Channel Allocation Scheme in Cellular System

Sudarshan Subhashrao Sonawane
Assistant Professor, Department of Computer Engineering, SGDCOE, Jalgaon (M.S.)
Email: sudars_2000@yahoo.com
Dr.A.J.Patil
Principal, SGDCOE, Jalgaon (M.S.)
Email: Anilj48@gmail.com
Dr.A.K.Sachan
Director, RITS, Bhopal (M.P.)
Email: sachanak_12@yahoo.com

ABSTRACT

Channel allocation scheme proposed for cellular systems. We start with allocation a set of channels to each cell in fixed channel assignment scheme. The scheme used for handling the high density cell problem because it proposes to move unused channels from suitable low density cells to the high density ones through a channel borrowing algorithm. Detailed simulation experiments are carried out in order to evaluate our proposed methodology. Performance comparison gives that the D-LBSB scheme performs better than a C-LBSB version in an overloaded system.

Keywords - Cellular networks, Channel allocation, Channel borrowing, Distributed Channel Allocation, Distributed Algorithm.

Date of Submission: April 07, 2010, Date of Acceptance: June 02, 2010

1. Introduction

In the field of the mobile communication and by the FCC still very limited frequency spectrum allocated to this service, the efficient management and sharing of the spectrum among numerous users become important issues. This limitation means that the frequency channels have to be reused as much as possible in order to support the many thousands of simultaneous calls that may arise in any typical mobile communication environment. Thus, evolved the concept of cellular architecture, which is conceived as a collection of geometric areas called cells (typically hexagonal-shaped), each serviced by a base station (BS).

In the fixed assignment (FA) schemes, a set of channels are permanently allocated to each cell, which can be reused in another cell, sufficiently distant, such that the co-channel interference is tolerable. Such a pair of cells is called co-channel cells. In one type of FA scheme, clusters of cells, called compact pattern (CP), are formed by finding the shortest distance between two co-channel cells, such that each cell within a compact pattern is assigned a different set of frequencies [19]. The advantage of an FA scheme is its simplicity, which is the primary reason why it is adopted in most of the existing systems. But the disadvantage is that if the number of calls exceeds the number of channels assigned to a cell, the excess calls are blocked. This problem can be partially alleviated by channel borrowing methods, in which a channel is borrowed from one of the neighboring cells in case of blocked calls, provided that it does not interfere with the existing calls.

The disadvantage of channel borrowing is that the borrowed channel has to be locked in those co-channel cells of the lender, which are non-co-channel cells of the borrower in order to avoid interference [7].

2. Related Work

While the motivation behind all basic channel assignment strategies is the better utilization of the available frequency spectrum with the consequent reduction of the call blocking probability in each cell, very few of them deal with the problem of non-uniformity of demand (or traffic) in different cells which may lead to a gross imbalance in the system performance. In the directed retry with Channel sharing scheme, it is assumed that the neighboring cells overlap and the users in the overlapping region are able to hear transmitters from the neighboring cells almost as well as in their own cell[5].

Whenever the cell starts getting overloaded, some of those users hand-off to the neighboring cells. The main drawbacks of this scheme are, increased number of hand-offs and co-channel interference and the need for Channel sharing dependent on the number of users in the overlap region. A cell is classified as ‘high density’, if its degree of coldness (defined as the ratio of the number of available channels to the total number of channels allocated to that cell) is less than or equal to some threshold value. Otherwise the cell is ‘low density’.

The LBSB scheme proposes to migrate a fixed number of channels from low density cells to a high density one through a centralized channel borrowing algorithm run periodically by an mobile switching center (MSC) server in charge of a group of cells. Aided by a channel allocation strategy within each cell, the centralized LBSB achieves almost perfect Channel borrowing and leads to a significant improvement over fixed assignment, simple borrowing [4]. Disadvantage of the LBSB strategy is that it is a centralized scheme and hence, too much depends on the central server in the MSC. Maintenance of continuous status information of the cells in a dynamic environment results in overheads such as wire line bandwidth wastage and increased delay [4].

3. Cell and User Classifications

A fixed assignment scheme is used to allocate the channels to each cell. A cell can be classified as high density or low density according to its degree of coldness, which is defined as

$$d_c = \text{number of available channels} / C$$

If $d_c \leq 5$ h, where $h > 0$ is a given threshold, the particular cell is high density, otherwise it is low density. Typical values of h are 0.2, 0.25 etc., and determined by the average call arrival and termination rates, and also by channel borrowing rates from other cells. The usefulness of the parameter h is to keep a subset of channels available so that even when a cell reaches the high density state, an originating call need not be blocked [1].

