Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Neighborhood Discovery and Topology Learning**
Date Submitted	**2006-11-07**
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Re:	IEEE 802.16j-06_027: "Call for Technical Proposals regarding IEEE Project P802.16j"
Abstract	Define topology learning and update mechanism
Purpose	For text changes in emerging amendment of IEEE 802.16e-2005 to support MMR functionality.
Notice	
Release	
Patent Policy and Procedures	

Neighborhood Discovery and Topology Learning

1 Introduction

This document is to describe neighborhood discovery mechanism in an MMR-enabled cell as an input for call for contribution of 802.16j task group. Neighborhood discovery is an important part in IEEE C802.16j table of contents [1].

In MMR-enabled cell, one or several RSs are introduced to improve coverage or enhance capacity. They may be interconnected (via or not via BS) as a logical view of chained, tree, and even multi-hop topology. MMR-BS is required to have the capability to collect and maintain the interconnection information between BS and RS, RS and RS, and RS and MS in order to provide a high-efficient radio resource allocation and network management. In addition, neighborhood relationship can change due to many events, such as new RS entry, RS neighbor-information report, mobile RS handover, RS exit (normal procedure and fault occurrence), topology adjustment due to system optimization, and etc. Hence, neighborhood discovery functionality is required at both RS and MMR-BS to keep the neighborhood relation up-to-date.

In this document, we propose a centralized mechanism for automatic real-time neighborhood discovery in order to reduce RS complexity. The basic idea of neighborhood discovery is that RS makes measurement while other RS is transmitting signals and report MMR-BS the measured CINR (or RSSI); BS will finally decide the neighborhood relation between different RSs by comparing the measurement values in the reports from all RSs.

2 Neighborhood discovery mechanism

According to the requirement in IEEE 802.16j TOC, there exist all kinds of neighborhood topology in MMR-enabled cell. Basically, a star or chain topology can be composed by MMR-BS and multiple RSs. In some case, the combination of them and multi-hop relaying may happen. In Figure-1, all kinds of neighborhood topology have been shown. Because MMR-BS needs to manage all its subordinate RSs (no matter it is used for coverage extension or capacity enhancement) and allocate radio resource to them, MMR-BS must have the knowledge of the neighborhood of each RSs in the MMR-enabled cell.

The neighborhood of a RS may changes due to many events, such as new RS entry, RS neighbor-information report, mobile RS handover, RS exit (normal procedure and fault occurrence), topology adjustment due to system optimization, and etc. Hence, neighborhood discovery should provide a mechanism to keep the neighborhood information of each RS up-to-date. Second, neighborhood discovery procedures must be consistent with former IEEE 802.16 standards. Finally, neighborhood discovery process cannot make the RS too complex and should be transparent to user terminals.

Typically, there are two different mechanisms to collect the neighborhood information: centralized discovery and distributed discovery. In distributed discovery, each RSs, as same as MMR-BS, needs to maintain an independent neighborhood list and broadcast that list to its neighbors periodically. RS becomes very complex in the distributed discovery mechanism because it needs not only to discover neighbor stations, but also to maintain a neighborhood table and broadcast its update. Also, distributed neighborhood discovery cannot make a quick response to the topology changes. Some time may be needed for a RS to broadcast its detected neighborhood changes. Meanwhile, MMR-BS still allocates radio resource based on the old topology, and the efficiency of resource allocation decreases. Therefore, centralized discovery is recommended in our contribution where RS is only need to send some measurement reports to MMR-BS. In the centralized discovery, neighborhood discovery is hosted in MMR-BS and RS. MS, basically, is transparent to this process. All kinds of RSs, including fixed RS, nomadic RS, and mobile RS, should report MMR_BS its capability and all the detected neighboring RSs together with their CINR (or RSSI) levels. MMR_BS is responsible to build and maintain a neighborhood topology table containing all its subordinate RSs and MSs according to the received reports from RSs. This topology is the basis of radio resource assignment, and MMR-BS will assign the radio resource based on the received bandwidth requirement and the topology information. Because RS need not to maintain any table, RS functionality becomes simple in centralized discovery. Also, as RS send a report right after the measurement, MMR-BS will be able to provide fast response to any topology change. In addition, the neighborhood topology table only exits at MMR-BS. Hence it is very easy to maintain. Although RS function for centralized discovery is very simple, RS still need to have measurement and report functionality. To realize that, IEEE 802.16j need to have some extra MAC-layer management messages: NBR_REP and NBR_RSP.

