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Channel Selection Strategies Based on Distributed Wireless Communication System*

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Abstract: Distributed wireless communication system (DWCS) is a novel communication system that is different from the traditional cellular systems, and channel assignment problems are parts of the keys, which concern if the predominance of the system can be attained. This paper examines the channel selection strategies based on the new system. Introducing dynamic channel assignment schemes to the new system, with CDMA technology, the channel resources can be suitably assigned. In this paper, the channel assignment process and the channel selection strategies of DWCS are described, and then the random SIR strategy, MAX SIR strategy, and MIN SIR strategy are simulated and analyzed. In low relative traffic, among the channel selection strategies, the blocking rate of MIN SIR strategy is the lowest, because, in natural, MIN SIR strategy is a channel compact pattern and the co-channel virtual cells can be packed so that the channel resources can be efficiently reused. In high relative traffic, performances of the random SIR strategy and MAX SIR strategy are better than MIN SIR strategy.

Keywords: DWCS, Dynamic channel assignment schemes, MIN SIR strategy, Virtual cells

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1. INTRODUCTION

In the past several decades, the traditional cellular communication systems have been adequately developed, but traditional methods would be not valid for higher spectrum efficiency, because cell splitting can not proceed with no limits, or it can lead to such as frequent hand-offs, system interference increasing, complicated spectrum planning, high cost and so on. A solution is adopting the network architecture based on distribution concepts, called distributed wireless communication system (DWCS)[2]. Distributed wireless networks simplify the base station in traditional cellular networks into antennas and signal converting devices, use fiber-optics to connect a certain number of antennas to processing nodes (PN), and to connect a certain number of processing nodes to control centers (CC), and then CCs access to core network. Processing nodes will also be connected with each other by fiber-optic. Each active user will simultaneously gain multiple antennas to communicate. The processing of signals from/to antenna is located in processing nodes not in antennas for distributed wireless communication system, which will get advantages from adopting advanced signal processing technology and distributed computing technology. The topology structure of distributed wireless communication system is showed in figure 1, the detail can be found on the paper [2].

The paper will discuss the channel selection strategies that are applied in the DWCS. First we simply introduce the concept of virtual cells, which will be concerned in channel assignments [2]. In DWCS, the traditional cell concept, which is centered on the base station, no longer exists. Instead, a new concept is proposed as virtual cell, which is MT-centered. For each mobile terminal (MT), the system will assign a set of distributed antennas to serve for the user on the basis of MT' location. Each MT has its own virtual cell, and it changes as the MT moves or the environment changes (e.g., change of system load). Virtual cell is not fixed in DWCS, which will change with the variety of user' service demands and mobility.

There are three types of channel allocation schemes in traditional cellular networks: fixed channel allocation (FCA), dynamic channel allocation (DCA), and hybrid channel allocation (HCA) [3]. Dynamic channel allocation can be divided into two methods with respect to the way of controlling they employ: centralized DCA and distributed DCA.

In DWCS, wireless resource management is so significant, the ascertaining of

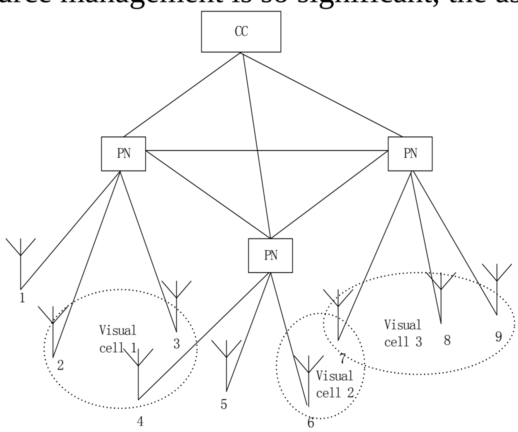

Figure 1 the topology structure of distributed wireless communication system

changing virtual cells and channel resource assignments are the keys to be taken into account.

