerings and high-velocity information connectivity has placed colossal strain on wireless cellular networks. using smartphones, multimedia packages, and cell offerings has led to efficient use of radio resources, which has become a primary undertaking. It is important to hold excessive quality of service (QoS) due to the fact that key performance parameters, together with new call blocking probability (CBP), handover call dropping probability (CDP), and channel usage, have a direct effect on machine performance [1], [2].

In wi-fi mobile networks, two types of calls exist, namely new calls and handoff calls. A new call is initiated from a cell and a handoff call occurs when a call in progress needs to be transferred to another cell due to the movement of the mobile user. As far as users are concerned, call dropping is much more annoying than call blocking a new call attempt. Hence, the vast number of call admission management (CAC) schemes give priority to handoff calls to reduce the frustration of the mobile users [2], [3].

Call Admission control (CAC) is a mechanism which controls the acceptance or rejection of calls attempting to access the radio resources in a wireless network. Many Call Admission control algorithms such as fixed guard Band (FGB), Fractional guard Channel (FGC), Local Fractional Channel (LFC) and thinning algorithms have been proposed that prefer handoff calls. Uniform Fractional Channel (UFC) algorithm is a probabilistic technique that controls the admission of new calls into the channel and tends to give more radio resources to the network and therefore increases the channel utilization as compared to other protect channel algorithms. But in high mobility scenario with heavy traffic, it does not favour handoff calls adequately [1], [2], [3].

To overcome these drawbacks, the Uniform Fractional Band (UFB) scheme was proposed, which breaks down total channels into non-priority, fractional-priority, and full-priority channels. This method slowly gives higher priority to handover calls while using channels efficiently and improving overall service quality (QoS) [6]. Recent research work reveals that adaptive and fractional reservation methods adopted in the latest

4G and 5G networks perform better than fixed CAC methods by adapting to the changes in the traffic pattern [4], [5], [7], [8]. This paper compares the performance of UFC and UFB schemes in terms of new call blocking probability, handover call dropping probability, and channel utilization to determine which scheme is more effective in balancing handover support and efficient use of channels.

II. LITERARURE SURVEY

Call Admission Control (CAC) algorithms the use of thinning-based probabilistic call acceptance consistent with the system k can efficaciously mitigate the depth of call arrivals at some stage in peak hours by using lowering the call arrival rate. This approach is greater beneficial for shielding handover calls and channel usage in comparison to strict shield channel rules Y. Fang [1]. a detailed analysis of handoff precedence schemes consists of techniques like shield channels, queuing, and fractional processing, highlighting the importance of recent name blockading probability, handover call drop probability, and device throughput in reaching suited Quality of service (QoS) in wi-fi cellular networks A. Sgora & D.D. Vergados [2].

The Uniform Fractional Channel (UFC) scheme proposes a probabilistic admission manipulate scheme where new calls are admitted with a uniform possibility inside a reserved protect area. The UFC scheme has been proven to decorate channel usage and mitigate handover call dropping in comparison to the conventional fixed guard channel schemes H. Beigy & M.R. Meybodi [3]. Despite the fact that, whilst the site visitors load is high and mobility is extended, the UFC scheme may additionally provide much less safety for handover calls, that may adversely affect the continuity of ongoing offerings.

Adaptive bandwidth-based totally CAC methods dynamically assign bandwidth by way of degrading non-actual-time offerings to help handover and precedence traffic. those strategies greatly improve QoS in multimedia wireless networks with varying bandwidth necessities M.Z. Chowdhury, Y.M. Jang& Z.J. Haas [4]. Multi-stage bandwidth model further improves performance with the aid of imparting extraordinary carrier levels for distinctive traffic classes, which helps handover and optimizes bandwidth usage in heterogeneous wi-fi networks M.Z. Chowdhury, Y.M. Jang [5].

The Uniform Fractional Band (UFB) set of rules fixes a positive fraction of the bandwidth as a protect band and lets in new connections fractionally within this band, accordingly giving increasing priority to handover calls. The UFB set of rules provides a lower handover losing opportunity and a higher bandwidth usage than channel-based totally reservation schemes Md. Asadur Rahman, M.Z. Chowdhury & Y.M. Jang [6]. latest research has also proven that fractional, adaptive, and dynamic CAC algorithms carry out higher than static algorithms in these days's 4G and 5G networks through adapting to real-time variations in traffic and handoff possibilities, thus offering better throughput and QoS Choudhary, N., Khaitan nee Gupta [7], Maharazu Mamman [8].

