AN INSIGHT TO CALL BLOCKING PROBABILITIES OF CHANNEL ASSIGNMENT SCHEMES

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ABSTRACT

In wireless mobile communication systems, the radio spectrum is limited resource. However, efficient use of such limited spectrum becomes more important when the two, three or more cells in the network become hot - spot. The use of available channels has been shown to improve the system capacity. The role of channel assignment scheme is to allocate channels to cells in such way as to minimize call-blocking probability or call dropping probability and also maximize the quality of service. Different channel allocation schemes are in use for mobile communication systems, of which the Hybrid channel allocation (HCA) a combination of Fixed and Dynamic channel allocation schemes (FCA and DCA respectively) was effective. In this paper, the performance of three different channel allocation schemes FCA, DCA and HCA will be analytically compared and the results are presented.

KEYWORDS: *HCA, QOS, call blocking probability, channel allocation, hotspot.*

I. INTRODUCTION

Technological advances and rapid development of handheld wireless terminals have facilitated the rapid growth of wireless communications and mobile computing. Taking ergonomic and economic factors into account, and considering the new trend in the telecommunications industry to provide ubiquitous information access, the population of mobile users will continue to grow at a tremendous rate. Another important developing phenomenon is the shift of many applications to multimedia platforms in order to present information more effectively.

The tremendous growth of the wireless/mobile user population, coupled with the bandwidth requirements of multimedia applications, requires efficient reuse of the scarce radio spectrum allocated to wireless/mobile communications. Efficient use of radio spectrum is also important from a cost-of service point of view, where the number of base stations required to service a given geographical area is an important factor. A reduction in the number of base stations, and hence in the cost of service, can be achieved by more efficient reuse of the radio spectrum. The basic prohibiting factor in radio spectrum reuse is interference caused by the environment or other mobiles. Interference can be reduced by deploying efficient radio subsystems and by making use of channel assignment techniques.

In the radio and transmission subsystems, techniques such as deployment of time and space diversity systems, use of low noise filters and efficient equalizers, and deployment of efficient modulation schemes can be used to suppress interference and to extract the desired signal. However, co-channel interference caused by frequency reuse is the most restraining factor on the overall system capacity in the wireless networks, and the main idea behind channel assignment algorithms is to make use of radio propagation path loss characteristics in order to minimize the carrier-to-interference ratio (CIR) and hence increase the radio spectrum re-use efficiency. The focus of this article is to provide an overview of different channel assignment algorithms and compare them in terms of performance, flexibility, and complexity. We first start by giving an overview of the channel assignment problem in a cellular environment and discuss the general idea behind major channel allocation schemes. Then we proceed to discuss different channel allocation schemes within each category .Here we made an simulational comparision of FCA,DCA,HCA in terms of blocking probability versus traffic load.

II. CHANNEL ALLOCATION SCHEMES

A given radio spectrum (or bandwidth) can be divided into a set of disjoint or non interfering radio channels. All such channels can be used simultaneously while maintaining an acceptable received radio signal. In order to divide a given radio spectrum into such channels many techniques such as frequency division (FD), time division (TD), or code division (CD) can be used. In FD, the spectrum is divided into disjoint frequency bands, whereas in TD the channel separation is achieved by dividing the usage of the channel into disjoint time periods called time slots. In CD, the channel separation is achieved by using different modulation codes. Furthermore, more elaborate techniques can be designed to divide a radio spectrum into a set of disjoint channels based on combining the above techniques. For example, a combination of TD and FD can be used by dividing each frequency band of an FD scheme into time slots. The major driving factor in determining the number of channels with certain quality that can be used for a given wireless spectrum is the level of received signal quality that can be achieved in each channel. The distance between two cells is defined as the Euclidean distance between the centers of the two cells.

Let Si(k) be denoted as the set (i) of wireless terminals that communicate with each other using the same channel k. By taking advantage of physical characteristics of the radio environment, the same channel k can be reused simultaneously by another set j if the members of sets i and j are spaced sufficiently apart. All such sets which use the same channel are referred to as co-channel sets or simply co-channels. The minimum distance at which co-channels can be reused with acceptable interference is called the "co-channel reuse distance," σ.

This is possible because due to propagation path loss in the radio environment, the average power received from a transmitter at distance d is proportional to PT d α where a is a number in the range of 3-5 depending on the physical environment, and PT is the average transmitter power. For example, for an indoor environment with a = 3.5, the average power at a distance 2d is about 9 percent of the average power received at distance d. Thus, by adjusting the transmitter power level and/or the distance between co-channels, a channel can be reused by a number of co-channels if the Carrier-to-Interference ratio (CIR) in each co-channel is above the minimum CIR value. Here the carrier power represents the received signal power in a channel, and the interference represents the sum of received signal powers of all co-channels.

