Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	Optimized handover clarifications
Date Submitted	**2006-09-22**
Source(s)	Itzik Shahar Itzik.shahar@intel.com Intel Corporation
Re:	IEEE 802.16e-2005
Abstract	This contribution provides text clarifying inconsistencies and missing functionality for optimized handover.
Purpose	Adopt proposed changes
Notice	This document has been prepared to assist IEEE 802.16. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein.
Release	The contributor grants a free, irrevocable license to the IEEE to incorporate material contained in this contribution, and any modifications thereof, in the creation of an IEEE Standards publication; to copyright in the IEEE's name any IEEE Standards publication even though it may include portions of this contribution; and at the IEEE's sole discretion to permit others to reproduce in whole or in part the resulting IEEE Standards publication. The contributor also acknowledges and accepts that this contribution may be made public by IEEE 802.16.
Patent Policy and Procedures	The contributor is familiar with the IEEE 802.16 Patent Policy and Procedures <http://ieee802.org/16/ipr/patents/policy.html>, including the statement "IEEE standards may include the known use of patent(s), including patent applications, provided the IEEE receives assurance from the patent holder or applicant with respect to patents essential for compliance with both mandatory and optional portions of the standard." Early disclosure to the Working Group of patent information that might be relevant to the standard is essential to reduce the possibility for delays in the development process and increase the likelihood that the draft publication will be approved for publication. Please notify the Chair <mailto:chair@wirelessman.org> as early as possible, in written or electronic form, if patented technology (or technology under patent application) might be incorporated into a draft standard being developed within the IEEE 802.16 Working Group. The Chair will disclose this notification via the IEEE 802.16 web site <http://ieee802.org/16/ipr/patents/notices>.

HO Clarifications (v2r8-a)

Itzik Shahar (Intel) - Chair of HO ad-hoc group in MTG

Major contributors (in alphabetic order of companies):

Leon Shousterman, Oleg Marinchenko – Alvarion
Phil Barber – Huawei
Aran Bergman, Avishay Shraga, Gedon Rosner – Intel
Kiseon Ryu - LG
Mark Marsan, Tom ~~Hatten~~ Hallin – Motorola
Brian Petry – Nextwave
Tricci So – Nortel
Brian Shim, Geunwhi Lim, Jicheol Lee, Sungwook Park, Youngmoon Son – Samsung

1. Motivation

Several HO related functionalities and expected behavior of the MS, serving BS and target BS during optimized HO are unclear or ambiguous in the IEEE802.16e-2005 standard.
MTG established an ad-hoc group to address issues related to optimized HO that may require modifications to the current spec.

2. Problems definitions and proposed remedies

2.1. Problem #1: HO optimization entry conditions are unclear

2.1.1. Problem description

The standard does not specify conditions for entering optimized HO.

2.1.2. Proposed remedy

Add text to clarify optimized HO entry conditions as follows: When the MOB_BSHO-REQ/RSP message includes one or more BSs in the recommended BS list, optimized HO may commence.
Note: Any BS in the recommended BS list, which is not derived from the MOB_NBR-ADV message, is not a target for optimized HO.

2.2. Problem #2: HO process optimization TLV and field alignment

2.2.1. Problem description

There are many messages in the standard that include the "HO process optimization" either as an integral message information element (MOB_NBR-ADV, MOB_BSHO-REQ/RSP, which are both 8 bits) or a TLV (RNG-RSP, which is 16 bits).
It is beneficial to align all representations of HO process optimization, i.e. align representations to the 8 LSBs of the HO process optimization TLV in RNG-RSP.

2.2.2. Proposed remedy

Define 'HO process optimization' as follows:

In 'HO process optimization' information element in MOB_NBR-ADV, MOB_BSHO-REQ and MOB_BSHO-RSP messages:

Bit[0]: Omit SBC-REQ/RSP messages
Bit[1]: Omit PKM Authentication phase except TEK phase
Bit[2]: Omit PKM TEK creation phase
Bit[3]: Omit DHCP phase
Bit[4]: Omit Time-of-Day acquisition phase
Bit[5]: Omit TFTP phase
Bit[6]: Full service and operational state transfer or sharing between serving BS and target BS (ARQ, timers, counters, MAC state machines, etc.)
Bit[7]: Omit REG-REQ/RSP messages

In 'HO process optimization' TLV in RNG-RSP:

Bit[0]: Omit SBC-REQ
Bit[1]: Omit PKM Authentication phase except TEK phase
Bit[2]: Omit PKM TEK creation phase
Bit[3]: Omit DHCP phase
Bit[4]: Omit Time-of-Day acquisition phase
Bit[5]: Omit TFTP phase
Bit[6]: Full service and operational state transfer or sharing between serving BS and target BS (ARQ, timers, counters, MAC state machines, etc.)
Bit[7]: Omit REG-REQ
Bit[8]: BS will send an unsolicited SBC-RSP message (in case capabilities of target BS are different from those of serving BS)
Bit[9]: Post-HO re-entry MS DL data pending at target BS
Bit[10]: BS will send an unsolicited REG-RSP message (in case capabilities of target BS are different from those of serving BS)
Bit[11]: target BS supports virtual SDU SN. If Bit#11=1 and MS supports SDU SN, it shall issue SN_REPORT upon completion of HO to target BS.
Bit[12]: MS shall send BWR header with zero BR as a notification of MS's successful re-entry registration.
Bit[13]: MS shall trigger a higher layer protocol required to refresh its traffic IP address (e.g. DHCP Discover [IETF RFC 2131] or Mobile IPv4 re-registration [IETF RFC 3344]).
Bits[14]-[15]: Reserved (set to zero)

2.3. Problem #3: HO process optimization bit definitions are unclear

2.3.1. Problem description

Some of the bit descriptions of 'HO process optimization' TLV in RNG-RSP are unclear or not well defined.

2.3.2. Proposed remedy

Add text to clarify the following:

Bit#6: Full service and operational state transfer or sharing between Serving BS and Target BS (all static and dynamic context, e.g. ARQ window contents, timers, counters, state machines).
When Bit#7 = 1, then data is pending at target BS, and the MS shall not change IP address (e.g. when migrating between IP subnets) until it has finished receiving all the pending data at the target BS.
When Bit#11 = 1, MS that supports SDU SN, shall issue SN_REPORT
When Bit#12 = 1, the MS shall acknowledge it has received and finished processing the RNG-RSP message.
The MS may use any of the following indications, as acknowledgement (all indications shall be uniquely identifiable):

- MS transmits data in unsolicited UL grant by the target BS (i.e. MS has pending UL data), using newly assigned traffic CID.

- MS transmits BW request header with BR per desired BW, when MS has pending UL data, using newly assigned traffic CID.
- MS transmits BW request header with BR=0, when MS has no pending UL data, using newly assigned basic CID.
- MS transmits HARQ ACK, using the ACKCH slot assigned by BS.

In any case, BS is not obliged to wait for an explicit acknowledgment from MS before transmitting DL data or issuing UL burst allocations assigned to the MS.

2.4. Problem #4: HO process optimization bit settings per scenario or system configuration

2.4.1. Problem description

It is unclear what should be the HO process optimization TLV value for various scenarios.

2.4.2. Proposed remedy

Clearly define in the standard, the following 'rules':

For non-managed SSs (i.e. SS that do not support secondary management connection), the optimization bits should be configured as follows:

- Bit#3 (omit DHCP) = 1
- Bit#4 (omit TOD) = 1
- Bit#5 (omit TFTP) = 1
- All other bits = Don't care (i.e. not dependant on SS management)

(Note: this does not restrict the bits settings for EUM).

Bit#0 (omit SBC-REQ) cannot be 0, when bit#8 (BS will issue unsolicited SBC-RSP) is set to 1.
Bit#9 (omit REG-REQ) cannot be 0, when bit#10 (BS will issue unsolicited REG-RSP) is set to 1.

For full optimized HO, with static and dynamic context sharing between serving BS and target BS, the optimization bits should be configured as follows:

- Bit#0 (Omit SBC-REQ) = 1
- Bit#1 (Omit PKM Authentication phase except TEK phase) = 1
- Bit#2 (Omit PKM TEK creation phase) = 1
- Bit#6 (Full service and operational state transfer or sharing between serving BS and Target BS) = 1
- Bit#8 (BS will send an unsolicited SBC-RSP message) = 1
- Bit#9 (Omit REG-REQ) = 1
- Bit#10 (BS will send an unsolicited REG-RSP message) = 1
- All other bits, except reserved bits = Don't care (i.e. not dependant on optimization case).

For full optimized HO, with only static context sharing between serving BS and target BS, the optimization bits should be configured as follows:

- Bit#0 (Omit SBC-REQ) = 1
- Bit#1 (Omit PKM Authentication phase except TEK phase) = 1
- Bit#2 (Omit PKM TEK creation phase) = 1
- Bit#6 (Full service and operational state transfer or sharing between Serving BS and target BS) = 0
- Bit#8 (BS will send an unsolicited SBC-RSP message) = 1
- Bit#9 (Omit REG-REQ) = 1
- Bit#10 (BS will send an unsolicited REG-RSP message) = 1
- All other bits, except reserved bits = Don't care (i.e. not dependant on optimization case).

