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Abstract	Fast Base Station Switch Process provides diversity gain without increasing much complexity comparing to the standard HO procedure in the current 802.16e system
Purpose	Adoption
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Fast Base Station Switch

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1. Introduction

Soft Hand Over (SHO) improves HO quality by means of macro-diversity. However, the potential gain may be marred by the associated complexity and overhead.

2. Overview of Proposed Solution

In this contribution we propose an alternative HO solution—fast Base Station switching (FBSS). FBSS utilizes selection diversity and fast switching mechanism to improve link quality with less complexity. Instead of frame-by-frame transmission synchronization required by SHO, a commonly shared MAC that can be achieved by Level 3 MAC context sharing or transfer among BSs facilities FBSS process. The FBSS offers the following benefits:

1. It provides diversity gain by allowing fast switching of data transmission from BS to another BS dynamically.
2. It does not require much PHY changes.
3. Since only BS is transmitting at any given time, the scheduler can be more flexible and optimized than in SHO (no data synchronization issue to worry about).
4. It can easily support data connection with H-ARQ.
5. It won't take up additional air link capacity/resource.

Before a detail description can be made for Fast BS Switching HO, a few definitions need to be made:

- *Serving BS*: A serving BS is a BS that has allocated resources to the MSS, i.e. assigned Basic CID, Primary Management CID, Secondary Management CID, data CIDs to the MSS and data service context.
  MSS should keep synchronization with a serving BS at all times.
- *Target BS*: A target BS is a BS that the MSS is intended to HO to. Once the HO process is successfully completed, a target BS becomes a serving BS.
- *Anchor BS*: An Anchor BS is the serving BS that is designated to transmit/receive data to/from the MSS at a given frame.
- *Active Set*: The active set contains a list of serving BSs to the MSS. The active set is managed by the MSS and BS.

The basic concept of FBSS is as follows.

The HO flow, procedures and HO message exchanges are similar to the standard in IEEE802.16e/D3. After network entry, the MSS will be notified by the Anchor BS its neighbor BS list through MOB_NBR_ADV MAC Management message. The BS shall also send this message whenever there is a change in the active set. The MOB_NBR_ADV

message will be modified to include MAHO Drop Threshold. (When CINR of a serving BS is less than MAHO Drop Threshold, the MSS should send MOB_MSSHO_REQ to requires dropping this serving BS from the active set.)

The MSS is only transmitting/receiving data to/from one of the serving BS (Anchor BS) at any given frame. The Anchor BS can change from frame to frame depending on the BS selection scheme. The MSS is informed of the switching of Anchor BS through two possible methods:

- Method 1: The MSS is required to process DL_MAP and UL_MAP from all serving BSs at each frame and determines which serving BS is the Anchor BS for the current frame;
- Method 2: The BS informs the MSS of the new Anchor BS through MOB_BSHO_REQ message.

The MSS monitors the downlink of all serving BSs in the active set and updates its preferred Anchor BS based on received CINR from all serving BS. The MSS chooses and sends its preferred Anchor BS to the current Anchor BS over fast feedback channel. The fast feedback channel is modified to include one more type of MSS reporting. When the BS receives the request, it may change the Anchor BS to the MSS preferred BS after all H-ARQ (if activated) re-transmissions are completed.

3. Proposed Text Changes

3.1. HO Message Modification

[*Modify the Neighbor Advertisement (MOB-NBR-ADV) message, to indicate which neighbor BS can be in FBSS and add MAHO Drop Threshold*]

6.3.2.3.50 Neighbor Advertisement (MOB-NBR-ADV) message

Table 92d – MOB-NBR-ADV Message Format

Syntax	Size	Notes
MOB-NBR-ADV_Message_Format () {		
Management Message Type = 49	8 bits	
MAHO Drop Threshold	6 bits	Threshold used by the MSS to drop a serving BS from the active set. This threshold is used for the MSS that is performing FBSS HO. It is in the unit of dB
Operator_ID	24 bits	Unique ID assigned to the operator
N_NEIGHBORS	8 bits	Neighbor BSs excluding BSs declared in FBSS_Neighbor for loop
For (I = 0; i < N_NEIGHBORS;i++) {		
Neighbor BS-ID	48 bits	
HO type support	8 bits	Bit 0: Break before Make Bit 1: Make before Break

		Bit 2: Soft HO Bit 3: FBSS HO Bit 4-7: reserved
DL Physical Frequency	32 bits	
Configuration Change Count	8 bits	Incremented each time the information for the associated neighbor BS has changed
If ((bit 2 of HO type support is == 1 ‖ bit 3 of HO type support is == 1) {		
Preamble sequence Ind	8 bits	Preamble index (see table 307)
}		
TLV Encoded Neighbor information	variable	TLV specific
}		
HMAC Tuple	21 bytes	
}		

