

A Parent Relay Station Selection for Efficient Grouping in IEEE 802.16j Mobile Multi-hop Relay Network

Jiwon Yoon¹, Youn-Soo Kim² and Hyung Seok Kim³

^{1,2,3} Department of Information and Communication Engineering, Sejong University
Gunja 98, Gwangjin-gu, Seoul, 143-737, Republic of Korea

E-mail: ¹jiwonyoon@sju.ac.kr, ²kys009@gmail.com, ³hyungkim@sejong.ac.kr

Abstract: The IEEE 802.16j task group uses the relay station (RS) for the extension of the coverage of the BS and enhancement of throughput. However, if a number of relay stations in a BS cell, the RSs may result in both more frequent handover and higher co-channel interference. To solve this problem, the grouping is required specified in IEEE 802.16j basement document. The selecting method of parent RS managing the group is not specified in base line document of IEEE 802.16j. We propose how to select the parent node in the RS group.

1. Introduction

The existing IEEE 802.16 [1,2] family of standards popularly known as WiMax focuses on providing a broadband wireless access in the metropolitan area network. WiMAX allows Non-Line-Of-Sight (NLOS) and Line-Of-Sight (LOS) communication in the frequency range below 11GHz and 10-66GHz respectively. Further, the QoS support and hard and soft handovers to support full mobility are implemented in WiMAX. Although, initially developed for a point-to-multi point (PMP) single hop communication, multi-hop relaying is recently receiving greater attention in the IEEE 802.16 working group (WG), specifically after the commencement of the IEEE 802.16j [3] MMR task group (TG). In IEEE 802.16j, Relay Station (RS) is developed to provide user throughput enhancement, coverage extension and capacity enhancement to IEEE 802.16. Some usage models of RSs were suggested in, including fixed infrastructure, in-building coverage, temporary coverage, and coverage on mobile vehicle.

Relay station functions are to relay user data and possibly control information between other stations, and to execute processes that indirectly support mobile multi-hop relay. There are two type of relay stations, one is transparent type, and another is non-transparent type. The transparent RS is used to the increase of the capacity of the BS. Thus the throughput enhance within BS coverage. It does not transmit own preamble, FCH, DL-/UL-MAP and DCD/UCD to MS. Thus the resource is managed by BS. The non-transparent RS transmits preamble, FCH, DL-MAP/UL-MAP and DCD/UCD. And this type is purpose for extension of the BS coverage. The MS, deployed out of BS cell, can receive service from the BS thorough the non-transparent RS.

Also, if RSs are configured to broadcast control signals such as preamble, FCH and MAP in a frame, over-the-air overhead might consume too large a part of the MR-BS's radio resource. This problem is getting serious as increasing the number of relays in an MR-cell (multi-hop relay cell). Finally, if a predefined resource is allocated to a specific RS, the resource utilization in an MR-BS would lack of

flexibility, and the system trucking efficiency would become lower.

When the RSs deployed in the vicinity of each other, RSs form a RS Group. Each member RS of RS Group acts like a RS. A group of RSs using a multicast RSID as the RS group ID. The multicast RSID is the same for all members in the group. And all the RS in the RS group transmit the same preamble, FCH, MAP as the super-ordinate station (MR-BS or RS). If the RS group not includes a BS, one of the RSs in the RS group is a non-transparent RS and all the others shall either transmit the same preamble, FCH, MAP as the non-transparent RS. Because of the RS group is managed with the non-transparent RS, the non-transparent RS is the parent RS of the RS group. Since the member of the RS group is decided by the location of the parent RS, the location of the parent is important.

For this purpose, we introduced a method of selecting parent RS for enhanced RS grouping. But the Baseline document not described the about selection of the parent RS in the RS group. Therefore we proposed the scheme about the parent RS selection in the RS group. This paper is configured as follow. In section II, we introduce the RS grouping and management message about RS and section III, we proposed about the selecting parent RS through the procedure and algorithm. We conclude the paper in the section 4.

2. Overview of IEEE 802.16j

2.1 RS grouping

Relay stations are generally simplified kind of a BS. The RS is use different preamble, FCH, MAP from the BS, the benefit is the potential gain from frequency reuse. However the coverage of the RS is small, if there are a number of RSs in the BS cell, the RSs may occur more frequently handover. And this case may result higher co-channel interference on FCH/MAP transmission. Thus when the RSs are located close to each other, BS decide make RS group. The RS group reduces interference [4]. Each RSs in the RS group are assigned multicast RSID as the RS group ID by the BS. The RS group acts like a one RS. Since he RS group has lager coverage than a RS, there would be a lower frequently handover. At entry, the RS can operate its own or form a new group, or join an existing group. The RS can perform measurements such as radio signal from the neighbors, and then report to BS. The BS corresponding the preamble sequence, and providing the RS group ID.

