Improving the Efficiency of Call Admission Control in Wireless Cellular Communication Networks by Frequency Sharing Techniques

Vikas Solanki [1], M. Qasim Rafiq[2]
[1]*(Department of Computer Science Engineering & IT, Mangalayatan University, Aligarh, India)*
[2] *(Department of Computer Science Engineering, AMU, Aligarh, India)*

ABSTRACT : *In this paper, a two-tier cellular communication wireless network is characterized by overlapping the service area for managing the new calls users having different mobility speed. The overlapping property of the two-tier system provides the advantages that share the traffic load to improve the efficiency of new calls subscriber with reservation of channels (guard channels) in cell to handle the ongoing old calls (handoff calls). Microcells are used to provide the services to slow-speed, high-intensity traffic area users and macrocells are overlaid over more than one microcells cater mainly too lower density, high-speed users. The two-tier of microcells and macrocells provide the secondary resource which provide the service to new calls as well as handoff calls with guard channels by overflow the slow speed users in macrocell and sharing the frequency in vertical as well as in horizontal directions in the upper layer. In this paper, we tried to optimize use of resources by using advantage of overlapping coverage of two-tier wireless cellular networks and frequency sharing techniques like VDFS and HDFS. The call lose probability of new calls are developed through numerical analysis. The VDFS and HDFS schemes are proposed and compared with the existing schemes of CAC. The result shows the new proposed schemes are more efficient.*

Keywords - *cellular network, two-tier communication system, load redirection, guard channel, frequency sharing.*

1. INTRODUCTION

In order to provide the efficient services against the huge demand of the wireless cellular communication networks, is the challenging issue. The radio spectrum range is limited and can't be catch up with increase of users demand for the wireless cellular communication networks. To release that stress one way is to design microcells. Moreover, microcells are not advantageous in the service area where user population is sparse with slow and high speed subscribers. Small cell systems induce an increase handovers by high speed mobile subscribers. Micro-macrocell overlay structures can overcome with these difficulties. Overlapping property of two-tier structure provides the advantages that share traffic load to improve the efficiency of call admission control. Call admission control (CAC) schemes are critical for the success of future generation of wireless networks. It provides the users to access a wireless network service. On the other hand, these are the decision making part of the network carriers that provide services to users with guaranteed quality and achieving maximum possible resource utilization. It is therefore conceivable that CAC policy is one of the critical design considerations in any wireless network. CAC schemes provide the services for both i.e. new as well as old call users. New call users are those who make the new connection in current cell for communication and required the frequency for connection establishment. On the other hand, old call users are those subscribers whose connections are already established, but due to mobility they have to change the cell for continuous communication. Therefore, they further require the frequency in another neighbouring cell for connection establishment, without breaking the connection. Earlier, CAC scheme called New Connection Establishment (NCE) or in short New Calls and latter CAC scheme is known as Handoff calls. Therefore, CAC schemes are categorized in two parts: one is for new calls and the second is for on going (old) calls.

A two-tier cellular network is characterized by macrocells and microcells overlapping in the service area. Larger cells, reside on the top layer are called macrocells, while smaller cells reside on the bottom layer are called microcells. Subscribers are assigned to microcell or macrocell based on their mobility speed.

Systems employing multitier cells have been considered in a number of publications. Several methods, for handling new calls and handoff traffic of the defined mobile subscriber speed classes are proposed and performance measures such as the probability of new call blocking, forced termination, and traffic capacity have been determined. In the case of a speed-insensitive selection mechanism, call originations are assigned to a default cell layer which is, in most cases, the lowest (microcell) layer [1-2]. It is proposed to direct a new/handoff for the appropriate tier based on its previous speed [3-4]. However, when there is no available channel on the preferred tier, the call will be directed to the other (un-preferred) tier. This is called an overflow. If a speed sensitive selection mechanism is used, arriving calls can be directed to the specific cell layer that depends on the speed class of the mobile station. Many works are also directed in the direction to optimize the performance of the system based on the factors such as roaming speed of users, level of cloudiness of an area, location management, and channel management etc. [5-11]. Two-way overflows are considered in between both tier and a take-back scheme is also proposed in which call is redirect from an un-preferred tier to the preferred tier at the time of handoff take place [12] and a channel rearrangement scheme is proposed by forcing a handset in the overlapping area to take an early handoff permanently [13].

In this paper, a two-tier system is proposed with Guard-Channels that are reserved to handle the handoff calls only. The aim of this work is to improve the performance of new calls by using overlapping property of the two-tier system that provides the advantage to share the traffic load with frequency sharing techniques in between micro-macrocell. By using the overlapping property of two-tier system the load of the cell may be transferred from lower tier to upper tier and vice-versa.

2. RESULT AND DISCUSSION

Let us assume that a macrocell is overlapping with n microcells, and a macrocell neighbouring to k macrocells. When a channel request arrives at the macrocell, and if the macrocell has no free channels, then the system force one of the slow calls exist in the macrocell to move into one of the other n overlapping corresponding empty microcells. On the contrary, when a channel request arrives at a microcell, and if the microcell has no free channels, then it can be either overflow to the macrocell, or force one of the calls in the macrocell to move into one of the other n-1 overlapping empty microcells. Thus, a channel becomes vacant in the macrocell and new call can be overflowed to the overlaid macrocell. It is observed that such frequency sharing provides lot of flexibilities to shift the load among the cells on the two-tiers in vertical direction, so the scheme is called the Vertical Direction Frequency Sharing (VDFS). In this paper, we restricted the fast speed user to overflow in microcell and if slow speed users overflowed to un-preferred tier then it will not return automatically, until it forced to overflow for serving the new/handoff calls in macrocell. In this system a fast moving calls do not shift to microcells and avoid the more handoff. Thus, overall system can avoid the more call dropping probability. The other scheme Horizontal Direction Frequency Sharing (HDFS) [13] works only in upper-tier with k neighbouring cells, when VDFS scheme fails and not able to provide the service for arriving calls. In the proposed system, some channels are reserved called Guard Channels, that are used only for providing the services to handoff calls. Therefore, guard channels can't be used for serving new call or overflow the new call in un-preferred tier. The proposed system used VDFS scheme prior to HDFS scheme to share the frequency in both tier for handle the traffic load. Table 1 shows the redirection of load in different schemes. Numerical analysis shows the performance comparison of different schemes and proposed schemes.

