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Title	Fast MSS-BS DL Data Flow Coordination for FBSS Support
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Re:	IEEE P802.16e/D5-2004
Abstract	A fast signaling mechanism is introduced to identify the next information unit to be transmitted by a new anchor BS while the MSS is in FBSS handoff. This is a revised contribution. Changes are highlighted in blue.
Purpose	Review and Adopt the suggested changes into P802.16e/D5
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1 Problem Statement

When an MSS is in FBSS HO, the MSS triggers a switch to a new anchor BS by sending a codeword on its CQICH indicating the TEMP_BS_ID corresponding to the new anchor BS. After the switch, a mechanism is required for the new anchor BS to identify the next information unit to continue transmissions to the MSS. In the current p802.16e/D5 text, in order for the new anchor BS to identify the next information unit to transmit, the old anchor BS needs to communicate with the new anchor BS to relay such information. This backhaul communication will incur latency in DL data transmission during FBSS.

2 Proposed Solution

This contribution proposes a MSS-assisted procedure to facilitate continuity of the DL data transmission when an MSS in FBSS HO moves to a new anchor BS. The proposed procedure removes the need and the associated latency of transferring data flow continuity information between the old and the new anchor BSs for DL connections.

The proposed solution is summarized below for DL connections:

- Depending on whether the connection is ARQ based or non-ARQ, the identity of the next information unit can be identified by the ARQ block sequence number currently defined in p802.16e/D5 or by a virtual MAC SDU sequence number respectively.
- During FBSS operation, the MSS provides the new Anchor BS with either the ARQ block sequence number or the MAC SDU sequence number for the selected connections.
- The support of SDU sequence number is optional for the SS and is communicated using the new capability TLV defined for REG-REQ/RSP messages. If the SDU sequence number capability is supported, the capability can be optionally enabled for certain connections using the new TLV for DSA-REQ/RSP.
- In the case of ARQ connections, the last ARQ block sequence number is already available at the MSS. For non-ARQ connections, the BS maintains a virtual MAC SDU sequence number. If the MSS supports the SDU_SN_ and SDU_SN is enabled for the DL connection, the BS provides the MAC SDU sequence number to the MSS through Fragmentation Subheader or Packing Subheader . A new format is defined for Fragmentation Subheader and Packing Subheader to support this option. During anchor switching procedure, the old anchor BS shall include Fragmentation subheader or Packing Subheader for all DL connections with SDU_SN option enabled until the expiration of the Anchor switch timer.
- At the expiration of the Anchor switch timer, the new anchor BS should assign UL resource for the MSS to transmit the sequence number(s) of ARQ block or MAC SDU. The MSS subsequently sends a new SN Report MAC header that includes the next ARQ Block or MAC SDU sequence number that it is expecting for each DL connections with SDU_SN enabled .
- The new anchor BS begins its communication with the MS with the requested ARQ block or MAC SDU
- In the process of transferring to the new anchor BS, the prior ARQ blocks or MAC SDUs pending retransmission are dealt with in the conventional manner, once the new anchor BS connection is established.
- To reduce feedback overhead, only the sequence numbers (not the CIDs) of the selected connections is included in the SN Report header. Thus a MAC header can feedback the

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sequence number of up to three connections (those numbers are listed based on index or value of CIDs at the new anchor BS). The MSS can send up to two SN Report headers to provide up to 6 sequence numbers. The order of sending the sequence number shall be in ascending order of the CID values at the new anchor BS of those selected connection with SDU_SN enabled.