As an example, consider Fig. 1 where a wireless station labelled R is at distance dt from a transmitter station labelled T using a narrowband radio channel. We refer to the radio channel used by T to communicate to R as the reference channel. In this figure, we have also shown five other stations labelled 1, 2, . . . , 5, which use the same channel as the reference channel to communicate with some other stations. Denoting the transmitted power of station i by Pi and the distance of station i from R by di, the average CIR at the reference station R is given by Eq. (1).

$$\mathrm{CIR} = \frac{P_t d_t^{-\alpha}}{\sum^{5} P_i d_i^{-\alpha} + N_0} \tag{1}$$

Where, N_o represents the environmental noise; to achieve a certain level of CIR at the reference station R, different methods can be used.

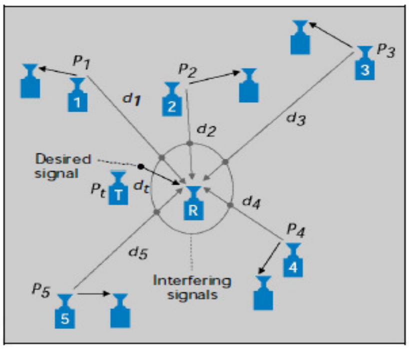

Fig. 1. Interference.

Three types of channel allocation strategies have been proposed and are divided into three categories: FCA, DCA and HCA. Fig.2. shows classification of these channel allocation strategies.

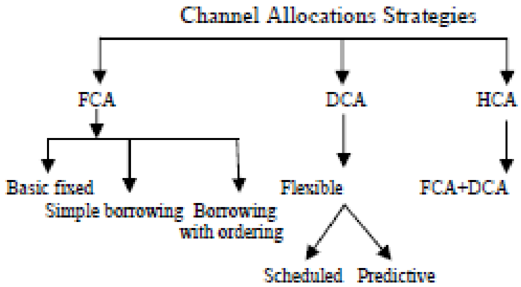

Fig.2. Classification of channel allocation strategies

In FCA, the area is divided into the number of cells and a number of channels are assigned to each cell according to some reuse pattern and considering interference depending on desired signal quality as shown in Fig. 3.

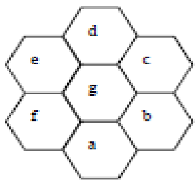

Fig.3. FCA strategy, a-g denote different sort of voice channels permanently assigned to cells

FCA is very simple, easy to implement but they do not adopt to change in traffic conditions and user distributions. However FCA could not attain a high efficiency of total channel usage over the whole service area if the traffic varies from cell to cell. In order to overcome this problem DCA strategy has been proposed. In DCA, channels are assigned dynamically over plural cells in accordance with traffic intensity.

In Flexible Channel Allocation (FICA) strategy, a set of available channels divided into two sets: fixed set and flexible set. The assignment of these emergency channels (fixed set and flexible set) among the cells done either in a scheduled or predictive manner. In Predictive strategy, the traffic intensity, call-blocking probability needs to be measured constantly at every cell site so that the reallocation of flexible channels carried out at any point in time. In Scheduled strategy, future changes in traffic distribution are pinpointed in time and space. To overcome these deficiencies, HCA scheme has been introduced. In HCA scheme total numbers of channels are divided into two sets: fixed set (same as FCA scheme) and dynamic set (same as DCA scheme).

III. CALL BLOCKING PROBABILITY

Several metrics can be used to evaluate and compare the performance of the proposed algorithm. The call blocking probability is defined as the ratio of the number of new calls initiated by a mobile host which cannot be supported by existing channel arrangement to the total number of new calls initiated. Call blocking probability (P_b) is given by the ratio of "number of calls lost by the system" to "the total number of new calls initiated".

IV. FIXED CHANNEL ALLOCATION

In the FCA strategy a set of nominal channels is permanently allocated to each cell for its exclusive use. Here a definite relationship is assumed between each channel and each cell, in accordance to co-channel reuse constraints.

The total number of available channels in the system C is divided into sets, and the minimum number of channel sets N required to serve the entire coverage area is related to the reuse distance 's'.

N = (1/3)σ^2, for hexagonal cells.

Here σ is defined as D/Ra, where Ra is the radius of the cell and D is the physical distance between the two cell centres [5]. N can assume only the integer values 3, 4, 7, 9, . . . as generally presented by the series, (i + j)2 – i, j, with i and j being integers [5, 7].]. Figures 4(a) and 4(b) give the allocation of channel sets to cells for N = 3 (0 = 3) and N = 7 (0 = 4.45), respectively.

In the simple FCA strategy, the same number of nominal channels is allocated to each cell. This uniform channel distribution is efficient if the traffic distribution of the system is also uniform. In that case, the overall average blocking probability of the mobile system is the same as the call blocking probability in a cell. Because traffic in cellular systems can be non uniform with temporal and spatial fluctuations, a uniform allocation of channels to cells may result in high blocking in some cells, while others might have a sizeable number of spare channels. This could result in poor channel utilization. It is therefore appropriate to tailor the number of channels in a cell to match the load in it by non uniform channel allocation or static borrowing. In non uniform channel allocation the number of nominal channels allocated to each cell depends on the expected traffic profile in that cell.