Table 1: Redirection of load in different schemes

Scheme Reference	**Strategy**	**No. of redirect**
12	Overflow+Take Back	1
13	Rearrange+Overflow	k+1
Proposed VDFS	VDFS with Guard channels	n
Proposed HDFS	HDFS with Guard channels	n+k

2.1 Proposed VDFS and HDFS Strategy

Let us consider that there is a channel request arriving at the macrocell M or one of n microcells m_i. If no channel is available in the cell to satisfy that request then proposed VDFS and HDFS strategy will take place, trying to find a channel for serving the said request. The VDFS strategy tries to find a channel by shifting calls in the vertical direction, i.e., from one tier to the other tier. When VDFS strategy fails to serve the request, HDFS strategy tries to find a channel by shifting calls in the horizontal direction on the higher tier. Simulation results shows that the proposed strategies improve the efficiency of wireless cellular networks even it contains the guard channels [14] to improve the performance of the handoff calls. In the following two sub-sections, we discuss channel sharing in vertical and horizontal directions. The first sub-section is for the VDFS strategy, while the combination of the two sub-sections is for the later strategy i.e. for HDFS strategy.

2.1.1 Vertical Direction Frequency Sharing (VDFS)

In VDFS strategy, the system transfers the calls between the two-tiers. The tiers may be either homogeneous or heterogeneous. In this work, tiers are considered as homogeneous. In the following, we separate the discussion into calls arriving at the lower tier and at the higher tier. When there is a channel request arriving to microcell (lower tier) m_i, $1 \leq i \leq n$, the operation is showing by the flowchart 'A' (Fig. 1). On the contrary, flowchart 'B' (Fig. 2) shows the operation encountered during the request arriving to macrocell M (Upper tier).

As shown in Fig. 3, a slow new subscriber S1 arrives at microcell $m_{1,}$ as represented by Vm1, that has no free channel (Free channels means, the number of available channels except the Guard Channels to handle the request for serving the proposed schemes/new calls in a cell).

The new arrival request Vm1 is handling as per algorithm shown by the flow chart 'A'. Therefore as per flowchart 'A' the operation 3 (Op. 3) is applied and subscriber will be overflowed to macrocell M because microcell m1 has no free channel to serve the request. But the macrocell M is also full, therefore the frequency sharing in vertical direction takes place and tries to pick the slow subscriber, which is currently served in macrocell M and then said subscriber can be handoff to corresponding microcell with a free channel. In the given example, shown in Fig. 3, the user P1 can be shifted to a channel in microcell m_2. After performing the operation 4 (Op.4), the channel is released by P1 user and macrocell M can be used by S1new subscriber (Op. 5).

2.1.2 Horizontal Direction Frequency Sharing (HDFS)

In this strategy, the calls are transferred horizontally with in upper tier. If previous strategy VDFS fails then HDFS take place. This strategy takes place by forcing the subscriber on macrocell M_i, $1 \leq i \leq k$ to early handoff in neighbouring cell as shown in flowchart 'C'(Fig. 4). Two new subscribers S1 and S2 arrive at microcell m1 and macrocell M respectively; both cells have already run out of channels (See Fig. 5). Subscribers P5 and P6 are two possible candidates who can take early handoff to M3 and M2 macrocells respectively. Suppose that user S1 arrive first to microcell m1that has no free channel(s), and then vertical handoff occurs to upper layer macrocell M, which is also run out of channels. But Fig. 5 shows that all corresponding microcell, to overlaid macrocell M also goes to out of channels, so operation 4 and 5 of flowchart 'A is not possible. Also, the failure of our VDFS implies that there is no free channels in microcells m_1, m_2, m_3,…., $m_{n,}$ covered by macrocell M. In such situation, HDFS scheme is applied in upper tier (Fig. 4). The subscriber P5 now takes early handoff to macrocell M3 to vacate the channel and may be allocated that channel to user S1.

3. ANALYSIS MODEL DESCRIPTION

It is assumed that cells are circular in shape and each macrocell covers 'n' microcells. Moreover, all cells in the same tier are statistically identical, and thus we can focus on the behaviour of only one cell and its interaction with neighbouring cells.

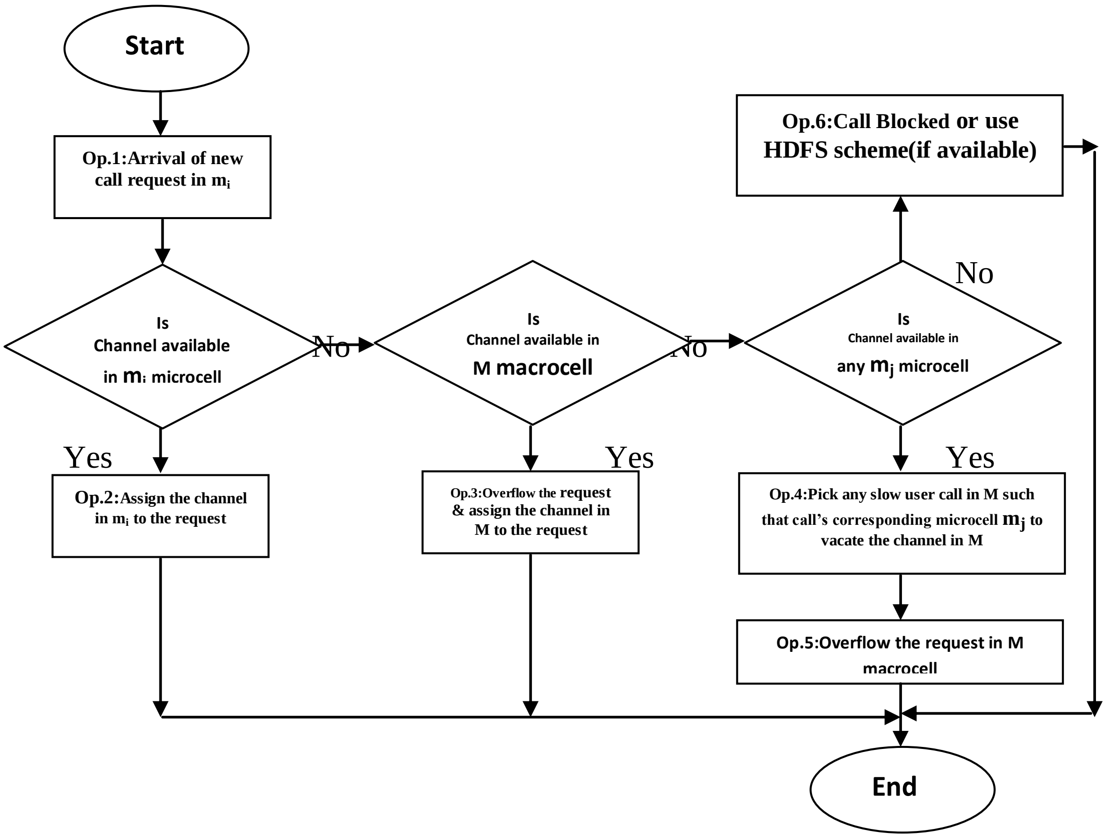

Figure 1: Flowchart 'A' showing Operations occurred on Call request arrived to microcell