Because of mobility of MT and flexibility of selecting of multiple antennas, dynamic channel assignment schemes are suitable for DWCS. In this paper, we will examine the dynamic channel assignment schemes on the basis of SIR, which is included in centralized DCA. In the section Ⅲ, we will simulate and analyze the channel assignment problems for DWCS, due to multiple antennas, the theory analysis is very difficult. We will select and assign the different frequencies or the different time-slots, which include many spread spectrum codes applied to distinguish the different users, and give the results of the blocking rates under the different channel selection strategies.

2. CHANNEL ASSIGNMENT PROCESS AND CHANNEL SELECTION STRATEGIES

In the paper, we mainly consider the assignment of the channel resources (frequencies or time-slots) for uplink of DWCS, because, for any system, channel assignments have to be primarily taken into account. Each frequency or each time-slot includes the orthogonal codes, and we assume that different frequencies or time-slots are orthogonal. In DWCS, the selection and assignment procedures for channel resources are mainly the selecting of frequencies or time-slots, since selected different frequencies or time-slots lead to different interference levels. CDMA is the system with limited interference. However, for the selection of different codes, the produced interference is the same, so here we only study and analyze the impacts of selection strategies for frequencies or time-slots. In DWCS, for antenna units and processing nodes, processing nodes and processing nodes, processing nodes and control centers are connected by fiber-optic, the centralized channel assignment schemes need the exchanging of a mount of signaling. Here, we need not to consider the signaling exchanging problems for the DWCS. The states of the assigned channels of all antennas units which are linked to different nodes can be gathered to CC or a certain processing node, and then the system selects the four antennas whose signals are the strongest to consist the visual cell for the MT. Adopting ideal power control, make the sum of signals received by four antennas be a fixed value, assuming that the total signal power received by antennas is s0, and equal-gain combination is employed. The SIR r_i of MT i can be calculated by the below equation:

$$r_i = \frac{S_0}{\sum_{\substack{j=1 \\ j \neq i}}^{M} \sum_{k=1}^{4} P_j G_{is(k)} + 4N_i} \tag{1}$$

For each user, the transmitted power of uplink can be calculated:

$$P_i = \frac{S_0}{\sum_{k=1}^{4} G_{is(k)}}$$

(2)

Define g_i as:

$$g_i = \frac{1}{\sum_{k=1}^{4} G_{is(k)}}$$

If ignore the impact of thermal noises, (1) can be denoted as:

$$r_i = \frac{g_i}{\sum_{\substack{j=1 \\ j \neq i}}^{M} g_j} \quad (3)$$

Where G_{ij} is the link gain between mobile i to the antenna j under the virtual cells, P_j is the transmitter power for MS j and M is the number of users for co-channels, which consists of all the codes included by mutual interference frequencies or time-slots for co-channels, $s(k)$ is the selected four antennas to server for MS i, $k = 1 \cdots 4$, and N_i is other noises.

G_{ij} is expressed as

$$G_{ij} = r^{-v} 10^{\xi/10} \quad (4)$$

Where r is the distance between from MS i to BS j, and ξ is the dB attenuation due to shadowing with mean zero and standard deviation σ. The typical values of σ and v are 5~12dB and 2~5, respectively.

2.1. Channel Assignment Process

The channel assignment process of DWCS is similar to that of traditional cellular system[3], but there are some differences. It includes the below several aspects:

1. Selecting the four antennas which will provide the maximal SIRs
2. Calculating the signal power transmitted by the MS
3. Execute the procedure of pre-access for feasibility check by calculating if all co-channel users can achieve their r^T s, if the new user is admitted.
4. Select the channel according to the channel selection strategies.
5. Interactive admission and initial power.

The procedure of pre-access: for each idle channel, find all the users included by co-channel, and calculate r_i by (3), so that when the user is accessed, the system guarantees:

$$r_i > r^T, \forall i \quad (5)$$

and simultaneously the SIRs of all the admitted users must be maintained. If the cases can be satisfied, the channel is feasible, or is not feasible and can be not assigned. If the system does not exist feasible channels, the user will be blocked.

