

# An Optimized Channel Assignment Strategy For Wireless Cellular Networks

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## Abstract

This paper presents an algorithm for channel assignment problem in wireless cellular networks. This algorithm is based on directional channel locking strategy. The task is to find channel assignment which reduces call blocking probability in wireless cellular network. This paper deals with a channel assignment technique and release technique based on borrowing channel from neighboring cell under heavy traffic condition. The performance of the proposed technique is here derived by computer simulations. Comparison with a Borrowing with Channel Ordering (BCO) technique under uniform and non-uniform traffic is shown to highlight the better performance of the proposed technique.

**Keywords:** Optimized Channel Assignment, Channel Locking with Direction, Borrowing with Channel Ordering

## 1. Introduction

The demand for mobile telephone service has been growing rapidly, while the electro-magnetic spectrum of frequencies allocated for this purpose remains limited. In mobile cellular network the geographical area covered by the network is assumed to be divided into a number of cells of hexagonal shape [3]. The whole bandwidth available for mobile users is divided into a set of carriers, sometimes called channels. Each cell in a cellular network is equipped with a base station and with a number of radio channels assigned according to the transmission power constraints and availability of spectrum.

A channel can be a frequency, a time slot or a code sequence. Any terminal residing in a cell can communicate through a radio link with the base station located in the cell, which communicates with the Mobile Switching Center (MSC), which in turn connected to the Public Switched Telephone Networks (PSTN). When a user initiates or receives a call, the user may roam around the area covered by

the network. If the mobile user moves from one cell to another, and the call from/to the user has not finished, the network has to handoff the call from one cell to another at the cell boundary crossing without user's awareness of handoff and without much degradation of the service quality.

The bandwidth limitations of these systems and possibility of interference among neighboring cells has prompted much research into effective assignment of available channels to requesting mobile units [1]. Channels are managed at each cell by channel assignment schemes based on co-channel reuse constraints. Several channel assignment schemes have been widely investigated [2] [4]. They are (1) Fixed Channel Assignment (FCA), (2) Dynamic Channel Assignment (DCA), (3) Hybrid Channel Assignment (HCA). In FCA scheme, a set of channels is permanently assigned to each base station. A new call can only be served if there is a free channel available in the cell. This scheme performs well only under uniform request patterns. To cope up with non-uniform request patterns, various dynamic channel allocation strategies have been proposed.

In DCA, all channels are kept in a central pool to be shared among the calls in all cells. A channel is eligible for use in any cell provided if the co-channel reuse constraint is satisfied. In HCA each cell has a static set of channels and can dynamically borrow additional channels. In a channel borrowing scheme, a cell that has used all its assigned channels can borrow free channels from its neighboring cells to accommodate handoffs. 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.

One variation of the hybrid scheme is called Borrowing with Channel Ordering (BCO) in which all the channels assigned to a cell are ordered. Local requests are satisfied by one end of the ordering while borrowing requests are satisfied by the other end. In this paper, we proposed an algorithm based

on channel locking and compared with BCO technique under uniform and non-uniform traffic.

A channel needs to be allocated to the cell by any one of multiple access schemes. In this paper we use scalable orthogonal frequency division multiple access (OFDMA). OFDMA is a method of encoding digital data on multiple carrier frequencies. Due to the increasing demand for high speed wireless services, OFDMA is required to use the bandwidth of the system more efficiently, while retaining a guaranteed Quality of Service (QoS). In OFDMA, the channel bandwidth is split into a number of narrowband subcarriers, which are orthogonal to each other. Each of these subcarriers undergo independent attenuation, thus providing frequency diversity.

## 2. System Model

The topological model considered in this paper is a group of hexagonal cells. Incoming calls at each cell can be served by any of the system channels. In a cellular system, channels used at one cell site may be also used at other cell sites in case of absence of Co-channel interference [4]. Co-channel interference is the radio interference between channels using the same frequency.