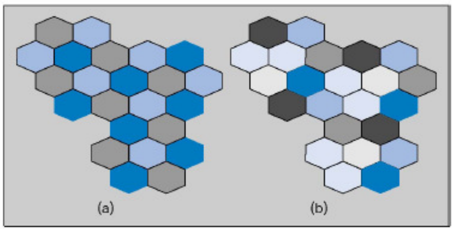

Figure 4a, 4b: Allocation of channel sets to cells for N =3 and N = 7 respectively

V. CHANNEL BORROWING SCHEMES

In a channel borrowing scheme, an acceptor cell that has used all its nominal channels can borrow free channels from its neighbouring cells (donors) to accommodate new calls. A channel can be borrowed by a cell if the borrowed channel does not interfere with existing calls. When a channel is borrowed, several other cells are prohibited from using it. This is called channel locking.

For example, for a hexagonal planar layout with reuse distance of one cell (σ = 3), a borrowed channel is locked in three additional neighbouring cells, as is shown in Fig. 5, while for a one-dimensional layout or a hexagonal planar grid layout with two-cell reuse distance, it is locked in two additional neighbouring cells.

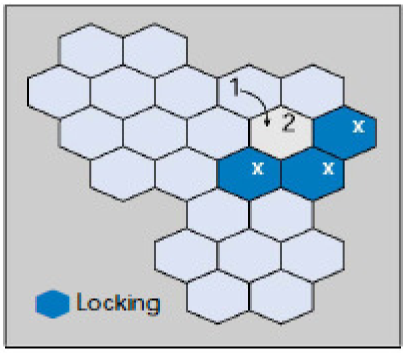

Figure.5. Channel Locking

The channel borrowing schemes can be divided into simple and hybrid. In simple channel borrowing schemes, any nominal channel in a cell can be borrowed by a neighbouring cell for temporary use. In hybrid channel borrowing strategies, the set of channels assigned to each cell is divided into two subsets, A (standard or local channels) and B (nonstandard or borrowable channels). Subset A is for use only in the nominally assigned cell, while subset B is allowed to be lent to neighbouring cells. Table 1 summarizes the channel borrowing schemes proposed in the literature.

Table 1. Channel Borrowing Schemes

Category	Scheme
Simple Channel Borrowing	• Simple borrowing (SB) • Borrow from the richest (SBR) • Basic algorithm (BA) • Basic algorithm with reassignment (BAR) • Borrow first avai lable (BFA)
Hybrid Channel Borrowing	• Simple hybrid borrowing scheme (S HCB) • Borrowing with channel ordering (BCO) • Borrowing with directional channel locking (BO CL) • Sharing with bias (S H B) Channel assignment with borrowing and • reassignment (CABR) • Ordered dynamic channel assignment with • Rearrangement

5.1 Simple Channel Borrowing Schemes

In the simple borrowing (SB) strategy , a nominal channel set is assigned to a cell, as in the FCA case. After all nominal channels are used; an available channel from a neighbouring cell is borrowed. To be available for borrowing, the channel must not interfere with existing calls. Although channel borrowing can reduce call blocking, it can cause interference in the donor cells from which the channel is borrowed and prevent future calls in these cells from being completed.
The SB strategy gives lower blocking probability than static FCA under light and moderate traffic, but static FCA performs better in heavy traffic conditions. This is due to the fact that in light and moderate traffic conditions, borrowing of channels provides a means to serve the fluctuations of offered traffic, and as long as the traffic intensity is low the number of donor cells is small. In heavy traffic, the channel borrowing may proliferate to such an extent, due to channel locking, that the channel usage efficiency drops drastically, causing an increase in blocking probability and a decrease in channel utilization.
The different schemes of simple channel borrowing are,

- Simple borrowing (SB)
- Borrow from the richest (SBR)
- Basic algorithm (BA)

- Basic algorithm with reassignment (BAR)
- Borrow first available (BFA)

5.1.1) Borrow from the Richest (SBR)

In this scheme, channels that are candidates for borrowing are available channels nominally assigned to one of the adjacent cells of the acceptor cell . If more than one adjacent cell has channels available for borrowing, a channel is borrowed from the cell with the greatest number of channels available for borrowing. As discussed earlier, channel borrowing can cause channel locking. The SBR scheme does not take channel locking into account when choosing a candidate channel for borrowing.

5.1 .2) Basic Algorithm (BA)

This is an improved version of the SBR strategy which takes channel locking into account when selecting a candidate channel for borrowing. This scheme tries to minimize the future call blocking probability in the cell that is most affected by the channel borrowing. As in the SBR case, channels that are candidates for borrowing are available channels nominally assigned to one of the adjacent cells of the acceptor cell. The algorithm chooses the candidate channel that maximizes the number of available nominal channels in the worst-case nominal celJ3 in distance σ to the acceptor cell.

5. 1.3) Basic Algorithm with Reassignment (BAR)

This scheme provides for the transfer of a call from a borrowed channel to a nominal channel whenever a nominal channel becomes available. The choice of the particular borrowed channel to be freed is again made in a manner that minimizes the maximum probability of future call blocking in the cell most affected by the borrowing, as in the BA scheme .

5.1. 4)Borrow First Available (BFA)

Instead of trying to optimize when borrowing, this algorithm selects the first candidate channel it finds . Here, the philosophy of the nominal channel assignment is also different. Instead of assigning channels directly to cells, the channels are divided into sets, and then each set is assigned to cells at reuse distance σ. These sets are numbered in sequence. When setting up a call, channel sets are searched in a prescribed sequence to find a candidate channel.