For each idle channel, the pre-access is applied. If feasible channels can be found, in the processing of pre-access, we can freely select any of the idle codes of the feasible channel, since we assume that the codes are orthogonal, and the different selection of codes do not influent the system performance.

2.2. Channel Selection Strategies

How to select channel is called channel selection strategy. When the below three cases can be satisfied, the blocking rates of different channel selection strategies can be obtained.

(1) To exist the idle channels

(2) $r_i > r^T$

(3) To ensure the admitted users not to be impacted, $r_m > r^T, m = 1, \cdots, L$ L is the number of the admitted users.

Here, all of the adopted channel selection strategies are based on the SIR, which can be measured or calculated. We consider the below three channel selection strategies:

- Random selection strategy:

Randomly select one channel from the channels satisfying the above three conditions.

- Maximal SIR selection strategy

Calculate the SIR values by pre-access procedure, and select the channel corresponding to maximal SIR from feasible channels.

- Minimal SIR selection strategy

Calculate the SIR values by pre-access process, and select the channel corresponding to minimal SIR from feasible channels.

From the viewpoint of frequency reuse, the different channel selection strategies determine the different average reuse distances, which product the different performances of system. The conclusions for DWCS are similar to the traditional systems. The channel selection strategy corresponding to smaller reuse distances can provide the system the higher frequency efficiency and space efficiency, hence it can increase capacity of system.

3. SYSTEM SIMULATION AND RESULTS

3.1. Simulation Parameters

We evaluate the performance of our system with snapshot simulations [1], the simulation area is finite i.e. no wraparound is used. The scenario is showed in figure 2, where circle denotes antenna, and solid lines represent street. For simplicity, we only build the 16 antennas, which are located on the top of the buildings. The distances between the streets are 200 meters, and the distances between antennas are also 200 meters. When estimating the path loss, the given path loss exponent is 4, and ignore the shadow fading and Rayleigh fading. Users are distributed uniformly on the streets. The strongest four antennas are selected, thus, with propagation in free space, only considering path loss means that the nearest four antennas are obtained. Totally the system exists 9 virtual cells, each antenna can provide the 10 channels

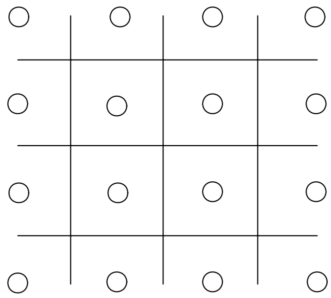

Figure 2 simulating scenario

(frequencies or time-slots), and each channel includes 8 spread spectrum codes. Our simulation is performed by snapshots, totally 30000 users are simulated.

When calculating SIRs, we attention only the interference from co-channels, e.g. co-frequency interference or co-time-slot interference. Here we simulate the performance of uplink. We assume that ideal power control is adopted. The sum of signals received by four antennas is set as a fixed value, and equal-gain combination is employed. From formula (2), we can calculate the transmitting signal power of each user. Before admitting user, the system executes the pre-access procedure, which does not assign channel to user, but proceed with the calculating and processing procedures of the system. Since the co-channel interference is the main interference constraint, the simulating ignores influence of other interferences. By the equation (1), we can calculate the SIR values to judge if the idle channels can be assigned. The target value of SIRs r^T is set by –8dB.

The blocking rate is used as the measurement for the performance of channel assignment. The user number of each snapshot can be calculated by relative traffic, user number=relative traffic $\times$channel number $\times$antenna number$\times$code number.

3.2. Simulating Results

We simulate the performance impacts as results from different SIR thresholds for random selection strategy. In figure 3, the blocking rates are depicted in cases of the thresholds of -4db, -6db, -8db,-10db,-12db and-∞. From the figure, we can find that when the threshold is less than –8dB, the system performance varieties are very small. In this case, the blocking rate of system is limited by system resources, not signal-interference rate. Here, we do not discuss the problems of the de-modulating, only mention the problems of channel assignment. Each frequency or each time-slot includes 8 codes, adopting ideal power control and ignoring the influence of thermal noise, by average, if all the codes are occupied by users, the SIR of each frequency or each time-slot for each antenna is 1/7, e.g.-8.5dB.

