Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Network Topology Advertisement for IEEE 802.16j**
Date Submitted	**2006-11-7**

Source(s)	Chie Ming Chou, Wern-Ho Sheen, Fang-Ching Ren, Jen-Shun Yang, chieming@itri.org.tw Tzu-Ming Lin, I-Kang Fu, Ching-Tarng Hsieh Industrial Technology Research Institute (ITRI) / National Chiao Tung University (NCTU) 195,Sec. 4, Chung Hsing Rd. Chutung, Hsinchu, Taiwan 310, R.O.C

Re:	IEEE 802.16j-06/027: “Call for Technical Proposals regarding IEEE Project P802.16j”
Abstract	This contribution describes procedures of network topology advertisement for 802.16j
Purpose	Propose a network topology advertisement procedure and required messages for IEEE 802.16j specification
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>.

1

Network Topology Advertisement for IEEE 802.16j

I. Introduction

In the specification of IEEE802.16e-2005, a BS shall broadcast information about the neighboring BSs to MSs to facilitate the operation of MAC layer handover procedures. In MR networks, an RS which acts like a BS to MSs also needs do the advertisement to their associated MSs. How to perform this functionality efficiently is a key design issue in MR networks, especially when there is a large number of RSs in the network. In this contribution, an efficient method for network topology advertisement for IEEE 802.16j is proposed. By defining new messages exchange between an MR-BS and RSs, the new method performs the network topology advertisement more efficiently than the one using only the legacy flow of message in IEEE802.16e-2005.

II. System Assumptions

According to IEEE802.16mmr-06/002r1 [1], the objective of MR is to provide coverage extension and/or throughput enhancement without any modifications on the MS specification. To support this, we assume RS behaves like a conventional BS to MSs and has its own BSID and preamble. Here RS's BSID has the same format as the legacy one. Besides, MR-BS is assumed to have full knowledge of the network topology which may be obtained over the backbone.

III. 2. Methods for Topology Advertisement in MR Networks

To help describe the network topology advertisement, we consider a simple relay network as an example, see Figure 1, which consists of two MR-BSs, three RSs, and five MSs. RS1 and RS2 are underMMR-BS1's control, and RS3 is under MMR-BS2's control.

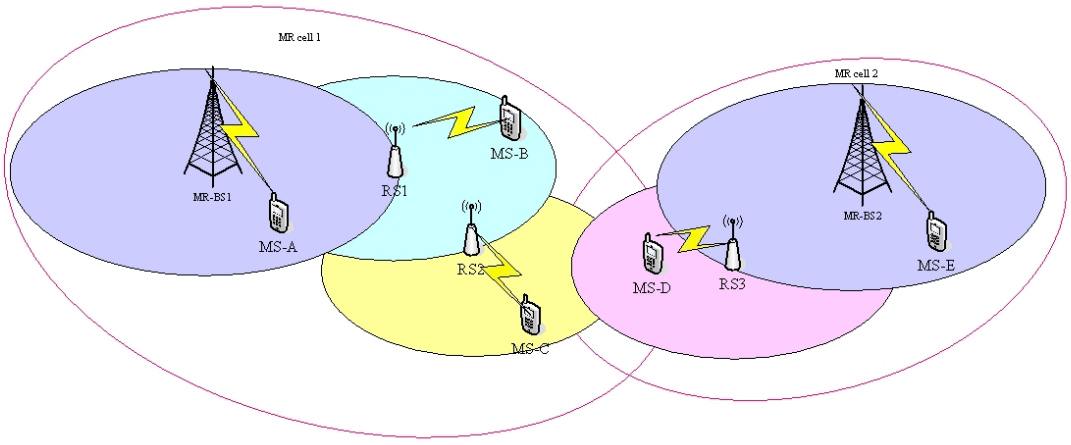

Figure 1 A simple relay network

Two methods will be discussed. In the first one, the existing IEEE 802.16e-2005 message MOB_NBR-ADV is employed without any change, and in the second one, in addition to MOB_NBR-ADV, a new flow of message exchanges between an MR-BS and RSs is employed to facilitate an efficient network topology advertisement.