[…]

Operator ID – the unique network ID shared by an association of BS

MAHO Drop Threshold - Threshold used by the MSS to drop a serving BS from the active set. This threshold is used for the MSS that is performing FBSS HO. It is in the unit of dB

HO type support – Indicates the types of HO supported by the neighbor BS

Preamble Ind – Preamble index used by the neighbor BS, which will help MSS quickly search neighbor BS

[…]

[*Modify the MSS HO Request (MOB-MSSHO-REQ) message, to indicate the list of recommended BSs for FBSS and provide the necessary CINR information of those BS and to add BS remove mechanism from the Active Set*]

6.3.2.3.55 MSS HO Request (MOB-MSSHO-REQ) message

[…]

Table 92i- MOB-MSSHO-REQ message Format

Syntax	**Size**	**Notes**
MOB-MSSHO-REQ_Message_Format() {		
Management Message Type = 53	8 bits	
Mode	2 bits	00: HO request 10: SHO/FBSS HO request: Active Set update 11: reserved
If (mode == 00) {		
for (i= 0;i<N_Recommended; i++) {		
Neighbor BS_ID	48 bits	Base station ID

BS CINR mean	8 bits	
Service level prediction	8 bits	
}		
Estimated action time	8 bits	The estimated action time shall be the time for the recommended target BS
}		
else if (mode == 10) {		
Anchor_BS_indicator	1 bit	1: the recommended Anchor BS is in the current Active Set 0: the recommended Anchor BS is not in the current Active Set
If (Anchor_BS_indicator == 1) {		
TEMP_BS_ID	3 bits	Active Set member ID of the recommended Anchor BS.
}		
Else {		
Neighbor BS_ID	48 bits	BS_ID of the recommended Anchor BS.
}		
BS CINR mean	8 bits	CINR mean of the Anchor BS
N_new_BSs	3 bits	Number of new BSs (excluding the recommended Anchor BS) which are recommeded to be added to the Active Set of the MSS
For (i= 0; i < N_new_BSs; i++) {		
Neighbor BS_ID	48 bits	
BS CINR mean	8 bts	
}		
N_current_BSs	3 bits	Number of BSs (excluding the recommended Anchor BS) currently in the Active Set of the MSS, which are recommended to be remained in the Active Set
For (i=0;i< N_current_BSs;i++) {		
TEMP_BS_ID	3 bits	Active Set member ID assigned when this BS is added to the Active Set
BS CINR mean	8 bits	
}		
Estimated action time	8 bits	Estimated action time when the Active Set is updated
}		
Reserved	Variable	As required
HMAC tuple	21 bytes	

}		

[*Modify the BS HO Response (MOB_BSHO-RSP) message, to indicate the list of recommended BSs for FBSS*]

6.3.2.3.56 BS HO Response (MOB_BSHO-RSP) message

[…]

Table 92j- MOB-BSHO-RSP Message Format

Syntax	**Size**	**Notes**
MOB-BSHO-RSP_Message_Format() {		
Management Message Type = 52	8 bits	
Mode	2 bits	00: HO request 01: SHO/FBSS request: Anchor BS update 10: SHO/FBSS request: Active Set update 11: reserved
If (Mode == 00) {		
Network Assisted HO supported	1 bit	Indicate that the BS supports Network assisted HO
N_Recommended	8 bits	
For (i= 0;i<N_Recommended; i++) {		
Neighbor BS_ID	48 bits	Base station ID
Service level prediction	8 bits	
}		
}		
else if (Mode ==01) {		
TEMP_BS_ID	3 bits	TEMP_BS_ID of the recommended Anchor BS
N_CIDs	8 bits	Number of CIDs needed to be reassigned
For (i= 0;i<N_CIDs;i++) {		
Current CID	16 bits	Currently assigned CID
New CID	16 bits	New CID to be used after Active Set is updated
}		
}		
if (Mode == 10) {		
Anchor_BS_indicator	1 bit	1: the recommended Anchor BS is in the current Active Set

