Radio Resource Management for Dynamic Channel Borrowing Scheme in Wireless Networks

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Radio Resource Management for Dynamic Channel Borrowing Scheme in Wireless Networks

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Abstract— Provisioning of Quality of Service (QoS) is the key concern for Radio Resource Management now-a-days. In this paper, an efficient dynamic channel borrowing architecture has been proposed that ensures better QoS. The proposed scheme lessens the problem of excessive overall call blocking probability without sacrificing bandwidth utilization. If a channel is borrowed from an adjacent cell and causes interference, in that case we also propose architecture that diminishes the interference problem. The numerical results show comparison between the proposed scheme and the conventional scheme before channel borrowing process. The results show a satisfactory performance that are in favor of the proposed scheme, in case of overall call blocking probability, bandwidth utilization and interference management.

Keywords- Dynamic channel borrowing, Quality of Service (QoS), overall call blocking probability, bandwidth utilization, cell bifurcation, interference management.

I. INTRODUCTION

To cope with the demand of modern wireless communication system, it is mandatory to make the maximum use of radio resources within limited bandwidth at each cell so that a user can have maximum Quality of Service (QoS) at all the time. In a network, there may be unoccupied channels in the cells. These unoccupied channels can be the hot cake to fulfill the need of the excessive users of the other cells, if a scheme can be developed so that maximum utilization of these channels can be ensured [1]-[3]. Being deep concern of the burning issue, we have proposed a scheme, where, if there is more traffic in a cell compared to number of channels, the cell has the opportunity to take required channels from other cells, if any, of course after interference management. In our scheme, the required number of channels of reference cell (i.e. the cell where traffic intensity is higher) will be borrowed from adjacent cells, having maximum number of unused available channels. We propose that for interference management, the reference cell will be bifurcated, named inner and outer part [4]. The required or available number of channels will be provided to the inner part users of the reference cell after borrowing for interference management.

In the previous time, fixed channel assignment (FCA) [5] and hybrid channel assignment (HCA) [6] have been proposed to utilize the bandwidth without considering interference management. A channel borrowing without locking (CBWL) scheme is proposed in [7]. In the scheme, cell borrows channels from its adjacent cells when a call arrives but can not be served by the normal channels. If the borrowed channels are obtained, the cell can use it with reduced power so that the borrowed channels are not necessary to be locked. In the proposed scheme, number of users greater than the number of channels of the cell can be accommodated by dynamically borrowing channels from other adjacent cells. That means either reference cell will take the required number of channels (Nreq) (if the available channels are greater than the required number of channels) or the available channels (Nav) (if the available channels are less than the required number of channels) from the adjacent cells.

The rest of this paper is organized as follows: Section II shows the proposed dynamic channel borrowing scheme with block diagram. Call blocking probability using the queuing analysis for the proposed scheme is shown in Section III. In Section IV, the numerical results for our proposed scheme are shown. Finally, conclusions are drawn in the last section.

II. PROPOSED DYNAMIC CHANNEL BORROWING SCHEME

Contemporary and future wireless network are required to serve maximum users. As there is excessive traffic now-a-days, a dynamic channel borrowing scheme can be an effective way, where maximum bandwidth utilization with less overall call blocking probability and QoS are ensured.

A. System model

We consider a cluster of seven cells where three types of reused frequencies named A, B, C are available. Fig. 1 shows the frequency allocation of cells before channel borrowing of the system. We assume that the cell 1 is the reference cell where the traffic intensity is higher than the six cells of the cluster. It is our deep contemplation that results, if a cell (say cell 2) is found with maximum number of unoccupied channels (Cunc), the reference cell will continuously borrow channels from that cell till channels are required in the reference cell. If the number of available channels is less than the required number of channels then the reference cell borrows the available channels. As the reference cell requires more channels, it can borrow channels from other cell (say cell 3) that has the different frequency band than that of the previous two cells (i.e. cell 1 and cell 2) which reduces the complexity of the system with commendable performance.

This procedure is shown in Fig. 2. In the meantime, whenever interference management is required, the reference cell is bifurcated and the borrowed channels are provided to the inner part users of the cell. This procedure is shown in Fig. 3.
B. Borrowing Architecture

If all the channels of reference cell (cell 1) are busy and traffic arrives, more $N_{req}$ channels are needed to keep them activated in cell 1. Fig. 4 shows the borrowing process of $N_{req}$ channels from the adjacent cell 2 or cell 4 or cell 6 and from the adjacent cell 3 or cell 5 or cell 7.

