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Title	**Fast Predicted Handover**
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Re:	**IEEE 802.16m-09/0034r2: IEEE 802.16m System Description Document (SDD)**
Abstract	Proposal on the handover procedure that enables minimum handover interruption by utilization of results of target ABS prediction.
Purpose	For review and adoption into 802.16m
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Fast Predicted Handover

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1. Objective

The objective of this contribution is to propose a handover mechanism that enables to reduce an interruption due to HO procedure.

2. Motivation and Problem Statement

The handover interruption time in IEEE 802.16 systems is caused by switching of the AMS (Advanced Mobile Station) from a S-ABS (Serving – Advanced Base Station) to a T-ABS (Target – Advanced Base Station). The handover procedure can be separated into several stages (Figure 1). Two stages, network topology advertisement and scanning of AMS's neighborhood, are performed before the handover process begins. These stages enable the AMS to investigate and collect information about neighboring ABSs.

The results obtained by the scanning process are used in the next step of the handover procedure, i.e. cell reselection. In this step, the possible T-ABS is selected based on channel parameters and offered QoS. Afterwards the handover decision and handover initiation phases are performed if all conditions and requirements for the handover are fulfilled. The first step after the handover initialization is synchronization to the downlink of the T-ABS. Before the synchronization is completed, the connection with the S-ABS should be closed and the AMS cannot neither receive nor transmit data. This time corresponds to the beginning of the handover interruption.

As soon as the synchronization with the downlink of T-ABS is finished, the AMS can start the next stage of handover – network re-entry procedure. The network re-entry consists of three substages: ranging, re-authorization and re-registration. At the beginning of the ranging process, the AMS obtains information of uplink channel through UCD (Uplink Channel Descriptor) and resource allocation by means of UL-MAP (Uplink MAP message). Then the ranging parameters (such as transmitting power, timing information or frequency offset) are exchanged. The ranging process is followed by the authorization and registration of the AMS to the T-ABS. After successful authorization and registration the AMS can start with normal operation. It means that the AMS can resume data exchange since the handover interruption is over.

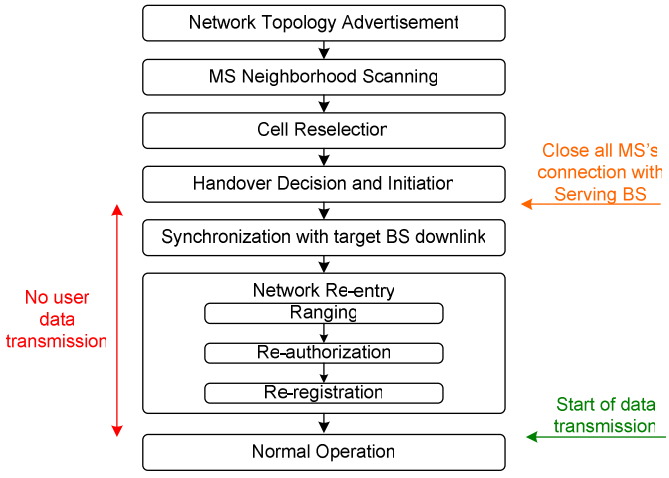

Figure 1. Phases of the handover procedure from the handover interruption point of view

3. Proposal of Fast Predicted HO

The utilization of prediction of users' movement enables the secure and fast handover using the new MAC management message Fast_HO-INFO. The structure of this message is presented in Table 1.

Syntax	**Size (bites)**	**Notes**
Fast_ HO-INFO{		
Message Type=TBD	8	
Access Code	24	Code for the fast access to the T-ABS
Originator	1	0... T-ABS – the assignment of access code 1... AMS – the verification of access code
If (Originator = 0) {		
Time of Code Life	14	Indication of the time when the Access code is valid. It is expressed as a number of frames in range from 10 to 2^{14}.
}		
If (Originator = 1) {		
AMS Address	48	AMS MAC address
}		
Reserved	1 or 7	
}		

Table 1. Structure of Fast_HO-INFO

The Fast_HO-INFO consists of randomly generated Access Code (AC). The AC is used to verification of the AMS. The AC is generated by the T-ABS. Furthermore, if the Fast_HO-INFO is transmitted by the AMS to T-ABS, the AMS ID is included to facilitate easier check of the validity of AC by the BS. If the Fast_HO-INFO is transmitted by the BS, the message contains information about duration of the validity of AC represented by Time of Code Life (ToCL). The ToCL indicates the number of frames within the AC is valid and can be used for AMS verification. After the expiration of ToCL, the AMS should ask for new AC or processed full (conventional) handover management message exchange.