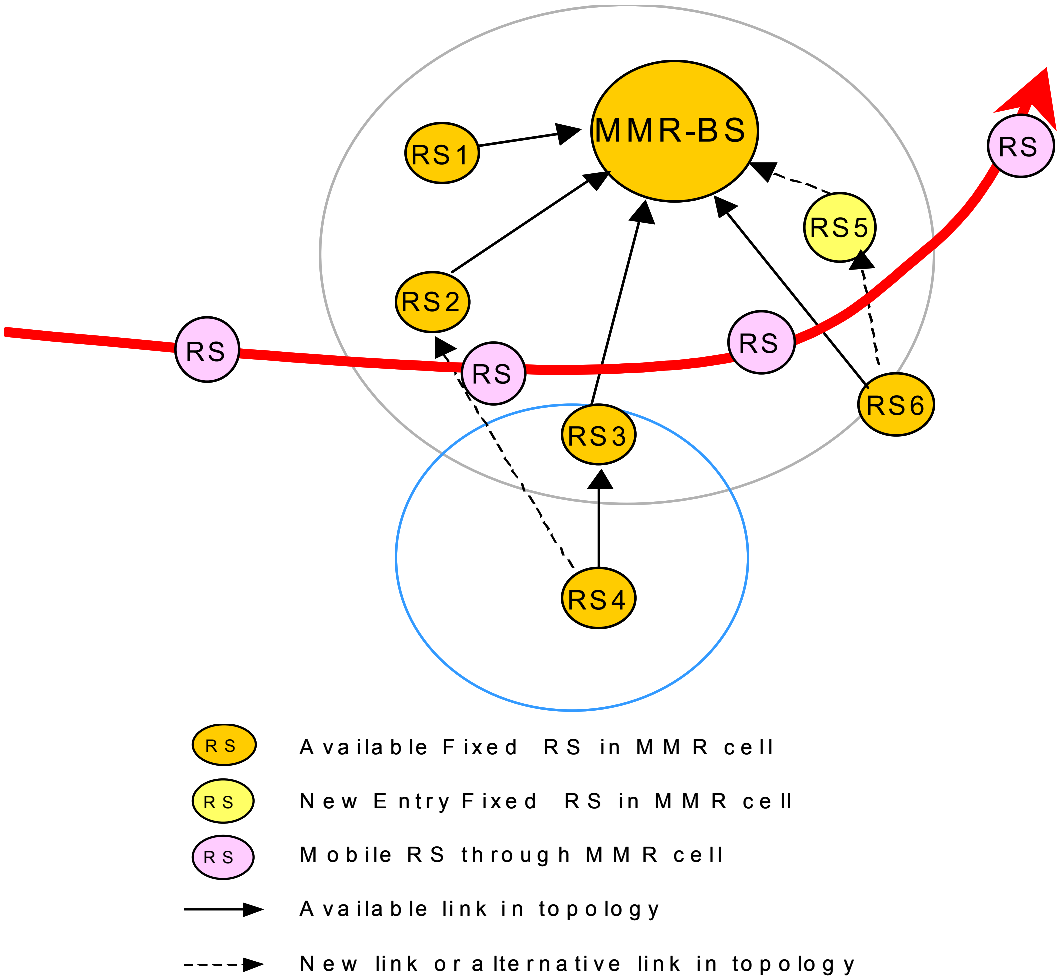

Figure 1: Neighborhood topology examples

The basic idea of centralized neighborhood discovery is that RS makes measurement while other RS is transmitting signals, and reports MMR-BS the measured CINR (or RSSI); MMR-BS will finally decide the neighborhood relation between different RSs by comparing the measurement values in the reports from all

RSs. In order to simplify the whole process, neighborhood discovery measurement is performed by RSs in the DL subframe where only MMR-BS and RSs are allowed to transmit.