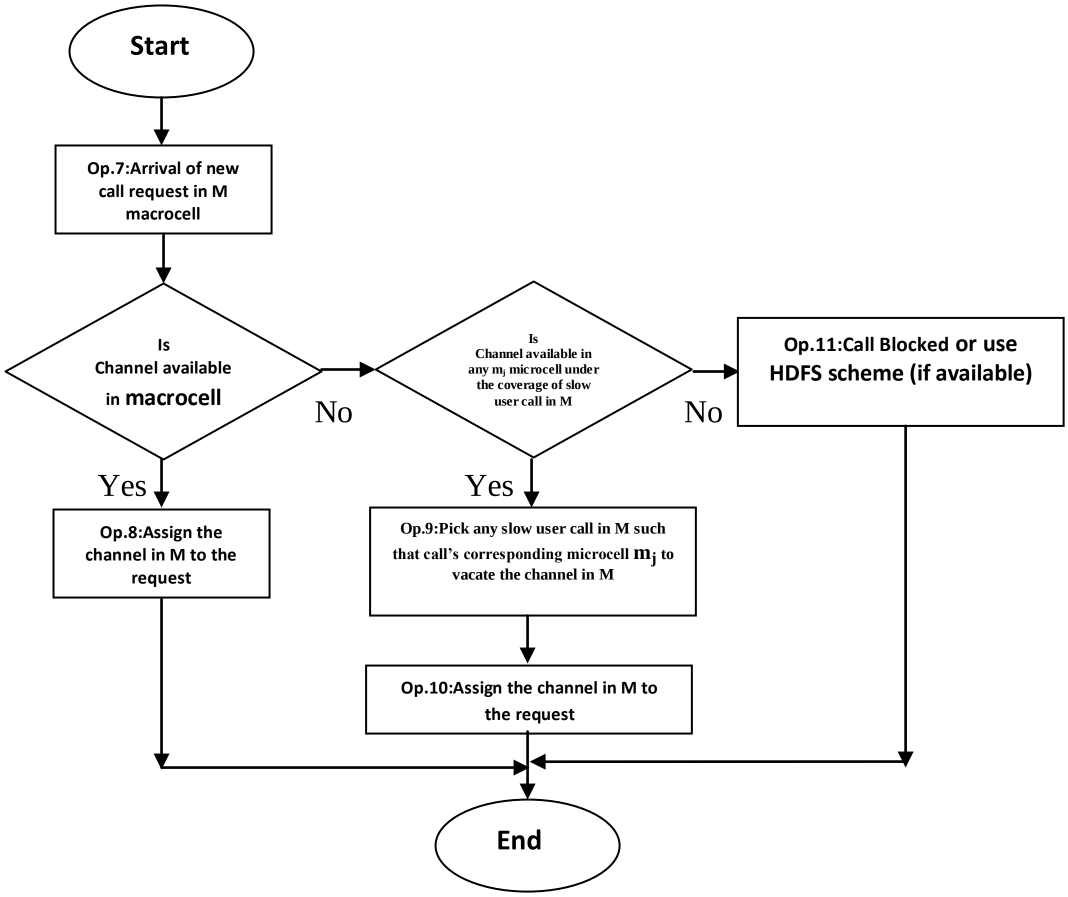

Figure 2: Flowchart 'B' showing Operations occurred on Call request arrived to macrocell

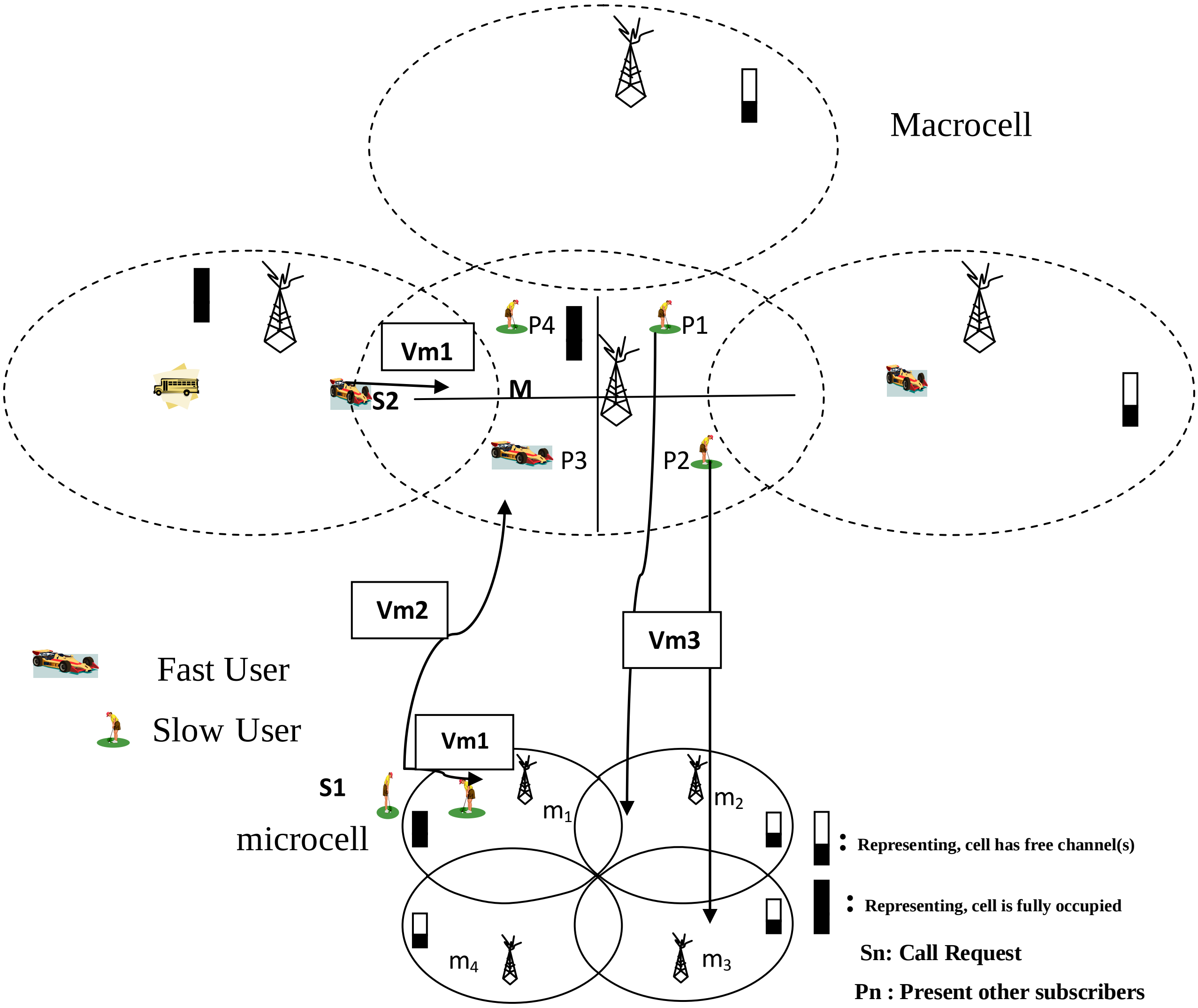

Figure 3: Channel sharing in the vertical direction for slow users

The radius of the circle for a subscriber to take a normal handoff on a macrocell is R_n, and that on a microcell is r_n. However, since there will be some overlapping between two macrocells/microcells, the radius of the circle for a subscriber to take an early handoff on a macrocell is R_e, and that on a microcell is r_e as shown in Fig. 6.