The maximum duration of the validity of AC depends on the frame duration, e.g. for 2 ms frames it is approximately 32.7 s (2^{14} x 2ms). The minimum value has to consider a number of frames between the delivery of AC to the AMS and the beginning of verification procedure (transmission of AC by the AMS to the T-ABS). The ToCL timer ensures that the AC cannot be later exploited for unauthorized network entry by another AMS and it reduce the requirements on the capacity of memory dedicated for storage of ACs of different AMSs. The overall MAC management message flow and principle of proposed FPHO is shown in Figure 2.

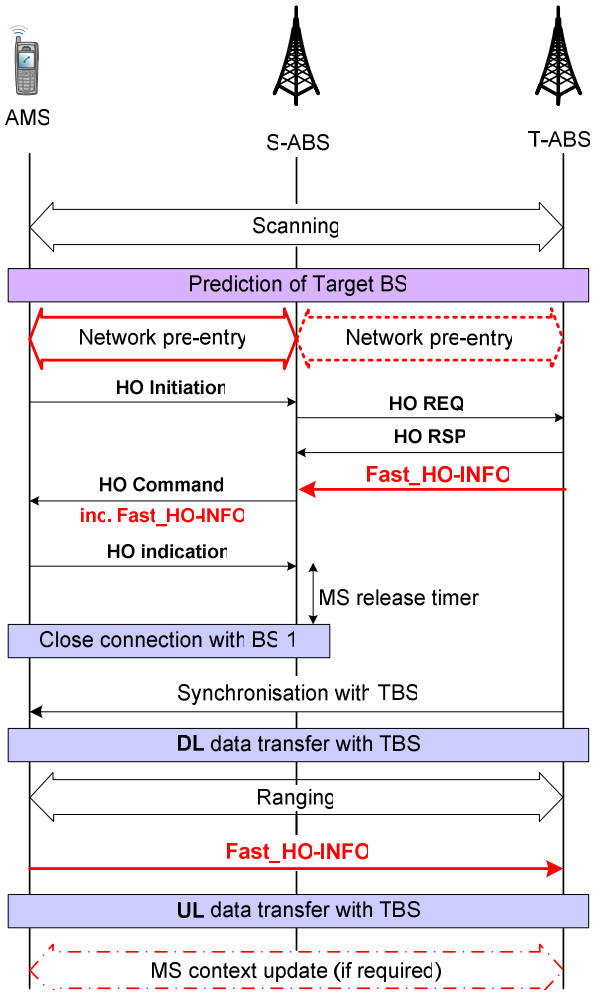

Figure 2. Flow of the management message exchange while prediction is used to reduce HO interruption (modifications are highlighted by red colour)

The AMS continuously scans its neighborhood as in conventional operation. Within normal operation it can predict the most probable T-ABS using methods for prediction (see e.g. [1]-[5]). Based on the prediction, the S-ABS checks the possibility of handover to the predicted T-ABS via backbone. If the T-ABS accepts handover, the AMS starts network re-entry procedure with predicted T-ABS via current S-ABS. Within this process, the AMS performs an authorization and registration to the T-ABS via S-ABS. Besides, the AMS obtains the CID used for communication with the T-ABS.

