PB/MC-CDMA 기반 two-hop 중계 망에서의 자원 할당 방식

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Resource Allocation in Two Hop Relay Network based on PB/MC-CDMA System

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ABSTRACT

In this paper, we discuss a proposed two hop relay network with PB/MC-CDMA(partial block MC-CDMA) technique. The main advantages of PB/MC-CDMA system are the increased cell capacity and the high quality of performances. In the system, we employ relay scheme to focus on the coverage reduction and hotspot problem, hotspot is a location where a cluster of users are blocked or dropped for the reason of insufficient frequency resources. Frequency resource allocation scheme is put forward in a three cells system according to each problem. The simulation result shows the performance of the two hop transmission is better than the direct transmission and the proposed network can support much more users to relief hotspot effect compared to the conventional one.

Key Words : Partial Block MC-CDMA; Relay network; Resource allocation; hotspot.

I. Introduction

Recently, there has been increasing interest in integrating relaying functionalities into cellular wireless networks. Multihop cellular networks(MCNs) can potentially enhance coverage, data rates, QoS performance in terms of call blocking probability, bit error rate, as well as QoS fairness for different cells.

PB/MC-CDMA is a technique based on MC-CDMA, it is superior to MC-CDMA for its better BER performance and increased cell capacity. The main characteristic of partial block MC-CDMA is that the whole frequency band is divided to several blocks, each block consists of a number of carriers and is spread by PN codes in the frequency domain. Users are divided by blocks, and the spreading code is reused in every block. By reusing the spreading code, the proposed scheme accommodates more users than the conventional MC-CDMA [8]. Moreover, the desired signal is interfered only by other users in the same block, not by all users as in the MC-CDMA [4, 5].

The next-generation cellular wireless networks will support high data rates and provide quality of service(QoS) for multimedia applications with increased network capacity. Many kindsof transmission method have been proposed. Above all, multi-carrier transmission systems, such as orthogonal frequency division multiplexing(OFDM) and multi-carrier code division multiple access(MC-CDMA) have been focused on because of the frequency efficiency and robustness against multipath propagation [3]. However, in the process of improvement in data transmission speed, increase in the required electric power of received signals caused by high-speed transmission, and system arrangement in frequency domain should be carefully considered [7, 9]. High electric power requirement for receiver lead to cell coverage reduction, this means more base station will be needed so as to deploy cells without dead spots. It is a hot issue for the next generation systems. Under limited frequency resources, hotspot problem is also a big issue, the conventional approach to increase network

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capacity is to install more base stations(BSs) to exploit spatial reuse. This solution is not very efficient because the cost of the BS transceiver is quite high. An alternative approach is to employ relay stations(RSs) as intermediate nodes to establish multihop communication paths between mobile stations(MSs) and their corresponding BSs.

This paper combines relay scheme and PB/MC-CDMA technique [4] in order to make use of their advantages to solve the above mentioned problems.

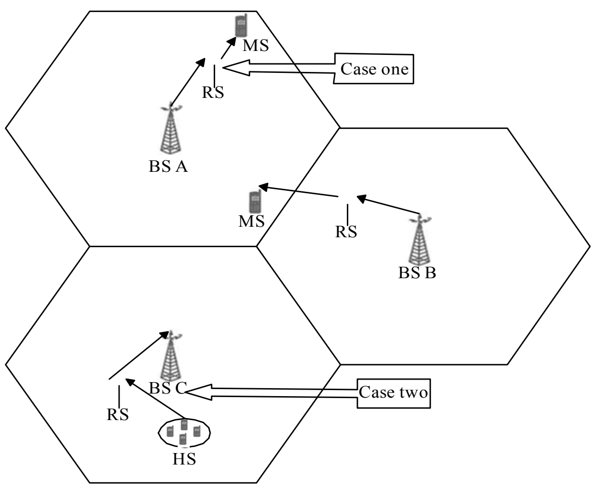
Existing architectures and protocols proposed for MCNs are very diverse and different in several aspects. RSs can be pre-installed by network operators or simply be other idle MS who are not transmitting their own data [3]. Also, depending on how radio resources are allocated for routing paths of active connections, different protocols at the medium access control and routing layers can be designed. Radio resources for MS at different hops may be allocated in time division multiple access(TDMA) or code division multiple access(CDMA) mode for the same hop [1].

The rest of this article is organized as follows. Section 2 is the system model. Frequency allocation scheme and relay station selection procedure is proposed in section 3, next is the simulation result and analysis, finally we draw a conclusion of this paper.