3 Proposed text draft

6.3.26 Relay station neighborhood discovery

Relay station neighborhood discovery is a process to find the changes in the connectivity conditions of an active RS to its neighbor stations. The discovery result should be reported to MMR-BS, who is responsible to generate and maintain a topology table according to the received reports from the subordinate RSs. That topology table will provide basic information to help MMR-BS allocate the radio resource to each RS. Once a new RS entry is finished, MMR-BS setups a new row item in the topology table and records its active access station. That item will be updated according to future measurement reports from RSs. If MMR-BS find that a RS exit the network, its corresponding contents in the topology table is deleted.

RS neighborhood discovery include following steps:
1) RS get the knowledge of transmission intervals and subchannels of each RS from DL-MAP.
2) RS measures signals transmitted from other RSs in DL subframe.
3) If the measured CINR/RSSI is greater than a threshold, RS send an unsolicited NBR-REP message to MMR-BS to report the existence of a new neighbor in the next UL allocation. One NBR-REP report message may contain measurement results of multiple RSs, and the same CID numbers as specified in DL-MAP are used as the identification of different RSs in the report.
4) MMR-BS will process the received reports and update the neighbor stations of each RS in the topology table. If a neighbor station can provide a better connection link by relay, that neighbor station is selected as the active access station of the RS and the original access station degrades to a neighbor station.

Topology table is updated due to the occurrence of some network events, such as new RS entry or RS re-entry, RS neighbor-information report, mobile RS handover, RS exit (normal procedure and fault occurrence), topology adjustment due to system optimization, and etc. It is recommended that: MS shall be not included in the topology table for the sake of stationary of topology table even resulting from frequent MS entry/exit events. In order to manage MSs effectively, a MS-attachment table is needed at MMR-BS to record that which RS (or BS) a MS is belonging to. RS, therefore, also reports detected MSs information to MMR-BS or parent RSs, triggered by MS entry and MS handover event, to indicate MMR-BS which RS that MS is connected to.

