Greedy-Based Dynamic Channel Assignment Strategy for Cellular Mobile Networks

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***Abstract*—This letter proposes a Greedy-based Dynamic Channel Assignment (GDCA) strategy in cellular mobile communication networks. Its main feature is that it dynamically allocates the channels based on greedy method. Instead of the regular hexagon cell shape considered by previous strategies such as BCO, BDCL, various CP-DCA, the new strategy can be applied to any irregular cell shape. In addition, it reuses channels in terms of C/I ratio criteria. By system simulation, the proposed strategy outperforms the still used FCA on call blocking probability, and even has better performance compared to BDCL and CPDCA etc.**

***Index Terms*—Cellular mobile communication, dynamic channel allocation, greedy method.**

I. Introduction

THE earliest channel assignment strategy is the fixed channel assignment (FCA) strategy. It mainly features its simple algorithm. Due to the time-variety of traffic load, it has lower resource efficiency. After that, researchers proposed many new channel assignment strategies or improvements of the previous ones such as BCO [1], BDCL [2] and various compact pattern (CP) based channel assignment strategies [3]–[5]. Currently, researchers are mostly concerned with the CP-DCA, and their proposed strategies greatly reduce the call blocking probability and increase the traffic-carrying capacity of the entire cellular system. But there exist two problems. The first is that the time and space complexity have not still been solved. Maybe with the development of computer technology, the problem will be solved naturally in the future. The second problem is that most of the strategies are based on the regular hexagon cell, which is rather different from the practical systems. Therefore, a strategy, which includes advantages of both FCA and DCA, is eager to be proposed. This paper presented a kind of Greedy-based Dynamic Channel Assignment (GDCA) strategy which features the exhaustive searching for cochannels dynamically in term of C/I ratio and its adaptation to any irregular cell. By simulation, the new strategy has significantly improved the system performance of the still used FCA, and even better than those of BCO, BDCL and CPDCA, etc. Therefore, it can be easily applied to practical use.

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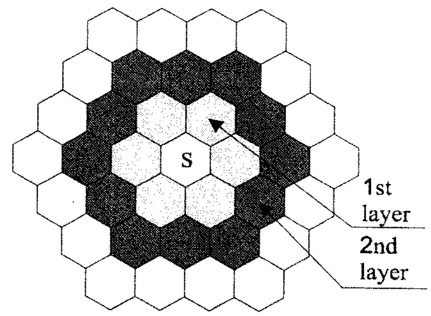

Fig. 1. Cellular channel cluster.

From the theory point of view, we can also generate the compact patterns for irregular cell [6]; e.g., we first obtain the cell set within the channel reuse distance (for an instance, the first and second layers of a cell shown in Fig. 1). Then we divide the compact patterns based the channel reuse distance. But for irregular cell, is there the original meaning of clockwise and counterclockwise rotation compact patterns in Fig. 1 of [4]. The answer should be indefinite. Therefore, we are unable to build a mathematical model to allocate and manage the channel resources. By our study, we find that for irregular cell, greedy based exhaustive searching for cochannel is rather feasible and efficient. By measuring the C/Iratio [7], we could get the every cell cluster within the its reuse distance. Instead of allocating an entire pattern in CP-based DCA, GDCA allocates a channel to a cell upon the request of a call arrival. That is to say, the cochannel pattern is irregular in GDA.

II. Greedy-Based Channel Allocation

Let the cell locations be represented by their (i, j) coordinates shown in Fig. 2 of [4]. There are M channels being kept in the central pool and they are numbered from 1 to M. Main parameters are defined as follows.

