Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**PDU sequencing in IEEE 802.16e Sleep Mode**
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Re:	IEEE 802.16e Sleep mode operation
Abstract	This document is to propose the response message corresponding to MOB_TRF-IND message and PDU sequence numbering on the new proposed message and existing MOB_TRF-IND message both in order to provide concrete sleeping mode operation and more power saving as well as synchronization between BS and MSS while in transmitting packet data. This document has been introduced as a one of proposals in the last meeting (IEEE802.16e-03-31).
Purpose	Present how the IEEE802.16a can be enhanced in order to support mobility.
Notice	
Release	
Patent Policy and Procedures	

PDU sequencing in IEEE802.16e Sleep Mode

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1 Problem Statement

The main motivation of the current sleeping mode operation is to save MSS power consumption based on the traffic pattern (4IPP model proposed by IEEE802.16e-03/15) during packet data transmission. Accordingly, traffic characteristics and its corresponding operation should be taken into account in terms of mobile environment. The current sleeping mode operation based on 4IPP traffic model is depicted in the figure 1.

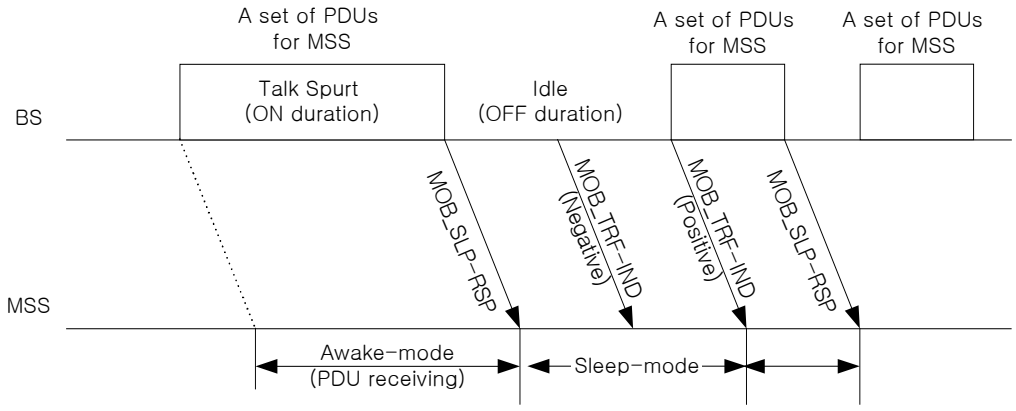

Figure 1. Call flow and PDU transmission in Sleep-mode and Awake-mode

Statement 1)

According to the current operation of sleeping mode operation, the state transition, BS initiated sleep-mode to awake-mode transition, is achieved by the one-side direction (from the BS). Therefore, the BS will send PDUs to the MSS without receiving response message that the MS is ready to receive PDUs from the BS, because there is no response message corresponding to MOB_TRF-IND message. If the message, MOB_TRF-IND, is corrupted or lost due to several kinds of damages through air interface under mobile environment, the second packet data burst, which consists of PDUs, must be lost and shall be retransmitted later. Accordingly, the PDU transmission without receiving response message would be so hazardous operation and it will be undesirable communication way. So, we propose the response message, MOB_TRF-CFN message, which means that the MSS is ready to receive the PDU. And this message must be a minimum requirement for generic communication theory.

Statement 2)

When the MSS and BS enter the awake-mode from the sleep-mode in order to resume PDU transmission, the both sides need to justify the PDU sequence number that has already been transmitted or is to be transmitted in order to avoid undesirable retransmission of duplicated PDU and protect the unexpected PDU loss. Because the MSS and BS are transited during the packet data session that PDU transmission is temporarily held for idle state of packet transmission, it can be possible that the PDU might be lost while going and coming between sleep-mode and awake-mode. Furthermore, if the mode change is achieved under irregular or uncompleted transmission, the PDU sequence number such as ARQ_TX_window_START and ARQ_RX_window_START may not be in the same. There may be two kinds of irregular operations such as sleep mode changing during uncompleted transmission that does not receive the corresponding response message from the MSS, and after receiving the corrupted response that the NACK has been received as an ACK. Figure 2 and Figure 3 show these irregular transmissions and sleeping mode transition.