		0: the recommended Anchor BS is not in the current Active Set
If (Anchor_BS_indicator == 1) {		
TEMP_BS_ID	3 bits	Active Set member ID of the recommended Anchor BS
}		
Else {		
Neighbor BS_ID	48 bits	BS_ID of the recommended Anchor BS
TEMP_BS_ID	3 bits	Active Set member ID assigned to this BS
}		
Service level prediction	8 bits	Service level predication of the recommended Anchor BS
N_new_BSs	3 bits	Number of new BSs (excluding the recommended Anchor BS) which are recommended to be added to the Active Set of the MSS
For (i= 0; I < N_new_BSs; i++) {		
Neighbor BS_ID	48 bits	
TEMP_BS_ID	3 bits	Active Set member ID assigned to this BS
Service level prediction	8 bits	
}		
N_current_BSs	3 bits	Number of BSs (excluding the recommended Anchor BS) currently in the Active Set of the MSS, which are recommended to be remained in the Active Set
For (i=0;i< N_current_BSs;i++) {		
TEMP_BS_ID	3 bits	Active Set member ID assigned to this BS
Service level prediction	8 bits	
}		
Action time	8 bits	Recommended action time when the Active Set shall be updated
N_CIDs	8 bits	Number of CIDs needed to be reassigned
For (i= 0;i<N_CIDs;i++) {		
Current CID	16 bits	Currently assigned CID
New CID	16 bits	New CID to be used after Active Set is updated
}		
}		

Reserved	Variable	As required
HMAC tuple	21 bytes	
}		

[*Modify the HO indication (MOB-HO-IND) message, to indicate the decided list of BSs for FBSS*]

6.3.2.3.57 HO Indication (MOB-HO-IND) message

[…]

Table 92k- MOB-HO-IND Message Format

Syntax	**Size**	**Notes**
MOB-HO-IND_Message_Format () {		
Management Message Type = 56	8 bits	
Reserved	5 bits	
Mode	2 bits	00: HO request 01: SHO/FBSS request: Anchor BS update 10: SHO/FBSS request: Active Set update 11: reserved
if (Mode == 00) {		
HO_IND_Type	2 bits	00: serving BS release 01: HO cancel 10: HO reject 11: reserved
Target_BS_ID	48 bits	
}		
else if (Mode == 01) {		
SHOFBSS_IND_Type	2 bits	00: confirm Anchor BS update 01: Anchor BS update cancel 10: Anchor BS update reject 11: reserved
If (SHOFBSS_IND_Type == 00) {		
Anchor BS ID	3 bits	TEMP_BS_ID of the Anchor BS
Action_time	8 bits	Action time when the Anchor BS shall be updated
}		
}		
if (Mode == 10) {		
SHOFBSS_IND_Type	2 bits	00: confirms Active Set update 01: Active Set update cancel 10: Active set update reject 11: reserved
If (SHOFBSS_IND_Type == 00) {		

Active Set Included Indicator	1 bit	1: Final decision of Active Set members included in the message 0: Active Set members are as specified in MOB_xxHO_RSP message. No Active Set information included in this message.
if (Active Set Included Indicator == 1) {		
Anchor BS ID	3 bits	TEMP_BS_ID of the Anchor BS
N_BS	3 bits	Number of BS in the Active Set, excluding the Anchor BS
for (i = 0; i < N_BS; i++) {		
TEMP_BS_ID	3 bits	Active Set member ID assigned
}		
}		
Action_time	8 bits	Action time when the Active Set shall be updated
}		
}		
HMAC tuple	21 bytes	
}		

[*Modify the BS HO Request (MOB-BFBSS-REQ) message, to indicate the list of recommended BSs for FBSS*]

6.3.2.3.54 BS HO Request (MOB-BSHO-REQ) message

[…]

Table 92h- MOB-BSHO-REQ message Format

Syntax	**Size**	**Notes**
MOB-BSHO-REQ_Message_Format() {		
Management Message Type = 52	8 bits	
Mode	2 bits	00: HO request 01: SHO/FBSS request: Anchor BS update 10: SHO/FBSS request: Active Set update 11: reserved
If (Mode == 00) {		
Network Assisted HO supported	1bit	Indicate that the BS supports Network assisted HO
N_Recommended	8 bits	
For (i= 0;i<N_Recommended; i++) {		
Neighbor BS_ID	48 bits	Base station ID