III. METHODOLOGY

In this paper, we consider a single cell with C circuit multiplexers (C channels) of fixed capacity. The cell is required to handle new calls generated locally, as well as hand-off calls from customers roaming out of the surrounding cells. Call arrivals and call duration are assumed to be identically and independently distributed with average service rate μ. In the system, hand-off calls are given a higher priority of service than new calls to preserve the QoS.

 Next, we probe two classes of CACs. In the UFC, new calls are accepted grounded on the acceptance factor α, and handoff calls are accepted only when the channels are available. In the UFB, the capacity of the system is partitioned into three classes of channels non-priority, fractional precedence, and handoff-only. New calls are completely accepted in the non-priority band, accepted with a factor of α in the fractional precedence band, and rejected in the handoff-only band. Handoff calls are accepted only when the channels are available.

3.1 Uniform Fractional Channel Scheme

        The decision to accept or reject a new call request is made in an aimless manner and is independent of the number of busy channels. The handoff calls are accepted. The UFC policy is decided by the guard band bit α for k = 0, 1, 2 ,... C-1. The new calls are rejected to accommodate the handoff calls. It is a good method to reduce the blocking probability of new calls[3,9]. The above system can also be effectively applied if the average appearance rates of handoff and new calls are low.

The steady-state probability of a state i, P(i), is expressed by the relation:

$$P(i) = \frac{(\alpha\lambda_n + \lambda_h)^i}{i!\,\mu^i}\,P(0)\,,\ 0 \le i \le C \tag{1}$$

Further, P(0) can be calculated from its own equation and is expressed by:

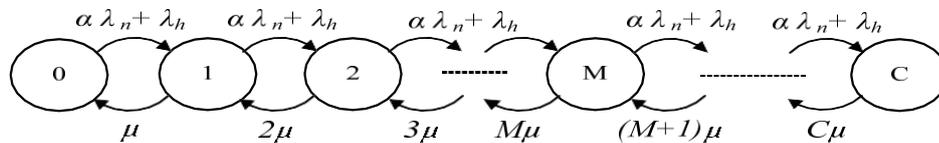$$P(0) = \left[\sum_{i=0}^{C} P(i)\right]^{-1} \tag{2}$$

Figure1: State transition diagram for the uniform fractional channel scheme

The Handover CDP and the new CBP are derived from equations (3) and (4)

The Handover Call Dropping Probability (CDP) is represented by P_D:

$$P_D = P(C) \tag{3}$$

The Handover Call Blocking Probability (CBP) is represented by P_B:

$$P_B = (1-\alpha)\sum_{i=0}^{C-1}\frac{(\alpha\lambda_n + \lambda_h)^i}{i!\,\mu^i}P(0) + P(C) \tag{4}$$

3.2 Uniform Fractional Band Scheme

The Uniform Fractional Band is basically a way to control how calls get admitted by splitting the total channels into three different bands. Each band has its own rules for letting calls through. There's a diagram in Figure 2 that shows how this looks in a simple one-dimensional setup.

First, the primary band doesn't favour any calls. New calls and handover calls are treated the same here. Both have an acceptance factor of 1, meaning they're fully accepted. Then, there's the second band, called the fractional band. Here, new calls have an acceptance factor less than 1, which they call C. But for all the channels in this band, new calls get this reduced acceptance factor, while handover calls still get accepted fully with a factor of 1. Finally, the third band is called the "definitive precedence band." This one only allows handover calls. New calls get an acceptance factor of 0, so they're not accepted at all in this band.

So, the UFB basically prioritizes handover calls more as you move through the bands, while new calls get fewer chances in the later bands. It's a way to manage call traffic and make sure ongoing calls don't drop.
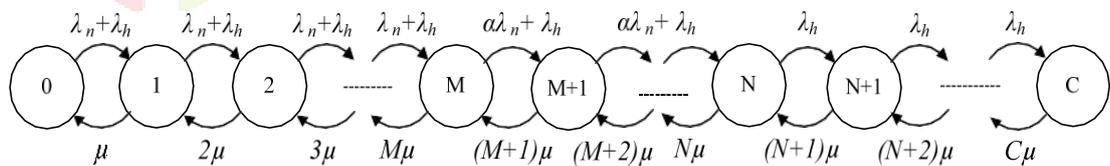

Figure 2: State transition rate diagram of the uniform fractional band scheme.