Ⅱ. SYSTEM MODEL

In this paper we classify the users to two kinds, one hop user-the normal user which randomly distribute in the cell, and two hop users. There are two kinds of two hop users. One of them is at the edge of the cell, after long distance multipath propagation the signal at receiver side is under the threshold of the required level so this kind of user was blocked, from this viewpoint the coverage of cell was decreased. To make the blocked users establish connection to base station(BS) without extra BS, the mobile station(MS) should find a relay station(RS) to transmit its information. At the first hop which means from BS to RS, we recover the power of the signal and then we re-transmitted it at the second hop from RS to MS. We can prove that the result of the direct transmission (from BS to MS) for this kind of distant user is inferior to the two hop relay scheme. The other kind of two hop user means the blocked or dropped users in hotspot. They can be supported by the reused frequency band.

Fig. 1 illustrates the system model, there are three cells in the network named Cell A, B and C, each has a base station(BS). MS means the mobile utilizer, MS in case one is one kind of two hop user as mentioned above. To emphasis the two hop users, one hop users are not displayed in the system. Actually, they randomly distribute in each cell. RS is an intermediate centre to relay information from MS to BS for the uplink case or from BS to MS for the downlink case. HS denotes the hotspot. Firstly, we need to understand the conception of hotspot. Hotspots occur when there is contention for bandwidth resources at some geographical location in a network and the currently available resources are not enough to sustain the needs of the users. This could potentially lead to users being blocked or dropped. We refer to such a location in the network as a hotspot [2]. There are several blocked or dropped users in the hotspot, to make the communication possible for these users, relay scheme was employed. Another function for relaying was to balance traffic load among highly loaded cells(hot cell) to lightly loaded cells(cool cell). So two hop user no matter which kind, not only can relay information to its home BS but also can set up a link to its neighbor BS through RS illustrated in Figure 1, relaying regulates traffic from hot cell to cool cell and make full use of the whole network resources [3].



BS: base station MS: mobile station
RS: relay station HS: hot spot

Figure 1. System model of the three-cell two hop relay network

Ⅲ. FREQUENCY ALLOCATION SCHEME AND RELAY STATION SELECTION

Next, we discuss the frequency allocation scheme for the two kinds of two hop users.

Figure2 is for case one, the two hop user is located in the margin of the cell. Because the distance from this user to BS is too long, there must be severe path loss during transmission, so at the receiver side the performance is bad. We need to find some method to provide user better service, two hop transmission is one feasible way and we can prove it by simulation.

The whole frequency bandwidth is divided into three part Ch 1, Ch 2, Ch3 and these three parts are distributed to Cell A, Cell B, and Cell C respectively. One hop users in each cell use the distributed frequency band. Here, we consider the downlink case, BS first use Ch 1 (the assigned bandwidth for Cell A) to communicate with RS and then the total information of all users is re-transmitted to different MSs through Ch 2. Similarly, two hop users in Cell B use Ch 2 for hop one and Ch 3 for hop two, and Cell C the same way as depicted in the figure. We can imagine if two hop users and one hop users in three cell transmit signals at the same time, there must be inter-cell interference, because two hop users at hop two reuse the frequency resources for one hop user, for example, two hop user in Cell A reuse Ch 2 at hop two which is the original bandwidth for one hop user in Cell B. So, time division multiple access(TDMA) is proposed to solve the interference problem. Time slot two is exclusive for two hop users at hop two and time slot one is shared both for one hop users and two hop users at hop one.

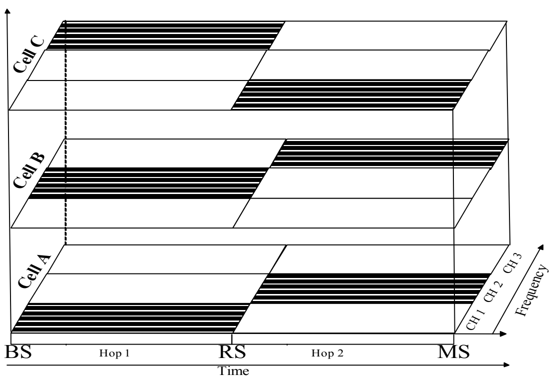


Figure 2. Frequency allocation scheme for Case one

I have to point that the cell capacity doesn't increase. The RS can be considered as a one hop user because they share the frequency band with one hop user. An example is that in Cell A one hop user and two hop user at hop one use the same frequency band Ch 1 to make communication with BS. The purpose of this kind of relaying is to improve the performance of the long distance user.