A. The Existing IEEE 802.16e-2005 Network Topology Advertisement

In this method, since there is no change in the existing way of doing network topology advertisement, one MOB_NBR-ADV containing all information of neighbors is broadcasted by the MR-BS for all RSs and MSs within the MR-cell. The first-hop RSs (RS1 in this example) receive this message and broadcast it to its associated subscribers without any modifications. The second-hop RSs (RS2 in this example) do the same, and so do the k-hop RSs for $k > 2$. A signal flow for this method is shown in Figure 2. Under this operation, an RS behaves like a repeater during the network topology advertisement. The neighbors in this method are defined from the view point of an MR-cell. Take Figure 1 as an example, MR-BS1 broadcasts an MOB_NBR-ADV which contains the information of MR-BS1, RS1, RS2, and RS3. As a result, all MSs (MS-A, MS-B and MS-C) under MR-cell 1 will receive the same information and learn the overall neighboring stations. However, some information in MOB_NBR-ADV may be useless for a specific MS and that results in an undue overhead. For example, the advertisement regarding RS3 is useless for MS-B. In addition, MS may waste a lot of resources for doing MS scanning.

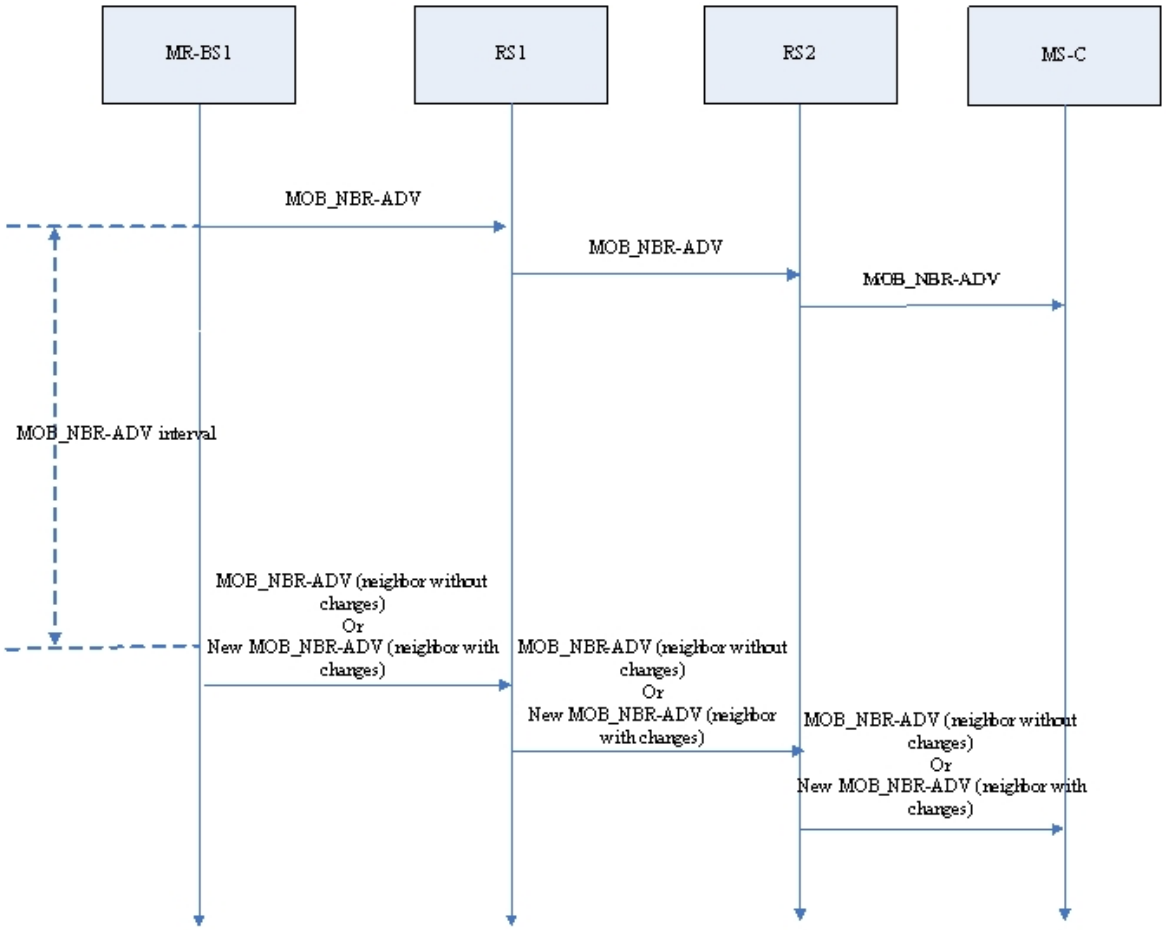

Figure 2 Example of signaling flow for the existing IEEE 802.16e-2005 method

B. The Proposed Method

The basic idea of this method is that an MR-BS unicasts a newly designed message to an RS to notify the changes of its neighbors. Based on this information, the RS broadcasts its own MOB_NBR-ADV in contrast to the previous method that all neighbors of the MR-cell will be broadcasted. According to this design, the neighbors are defined from the view point of the MR-BS or RS. Take Figure 1 as an example: MR-BS1's neighbors are RS1; RS2's neighbors are MR-BS1 and RS3; RS3's neighbors are RS2 and RS4. Since an MS only receive relevant neighborhood information. This can avoid unnecessary MS scanning and reduce the operational load during HO procedures for MR systems.

To implement this method, new MOB_RS_NBR-REQ and MOB_RS_NBR-RSP messages between MR-BS and RS are required. As shown in Figure 3, after learning that there are changes in the neighbors of RS1 and RS2, the MR-BS unicasts MOB_RS_NBR-REQ messages to respective RSs, and in response, RS1 and RS2 send MOB_RS_NBR-RSP messages to confirm the changes. At the same time, RS1 and RS2 update their information in their MOB_NBR-ADV messages and broadcast to their associated subscribers.