The rule for selecting handover calls is a simple two-level rule. From this, the steady-state probability P(i) satisfies this equation:

$$P(i) = \begin{cases} \dfrac{(\lambda_n + \lambda_h)^i}{i!\,\mu^i}\,P(0)\,, & 0 \le i \le M \\[2ex] \dfrac{(\lambda_n + \lambda_h)^i(\alpha\lambda_n + \lambda_h)^{i-M}}{i!\,\mu^i}\,P(0), & M \le i \le N \\[2ex] \dfrac{(\lambda_n + \lambda_h)^M(\alpha\lambda_n + \lambda_h)^{N-M}\lambda_h^{i-N}}{i!\,\mu^i}\,P(0), & N \le i \le C \end{cases} \tag{5}$$

Acceptance pattern from band 0 to C, with maximum acceptance at C:

- Non-Priority band ($0 \leq i \leq M$): all calls are accepted.
- Fractional band ($M \leq i \leq N$): new calls are accepted with probability α.
- Priority band ($N \leq i \leq C$): only handover calls are accepted.

P(0) is derived from equation (2). The performance measures for new and handover calls are expressed as:

The Handover Call Dropping Probability (CDP), denoted P_D:

$$P_D = P(C)$$

(6)

The New Call Blocking Probability (CBP), denoted P_B:

$$P_B = (1-\alpha) \sum_{i=M}^{N-1} \frac{(\lambda_n + \lambda_h)^M (\alpha\lambda_n + \lambda_h)^{i-M}}{i!\,\mu^i} P(0) + \sum_{i=N}^{C} \frac{\lambda_n^{i-N}(\lambda_n + \lambda_h)^M (\alpha\lambda_n + \lambda_h)^{N-M}}{i!\,\mu^i} P(0)$$

(7)

Key Parameters:

- Total channels in a cell: C
- New call arrival rate: λ_n
- Handover call arrival rate: λ_h
- Mean service rate: μ
- State i represents i ongoing calls, where i=0,1,2,…,C.

IV. RESULTS AND DISCUSSION

This abstract presents the performance analysis of Uniform Fractional Channel (UFC) and Uniform Fractional Band (UFB) channel access algorithms by both logical and graphical approaches. The new call blocking probability (PB) and handover call dropping probability (PD) will be studied as the performance criteria for the quality of service (QoS).

The performance criteria used are:
- Four graphs depicting the performance of the Uniform Fractional Channel scheme
- Four graphs illustrating the performance of the Uniform Fractional Band scheme
- Four relative graphs overlaying the results of both schemes

These graphs present the performance comparison between Uniform fractional channel (UFC) and Uniform fractional band (UFB) algorithms using some performance parameters related to quality of service similar as new call blocking probability, handover call dropping probability versus business weight and available channels.

4.1 Uniform Fractional Channel Scheme
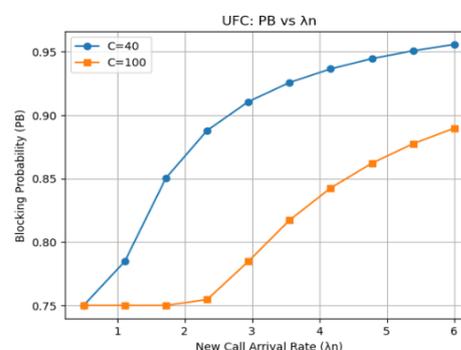### 4.1.1 New Call Arrival Rate (λ_n) vs Blocking Probability

Figure 3: New Call Arrival Rate (λ_n) vs Blocking Probability

From Fig.3, it is observed that as the new call arrival rate increases, the blocking probability also increases steadily. Initially, the curve starts at a lower value and then rises sharply in the beginning, after which it continues to increase smoothly as λ_n increases further. The overall trend clearly shows a continuous upward behaviour of blocking probability with respect to the increase in λ_n.
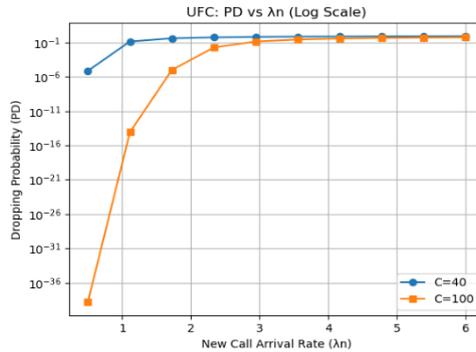
4.1.2 New Call Arrival Rate (λ_n) vs Dropping Probability