-

3 Proposed Text Changes

[Add a new section 6.3.2.1.6]

6.3.2.1.6 SN Report Header

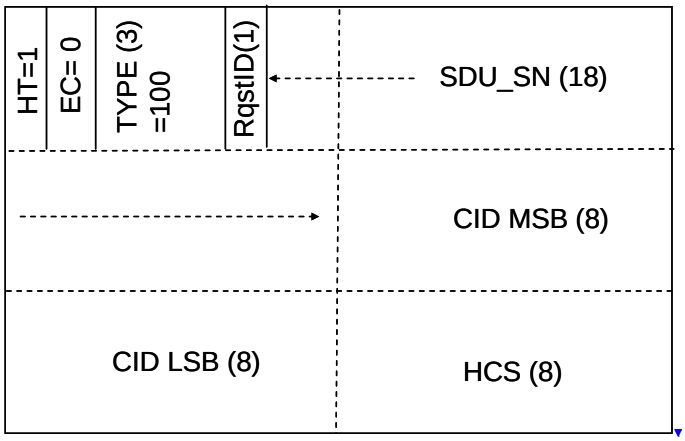

Figure 1: SN Report Header Format

The SN Report Header shall be of the form illustrated in Figure 1. The SN Report header shall have the following properties:

a) The length of the header shall always be 6 bytes

b) The EC field shall be set to 0, indicating no encryption

c) The CID shall indicate the basic connection of the MSSfor which the SN Report is being sent.

d) The SDU SN field shall indicate the LSB of the next ARQ BSN or the virtual MAC SDU Sequence number for the active connections. The LSB of the ARQ BSN or virtual MAC SDU sequence number for each connection is provided. At most 3 SNs can be provided in each SN Report Header in numerical ascending order of the CID values of the connections with sequence number feedback enabled.

e) The RqstID field may be used to indicate whether the SN Report header is the first or second of two consecutive SN Report headers, to accommodate up to 6 active connections. The fields of the SN Report header are defined in Table 1. Every header is encoded, starting with the HT and EC fields. The coding of these fields is such that the first byte of a MAC header shall never have the value of 0xFX. This prevents false detection of the stuff byte.

Table 1 – SN Report Header Fields

Name	Lengt	Description

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	h (bits)	
SDU_SN_1	6	The ARQ BSN (LSB) or MAC SDU SN (LSB) for the first CID in this header. The order of reporting the SNs for the connections is predetermined as indicated in Section 6.3.20.2.6.2.2.
SDU_SN_2	6	The ARQ BSN (LSB) or MAC SDU SN (LSB) for the second CID in this header.
SDU_SN_3	6	The ARQ BSN (LSB) or MAC SDU SN (LSB) for the third CID in this header.
CID	16	Basic Connection Identifier
EC	1	Encryption Control. Always set to 0
HCS	8	Header Check Sequence
HT	1	Header Type = 1
Type	3	Set to 0b100. Indicates that it is a SN Report header
RqstID	1	Set to 0 to indicate that this is the first SN Report header. Set to 1 to indicate that this is a second SN Report header with up to 3 additional connections reported

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[…]

[Modify section 6.3.2.2.1]

6.3.2.2.2.1 Fragmentation Subheader

[…]

Table 8 – Fragmentation subheader format

Syntex	Size	Note
Fragmentation Subheader() {		
FC	2 bits	Indicates the fragmentation state of the payload: 00 = no fragmentation 01 = last fragment 10 = first fragment 11 = continuing (middle) fragment
if (ARQ-enabled Connection)		
BSN	11 bits	Sequence number of first block in the current SDU fragment
else if (SDU_SN enabled connection){		This format shall only be used for DL connections
SDU_SN	7 bits	Sequence number of the first SDU in the current MAC PDU. The sequence number is incremented by one (modulo 128) for every SDU (not SDU segments).
FSN	4 bits	Sequence number of the SDU fragments. This sequence number is incremented by one (modulo 16) for every SDU fragment including

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		unfragmented SDUs.
}		
else {		
if (Type bit Extended Type)		See Table 6
FSN	11 bits.	Sequence number of the current SDU fragment. This field increments by one (modulo 2048) for each fragment, including unfragmented SDUs
else		
FSN	3 bits	Sequence number of the current SDU fragment. This field increments by one (modulo 8) for each fragment, including unfragmented SDUs.
}		
reserved	3 bits	Shall be set to zero
}		