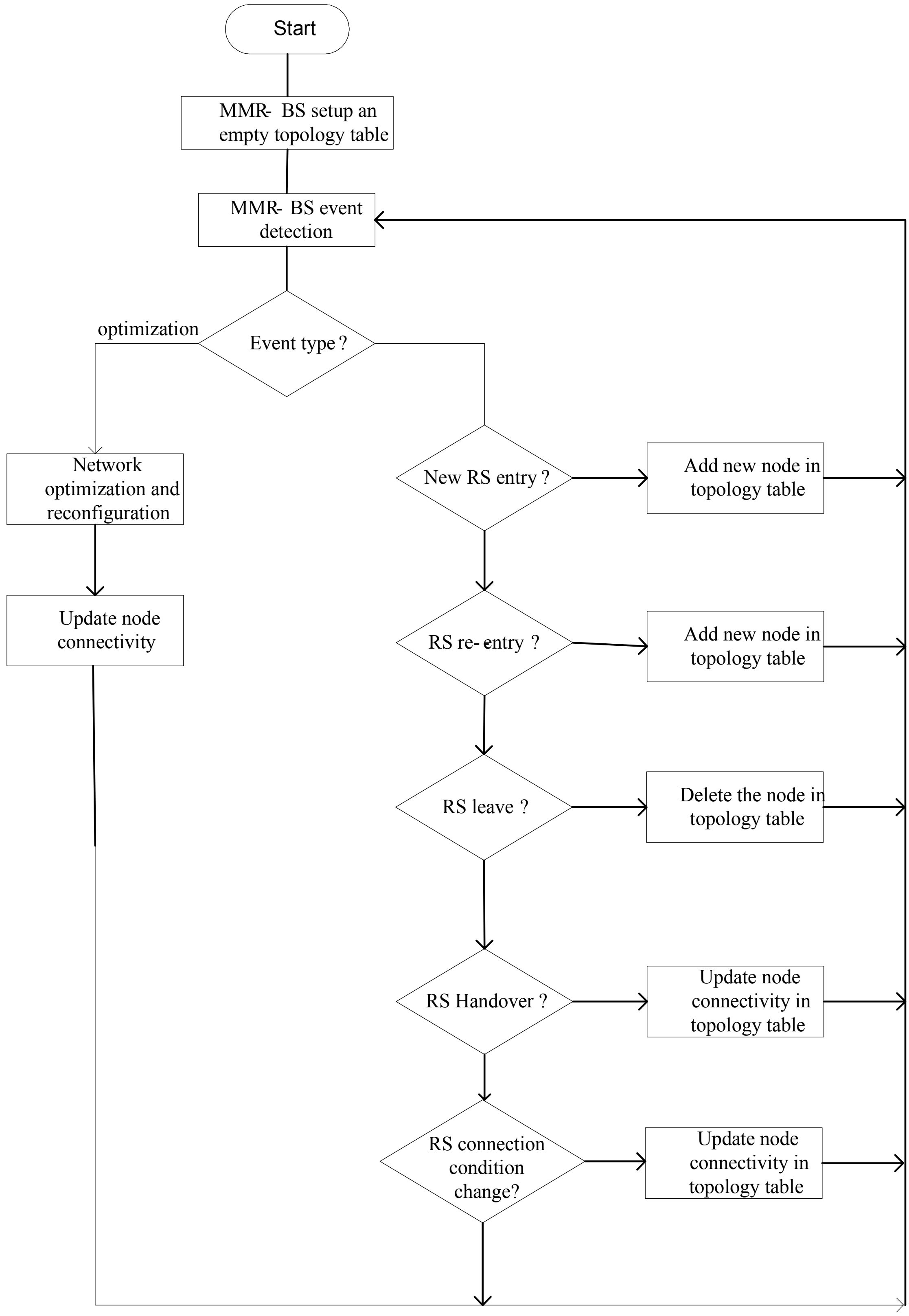

Figure 2: The neighborhood topology learning and maintenance procedures

This neighborhood topology learning and updating mechanism is centrally controlled by MMR-BS. The neighborhood topology learning and maintenance procedure can be divided into the following steps, as depicted in Figure 2.

1) MMR-BS sets up an empty topology table during its initialization phase. This topology table could be empty or configured by the operators with some parameters to reflect existing RSs. It will be used to store connectivity conditions between all the RSs in MMR cell.
2) Once MMR-BS detects an event that may change MMR-cell topology, it will act according to the type of received event. If the event is an optimization and reconfiguration command from management unit, MMR-BS will first do some optimization work based on all the available information to update the topology.
3) If the event is a new RS network entry, RS re-entry, or RS leave, MMR-BS adds new nodes or deletes the corresponding nodes in its topology. There are two reasons for RS leave: one is regular RS power off, and the other is RS node failure. A timely topology update therefore can provide a better network reliability.
4) If the event is a RS handover or RS connection condition change, MMR-BS shall update the topology connectivity according to the new connection conditions. The event of RS connection change happens when a RS reports a much larger CINR (or RSSI) in its neighbor RS measurement. In this case, topology need to be updated because that neighbor RS may provide a better throughput by using a multi-hop relayed link.

After topology update, MMR-BS shall send the new neighborhood information to the affected MSs in order to facilitate the operation of MAC layer handover procedures. This can be realized by MOB_NBR_ADV sent from MMR-BS to those MSs. RS shall only forward MOB_NBR_ADV to its MSs without any change.