For full NW entry, with only static context sharing between serving BS and target BS, the

optimization bits should be configured as follows:

- Bit#0 (Omit SBC-REQ) = 0
- Bit#1 (Omit PKM Authentication phase except TEK phase) = 0
- Bit#2 (Omit PKM TEK creation phase) = 0
- Bit#6 (Full service and operational state transfer or sharing between Serving BS and target BS) = 0
- Bit#8 (BS will send an unsolicited SBC-RSP message) = 0
- Bit#9 (Omit REG-REQ) = 0
- Bit#10 (BS will send an unsolicited REG-RSP message) = 0
- All other bits, except reserved bits = Don't care (i.e. not dependant on optimization case).

Note that in this case, RNG-RSP message will not be signed with HMAC/CMAC.

2.5. Problem #5: REG-RSP compound TLV

2.5.1. Problem description

During HO, RNG-RSP shall include CID update TLV and SAID update TLV and optionally, SA_TEK-Challenge TLV. It is unclear whether these are TLVs of RNG-RSP message or TLVs within the REG-RSP compound TLV, which is part of the RNG-RSP message

2.5.2. Proposed remedy

Clarify that CID update TLV, SAID update TLV and SA_TEK-Challenge TLV are all REG-RSP TLVs and may be included in RNG-RSP message only as part of the REG-RSP compound TLV.

2.6. Problem #6: Definitions of static and dynamic context

2.6.1. Problem description

It is beneficial to distinguish between two types of context that are transferred from the serving BS to the target BS during HO preparation phase, namely static context and dynamic context.

2.6.2. Proposed remedy

Define new terms; static and dynamic context
Static context: all configuration parameters that were acquired during initial NW entry or later, via of exchange of information between the BS and MS. Examples: all SBC-RSP and REG-RSP parameters, all service flow encodings from DSx message exchanges etc.
Note: security context is always considered static context (EAP authenticator doesn't change during HO).
Dynamic context: all counters, timers, state machine status, data buffer contents (e.g. ARQ window).
Note: Transaction states, which may impact configuration parameters, are considered dynamic context until complete, which by then is considered static context.

2.7. Problem #7: HO context and states, details per category

2.7.1. Problem description

The standard does not explicitly specify contexts management from the point-of-view of the MS, the serving BS and the target BS:
From the MS perspective, it is unclear how should it should handle the serving BS context upon HO (in case HO cancellation is supported) and what should be the initial settings of the context when arriving at the target BS (for NW re-entry). From the serving BS perspective, it is unclear what MS context should be retained upon HO (in case HO cancellation is supported). From the target BS perspective, it is unclear what should be the initial settings of the MS context when the MS starts NW re-entry with the target BS.

2.7.2. Proposed remedy

Specify, per context category, what should be the expected behavior of the MS, serving BS and target BS during HO (can be added as separate annex).
Categories: Data integrity (per service flow type, e.g. ARQ, non-ARQ), service flow parameters, PHY parameters, Channel descriptor parameters, ranging parameters, basic capabilities parameters, security parameters, outstanding BW requests, TPC parameters, sleep mode settings etc.

2.8. Problem #8: HARQ ACID remapping during HO

2.8.1. Problem description

The standard does not specify how HARQ ACIDs are remapped during HO.

2.8.2. Proposed remedy

Add text to clarify that HARQ ACIDs are unchanged during HO to the target BS, as they are SFID-specific.

2.9. Problem #9: Unsolicited grant for HO messages

2.9.1. Problem description

HO may be initiated due to bad link conditions between the MS and the serving BS. In this case, the duration of HO preparation, which is a known sequence of message exchanges, should be minimized. Hence, it is beneficial for MS, if the serving BS, after transmitting the MOB_BSHO-RSP message, will allocate unsolicited UL grant for transmission of MOB_HO-IND (the alternative could be that MS will issue contention-based BW request, which may take longer due to misdetections at the BS). However, in order to issue such allocation without wasting resources, the BS must know when the MS will be able to transmit MOB_HO-IND message, i.e. how long it will take it to process the MOB_BSHO-RSP message. The BS shall indicate to the MS that intends to allocate unsolicited UL grant, via setting a unique bit, 'unsolicited BW for HO indication', to one. Otherwise, the MS may transmit BW request needlessly, waste more serving BS resources and prolong HO latency.

2.9.2. Proposed remedy

Add a timer, which value shall be negotiated during registration phase of initial NW entry, named 'HO indication readiness' timer. In REG-REQ, the MS will include this TLV with the minimum supported value supported by the MS. In REG-RSP, the BS will include this TLV with the minimum supported value supported by the BS, which shall be equal to- or greater than the MS value, and will be the minimum timing for the unsolicited UL grant (exact timing depends on BS scheduling).
Add a 'unsolicited UL BW for HO-IND' bit in MOB_BSHO-REQ/RSP messages.

2.10. Problem #10: Data interruption time at Serving BS during HO preparation phase

2.10.1. Problem description

The standard is unclear regarding the timing of data interruption at the serving BS during HO preparation.
Specifically, MOB_HO-IND message with HO release is described as a recommendation and is not mandatory. If MS performs HO without sending MOB_HO-IND with HO release, the serving BS will continue transmission of DL and UL allocations until the serving BS receives a notification of HO completion from the target BS (via backhaul) or until it receives MOB_HO-IND with HO cancel or until it decides MS is no longer available (via keep-alive mechanism)

2.10.2. Proposed remedy

Add text to define that when the serving BS indicates, thru setting 'unsolicited BW for HO indication'=1 in MOB_BSHO-RSP, it will allocate an unsolicited UL grant for the transmission of MOB_HO-IND, the serving BS may stop all DL and UL allocations for the MS, after "HO indication readiness time". When this bit is set to zero, the serving BS will not allocate special UL grant for the MS and the MS may have to request BW, unless such is provided regardless of the HO procedure.

2.11. Problem #11: Action time definition

2.11.1. Problem description

In response to MOB_MSHO-REQ from the MS, the serving BS transmits a MOB_BSHO-RSP with 'Action time', a common information element for all recommended BSs in the message. 'Action time' is defined as the time when the target BS will issue Fast_ranging_IE for non-contention ranging, thus all target BSs (in the recommended BS list) are required to issue Fast_ranging_IE at the exact same time. This may be problematic for the network and effectively would mean that the target BS with the longest action time would determine the value of 'action time' in the MOB_BSHO-RSP message.

2.11.2. Proposed remedy

Modify the definition of action time to reflect the following: "target BSs shall assign a Fast_ranging_IE no earlier than defined via 'action time' ". Effectively, 'action time' shall be the earliest action time (i.e. smallest value) committed by the recommended target BSs. The MS, after switching to the target BS, may wait for Fast_Ranging_IE, until 'action time' or later, before it decides to perform non-coordinated HO with the target BS or decides to HO to another target BS. The amount of time MS shall wait to receive Fast_Ranging_IE, after 'action time', is defined by T55 (effectively defines the max allowed difference between minimum and maximum value of action time, provided by the recommended BSs).

T55 shall be included in the global constants and parameters list, table 342.

System	Name	Time reference	Minimum value	Default value	Maximum value
BS, MS	T55	Upon expiration of this timer, the MS shall not expect the Target BS to allocate a transmit opportunity via Fast_Ranging_IE	8 frames after the time defined in action time		

2.12. Problem #12: Calculation of action time

2.12.1. Problem description

'Action time' in MOB_BSHO-REQ/RSP message indicates the time (relative to the transmission time of the message) where Fast_Ranging_IE will be transmitted by the target BS.
However 'action time' calculation by the serving BS is not possible without the knowledge of

1) the MOB_BSHO-RSP message processing time by MS, i.e. minimum time from MOB_BSHO-RSP to MOB_HO-IND (already defined in this contribution as 'HO indication readiness' timer), and
2) the BS switching time by the MS, i.e. minimum time from transmitting MOB_HO-IND at the serving BS until transmitting RNG-REQ at the target BS.

2.12.2. Proposed remedy

Add timers, which values shall be negotiated during registration phase of initial NW entry:
'HO indication readiness timer' (See also 2.9.2 in this document) and 'BS switching timer'.
'BS switching timer' shall include a single byte with two nibbles; one to define BS switching time in case of intra-FA HO, and one to BS switching time in case of inter-FA HO.

In REG-REQ, the MS will include these TLVs with the minimum supported value supported by the MS. In REG-RSP, the BS will include these TLVs with the minimum supported value supported by the BS, which shall be equal to- or greater than the MS value.
Note that 'BS switching timer' in REG-REQ is defined as the minimum supported time by MS from transmitting MOB_HO-IND at the serving BS, until MS readiness for reception of Fast_Ranging_IE at the target BS.

2.13. Problem #13: HO cancellation ambiguities

2.13.1. Problem description

The standard has ambiguous definitions of when HO cancellation may be performed by the MS: in page 239: "HO Cancellation - An MS may cancel HO at any time prior to expiration of Resource_Retain_Time interval after transmission of MOB_HO-IND message". This could mean that MS may cancel HO, via MOB_HO-IND with HO cancel, only after it transmitted MOB_HO-IND with HO release. It could also simply mean that MS may cancel HO by transmitting MOB_HO-IND with HO cancel.

2.13.2. Proposed remedy

Clarify text in p.239, that MS may cancel HO any time after MOB_MSHO-REQ or MOB_BSHO-REQ, via MOB_HO-IND with HO cancel (just as written in 6.3.22.2.3).

