Interference Management Scheme for Wireless Sensor Network

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Abstract. In this paper, we propose a resource allocation scheme in the frequency and time domain, to reduce interference in the Heterogeneous Network (HetNet) scenario for wireless sensor network. In the frequency domain, the macrocell allocates frequency band by using Soft Frequency Reuse (SFR), and the picocell chooses sub-bands that are not used in the macrocell sector, to avoid interference. In addition, to allocate the limited frequency resource is difficult. Therefore, we can manage the cross-tier interference using Almost Blank Subframe (ABS) in the time domain. Simulation results show that the proposed scheme can improve the spectrum efficiency of macrocell and picocell users. Eventually, the proposed scheme can improve overall sensor network performance.

Keywords: ABS, HetNet, Interference, Sensor Network, SFR

1 Introduction

Recently, small cells have been developed to gain cell subdivision, according to trends of the increase of data rate and bandwidth. Also, cells of hot zone form, such as the picocell, developed in specific areas, are becoming common for offloading explosion data traffic.

A network consisting of small cells, such as the low-cost, low-power picocell over the maroccell, is called a HetNet. Despite the significant network performance leap expected from deploying picocells, there are numerous challenging technical problems that need to be overcome. One of these major problems is interference management between the macrocell and picocell. Cross-tier interference problems are significantly challenging in co-channel HetNet deployment [1].

The throughput degradation is caused by low channel quality of multihop sensor network due to interference between the Ubiquitous Sensor Network (USN) application and heterogeneous (WiFi, Bluetooth, etc.) device in HetNet scenario. Packet loss can bring serious malfunction of USN that have become bigger.

Therefore, conventional radio resource management techniques are not suitable for HetNet. Thus, it is essential to adopt an effective and robust interference management
scheme that could mitigate the co-tier interference, and reduce the cross-tier interference considerably [2-4], in order to enhance the throughput of the overall sensor network.

In this paper, we propose not only co-tier interference management, but also cross-tier interference management in the HetNet scenario for wireless sensor network. Resource allocation is done by SFR and ABS, to manage the interference in the frequency and time domain, respectively. The rest of the paper is organized as follows: in the next section, shows the proposed scheme and section 3 shows a performance analysis of the proposed scheme through simulation. Finally, we conclude the results in section 4.

2 The Proposed Scheme

In this section, we proposed a new scheme that allocates resource in the frequency and time domain. In the frequency domain, resource is allocated based on SFR. Additionally, resource is allocated based on ABS in the time domain.

2.1 Frequency Domain

We allocate the frequency band into macrocell and picocell, based on SFR for intercell interference management, as depicted in Figure 1 (a). The macrocell coverage is divided into a center zone and edge region, each of which include three sectors, denoted by C1, C2, and C3, and E1, E2, and E3. The whole frequency band is partitioned into three parts, denoted by A, B, and C.

Fig. 1. The proposed interference management scheme using SFR in the frequency domain: (a) Frequency planning, and (b) Power allocation.

For the macrocell, a different frequency sub-band is allocated to each macrocell sub-area, according to the SFR. A reuse factor of one is applied in the center zone, while the edge region adopts a factor of three. The entire frequency bands are used in the center zone, and sub-bands A, B and C are applied in the E1, E2 and E3 regions, respectively. Also, the overall system efficiency is increased, by reducing the transmission power in the center zone of the macrocell, as illustrated in Figure 1 (b).
Under this circumstance, the picocell chooses sub-bands that are not used in the macrocell sub-area. For example, when a picocell is located in the region E1, it uses sub-bands B and C, while the macrocell uses sub-band A. However, when a picocell is located in the center zone, it uses the entire frequency band, because when a macrocell is located in the center zone, it uses the entire frequency band.

2.2 Time Domain

When a picocell is located in the center zone of a macrocell, it uses the entire frequency band. The interference problem between the macrocell and picocell still exists. Therefore, we solve the cross-tier interference, by applying the ABS in the time domain.

The aggressor macrocell uses ABS, which doesn’t transmit a signal during some subframe for the victim pico user, as depicted in Figure 2. Therefore, the picocell can avoid interference, by transmitting a signal during the ABS of the macrocell.

![Fig. 2. The proposed interference management scheme using ABS in the time domain.](image)

3 Simulation Results and Performance Analysis

3.1 Simulation Model and Simulation Parameters

The simulation results are based on 3GPP LTE-Advanced system level simulation parameters [5]. The overall network is composed of 7 macrocells, and picocells are randomly deployed over the macrocells. The number of picocells is 3 in one macrocell coverage. The main simulation parameters are listed in Table 1.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Cells</td>
<td>Macrocell: 7</td>
</tr>
<tr>
<td></td>
<td>Picocell: 3/Macro</td>
</tr>
<tr>
<td>Cell Coverage</td>
<td>Radius 1km (ISD = 1,732m)</td>
</tr>
<tr>
<td>Channel Bandwidth</td>
<td>10MHz</td>
</tr>
<tr>
<td>BS Transmit Power</td>
<td>Macrocell: 46dBm</td>
</tr>
<tr>
<td></td>
<td>Picocell: 30dBm</td>
</tr>
<tr>
<td>Size of Center zone</td>
<td>0.63 of macrocell coverage</td>
</tr>
<tr>
<td>White Noise Power Density</td>
<td>-174 dBm/Hz</td>
</tr>
</tbody>
</table>
3.2 Performance Analysis of Proposed Scheme

The proposed scheme is compared with several comparison schemes, as follows. In the No ICIC scheme, both macro and pico sensors are randomly assigned from the full frequency band. Also, SFR is the proposed scheme that assigns the resource using only SFR in the frequency domain, and ABS with SFR is the proposed scheme that assigns the resource using SFR and ABS in the frequency and time domain, respectively.

Figure 3 and Figure 4 show the CDF of the macro user and pico sensors spectrum efficiency, respectively, and Figure 5 shows the spectrum efficiency of total sensor.

It can be seen that the spectrum efficiency is improved in the following order: No ICIC, SFR, and ABS with SFR.
4 Conclusions

We propose an interference management scheme in the HetNet scenario for sensor network, by allocating resource in the frequency and time domains. In the frequency domain, under the macrocell allocating frequency band by the SFR, the picocell chooses sub-bands that are not used in the macrocell sector, to avoid interference. In addition, to allocate the limited frequency resource is difficult. Therefore, we can manage the cross-tier interference, using ABS in the time domain. Simulation results demonstrate that the proposed scheme can improve the performance, in terms of SINR and spectrum efficiency.

We expect that the proposed scheme configures a more efficient sensor environment, due to the improvement of performance. Also, this can improve the overall cell performance in the HetNet scenario for the wireless sensor network.

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