Figure 4: New Call Arrival Rate (λ_n) vs Dropping Probability

As shown in Fig. 4, the probability of call dropping is small at the beginning and will greatly increase with the increment of the New Call Arrival Rate λ_n. In the small value area, the speed of the increasing slope is fast and steep in the initial stage, and it will become slow along with the increasing λ_n.

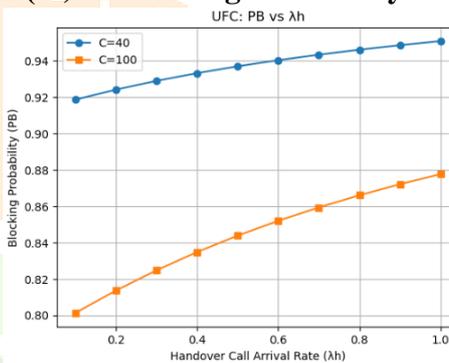### 4.1.3 Handover Call Arrival Rate (λ_h) vs Blocking Probability

Figure 5: Handover Call Arrival Rate (λ_h) vs Blocking Probability

As shown in Fig. 5, the blocking rate is boosting with the increase of the Handover Call Arrival Rate(λ_h). The increase is steady but veritably slowly; there's no unforeseen increase of the blocking rate for all the values of λ_h. also, the blocking rate is boosting for all the curves of the graph, and for large values of λ_h, the blocking rate of the smallest rate is lesser than the other rates.
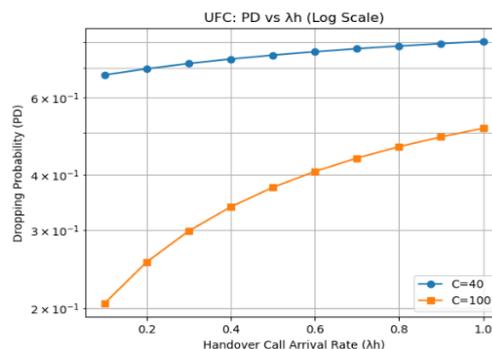
4.1.4 Handover Call Arrival Rate (λ_h) vs Dropping Probability

Figure 6: Handover Call Arrival Rate (λ_h) vs Dropping Probability

From Fig.6, that as the λ_h increases, the dropping probability also increases, though at a slow rate. This increases smoothly without breaks. It is also clear that during the whole process, the upper line remains higher than the lower line, though the rates at which they are increasing remain almost similar. When the handover calls arrival increases, it is also clear that the dropping probability also increases, as can be seen from the graph.

4.2 Uniform Fractional Band Scheme
4.2.1 New Call Arrival Rate (λ_n) vs Blocking Probability
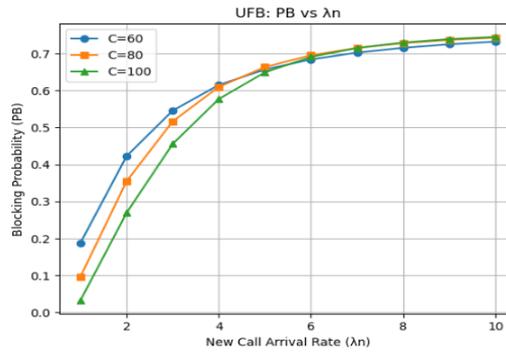

Figure 7: New Call Arrival Rate (λ_n) vs Blocking Probability

From Fig. 7, It's noted that, at first, the curves increase acutely, and also the curves start boosting easily with an increase in New Call Arrival Rate(λ_n). For lower values of New Call Arrival Rate(λ_n), a clear difference is noted between the curves, but with an increase in New Call Arrival Rate(λ_n) towards advanced values, curves tend towards each other while still boosting with a harmonious rate.
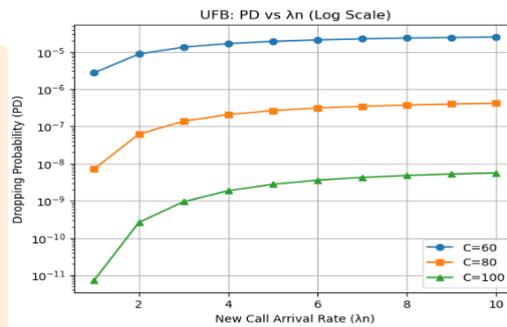
4.2.2 New Call Arrival Rate (λ_n) vs Dropping Probability