[Modify section 6.3.2.2.3]

6.3.2.2.2.3 Packing Subheader

[…]

Table 11 – Packing subheader format

Syntex	Size	Note
Packing Subheader() {		
FC	2 bits	Indicates the fragmentation state of the payload: 00 = no fragmentation 01 = last fragment 10 = first fragment 11 = continuing (middle) fragment
if (ARQ-enabled Connection)		
BSN	11 bits	Sequence number of first block in the current SDU fragment
else if (SDU_SN enabled connection){		This format shall only be used for DL connections
SDU_SN	7 bits	Sequence number of the first SDU in the current MAC PDU. The sequence number is incremented by one (modulo 128) for every SDU (not SDU segments).
FSN	4 bits	Sequence number of the SDU fragments. This sequence number is incremented by one (modulo 16) for every SDU fragment including unfragmented SDUs.
}		
else {		

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if (Type bit Extended Type)		See Table 6
FSN	11 bits.	Sequence number of the current SDU fragment. This field increments by one (modulo 2048) for each fragment, including unfragmented SDUs
else		
FSN	3 bits	Sequence number of the current SDU fragment. This field increments by one (modulo 8) for each fragment, including unfragmented SDUs.
}		
Length	11 bits	
}		

[Modify section 6.3.20.2.6.2.1]

6.3.20.2.6.2.1 Fast Anchor BS Selection Feedback Mechanism

[…]

The current anchor BS may send the Anchor_Switch_IE prior to the expiry of the switching timer to do one of the following: 1) acknowledge the MSS' switch indication and/or assign a CQICH at the new Anchor BS (BS B), and/or specify a new action time when the switch shall occur, and/or specify a new anchor BS to switch to; 2) cancel the MSS switching event. If the MSS does not receive an Anchor_BS_switch_IE prior to the expiry of the switching timer, the MSS shall switch to the new Anchor BS after the expiry of the switching timer. If the MSS receives an Anchor_BS_Switch_IE prior to the expiry of the switching timer with no cancellation and no new action time specified, the MSS shall switch to the new Anchor BS after the expiry of the switching timer. If the MSS receives an Anchor_BS_Switch_IE prior to the expiry of the switching timer with new action time specified, the MSS shall switch to the new Anchor BS at the action time specified. If the MSS receives an Anchor_BS_Switch_IE with cancellation prior to the expiry of the switching timer, the MSS shall cancel the switching operation. If the MSS successfully decodes an Anchor_BS_Switch_IE, the MSS shall acknowledge the reception of the IE using the allocated codeword over the CQICH.

Deleted: and/or specify the virtual MAC SDU sequence number of the connections with MSS sequence number feedback enabled

Deleted: If MSS sequence number feedback is enabled for one or more of the non-ARQ connections of the MSS, the BS shall send the Anchor_BS_Switch_IE prior to the expiration of the switching timer, to specify the virtual MAC SDU sequence number of the corresponding connections.

If MSS SDU sequence number support is enabled for one or more of the non-ARQ connections of the MSS, the BS shall include Fragmentation Subheader or Packing Subheader in MAC PDU of those connections until the expiration of the switching timer, to specify the MAC SDU sequence number of the corresponding connections.

[…]

[Add a new section 6.3.20.2.6.2.2]

6.3.20.2.6.2.2 MSS-Assisted Coordination of DL transmission at New Anchor BS

Once the MSS has successfully switched to the new anchor BSS, to maintain continuity of transmission to the MSS between the old and new anchor BSs, the last successfully received information unit needs to be identified to the new anchor BS. Depending on whether the connection is ARQ based or non-ARQ, the identity of the next information unit can be given by the ARQ block sequence number or the MAC SDU sequence number respectively.

MSS can optionally support the feedback of ARQ block sequence number or the virtual MAC SDU sequence number after the MSS has successfully switched to the new anchor BS. The capability and the support for each connection are defined in the REQ-REQ/RSP and DSA-REQ/RSP TLVs respectively.