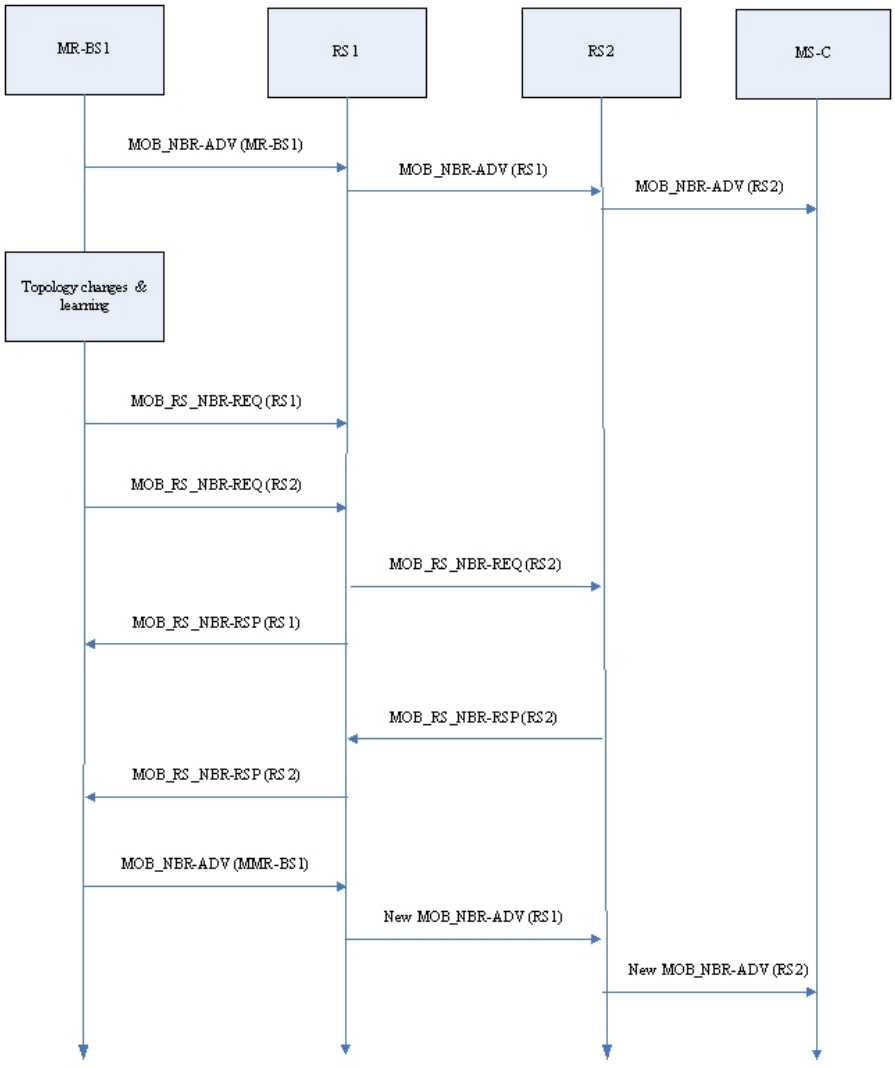

Figure 3 Example of signaling flow for proposed method

C. Resource Utilization and Comparisons

To analyze the resource utilization of these two methods, we assume there are total of *M* stations including one MR-BS and *M-1* RSs shall advertise their neighborhood information in an MR-cell. Denote n_i be the number of stations needed to be advertised by the station *i*, and *N* be the number of stations needed to be advertised by the MR-cell. Since in the existing IEEE 802.16e-2005 network topology advertisement, every MR-BS and RS has to broadcast the information of all the advertised stations, the required radio resource is

$$\text{Required Radio Resources} \propto M \cdot N \quad (1)$$