4. Load Balancing for Complete High Density spot

In order to satisfy the channel demand of overloaded (high density) cells, the underlying idea behind our load-balancing scheme is the migration of channels between cells through channel borrowing mechanism. Channel migration takes place between a borrower and a lender cell. Unlike in LBSB scheme, the borrower (high density) cell does not have the opportunity to select its lender among all the low density cells in its compact pattern.

A high density cell in 'Ring i' of a complete high density spot can borrow channels only from its adjacent cells in 'Ring i+l' or the 'First Peripheral Ring' if 'Ring i' is the outermost ring of the high density spot. This structured borrowing mechanism reduces the amount of co-channel interference between the borrower cell and the co-channel cells of the lender using the borrowed channel. Thus, the number of cells in which the borrowed channel needs to be locked is at the most two in this case.

A high density cell in 'Ring i' should borrow sufficient number of channels so that not only can it satisfy its own requirement *X,* but also cater for the channel demand from adjacent high density cells in 'Ring i-1'. Note that only local channels of a cell are lended on demand to adjacent cells in the next inner ring. After borrowing channels from adjacent cells, a ring i cell reassigns the borrowed channels (by intra-cellular handoff) to some of the users to release sufficient number of local channels and meets the demands of the ring i-1 cells[3].

We also assume that all cells in the 'First Peripheral Ring' are able to provide the required number of channels to the high density spot without exhausting their channel set or becoming high density themselves. If this is not true, channels are borrowed from multiple 'Peripheral Rings' and the algorithm adopted is the same as in the more general case of an incomplete high density spot.

5. Channel Borrowing for Incomplete High Density Spot

Let us fix one of the six emanating chains of corner cells as the reference chain. The co-ordinate of such a corner cell is (i,0) if it belongs to ring i. Moving in the anti-clockwise direction along ring i from the corner cell Ci,o, the co-ordinate of the jth cell will be (i , j) . Here we distinguish between the cells arrays since the same set of co-ordinates cannot be assigned to cells within different cell arrays.

A low density cell is further classified into three groups low density safe, low density semi-safe and low density unsafe according to the demands of the adjacent cell(s) of the next inner ring and the number of channels available within the cell. Here the first four rows are for the case of corner cells, while the last four rows for the case of non-corner cells.

6. Distributed Load Adjustment Algorithm

It consists of a resource migration (or channel borrowing) algorithm and a resource allocation (or channel assignment) algorithm. It is the resource migration algorithm, which distinguishes the Distributed-LBSB from its centralized counterpart [1].

The underlying idea is the migration of channels by a novel channel-borrowing algorithm, from the low density cells to the high density ones. We assume that the base station transmitter of each cell has the capability of transmitting any of the frequencies of the available spectrum. When a channel is borrowed by a cell, the same channel has to be locked in the transmitters of the lender cell as well as those co-channel cells of the lender, which are non-co-channel cells to the borrower, followed by unlocking it in the transmitter of the borrower cell [2]. A low density cell is not allowed to borrow channels from any other cell. Similarly, a high density cell cannot lend any channel to another cell. The privilege of borrowing channels is strictly limited to high density cells and the 'departing' users in such a cell have the highest priority of using the borrowed channels.

Also a certain number of channels need to be borrowed to relieve pressure from the high density cells. When a cell is high density and channel migration is needed, channels are borrowed from some low density cells (selected on the

basis of borrowing criteria) and stored in the available channel set of the borrower cell as borrowed channels.
How these available channels are assigned to the users in a cell to maximize resource utilization is the problem of resource allocation. Under suitable conditions, borrowed channels are re-assigned to 'departing' users in the cell and the local channels, which they were using, are returned to the available channel set. Thus the channel set of the high density cell is replenished. The three parameters determining the suitability of a low density cell as the potential lender, G, are stated below:

- **Degree of coldness: -** d_c (G). The lower density the cell, the more suitable it is for lending a channel.
- **Nearness: -** given by the cell-distance D (B, G) between the borrower B and lender G. A small value of D (B, G) reduces delay in the wire-line network during channel borrowing.
- **High density cell channel blockade: -** H (B, G). This is the number of higher density co-channel cells of G, which are non-co-channel cells of B. A small value of H (B, G) is desirable.