The arrival rates of new calls and handoff calls for both low and high speed users are assumed to be Poisson processes. The Poisson distribution is a suitable approach to represent handoff calls [15].

Handoff calls have burst characteristics, so occur at different rates. The cell dwelling time (CDT) is the time a mobile user spends in a cell before it is handed off to another cell. It depends on the speed of the mobile user and the size of the cell. The cell dwelling time [12] can be calculated as follows:

$$\frac{1}{\mu_d} = \frac{\pi r}{2V}$$

Where V is the velocity of subscriber and r is the radius of the cell.

Note: Subscript s and f are indicating slow and fast user respectively while superscript m and M represent microcell and macrocell respectively.

The inverse of the cell dwell time is the cell cross-over rate (CCOR) and therefore, for slow and fast subscribers in macrocell are μ_{ds}^{M} and μ_{df}^{M} respectively as follows:

$$\mu_{ds}^{M} = \frac{2V_s}{\pi R_n} \quad ;$$

$$\mu_{df}^{M} = \frac{2V_f}{\pi R_n}$$

The handoff probabilities [16] for fast and slow subscribers in a macrocell are

$$P_{hf}^{M} = \frac{\mu_{df}^{M}}{\mu_e + \mu_{df}^{M}}$$

$$P_{hs}^{M} = \frac{\mu_{ds}^{M}}{\mu_e + \mu_{ds}^{M}}$$

Where μ_e is the inverse of the mean unencumbered call duration time. The *unencumbered call duration (UCD)* of a call is the amount of time that the call may remain in progress if it can continue to complete without being dropped, and it also follows a negative exponential distribution. The mean channel occupancy time (COT) / session duration is the mean of minimum of unencumbered call duration and cell dwell time [16], which should be

$$1/\mu_{ef}^{M} = \frac{1}{\mu_e + \mu_{df}^{M}}$$

$$1/\mu_{es}^{M} = \frac{1}{\mu_e + \mu_{ds}^{M}}$$

for fast and slow subscribers respectively.

All the derivations that are discussed above for macrocell can be recalculating for microcell and can be represented as follows:

$$\mu_{ds}^{m} = \frac{2V_s}{\pi r_n}$$

$$P_{hs}^{m} = \frac{\mu_{ds}^{m}}{\mu_e + \mu_{ds}^{m}}$$

$$1/\mu_{es}^{m} = \frac{1}{\mu_e + \mu_{ds}^{m}}$$

Some more traffic parameters that are used in performance analysis of VDFS and HDFS are as follows:

A. For macrocell

Description	subscriber fast	subscriber slow
1. Traffic rate of new calls	λ_{nf}^{M}	-
2. Traffic rate of handoff calls	λ_{hf}^{M}	λ_{hs}^{M}
3. Traffic rate of overflow calls	-	λ_{os}^{M}
4. Traffic rate of vertical direction calls	-	λ_{vs}^{M}
5. Traffic rate of horizontal direction calls	λ_{zf}^{M}	λ_{zs}^{M}
6. Aggregate traffic rate	λ_{tf}^{M}	λ_{ts}^{M}

B. For microcell

Description	subscriber fast	subscriber slow
1. Traffic rate of new calls	–	λ_{ns}^{m}
2. Traffic rate of handoff calls	–	λ_{hs}^{m}
3. Traffic rate of overflow calls	–	–
4. Traffic rate of vertical direction calls	–	λ_{vs}^{m}
5. Traffic rate of horizontal direction calls	–	–
6. Aggregate traffic rate	–	λ_{ts}^{m}

4. PERFORMANCE MEASUREMENT AND ANALYSIS

In this section, analysis is made of proposed model described above. The traffic flows include new, handoff calls, and those incurred by vertical and vertical-horizontal direction frequency sharing. These traffic flows are all assumed to follow the Poisson process. It is assumed that C_T and C_R are the total number of available channels and guard channels for handoff calls in each cell respectively. Therefore, vacant number of channels to handle the new calls are C_A=C_T-C_R. If the free channels in a cell are greater than C_R then there will be no problem to handle handoff as well as call set up of new calls. But, if any cell has less or equal number of channels than C_R, a free channel performing only handoff and though new calls, or overflow the slow speed user/forced handoff in upper tier are handled by proposed VDFS and/or HDFS schemes.