On the other hand, for the proposed method, since only the information of relevant advertised stations needs to be broadcasted by the MR-BS and RSs, the required radio resource is

$$\text{Required Radio Resource} \propto \sum_{i=1}^{M} n_i \quad (2)$$

It can be observed that $\sum_{i=1}^{M} n_i < M \cdot N$ because $n_i < N$. $\eta = \sum_{i=1}^{M} n_i \Big/ (M \cdot N)$ will be employed as the figure of merit for comparison of the two methods.

C.1 Multi-hop coverage extension usage

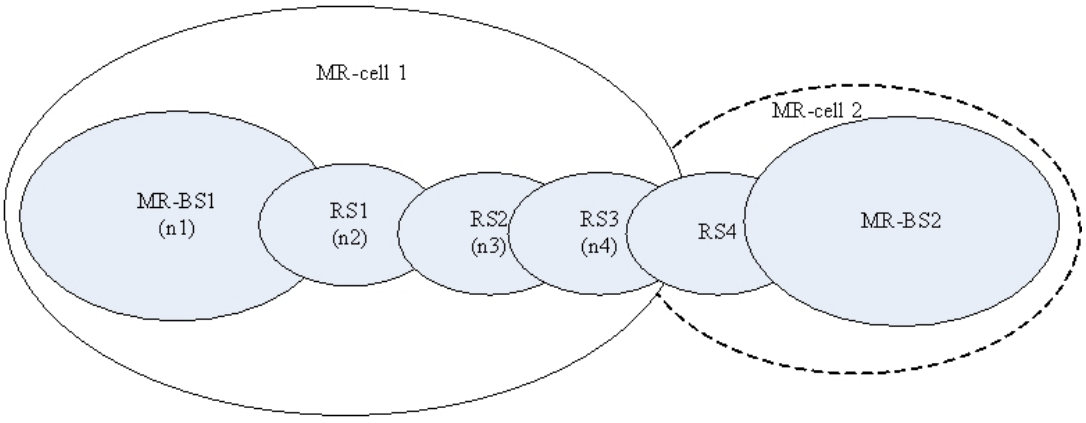

Figure 4 Example of multi-hop coverage extension usage scenario

In this example, in MR-cell 1, *M*=4, *N*=5, $n_1 = 2, n_2 = 3, n_3 = 3, n_4 = 3$, and

