Management of Channelization Codes of WCDMA

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ABSTRACT
Reconfigurations of downlink dedicated channels are often necessary during call setup to eliminate code blocking encountered in 3G WCDMA systems. Orthogonal Variable Spreading Factor (OSVF) is the management scheme used to assign codes. Considering single code operation, the performance of a code selection scheme called Recursive Fewer Codes Blocked scheme (RFCB) has been studied. RFCB manages to mitigate code blocking and thus minimizes the fragmentation of the OVSF code tree capacity.

Keywords: Code reassignments, set up delay, WCDMA, code blocking, OVSF codes.

1. INTRODUCTION
Third Generation (3G) mobile devices and services will enable wireless communications to provide online, real-time connectivity and varied range of services.3G wireless technology will allow an individual to have immediate access to location-specific services that offer information on demand. High-speed downlink packet access (HSDPA), has enhanced uplink and multimedia broadcast multicast services (MBMS) has significantly enhanced the performance of existing networks.

Wideband code-division multiple access (WCDMA) was initially proposed and engineered with a vision that already has shown that it is future proof. WCDMA was designed to provide high performance to applications that need a varying level of Quality of Service (QoS). The original design choice seems to be well aligned with the future, where all applications and services can be carried over IP networks using IP protocols. This trend favours new applications where mobile users have several parallel ongoing sessions based on one or several applications. At the same time WCDMA is developing and achieving targets set by 3G, far outperforming any other wireless technology. Furthermore, the possibility to complement WCDMA coverage and capacity wireless LAN (WLAN) solutions will be discussed briefly. Even though WCDMA is exceeding its initial capability targets, there is still a need for a quantum leap in air interface development in the longer term. The quantumleap can be seen as the fourth generation (4G).

Recently, there has been great interest in the OVSF code assignment problem encountered on the forward link of the WCDMA wireless interface. In this paper, we study an OVSF code selection scheme that can be used in the assignment process. We also study the use of RFCB scheme to minimize the fragmentation of the code tree [2]. But elimination of code blocking leads to a set up delay in the incoming call. We study methods to decrease this set up delay with tolerable increase in the signalling overhead [3].

The paper is organized as follows Section II explains the system model and code blocking. Management of channel-ization codes and minimization of call set up delay are mentioned in Section III and IV respectively. Section V is the future scope. The paper is concluded by a brief summary, acknowledgement and references.

2. SYSTEM MODEL

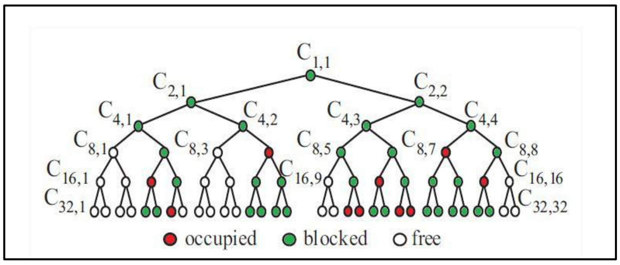

Fig. 1. Code blocking due to OVSF [2]

The generation of the OVSF codes is based on a tree structure, as the one shown in figure 1. Each node in the tree represents a channelization code, denoted as CSF, k, where SF is the spreading factor of the code and k is the code number, 1 k SF. As the spreading factor increases the transmission rate supported decreases. The codes at the lowest level have maximum SF (SFmax) and therefore minimum data rate, denoted by R. The transmission rate supported by an OVSF code with spreading factor SF is always a multiple of a power of two of the lowest available rate and SF is 1,2,4,8...

$$k = SF_{max} \qquad (1)$$

The occupied OVSF codes have to be orthogonal to each other to minimize multiple access interference. Two OVSF codes are orthogonal if and only if none of them is an ancestor of the other. Therefore, once a code is assigned all of its ancestor and descendants cannot be used until the code is released. These codes as referred as blocked codes. Free, occupied and blocked codes are depicted in Figure 1.

3. MANAGEMENT OF CHANNELIZATION CODES
OVSF is a scheme where all the ancestors and descendants of an occupied code cannot be used and are referred to as blocked codes. The system may have capacity but the nodes are blocked due to which the actual capacity of the system is much below the ideal capacity. This deteriorates the performance of the system and steps should be taken to overcome this problem. Recursive Fewer Codes Blocked Scheme (RFCB) is used to overcome the problem of OVSF. This paper involves study of two possible tie resolving criteria for various possible ties that may occur to reduce the code blocking.

3.1 Tie Resolving Criteria 1
In case there is a need of 4R in the last row. There are three options. From the system shown in figure 1 one can select $C_{4,2}$, $C_{4,1}$ or $C_{2,2}$. One needs to decide which one to select out of these three. The tie resolving criterion is selects the branch that is fragmented the most. In this case it is $C_{2,2}$.

Consider the situation where there is a need of simultaneous 4R. In this case there are only two options $C_{4;1}$ and $C_{4;2}$. We select the branch which is most fragmented. In the case of equal fragmentation, select the branch with maximum blocked codes. Here $C_{4;1}$ selected as shown in figure 2.