2.14. Problem #14: Trigger for autonomous intra-FA scanning

2.14.1. Problem description

The serving BS have no assurance that the MS is performing autonomous scanning of neighboring BSs (NBSs), since it is not obliged to send MOB_SCN-REQ message in autonomous scanning.

2.14.2. Proposed remedy

Add text to add functionality to trigger action, so that MS may initiate autonomous scanning when trigger conditions, determined by the BS, are met.

2.15. Problem #15: MS initiated scan request, in addition to triggers for scan requests

2.15.1. Problem description

The standard is unclear, whether MS is allowed to transmit MOB_MSHO-REQ or MOB_SCN-REQ messages autonomously, in addition to transmitting these messages according to triggers defined by the BS via DCD and MOB_NBR-ADV messages

2.15.2. Proposed remedy

Add text to clarify, that MS is allowed to transmit MOB_MSHO-REQ or MOB_SCN-REQ messages autonomously, in addition to transmitting these messages according to triggers defined by the BS via DCD and MOB_NBR-ADV messages.

2.16. Problem #16: HO during re-authentication

2.16.1. Problem description

The standard is unclear wrt MS, serving BS and target BS operation in case MS performs HO during re-authentication procedure

2.16.2. Proposed remedy

Add text to clarify behavior

2.17. Problem #17: MOB_NBR-ADV message ambiguities

2.17.1. Problem description

MOB_NBR-ADV message may include multiple representations of the same information, e.g. BS_EIRP, DCD configuration change count etc.
In general (not specifically related to NBR-ADV), the issue of multiple presentations of the same information in the same message, should be clarified. Examples:

- in case of more than one 'service level prediction' TLV in RNG-RSP message, the MS should use the last TLV.
- in case of multiple 'CID update' TLVs in RNG-RSP message, the MS should use the all TLVs.

2.17.2. Proposed remedy

The group agreed with the proposed text as follows (for general case):
'In case of multiple presentations of the same TLV and/or encoded parameter information in the same MAC management message, the last presentation shall be used, unless specifically defined that multiple presentations is allows, in which case all shall be used..

Regarding MOB_NBR-ADV message: the group decided to define that DCD settings and UCD settings shall include the original DCD and UCD messages, but exclude GMH, CRC and any information elements already presented within the message (e.g. BS_EIRP and DCD/UCD configuration change count).

2.18. Problem #18: PHY profile ID misplacement

2.18.1. Problem description

Table 109g, with description of PHY profile ID appears in a misleading way, as if belonging to PHY mode ID.

2.18.2. Proposed remedy

Place table 109g after PHY profile ID description

2.19. Problem #19: RNG-RSP with PHY corrections and HMAC/CMAC.

2.19.1. Problem description

RNG-RSP message is used for several purposes, some PHY related (e.g. PHY corrections in ranging, which should be performed fast, so corrections are performed by the MS soon after the time of estimating the offsets by the BS) and some MAC related (e.g. CMAC for authentication, which is not time critical). For proper separation between PHY and MAC instructions and to allow faster response to PHY instructions, it is beneficial to exclude PHY corrections in HMAC/CMAC signed RNG-RSP message, e.g. during HO and periodic ranging. The BS can transmit and unsolicited RNG-RSP with PHY corrections any time after sending HMAC/CMAC signed RNG-RSP (and assigned basic CID).

2.19.2. Proposed remedy

Add text to clarify that RNG-RSP message during HO (which is signed with HMAC/CMAC) may include PHY correction TLVs and the MS should change PHY corrections as instructed, but is not required to do so within RNG-RSP processing time.

2.20. Problem #20: Open-loop TPC mode during HO.

2.20.1. Problem description

The standard in unclear wrt TPC (transmit power control) during HO. The MS may operate in OL-TPC (open-loop TPC) mode at the serving BS at the time of HO to the target BS. As the MS context is transferred from the serving BS to the target BS, the target BS can know the MS' last used TPC mode. If the last used TPC mode was OL-TPC, then there's no need for PMC-RSP (upon HO completion) to set the TPC mode to OL-TPC, unless the preferred mode of operation is CL-TPC (closed-loop TPC). However, the standard also specifies that the default TPC mode during NW entry and re-entry is CL-TPC. From that, the MS shall operate in CL-TPC even if it was in OL-TPC mode at the serving BS and the target BS would have to transmit an unsolicited PMC-RSP message to change the TPC mode back to OL-TPC.
These two descriptions are ambiguous.

2.20.2. Proposed remedy

Add text to clarify that during optimized HO, the MS shall continue to use the same TPC mode at the target BS, as was used in the serving BS. Regardless, the target BS may transmit unsolicited PMC-RSP message to determine its preferred TPC mode of operation.
Note: during HO CDMA ranging, MS shall apply CL-TPC as specified for CDMA ranging, in general. Upon transmission of RNG-REQ message, the power corrections may be performed per the TPC mode last used at the serving BS.

3. Changes summary

[Note to the editor: The changes have been madewith "track changes" mode enabled]

3.1. Changes for remedy #1

[In 802.16e-2005, section 6.3.22.2, modify as follows:]

Ranging—MS and target BS shall conduct Initial Ranging per 6.3.9.5 or Handover Ranging per 6.3.10.3.3. If MS RNG-REQ includes serving BSID, then target BS may make a request to serving BS for information on the MS over the backbone network and serving BS may respond. Regardless of having received MS information from serving BS, target BS may request MS information from the backbone network. Network re-entry proceeds per 6.3.9.5 except as may be shortened by target BS possession of MS information obtained from serving BS over the backbone network. This type of HO is considered optimized HO. Depending on the amount of that information target BS may decide to skip one or several of the following Network Entry steps:

3.2. Changes for remedy #2 and remedy #3 -

[In 802.16e-2005, table 109f, modify as follows:]

HO Process Optimization	8 bits	HO Process Optimization is provided as part of this message is indicative only. HO process requirements may change at time of actual HO. For each Bit location, a value of '0' indicates the associated reentry management messages shall be required, a value of '1' indicates the reentry management message may be omitted. Regardless of the HO Process Optimization TLV settings, the target BS may send unsolicited SBC-RSP and/ or REG-RSP management messages Bit #0: Omit SBC-REQ/RSP management messages during re-entry processing Bit #1: Omit PKM Authentication phase except TEK phase during current re-entry processing Bit #2: Omit PKM TEK creation phase during reentry processing ~~Bit #3: Omit REG-REQ/RSP management during current re-entry processing~~ Bit #34: Omit Network Address Acquisition management messages during current reentry processing Bit #45: Omit Time of Day Acquisition management messages during current reentry processing Bit #56: Omit TFTP management messages during current re-entry processing Bit #67: Full service and operational state transfer or sharing between serving BS and target BS (All static and dynamic context, e.g. ARQ window contents, timers, counters, state machines)~~(ARQ, timers, counters, MAC state machines, etc…)~~. Bit #7: Omit REG-REQ/RSP management during current re-entry processing

[In 802.16e-2005, page 124, modify as follows:]

HO Process Optimization
HO Process Optimization is provided as part of this message is indicative only. HO process requirements may change at time of actual HO. For each Bit location, a value of '0' indicates the associated reentry management messages shall be required, a value of '1' indicates the reentry management message may be omitted. Regardless of the HO Process Optimization TLV settings, the target BS may send unsolicited SBC-RSP and/ or REG-RSP management messages
Bit #0: Omit SBC-REQ/RSP management messages during re-entry processing
Bit #1: Omit PKM Authentication phase except TEK phase during current re-entry processing
Bit #2: Omit PKM TEK creation phase during reentry processing
~~Bit #3: Omit REG-REQ/RSP management during current re-entry processing~~
Bit #34: Omit Network Address Acquisition management messages during current reentry processing
Bit #45: Omit Time of Day Acquisition management messages during current reentry processing
Bit #56: Omit TFTP management messages during current re-entry processing
Bit #67: Full service and operational state transfer or sharing between serving BS and target BS (All static and dynamic context, e.g. ARQ window contents, timers, counters, state machines)~~(ARQ, timers, counters, MAC state machines, etc…)~~.
Bit #7: Omit REG-REQ/RSP management during current re-entry processing

[In 802.16e-2005, page 144, modify as follows:]

HO Process Optimization
HO Process Optimization is provided as part of this message is indicative only. HO process requirements may change at time of actual HO. For each Bit location, a value of '0' indicates the associated reentry management messages shall be required, a value of '1' indicates the reentry management message may be omitted. Regardless of the HO Process Optimization TLV settings, the target BS may send unsolicited SBC-RSP and/ or REG-RSP management messages
Bit #0: Omit SBC-REQ/RSP management messages during re-entry processing
Bit #1: Omit PKM Authentication phase except TEK phase during current re-entry processing
Bit #2: Omit PKM TEK creation phase during reentry processing
~~Bit #3: Omit REG-REQ/RSP management during current re-entry processing~~
Bit #34: Omit Network Address Acquisition management messages during current reentry processing
Bit #45: Omit Time of Day Acquisition management messages during current reentry processing

Bit #5~~6~~: Omit TFTP management messages during current re-entry processing
Bit #6~~7~~: Full service and operational state transfer or sharing between serving BS and target BS (All static and dynamic context, e.g. ARQ window contents, timers, counters, state machines)~~(ARQ, timers, counters, MAC state machines, etc…)~~.
Bit #7: Omit REG-REQ/RSP management during current re-entry processing

[In 802.16e-2005, page 156-157, modify as follows:]