$$\eta = \frac{2+3+3+3}{4 \cdot 5} = 0.55$$

C.2 Coverage hole usage:

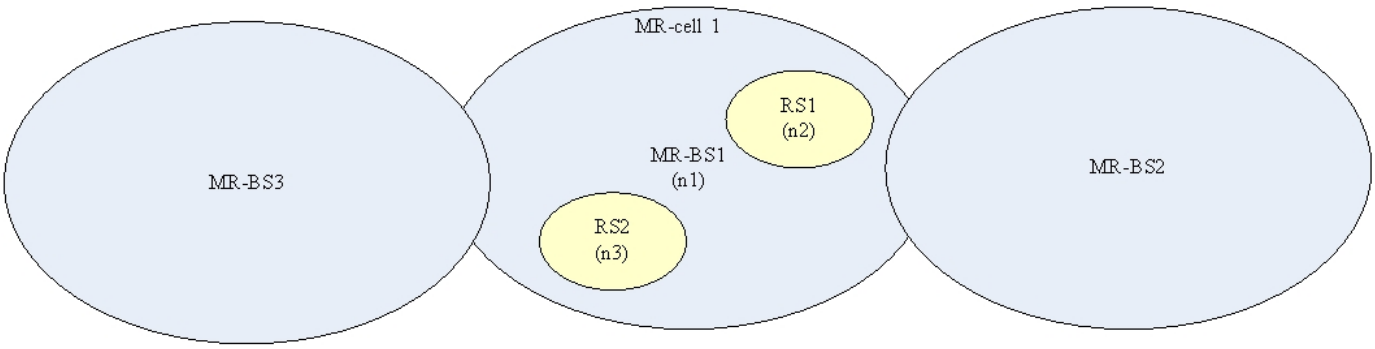

Figure 5 Example of coverage hole usage scenario

In this case, *M*=3, *N*=5, $n_1 = 5, n_2 = 2, n_3 = 2$, and

$$\eta = \frac{5+2+2}{3\times 5} = 0.6$$

C.3 Two-hop coverage extension usage

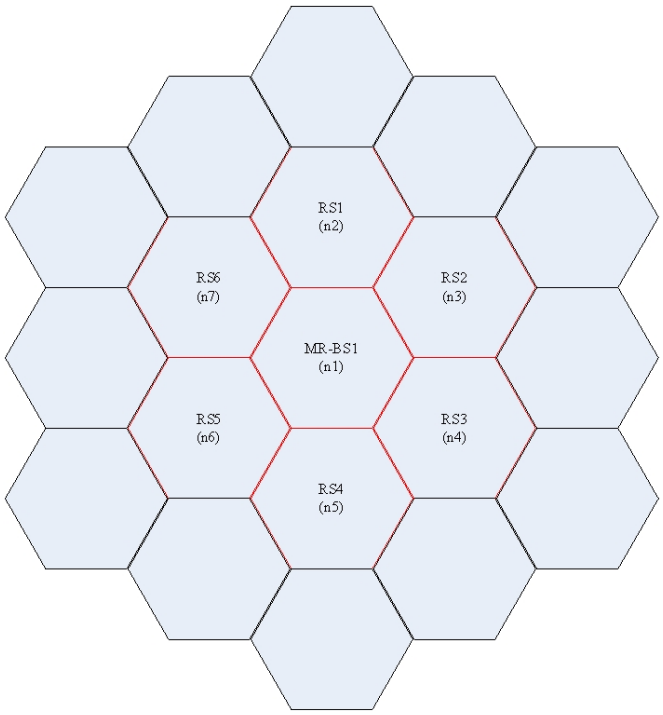

Figure 6 Example of two-hop coverage extension usage scenario

In this case, in MR-cell 1, *M*=7, *N*=19, $n_i = 7, i = 1 \cdots 7$, and

$$\eta = \frac{7\times 7}{7\times 19} \approx 0.37$$

Clearly the proposed method is more efficiently than the existing method in all three cases. Note that in the proposed method, when there is a neighborhood change, the signaling flow given in Figure 3 needs to be performed in order to notify RSs the changes. It is foreseen that this type of messages exchange happens very infrequently. Table 1 gives qualitative comparison of the two methods.

Table 1 Comparison of the two methods

	Required new message	Consumed resources for advertisement	Given information confuse MS
The existing IEEE 802.16e-2005 network topology advertisement	No	Larger	Yes
The proposed method	Yes	Smaller	No

IV. Proposed Texts

----------Start text proposal----------

6.3.22 MAC layer handover procedures [3]

[Insert the following text into this section]

A MR-BS shall notify the changes of neighborhood information using the MOB_RS_NBR-REQ message to its related subordinate RSs. A MOB_RS_NBR-RSP message is transmitted by RS to confirm the results. After receiving MOB_RS_NBR-REQ message, RS will update its neighborhood information and originate its own MOB_NBR-ADV message for network topology advertisement.

6.3.2.3 MAC management messages

[Insert the following text into this section]

Add the columns into Table 14 as indicated

Table 14—MAC Management messages

Type	Message name	Message description	Connection
67	MOB_RS_NBR-REQ	RS neighborhood information request message	Basic
68	MOB_RS_NBR-RSP	RS neighborhood information response message	Basic

RS Neighborhood Request (MOB_RS_NBR-REQ) message

