Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Enhanced Handover Mechanism in IEEE P802.16e/D2-2004**
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Source(s)	Jung-Won Kim & Seungeun Hong Samsung Electronic, Suwon P.O.Box 105, 416, Maetan-3dong, Paldal-gu, Suwon-si,Gyeonggi-do, Korea 442-742 Jungwon74.kim@samsung.com
Re:	Call for inputs for the Handoff Ad-hoc group
Abstract	This contribution describes Enhanced MBB Handover in IEEE P802.16e/D2-2004 by letting the MSS actively manage its session information stored at the BS.
Purpose	Handoff Ad Hoc draft proposal for the IEEE802.16e group.
Notice	
Release	
Patent Policy and Procedures	

Enhanced Handover Mechanism in IEEE P802.16e/D2-2004

Jung-Won Kim and Seungeun Hong

SAMSUNG Electronics Co., Ltd

1. Introduction

As per the current IEEE 802.16 standard, the handover procedures necessitate many message exchanges, which results in unbearably long delay for an MSS to change its serving BS. An MBB handover scheme is strongly desired since it reduces the number of message exchanges and the handover delay. This contribution presents an MBB handover scheme which refines the session information management process.

If an MSS wants to make a handover following the current specification, it has to first acquire the topology of its neighborhood. It informs of the list of the neighboring BS through the MOB-NBR-ADV MAC management message. Later, it scans its neighbor BS, estimates their channel quality, and associates with them. Then, when it decides to which BS it will hand-over, it may or may not close the connection with the serving BS depending on whether to make a BBM or MBB handover. Second, it should synchronize with its target BS and obtain downlink and uplink parameters. Third, it should perform ranging to adjust uplink parameters. Fourth, it should make a new security association with the new serving BS. Finally, the MSS should re-register and re-establish service flows.

In IEEE 802.16, we can denote an MBB handover is performed if and only if the target BS or the neighbor BS have the session information a priori and the serving BS keeps them a posteriori. However, the current standard draft describes that an MBB handover is accomplished simply if the session information kept at the previous serving BS is released just after the MSS re-established its service flows and began normal operation. In some cases, the MSS may want to connect again with the old serving BS just after it erased the session information. According to the current specification, the MSS should perform a regular handover including the network re-entry procedure. Hence, it is hard to say that a ‘true’ MBB handover has been performed. Although the current specification provides a method to inform the session information of the MSS of the target BS just before a handover takes place over the backbone network, a smooth and delay-shortened handover cannot be expected if the unexpected event on the backbone network deferred the transfer of the session information. Furthermore, handover drops and elongated ping pong handovers are still highly probable, since the session information is released by the network not by the command of the MSS which can estimate the channel states to the neighboring BS.

The handover scheme proposed in this contribution lets the MSS actively manage the set of the BS which should keep its session information. We call these BS keeping the session information of the MSS as the *active BS*. The proposed scheme enables that the active BS maintain the most updated information and the serving BS lets the targeted active BS prepare the handover by the simple signaling of the MSS. In addition, the MSS following the proposed scheme can negotiate the capability and obtain the session information prepared by the active BS in advance. For this reason, the delay can be shortened significantly. Furthermore, since the session information kept at the active BS can be released only by the MSS command, the proposed handover scheme minimizes the message exchanges even in case of ping pong.

2. Proposed Enhanced Handover Mechanism

2.1 Concept of active BS set for enhanced handover

Figure1 shows how to manage the active BS set by procedures of 'Combined addition and switch', 'Addition', 'Switch', and 'Removal'.