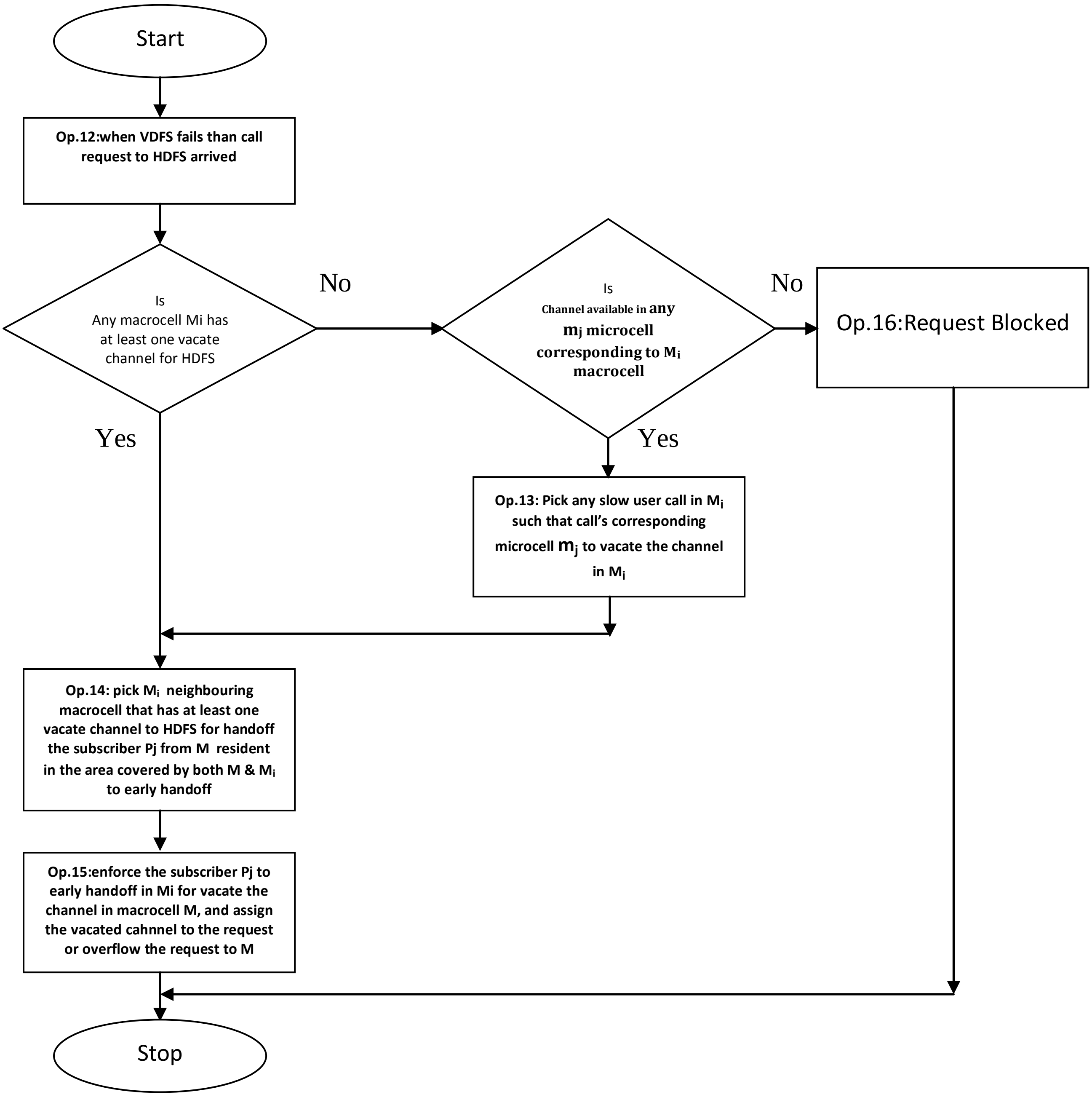

Figure 4: Flowchart 'C' showing Operations occurred on Call request to HDFS

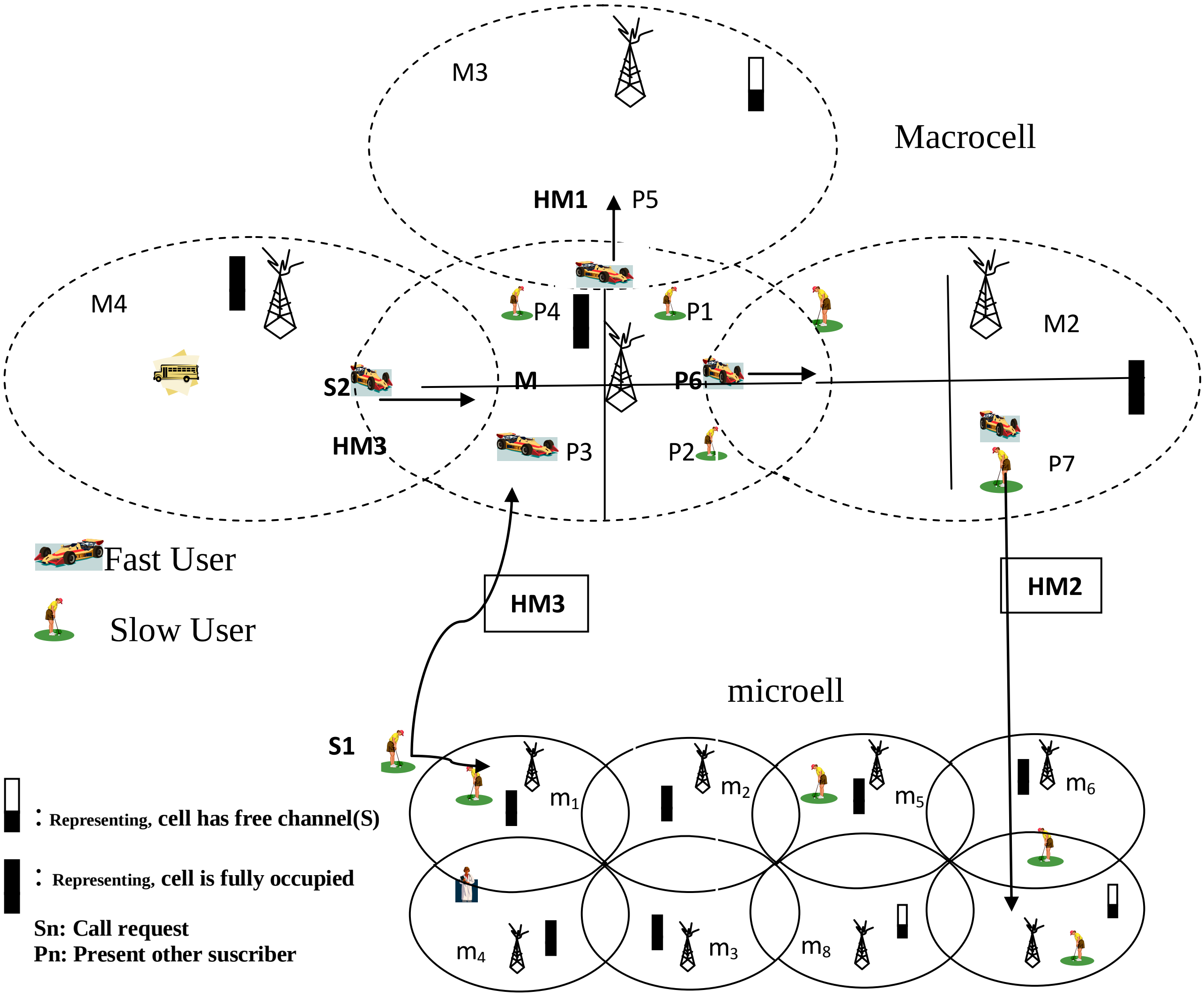

Figure 5: Channel sharing in the horizontal direction for slow subscribers and fast subscribers