In addition to provide flexibility and redundancy of the network, MMR-BS may have the following schemes to distribute topology table if necessary. The topology information shall be transported in the basic management connection of RS. In multi-hop relay link, medium RS shall only be responsible to forward the MAC management messages to the destination RS.

1) MMR-BS maintain topology tables itself, and don't distribute the topology table to RSs. RS therefore has no topology knowledge at all. In this method, the overhead of control information is low although the flexibility of the network is not high. This scheme is suitable to small network dimension.
2) Organize all the RSs in MMR cell into cluster structure. A cluster RS is the RS that is designated to maintain topology information for a group of RS. MMR-BS distributes related topology information to the cluster RS regularly. In this scheme, the overhead of control information is medium, and network becomes more redundancy.
3) MMR-BS broadcast part of or full topology table to all the RSs in MMR cell, and all RSs have the part of or full topology table. The network becomes high flexible and the overhead of control information is also high. This scheme is suitable to large-scale network.

To enable RS with the capability to send measurement results of multiple RSs in one report message, NBR-REP and NBR-RSP messages are added in the MAC management messages. The following changes and additions need to be added in IEEE 802.16.

6.3.2.3 MAC management messages

Change the last line of Table 14 as indicated:

67	NBR_REP	Neighborhood information report	Primary managment
68	NBR_RSP	Neighborhood information response	Primary management
69-255		Reserved	—

Insert new subclause 6.3.2.3.62:

6.3.2.3.62 MMR Neighbor Discovery Report (NBR_REP) message

An NBR_REP shall be transmitted by the RS to BS when some new neighbors of it are detected. Neighbor detection mechanism depends on the measurement result of that RS when another RS is transmitting in the DL subframe. The measured metrics can be CINR, RSSI, or both.

To provide flexibility, the message parameters following CID shall be encoded in a TLV form.

A RS should generate NBR_REPs in the form shown in Table 109za, including the following parameters:

CID

The CID as same as specified in DL-MAP for that transmission interval and subchannels are used as the identification of the reported neighbor RS.

All other parameters are coded as TLV tuples, as defined in 11.XX.

Table 109za—MMR Neighbor Discovery Report (NBR_REP) message format

Syntax	Size	Notes
NBR_REP message format (){	—	—
Management message type = 67	8 bits	—
For (i=1; i<=n; i++) {		For each reported neighbor 1 through n
CID	16 bits	
TLV Encoded Attributes	variable	TLV Specific
}		
}	—	—

6.3.2.3.63 MMR Neighbor Discovery Response (NBR_RSP) message

An NBR_RSP shall be transmitted by the BS as an optional response to NBR-REP. An unsolicited NBR_RSP can be sent by BS to inform RS its new access RS and neighboring RSs.

To provide flexibility, the message parameters following CID shall be encoded in a TLV form.

A RS should generate NBR_RSPs in the form shown in Table 109zb, including the following parameters:

RS ID

The ID of the neighboring RS.

CID

CID of the neighboring RS's basic management connection.

Supported Profile

The modulation and coding profile for the radio link between the RS and its neighbor.

Table 109zb—MMR Neighbor Discovery Response (NBR_RSP) message format

Syntax	Size	Notes
NBR _RSP format (){	—	—
Management message type = 68	8 bits	—
Access BS or RS ID	8 bits	
CID of Access BS or RS	16 bits	
Supported profile of Access BS or RS	variable	TLV Specific
For (i=1; i<=n; i++) {		For each reported neighbor 1 through n
RS ID	8 bits	
CID	16 bits	
Profile	variable	TLV Specific
}		
}		

References

[1] IEEE 802.16j-06_016r1, "Proposed Technical Requirements Guideline for IEEE 802.16 Relay TG"

[2] IEEE 802.16j-06_017r2, "Table of Contents of Task Group Working Document"

[3] IEEE C80216mmr-05_023, "Recommendation on 802.16 MMR with Backward Compatibility"