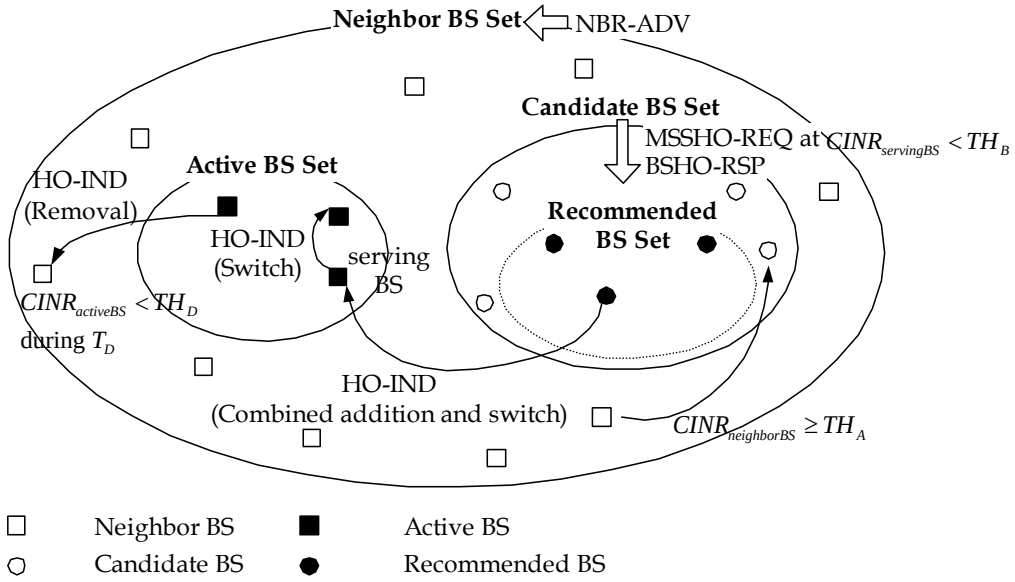

Figure 1 – Active BS set management

- Definitions
  - **Neighbor BS set:** This is defined as the set of neighbor BSs whose downlink/uplink channel descriptors are notified to the MSS through NBR-ADV from current Serving BS. The MSS can demodulate the downlink transmission from any neighbor BSs.

  - **Candidate BS set:** This is a subset of the neighbor BS set and includes the candidate BSs of which CINRs are above a predefined threshold (TH_A). In order to ask the Serving BS for handover, an MSS may send MSSHO-REQ message including each (BS ID, CINR) pair of all candidate BSs.

  - **Recommended BS set**: This is a subset of the candidate BS set and is notified to an MSS, which sent MSSHO-REQ message, through BSHO-RSP from the current Serving BS. A recommended BS can provide the MSS with some level of service.

  - **Active BS set**: This is defined as the set of BSs with which an MSS can skip all procedures except ranging process at network re-entry. The MSS will select one or more recommended BSs from which the MSS can expect good service, and will insert it or them into active BS set. The MSS can also remove one or more BSs from active BS set.

2.2 BS set management and enhanced handover procedures

2.2.1 Combined addition and switch

Compared with the existing procedure (HO_IND_type=Serving BS release), there is a little difference between them, but in our combined addition and switch procedure, the termination of service with the previous Serving BS shall not take place until the MSS requests to the previous Serving BS the termination via current Serving BS. In other words, the MSS maintains the active BS set containing the previous Serving BS and current Serving BS after the handover by 'combined addition and switch'.

2.2.2 Switch

Assuming that an MSS has its active BS set containing two or more active BSs, the MSS can quickly migrate from the air-interface provided by the current Serving BS to the air-interface provided by another active BS. The quick migration (so called switch) where the MSS can skip all procedures except ranging process at network re-entry with the active BS is possible because the active BS maintains the MSS service context.

The MSS can switch into the another active BS by sending/receiving SCN-REQ/RSP message to/from the current Serving BS, there is, however, two major limitations as follow: 1) the MSS should return to the Serving BS after scan duration; 2) the target active BS is not able to provide a non-contention based initial-ranging opportunity because it has no idea when the MSS enters. Thus, we re-use HO-IND MAC message, expanding the HO_IND_type of 2 bits into 8 bits and adding 'switch' type to the HO_IND_type. The MSS sends MOB_EHC-HO-IND(HO_IND_type=switch) MAC message to the current Serving BS, and the Serving BS should be able to notify the MSS' switch to the corresponding active BS. The active BS is required to provide fast ranging IE in order to support the quick migration.

2.2.3 Removal

An MSS which maintains the active BS set must periodically scan its active BSs. Based on the information obtained by the scanning, the MSS should be able to remove one or more BSs from its active BS set if their CINR is below the predefined threshold (TH_D). In this case, we also use MOB_EHC-HO-IND MAC message where HO_IND_type has new type 'Removal'.

Figure D18 depicts an example of MSS-initiated handover procedures by 'combined addition and switch', 'switch', and 'removal'. The ping-pong effect can be mitigated by the procedure of switch between active BSs. In figure D18, a new inter-base station message, HO-command, is introduced. This message is sent by Serving BS to notify target BS (or active BS) what a certain MSS intends to do. The primary use is to notify target BS that the MSS will enter it. The target BS may provide fast ranging IE in UL-MAP for the MSS. The message may be sent upon switch of Serving BS and removal of active BS. The message contains the following information (tbd).

3. Text to be inserted to standard

1.4.1.2 MAC layer HO procedures

[Add the following to section 1.4.1.2.4:]

1.4.1.2.5 Enhanced handover mechanism for supporting Active BS set.

This mechanism may be used for enhanced handover procedure.

At enhanced handover mechanism for supporting active BS set, the MSS performs the steps as shown in Figure D14-D19.

We describe the procedures to add/change/delete a service flow when a certain MSS has multiple active BSs. The active BS denotes a BS that has "MSS service context" and need not network re-entry procedures except initial ranging when the MSS hand-over to the BS. Active BS set consist of one or more number of active BSs for an MSS.