A summary of the comparison results between the BFA, SBR, BA and BAR schemes is given in table 2.

Table 2. Comparison between BFA, SBR, BA, and BAR

Scheme	Complexity	Flexibility	Performance # of tests to locate borrowable channel
Borrow from the richest (SBR)	Moderate	Moderate	Few
Basic algorithm (BA)	High	Moderate	A lot
Basic algorithm with reassignment (BAR)	High	Moderate	A lot
Borrow first available (BFA)	Low	Low	Very few

VI. HYBRID CHANNEL BORROWING SYSTEMS

The different schemes of hybrid channel borrowing are,

- Simple hybrid borrowing scheme (S HCB)
- Borrowing with channel ordering (BCO)
- Borrowing with directional channel locking (BO CL)
- Sharing with bias (S H B) Channel assignment with borrowing and
- reassignment (CABR)
- Ordered dynamic channel assignment with Re arrangement

6.1. Simple Hybrid Channel Borrowing Strategy (SHCB)

In the SHCB strategy the set of channels assigned to each cell is divided into two subsets, A (standard) and B (borrowable) channels. Subset A is nominally assigned in each cell, while subset B is allowed to be lent to neighbouring cells. The ratio I AI: I B I is determined a priori, depending on an estimation of the traffic conditions, and can be adapted dynamically in a scheduled or predictive manner.

6.2. Borrowing with Channel Ordering (BCO)

The BCO is analyzed in ordering technique outperforms SHCB by dynamically varying the local to borrowable channel ratio according to changing traffic conditions. In the BC strategy, all nominal channels are ordered such that the first channel has the highest priority for being assigned to the next local call, and the last channel is given the highest priority for being borrowed by the neighbouring cells. A variation of 1the BCO strategy, called BCG with reassignment, allows intercellular handoff, that is, immediate reallocation of a released high-rank channel to a call existing in a lower-rank channel in order to minimize the channel locking effect when a channel is borrowed several other cells are prohibited from using it .this effect is called ''channel locking''.

6.3 Borrowing with Directional Channel Locking (BDCL)

In the BCO strategy, a channel is suitable for borrowing only if it is simultaneously free in three Nearby co-channel cells. This requirement is too stringent and decreases the number of channels available for borrowing. In the BDCL strategy, the channel locking in the co-channel cells is restricted to those directions affected by the borrowing. Thus, the number of channels available for borrowing is greater than that in the BCO strategy. To determine in which case a "locked" channel can be borrowed, "lock directions" are specified for each locked channel. The scheme also incorporates reallocation of calls from borrowed to nominal channels and between borrowed channels in order to minimize the channel borrowing of future calls, especially the multiple-channel borrowing observed during heavy traffic.

6.4 Sharing with Bias (SHB)

The SHB strategy is similar to the join biased queue rule which is a simple but effective way to balance the load of servers in the presence of unbalanced traffic. Each cell in the system is divided in three sectors, X, Y, Z. Only calls initiated in one of these sectors can borrow channels from the two adjacent cells neighbouring it (donor cells). In addition, the nominal channels in donor cells are divided in two subsets, A and B, as in the SHCB case. Channels from set A can only be used inside the donor cell, while channels in set B can be loaned to an acceptor cell.

6.5 Channel Assignment with Borrowing and Reassignment (CARB)

The CARB scheme proposed is statistically optimum in a certain min-max sense. Here channels are borrowed on the basis of causing the least harm to neighbouring cells in terms of future call blocking probability. Likewise, reassignment of borrowed channels is done in away to cause maximum relief to neighbouring cells.

6.6 Ordered Channel Assignment Scheme with Rearrangement (ODCA)

The proposed ODCA scheme combines the merits of CARB and BCO with improvements to yield higher performance. In ODCA, when a call requests service, the base station of the cell checks to see if there are any nominal channels available. If there are channels available, the user will be assigned one on an ordered basis, as in BCO. Here all channels are numbered in predetermined order according to the same criterion as in the CARB scheme, and the lowest numbered available idle channel is always selected. If all nominal channels are busy, the cell may borrow a nonstandard channel from a neighbouring cell. Once a nonstandard channel is assigned, the availability lists of all affected cells where the assigned channel can cause interference are updated. Whenever a channel is no longer required, the availability lists of the affected cells are updated accordingly. Whenever a standard channel is available, the channel reassignment procedure is initiated to ensure efficient utilization. If there is a nonstandard channel in use in the cell, the call served by that channel is switched to the newly freed standard channel; the necessary availability lists are also updated. If no nonstandard channels are used in the cell, a call served by a standard channel with lower priority than the newly freed one is switched to the newly freed channel. A summary of the comparison results between the fixed channel allocation schemes is given in table 3.

Table 3. Comparison between fixed channel allocation schemes.