1) *Channel assign sign:* $C = [c_1, c_2, \cdots, c_M]$ defines whether each channel in the channel pool is assigned or not, where

$$c_i = \begin{cases} 0, & \text{channel has not been assigned} \\ 1, & \text{channel has been assigned} \end{cases}$$

2) *Channel status:* $ST(m) = [st_{ij}(m)]$ represents the status of channel m, where

$$st_{ij}(m) = \begin{cases} 0, & \text{channel } m \text{ is idle in local cell} \\ 1, & \text{channel } m \text{ is allocated to local cell} \\ 2, & \text{channel } m \text{ is borrowed by neigboring cell} \\ 3, & \text{channel } m \text{ is locked by cocells} \end{cases}$$

3) *Richest* cell channel status: $BS(m) = [bs_{xy}(m)]$ represents the status of channel m in the *richest* neighboring cell (x, y) of cell (i, j) (containing the maximum number of lending channels), where

$$bs_{xy}(m) = \begin{cases} 0, & \text{channel } m \text{ unsatisfies the lending conditions} \\ 1, & \text{channel } m \text{ satisfies the lending conditions.} \end{cases}$$

When a call request is arrived at cell (i, j), a channel is allocated according to following algorithm:

```
// Greedy allocation
for m = 1 to M do
 if ((st_m == 0) // channel m is idle in cell (i, j)
   and (c_m == 1) // channel m is assigned to other cells
   and (NoInterference(m))) // No cochannel interference judged by C/I ratio
    begin
     st_m = 1;
     allocate channel m to the call request;
     return;
    end
// request an idle channel
for m = 1 to M do
 if (c_m == 0)
   begin
    st_m = 1;
     c_m = 1;
    return;
   end
// Otherwise, borrow a channel from its neighboring cell
if (FreeChInReuseDist(i, j) == 0) // Calculate the number of lending channels within the reuse distance. If it is 0, clear and block the call;
else
 begin
 n = MinPbChannel(i, j, x, y); // borrow an optimal
 // channel from its richest neighboring cell (x, y)
 st_n = 2;
 LockCochannel(n, i, j, x, y); // Lock the cochannels
end
```

From the theoretical analysis, we can select the borrowed channel based on (1)–(3). But the simulation shows that the algorithm can be simplified by selecting a channel that meets the lending conditions and has the highest order in the channel pool, while this simplification causes only minor performance degradation.

$$R_{i,j} = \lambda_{i,j} \left[\sum_{k=0}^{n_{i,j}} \frac{\lambda_{i,j}^k}{k!} \right]^{-1} \frac{\lambda_{i,j}^{n_{i,j}}}{n_{i,j}!} \tag{1}$$

where, $\lambda_{i,j}$ denotes traffic load in cell (i, j), $n_{i,j}$ the channels allocated to it. For Poisson call arrivals and exponential duration, $R_{i,j}$ represents the call blocking rate in cell (i, j).

$$pb = \sum R_{i,j} \tag{2}$$

$$\min\_pb = \min_{x \in U} \left\{ \sum R_{i,j} \right\} \tag{3}$$

where, U is the channel set which meets the lending conditions in the richest cell.

III. Channel Packing

When a call terminated, we pack the channel according to following algorithm:

```
// Find the cell with max number of borrowed channels
max = maximum number of borrowed channels;
if (max == 0) // release a local channel
 for m = 1 to M do
  if (st_m == 1)
   begin
    st_m == 0;
    if (ChannelFree(m)) // if channel m is idle in entire system
     c_m = 0; // then retrieve the channel
    return;
   end
// For borrowed channels, release a borrowed channel
for m = 1 to M do
 if (st_m == 2)
 begin
  st_m == 0;
  decrease the number of borrowed channels;
  break;
   end
unlock the locked channels;
if (ChannelFree(m))
 c_m = 0;
```

IV. System Simulation

The simulation models are shown in [4, Figs. 3 and 6]. Here the reuse pattern $N = 7$. The average call duration time is 3 min. For comparison, here we also give the simulation performance of FCA, BDCL and CPDCA. In addition, we give two kinds of simulation results for GDCA, i.e. GDCA with channel Borrowing (GDCA/B) and without channel Borrowing (GDCA/NB). Figs. 2 and 3 show that at the blocking probability of 0.02, GDCA/B can carry 7.5% and 3.7% more traffic load than those of CPDCA with the Figs. 3 and 6 traffic distributions of [4], respectively.