In general, service flows of an MSS may be added, changed, or deleted easily. But, when an MSS has been associated with a set of active BSs, the manipulations of service flows of an MSS should be done simultaneously at each active BS for consistency of context such as service flow parameters, security association, MSS capabilities, and so on. Therefore, an MSS that has more than two active BSs needs additional procedures to manipulate service flows in active BSs other than the current serving BS. In result,

the number of service flows for an MSS in one active BS is always preserved to be equal to that of another active BS.

After procedures of add/change/delete a service flow is finished the MSS can quickly migrate from the air-interface provided by the current Serving BS to the air-interface provided by another active BS such as combined addition and switch, addition, switch and removal.

1.4.1.2.5.2 BS set management and enhanced handover procedures

1.4.1.2.5.2.1 Combined addition and switch

Compared with the existing procedure (HO_IND_type=Serving BS release), there is a little difference between them, but in our combined addition and switch procedure, the termination of service with the previous Serving BS shall not take place until the MSS requests to the previous Serving BS the termination via current Serving BS. In other words, the MSS maintains the active BS set containing the previous Serving BS and current Serving BS after the handover by 'combined addition and switch'.

1.4.1.2.5.2.2 Switch

Assuming that an MSS has its active BS set containing two or more active BSs, the MSS can quickly migrate from the air-interface provided by the current Serving BS to the air-interface provided by another active BS. The quick migration (so called switch) where the MSS can skip all procedures except ranging process at network re-entry with the active BS is possible because the active BS maintains the MSS service context.

The MSS can switch into the another active BS by sending/receiving SCN-REQ/RSP message to/from the current Serving BS, there is, however, two major limitations as follow: 1) the MSS should return to the Serving BS after scan duration; 2) the target active BS is not able to provide a non-contention based initial-ranging opportunity because it has no idea when the MSS enters. Thus, we enhance MOB_EHC-HO-IND MAC message, expanding the HO_IND_type of 2 bits into 8 bits and adding 'switch' type to the HO_IND_type. The MSS sends MOB_EHC-HO-IND(HO_IND_type=switch) MAC message to the current Serving BS, and the Serving BS should be able to notify the MSS' switch to the corresponding active BS. The active BS is required to provide fast ranging IE in order to support the quick migration.

1.4.1.2.5.2.3 Removal

An MSS which maintains the active BS set must periodically scan its active BSs. Based on the information obtained by the scanning, the MSS should be able to remove one or more BSs from its active BS set if their CINR is below the predefined threshold (TH_D). In this case, we also use MOB_EHC-HO-IND MAC message where HO_IND_type has new type 'Removal'.

Figure D18 depicts an example of MSS-initiated handover procedures by 'combined addition and switch', 'switch', and 'removal'. The ping-pong effect can be mitigated by the procedure of switch between active BSs. In figure D18, a new inter-base station message, HO-command, is introduced. This message is sent by Serving BS to notify target BS (or active BS) what a certain MSS intends to do. The primary use is to notify target BS that the MSS will enter it. The target BS may provide fast ranging IE in UL-MAP for the MSS. The message may be sent upon switch of Serving BS and removal of active BS. The message contains the following information (tbd).

In addition to the above mitigation of ping-pong effect, a near-seamless handover to new target BS is needed. For the purpose, we introduce 'addition' procedure as follows.

3. Definitions

3.5 Base Station

[Add the follwoing text to section 3.5:]

3.5.4 Neighbor BS Set

This is defined as the set of neighbor BSs whose downlink/uplink channel descriptors are notified to the MSS through NBR-ADV from current Serving BS

3.5.5 Candidate BS Set

This is defined as the set of neighbor BSs whose downlink/uplink channel descriptors are notified to the MSS through NBR-ADV from current Serving BS

3.5.6 Recommended BS Set

This is a subset of the candidate BS set and is notified to an MSS, which sent MSSHO-REQ message, through BSHO-RSP from the current Serving BS. A recommended BS can provide the MSS with some level of service.

3.5.7 Active BS set

This is defined as the set of BSs with which an MSS can skip all procedures except ranging process at network re-entry. The MSS will select one or more recommended BSs from which the MSS can expect good service, and will insert it or them into active BS set.

6.4.2.3.53 Enhanced HO Indication (MOB_EHC-HO-IND) message

If the system support active BS set the serving BS sends the message in Table 85m. Compared with the existing procedure (HO_IND_type=Serving BS release), there is a little difference between them, but in our combined addition and switch procedure. An MSS shall transmit a MOB_EHC-HO-IND message for final indication that it is about to perform a HO. We can use an ***unsolicited*** MOB_EHC-HO-IND message to add the new Active BS and switch to the new Active BS demanded by MSS.