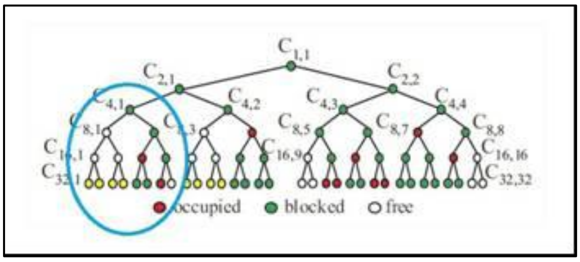

Fig. 2. Tie resolving criteria 1

3.2 TIE RESOLVING CRITERIA 2

Consider a need for capacity of only 2R. This is available at C16,1, C16,2, C16,5, C16,9 and C16,16. Branch with maximum occupied codes in selected first. This procedure is continued till the tie is resolved. This leaves only two options that are C16,9 and C16,16. Both of these have the same level of fragmentation. Therefore to resolve the final tie the option to the left that is C16,9 is selected as shown in figure 3.

4. MINIMIZING CALL SET UP DELAY

Using of RFCB to eliminate code blocking results in signaling overhead which leads to an unacceptable increase in the incoming call set up delay. Codes have to be reconfigured to decrease the set up delay with tolerable increase in signaling overhead. Consider the system shown in figure 4. In this system there is a capacity need of 8R.The system has to be reconfigured.

In this system since the capacity of 8R it is not directly available. To reduce the incoming call set up delay and obtain a capacity of 8R code blocks are reconfigured. Since C4,1, C4,2, C4,3 and C4,4 are all blocked there is a need to vacate any one of this code. In case C4,4 is vacated as shown in figure 5.

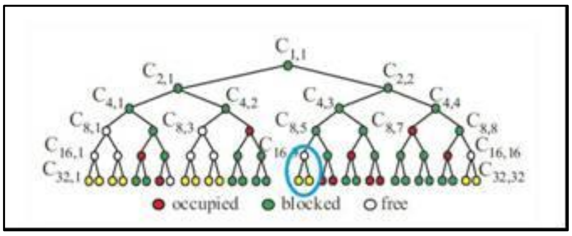

Fig. 3 Tie resolving criteria 2

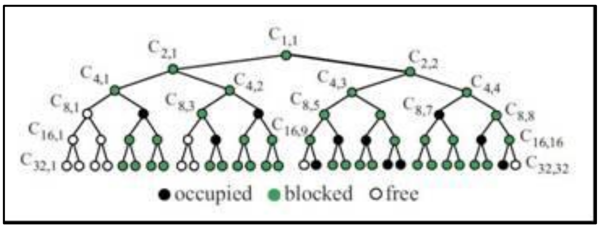

Fig. 4 System diagram for reconfiguration

For vacating the code there is a need to shift all the current ongoing calls to some new location. Codes C8;7, C16;15 and C32;31 are reallocated to C8;1, C16;5 and C32;17 respectively as shown in figure 6.

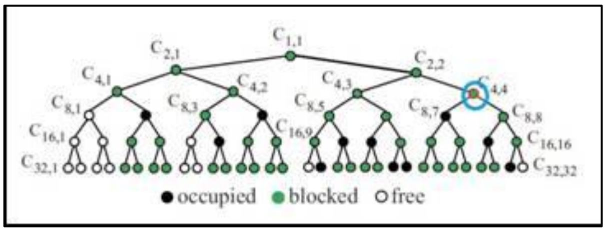

Fig.5 Reconfiguration of codes

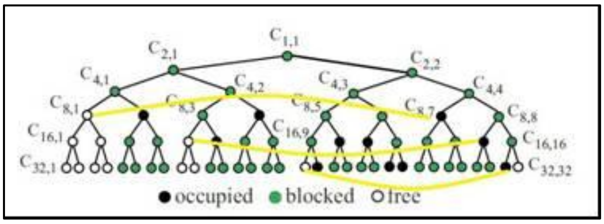

Fig. 6 System reconfiguration

However the reconfiguration may fail due to the number of levels in the system. Each layer adds a delay of 220 ms. If all the codes can be transmitted simultaneously the total incoming call set up delay will be only 220 ms. This is obtained by using the following algorithms.

4.1 Algorithm Code Pattern Search and Topology Search

This is the algorithm used to detect the code to be vacated in a way that the calls are not dropped. None for the existing calls should be dropped to place a new call. All the codes should be shifted in a way such that none of the existing calls are dropped.

4.2 Fewer Codes Blocked and Minimum Delay

If an incoming call of rate kR, k = 1, 2, 4, 8, . . . arrives and the system has enough free capacity to serve it, then, if there is one or more free candidate codes to support a rate of kR, FCB selects the most appropriate one. Otherwise, there are no free candidate codes to support a rate of kR and MD selects the sub tree to be vacated.

5. FUTURE SCOPE

The system used to reduce code blocking is RFCB. This scheme reduces the blocking but does not completely eliminate it. Both the descendents and the ascendants are still blocked. We need to propose an algorithm that can completely eliminate the code blocking.

In the studied algorithms the incoming call set up delay is reduced only if all the calls are transferred simultaneously. However this may result in dropped calls. The delay is not reduced significantly. A system could be introduced that reduces the set up delay under all possible configurations.

6. CONCLUSIONS

The paper studied Recursive Fewer Block Codes (RFCB) to minimize the code blocking that occurs due to Orthogonal Variable Spreading Factor (OVSF). This reduces the code blocking but does not completely eliminate it also it increases the incoming call set up delay by 220 ms at every level. Algorithms to reduce this call set up delay by transferring all the codes at every layer simultaneously have been studied.

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