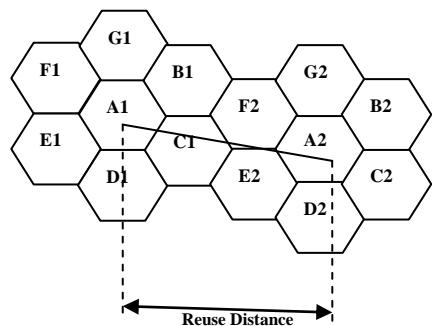


Fig.1 Model Reuse Distance

The Co-channel interference cannot be suppressed totally, so that a tolerable value of Co-channel interference is obtained by maintaining a minimum separation distance also called as reuse distance [5] [6]. Cells may only use the same channels if the distance of their centers is equal or multiple of this reuse distance. In fact the distance between the Co-channels is increased; definitely the Co-channel interference is reduced. The reuse distance used in this model is assumed to be three cell units.

The Fig.1 clearly specifies Co-channel reuse distance between cell A<sub>1</sub> in cluster 1 and cell A<sub>2</sub> in

cluster 2. Hence the distance is very low; the Co-channel interference is very high.

A group of channel is initially allocated to every cell in the system, so every cell has a list of nominal channels. When a call request occurs in a cell, the nominal channels of this cell are tested. Once a free channel is found, it is assigned to the call. If all the nominal channels are busy, a channel is borrowed from the adjacent cell. When a channel x is borrowed by a cell, say B, from a cell, say A, there is a possibility that the same channels will be used by cells that belong to the reuse distance of A and interfere with cell B. Hence a proper channel must be borrowed.

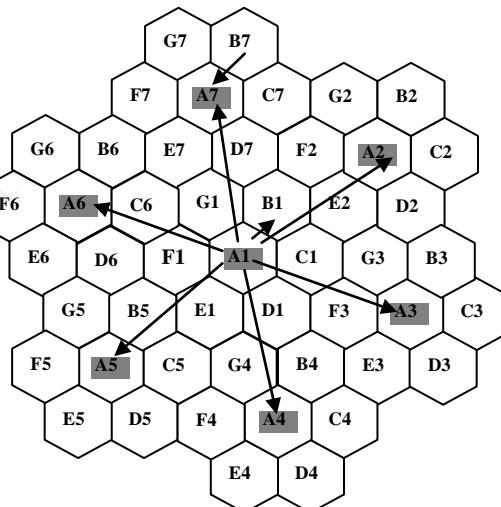


Fig. 2 Channel Assignment

The objective of channel allocation is to assign a required number of channels to each cell such that both the efficient frequency spectrum utilization is provided and interference effects are minimized. In BCO a channel set is nominally assigned to each cell. When all fixed channels become busy, the cell borrows channels from adjacent cells under the condition of no interference. Otherwise, the call is blocked. When a channel is borrowed, several other cells are prohibited from using that channel.

Fig.2 shows seven clusters in a network and each cluster with seven cells. When a call request occurs in cell B<sub>1</sub>, and all the nominal channels are

busy, then channels x is borrowed from cell A1. After borrowing, channel x is locked in the Co-channel cells which are within the reuse distance of the cell A1. They are A2, A3...A7 and also highlighted. Now channel x cannot be used to serve a call in any of these Co-channels and cannot be borrowed by the neighboring cells of these Co-channels. For example, cell B7, a neighbor of A7, cannot borrow channel x from cell A3. However B1 and B7 are three cell units apart, B7 can use channel x without interfering the calls in cell B1. Thus the number of channels available for borrowing is low. To avoid this problem our algorithm uses Channel Locking with Direction (CLD) strategy.

In this strategy lock directions are specified for each locked channels. So when a channel is borrowed, the locking of this channel in the Co-channel cells is restricted only to those affected by this borrowing. So the number of channels available for borrowing is greater than that of the BCO strategy.