Figure 8: New Call Arrival Rate (λ_n) vs Dropping Probability

It's observed from Fig. 8 that as the value of λ_n increases, the dropping probability also increases for all curves. Originally, the values are veritably small, also they rise for upping values of λ_n. The rate at which the values rise is advanced at lower values of λ_n, also becomes slower at advanced values. All the curves display an analogous pattern of raising as the value of λ_n increases, with one curve advanced, another in the middle, and the remaining lower.

4.2.3 Handover Call Arrival Rate (λ_h) vs Blocking Probability
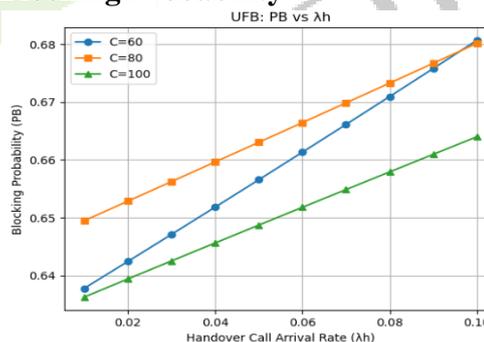

Figure 9: Handover Call Arrival Rate (λ_h) vs Blocking Probability

From Fig.9 above, it's seen that as the handover arrival rates increase in λ_h, there's steady growth in blocking probabilities. As λ_h increases, the increase in blocking probabilities becomes almost linear and straight without any jumps along the way. The topmost line remains at the top while the middle one floats around the bottom one. All the lines increase at the same rate as the λ_h increases. The increase in the lines is almost similar even as they move apart.

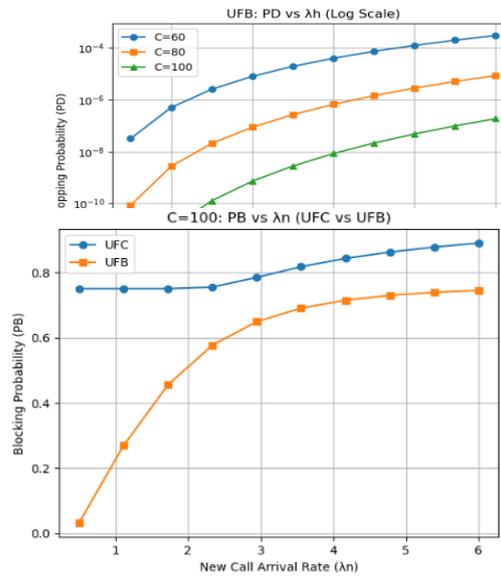### 4.2.4 Handover Call Arrival Rate (λ_h) vs Dropping Probability

Figure 10: Handover Call Arrival Rate (λ_h) vs Dropping Probability

From Fig. 10 above, it is observed that with an increase in handover call arrival rates, the increasing trend of dropping probability is observed for all curves. All values are initially very low; then they increase with an increase in handover call arrival rates. The increase in dropping probability is sharper at lower values and then gradual at higher values of handover call arrival rates. One value is high, one is in the middle, and one is low. However, all are increasing with an increase in handover call arrival rates.

4.3 Comparison of UFC and UFB

4.3.1 New Call Arrival Rate (λ_n) vs Blocking Probability

Figure 11: New Call Arrival Rate (λ_n) vs Blocking Probability

It is easily seen from Fig. 11 that the PB increases with the new call arrival rate for both schemes. The PB for the UFB scheme starts from a truly low value, while the PB for the UFC scheme increases gradually from a high value as the new call arrival rate increases. The UFC curve is above the UFB curve for all values of λ_n, and both curves are increasing with λ_n