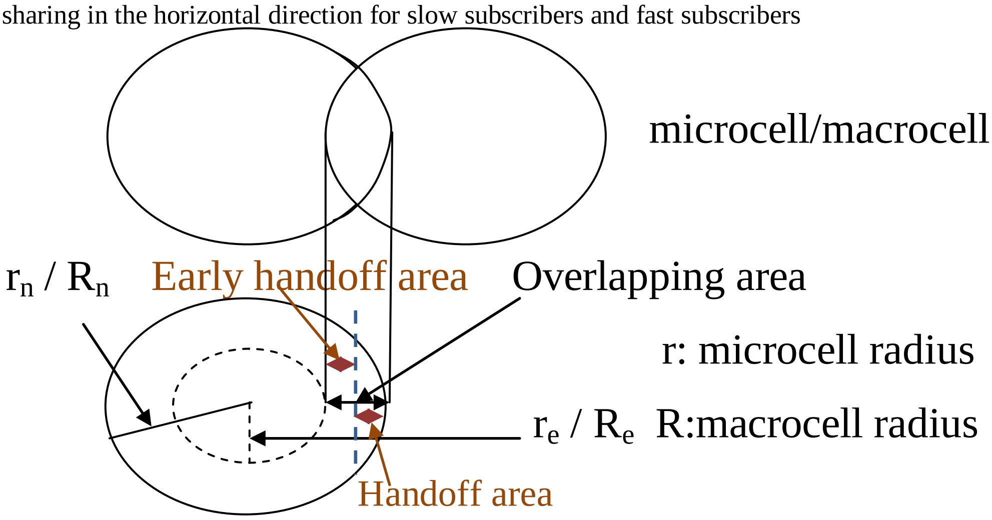

Figure 6: Radii of the circles for the subscribers to take normal handoff and an early handoff

4.1 Performance of Using Vertical Direction Frequency Sharing

The target is to give the efficient scheme for handling the new calls, so that system will reduce the call lose probability of new calls. Therefore, the ***calls lose probabilities*** P_{lf} and P_{ls} of new calls for fast and slow subscribers respectively are derived. These are the probability for a channel request being refused after the vertical direction frequency sharing.

Therefore call loss probabilities are:

$$P_{lf} = P_b^M P_{vs}$$

$$P_{ls} = P_b^m P_b^M P_{vs}$$

Where P_{vs} is the failure probability of the sharing the vertical direction

$$P_{vs} = 1 - P_{sv}(1 - P_b^m) \qquad (1)$$

Where $(1 - P_b^m)$ is the probability of microcell has at least one free channel and P_{sv} is the probability having a slow subscriber that is currently served by the macrocell and also covered by the microcell to served them.

$$P_{sv} = 1 - \left(\frac{n-1}{n}\right) c_A^M (1 - P_s) \qquad (2)$$

Where $\left(\frac{n-1}{n}\right) c_A^M (1 - P_s)$ represents the probability of all slow subscriber serving in macrocell are not located in this particular microcell and P_s is the probability of slow subscribers located in the macrocell for the same area.

The P_b^M, and P_b^m is the probability that a mobile subscriber has no free channel in a macrocell and microcell respectively.

$$P_b^M = \frac{\frac{\left(\frac{\lambda_{tf}^M}{\mu_{ef}^M} + \frac{\lambda_{ts}^M}{\mu_{es}^M}\right)^{c_A^M}}{c_A^M!}}{\sum_{l=0}^{c_A^M} \frac{\left(\frac{\lambda_{tf}^M}{\mu_{ef}^M} + \frac{\lambda_{ts}^M}{\mu_{es}^M}\right)^l}{l!}} \qquad (3)$$

$$P_b^m = \frac{\frac{\left(\frac{\lambda_{ts}^m}{\mu_{es}^m}\right)^{c_A^m}}{c_A^m!}}{\sum_{l=0}^{c_A^m} \frac{\left(\frac{\lambda_{ts}^m}{\mu_{es}^m}\right)^l}{l!}} \qquad (4)$$

Here $\left(\frac{\lambda_{tf}^M}{\mu_{ef}^M} + \frac{\lambda_{ts}^M}{\mu_{es}^M}\right)$ and $\left(\frac{\lambda_{ts}^m}{\mu_{es}^m}\right)$ are the traffics contributed by the subscribers on macrocell and microcell respectively for available channels.

Let variables λ_{tf}^M, λ_{ts}^M, and λ_{ts}^m denotes the arrival rates and μ_{ef}^M, μ_{es}^M, and μ_{es}^m, denotes the service rates.

Next, it is need to calculate the aggregate traffic λ_{tf}^M, λ_{ts}^M, and λ_{ts}^m by analysis model [17]. These traffics are composed of new calls, handoff calls, overflow calls, and channel sharing calls. Variable λ_{tf}^M is aggregate traffic rate incurred by new calls and handoff calls into macrocell by the fast subscribers:

$$\lambda_{tf}^M = \lambda_{nf}^M + \lambda_{hf}^M$$

Where

$$\lambda_{hf}^M = \lambda_{tf}^M (1 - P_b^M) P_{hf}^M$$

Here λ_{hf}^M means the handoff rate, is the aggregate traffic rate itself successfully stays in the macrocell $\lambda_{tf}^M (1 - P_b^M)$ times with the handoff probability P_{hf}^M. Similarly, λ_{ts}^M is the aggregate traffic rate incurred by overflow calls and handoff calls into a macrocell by slow mobile subscribers.

$$\lambda_{ts}^M = \lambda_{os}^M + \lambda_{hs}^M$$

Where

$$\lambda_{os}^M = n \lambda_{ts}^m P_b^m$$

Here λ_{os}^{M} means the overflow rate incurred by overflow from the n microcells covered by the macrocell and λ_{hs}^{M} is the handoff calls into a macrocell by slow mobile subscribers, which equals the slow subscribers successfully staying on the high tier $\lambda_{ts}^{M}(1-P_b^{M})$ times the handoff probability P_{hs}^{M}, that is

$$\lambda_{hs}^{M} = \lambda_{ts}^{M}(1 - P_b^{M})\, P_{hs}^{M}$$

The traffic rate of λ_{ts}^{m} is incurred by new calls, handoff calls, and calls caused by channel-sharing for slow subscribers:

$$\lambda_{ts}^{m} = \lambda_{ns}^{m} + \lambda_{hs}^{m} + \lambda_{vs}^{m}$$

Where λ_{hs}^{m} is the handoff calls equals the slow subscriber successfully handoff on lower tier

$$\lambda_{hs}^{m} = \lambda_{ts}^{m}(1 - P_b^{m}) P_{hs}^{m}$$

and $\lambda_{vs}^{m}$is caused by vertical direction frequency sharing strategy,

$$\lambda_{vs}^{m} = \frac{\lambda_{vs}^{M}}{n}\left(\frac{\lambda_{ts}^{M}}{\lambda_{ts}^{M} + \lambda_{tf}^{M}}\right)P_{cvs}$$

Here λ_{vs}^{M} is the load caused by the vertical direction frequency sharing by slow subscriber in the physical area covered by a macrocell (including one macrocell and n microcell) and P_{cvs} times is the probability that a subscriber in macrocell can be rearranged to a microcell but only a fraction 1/n of the load will be injected to the microcell. The rate λ_{vs}^{M} can be derived as follows:

$$\lambda_{vs}^{M} = n(\lambda_{ns}^{m} + \lambda_{hs}^{m})P_b^{m} P_b^{M},$$

It equals the new call arrival rate and handoff call rate of slow subscribers into the n microcells $n(\lambda_{ns}^{m} + \lambda_{hs}^{m})$, P_b^{m} is times probability that they see no free channel in the local microcell, and P_b^{M} times probability that they see no free channel in the macrocell.