7. Channel Borrowing Strategy

Each base station is capable of running the channel-borrowing algorithm when its cell reaches the high density state. We assume that each cell knows the set NCC of its non-co-channel cells, the set of cells forming its compact pattern CP NCC, as well as the set CC of its co-channel cells. For the implementation of the distributed channel-borrowing algorithm, each cell maintains three local parameters:

(i) its own degree of coldness, d_c
(ii) the set H_{NCC} of its high density non-co-channel cells,
(iii) the set H_{cc} of its high density co-channel cells.

Whenever there is a channel allocation, blockade or release in the cell, the value of d, is updated. We assume that every cell in the system maintains its H_{cc}, independent of the running of the Channel borrowing algorithm. This means that whenever a cell changes its state (high density or low density), it informs all its co-channel cells. The set H_{NCC} is computed by the high density cell B at the initialization phase of the channel-borrowing algorithm described below.

If one of the non-co-channel cells of B changes state, H_{NCC} of B is updated. Three global parameters are used by all the cells in the channel borrowing algorithm. These are d^{avg}_c ,h and C, which are used to compute the number X of channels to borrow and the width r of the threshold region for the cell[9].

We assume that C, the fixed number of channels initially assigned to each cell, is known to all the cells. Before starting the channel borrowing algorithm, a newly formed high density cell initiates the d^{avg}_c computation by broadcasting a message to all other cells in the system inquiring about their dc values.

Thus the newly formed high density cell knows the state of all other cells. The value of h is computed once and for all at the MSC due to the small range of variation of h and the computation intensive nature of evaluating h. A base station server runs the channel-borrowing algorithm, described next, as soon as the corresponding cell B becomes high density.

7.1 Algorithm Channel-Borrow

Initialization Phase

1. Send messages to all other cells in the system inquiring about their d_c's. Compute d^{avg}_c and H_{NCC} from the received information's.
2. with the help of the known global parameters C, d^{avg}_c and h and known meter K (spatial density of mobile users in the cell), the width of the threshold region r, is estimated and the value of X is computed [1].
3. With the help of r and the user classification algorithm the array NumDepart is computed.

Main body Phase

1. Send messages to the low density neighboring cells G for which Numdepart [G] > 0, requesting the computed value of the function F (B, G).Three information's are sent to the probable lender G in the request message -
(i) the set NCC (ii) the set H_{NCC} and (iii)D (B, G)=1.Cell G computes the number of its high density co-channel cells H (B, G) which are non-co-channel to B by comparing the received H_{NCC} with its own HCC. Then G computes the function F (B, G) and sends it to B [4].
2. The set of neighboring low density cells in Step 1 are ordered according to decreasing values of the received F (B, G) and then selected according to the listed order for channel borrowing. The selected cell computes the set of its co-channel cells, which are non-co-channel with B by comparing the received set NCC with its own set CC.
3. Channels are borrowed from the j^{th} selected cell until either the basic borrowing criterion is violated, or the number of borrowed channels =NumDepart [j]. Upon each lending, the lender cell instructs its co-channel cells which are non-co-channel with the borrower cell (computed in Step 2) to lock the lended channel. Repeat Step 3 until either (i) the required number X of channels are borrowed, or (ii) the list of cells are exhausted [6]. Terminate for case (i).
4. Send a message to each cell G' in its compact patter (excluding the neighboring set of cells mentioned in Step l), requesting the computed value of F (B, G') if G' is in the low density state. The parameters required for this computation, namely, the cell distance D (B, G') and the set H_{NCC}, and also the set NCC are conveyed in this message. Note that, only the low density cells in the compact pattern of B respond to this message.

5. Select the cell, G', with min {F (B, G')} for channel borrowing, if the basic borrowing criterion is satisfied. The selected cell G' computes the set of its co-channel cells which are non-co-channel to B by comparing the received NCC from B with its own CC. These cells are instructed to lock the borrowed channel. Repeat Steps 4 and 5 until the required number of channels is borrowed. In Step 4**,** a particular high density cell B asks for the recomputed values of the function F from all the cells in its compact pattern because, due to the distributed nature of the algorithm, global information of the current status of each cell is required.

8. Channel Assignment Strategy

This is same as the strategy used in the centralized version of LBSB. The set of available channels in a high density cell can be divided into local channels and borrowed channels. For example, low density cells contain only local channels. The channel demands arising in a high density cell can be divided into four priority classes, which are enumerated below in the order of decreasing priority [13].

- Class 1 demands: These are hand-off request which get the highest priority to make sure that the probability of disrupting an ongoing call is minimized.
- Class 2 demands: These are channel requests made by originating calls.
- Class 3 demands: These are Type 1 channel re-assignment requests. Channel re-assignment requests are not generated by a mobile user, but generated internally by a base station function, which continuously monitors the state of channel assignments to the users in the cell.
- Class 4 demands: These are Type 2 channel reassignment requests also generated internally.