For the downlink, the members of an RS group may be configured to forward traffic data for only specific subordinate terminal nodes. In this way, two RSs in the same RS group may transmit to two different MSs/SSs at

the same time. And transmissions may be scheduled such that multiple RSs in the RS group may transmit to the same MS to exploit macro-diversity. When the RS detect the strong interference from other RS or other RS group, the RS can request to be removed from the RS group and it operate on its own. It selects or is assigned other segment.

If the RS group includes a BS, the RS in the RS group shall either transmit same preamble, FCH, MAP as the BS. If the RS group not includes a BS, one RS of the RS group is a non-transparent RS and the other RS in the RS group transmit same preamble, FCH, MAP as the non-transparent RS.

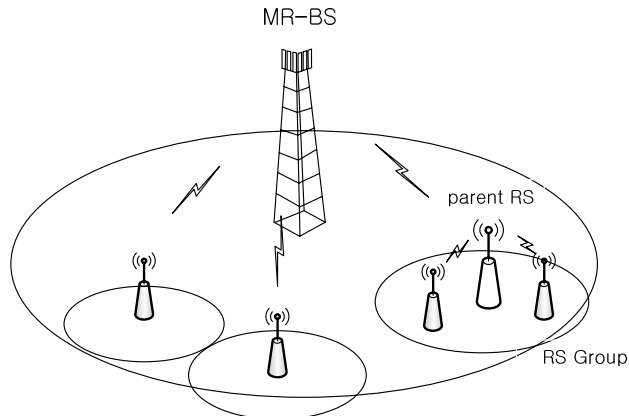


Figure 1. An example of RS grouping

2. 2 Messages

- RS_Config-RCM/REQ

This messages use for the purpose of RS configuration. RS request removal from an RS group or request preamble configuration. MR-BS may transmit this RS_Config-REQ as a response to an RS_Config-REQ.

- RS_Member_List_Update

The RS group parent may transmit this message as a multicast message to update the group members with of the traffic burst they shall forward. When there is a change in the connection list of the RS group members this message is transmitted.

- RS_NBR-MEAS-REP

This message may be transmitted by an RS to the MR-BS or super-ordinate RS on its basic connection. It shall include physical CINR or RSSI of the preamble index, and report the preamble index with the least signal strength.

- MR_LOC-REQ/RSP

This message may use for the location information of the RS. MR_LOC-RSP message shall be transmitted in response to a MR_LOC-REQ message. There is a LLA_IE() syntax in the MR_LOC-RSP message. This message includes the Latitude, the Longitude and the Altitude of the Relay station.

3. Proposed Scheme

In this section, we introduce the method of the selecting parent RS in the RS group. In order to make the group with two RSs, criteria which helps to select one of the RSs as a parent RS is needed. The group is formed by the selected parent RS. Because the parent RS manages all the RSs that

belong to the RS group, the signal quality between the parent RS and MR-BS should be higher than the signal qualities between the parent RS and other RSs. As a measure for the signal quality, we use Received Signal Strength Indication (RSSI).

When another RS comes into the area of the existing RS group, it may make an interference with RSs of the group. All the RSs including the new RS in this group need not select a new parent RS because the new RS can directly receive the preamble from the existing parent RS. Thus, MR-BS assigns the RS group ID to the new RS which makes interference. It means that the new RS becomes a sub-ordinate station of the existing parent RS.

When a new RS is out of parent RS's coverage and makes an interference with the RSs in the group, the new RS can not directly communicate with the parent RS. Thus the new RS cannot join the RS group. If the MR-BS finds an RS which can communicate with both the new RS and all other RSs in the RS group, the MR-BS can replace the existing parent RS with the RS. The important factor during the procedure of replacing the parent RS is locations of all the RSs in the RS group and a new RS making interference.

Selecting a new parent RS is presented in Fig.1. RS1, RS2 and RS3 constitute a RS group. The RS2 is the non-transparent RS of the group and is the parent RS of the group. When RS4 which is a new RS appears and makes interference, they report the interference message to their MR-BS using the RS_NBR-MEAS-REP message.