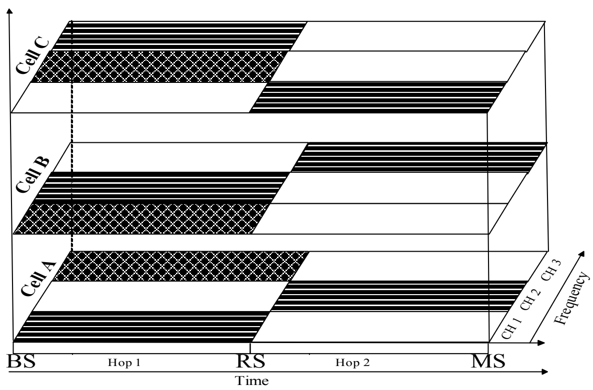


Figure 3. Frequency allocation scheme for Case two

Figure3 is for case two which is put forward to deal with hot spot problem. In this case even the location of the newly access is very near to the BS, it still can't connect with BS because the limited frequency resources can't support this new user. Hence, the relay scheme is necessary to make the communication possible. We also call the blocked or dropped users in hotspot two hop users.

The frequency allocation scheme is almost the same as the previous one, the main difference is that at time slot two one hop user and two hop user no longer share the frequency band because the cell capacity has reached the maximum value and BS have to find other frequency resource to set up a link with the hotspot user. As discussed before, TDMA is introduced to avoid inter-cell interference between different hops, however, in this case only in time slot one there are inter-cell interference because the bandwidth used to sustain the hotspot user is the same as the bandwidth distributed for one hop users, such as two hop user in Cell A reused the frequency band Ch 3 which is for one hop user in Cell C to make communication at time slot one. This kind of interference can be reduced by using code division multiple access(CDMA), one hop user and two hop user using the same bandwidth are distinguished by the different code. In this sense, the cell capacity can be increased a lot. Here the dominant of PB technique is highlighted, because the extra code can be used to avoid inter-cell interference at the same time slot.

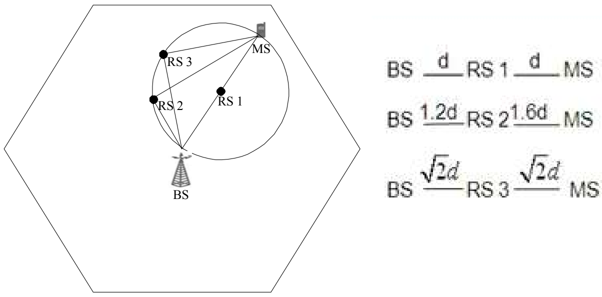


Figure 4. RS selection for case one

Frequency selection is an important part in the relay network. The relay station selection protocol works as follows. For Case one, an MS that wishes to establish a new connection with the corresponding BS periodically broadcasts an RS request message which contains its own link gain from the BS. Other idle MSs in the network estimate their link gains from the BS. Upon receiving the RS request message, any idle MS could respond with an RS response message to serve as the RS for the requesting MS if its link gain from the BS is better than that in the RS request message. The location of the potential RSs is estimated to satisfy the condition that it is in the circled range, the first qualified MS is selected as RS. Then the requesting MS broadcasts an RS cancel message that contains the ID of the chosen RS to cancel other pending RS response transmissions from other idle MSs. The BS also receives the RS cancel message and data transmission can begin between MS and the corresponding BS via the chosen RS. We make simulation for different RSs shown in Figure 4.

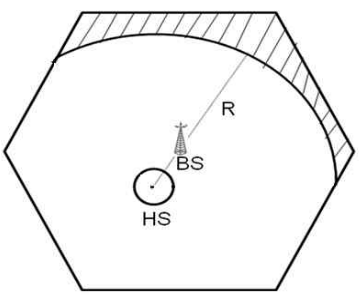


Figure 5. RS selection for case two

For Case two, we use almost the same procedure to select RS as for Case one, the only difference is the range for candidate RSs. The potential RS can be in any place of the cell, except the shadowed range, shown in fig. 5. Because in the shadowed range, the distance between hotspot MS and the selected RS is larger than the cell radius R, it will affect the final performance of the hotspot user. Theoretically, the cell capacity can be twice of the original one.

IV. SIMULATION RESULT

A. Parameter

We got BER performance by computer simulation.

Figure6 is the packet structure [4] for each kind of user. In each cell both one hop users and two hop users use PB/MC-CDMA technique to transmit data. We make simulation under an 18-path exponential Rayleigh fading channel model with a one sample delay interval between each paths and the attenuation of the adjacent path is 1 dB [5]. Table 1 gives some parameters of the simulation.