9. Comparison of centralized-LBSB and Distributed-LBSB

The proposed distributed scheme LBSB is run concurrently in all the high density cells in the system, while the centralized scheme, LBSB is run periodically at the MSC.

N_h	$T_{central}$	$T_{distributed}$	S_p
5	163.3	58.3	2.8
10	323.8	58.7	5.5
15	516.9	58.8	8.8
20	644.4	58.6	10.9
25	835.8	58.5	14.2
30	1045.0	58.8	17.7
35	1158.3	58.7	19.7
40	1527.7	58.7	26.0
45	1749.1	58.3	30.0
50	2125.6	58.6	36.2

Table 1: Speed Up Ratios

T obtained from experiments is shown in table 1 speed up defined as $S_{p:}$ - $T_{central}$ / $T_{distributed}$
Where $S_{p:}$ - Speed –up

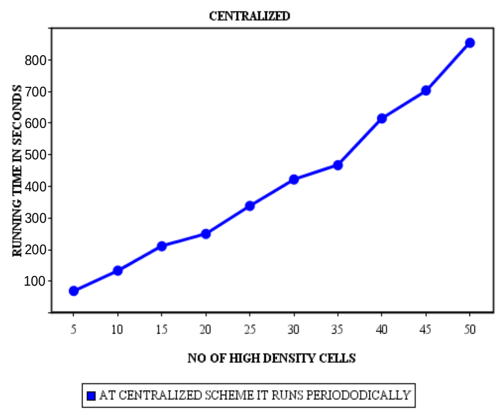


Fig.1 Centralized Scheme

Hence, a system running the distributed scheme is more sensitive to any channel imbalance and seeks to rectify it by triggering off the channel-borrowing algorithm immediately at the point of imbalance, namely, a high density cell. The effectiveness of the centralized scheme can be severely limited by the choice of a suitable period to run the algorithm. The period should be dynamically varied, with shorter periods ideal in case of frequent load variation and longer periods suitable for a more stable system.

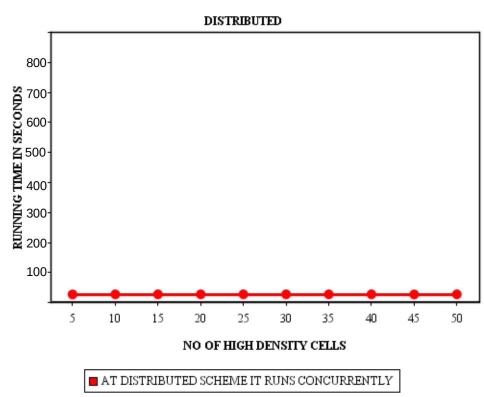


Fig.2 Distributed Scheme

From figure, as the number of high density cells is increased, the running time of the distributed scheme remains approximately constant. The algorithm works concurrently in all the high density cells and since the total message delay is independent of the number of high density cells. The running time of the centralized scheme, on the other hand, increases with a progressively higher rate as number of high density cell is increased.

10. Conclusion

A Channel Allocation Scheme for (D-LBSB) algorithm is proposed for the channel assignment problem in cellular mobile networks. A novel distributed channel borrowing strategy is proposed where channels are borrowed by a high density cell from suitable low density cells. The suitability of a low density cell as a lender is determined by an optimization function consisting of three cell parameters, namely, the degree of coldness, nearness and high density cell channel blockade. We conclude that in a region with a large number of high density cells, the distributed scheme for channel allocation performs better.

References

[1]. S.K.Das, S.K.Sen &R.Jayaram A dynamic load balancing strategy for channel assignment using selective borrowing in cellular mobile environments, *ACM Baltzer wireless networks 3,5* (1997) 333-347.

[2]. Azzedine Boukerde, Sungbum Hong & Tom Jacom A distributed algorithm for dynamic channel allocation, *mobile networks & applications* 115-126, 2002.

[3]. Gunohong Cao & Mukesh Singhal An adaptive distributed channel allocation strategy for cellular networks, *Journal of parallel & distributed computing 60*,451-473(2000).

[4]. S.Das,S.Sen, R. Jayaram Load Balancing Strategies for the Hot Cell Problem in Cellular Mobile Environment, *Technical Report, Center for Research in Parallel and Distributed Computing,* University of North Texas, 1996.