OFDM is a Frequency Division Multiplexing scheme used as a digital multi carrier modulation method. A large number of closely spaced orthogonal sub-carrier signals are used to carry data on several parallel data streams or channels. Each sub-carrier is modulated with a conventional modulation scheme such as quadrature amplitude modulation or phase-shift keying at a low symbol rate, maintaining total data rates similar to conventional single-carrier modulation schemes in the same bandwidth.

### 3. Channel Locking with Direction Algorithm

The channel locking with direction algorithm proposed in this paper allocates the radio resources optimally within multiuser OFDMA system. Power and subcarriers have considered as the radio resources where frequency diversity is required. As the number of users increases, the frequency diversity also increases along with the optimum uses of the power. Thus this algorithm allocates the channel by efficiently utilizing the frequency spectrum and minimizes the interference effects.

Consider Fig.3, let cell B1 borrow channel x from cell A1, then channel x in all the Co-channel cells are locked in appropriate direction. For example channel x in cell A7 needs to be locked in lower direction only i.e. in C7, D7 and E7. Now B7 can borrow channel x from A7 without interfering call in cell B1. Since B7 is in non-locking direction of A7, channel x is not locked to cell B7.

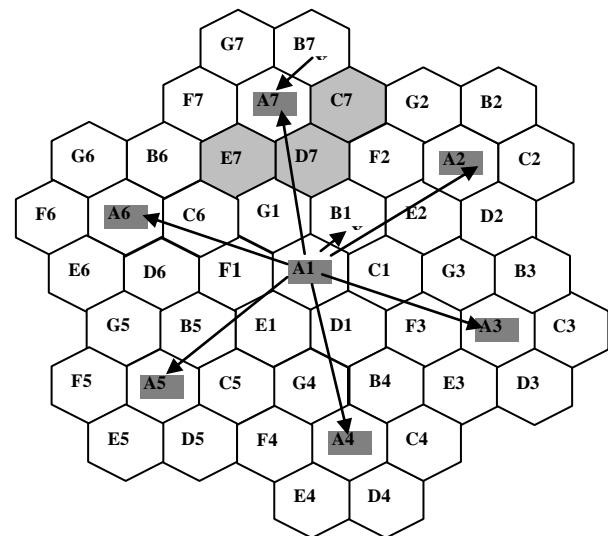


Fig. 3 Channel locking with direction

To minimize channel borrowing, the channel-reallocation concept is also implemented in this paper. When a call on a nominal channel terminates and there is another call on a borrowed channel, the call on the borrowed channel is switched to the nominal channel. Now the borrowed channel is released. When a channel is completely unlocked (unlocked in all direction) by the termination of calls in the interfering cell, any call on a borrowed channel is immediately switched to this channel. The channel reallocation method can minimize the number of call progressing on the borrowed channels.

### Algorithm for Channel Assignment

FC – Free Channel, SC – Servicing Channel, LC – Locked Channel

Call request arrived in a cell A

1. IF FC[A] is not empty
  - (i) Assign the first Channel in FC[A] to serve the call
  - (ii) Move the Channel from FC[A] to SC[A]
2. Else if all the Channels are busy
 

Searches through all neighboring cells of A to identify all the free Channels and called as list F1. All the 'locked' channels but with cell A in the non-locking direction and call this list as F2.
3. IF F1 is not empty
 

Allocate any channels in F1 and lock that channel in first tier Co-channel cells

Else if F2 is not empty

- (i) Assign the particular Channel in F2 and denote the assigned Channels as X,
- (ii) The first tier Co- Channel cells will lock Channel X in the appropriate directions.
- (iii) Move Channel X from the FC list to the LC lists of the Co-channel cells.
- (iv) Cell A is also recorded in LC to indicate that it is responsible for locking Channel X.

Else Block the call.

