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Re:	IEEE P802.16e/D4-2004	
Abstract	In this contribution, the inter-FA load balancing scheme at initial entries and handovers is proposed.	
Purpose	Review and Adopt the suggested changes into P802.16e/D4	
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**Load-Balancing FA Selection in Initial Entries and Handovers in Multi-FA
Systems IEEE 802.16e**

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1. Introduction

In current cellular system environment, BSs can have multiple frequency assignments (FAs, multiple carrier channels). In IEEE 802.16e, such deployments are possible, and the harmonization ad hoc group agreed on supporting multi-FA BSs – the configuration would be a little different since IEEE 802.16e BSs shall have a single FA, but co-located BSs which have different BS-IDs from those of co-located BSs can be distinguished by the co-located FA indicators in the PHY Profile ID in NBR-ADV. In such a case, for the efficiency, load balancing per FA (for example, distributing the users over the available FAs, or redirecting services to other FAs) is necessary. This is also for preventing from unnecessary additional network re-entry tries of MSS induced by overload.

Load balancing should be considered from initial network entry stage. It can be achieved by letting an MSS choose an FA according a hashing algorithm. Then, we would see balanced number of MSSs per FA statistically. For MSSs in normal operation, the service redirection for load balancing can be achieved by BS initiated handover between FAs, which can be supported by current handover algorithm.

Furthermore, load balancing among multiple FAs should also be considered for MSSs in idle mode. In this case, since a MSS in idle mode should monitor downlink at a FA to receive the paging, the number of SSs for each FA affect on the load for paging message. Without a proper algorithm, since all the BSs in the paging group should broadcast the same paging over all the FAs, the MOB-PAG-ADV gets larger. To avoid this problem, a rule which FA an MSS chooses to monitor its paging indication should be made. In order to solve these problems, we propose the following algorithm for load balancing among multiple FAs.

2. Proposed Solutions

A. Load Balancing in initial entry

- i. When an MSS turns on its power, it would search for a BS which has the strongest preamble strength. After the MSS finishes the DL synchronization and before it starts performing the initial entry ranging, it should receive the**

NBR-ADV of the target BS to check if the BS that it tries to connect has multiple FA by receiving the NBR-ADV. (Note that this condition does not elongate the network entry procedure since the frequency of broadcasting the NBR-ADV is higher than that of DCD/UCD, which are the essential ones to proceed the initial entry.) If the target BS is a single FA BS, the MSS follows the normal network entry procedure. If the target BS is a multi-FA BS, the MSS should perform the following FA Hashing procedure, and then it should re-synchronize and make an entry to the FA chosen through the procedure.

ii. FA Hashing Procedure

- 1. After an MSS receives the NBR-ADV and recognizes the multiple FA in the target BS, it collects all the BS-IDs of co-located FAs and sorts the BS-IDs in increasing order. (Note that each BS-ID is binding with one of FAs that the BS has.) Then, the MSS indexes the FA from 0 to F-1 where F is the number of co-located FAs.**
- 2. If the MSS MAC address is M, the MSS selects the R-th FA where R is the common residue of M divided by F, or $R = \text{mod}(M, F)$.**
- 3. If the chosen FA (the R-th FA in the ordered lists of FAs from the FA hashing procedure 1) is different from the currently synchronized FA, MSS should try to make a normal initial entry to the chosen FA.**

B. Load Balancing in idle mode

- i. When the structure of FAs of the current BS is different from that of the previous one (the MSS knows it from the NBR-ADV of the previous BS), MSS should continuously monitor downlink broadcast messages until receiving the NBR-ADV message.**
- ii. After receiving the NBR-ADV message, MSS select an FA with the same way of the FA hashing procedure of initial network entry. MSS monitors the broadcast message of the correctly chosen FA and will receive the PAG-ADV from the selected FA.**

C. Paging optimization

- i. A paging multi-FA BS selects an FA for an MSS with the FA hashing procedure and transmits the PAG-ADV for the mobile only on the hashed FA.**

D. Inter-FA-Intra-BS Handover

- i. Although this kind of handover is well supported without any text changes, this section provides a scenario.**
- ii. When a BS finds a reason for inter-FA-intra-BS handover of certain users (for**

example, service redirection for the purpose of load balancing can be required when a certain FA is too crowded to accommodate additional bandwidth requests), the BS can request a BS initiated HO using MOB-BSHO-REQ.

- iii. In the MOB-BSHO-REQ message, the BS can easily indicate the directed FA by putting the associated BS-ID. Furthermore, although FAs have different BS-ID, these FAs can be a single logical entity. The optimized HO can be performed (omitting SBC, PKM, REG negotiations and the IP refreshing procedure, etc).

3. Proposed Text Changes

[Add the sections 6.3.9.1.1 at line 44, page 53]

6.3.9.1.1 Network entry FA Selection in Multiple FA Networks Network Entry

After the MSS is successfully synchronized with the downlink, the MSS shall search and wait for the NBR-ADV MAC management message to check if it is synchronized to and trying to establish the connection with the right frequency assignment (FA). If the MSS does not receive the MOB-NBR-ADV within the maximum MOB-NBR-ADV interval, the MSS shall stay and proceed the initial network entry with the currently synchronized FA. At the acquisition of NBR-ADV, the MSS shall check if the BS has multiple FAs, which can be achieved by examining if any neighboring BSs in NBR-ADV are checked by the Co-located FA indicator bit in the PHY Profile ID. If so, the MSS shall perform the following FA Hashing algorithm. Otherwise, it shall follow the rest of the network entry procedure.

FA Hashing Algorithm

1. The MSS shall establish an ordered list of the co-located FAs including the currently synchronized BS (actually FA) from the acquired NBR-ADV. The ordering shall be made by the BS-IDs of the co-located FAs in the ascending order.
2. If the number of the co-located FAs is N , the MSS shall find the R -th FA in the list (the first FA in the list is numbered as zero), where R is the residue of MSS MAC address divided by N . In other words, $R = \text{MSS MAC Address modulo } N$.
3. If the currently synchronized FA is the one selected by the above algorithm, the MSS shall follow the rest of the network entry procedure. Otherwise, the MSS shall try to synchronize the selected FA.

[Add the following sections 6.3.21.2.1 at line13 page 84]

6.3.21.2.1 Cell FA selection in Multiple FA Networks

When MSS selects new preferred BS in multiple FA networks, MSS choose the FA by the FA Hashing Algorithm in 6.3.9.1.1 and after selection MSS shall monitor only the FA to monitor the paging.

[Add the following at the last of sections 6.3.21.7 at line26 page 85]

The BS shall broadcast the paging for a MSS only at the FA selected by the FA Hashing Algorithm described in 6.3.9.1.1.