Scheme	Complexity	Flexibility	Performance
Simple FCA	Low	Low	Better than dynamic and hybrid borrowing in heavy traffic
Static Borrowing	Low-moderate	Moderate	Better than FCA
Simple Channel Borrowing	Moderate-high	High	Better than FCA and static borrowing in light and moderate traffic
Hybrid Channel Borrowing	Moderate	Moderate	Better than FCA in light and moderate traffic Better than simple channel borrowing in heavy loads

VII. DYNAMIC CHANNEL ALLOCATION

Due to short-term temporal and spatial variations of traffic in cellular systems, FCA schemes are not able to attain high channel efficiency. To overcome this, DCA schemes have been studied during the past 20 years. In contrast to FCA, there is no fixed relationship between channels and cells in DCA. All channels are kept in a central pool and are assigned dynamically to radio cells as new calls arrive in the system. After a call is completed, its channel is returned to the central pool.

In DCA, a channel is eligible for use in any cell provided that signal interference constraints are satisfied. Because, in general, more than one channel might be available in the central pool to be assigned to a cell that requires a channel, some strategy must be applied to select the assigned channel.

Based on information used for channel assignment, DCA strategies could be classified either as call-by-call DCA or adaptive DCA schemes [27]. In the call-by-call DCA, the channel assignment is based only on current channel usage conditions in the service area, while in adaptive DCA the channel assignment is adaptively carried out using information on the previous as well as present channel usage conditions. Finally, DCA schemes can be also divided into centralized and distributed schemes with respect to the type of control they employ.

7.1. Centralized DCA Schemes

In centralized DCA schemes, a channel from the central pool is assigned to a call for temporary use by a centralized controller. The difference between these schemes is the specific cost function used for selecting one of the candidate channels for assignment.

7.2. First Available (FA)

The simplest of the DCA schemes is the FA strategy. In FA the first available channel within the reuse distance encountered during a channel search is assigned to the call. The FA strategy minimizes the system computational time; and, as shown by simulation . For a linear cellular mobile system, it provides an increase of 20 percent in the total handled traffic compared to FCA for low and moderate traffic loads.

7.3. Locally Optimized Dynamic Assignment (LODA)

In the LODA strategy, the selected cost function is based on the future blocking probability in the vicinity of the cell in which a call is initiated.

7.4. Channel Reuse Optimization Schemes

The objective of any mobile system is to maximize the efficiency of the system. Maximum efficiency is equivalent to maximum utilization of every channel in the system. It is obvious that the shorter the channel reuse distance, the greater the channel reuse over the whole service area. The cost functions selected in the following schemes attempt to maximize the efficiency of the system by optimizing the reuse of a channel in the system area.

7.5. Selection with Maximum Usage on the Reuse Ring (RING)

In the RING strategy, a candidate channel is selected which is in use in the most cells in the co-channel set. If more than one channel has this maximum usage, an arbitrary selection among such channels is made to serve the call. If none is available, the selection is made based on the FA scheme.

7.6 Mean Square (MSQ). Nearest Neighbour NN) Nearest Neighbour plus One (NN + 1) - The MSQ

The MSQ scheme selects the available channel that minimizes the mean square of the distance among the cells using the same channel. The NN strategy selects the available channel occupied in the nearest cell in distance $\geq \sigma$, while the NN + 1 scheme selects an eligible channel occupied in the nearest cell within distance $\geq \sigma + 1$ or distance σ if an available channel is not found in distance $\sigma + 1$.

VIII. DISTRIBUTED DCA SCHEMES

Microcellular systems have shown great potential for capacity improvement in high-density personal communication networks. However, propagation characteristics will be less predictable and network control requirements more intense than in the present systems. Several simulation and analysis results have shown that centralized DCA schemes can produce near-optimum channel allocation, but at the expense of a high centralization overhead. Distributed schemes are therefore more attractive for implementation in micro cellular systems, due to the simplicity of the assignment algorithm in each base station.

The proposed distributed DCA schemes use either local information about the current available channels in the cell's vicinity (cell-based) or signal strength measurements.

In cell-based schemes a channel is allocated to a call by the base station at which the call is initiated. The difference with the centralized approach is that each base station keeps information about the current available channels in its vicinity. The channel pattern information is updated by exchanging status information between base stations. The cell-based scheme provides near-optimum channel allocation at the expense of excessive exchange of status information between base stations, especially under heavy traffic loads. excessive exchange of status information between base stations, especially under heavy traffic loads.

Particularly appealing are the DCA interference adaptation schemes that rely on signal strength measurements. In these schemes a base station uses only local information, without the need to communicate with any other base station in the network. Thus, the system is self-organizing, and channels can be placed or added everywhere, as needed, to increase capacity or to improve radio coverage in a distributed fashion. These schemes allow fast real-time processing and maximal channel packing at the expense of increased co channel interference probability with respect to ongoing calls in adjacent cells, which may lead to undesirable effects such as interruption, deadlock, and instability.

8.1. Local Packing Dynamic Distributed Channel Assignment (LP-DDCA)

In the LP-DDCA scheme each base station assigns channels to calls using the augmented channel occupancy (ACO) matrix, which contains necessary and sufficient local information for the base station to make a channel assignment decision.