In figure 4, the performances of the several channel selection strategies, such as random selection strategy, MAX SIR strategy, and MIN SIR strategy are provided. From the figure, we can see that in the small relative traffic, The performance of MIN SIR is the best in all the

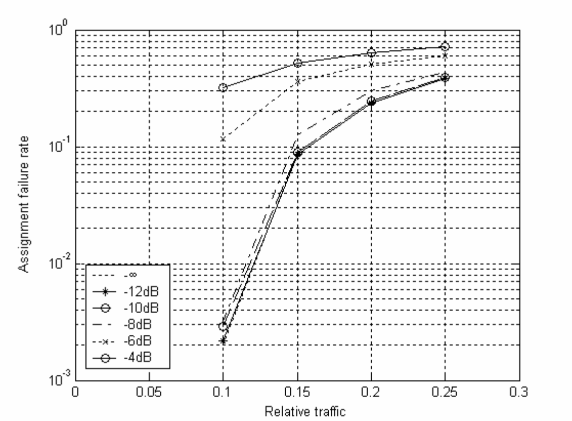

Figure3 the blocking rates of random selection strategy under the thresholds of -4db, -6db, -8db,-10db,-12db and-∞

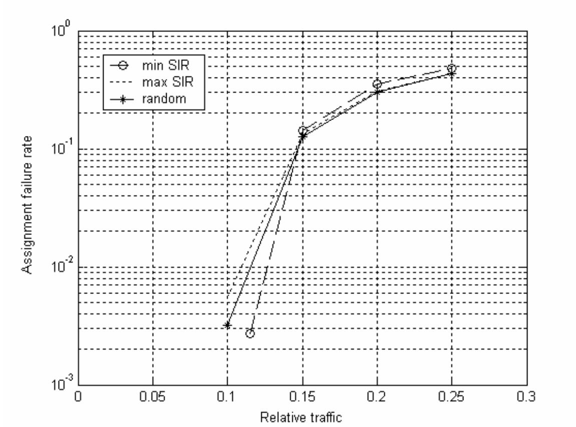

Figure4 Comparison of several channel selection strategies

strategies, whereas, that of the MAX SIR strategy is the worst, the performance of random selection strategy is in the middle of the front two strategies. In large relative traffic case, the blocking rates of random and MAX SIR strategies are almost coincided, where the performance of MIN SIR is the worst. In small relative traffic, because the MIN SIR strategy can realize the tightest compact for channel assignment, which means the more users can be contained. Under the limit of a certain number of users, it implies the lowest blocking rate. In addition, the MAX SIR produces the most redundancy for channel assignment, so the contained user number is relatively small, which implies the most blocking rate. In large relative traffic, the performance of MIN SIR is a little less than those of the other selection strategies, MIN SIR strategy means selecting the channel corresponding to the maximal interference so that the user number served by system is less. Noticing the complexity, random selection strategy is the lowest, whereas, complexities of MAX SIR and MIN SIR strategies are larger than random selection strategy.

4. SUMMARY AND PROSPECT

The paper discusses the channel selection strategies used in the distributed wireless communication system. First, provides the channel selection processing, and then simulates and analyzes the performances of the random SIR, MIN SIR, MAX SIR channel selection strategies. In low relative traffic, the performance of MIN SIR strategy is the best in the several section strategies and has the lowest blocking rate, whereas, MAX SIR strategy do not attain high channel efficiency and the blocking rate is the biggest one. In high relative traffic, the random strategy and the MAX SIR strategy are better in the blocking rate. From the viewpoint of the complexities of the several channel selection strategies, random selection strategy is the lowest, MAX SIR and MIN SIR strategies are larger than random selection strategy.

Distributed wireless communication system is a novel architecture. The channel assignment problems in wireless resource management for DWCS are the key technologies, which are the crucial aspects for achieving the advantages from the new system. Selection of the antenna, selection of channels and assignment of powers will become the main aspects in future researches for DWCS.

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