Table 85m— MOB_EHC-HO-IND Message Format

Syntax	Size	Notes
MOB_EHC-HO-IND_Message_Format () {		
Message Type	**8 bits**	**0x36=54**
HO_IND_type	**8 bits**	**0x00: Serving BS release** **0x01=HO cancel** **0x02=HO reject** **0x03=Combined addition and switch** **0x04=Switch** **0x05=Removal** **0x06~FF=Reserved**
If (HO_IND_type =0x00, 0x03 or 0x04)		
SWITCH_BS ID	**48 bits**	**Target BS ID**
else if (HO_IND_type=0x05) {		
Num_of_BSs	**8 bits**	**Number of BSs to be removed**
for (i=0; I<Num_of_BSs;i++) {		
BS ID	**48 bits**	**BS to be removed**
}		
}		
HMAC Tuple		
}		

D.3.2 Enhanced handover procedures

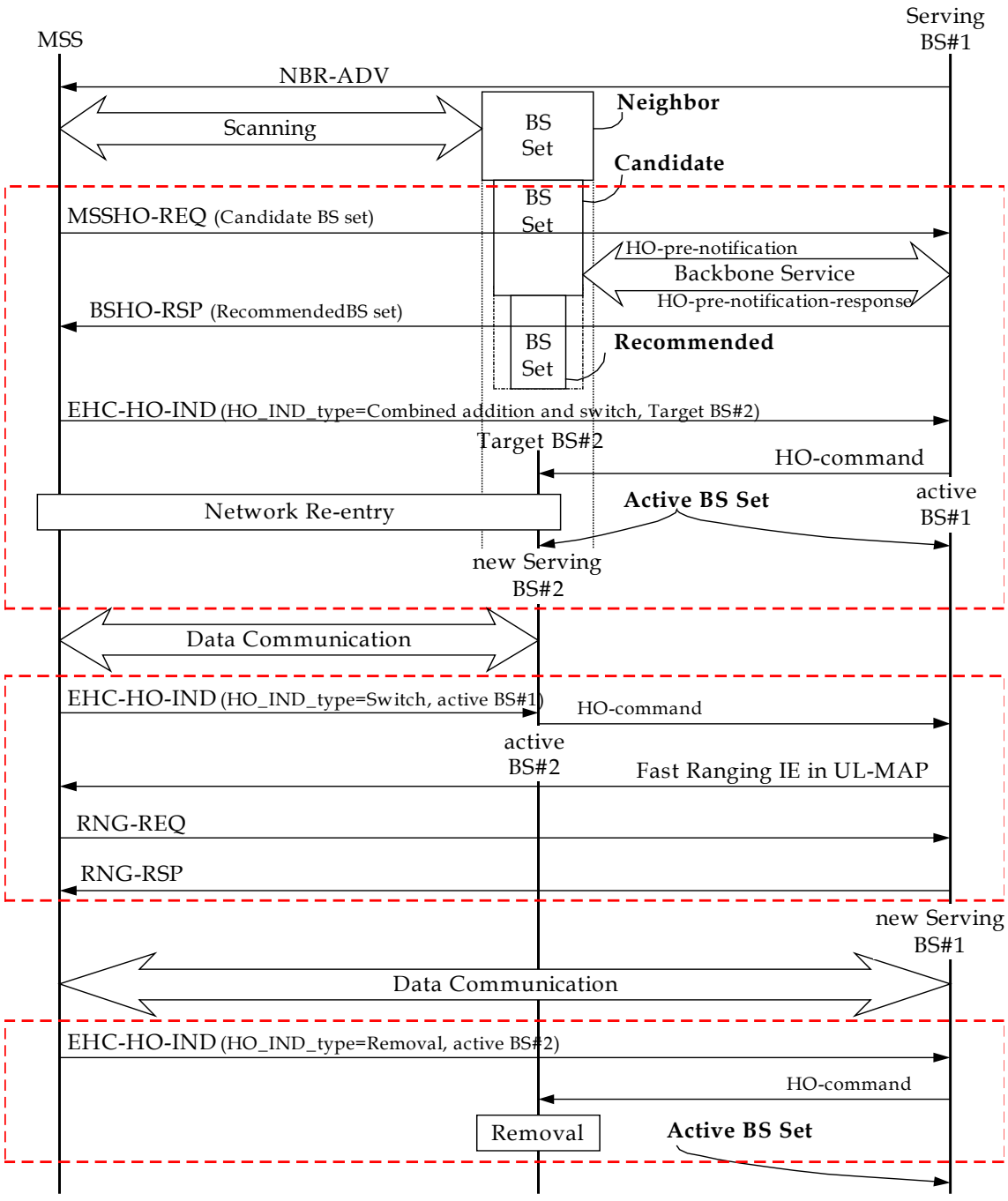

Figure D.18. An example of MSS-initiated handover procedures by 'combined addition and switch', 'switch', and 'removal'

Reference

[1] IEEE C802.16e-03/20r1 "IEEE 802.16e Handoff Draft"