Finally the term $\left(\frac{\lambda_{ts}^{M}}{\lambda_{ts}^{M}+\lambda_{tf}^{M}}\right)$ is the ratio of vertical direction frequency sharing flows by slow subscribers into microcells.

4.2 Performance of Using Horizontal Direction Frequency Sharing

In this section, analysis is made of the proposed Horizontal Direction Frequency Sharing scheme. If a mobile subscriber call request found no free channel in its local cell then previously discussed VDFS take place first. HDFS scheme takes place, if VDFS scheme fail to perform. The goals is to drive the ***call lose probabilities*** P_{lf} and P_{ls} of new calls for fast and slow subscribers respectively.

The call loss probabilities are:

$$P_{lf} = P_b^{M} P_{vs} P_z$$

$$P_{ls} = P_b^{m} P_b^{M} P_{vs} P_z$$

Where probability$P_{vs}$is the failure probability of vertical direction sharing as given in 1, and P_z is the failure probability of horizontal direction sharing is as follows:

$$P_z = 1 - P_{est}^{M}\left((1 - P_b^{M})(1 - P_{vs}^{'})\right)$$

Where $P_{vs}^{'}$ is the failure probability of vertical direction sharing for macrocell M_i as given in 1, and P_{est}^{M} is the probability for staying at least one subscriber in early handoff area given as:

$$P_{est}^{M} = 1 - \left(\frac{(R_e)^2}{(R_n)^2}\right)^{C_A^{M}}$$

P_b^{M}, and P_b^{m}can be derived as (3) and (4) respectively, but their values are different for different aggregate traffic rates. The horizontal direction sharing affects only traffic flows on macrocell, therefore λ_{ts}^{m} in microcell are same as that in the vertical direction frequency sharing as discussed in section 4.1, but their value are dependent on P_b^{M}, and $P_b^{m}$when derived as for horizontal direction sharing.

In macrocell, the aggregate rate λ_{tf}^{M} incurred by new calls, handoff calls, and horizontal direction sharing calls for fast subscriber:

$$\lambda_{tf}^{M} = \lambda_{nf}^{M} + \lambda_{hf}^{M} + \lambda_{zf}^{M}$$

λ_{zf}^{M} caused by horizontal direction sharing can be calculated as:

$$\lambda_{zf}^{M} = (\lambda_{nf}^{M} + \lambda_{hf}^{M}) P_b^M P_{vs} P_{est}^M$$

It equals the new call arrival rate and handoff rate into macrocell$(\lambda_{nf}^{M} + \lambda_{hf}^{M})$, times probability that they found no free channel in the macrocellP_b^M, times probability that they fail in vertical direction sharingP_{vs}, and times probability that at least one subscriber staying in early handoff areaP_{est}^M. Similarly λ_{ts}^{M} is the aggregate traffic rate incurred by overflow calls, handoff calls, and horizontal direction sharing in macrocell by slow subscribers:

$$\lambda_{ts}^{M} = \lambda_{os}^{M} + \lambda_{hs}^{M} + \lambda_{zs}^{M}$$

Where λ_{zs}^{M} is horizontal direction sharing by slow subscriber,

$$\lambda_{zs}^{M} = n(\lambda_{ns}^{m} + \lambda_{hs}^{m}) P_b^m P_b^M P_{vs} P_{est}^M$$

which equals the new call arrival rate and handoff rate of slow subscribers into the n microcells $n(\lambda_{ns}^{m} + \lambda_{hs}^{m})$, times the probabilities that they found no free channel in the local microcell P_b^m, and neither in the macrocell P_b^M, times the probability that they fail in vertical direction sharing P_{vs}, and times probability that at least one subscriber staying in early handoff area P_{est}^M.

5. NUMERICAL EXAMPLES AND DISCUSSION

We consider 4 cases denoted from (a) to (d) for comparison as follows:

a) The call loses probabilities of **Take Back (TB)** scheme in reference [12] for fast and slow subscribers are denoted by$P_b^M P_b^m$, and P_b^m P_b^M respectively.

b) The call loses probabilities of **Channel Rearrangement (CR)** scheme in reference [13] for fast and slow subscribers are denoted by$P_b^M P_R$, and $P_b^m P_r P_b^M$ respectiely.

c) The call loses probabilities of **Vertical Direction Frequency Sharing (VDFS)** scheme for fast and slow subscribers are denoted by $P_b^M P_{vs}$, and $P_b^m P_b^M P_{vs}$ respectively.

d) The call loses probabilities of **Horizontal Direction Frequency Sharing (HDFS)** scheme for fast and slow subscribers are denoted by $P_b^M P_{vs} P_z$, and $P_b^m P_b^M P_{vs} P_z$ respectively.

It is assumed that the total traffic to the entire area follows the Poisson process with the rate λ and the fraction q of this traffic from slow mobile subscribers.

To compare the different strategies listed (a) to (d), we assumed some parameters as shown in Table 2

In Table 2, q is tune the amount of slow subscriber in an area and n takes care of size difference between macrocell and microcell. Here assume that n=4, q=0.5 and the mean holding time for a call is 140 seconds.

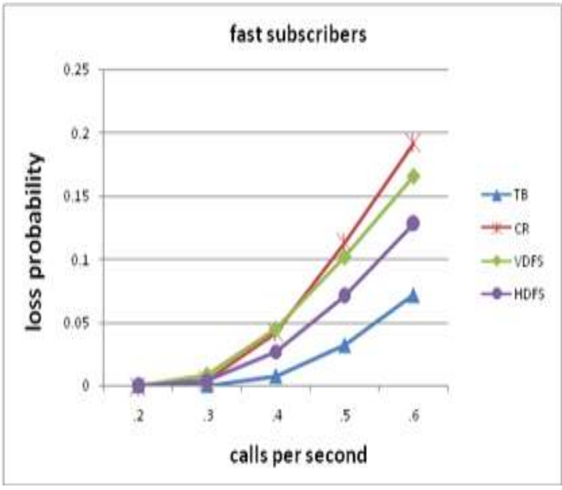

Figure 7: Comparison of numerical analysis on call loss probability with (.2 to.6) call arrival rate for fast subscribers

Table 2: List of parameters taken for performance comparison

S.No.	Parameter name	Value	
		Macrocell	Microcell
1	Radius	800 m	400 m
2	Average velocity	40 km/hr	4km/hr
3	The call arrival rate of slow subscriber	$q\lambda$	$q\lambda/n$
4	The call arrival rate of fast subscriber	$(1 - q)\lambda$	0
5	Number of channels	37	9
6	Guard channels	8	2