### Channel Reallocation Procedure

1. When a call on a nominal Channel terminates and there is another call on a borrowed Channel, the call on the borrowed Channel is switched to the nominal Channel. The borrowed Channel is released.
2. When a Channel is completely unlocked (i.e. un-locked in all six directions) by the termination of calls in the interfering cell, any call on a borrowed Channel is immediately switched to this Channel.

### Algorithm for Channel Release

1. If Channel X is not a borrowed Channel, it is moved from SC (P) to FC (P).
2. (a) If Channel X is borrowed from cell B, the locking of Channel X is removed from the LC lists of cell B and its two nearby Co- Channel cells A2 and A3.  
(b) After cell B gets back Channel X, it performs the Channel reallocation procedure and updates the status table accordingly.

This algorithm uses three lists, each for free channel, servicing channel and locked channel respectively. All the free channels of a cell are stored in free channel list. When a call request occur it first check its free channel list, if there is a free channel it is assigned to service a call. Whenever a channel is assigned to service a call it is transferred to the

servicing channel list. If all the channels are busy then it will search all neighboring cells and store the free channel of it in a list F1. Also, any locked channels but they are in non-locking direction is stored in a list F2.

If F1 has some channels then assign one channel and lock it in the appropriate direction and move it from free channel list to locked channel list. If F1 is empty means search the list F2 and assign the channel and then move it from free channel list to locked channel list. If both the lists are empty then block the call. Finally call the reallocation procedure to release the channel.

In this algorithm the channels are assigned efficiently so that the estimated blocking probability for future calls is minimized.

### 4. Performance analysis

Due to the flexibility nature of resource allocation, significant reduction in outage probability is measured. A notable amount of reduction in BER is observed with lower transmit power, while exploiting the proposed algorithm. To evaluate the performance of the proposed algorithm three different modulation schemes (i.e. BPSK, QPSK, M-QAM) have been considered.

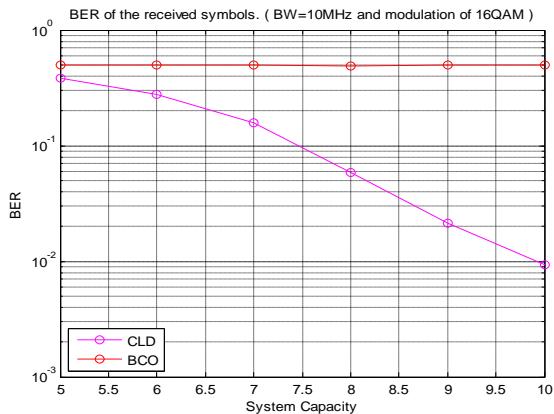
The objective of the access method is to ensure QoS. At the physical layer, QoS is equal to an acceptable signal to noise ratio or Bit Error Rate (BER) at receiver. At the access layer, QoS can be expressed in terms of a blocking probability.

Fig. 4 shows the system performance in terms of BER for both BCO and CLD; when all cells in the network have the same arrival rate. Modulation scheme used here is 16-QAM.

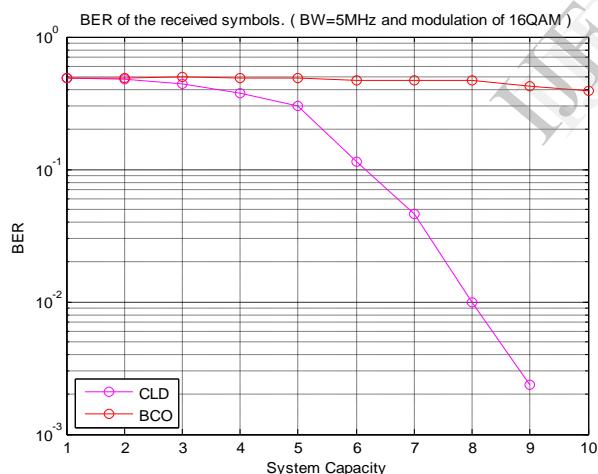
Fig. 5 compares the performance of BCO and CLD in the non-uniform traffic load. From this we found that CLD is better than BCO.