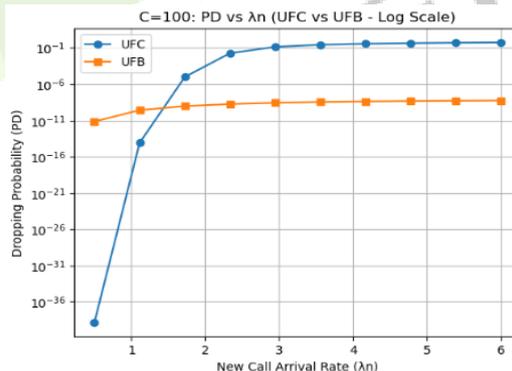### 4.3.2 New Call Arrival Rate (λ_n) vs Dropping Probability

Figure 12: New Call Arrival Rate (λ_n) vs Dropping Probability

Looking at Fig.12, when more new calls arrive, the chance of a call being dropped rises in both methods. At first, in UFC,dropping occurs very rarely - then suddenly climbs fast as λ_n grows. In contrast, UFB shows a steady climb from the start. Over time, the rise becomes continuous for both; however, UFC's peak stays far above UFB's.

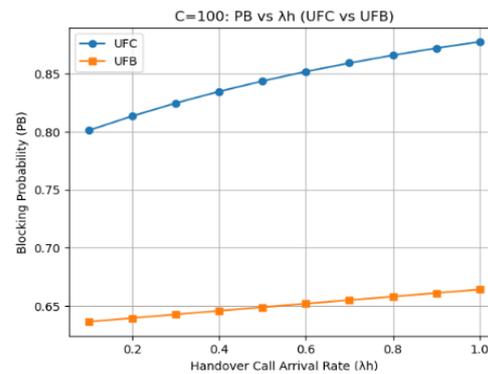### 4.3.3 Handover Call Arrival Rate (λ_h) vs Blocking Probability

Figure 13: Handover Call Arrival Rate (λ_h) vs Blocking Probability

From Fig. 13, the blocking probability is raising when the Handover Call Arrival Rate(λ_h) is upping. The slope of this increase is slow in all the range of the graph, but it's sufficient to keep always larger values for the blocking probability of the UFC, than for the UFB. Also, in all the points of the plot the PB of UFC is ahead of the one of UFB, and they both tend to increase along the same direction, when the handover call arrival rate increases.

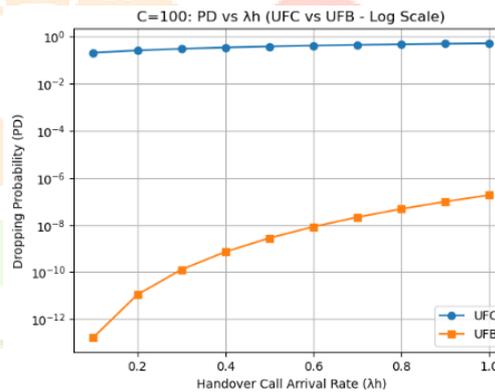### 4.3.4 Handover Call Arrival Rate (λ_h) vs Dropping Probability

Figure 14: Handover Call Arrival Rate (λ_h) vs Dropping Probability

Figure 14, It's very clear from the below plots that for the UFC, the drop-out probability is high for all the frequencies, and it increases as the call arrival rate is increased. For the UFB case, the drop-out probability is nearly zero for small values of λ, i.e. for low call arrival rates, and it increases very slowly. In addition, for all the plots in the below sub-figure, one arc always remains above λ_h while the other remains below it. also, they don't cross over to each other.

V. CONCLUSIONS

From our analysis, the graphs of the UFC scheme, it's Observed that the blocking probability as well as the dropping probability increases with the increase in traffic load. As the new call arrival rate(λ_n) increases, the blocking probability of new calls increases because there are smaller channels available to accommodate new calls. Also, as the handover arrival rate(λ_h) increases, the dropping probability increases because handover calls can be accepted only if a channel is available.

The UFB scheme is initiate to perform better because it's a multi-band channel allocation scheme. As the new call arrival rate(λ_n) increases, the blocking probability increases, but at a slower rate because of the fractional band, allowing flexible acceptance of new calls. Also, as the handover arrival rate(λ_h) increases, the dropping probability is like lower because of priority channels available for handover calls.

When we compare both the UFC scheme and UFB scheme, it's found that both have a raising blocking probability as well as dropping probability with an increase in λ_n and λ_h values for both schemes. But in UFC, the blocking probability is advanced, whereas in UFB, the probabilities are lower because of effective channel allocation and protection of handover calls. thus, it can be concluded that the UFB scheme is better than the UFC scheme.

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