The important issue is how to initiate the pre-entry procedure. Both, the S-ABS or AMS can initiate the procedure by transmission of RNG_RSP or RNG-REQ respectively. One of the eight reserved bits (see IEEE802.16e) can indicate that the message belongs to pre-registration procedure or to conventional IEEE 802.16e registration. Then the RNG-REG/RSP messages contain: 8-bits message type, 1-bit indication of conventional registration / fast handover pre-registration (if =0 then the conventional procedure, if =1 then fast handover pre-registration procedure is going to be performed), 7 reserved bits and TLV information. The pre-registration and pre-authorization procedures use the new messages (PREG_REQ/RPS and PPKM_REQ/RPS respectively) with the same content like conventional IEEE802.16e authorization and registration messages (excluding field “Type of Message”, this field must be different). The new management messages have to be designed to keep backward compatibility with older version of standard. The design of proposed messages can be based on the content of original conventional messages. The new messages have to be created due to no available bit for distinguishing of the conventional entry and pre-entry procedure since no reserved bit is

available and since TLV is included. The above described method do not increase overhead of the handover procedure since no additional bits or messages are required. Another way of network pre-entry initialization is to design new messages that inform the AMS or S-ABS that the following messages (up to Fast_HO-INFO) belong to network-pre-entry procedure. This solution needs no modification in current MAC management messages. However, it increases overhead as two messages must be sent (info about beginning of pre-entry and confirmation message).

The network pre-entry process is finished by the generation of AC for verification of the AMS by the predicted T-ABS. This code is sent to the AMS via S-ABS in Fast_HO-INFO. It can be transmitted as a stand alone message or it can be added to the end of MOB_BSHO-REQ message. The transmission of Fast_HO-INFO message pasted to the MOB_BSHO-REQ brings following modifications in MOB_BSHO-REQ:

- use a bit to indicate the presence of information about fast handover
- add 2 fields from Fast_HO-INFO: Access Code and Time of Code Life.

The one of the padding bits included in MOB_BSHO-REQ can be used for indication of the Fast_HO-INFO fields. Therefore it does not increase the size of message. The size of message will be increased by AC and ToCL by 38 bits (see Table 1). The second approach, transmission of Fast_HO-INFO by S-ABS to AMS, results to the minor increase of the overhead due to the introduction of new messages (the field “Type of Message” is sent redundantly).

After reception of MOB_BSHO-REQ with Fast_HO-INFO, the AMS releases the connections with the S-ABS (using MOB-HO-IND message) and executes synchronization with the T-ABS. At this time, transmitted data is stored in a buffer at the new S-ABS. When the synchronization is completed, the ranging is accomplished. The ranging process is followed by transmission of Fast_HO-INFO from AMS to the new S-ABS. When the verification is successful, the new S-ABS starts the transmission of data stored in the buffer. The AMS is informed about successful verification by a reception of the first packet from the new S-ABS.

If the AMS or T-ABS needs an update of pre-registration and pre-authorization parameters, it can call the conventional procedures later.

An evaluation of the FPHO proposal is presented in [6].

4. Proposed Text

On the IEEE 802.16m-09/0034r2, page 46, insert new subsection before 10.3.3

----------Start of the Text----------

10.3.3 Fast Predicted Handover (FPHO)

To reduce handover interruption, the FPHO can be performed if a prediction of T-ABS is successfully executed. The message flow of FPHO is presented in Figure FA.