HO Process Optimization
HO Process Optimization is provided as part of this message is indicative only. HO process requirements may change at time of actual HO. For each Bit location, a value of '0' indicates the associated reentry management messages shall be required, a value of '1' indicates the reentry management message may be omitted. Regardless of the HO Process Optimization TLV settings, the target BS may send unsolicited SBC-RSP and/ or REG-RSP management messages
Bit #0: Omit SBC-REQ/RSP management messages during re-entry processing
Bit #1: Omit PKM Authentication phase except TEK phase during current re-entry processing
Bit #2: Omit PKM TEK creation phase during reentry processing
~~Bit #3: Omit REG-REQ/RSP management during current re-entry processing~~
Bit #3~~4~~: Omit Network Address Acquisition management messages during current reentry processing
Bit #4~~5~~: Omit Time of Day Acquisition management messages during current reentry processing
Bit #5~~6~~: Omit TFTP management messages during current re-entry processing
Bit #6~~7~~: Full service and operational state transfer or sharing between serving BS and target BS (All static and dynamic context, e.g. ARQ window contents, timers, counters, state machines)~~(ARQ, timers, counters, MAC state machines, etc…)~~.
Bit #7: Omit REG-REQ/RSP management during current re-entry processing

[In 802.16e-2005, page 239, modify as follows:]

Depending on the amount of that information target BS may decide to skip one or several of the following Network Entry steps:
1) Negotiate basic capabilities (Bit #0 in HO Process Optimization TLV in RNG-RSP is set)
2) PKM Authentication phase (Bit #1 in HO Process Optimization TLV is set)
3) TEK establishment phase (Bit #2 in HO Process Optimization TLV is set)
4) Send REG-REQ (Bit #7~~9~~ in HO Process Optimization TLV is set)
5) BS may send unsolicited REG-RSP message with updated capabilities information or skip REG-RSP message when no TLV information to be updated (Bit #10 in HO Process Optimization TLV is set)

In case Bit #6 in HO Process Optimization TLV is set, full service and operational state transfer or sharing between Serving BS and target BS is assumed (All static and dynamic context, e.g. ARQ window contents, timers, counters, state machines), so BS and MS do not exchange network re-entry messages after ranging before resuming normal operations. A full list of optimization capabilities is provided in definition of HO Process Optimization TLV (Table 367).

[In 802.16e-2005, page 245, modify as follows:]

During HO, the target BS may notify the MS, through the Bit #9~~7~~ MS DL data pending element of the HO Process Optimization TLV item in RNG-RSP, of post-HO re-entry MS DL data pending. Upon MS successful re-entry at the target BS, now the new serving BS, the new serving BS can transmit forwarded data (called "pre-HO pending MS DL data") to the MS. After completing reception of any HO pending MS DL data retained and forwarded, the MS may re-establish IP connectivity and the new serving BS may send a backbone message to request the old serving BS or other network entity to stop forwarding pre-HO pending MS DL data.

[In 802.16e-2005, table 367, page 681, modify as follows:]

HO Process Optimization	21	2	For each Bit location, a value of '0' indicates the associated re-entry management messages shall be required, a value of '1' indicates the re-entry management message ~~may~~ should be omitted. Bit #0: Omit SBC-REQ management messages during current re-entry processing Bit #1: Omit PKM Authentication phase except TEK phase during current re-entry processing Bit #2: Omit PKM TEK creation phase during reentry processing Bit #3: Omit Network Address Acquisition management messages during current reentry processing Bit #4: Omit Time of Day Acquisition management messages during current reentry processing Bit #5: Omit TFTP management messages during current re-entry processing Bit #6: Full service and operational state transfer or sharing between Serving BS and target BS (All static and dynamic context, e.g. ARQ window contents, timers, counters, state machines) ~~(ARQ, timers, counters, MAC state machines, etc.)~~ Bit #7: ~~post-HO re-entry MS DL data pending at target BS~~ Omit REG-REQ management message during current re-entry processing Bit #8: BS shall send an unsolicited SBC-RSP management message with updated capabilities information in case capabilities of target BS are different from the ones of Serving BS Bit #9: ~~Omit REG-REQ management message during current re-entry processing~~ post-HO re-entry MS DL data pending at target BS Bit #10: BS shall send an unsolicited REG-RSP management message with updated capabilities information Bit #11: (Target) BS supports virtual SDU SN. If Bit#11=1 and MS supports SDU SN, it shall issue SN_REPORT upon completion of HO to this BS. Bit #12: MS shall send ~~Bandwidth Request header with zero BR as~~ a notification of MS's successful re-entry registration. - Bit #13: If this bit is set to 1, MS shall trigger a higher layer protocol required to refresh its traffic IP address (e.g. DHCP Discover [IETF RFC 2131] or Mobile IPv4 re-registration [IETF RFC 3344]). #14–15: Reserved	All

[In 802.16e-2005, 6.3.22.2.7*, page 245, insert a new paragraph after paragraph 4 as follows:]*

When optimization bit #8 is cleared (=0) the BS shall send an unsolicited SBC-RSP management message with updated capabilities information.
When optimization bit #10 is cleared (=0) the BS shall send an unsolicited REG-RSP management message with updated capabilities information.

- .

When optimization bit #12 is set the MS may use any uniquely identifiable indication as notification of MS's successful re-entry registration, following are examples of such indications:

- MS transmits data in unsolicited UL grant by the target BS (i.e. MS has pending UL data), using newly assigned traffic CID.
- MS transmits Bandwidth request header of type 0b000 or 0b001 with BR per desired BW, when MS has pending UL data, using newly assigned traffic CID.
- MS transmits Bandwidth request header of type 0b000 or 0b001 with BR=0, when MS has no pending UL data, using newly assigned basic CID.

- MS transmits HARQ ACK, using the ACKCH slot assigned by the target BS.
- MS transmits CQI code, using the CQICH slot assigned by the target BS.

[In 802.16e-2005, page 245, modify paragraph 4 as follows:]

If the MS finishes the re-entry registration procedure by successfully receiving either an unsolicited REGRSP message or a RNG-RSP message including REG-RSP specific TLV items, the MS shall send ~~a Bandwidth Request header with zero BR field~~ a notification of MS's successful reentry registration when Bit #12 of the HO Process Optimization TLV in the RNGRSP message is set to one (see 6.3.22.2.7). ~~If the BS receives a Bandwidth Request header with zero BR after sending either the unsolicited REG-RSP message or the RNG-RSP message including REG-RSP specific TLV items, the BS regards the Bandwidth Request header as a notification of MS's successful re-entry registration.~~

[In 802.16e-2005, table 367, page 682, modify as follows:]

REG-RSP encodings	30	Variable	REG-RSP TLV items for HO optimization ~~Only transmitted~~ May only be included if HO Process Optimization [bit#~~79~~]==1.	All

3.3. Changes for remedy #4

[In 802.16e-2005, insert a new subclause 6.3.22.2.10, as follows:]

6.3.22.2.10 HO optimization rules and scenarios

The bitmap of the HO process optimization TLV in RNG-RSP message during HO shall be set according to the following rules ~~and scenarios~~:

Non-managed SS (i.e. SSs that do not support secondary management connection):

- HO process optimization bit#3 = 1 (omit DHCP)
- HO process optimization bit#4 = 1 (omit time-of-day acquisition)
- HO process optimization bit#5 = 1 (omit TFTP phase)
- All other bits: don't care (i.e. do not depend on SS management support)

SBC-REQ/RSP consistency:

When HO process optimization bit#8 is set to 1, HO process optimization bit#0 ~~(omit SBC-REQ)~~ shall be set to 1 ~~cannot be set to zero~~ 0 ~~, when HO process optimization bit#8 (BS will send unsolicited SBC-RSP) is set to one~~.

REG-REQ/RSP consistency:

When HO process optimization bit#10 is set to 1, HO process optimization bit#7 ~~(omit REG-REQ) cannot be set to zero~~ 0, shall be set to 1 ~~when HO process optimization bit#10 (BS will send unsolicited REG-RSP) is set to one.~~

The bitmap of the HO process optimization TLV in RNG-RSP message during HO shall be set according to the following scenarios:

~~**The following text describes recommended HO scenarios:**~~

Full optimized HO scenario

Both static and dynamic context are shared between the serving BS and the target BS.

HO process optimization TLV settings:

- HO process optimization bit#0 = 1
- HO process optimization bit#1 = 1
- HO process optimization bit#2 = 1
- HO process optimization bit#6 = 1
- HO process optimization bit#7 = 1
- HO process optimization bit#8 = 1
- HO process optimization bit#10 = 1
- All other bits, except reserved bits = Don't care (i.e. not dependant on optimization case).

Full optimized HO scenario with TEK updates

Both static and dynamic context are shared between the serving BS and the target BS.

HO process optimization TLV settings:

- HO process optimization bit#0 = 1
- HO process optimization bit#1 = 1
- HO process optimization bit#2 = 0 (When SA-TEK Update TLV is sent in RNG-RSP)
- HO process optimization bit#6 = 1
- HO process optimization bit#7 = 1
- HO process optimization bit#8 = 1
- HO process optimization bit#10 = 1
- All other bits, except reserved bits = Don't care (i.e. not dependant on optimization case).

Optimized HO with static context sharing scenario

Static context only (i.e. no dynamic context) is shared between the serving BS and the target BS.