Service level prediction	8 bits	
}		
}		
else if (Mode == 01) {		
TEMP_BS_ID	3 bits	TEMP_BS_ID of the recommended Anchor BS
Estimated action time	8 bits	Estimated action time when the Anchor BS is updated
}		
Else if (Mode == 10) {		
Anchor_BS_indicator	1 bit	1: the recommended Anchor BS is in the current Active Set 0: the recommended Anchor BS is not in the current Active Set
If (Anchor_BS_indicator == 1) {		
TEMP_BS_ID	3 bits	Active Set member ID of the recommended Anchor BS.
}		
Else {		
Neighbor BS_ID	48 bits	BS_ID of the recommended Anchor BS.
TEMP_BS_ID	3 bits	Active Set member ID assigned to this BS
}		
Service level prediction	8 bits	Service level prediction of the recommended Anchor BS
N_new_BSs	3 bits	Number of new BSs (excluding the recommended Anchor BS) which are recommended to be added to the Active Set of the MSS
For (i= 0; I < N_new_BSs; i++) {		
Neighbor BS_ID	48 bits	
TEMP_BS_ID	3 bits	Active Set member ID assigned to this BS
Service level prediction	8 bits	
}		
N_current_BSs	3 bits	Number of BSs (excluding the recommended Anchor BS) currently in the Active Set of the MSS, which are recommended to be remained in the Active Set
For (i=0;i< N_current_BSs;i++) {		
TEMP_BS_ID	3 bits	Active Set member ID assigned to this BS

Service level prediction	8 bits	
}		
Estimated action time	8 bits	Action time when the Active Set shall be updated
N_CIDs	8 bits	Number of CIDs needed to be reassigned
For (i= 0;i<N_CIDs;i++) {		
Current CID	16 bits	Currently assigned CID
New_CID	16 bits	New CID to be used after Active Set is updated
}		
}		
Reserved	Variable	As required
HMAC tuple	21 bytes	
}		

[*Modify the MSS HO Response (MOB-MSFBSS-RSP) message, to indicate the list of recommended BSs for FBSS and provide the necessary CINR information of those BS*]

6.3.2.3.xx MSS HO Response (MOB-MSSHO-RSP) message

[…]

Table xx- MOB-MSSHO-RSP message Format

Syntax	**Size**	**Notes**
MOB-MSSHO-RSP_Message_Format() {		
Management Message Type = 59	8 bits	
Mode	2 bits	01: SHO/FBSS request: Anchor BS update 10: SHO/FBSS request: Active Set update 11: reserved
if (Mode == 01) {		
TEMP_BS_ID	3 bits	TEMP_BS_ID of the recommended Anchor BS
BS CINR mean	8 bits	
Estimated action time	8 bits	Estimated action time when the Anchor BS is updated
}		
Else if (Mode == 10) {		
Anchor_BS ID	3 bit	TEMP_BS_ID of the recommended Anchor BS
Anchor BS CINR mean	8 bits	

N_BS	3 bits	Number of BSs excluding the Anchor BS, in the recommended Active Set
for (i= 0; i < N BSs; i++) {		
TEMP_BS_ID	3 bits	
BS CINR mean	8 bits	
}		
Estimated action time	8 bits	Estimated action time when the Active Set is updated
}		
Reserved	Variable	As required
HMAC tuple	21 bytes	
}		

[*Modify the FAST-FEEDBACK allocation subheader, to include the FBSS mode*]

Table 13-FAST-FEEDBACK allocation subheader format

Syntax	Size	Notes
FAST-FEEDBACL allocation Subheader {		
Allocation offset	6 bits	
Feedback type	3 bits	000 - Fast DL measurement 001 - Fast MIMO feedback, antenna #0 010 - Fast MIMO feedback, antenna #1 011 – MIMO mode and permutation mode feedback 100 – Preferred Anchor BS
Reserved	7 bits	
}		

Preferred Anchor BS is added to allow the MSS to notify the BS quickly its preferred Anchor BS.

3.2. Text change

[*Add the following text to section 6.3.20.1.1*]

In order to support FBSS, a BS shall broadcast information about which neighbor BSs are able to support FBSS with this BS, using the MOB-NBR-ADV MAC Management message. In addition, the MSS shall keep in synchronization with all members of Active set.

[*Add the following text to section 6.3.20.2*]

When the FBSS HO is support the following stages shall be supported by the BS and the MSS:

- FBSS HO Decision - A FBSS handover begins with a decision for an MSS to monitor and be synchronized with multiple BSs at the same time while transmits/receives from the Anchor BS. A FBSS handover can be triggered by either MOB_MSSHO_REQ or MOB_BSHO_REQ messages.

- Active Set Selection/Update – An MSS is required to scan the neighbor BS and selects BSs that are suitable to be included in the active set. The MSS shall report the selected BSs and the active set update procedure shall be performed by the BS and the MSS.
- Anchor BS Selection/Update – An MSS is required to monitor the BSs that are included in the active set at all time. The MSS selects its preferred Anchor BS from the active set and reports it via Fast Feedback channel. An Anchor BS Update procedure may be performed by the BS.