8.2. Moving Direction (MD)

The MD strategy was proposed in for one-dimensional microcellular systems. In these systems, forced call termination and channel changing occur frequently because of their small cell size . The MD strategy uses information on moving directions of the mobile units to decrease both the forced call termination blocking probability and the channel changing. An available channel is selected among those assigned to mobile units that are elsewhere in the service area and moving in the same direction as the mobile in question. The search for such a channel starts from the nearest non interfering cell to the one where the new call was initiated, and stops at the cell that is α reuse distances away, where α is a parameter.

8.3 LP-DDCA with ACI Constraint

A modified version of the LP-DDCA scheme was proposed that incorporates the ACI constraint. The variation of LP-DDCA imposes additional conditions on the channel selection from the ACO matrix. If the required channel separation between channels to avoid ACI interference is Nadj, the Nadj - 1 column to the left and right of that channel should have empty entries in the first row of the ACO matrix. When a call requests service from cell i, its base station searches in the first row of the ACO matrix for a group of 2Nadj - 1 consecutive empty entries where the centre column of the group is empty. If successful, it assigns the channel; otherwise, the base station searches for 2Nadj – 1 consecutive empty entries in the first row, where the centre columns has only one mark. If a channel is found, it checks to see whether the cell that uses the channel has additional channels available. In that case, it sends a message to the corresponding cell, and the base station of that cell switches the call using the channel in relation to a new one. Thus, the base station of cell i can use the channel. Otherwise the call is blocked.

IX. COMPARISON BETWEEN FCA AND DCA

In general, there is a trade-off between quality of service, the implementation complexity of the channel allocation algorithms, and spectrum utilization efficiency. Under low traffic intensity, DCA strategies perform better. However, FCA schemes become superior at high offered traffic, especially in the case of uniform traffic. In the case of non uniform traffic and light to moderate loads, it is believed that the DCA scheme will perform better due to the fact that under low traffic intensity, DCA uses channels more efficiently than FCA. In the FCA case channels are pre assigned to cells, so there are occasions when, due to fluctuation in traffic, calls are blocked, even though there are channels available in adjacent cells. In addition, a basic fact of telephone traffic engineering is that a server with capacity C is more efficient than a number of small ones with the same total aggregate capacity. That is, for the same average blocking probability a system with high capacity has higher utilization. FCA schemes behave like a number of small groups of servers, while DCA provides a way of making these small groups of servers behave like a larger server. Then It is observed that in Fig. 6, with low traffic intensity DCA uses channels more efficiently than FCA because of flexible channel assignment and shows good performance. But with high traffic intensity, DCA does not show better performance than FCA as stated above.

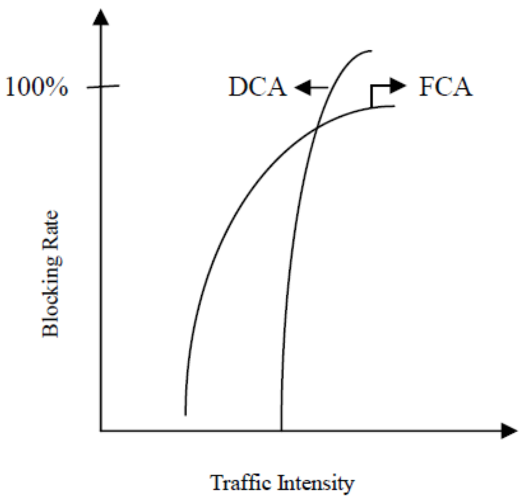

Fig.6 . Traffic intensity and blocking rate.

A summary of the comparison between the fixed channel allocation schemes and dynamic channel allocation schemes is given in table 4.

Table 4. Comparison between the fixed channel allocation schemes and dynamic channel allocation schemes

FCA	DCA
Performs better under heavy traffic. Low flexibility in channel assignment. Maximum channel reusability. Sensitive to time and spatial changes. Not stable grade of service per cell in an interference cell group. High forced call termination probability. Suitable for large cell environment. Low flexibility.	Performs better under light/moderate traffic. Flexible allocation of channels. Not always Maximum channel reusability. Insensitive to time and spatial changes. Stable grade of service per cell in an interference cell group. Low to moderate forced call termination probability. Suitable in micro-cellular environment. High flexibility.
Radio equipment covers all channels assigned to the cell.	Radio equipment covers the temporary channels assigned the cell.

Independent channel control fully centralized to fully distribute. Low computational effort. Low call setup delay. Low implementation complexity. Complex, labour intensive frequency planning. Low signalling load. Centralized control.	Control dependent on the scheme. High computational effort. Moderate call setup delay. Moderate implementation complexity. No frequency planning. Moderate to high signalling load. Centralized, decentralized, distributed control depending on the scheme.

X. HYBRID CHANNEL ALLOCATION

Hybrid channel assignment schemes are a mixture of the FCA and DCA techniques. In HCA, the total number of channels available for service is divided into fixed and dynamic sets. The fixed set contains a number of nominal channels that are assigned to cells as in the FCA schemes and, in all cases, are to be preferred for use in their respective cells. The second set of channels is shared by all users in the system to increase flexibility. When a call requires service from a cell and all of its nominal channels are busy, a channel from the dynamic set is assigned to the call. The channel assignment procedure from the dynamic set follows any of the DCA strategies described in the previous section. Variations of the main HCA schemes include HCA with channel reordering and HCA schemes where calls that cannot find an available channel are queued instead of blocked . The call blocking probability for an HCA scheme is defined as the probability that a call arriving to a cell finds both the fixed and dynamic channels busy.