HO process optimization TLV settings:

- HO process optimization bit#0 = 1
- HO process optimization bit#1 = 1
- HO process optimization bit#2 = 0 (When SA-TEK Update TLV is sent in RNG-RSP)

- HO process optimization bit#6 = 0
- HO process optimization bit#7 = 1
- HO process optimization bit#8 = 1
- HO process optimization bit#10 = 1
- All other bits, except reserved bits = Don't care (i.e. not dependant on optimization case).

Full network entry (no optimization):
No context sharing between the serving BS and the target BS.
HO process optimization TLV settings:

- HO process optimization bit#0 = 0
- HO process optimization bit#1 = 0
- HO process optimization bit#2 = 0
- HO process optimization bit#6 = 0
- HO process optimization bit#7 = 0
- HO process optimization bit#8 = 0
- HO process optimization bit#10 = 0
- HO process optimization bit#11 = 0
- HO process optimization bit#12 = 0
- HO process optimization bit#13 = 0
- All other bits, except reserved bits = Don't care (i.e. not dependant on optimization case).

~~Note that in this case,~~ In this scenario the RNG-RSP message carrying the HO process optimization TLV above will not be signed with HMAC/CMAC.

3.4. Changes for remedy #5

[In 802.16e-2005, section 6.3.1.1, page 18, modify as follows:]

The CIDs for these connections shall be assigned in the ~~RNG-RSP and~~ REG-RSP message or in the REG-RSP TLV in the RNG-RSP message~~s~~. The message dialogs provide three CID values. The same CID value is assigned to both members (uplink and downlink) of each connection pair.

[In 802.16e-2005, page 239, modify as follows:]

If TLVs for re-establishment of connections (11.7.9) appear in ~~RNG-RSP (REG-RSP)~~ the REG-RSP message or in the REG-RSP encodings TLV in the RNG-RSP message, DSA-REQ/RSP procedure shall not be used for this purpose. In this case, re-establishment of connections starts immediately after ~~RNG~~REG-RSP (~~REG-RSP~~message or TLV in RNG-RSP message); the BS shall provide sufficient time to the MS to process connections information as specified by MS HO connections parameters processing time TLV.

[In 802.16e-2005, page 245, modify as follows:]

If MS RNG-REQ includes a serving BSID and Ranging Purpose Indication TLV with Bit #0 set to 1, and target BS has received a backbone message containing MS information, the target BS may use MS service and operational information obtained over the backbone network to build and send a REG-RSP ~~management~~ message or a RNG-RSP message with REG-RSP encodings TLV that includes service flow remapping information in SFID, New_CID and Connection_Info TLVs.

[In 802.16e-2005, page 268, modify as follows:]

If MS RNG-REQ includes Ranging Purpose Indication TLV with Bit #0 set to 1 and Paging Controller ID TLVs, and target BS has received a backbone message containing MS information, the target BS may use MS service and operational information obtained over the backbone network to build and send a REG-RSP ~~management~~ message or a RNG-RSP message with REG-RSP encodings TLV that includes service flow remapping information in SFID, New_CID, and Connection_Info TLVs.

3.5. Changes for remedy #6

[In 802.16e-2005, section 6.3.22.2, page 239, modify as follows:]

Ranging—MS and target BS shall conduct Initial Ranging per 6.3.9.5 or Handover Ranging per 6.3.10.3.3. If MS RNG-REQ includes serving BSID, then target BS may make a request to serving BS for information on the MS over the backbone network and serving BS may respond. Regardless of having received MS information from serving BS, target BS may request MS information from the backbone network. Network re-entry proceeds per 6.3.9.5 except as may be shortened by target BS possession of MS information obtained from serving BS over the backbone network.

MS information (or MS context) may include static context and dynamic context, where static context consists of all configuration parameters that were acquired during initial NW entry or later, via of exchange of information between the BS and MS (for example, all SBC-RSP and REG-RSP parameters, all service flow encodings from DSx message exchanges etc) and dynamic context consists of all counters, timers, state machine status, data buffer contents (e.g. ARQ window).

Transaction states, which may impact configuration parameters, are considered dynamic context until complete, which by then is considered static context.

Note: security context is always considered static context.

Depending on the amount of that information target BS may decide to skip one or several of the following Network Entry steps:

3.6. Changes for remedy #6, #7, #8, #16, #20 and #21

[In 802.16e-2005, add new section as follows:]

6.3.22.2.8.1 Context management during optimized HO

The MS may use any context at the target BS (static and dynamic) that was acquired with the serving BS, if it supports optimized HO. However, some of the dynamic context may change to accommodate proper NW re-entry operation at the target BS.
The MS shall retain its context with the serving BS, if HO cancellation is supported by both the serving BS and the MS. Some of the dynamic context may change, to accommodate proper operation upon HO cancellation.

The following specifies the expected settings of the MS context during HO (The context is categorized for simplicity of depiction):

6.3.22.2.8.1.1 ~~1~~**BS PHY settings**
~~<=~~ K~~k~~nowledge about the BS maintained by MS (e.g. FFT size, BW, CP, frame size, DL frequency etc.~~)>~~

~~MS context with Serving BS: Maintained with resource retain timer.~~
~~MS context with Target BS: Replaced with target BS parameters, acquired thru neighbor advertisement (e.g. FFT size, BW, CP, frame size, DL frequency etc.)~~

MS may maintain ~~S~~serving BS PHY settings until expiration of resource retain timer or until successful HO to the ~~T~~target BS

6.3.22.2.8.1.2 ~~1.~~**BS Channel descriptor settings:**
~~<=~~ K~~k~~nowledge about the BS maintained by MS.~~>~~

MS may maintain ~~S~~serving BS Channel descriptor settings until expiration of resource retain timer or until successful HO to the ~~T~~target BS

~~MS context with Serving BS: Maintained with resource retain timer.~~
Target BS c~~C~~hannel descriptor settings are acquired by MS via neighbor advertisement, in association with Configuration Change Count value (CCC).
~~MS context with Target BS: Replaced with target BS parameters, acquired thru neighbor advertisement.~~

During the HO MS must verify that the DCD/UCD configuration change counts (CCCs) of the target BS (according to DL/UL-MAP) ~~is consistent with~~ are identical to DCD/UCD CCCs as they appeared in MOB_NBR-ADV message of the serving BS, then target~~T~~ BS c~~C~~hannel descriptor settings shall be used by the MS during Network Re-entry. ~~If not,~~ Otherwise, MS ~~must~~ shall wait until it receive~~sd~~ ~~to obtain~~ DCD/UCD or cancel HO or perform HO to another target BS. T1 and T12 are reset upon successful match.

6.3.22.2.8.1.3 Ranging settings:
MS context with Serving BS: All timers and associated retry counters are reset (T2, T3, T4 etc).
MS context with Target BS: All timers and associated retry counters are reset (T2, T3, T4 etc).
T2 is restarted upon obtaining both DCD and UCD.
If Fast_ranging_IE is used, MS may perform autonomous ranging or use parameters acquired thru association (if supported). In case of autonomous ranging failure, MS may perform CDMA ranging with HO codes or cancel HO or attempt HO to another target BS.
MS shall restart T4 upon successful ranging completion (fast ranging or CDMA ranging).

6.3.22.2.8.1.4 Basic capabilities settings:
MS context with Serving BS: Maintained with resource retain timer.
MS context with Target BS: If static context is shared and basic capabilities of the target BS differ from the serving BS, then the target BS shall convey updated basic capabilities (only TLVs with the different capabilities). The target BS instructs how basic capabilities shall be updated via HO process optimization TLV settings: If bit#0=0, then MS shall send SBC-REQ message (to which the target BS will respond with SBC-RSP message). If bit#0=1 AND bit#8=1, then MS shall await an unsolicited SBC-RSP message.
In case of full optimized HO, the target BS should not update any basic capabilities.

6.3.22.2.8.1.5 Registration settings:

MS context with Serving BS: Maintained with resource retain timer.
MS context with Target BS: If static context is shared between the serving BS and the target BS and capabilities of the target BS, as defined thru registration, differ from the serving BS, then the target BS shall convey updated capabilities (only TLVs with the different capabilities). The target BS instructs how registration capabilities shall be updated via HO process optimization TLV settings: If bit#7=0, then MS shall send REG-REQ message to which the target BS shall respond with REGC-RSP message. If bit#7=1and bit#10=1, then MS shall await an unsolicited REG-RSP TLV.
In case of full optimized HO, the target BS should not update any registration settings (excluding CIDs, SAIDs).

6.3.22.2.8.1.6 Service flows settings:

6.3.22.2.8.1.6.1 Service flows – static context:

Service flows configuration is considered static context.
MS context with Serving BS: Maintained with resource retain timer.
MS context with Target BS: When static context is shared between the serving BS and the target BS, then all service flow parameters remain unchanged (except for CIDs and SAIDs that may change).
When service flow parameters at the target BS are different than the serving BS, the target BS shall use DSC-REQ messages upon HO completion, to change the configuration of the connections, as required.