[*Add a section 6.3.20.2.6*]

6.3.20.2.6. FBSS HO Decision and Initiation

While in FBSS, the MSS and the BS network maintains a list of BSs that are involved in FBSS with the MSS. This list of BSs is called the Active Set. The MSS only communicates with one BS (Anchor BS) from the active set at a time. However, the MSS is require to monitor and to be synchronized of all BSs in the Active set. In addition, the BSs in the active set shall have all MSS related information including service flows, connections information, privacy information, etc.

The FBSS HO Decision starts with a notification of MSS intent to handover through MOB-MSSHO-REQ or MOB-BSHO-REQ. This notification is required for FBSS HO. Acknowledgement with MOB-BSHO-RSP of a notification is required, but one with MOB-MSSHO-RSP is recommended by not required.

If an MSS that transmitted a MOB-MSSHO-REQ message detects an incoming MOB-BSHO-REQ message, it may respond with a MOB-MSSHO-RSP message and ignore its own request. Similarly, a BS that transmitted a MOB-BSHO-REQ message shall ignore any MOB-MSSHO-REQ messages from the same MSS and shall await a MOB-MSSHO-RSP message or MOB-HO-IND message, or retry the MOB-BSHO-REQ message.

6.3.20.2.6.1 Active Set Update

Active set update shall be the same as defined for SHO procedure except the following:

When a new BS is added to an MSS' Active Set, the MSS shall not perform the HO procedure as defined in Figure 14h. The MSS may optionally perform ranging but shall not perform the rest of procedures, namely, synchronize and obtain parameters with new DL and UL; perform re-authorization, re-register/re-establish service flows, and re-establish IP connectivity.

6.3.20.2.6.1 Anchor BS Update

The MSS reports its preferred anchor BS via fast feedback channel periodically. The preferred Anchor BSs shall be within the current Active Set of the MSS. The MSS may select the preferred Anchor BS through the previously performed signal strength measurement. The BS decides the current Anchor BS base on the MSS report.

There are two modes of the Anchor BS Update may be supported by the BS and the MSS. The Anchor BS update mode shall be negotiated and determined as part of SS Basic

capability negotiation at initial network entry. The Anchor BS Update modes are defined as the following:

- MAP monitoring: The MSS is required to monitor the DL_MAP/UL_MAP from all BS in the active set. The MSS is informed of the current Anchor BS based on the allocation assignment contained in the DL_MAP/UL_MAP.
- MAC messaging: The BS informs the MSS of the Anchor BS update through MOB-BSHO-REQ or MOB-BSHO-RSP message with the estimated switching time. The MSS shall update its Anchor BS based on the information received in MOB-BSHO-REQ or MOB-BSHO-RSP. The MSS also shall indicate its acceptance of the new anchor BS through MOB-HO-IND, with SHOFBSS_IND_type field set to “00”. The MSS may reject the Anchor BS update instruction by the BS, by setting the SHOFBSS_IND_type field in MOB-HO-IND to ‘10’ (Anchor BS update reject). The BS may reconfigure the Anchor BS list and retransmit MOB-BSHO-RSP or MOB-BSHO-REQ message to the MSS. After an MSS or BS has initiated an Anchor BS update using MOB-MSSHO/BSHO-REQ, the MSS may cancel Anchor BS update at any time. The cancellation shall be made through transmission of a MOB-HO-IND with SHOFBSS_IND_type field set to ’01’.

[*Modify sections 8.4.5.4.10.1-3*]

[*Change the 2 bits reference to the Feedback Type field to 3 bits*]

[*Add a section 8.4.5.4.10.4*]

8.4.5.4.10.4 FBSS BS Selection Feedback

When the FAST-FEEDBACK subheader Feedback Type field is ‘100’, MSS in the optional FBSS HO procedure shall send its selection of the preferred Anchor BS to the current Anchor BS.

Table xxx – Encoding of BS numbering in Active Set

Value	Description
0b0000	BS #1 in Active Set
0b0001	BS #2 in Active Set
0b0002	BS #3 in Active Set

In FBSS HO procedure, the MSS monitors the signal strength of the serving BSs every frame and choose it's preferred Anchor BS and send it to current Anchor BS through the assigned Fast-feedback channel. Table xxx shows the encoding of BS numbering in the Active Set.

[*Add a section 11.7.10.2*]

11.7.10.2 Handoff supported

This field indicates what type(s) of HO the MSS supports. A bit value of 0 indicates “not supported” while 1 indicates it is supported.

Type	Length	Value
19	1	Bit #0: SHO Supported Bit #1: FBSS HO – Multi-BS MAP Supported Bit #2: FBSS HO – Single-BS MAP Supported Bit #3 - #7: reserved, shall be set to zero