Fig. 1. Frequency allocation before channel borrowing process.

Fig. 2. Frequency allocation after channel borrowing process without interference management.

Fig. 3. Frequency allocation after channel borrowing process with interference management.

Fig. 4. Dynamic channel borrowing process.

$N_{req}$ channels will be borrowed from the cell with the maximum number of unoccupied channels of same frequency band.

Fig. 5 shows the selection of the adjacent cell with maximum number of unoccupied channels. If cell 2 becomes the desired cell and $N_{req}$ is less than $N_{av,2}$ (the number of channels available in cell 2) then cell 1 borrows $N_{req}$ channels and the total number of channels of cell 1 becomes $N+N_{req}$. If $N_{req}$ is greater than $N_{av,2}$ then cell 1 borrows the total number of unoccupied channels and the total number of channels of cell 1 will be $N+N_{av,2}$. If the total $N_{req}$ channels is not fulfilled, then cell 1 can borrow channels from the cell with the maximum number of unoccupied channels among cell 3, cell 5 and cell 7 (assume cell 3). If $N_{req(new)} (N_{req(new)} = N_{req} - N_{av,2})$ is less than $N_{av,3}$ (the number of channels available in cell 3), then the total number of channels of cell 1 becomes $N+N_{av,2}+N_{req(new)}$. If $N_{req(new)}$ is greater than $N_{av,3}$ then cell 1 borrows $N_{av,3}$ channels and the total number of channels of cell 1 becomes $N+N_{av,2}+N_{av,3}$.

C. Interference Management

Fig. 2 shows that $B'$ and $C'$ channels are borrowed from cell 2 and cell 3, respectively to the reference cell (cell 1). So, the bandwidth of cell 1 is increased from $A$ to $(A+B'+C')$. Due to the $B'$ channels, users can get interference from cell 4 and cell 6 as they have same frequency band. Similarly, for $C'$ channels, the users also have interference from cell 3 and cell 5 due to the reused frequencies of the cells. So, there creates an inevitability to manage the interfering channels.
Now for the management of interference, as shown in Fig. 3, the inner part users of cell 1 are provided with \((B' + C')\) channels and the outer part users are provided with the original number of channels of the reference cell.

In our proposed scheme, we use Okumura-Hata model for macro-cellular path loss calculation [8]. If the height of the base station be \(h_b\), height of the mobile antenna be \(h_m\), radius of the cell be \(d\) and \(f_c\) be the centre frequency then the Hata model shows a relationship between them which is used for interference calculation.

\[
L = 69.55 + 26.16 \log f_c - 13.82 \log h_b \\
- a(h_m) + (44.9 - 6.55 \log h_b) \log d
\]

where \(a(h_m) = 1.1(\log f_c - 0.7)h_m - (1.56 \log f_c - 0.8)\)

III. QUEUING ANALYSIS

The proposed scheme can be modeled as \(M/M/K/K\) queuing system and the call arriving processes are assumed to be Poisson. The Markov chain of the proposed scheme before borrowing channels is shown in Fig. 6 and the Markov chain for the proposed scheme is shown in Fig. 7. From Fig. 6 and Fig. 7, it is clear that the arrival rate and departure rate is constant in each cell. Here, \(N_1\) and \(N_1'\) represent the total number of channels in cell 1 (Reference cell) before and after borrowing channels, respectively.

Similarly, \(N_2\) and \(N_2'\) represent the total number of channels in cell 2 and cell 3 before channel borrowing process, respectively. \(N_1'\) and \(N_2'\) represent the total number of channels in cell 2 and cell 3 after channel borrowing process, respectively. Besides, \(\lambda_1\), \(\lambda_2\) and \(\lambda_3\) indicate the call arrival rate for cell 1, cell 2 and cell 3, respectively while \(\mu_1\), \(\mu_2\) and \(\mu_3\) indicate the channel release time for cell 1, cell 2 and cell 3, respectively.