[5]. E. Del Re, R. Fantacci, G. Giambene Handover and Dynamic channel allocation techniques in mobile cellular networks, *IEEE Trans. Veh. Technol., vol. VT-44*, no. 2, May 1995.

[6]. Megumi HISAYUKI, Yoshiaki KAKUDA, Kuniyasu SUZAKI Dynamic Load Balancing Using Network Transferable Computer, *Proceedings of the 25th IEEE International Conference on Distributed Computing Systems Workshops(ICDCSW05)*,2005 IEEE.

[7]. Jeremy Casas, Ravi Konuru. Steve W. Otto. Robert Prouty and Jonathan Walpole Adaptive Load Migration System for PVM, *IEEE Trans. on Parallel and Distributed System*, 1994.

[8]. Bhaskar Ghosh and S.Muthukrighnan, Dynamic Load Balancing in Parallel and Distributed Networks by Random Matchings, *ACM.* 1994.

[9]. Evsen Yanmaz and Ozan K. Tonguz Handover Performance of Dynamic Load Balancing Schemes in Cellular Networks, *Proceedings of the 10th IEEE Symposium on Computers and Communications (ISCC 2005)*.

[10]. S. Das, S. Sen, R. Jayaram A Dynamic Load Balancing Strategy for Channel Assignment Using Selective Borrowing in Cellular Mobile Environment, *Proceedings of IEEE/ACM Conference on Mobile computing and Net-working (Mobicom '96)* pp. 73 - 84, Nov. 1996.

[11]. T.J. Kahwa and N. D. Georganas A hybrid channel assignment scheme in large scale, cellular structured mobile communication systems, *IEEE Trans. Communication.,* vol.COM-26, no. 4, Apr 1978.

[12]. S. M.Elnoubi, R.Singh, S. C. Gupta A new frequency channel assignment in high capacity mobile communication systems, *IEEE Veh. Technol.,*vol. VT-31, no. 3, Aug. 1982.

[13]. M.Zhang and T. S. Yum Comparisons of channel assignment strategies in cellular mobile telephone systems, *IEEE Trans. Veh. Technol.,* Vol. 38, Nov 1989.

[14]. Z. Xu and P. B. Mirchandani, Virtually fixed channel assignment for cellular radio-telephone systems: a model and evaluation, *IEEE International Conference on Communications*, Chicago, 1992.

[15]. Tajima and K. Imamura, A strategy for flexible channel assignment in mobile communication systems, *IEEE Trans. Veh. Technol., vol. VT-37*, May 1988.

[16]. M. Duque-Anton, D. Kunz and B. Ruber, Channel Assignment for cellular radio using simulated annealing, *IEEE Trans. Veh. Technol., vol. VT-42*, Feb. 1993.

[17]. S. Tekinay and B. Jabbari, Handover and channel assignment in mobile cellular network, *IEEE Communication Magazine*, Nov. 1991.

[18]. J. Karlsson and B. Eklundh, A cellular mobile telephone system with load sharing - an enhancement of directed retry, *IEEE fins. Communications, vol. 37*, No. 5, May 1989.

[19]. H. Jiang and S.S. Rappaport, CBWL: A new channel assignment and sharing method for cellular communication systems, *IEEE Pans. Veh. Technol., vol. 43*, No. 2, May 1994.

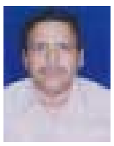
Authors Biography

Sudarshan Subhashrao Sonawane is presently working as Assistant Professor in Department of Computer Engineering SGDCOE, Jalgaon (M.S.) India. His present research interests are in areas of Mobile Computing, Wireless

Volume: 02 Issue: 01 Pages: 452-457 (2010)

sensor network and Wireless Communication. He has published papers in International Journals and International Conferences.

Dr.A.J.Patil is presently working as Principal in Shri. Gulabrao deokar College of Engineering, Jalgaon (M.S.) India. Out of his 23 years Teaching Experience he worked as a Assistant Professor and Professor in Engineering Colleges and also a member of various committees of University as academic and research level His Areas of interests are in Mobile Ad-hoc network, Wireless Communication, Digital image processing, Power Electronics and Biometric Security.



Dr.A.K. Sachan is currently working as director in Radharaman Institute of Technoloy & Science, Bhopal (M.P.) India. He has more than 21 years teaching & research experience. He had completed his PhD in Computer Science & Engineering, 2007. He has published more than 25 research papers in National and International reputed journals & Conferences. His areas of interests in Mobile Computing, Adhoc Networks, Digital Image Processing.