V. Conclusion

This letter proposes a new kind of DCA—Greedy-based DCA. The new proposed strategy is extension and improvement

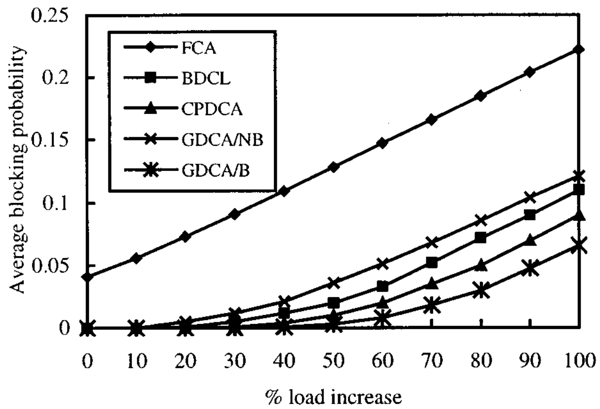

Fig. 2. Blocking performance for traffic distribution 1 with 70 channels.

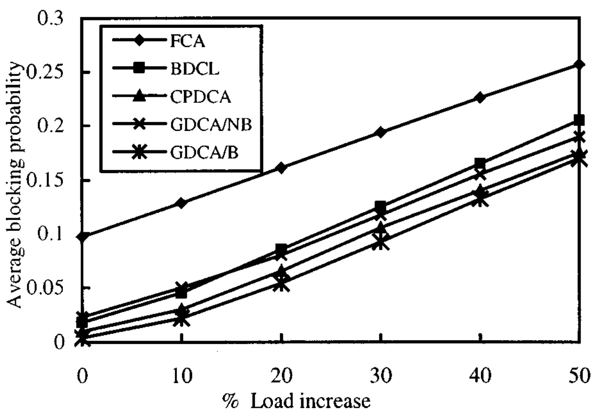

Fig. 3. Blocking performance for traffic distribution 2 with 210 channels.

of CPDCA and CPCB [5] etc. By inheriting and absorbing the features of CPCB, C/I-based DCA and Greedy method, especially (2) and (3), it optimizes the performances of the related algorithms. The new strategy aims at generating cochannels dynamically and handling irregular cell shape. The acquired system performance is superior to FCA, BDCL and CPDCA. The other important feature is that the algorithm for GDCA is much simpler than CPDCA and its variations. The results are very significant for applying the theoretical study to practical application. At the same time, the simulation reveals that if the performance is permitted, GDCA/NB is also an even more effective strategy in practical application.

References

[1] S. M. Elnoubi and R. Singh *et al.*, “A new frequency channel assignment algorithm in high capacity mobile communication systems,” *IEEE Trans. Veh. Technol.*, vol. VT-31, pp. 125–131, Aug. 1982.

[2] M. Zhang and T. P. Yum, “Comparisons of channel assignment strategies in cellular mobile telephone systems,” *IEEE Trans. Veh. Technol.*, vol. 38, pp. 211–215, Nov. 1989.

[3] M. Zhang and T. P. Yum, “The nonuniform compact pattern allocation algorithm for cellular mobile systems,” *IEEE Trans. Veh. Technol.*, vol. 40, pp. 387–391, May 1991.

[4] K. L. Yeung and T. P. Yum, “Compact pattern based dynamic channel assignment for cellular mobile systems,” *IEEE Trans. Veh. Technol.*, vol. 43, pp. 892–896, Nov. 1994.

[5] X. Fang, C. Zhu, and P. Fan, “Compact pattern based channel borrowing assignment strategy in cellular mobile networks,” in *Proc. IEEE VTC’99*, May 1999, pp. 6–9.

[6] K. L. Yeung and T. P. Yum, “The optimization of nominal channel allocation in cellular mobile systems,” in *Proc. IEEE ICC’93*, 1993, pp. 915–919.

[7] H. Panzae and R. Heck, “Adaptive resource allocation in metropolitan area cellular mobile radio systems,” in *Proc. IEEE VTC’90*, 1990, pp. 638–645.