MR-BS supporting mobile functionality shall be capable of transmitting MOB_RS_NBR-REQ management messages to related subordinate RSs after topology learning. The message indicates the changes of RSs' neighborhood and help origination of RS's MOB_NBR-ADV message. The message shall be transmitted on the basic CID.

The format of the MOB_RS_NBR message is depicted in Table A.

Table A—MOB_RS_NBR-REQ message format

Syntax	Size	Notes
MOB_RS_NBR-REQ_Message_format(){	—	—
Management Message Type=67	8 bits	—
Advertisement interval	5 bits	In unit of second. Indicates RS the MOB_NBR-ADV interval
Add-neighbor bitmap	1 bits	If set to 1, add information in MOB_NBR-ADV If set to 0, no action
Delete-neighbor bitmap	1 bits	If set to 1, delete information in MOB_NBR-ADV If set to 0, no action
Padding	1 bits	For alignment to byte boundary
If (Add-neighbor bitmap = =1){	—	—
Skip-optional-files bitmap	8 bits	Bit [0]: if set to 1, omit Operator ID field. Bit [1]: if set to 1, omit NBR BS ID field. Bit [2]: if set to 1, omit HO process optimization field. Bit [3]: if set to 1, omit QoS related fields. Bit [4]–[7]: *Reserved.*
If (Skip-optional-fields-[0]=0){	—	—
Operator ID	24 bits	Unique ID assigned to the operator.
}	—	—
Fragmentation Index	4 bits	Indicates the current fragmentation index.
Total Fragmentation	4 bits	Indicates the total number of fragmentations.
New_N_NEIGHBORS	8 bits	Number of new neighbors for this RS
For (j=0; j<New_N_NEIGHBORS;j++){	—	—
Length	8 bits	Length of message information within the iteration of New_N_NEIGHBOR in bytes.
PHY Profile ID	8 bits	Aggregated IDs of Co-located FA Indicator, FA Configuration Indicator, FFT size, Bandwidth, Operation Mode of the starting subchannelization of a frame and Channel Number.
If (FA Index Indicator = =1){	—	—
FA index	8 bits	This field, Frequency Assignment Index, is present only the FA Index Indicator in PHY Profile ID is set. Otherwise, the neighbor Station has the same FA Index or the center frequency is indicated using the TLV encoded information.
}	—	—
If (Station EIRP Indicator = =1){	—	—
Station EIRP	8 bits	Signed Integer from –128 to 127 in unit of dBm This field is present only if the Station EIRP indicator is set in PHY Profile ID. Otherwise, the Station has the same EIRP as the serving Station.
}	—	—