Suppose, \(M\) be the number of cells in a cluster and maximum number of calls that can be accommodated in a cell \(m\) before channel borrowing and after channel borrowing are
Let, $P_m(i)$ be the steady state probability of the system in state $i$ for cell $m$.

$$N_m \sum_{i=0}^{N_m} P_m(i) = 1 \quad (2)$$

In the system, $\lambda_m$ and $\mu_m$ represent the call arrival rate and channel release rate for cell $m$, respectively.

$$P_m(i) = \frac{(\lambda_m)^i}{i!\mu_m} P_m(0), \quad 0 \leq i \leq N_m \quad (3)$$

$$P_m(0) = \left[ \frac{N_m}{\sum_{i=0}^{N_m} (\lambda_m)^i / i!\mu_m^i} \right]^{-1} \quad (4)$$

Thus, from (2) to (4), the call blocking probability $P_{bm}$ and overall call blocking probability of the system $P_{by}$ can be calculated as per equations (5) and (6) shown below.

$$P_{bm} = \frac{\lambda_m}{N_m \mu_m} P(0) \quad (5)$$

$$P_{by} = 1 - \sum_{m=1}^{M} \frac{\lambda_m (1 - P_{bm})}{M \sum_{m=1}^{M} N_m} \quad (6)$$

### IV. NUMERICAL RESULT

In this section, we evaluate the performances in terms of overall call blocking probability, overall bandwidth utilization, and signal to interference plus noise ratio (SINR) level of the proposed dynamic channel borrowing scheme with conventional scheme i.e. method without channel borrowing. We consider a cluster of seven cells that has three types of reused frequency band. The summation of the respective call arrival rate of the cells in the cluster is defined as total call arrival rate. We consider only the 1st and 2nd tier of the reference cell for interference management. Table 1 summarizes the values of the parameters that are used in our analysis.

![Fig. 8. Comparison of overall call blocking probability.](image)

**TABLE 1: Summary of the parameter values used in analysis**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cells in each cluster</td>
<td>7</td>
</tr>
<tr>
<td>Number of original channels in each cell</td>
<td>100</td>
</tr>
<tr>
<td>Number of reused frequency bands</td>
<td>3</td>
</tr>
<tr>
<td>Threshold value of channels for borrowing in each cell</td>
<td>70</td>
</tr>
<tr>
<td>Centre frequency</td>
<td>1800 MHz</td>
</tr>
<tr>
<td>Transmit signal power by the BS</td>
<td>1.50 kw</td>
</tr>
<tr>
<td>Height of the BS</td>
<td>100 m</td>
</tr>
<tr>
<td>Height of mobile antenna</td>
<td>5 m</td>
</tr>
<tr>
<td>Average channel holding time</td>
<td>90 sec</td>
</tr>
<tr>
<td>Cell radius</td>
<td>1 km</td>
</tr>
</tbody>
</table>

Fig. 8 depicts the overall call blocking probability of the proposed scheme which is compared to the conventional scheme where dynamic channel borrowing is absent. The traffic intensity in every cell is less than available number of original channels when the total call arrival rate is low. So, the overall call blocking probability of the proposed scheme shows nearly identical performance for both schemes. With the increment of total call arrival rate, the reference cell needs more channels to provide the additional number of traffic. Consequently, the overall call blocking probability of the proposed model decreases considerably as the extra number of traffic is kept activated due to dynamic channel borrowing process. The figure describes the nobility of proposed scheme by showing less overall call blocking probability compared to the conventional scheme.

Fig. 9 shows that the bandwidth utilization for the system based on the proposed scheme and differentiates the performances with the conventional scheme without channel borrowing process. Small variation of bandwidth utilization for both schemes is observed for lower value of total call arrival rate as the traffic intensity in the cells of the cluster is not high. With the augmentation of total call arrival rate, the proposed scheme illustrates better performance compared to the conventional model. Thus the proposed scheme guarantees maximum bandwidth utilization.

Fig. 10 shows the SINR levels of the proposed scheme and the conventional scheme without interference management after dynamic channel borrowing. The result implies that the
Our deep scrutiny and simulation results show that the proposed scheme is quite operational with reduced overall call blocking probability without sacrificing bandwidth utilization as compared to the conventional scheme. The salient feature of the proposed scheme is the use of similar frequency band at the same time. The proposed scheme also does the interference management. To make it operative, different conditions are illustrated in this paper for dynamic channel borrowing that may draw the attention for future wireless networks. Multiclass traffic, MIMO, inter-carrier interference management in OFDMA, interference declination in multicellular networks and femtocellular networks are our future research contents.

V. CONCLUSION

SINR level decreases with the increment of the distance between the base station (BS) and the user of the reference cell. The SINR level becomes insignificant when the user is far away from the BS. As the reference cell is bifurcated and the interfering channels are provided to the inner part users, they receive strong signal from the BS of the reference cell and insignificant interfering signal from the BS of the adjacent cells. So, the SINR level can be increased which is very significant in case of channel borrowing architecture in comparison with the SINR level without interference management.

REFERENCES