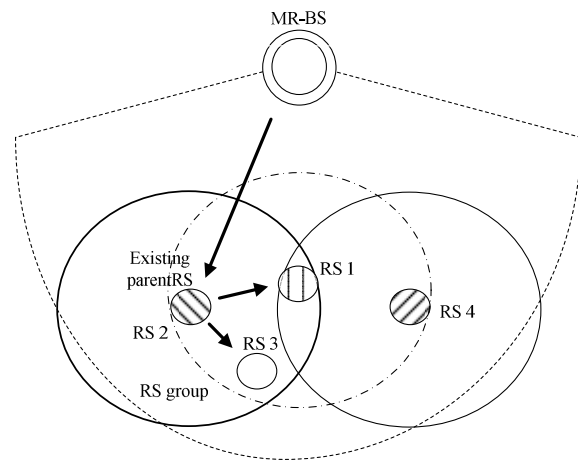


Figure 2. An example of selecting parent RS in the RS group

The MR-BS becomes aware of the interference by the RS_NBR-MEAS-REP message. Then, the MR-BS considers adding RS4 to the existing group. However, the RS4 cannot join the existing RS group, because RS4 is beyond the RS2's range. If RS1 is the parent RS of the group, the RS 4 can join the RS group. The RS3 cannot be a candidate of the parent RS in the group, because its coverage range is not enough to communicate with the RS4. If changing the parent RS causes any RS to be removed from the existing group, the MR-BS does not carry out this procedure and the new RS operates independently.

3.1 Procedure

When a new RS is introduced in other RS's range, a group of other RSs estimates neighbor signal and reports it to the BS. Then the MR-BS requests the location information of both the RS group and the new RS which make interference. MR-BS estimates the location information through MR_LOC-RSP message. The MR_LOC-RSP message includes LLA_IE and it represents the Latitude and Longitude, Altitude. In the Figure.2, the RS 4 makes the interference, then the BS request the location information and the RS send the location information and the MR-BS calculates the average of the location value of the RS 2 and RS 4, the MR-BS selects the candidate for parent RS in this RS group. The MR-BS considers the RS's coverage range, and selects the candidates if there is the RS can involve the new RS in the RS group. Then the RS group can involve all RSs. If there is another RS which can involve both RS 2 and all the RS in the group, the RS is also candidate for parent RS. The MR-BS have to select one parent RS, thus there is required another criteria. Since the parent RS manage all RS in the group, it has to have good signal quality. The WiMAX can measurement the signal quality by the RSSI and CINR.

After selecting parent RS, the MR-BS have to execute changing the parent RS from old parent RS to new parent RS. This process occur by MR-BS send the RS_PARS-REQ message which involve the MAC address of the new parent RS. When the existing parent RS received the message, it sends the information about all the RS in the RS group to the new parent RS. Then the new selected RS acts as the parent of the group. The new parent RS can make the new RS group.

After the changing parent RS, the MR-BS sent the message about join the RS group to the new access RS. This message involve the multicast ID of the group, the new access RS can use the preamble that same as the group. When the access RS is in the RS group, the forming the RS group is done.

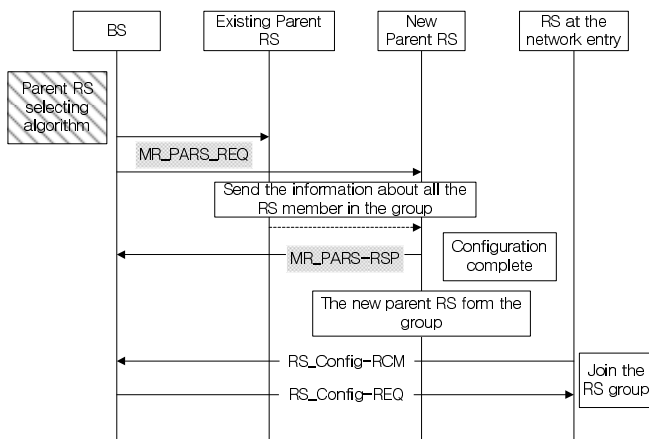


Figure 3. The example for the proposed selecting parent RS signaling

3.2 Messages

Table 1 and Table 2 describe the proposed MR_PARS_REQ/RSP messages. They are the proposed control messages for indication of parent RS in the group. If the existing parent RS received MR_PARS-REQ message, it sends the information of managed child RSs of the group to the newly selected parent RS. The message includes the value of MAC address of the new parent RS. When the MR_PARS-REQ message report type is '00', the MR-BS decides not change about the parent RS. If the report type is '01', it is for the existed parent RS. When the existing parent RS receive this message, it starts sending the information about all the member of the group, and it stop to service as the parent RS. The report type is '10', it is for the new parent RS. When the new parent RS receive the message, the RS execute the reconfiguration of RS group.

Table 1. MR_PARS-REQ message format

Syntax	Size	Notes
MR_PARS_REQ_MESSAGE_FOR_MAT(){	-	-
Management Message type =	8 bits	-
Request type	2 bits	00 = Not change parent RS 01 = for existing parent RS 10 = for new parent RS
If(Request type = 01){		
Parent RS ID	48 bits	The 48bits MAC address of the selected parent RS
}		
If(Request type = 10) {		
}		
}		

Table 2. MR_PARS-RSP message format

Syntax	Size	Notes
MR_PARS_RSP_MESSAGE_FOR_MAT(){		
Management Message type =	8 bits	
}		

The MR_PARS-RSP message may be transmitted by RS to acknowledge the reception of the MR_PARS-REQ message.