If (Skip-optional-fields[1]=0){	—	—
Neighbor BSID	24 bits	This is an optional field for OFDMA PHY and it is omitted or skipped if Skip optional fields Flag = 1.
}	—	—
Preamble Index/Subchannel Index	8 bits	This parameter defines the OFDMA PHY specific preamble
If (Skip-optional-field[2]=0){	—	—
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 Station 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 re-entry processing Bit #3: Omit REG-REQ/RSP management during current re-entry processing Bit #4: Omit Network Address Acquisition management messages during current re-entry processing Bit #5: Omit Time of Day Acquisition management messages during current reentry processing Bit #6: Omit TFTP management messages during current re-entry processing Bit #7: Full service and operational state transfer or sharing between serving station and target station (ARQ, timers, counters, MAC state machines, etc…)
}	—	—
If (Skip-optional-field[3]=0){	—	—
Scheduling Service Supported	8 bits	Bitmap to indicate if Station supports a particular scheduling service. 1 indicates support, 0 indicates not support: Bit #0: Unsolicited Grant Service (UGS) Bit #1: Real-time Polling Service (rtPS) Bit #2: Non-real-time Polling Service (nrtPS) Bit #3: Best Effort Bit #4: Extended real-time Polling Service (ertPS)

		If the value of bit 0 through bit 4 is 0b00000, it indicates no information on service available. Bits #5–7: *Reserved*; shall be set to zero.
}	—	—
DCD Configuration Change Count	4 bits	This represents the 4 LSBs of the Neighbor Station current DCD configuration change count.
UCD Configuration Change Count	4 bits	This represents the 4 LSBs of the Neighbor Station current DCD configuration change count.
TLV Encoded Neighbor information	variable	TLV specific
}	—	—
}		
If (Delete-neighbor bitmap = =1){	—	—
Delete_N_NEIGHBORS	8 bits	Number of neighbors shall be deleted for this RS
For (j=0; j< Delete_N_NEIGHBORS;j++){	—	—
Preamble Index	8 bits	Indicate the deleted neighbors
}	—	—
}	—	—
}	—	—

RS Neighborhood Response (MOB_RS_NBR-RSP) message

This message shall be transmitted by RS in response to the MOB_RS_NBR-REQ message and confirm its relevant neighborhood. The message shall be transmitted on the basic CID.

The format of the MOB_RS_NBR message is depicted in Table B.

Table B—MOB_RS_NBR-RSP message format

Syntax	Size	Notes
MOB_RS_NBR-RSP_Message_format(){	—	—
Management Message Type=68	8 bits	—
N_NEIGHBORS	8 bits	Number of neighbors for this RS
For (j=0; j< N_NEIGHBORS; j++){	—	—
Preamble Index	8 bits	Indicate the neighbors
}	—	—
}	—	—

----------End of text proposal----------

References

[1] IEEE 802.16mmr-06/002r1, “Draft P802.16j PAR and Five Criteria: Mobile Multihop Reply”.

[2] IEEE 802.16j-06/016r1, “Proposed Technical Requirements Guideline for IEEE 802.16 Relay TG”.

[3] IEEE 802.16j-06/017r2, “Table of Contents of Task Group Working Document”.