6.3.22.2.8.1.6.2 Service flows – dynamic context, non-ARQ enabled connections:

~~Non-ARQ is typically real-time traffic, in which case latency is the critical factor and packet drops are allowed~~.
MS context with Serving BS: SDU fragments are maintained with resource retain timer.
MS context with Target BS:
Downlink: Either continuation at fragment-level or SDU-level is allowed.
Continuation at fragment-level: The target BS may transmit the fragment, following the last SDU fragment that was transmitted by the serving BS. For example: If a SDU consists of fragments A and B, and due to HO, the serving BS transmitted fragment A, but not B, then the target BS shall continue from fragment B (not retransmit fragment A).
Continuation at SDU-level: The target BS may retransmit last outstanding SDU or drop it and continue to next complete SDU.
Upon HO completion, if commanded by the target BS (via bit#12=1), the MS shall transmit SN_REPORT header with last received SDU SN per SDU SN-enabled CID.
Uplink: The MS shall transmit to the target BS the fragment after the last transmitted fragment at the serving BS (regardless of bit#6 setting).

6.3.22.2.8.1.6.3 Service flows – dynamic context, ARQ enabled connections:

MS context with Serving BS: ARQ window contents shall be maintained with resource retain timer. The serving BS may pause or reset timers associated with ARQ Blocks. MS shall continue the timers.
MS context with Target BS :
If bit#6=0, ARQ window shall be reset automatically by transmitters (MS and target BS), without explicit ARQ_reset. Regardless, MS and/or target BS may send ARQ_reset.

If bit#6=1, then the following behavior is expected upon HO completion:

- ARQ window contents shall be transferred from the serving BS to the target BS. Target BS shall continue BSN numbering from serving BS (in both DL and UL).Target BS may pause or reset timers associated with ARQ Blocks.
- The Target BS shall continue the BSN numbering from the serving BS for both DL and UL connections.

Downlink:

- If MS received DISCARD message from the serving BS but couldn't reply with acknowledgement, the MS shall send the acknowledgement to the target BS. The MS may send the acknowledgements immediately after HO completion or may postpone it depending on the state of its internal timers.
- The Target BS shall never transmit the ARQ blocks up to the one specified in the last DISCARD message from the serving BS. The target BS may re-transmit the DISCARD message (first transmitted by the serving BS) immediately after HO or it may postpone the retransmission up until ARQ_RETRY_TIMEOUT after HO completion. If the target BS does not receive the acknowledgement for the discarded blocks it shall retransmit DISCARD message at the intervals equal to ARQ_RETRY_TIMEOUT until it receives the acknowledgement.
- If the MS had successfully received an ARQ block from the serving BS but couldn't reply send the

acknowledgement to the serving BS, the MS shall send the acknowledgement to the target BS. The MS shall send the acknowledgements immediately after HO completion or may postpone it depending on the state of its internal timers.

- If the serving BS has transmitted an ARQ block to the MS, but it was not acknowledged by the MS, the target BS shall start retransmitting the ARQ block either immediately after HO completion or later, depending on the state of the internal timers, until it receives the acknowledgement from the MS.
- If the serving BS has transmitted an ARQ block to the MS, and it was acknowledged by the MS, the target BS shall not transmit it again.

Uplink:

- The MS assumes that the network is capable of re-assembling the SDU parts, which may have been received by different Base Stations.
- If the serving BS has successfully received an ARQ block from the MS, but couldn't reply with acknowledgement to the MS, the target BS shall send the acknowledgement to the MS. The target BS may send the acknowledgements immediately after HO completion or may postpone it depending on the state of its internal timers.
- If the MS has been transmitted an ARQ block to the serving BS, but did not receive acknowledgement from the serving BS, the MS shall start retransmitting it to the target BS either immediately after HO completion or later, depending on the state of the internal timers until it receives the acknowledgement from the MS.
- If the MS has transmitted an ARQ block to the serving BS, and received acknowledgement from the serving BS, the MS shall not transmit it again upon HO completion.

6.3.22.2.8.1.6.4 Service flows – dynamic context, HARQ enabled connections:

MS context with Serving BS: All dynamic HARQ context is reset in both DL and UL. HARQ data buffers are purged, buffered softbits are cleared. AI_SN on all ACIDs are set to zero.
MS context with Target BS: All dynamic HARQ context is reset in both DL and UL. HARQ data buffers are purged, buffered softbits are cleared. AI_SN on all ACIDs are set to zero. Regardless of bit #6, HARQ ACID and channel mapping is maintained (unique per service flow). PDU SN (if enabled) shall be reset and then follow the rules of service flow state for non-ARQ and ARQ connections as described above.

6.3.22.2.8.1.6.6 Outstanding bandwidth requests:

MS context with Serving BS: Reset.
MS context with Target BS: Reset (not transferred from the serving BS). MS must transmit bandwidth request of remaining (outstanding) bytes.

6.3.22.2.8.1.7 Security settings:

MS context with Serving BS: Maintained with resource retain timer
MS context with Target BS: Context is handled per bit#1 and bit#2 settings.

Bit #1=0 AND bit#2=0:	Perform re-authentication and SA-TEK 3-way handshake. BS should include SA-TEK-Update TLV in the SA-TEK-Response message. In addition, the RNG-RSP message does not include SA-TEK-Update TLV or SA Challenge Tuple TLV.
Bit #1=0 AND bit#2=1:	Not used. MS shall silently ignore RNG-RSP message.
Bit #1=1 AND bit#2=0:	One of two options is allowed: Option 1: SA-TEK-Update TLV is included in the RNG-RSP message and updates the TEKS for all the SAs. In this way SA-TEK 3-way handshake shall not occur. SA Challenge Tuple TLV shall not be included in the RNG-RSP message Option 2: SA-TEK-Update TLV is included in a SA-TEK-Response message. In this case, SA-TEK 3-way handshake is performed with SA Challenge Tuple TLV included in the RNG-RSP message.
Bit #1=1 AND bit#2=1:	Re-authentication and SA-TEK 3-way handshake is not performed. The RNG-RSP message does not include SA-TEK-Update TLV nor SA Challenge Tuple TLV. All the TEKs received from the serving BS are reused. All PMK timers are maintained.

SAID update:
When SAID_update TLV is excluded from the RNG-RSP message during network re-entry, it means that SAID value(s) will be the same value(s) as the value(s) used in previous serving BS and the value of Primary SAID will be implicitly updated because MS and BS use the same value as that of Basic CID.
Regardless, the target BS may include SAID_update TLV within RNG-RSP message.
When target BS allocates SAID during handover re-entry, the target BS should allocate the new SAID with same value of SAID which was used in serving BS in order to avoid possible mismatch of old SAID.

For more information on security context management during HO, see section 6.3.22.2.8, HO during re-authentication.

6.3.22.2.8.1.8 Power Saving Class settings:
MS context with Serving BS: Maintained with resource retain timer
MS context with Target BS:
All Power Saving Class related configurations, timers and states are reset
MS shall exit sleep mode to perform HO. MS may reenter sleep mode, upon HO completion, by transmitting MOB_SLP-REQ, which shall include all requested Power Saving Class configurations.

3.7. Changes for remedy #9, #10, #11 and #12

[In 802.16e-2005, section 11.7.13, add the following subsection:]

11.7.13.4 Handover Indication Readiness Timer

During HO preparation phase, after transmitting the MOB_BSHO-REQ or the MOB_BSHO-RSP messages, the serving BS may allocate an unsolicited UL grant to enable MS to transmit MOB_HO-IND without issuing BW request.
During initial network entry, MS may transmit REG-REQ with Handover Indication Readiness Timer TLV, which is used to declare the minimum time it may require to process MOB_BSHO-REQ or MOB_BSHO-RSP messages.
The BS shall respond in REG-RSP with Handover Indication Readiness Timer TLV.. The value included in REG-RSP shall be the greater of the MS supported value and the BS supported value (The BS value is the minimum time required to allocate an unsolicited UL grant). Handover Indication Readiness Timer is relative to the frame in which MOB_BSHO-REQ/RSP message is transmitted.
A value of 1 means the HO indication may be sent in the frame succeeding MOB_BSHO-REQ/RSP.

Type	Length	Value	Scope
46	1	In frames . Default = 2	REG-REQ, REG-RSP

11.7.13.5 BS Switching Timer

The serving BS uses Handover Indication Readiness Timer (11.7.13.4) and BS Switching Timer to determine Action Time in MOB_BSHO-REQ/RSP messages.
BS Switching Timer is the minimum time the MS requires between transmission of MOB_HO-IND message at the serving BS, until it is able to receive Fast_Ranging_IE at the target BS.

Type	Length	Value	Scope
47	1	Minimum time from transmission of MOB_HO-IND at the serving BS until proper reception of Fast_Ranging_IE at the target BS [in frames, minimum value is 1] Bit#0-#3: minimum time for intra-FA HO default = 2 Bit#4-#7: minimum time for inter-FA HO default = 3	REG-REQ

[In 802.16e-2005, section 6.3.2.3.7, page 56, modify as follows:]

For an MS, the REG-REQ (on initial network entry) shall contain the following TLVs:
Handover supported (11.7.12).
HO Process Optimization MS Timer (11.7.13.2)
Handover Indication Readiness Timer (11.7.13.4)
BS Switching Timer (11.7.13.5)
Mobility parameters support (11.7.14).

[In 802.16e-2005, section 6.3.2.3.8, page 58, modify as follows:]

For an MS, the REG-RSP (on initial network entry) shall contain the following TLVs:
Handover supported (11.7.12).
System Resource_Retain_Time (11.7.13.1)
HO Process Optimization MS Timer (11.7.13.2)
MS Handover Retransmission Timer (11.7.13.3)
Handover Indication Readiness Timer (11.7.13.4)
~~**BS Switching Timer (11.7.13.5)**~~
Mobility parameters support (11.7.14).