For the connections that have SDU_SN enabled, the following procedures shall be performed by the BS and the MSS:

- For ARQ connections, the ARQ block sequence number is already available at the MSS. For non-ARQ connections, the BS shall use the SDU_SN enabled Fragmentation subheader and Packing subheader format in which MAC SDU sequence number is included. The BS shall include a Fragmentation subheader or a Paking subheader at least once every 2^p MAC PDUs, where p is specified in the SDU_SN support TLV (section 11.7.8.9). Upon receiving anchor BS switching request from the MSS, the old anchor BS shall include Fragmentation Subheader or Packing Subheader in MAC PDU until the expiration of the switching timer. The MSS shall maintain MAC SDU sequence number based on the information received from the BS. When the MSS receives a MAC PDU without Fragmentation subheader or Packing subheader, the MSS shall increment the MAC SDU sequence number by one for every SDU received. When the MSS receives MAC SDU sequence number from the BS, it shall reset the MAC SDU sequence number based on the value included in Fragmentation subheader or Packing subheader.
- At the expiration of the Anchor switch timer, the new anchor BS should assign UL resource for the MSS to transmit the LSB of the sequence number(s) of ARQ block or virtual MAC SDU on the SN Report MAC header (Section 6.3.2.1.4). The MSS subsequently sends up to two SN Report MAC headers that include the next ARQ Block (or virtual MAC SDU) sequence number that it is expecting for each of its connections that have sequence number feedback enabled. The MSS shall send the sequence number in numerical ascending order of the values of the CIDs values.
- Once the handover to the new anchor BS has been completed, acknowledgement and/or retransmission of any outstanding ARQ blocks is handled in the conventional manner.

[Add a new section 11.7.8.9]

11.7.8.9 SDU_SN support

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Deleted: The BS transmits the list of virtual MAC SDU sequence numbers to the MSS in the Anchor BS Switch_IE (Section 8.4.5.4.2.1) in numerical ascending order ot the CID values of the connections with sequence number feedback enabled.
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Inserted: 10 MAC PDUs
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Deleted: For the uplink FBSS procedure, the continuation of transmission of information units between the old anchor and the new anchor will be determined by the information shared during registration in the REG-RSP TLV encodings of the BS capability to process FBSS_SN Feedback. Based on the BS capability to support FBSS_SN feedback, the MSS switches to the new anchor BS only after the full MAC SDU has been transmitted. For those ARQ BSNs which are not ACKed by the old anchor BS, the MSS retransmits the respective MAC SDUs to the new anchor. The ARQ BSN in the FBSS SN Request Header refers to the BSN associated with (the start of) the next SDU to be sent by the MSS.
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Deleted: *[Modify section 8.4.5.4.21]*¶
8.4.5.4.21 Anchor_BS_Switch_IE¶
The Anchor_BS_switch_IE is sent by a BS to indicate to one or more MSS(s) to switch to a new specified Anchor BS at specific action time, or to cancel the switch. The Anchor_BS_switch_IE can also be used to allocate CQICH at the new Anchor BS.¶
¶
¶
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Table 300i - Anchor_BS_switch_IE format¶
¶
Syntax … [1]
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This field indicates whether or not the SS supports the use of SDU sequence nubmer. A value of 0 indicates no support for SDU_SN. A value of 1 indicates that the SS supports SDU_SN.

Type	Length	Value	Scope
18	1	Bit #0: 0 - No SDU_SN Feedback; 1 - Supports SDU_SN Feedback (default) Bit #1 - #3 (=p): period of SDU_SN transmission for non-ARQ connection = once every 2^p MAC PDUs.	REG_REQ REG_RSP

[Add a new section 11.13.20]

11.13.20 SDU_SN Enabled

This field indicates whether or not the SDU_SN is enabled for the given connection. A value of 0 indicates that the SDU_SN is not enabled. A value of 1 indicates that the SDU_SN is enabled.