Performance evaluation results of different HCA schemes have been compared. Theoretical study has done for an HCA scheme with Erlang-b service discipline for uniform size and shape cells where traffic is uniformly distributed over the whole system. The measure of interest is the probability of blocking as the load increases for different ratios of fixed to dynamic cells. For a system with fixed to dynamic channel ratio 3 : 1 , the HCA gives a better grade of service than FCA for load increases up to 50 percent. Beyond this load HCA has been found to perform better by case study.. A similar pattern of behaviour is obtained from the analysis where the HCA scheme employed uses the FA DCA scheme and Erlang-c service discipline (calls that cannot find an available channel are queued instead of blocked). In addition, the HCA scheme with Erlang-c service discipline has lower probability of blocking than the HCA scheme with Erlang-b service discipline.

In order to simplify the analysis of HCA we approximate the call blocking probability as a product of random pool as fixed channel allocation blocking probability and non random pool as dynamic channel allocation blocking probability.

In comparison with all those channel allocation schemes in terms of call blocking probability HCA performs better results by using hotspot notification and central pool .The main advantage of central pool is that when new call arrives in hotspot cell automatically a channel is assigned to that call from central pool as long as traffic in the cell goes to normal level. Channels in central pools are accessible to hotspot cells. HCA plays a major role to minimise call blocking probability and effects positively on performance of system due to increased tracking capacity. HCA designs to take advantages of both FCA and DCA. An attempt is made to reduce call blocking probability by using hotspot notification.

XI. HCA ALGORITHM

It consists of two phases

- Channel acquisition phase
- Channel release phase

11.1. Channel Acquisition Phase

Set level (L = 0) at the beginning to indicate that the channel request can be accommodated from the first group (A) and there is no hot-spot cell in the network.

1. When a mobile host wants to initiate a call, it has to send a channel request on the control channel to its related base station.

2. If the base station has an available channel from first group (A), it will assign a channel to mobile host.

3. If no channel from the first group (A) is available, then base station updates the value of *(L)* as shown in Fig.7.

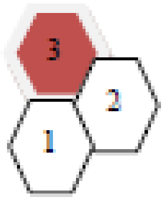

Fig. 7 . Cell no.3 is hot-spot cell, *L=1*

L = L + 1
L = 0 + 1 = 1
L = max(L, M)
4. The base station then sends a request to borrow a channel from the central pool located at MSC. It also includes the current value and maximum value of (L).

11.2. Channel Release Phase

1. The MSC, on receiving channel request from the base stations assign up to the (L) channels if available from dynamic pool.
2. When the base station successfully acquires channel from the dynamic pool at MSC, it also adds a channel to its temporary pool (T).
3. When a call terminates on a channel at a mobile host, the base station needs to find out which type of channel the call belonged to.
4. If channel is belonged to dynamic pool at MSC the base station estimates current level of hot-spot (h) in the cell as shown in Fig. 8.

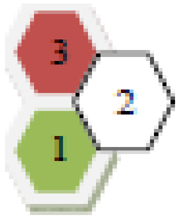

Fig.8. Estimation of current hot-spot level *(h),* cell no.1 and 3 hot-spot cells, *h=2*

5. If (h <= L) meaning that the congestion in the cell is same or easing, the base station checks its temporary pool (T) and retains up to (h) channels in random order and all the remaining channels in (T) are returned back to MSC.
6. If (h > L) meaning that the congestion in the cell is getting worse, the channel is retained in the cell. The channel is not returned back to MSC.
7. If MSC is unable to assign even one channel, the call will be blocked.

XII. SIMULATIONS

12.1. Simulated result of FCA:

$$B = A^2/2/(1 + A + A^2/2)$$

The resultant performance curve in this case plotting the blocking probability' B' versus load intensity of traffic by using above formula.

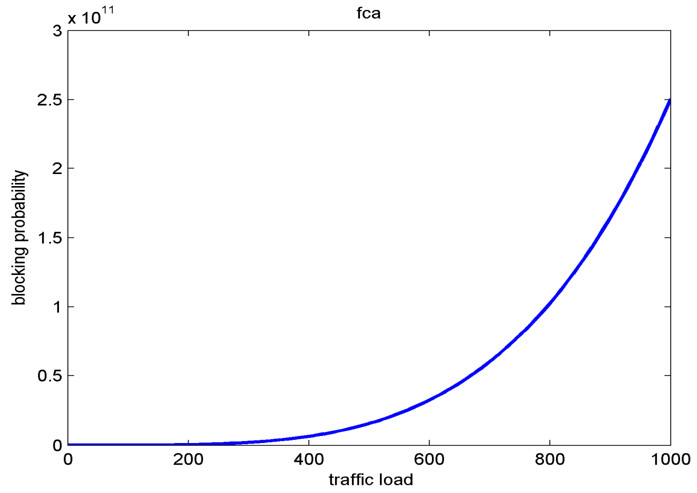

Fig .9 blocking probability versus traffic load plot of Fca

12.2. Theoretical result of HCA:

The blocking probability (P_b) in HCA is given by as Eq. (2)

$$p_b = \frac{\frac{A^N}{N!}}{\sum_{k=0}^{N} \frac{A^k}{k!}} \tag{2}$$

Where A is given by A = λ/μ, which is successive call time arrivals. In which, λ is the call arrival rate per second, μ is average call departure rate of users per second, and N is number of channels in the system.