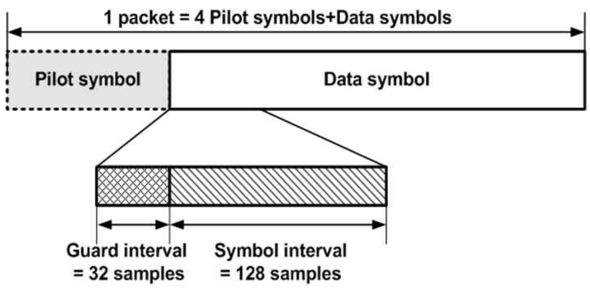


Figure 6. Packet structure

Table 1. Parameter for simulation

Parameter	Value
Subcarrier for each cell	128
FFT/IFFT Point	128
Spreading Code	Walsh-Hadamard code
Modulation	QPSK
Number of data in each packet	64
Number of pilot in each packet	4
Guard interval	32
Spreading Factor	16

B. Simulation result

Figure 7 shows the BER performance of two hop users with different relay station and distant user without relay station. Figure 4 displays different location of RSs. We know that the most distant way from BS to MS via RS at the circled range is for relay station RS 3 and the nearest distance is for RS 1. AS we all know distance is inversely proportional to performances, so for any RS in the circled range, the performance line should be laid between the simulation result of RS 1 and RS 3. As depicted in figure 4, we assume the distance from BS to RS 1, RS 1 to MS both d, and from BS to MS 2d. If we choose RS 2 or RS 3 as intermediate centre, the distance of each hop is larger than d. Simulation result proved our assumption. We can see that RS 1 is the best case and RS 3 is the worst case. Even the worst case, it still outperformed the direct transmission.

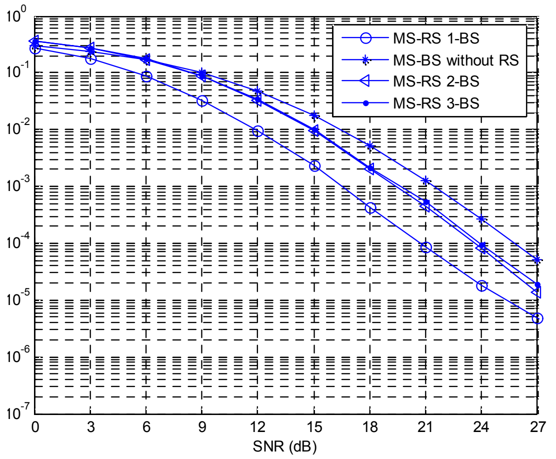


Figure 7. BER performance of direct transmission and two hop transmission for Case one

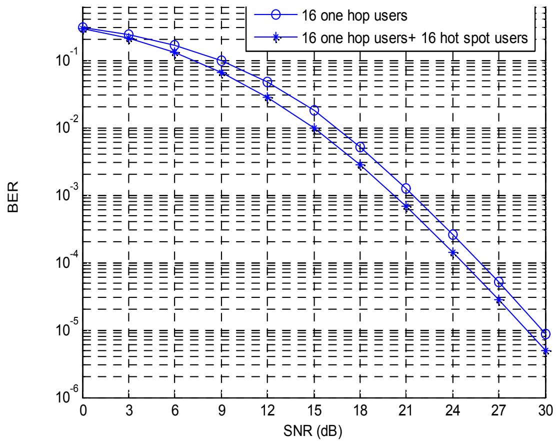


Figure 8. Average BER performance of one hop user and hotspot user in a cell (total 32 users) with comparison to the cell capacity (16 users)

Figure8 shows the BER performance of hotspot users together with one hop users in one cell. Suppose one cell can support 16 users, the proposed system can support 16 extra hotspot users. From the simulation result, we can observe that the proposed system increase the cell capacity at the same time improve the performance a little. The reason for the improvement is that hot spot users recovered the power at relay station, so path loss for two hop user was relative smaller than that of one hop user, which results in the better performance. Figure 8 shows the average BER performance for hot spot users and one hop users, so compared with the system with cell capacity of 16 one hop users, the proposed system has a little improvement. We could get conclusion that the proposed system can double the cell capacity without degrading the performance.

V. CONCLUSION

In this paper we propose the two hop relay system to achieve high performance of distant user and to alleviate the hot spot effect. The PB/MC-CDMA technique guarantees the good performance, because of its better BER performance and high cell capacity. The most important is that simulation results testify the proposed system and show that the performance was indeed improved.

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