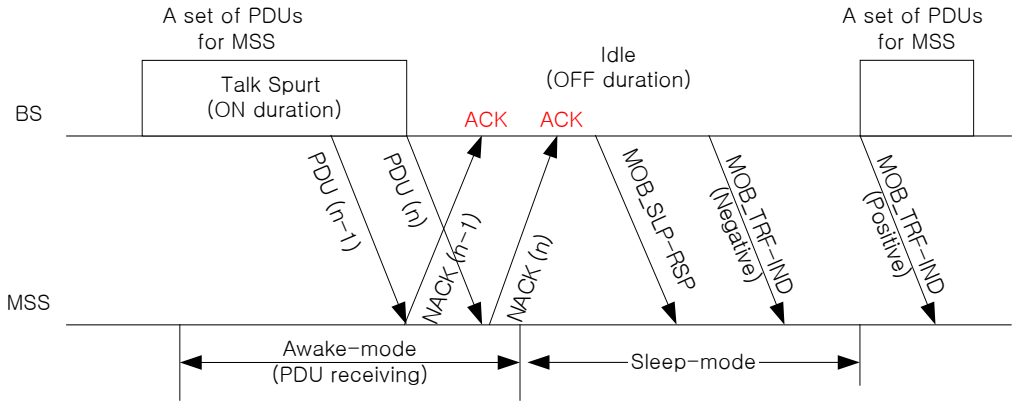

Figure 2. Corrupted transmission and sleeping mode transition

In figure 2, because the BS has been received ACKs by corruption even the MSS transmitted NACK for n and n-1 PDU, respectively, the BS will complete the transmission for this packet data burst and transmit MOB_SLP_RSP message to indicate mode change, awake mode to sleep mode. Accordingly, the MSS shall be transited into the sleep mode without supplementary packet receiving corresponding to NACKed PDUs (n and n-1). In this case, the ARQ_TX_window_START will be set to "n+1" at the BS side and ARQ_RX_window_START will be set to "n-1". After sleeping mode, the BS will resume PDU transmission with next PDU sequence number, PDU (n+1), at the next packet data burst transmission even the MSS effectively or successfully received up to PDU (n-2). To avoid this kind of asynchronous transmission, PDU sequence number for ARQ_TX and ARQ_RX

window start value should be indicated and exchanged between the BS and MSS through both MOB_TRF_IND message and MOB_TRF_CFN message proposed, respectively.

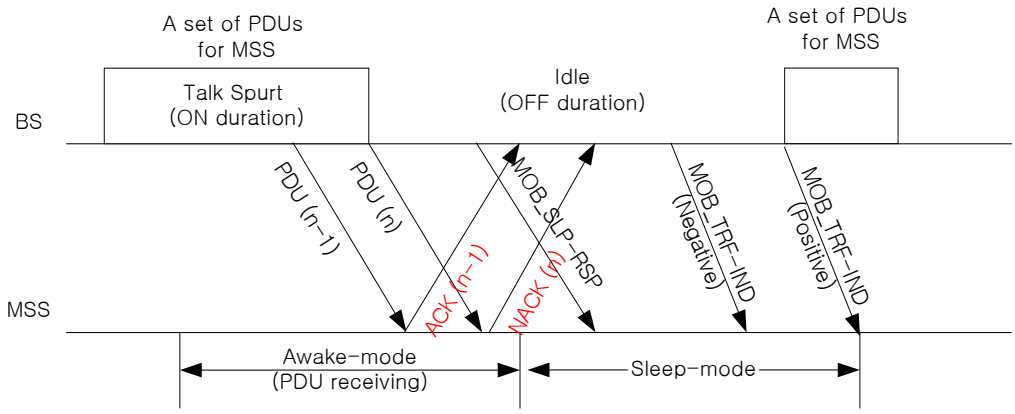

Figure 3. Uncompleted transmission and sleeping mode transition

Figure 3 shows the mode changes during uncompleted transmission. If the BS transmits the MOB_SLP_RSP message to the MSS without receiving response message to the PDUs generated from the end portion of the burst, the PDU sequence number transmitted and received can be different between the BS and MSS. For more power saving, the BS can do this operation to accelerate fast sleep mode transition, and PDUs (n) reported and received as NACKed after transmitting MOB_SLP_RSP message will be transmitted at the beginning of the next packet data burst transmission. To avoid this kind of asynchronous transmission, PDU sequence number for ARQ_TX and ARQ_RX window start value should be indicated and exchanged between the BS and MSS through both MOB_TRF_IND message and MOB_TRF_CFN message proposed.