Type	Length	Value	Scope
[145/146].28	1	0 SDU_SN not enabled 1 SDU_SN enabled (default)	DSA_REQ DSA_RSP DSC_REQ DSC_RSP

[Modify section 8.4.5.4.21]

8.4.5.4.21 Anchor_BS_Switch_IE

The Anchor_BS_switch_IE is sent by a BS to indicate to one or more MSS(s) to switch to a new specified Anchor BS at specific action time, or to cancel the switch. The Anchor_BS_switch_IE can also be used to allocate CQICH at the new Anchor BS.

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Table 300i - Anchor_BS_switch_IE format

Syntax	Size	Notes
Anchor_BS switch_IE() {		
Extended DIUC	4 bits	AS = 0x07
Length	4 bits	Length of the message in bytes
N_Anchor_BS_switch	4 bits	Number of Anchor BS switching indicated in this IE
for (i = 0; i< N_Anchor_BS_switch; i++) {		
CID	16 bits	Basic CID of a MSS whose anchor BS switching is indicated in this IE
Action code	2 bits	00 – The MSS shall switch to the Anchor BS specified in the fast Anchor BS selection information in the FAST FEEDBACK channel, at the default time specified by the switching period defined in the DCD. 01 – The MSS shall switch to the Anchor BS specified in this IE and at the action time specified in this IE. 10 – The MSS shall cancel all anchor switching procedure, stop switching timer and remain on the current anchor BS; 11 – reserved
If (Action code == 01) {		
Action time (A)	3 bits	In units of frames. 000 means the MSS shall switch at the default time specified by the switching period defined in the DCD

TEMP_BS_ID	3 bits	TEMP_BS_ID of the anchor BS to switch to. (TEMP_BS_ID is the assigned ID to the BS when it was added to the active set of a MSS)
}		
If (Action code == 00 || Action code == 01)		
{		
CQICH Alloction Indicator	1 bit	To indicate if CQICH allocation at the new Anchor BS is included in this IE.
If (CQICH Allocation Indicator == 1) {		
CQICH_ID	Variable	Index to uniquely identify he CQICH resource assigned to the MSS after the MSS switched to the new anchor BS
Feedback channel offset	6 bits	Index to the fast feedback channel region of the new Anchor BS marked by UIUC=0
Period (=p)	2 bits	A CQI feedback is transmitted on the CQICH every 2^p frames.
Frame offset	3 bits	The SS starts reporting at the frame of which the number has the same 3 LSB as the specified frame offset. If the current frame is specified, the SS should start reporting in 8 frames
Duration (=d)	3 bits	A CQI feedback is transmitted on the CQI channels indexed by the CQICH_ID for 10 x 2^d frames. If d ==0, the CQI-CH is de-allocated. If d == 111, the SS should report until the BS command for the SS to stop.
MIMO_permutation_feedback_cycle	2 bits	00 = No MIMO and permutation mode feedback 01 = the MIMO and permutation mode indication shall be transmitted on the CQICH

		indexed by the CQICH_ID every 4 frames. The first indication is sent on the 8th CQICH frame. 10 = the MIMO mode and permultation mode indication shall be transmitted on the CQICH indexed by the CQICH_ID every 8 frames. The first indication is sent on the 8th CQICH frame. 11 = the MIMO mode and permultation mode indication shall be transmitted on the CQICH indexed by the CQICH_ID every 16 frames. The first indication is sent on the 16th CQICH frame.
}		
MAC SDU SN included	1 bit	1: MAC SDU sequence number is included in this IE 0: MAC SDU sequence number is not included in this IE
if (MAC SDU SN included == 1) {		
For (i=0; i<number of connections; i++){		Number of connections is the number of non-ARQ connections that have sequence number feedback enabled. It is known between the BS and the MSS after connection setup.
MAC SDU SN	6 bits	MAC SDU sequence number
}		
}		
}		
}		

[…]