3.3 Algorithm

When the BS receives the MR_LOC-RSP message, the BS can estimate the mean value of the location of the RSs. The MR_LOC-RSP message includes the latitude and the

longitude value. The new parent RS is centrally located between existing parent RS and new RS at the network entry, because the parent RS involve the all the RS in the same RS group. So First, we need the location information about the existing parent RS and the new RS which make the interference. The received message represented (a,b),(c,d). The 'a' is latitude value of the existing parent RS and the 'b' is longitude value. The (c,d) represent the location information of the new RS which make the interference with the RS group.

In Figure 4, the part of overlap RS 1 coverage and RS 2 coverage is coverage of the candidate parent RS. For the find the location of the RS, MR-BS estimate the coverage of candidate the parent by the location of both existing parent RS and new RS.

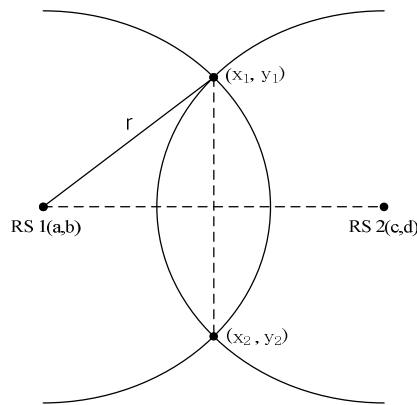


Figure 4. A location coverage of the candidate RS

First, MR-BS can estimate the coverage of the existing parent RS and then it estimate the coverage of the new RS at the network entry. The section that the two of the RS overlap is the coverage area of the candidate RS. Using the coordinate of RS1 and RS2, MR-BS can compute the mean value of the RS1 and RS2. And then intersection point is estimated by the MR-BS using the mean value mentioned above and the coverage of the RS.

After getting the intersection point of two circles, in the coverage from intersection 1 to intersection 2, RS 1 and RS 2 are estimated :

$$\begin{aligned}
 (x - c)^2 + (y - d)^2 \leq r^2 \cap (x - a)^2 + (y - b)^2 \leq r^2 \\
 x_2 \leq x \leq x_1 \\
 y_2 \leq y \leq y_1
 \end{aligned} \tag{1}$$

The coverage of candidate parent RS is derived from the circular equation. The (a,b) and (c,d) are coordinates for RS1 and RS 2, respectively. The 'r' is the radius of coverage of RS. We assume that the coverage range of the RS is the same to all of the RSs. And since the candidate RS has to be located in the coverage area between RS 1 and RS 2, we using the intersection of RS 1's equation and RS 2's equation in the equation (1). Note that the x and y are limited from x1 to x2 and from y1 to y2, respectively.

Since the candidate RS may include the whole RS in the RS group, if the candidate RS's coverage is not satisfied with the other RS in the RS group, the candidate RS is removed. The BS can select many candidate RSs. When the

MR-BS choose more than one of candidate parent RS, the MR-BS make table about the list of candidate parent RS. Because the MR-BS has to choice only one RS, it needs other criteria. In the WiMAX, the measurement about signal quality is used by RSSI and CINR. The candidate RSs can choose by the RSSI.

4. Conclusion

In this paper, we propose the method of determining appropriate parent RS among many RSs and making a group of RSs organized around the parent RS in IEEE 802.16j MMR networks. After the MR-BS receives the RSSI value from RSs, MR-BS decides to select the parent RS which has the best signal quality. And then, the RS group is organized by the selected parent RS. When a new RS is established, our method is able to determine if the new RS may be included in the existing group by using location information of the new RS and the existing parent RS.

Acknowledgment

This work was supported by Seoul R&BD program.

References

- [1] "IEEE Standard for Local and Metropolitan Area Networks Part 16: Air Interface for Fixed Broadband Wireless Systems", IEEE Std. 802.16-2004.
- [2] "IEEE Standard for Local and Metropolitan Area Networks Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems", IEEE Std. 802.16e-2005.
- [3] IEEE 802.16j-06/0264r4. "Baseline Document for Draft Standard for Local and Metropolitan Area Networks Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems Multi-hop Relay Specification", IEEE 802.16j WG. 2007.6.
- [4] IEEE 802.16j-07/144. "Virtual Relay Grouping Concept to Support RSs Sharing the Same Preamble", IEEE 802.16j WG. 2007.3.