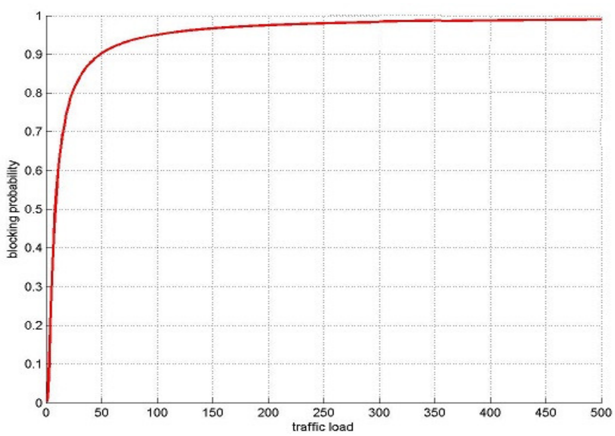

Fig.10 blocking probability versus traffic load plot of HCA

12.3. Simulated result of HCA:

The simulation result is shown in Fig. 11, HCA simulates with dynamic pool, MSC does not have fixed number of channels. There is no fixed relationship between channels and cells. It keeps changing randomly within the range (here it is 50). This simulates the scenario, when a base station due to hot-spot has borrowed and retained the channels from MSC. Therefore, MSC has less than allocated channels to lend to other base stations. This indirectly simulates the effect of hot-spot in the network.

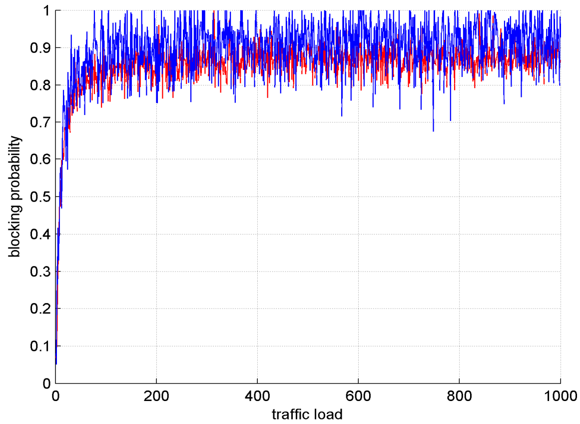

Fig.11 Simulated blocking probability versus traffic load of HCA

Simulation tool:
In order to evaluate the performance of channel assignment schemes we simulate the FCA,DCA,HCA in terms of blocking probability versus traffic load by using MATLAB 7.8.0.347(R 2009a).the reference we have taken into consideration for simulation is ‘’An introduction to matlab” by ‘’Rudhra pratap’’ &and the latest reference papers regarding to channel assignment schemes using matlab software .The parameters taken into consideration are “blocking probability(B)”,’’traffic load(A)’’,’’number of channels(N)’’,’’call arrival rate(ƛ)’’.

XIII. CONCLUSION

In Fixed Channel Allocation (FCA), a call attempt at a cell site can only be served by the unoccupied channels of cell site. FCA is very simple, easy to implement but they do not adopt to change in traffic conditions and user distributions. However FCA could not attain a high efficiency of total channel usage over the whole service area if the traffic varies from cell to cell. In order to overcome this problem DCA strategy has been proposed. In DCA, channels are assigned dynamically over plural cells in accordance with traffic intensity. Various strategies are proposed to increase channel usage efficiency in DCA. The disadvantage of DCA is high blocking rate when compared to FCA. The main advantage of this algorithm is that it can adapt to dynamic strategy at low traffic load and to fixed strategy at higher traffic intensity load and to fixed strategy at higher traffic intensity. If we increase the value of hot-spot level *(L)*, the system performance in both regions of the low and high traffic intensity. From the above discussion it can be deemed that hybrid channel allocation algorithm sends a multi-level hot-spot notification to the central pool on each channel request which cannot be satisfied locally at the base station. This notification will request more than one channel be assigned to the requesting cell, proportional to the current hot-spot level (L) of the cell. This also reduce control message overhead needed to acquire each channels individually. When a call using such a borrowed channel terminates, the cell may retain the channel depending upon its current hot-spot level (h).The simulation study of the protocol indicates that the protocol has low overhead, and it behaves similar to the FCA at high traffic and to the DCA at low traffic loads. so by the experimental and simulated evaluations of all channel assignment schemes we proposed that HCA will give the appropriate results in reducing call blocking probability.further research has to be continued on HCA by increasing number of hotspot levels by considering interference as a main parameter.

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