Therefore, we propose the new information element, 8bits on the MOB_TRF-IND message and MOB_TRF-CFN proposed message, in order to guarantee the reliable PDU transfer under the synchronized ARQ_TX_window_START and ARQ_RX_window_START. These additional procedures are to maintain the transmission synchronization as well as to save the power consumption from undesirable retransmission or aperture transmission.

2 Proposed Remedy (Text changes)

6.2.2.3.42 Traffic Indication message (MOB_TRF-IND)

This message is sent from BS to MSS on the broadcast CID. The message is intended for MSS's that are in sleep-mode, and is sent during those MSS's listening-intervals. The message indicates whether there has been traffic addressed to each MSS that is in sleep-mode. An MSS that is in sleep-mode, during its listening-interval shall decode this message to seek an indication addressed to itself.

When an MSS awakens, it will check the frame number to ensure that it did not lose frame synchronization with the BS, and it shall check the PDU sequence number, in order to ensure the PDU sequence number exchanged reliably, if it does not find any positive indication in the MOB_TRF-IND message, it will consider this as a negative indication and shall return to sleep mode.

The PDU sequence number is the FSN of the first Fragment of the PDU to be transmitted to the MSS and also reflects the status of pending PDUs from the last transmission and ARQ window when ARQ is used for each connection.

Table 56ac – Traffic-Indication (MOB_TRF-IND) message format

Syntax	Size	Notes
TRF-IND_Message_Format() {		
Management message type = 47	8 bit	
Num-positive	8 bit	
for (i=0; i< Num-positive; i++) {		
CID	16 bit	Basic CID of the MSS
Start-time	7 bit	
PDU sequence number	11 bit	The FSN of the first Fragment of the PDU which will be transmitted
}		
}		

Parameters shall be as follows:

Num-positive

Number of CIDs on the positive indication list.

Start-time

The number of MAC frames (not including the frame in which the message has been received) until the MSS shall enter the awake-mode.

PDU sequence number

The FSN of the first Fragment of the PDU that will be transmitted

6.2.2.3.XX Traffic Confirm message (TRF-CFN)

The TRF-CFN message shall be sent from MSS to a BS on the MSS's basic CID in response to a MOB_TRF-IND message. The MSS and BS shall enter awake-mode using the parameters indicated in the message.

In this message, the PDU sequence number is the FSN of the first Fragment of the PDU to be transmitted to the MSS and also reflects the status of pending PDUs from the last transmission and ARQ window when ARQ is used for each connection.

Table xxx: Traffic-Confirmation (TRF-CFN) message format

Syntax	Size	Notes
TRF-CFN_Message_Format() {		
Management message type = XX	8 bit	
CID	16 bit	Basic CID of the MSS
PDU sequence	8 bit	The FSN of the first Fragment of the PDU which will be transmitted
}		

Parameters shall be as follows:

PDU sequence number

The FSN of the first Fragment of the PDU that will be transmitted

6.2.16.3. Traffic Indication Signaling

A BS shall notify each MSS in sleep-mode, during its listening-interval, if traffic has been addressed to it. The indication is sent on the MOB_TRF-IND broadcasting message. The MSS shall examine the MAC frame number from the PHY Synchronization Field and shall verify it synchronization with the BS. If the expected MAC frame number is different that found frame number, the SS shall return into awake mode. If the PDU sequence number indicated in the MOB_TRF-IND message and TRF_CFN message is different, the PDU transmission shall be resumed from the PDU with lower sequence number.

If the MSS did not find any positive indication with it's CID in the MOB_TRF-IND it shall consider this as a negative indication and shall continue in sleep mode. For example of sleep mode operation, see Annex D.

References

[1] IEEE 802.16e-03/15, “IEEE 802.16e Sleep Mode”

[2] IEEE Std 802.16-2001 “Part 16: Air Interface for Fixed Broadband Wireless Acce ss Systems”

[3] IEEE P802.16a/D7-2002 “Part 16: Air Interface for Fixed Broadband Wireless Acc ess Systems – Medium Access Control Modifications and Additional Physical Lay er Specifications for 2-11 GHz”

[4] IEEE 802.16.3c-01/30r1 “Traffic Model for 802.16 TG3 MAC/PHY Simulations”

[5] IEEE 802.16e-03/02, “Call for Proposals on IEEE Project 802.16e: Mobility Enhan cements to IEEE Standard 802.16/802.16a”

[6] IEEE 802.16e-03/07r2, “Part 16: Air interface for Broadband Wireless Access Systems-Amendment 4: Mobility Enhancement