Table 3: Number of assumed channels in the different schemes to be compared

S.No.	Scheme	Guard Channels (microcell, macrocell)	Available number of channels- C_A	
			Slow subscriber	Fast subscriber
1	TB scheme	0 , 0	9	37
2	CR scheme	0 , 0	9	37
3	VDFS	2 , 8	7	29
4	HDFS	2 , 8	7	29

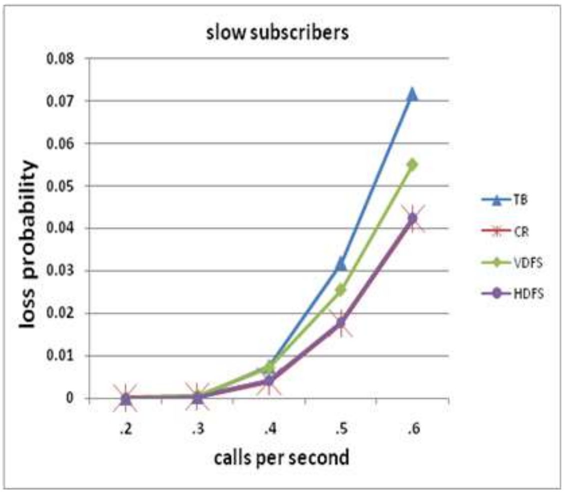

Figure 8: Comparison of numerical analysis on call loss probability with (.2 to.6) call arrival rate for slow subscribers

To different schemes mentioned above from (a) to (d), the calls lose probability is calculated and compared (Fig. 7 and 8) for fast and slow subscribers. It is assumed that for fast and slow subscribers, the available channels in the cell shown in Table 3.

It is found that, for fast subscribers, the CR scheme redirects the traffic only to neighbouring macrocell, if the current macrocell M is fully occupied. As per Fig. 7, it performs the worst as it does not release the traffic effectively. The TB scheme overflows a call to the overlaid microcell, with take-back strategy, at the time of handoff and thus performs better than CR for fast subscribers. The VDFS scheme performs better than CR because it pushes slow subscribers on the macrocell to its overlaid microcells even the VHFS scheme has less number of channels as compared to CR schemes. The channels are reserved (guard channels) for handoff calls in proposed schemes. There are multiple microcells to take the load of a macrocell. Fig. 7 shows that VDFS scheme has less call loss probability compare to CR scheme. HDFS scheme performs better than VDFS, because it also transfers the load to neighbouring.

For slow subscribers the CR scheme perform better than TB, as it has channel rearrangement strategy with overflow scheme, that has more redirecting choices as compare to TB (Fig. 8). The VDFS and HDFS schemes perform similar trend for both fast and slow subscribers. According to Fig. 8, the call loss probability of CR and HDFS scheme is same even the HDFS scheme has less channels, reserve as the guard channels for handle the handoff calls.

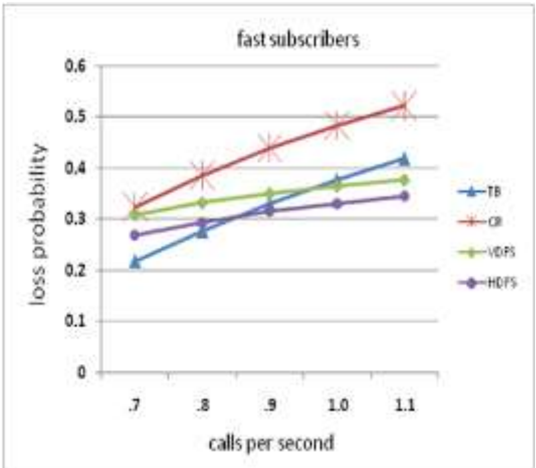

Figure 9: Comparison of numerical analysis on call loss probability with (.7 to1.1) call arrival rate for fast subscribers

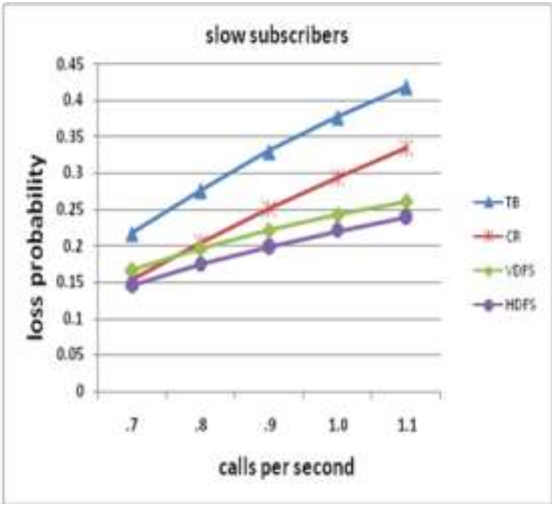

Figure 10: Comparison of numerical analysis on call loss probability with (.7 to1.1) call arrival rate for slow subscribers

The proposed schemes are suggested to provide the service to slow speed users with high intensity traffic area and macrocells are overlaid over more than one microcell cater mainly to lower density with high speed subscribers. The VDFS and HDFS schemes performs similar trend for fast and slow subscriber. Now, as soon as the total traffic rate is increased to the entire area, the value of tune the strength of slow subscribers is increased to q=0.7, It is also observed that the results for proposed schemes are too good in comparison to TB, and CR schemes (Fig. 9, 10). HDFS scheme performs even better than VDFS scheme. The call loss probability of the proposed scheme is, therefore, better than TB, and CR schemes in the area where services to slow speed users with high intensity traffic area, and high speed subscribers with lower density area, even that the proposed schemes reserve the guard channels for the handoff calls (Fig. 9 and 10).

6. CONCLUSION

In this paper, the VDFS & HDFS schemes perform better for new arrival calls; even it contains less channels in comparison to conventional strategies for handle the new calls. The proposed schemes have guard channels as a reserve channels to handle the handoff calls only. An analytical model has been developed to derive some useful performance indices. The methods to improve the call loss probability in the service area that contains user population in sparse with slow and high speed users is proposed by taking the advantage of overlapping coverage of two-tier system. Thus, it is possible to share the load in between two-tier of highly populated area for slow subscribers and less dense to fast subscribers. It is also found that a significant reduction is obtained in call loss probability for VDFS and HDFS scheme in comparison to TB and CR schemes. The VDFS and HDFS schemes performs similar trend for fast and slow subscribers also. The proposed schemes shows better performance in comparison to TB and CR schemes for both kinds of subscribers, even the total traffic rate is increased to entire area, value of tune the strength of the slow subscribers is increased.

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