The performance of the channel allocation schemes has been derived in terms of the blocking probability for the incoming calls. The blocking probability is computed for the nine central cells. Simulation results were obtained and are shown in Figs. 6-8 for the cases of uniform and non-uniform traffic load conditions. The term blocking probability is the ratio of the non-accepted calls to the total number of calls that arrive in the cellular system.

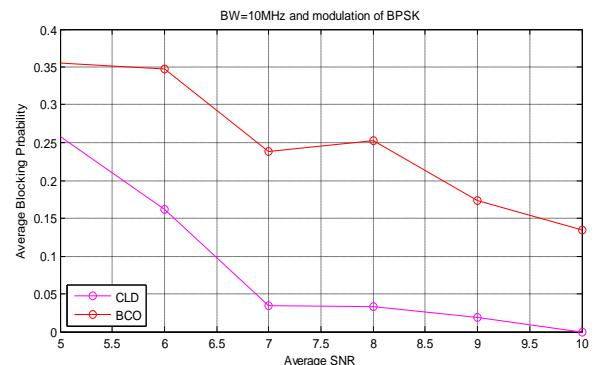
Fig.6 shows the performance of the algorithm in BPSK modulation scheme. Fig.7 and Fig.8 shows the performance of the algorithm in 16-QAM. Here we considered Signal to Noise ratio. In all the cases our proposed algorithm gives better performance than BCO strategy.



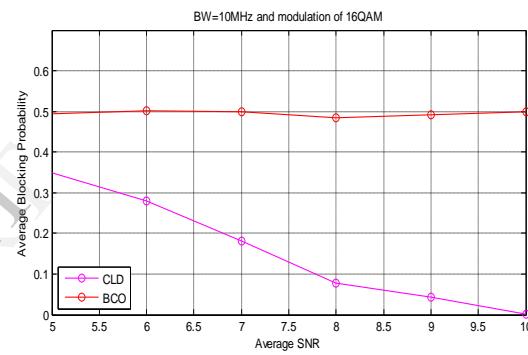
**Fig. 4 System Performance under uniform traffic load**



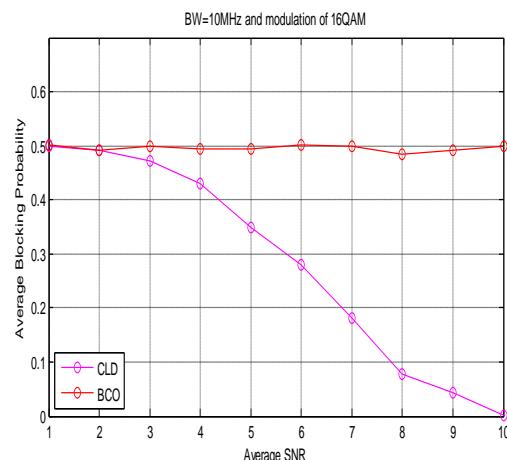
**Fig. 5 System Performance under non-uniform traffic load**



**Fig. 6 Performance of the algorithm under uniform traffic load with BPSK**



**Fig. 7 Performance of the algorithm under uniform traffic load**



**Fig. 8 Performance of the algorithm under non-uniform traffic load**

## 5. Conclusion

An algorithm for channel assignment in wireless cellular network was presented in this paper. Most of the dynamic assignment type strategies are based on the channel borrowing concept. Our study shows that, the channel locking with direction and channel reallocation concept can give lower blocking probability than that the other proposed strategy. Performance is considered under both uniform and non-uniform traffic conditions. Simulation results shows that the proposed algorithm is better than that of BCO method. For performance analysis we use both the BER and blocking probability. The channel reallocation concept keeps the traffic carried by borrowed channels minimum. The application of this algorithm to high capacity wireless cellular communication system will utilize the spectrum efficiently.

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