[In 802.16e-2005, table 109n, page 150, modify as follows:]

Resource Retain Flag	1 bit	0: Release connection information. 1: Retain connection information.
Unsolicited UL grant for HO-IND flag	1 bit	0: BS will not allocate unsolicited UL grant for HO_IND 1: BS will allocate unsolicited UL grant for HO indication after 'HO indication readiness time'
Reserved	~~7~~6 bits	Shall be set to zero
For (j=0 ; j<N_Recommended ; j++) {	-	Neighbor base stations shall be presented in an order such that the first presented is the one most recommended and the last presented is the least recommended.

[In 802.16e-2005, page 156, modify as follows:]

Resource Retain Flag
The Resource Retain Flag indicates whether the serving BS will retain or delete the connection information of the MS upon receiving MOB_HO-IND with HO_IND_type=0b00. If the flag is set to 1, the serving BS will retain the MS's connection information during the time in Resource Retain Time field. If Resource Retain Flag=01 then the serving BS and MS shall use the System Resource Retain Time timer. If the flag is set to 0, the serving BS will discard the MS's connection information.

Unsolicited UL Grant for HO-IND flag
The Unsolicited UL Grant for HO-IND flag indicates whether the serving BS will grant an unsolicited UL allocation for MS transmission of MOB_HO-IND message. If the Unsolicited UL Grant for HO-IND flag is set to 1, the serving BS will grant an unsolicited UL allocation for MOB_HO-IND message ~~before~~after expiration of Handover Indication Readiness Timer (see 11.7.13.4).

If the Unsolicited UL Grant for HO-IND flag is set to 0, then the MS shall not expect any unsolicited UL grant.

For Mode=0b000 for each recommended neighbor BS…

[In 802.16e-2005, table 109l, page 137, modify as follows:]

Resource Retain Flag	1 bit	0: MS resource release. 1: MS resource retain.
Unsolicited UL grant for HO-IND flag	1 bit	0: BS will not allocate unsolicited UL grant for HO_IND 1: BS will allocate unsolicited UL grant for HO indication after 'HO indication readiness time'
Reserved	56 bits	Shall be set to zero
For (j=0 ; j<N_Recommended ; j++) {	-	N_Recommended can be derived from the known length of the message.

[In 802.16e-2005, page 143 modify as follows:]

Resource Retain Flag
The Resource Retain Flag indicates whether the serving BS will retain or delete the connection information of the MS upon receiving MOB_HO-IND with HO_IND_type=0b00. If the flag is set to 1, the serving BS will retain the MS's connection information during the time in Resource Retain Time field. If Resource Retain Flag=1 and Resource Retain Time is not included as a TLV item in the message, then the serving BS and MS shall use the System Resource Retain Time timer. If the flag is set to 0, the serving BS will discard the MS's connection information.

Unsolicited UL Grant for HO-IND flag
The Unsolicited UL Grant for HO-IND flag indicates whether the serving BS will grant an unsolicited UL allocation for

MS transmission of MOB_HO-IND message. If the Unsolicited UL Grant for HO-IND flag is set to 1, the serving BS will grant an unsolicited UL allocation for MOB_HO-IND message after expiration of Handover Indication Readiness Timer (see 11.7.13.4).

If the Unsolicited UL Grant for HO-IND flag is set to 0, then the MS shall not expect any unsolicited UL grant.

…

Action Time
For HO, this value is defined as number of frames until the Target BS allocates a dedicated transmission opportunity for RNG-REQ message to be transmitted by the MS using Fast_Ranging_IE. Dedicated allocation for transmission of RNG-REQ means that channel parameters learned by the MS during Association of that BS stay valid and can be reused during actual Network Re-entry without preceding CDMA-based Initial Ranging. This parameter is decided by the Serving BS based on the information obtained from potential Target BSs over the backbone.
For MDHO/FBSS, this is the time of update of Anchor BS and/or Diversity Set. A value of zero in this parameter signifies that this parameter should be ignored.

For Mode=0b0000, for each recommended neighbor BS, the following parameters shall be included:
Network Assisted HO supported
Indicates that the BS supports Network Assisted HO, 1=supported, 0=not supported

[In 802.16e-2005, section 6.3.22.2, page 243, modify as follows:]
Serving BS may notify one or more potential target BS over the backbone network of MS intent to handover. Serving BS may also send MS information to potential target BS over the backbone to expedite handover.

In order to verify the MS can complete the HO preparation phase in time to receive the ~~f~~Fast_R~~r~~anging_IE~~ie~~ in the target base station (i.e. after action time), the serving BS may grant an unsolicited UL allocation for transmission of MOB_HO-IND message. In this case, the Unsolicited UL Grant for HO-IND flag in MOB_BSHO-REQ/RSP message serving BS should be set to 1.. Upon expiration of Handover Indication Readiness Timer the serving BS should grant an UL allocation to the MS, with a size enough for transmission of MOB_HO-IND message.

The serving BS may continue to issue DL and UL allocations to the MS until expiration of Handover Indication Readiness Timer or until MOB_HO-IND with HO_IND_type=0b00 was received or until it received an indication from the target BS (over the backbone) that MS successfully completed its HO attempt or until it decides that the MS is no longer available.
The MS that sent MOB_HO-IND with option HO_IND_type = 0b00 indicating commitment to HO and intent to release the serving BS, shall not be expected to monitor serving BS DL traffic after transmission of the MOB_HO-IND message.

3.8. Changes for remedy #11 and #12

[In 802.16e-2005, section 6.3.22.2, page 242, modify as follows:]

Serving BS criteria for recommendation of target BS may include factors such as expected MS performance at potential target BS and MS QoS requirements. Serving BS may obtain expected MS performance at potential target BS through the exchange of backbone messages with that BS. Serving BS may negotiate location of common time interval where dedicated initial ranging transmission opportunity for the MS will be provided by all potential target BSs. This information may be included into MOB_BSHO-RSP message, and is indicated by Action Time.

Dedicated allocation for transmission of RNG-REQ means that channel parameters learned by the MS autonomously, based on information acquired at the time of HO with the target BS or during Association of that BS are considered valid during sufficient time and can be reused for actual Network Re-entry without preceding CDMA Ranging. Information such as indicators of link quality in the UL direction learned by the MS during Association, may be provided to the Serving BS over the backbone.

[In 802.16e-2005, section 6.3.22.2.4, page 243, modify as follows:]

6.3.22.2.4 ~~Use of scanning and association results~~Fast Ranging

For the purpose of expediting NW re-entry of the MS with the target BS, the serving BS may negotiate with target BS allocation of an non-contention-based ranging opportunity for the MS, i.e. an unsolicited UL allocation for transmission of RNG-REQ message. The agreed time shall take into account the Handover Indication Readiness Timer (see 11.7.13.4) and BS Switching Timer (see 11.7.13.5).

The MS may learn the required ranging parameters at the target BS at the time of HO. ~~MS may~~ Ranging parameters are based on PHY parameters of the serving BS at the time of HO indication and PHY parameters acquired from the target BS during or prior to HO, or during scanning of ~~-~~target neighbor BSs and optionally ~~try~~ association.

The serving BS shall indicate the time of the fast (i.e. non-contention-based) ranging opportunity, negotiated with the potential target BSs, via Action Time field in the MOB_BSHO-REQ/RSP message.

Action Time is the earliest time (i.e. smallest value) for allocation of fast ranging opportunity that was committed by the target BSs recommended in the message.

The target BS(s) shall indicate the fast ranging allocation in the UL-MAP via Fast_Ranging_IE (see 8.2.1.9.3.6, 8.3.6.3.9, and 8.4.5.4.21. Fast ranging Information Element). The Action time + T55 provides a bounded interval during which the MS may expect to receive Fast_Ranging_IE:

T55 starts in the frame after the MS expects to receive Fast_Ranging_IE, derived by Action Time.

Upon expiration of this timer, the MS shall not expect the Target BS to grant an UL allocation via Fast_Ranging_IE and shall release the HO ID

~~If the target BS had previously received HO notification from serving BS over the backbone, then target BS may place a Fast_Ranging_IE() (see 8.2.1.9.3.6, 8.3.6.3.9, and 8.4.5.4.21. Fast ranging Information Element) in the UL-MAP to allocate a non-contention-based Initial Ranging opportunity. MS shall scan target BS for UL-MAP that includes either a contention- or non-contention-based MS Initial Ranging opportunity.~~

[In 802.16e-2005, table 342, add the following:]

BS, MS	T55	This timer starts in the frame where MS expects to receive Fast_Ranging_IE. Upon expiration of this timer, the MS shall not expect the Target BS to grant an UL allocation via Fast_Ranging_IE and shall release the HO ID	8		

3.9. Changes for remedy #13

[In 802.16e-2005, section 6.3.22.2, page 239, modify as follows:]

— HO Cancellation—An MS may cancel HO via MOB_HO-IND message at any time prior to expiration of Resource_Retain_Time interval after transmission of ~~MOB_HO-IND message.~~MOB_MSHO-REQ (in case of MS initiated HO) or MOB_BSHO-REQ (in case of BS initiated HO).