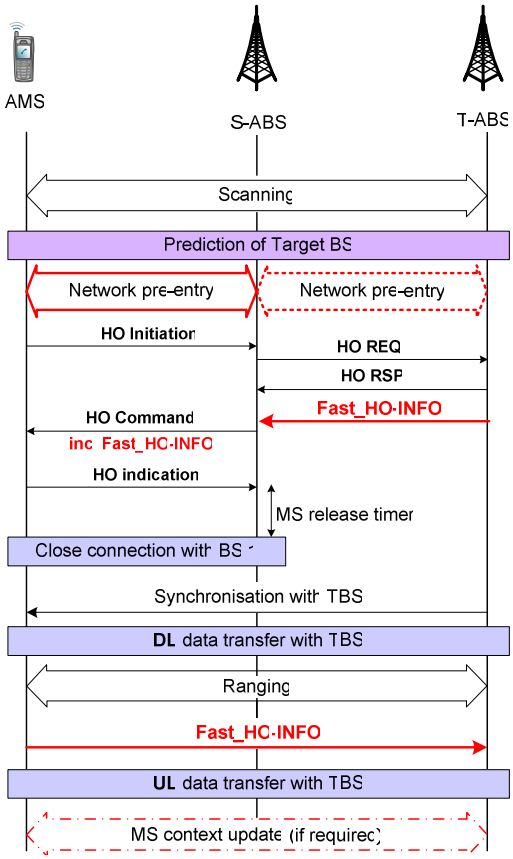

Figure FA. Flow of the management message exchange while FP HO is performed

10.3.3.1 Network pre-entry

Based on the prediction, the S-ABS checks the possibility of handover to the predicted T-ABS via backbone. If the T-ABS accepts handover, the AMS starts network re-entry procedure with predicted T-ABS via current S-ABS. Within this process, the AMS performs an authorization and registration to the T-ABS via S-ABS. Moreover, the AMS obtains the CID used for communication with the T-ABS.

Both, the S-ABS or AMS can initiate the procedure by transmission of Ranging Response or Ranging Request respectively.

The pre-registration and pre-authorization procedures are accomplished via Pre-registration Request/Response messages and Pre-registration Key Management Request/Response respectively.

The network pre-entry process is finished by the generation of AC for verification of the AMS by the predicted T-ABS. This code is sent to the AMS via S-ABS in Fast_HO-INFO. The structure of this message is presented in Table TA.

Syntax	**Size (bites)**	**Notes**
Fast_ HO-INFO{		
Message Type=TBD	8	
Access Code	24	Code for the fast access to the T-ABS
Originator	1	0... T-ABS – the assignment of access code 1... AMS – the verification of access code

If (Originator = 0) {		
Time of Code Life	14	Indication of the time when the Access code is valid. It is expressed as a number of frames in range from 10 to 2^{14}.
}		
If (Originator = 1) {		
AMS Address	48	MS MAC address
}		
Reserved	1 or 7	
}		

Table TA. Structure of Fast_HO-INFO

The Fast_HO-INFO message consists of:

Access Code (AC) – randomly generated code used to verification of the AMS. The AC is generated by the T-ABS. Furthermore, if the Fast_HO-INFO is transmitted by the AMS to T-ABS, the AMS ID is included to facilitate easier check of the validity of AC by the T-ABS.

Originator – Define a source (AMS or T-ABS) of message.

Time of Code Life (ToCL) – duration of the validity of AC. Included only if the originator of Fast_HO-INFO is the T-ABS. The ToCL indicates the number of frames within the AC is valid and can be used for AMS verification. After the expiration of ToCL, the AMS should ask for new AC or processed full handover management message exchange. The ToCL timer ensures that the AC cannot be later exploited for unauthorized network entry by another AMS and it reduce the requirements on the capacity of memory dedicated for storage of ACs of different AMSs.

AMS Address – identification of AMS. Included only if the AMS is an originator of Fast_HO-INFO.

10.3.3.2 HO Initialization

Initialization phase is executed like in conventional case (see 10.3.2.2.1), only Fast_HO-INFO message is transmitted from T-ABS to AMS.

10.3.3.3 HO Preparation and Execution

After reception of HO Command with Fast_HO-INFO, the AMS releases the connections with the S-ABS and completes synchronization with the T-ABS. Consequently, the ranging of AMS to T-ABS is performed. The ranging process is followed by transmission of Fast_HO-INFO from AMS to the T-ABS to verify accessing AMS. The AMS is informed about successful verification by a reception of the first data from the new S-ABS.
If the AMS or BS needs an update of pre-registration and pre-authorization parameters, it can call the conventional procedures later.

10.3.2.2.4 HO Cancellation

After HO is initiated, the handover may be canceled by AMS at any phase during HO procedure. After the HO cancellation is performed, the AMS and serving ABS resume their normal operation.
The network can advertise HO cancellation trigger conditions. When one or more of these trigger conditions are met the AMS cancels the HO.

----------End of the Text----------

References

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[6] K. Sambale et.al., “Mechanisms for increasing the efficiency of MAC/PHY protocols,” Deliverable D8 of ICT-215282 STP ROCKET project, November 2009.