3.10. Changes for remedy #14

[In 802.16e-2005, table 358b, page 676, modify as follows:]

Trigger; Type/function/action TLV format (Table 358b)

Name	Length	Value
Type	2 bits (MSB)	Trigger metric type: 0x0: CINR metric 0x1: RSSI metric 0x2: RTD metric 0x3: *Reserved*
Function	3 bits	Computation defining trigger condition: 0x0: *Reserved* 0x1: Metric of neighbor BS is greater than absolute value 0x2: Metric of neighbor BS is less than absolute value 0x3: Metric of neighbor BS is greater than serving BS metric by relative value 0x4: Metric of neighbor BS is less than serving BS metric by relative value 0x5: Metric of serving BS greater than absolute value 0x6: Metric of serving BS less than absolute value 0x7: *Reserved* *NOTE: 0x1-0x4 are not applicable to RTD trigger metric*
Action	3 bits (LSB)	Action performed upon reaching trigger condition: 0x0: *Reserved* 0x1: Respond on trigger with MOB_SCN-REP after the end of each scanning interval 0x2: Respond on trigger with MOB_MSHO-REQ 0x3: On trigger, MS shall start scanning process by sending MOB_SCN-REQ 0x4 On trigger, MS should perform scanning 0x5-0x7: *Reserved* *NOTE—0x3 ~~is~~ and 0x4 are not applicable when neighbor BS metrics are defined (i.e., only Function values 0x5-6 are applicable).*

3.11. Changes for remedy #15

[In 802.16e-2005, page 676 (after table 358b), add text as follows:]

The RTD trigger shall only be measured on the serving BS rather than relative to or from neighbor BSs. The trigger functions 0x5 and 0x6 shall be the only applicable ones for the RTD trigger. When the Type is set to RTD metric (i.e., 0x2), only either of the trigger functions 0x5 or 0x6 shall be applicable.

The MS may transmit MOB_MSHO-REQ and MOB_SCN-REQ messages autonomously, i.e. in addition to messages prompted by trigger conditions.

[In 802.16e-2005, page 665 (after table 348g, just before section 11.3, add text as follows:]

The MS may transmit MOB_MSHO-REQ and MOB_SCN-REQ messages autonomously, i.e. in addition to messages prompted by trigger conditions.

3.12. Changes for remedy #17

[In 802.16e-2005, section 6.3.2.3, page 44, add text as follows:]

…MAC management messages that have a Type value specified in Table 14 as "*Reserved*," or those not containing all required parameters or containing erroneously encoded parameters, shall be silently discarded. In case of MAC management messages with multiple presentations of the same TLV and/or encoded parameter information, the last presentation shall be used, unless otherwise specified that multiple presentations are allowed (e.g. Downlink_Burst_Profile TLV in DCD message), in which case all presentations shall be used.

[In 802.16e-2005, section 6.3.2.3.47, page 124-125, modify as follows:]

DCD_settings

The DCD_settings is a compound TLV ~~value~~ that encapsulates TLVs from the neighbor BS' ~~a~~ DCD message ~~(excluding the generic MAC header and CRC)~~ that may be transmitted in the advertised BS downlink channel. This information is intended to enable fast synchronization of the MS with the advertised BS downlink.

The DCD settings fields shall contain only neighbor's DCD TLV values that are different from the serving BS corresponding values. Neighbor BS DCD TLVs that are already represented within the fixed fields of the MOB_NBR-ADV message (e.g. BS_EIRP, DCD configuration change count, neighbor BSID) shall be excluded. For values that are not included, the MS shall assume they are identical to the corresponding values of the serving BS. The duplicate TLV encoding parameters within a Neighbor BS shall not be included in DCD setting.

UCD_settings

The UCD_settings is a compound TLV ~~value~~ that encapsulates TLVs from the neighbor BS' ~~a~~ UCD message ~~(excluding the generic MAC header and CRC)~~ that may be transmitted in the advertised BS downlink channel. This information is intended to enable fast synchronization of the MS with the advertised BS uplink.

The UCD settings fields shall contain only neighbor's UCD TLV values that are different from the serving BS's corresponding values. Neighbor BS UCD TLVs that are already represented within the fixed fields of the MOB_NBR-ADV message (e.g. UCD configuration change count) shall be excluded. For values that are not included, the MS shall assume they are identical to the serving BS's corresponding values. The duplicate TLV encoding within a Neighbor BS shall not be included in UCD setting.

Note: the fixed fields of the neighbor BS' UCD message may be represented by UCD TLVs 198 through 201.

[In 802.16e-2005, section 11.1.7, page 664, modify as follows:]

Name	Type (1 byte)	Length (1 byte)	Value (variable-length)
DCD_settings	1	*Variable*	The DCD_settings is a compound TLV ~~value~~ that encapsulates TLVs from the neighbor BS' ~~a~~ DCD message ~~(excluding the generic MAC header and CRC)~~ that may be transmitted in the advertised BS downlink channel. This information is intended to enable fast synchronization of the MS with the advertised BS downlink. The DCD settings fields shall contain only neighbor's DCD TLV values that are different from the serving BS corresponding values. Neighbor BS DCD TLVs that are already represented within the fixed fields of the MOB_NBR-ADV message (e.g. BS_EIRP, DCD configuration change count, neighbor BSID) shall be excluded. For values that are not included, the MS shall assume they are identical to the corresponding values of the serving BS. The duplicate TLV encoding parameters within a Neighbor BS shall not be included in DCD setting.
UCD_settings	2	*Variable*	The UCD_settings is a compound TLV ~~value~~ that encapsulates TLVs from the neighbor BS' ~~a~~ UCD message ~~(excluding the generic MAC header and CRC)~~ that may be transmitted in the advertised BS downlink channel. This information is intended to enable fast synchronization of the MS with the advertised BS uplink. The UCD settings fields shall contain only neighbor's UCD TLV values that are different from the serving BS's corresponding values. Neighbor BS UCD TLVs that are already represented within the fixed fields of the MOB_NBR-ADV message (e.g. UCD configuration change count) shall be excluded. For values that are not included, the MS shall assume they are identical to the serving BS's corresponding values. The duplicate TLV encoding within a Neighbor BS shall not be included in UCD setting.

3.13. Changes for remedy #18

[In 802.16e-2005, page 125, relocate table 109g and place it as follows:]

PHY Profile ID

The PHY Profile ID is the aggregate ID's including the Co-located FA Indicator bit, the FA Configuration indicator bit, Time/Frequency Synchronization Indicator, BS EIRP Indicator, DCD/UCD Reference Indicator, FA Index Indicator, and the FA (Frequency Assignment) number. For systems using OFDM or OFDMA, the bit-by-bit definition of the PHY Profile ID is shown in Table 109g. If the Co-located FA Indicator bit is set, the following field of the NBR-ADV element including Preamble Index, HO Process Optimization, DCD/UCD Configuration Change Count, and TLV Encoded Neighbor Information may be omitted.

Table 109g—Bit-by-bit definition of PHY Profile ID of the BS

Item	Size	Notes
Co-located FA Indicator	1 bit	If the BS (or FA) is co-located with the serving BS, this bit is set to 1.
FA Configuration Indicator	1 bit	If this bit is set 1, the BS has the same FA configuration (the same number of FAs as well as their frequencies) as the BS broadcasting the NBR-ADV.
Time/Frequency Synchronization Indicator	2 bits	0b00 = Unsynchronized 0b01 = Time synchronization 0b10 = Time and Frequency synchronization If time synchronization is indicated for the OFDMA PHY, then the downlink frames transmitted by the serving BS and the Neighbor BS shall be synchronized to a level of at least 1/8 cyclic prefix length. If frequency synchronization is indicated for the OFDMA PHY, then the BS reference clocks shall be synchronized to a level that yields RF center frequency offset of no more than 1% of the OFDMA carrier spacing of the Neighbor BS.
BS EIRP Indicator	1 bit	If this bit is set, the BS EIRP follows the PHY Profile ID.
DCD/UCD Reference Indicator	1 bit	1: The DCD/UCD settings of this neighbor BS are the same as those of the preceding neighbor BS unless the TLV information specifies. 0: The DCD/UCD settings of this neighbor BS are the same as those of the serving BS unless the TLV information specifies.
FA Index Indicator	1 bit	Only if this bit is set to 1, the FA Index follows the PHY Profile ID. In addition, if the FA Indicator is followed, the DL center frequency shall be omitted in the DCD/UCD difference TLV information.
Trigger Reference Indicator	1 bit	The Trigger Reference Indicator is related to the Neighbor BS trigger metric TLV information of this neighbor BS. 1: The trigger settings of this neighbor BS are the same as those of the preceding neighbor BS. 0: The trigger settings of this neighbor BS are the same as those provided by the serving BS (via DCD).If the TLV information is present, it overrides values inherited from preceding neighbor BS.

FA Index

Only if the FA Index Indicator bit in the PHY Profile ID is set to 1, the FA Index follows the PHY Profile ID. In addition, if the FA Indicator is followed, the DL center frequency shall be omitted in the DCD/UCD difference TLV information. The bit-by-bit definition shall be determined by a service provider or a governmental body like FCC.

3.14. Changes for remedy #19

[In 802.16e-2005, section 6.3.22.2, page 239, modify as follows:]

...In case Key Request/Key Reply handshake is not omitted, BS shall send REG-RSP, solicited or not. If REG-RSP is not omitted, network re-entry process completes with REG-RSP message.
In case the RNG-RSP message includes PHY adjustment TLVs (i.e. Timing Adjust, Power Level Adjust, Offset Frequency Adjust), the MS shall immediately correct PHY offset accordingly, but is not required to complete within the duration of RNG-RSP processing time (Table 342).

— Termination of MS Context…