Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Reusing the Radio Resources in IEEE 802.16j Multi-hop Relay System**
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Re:	IEEE 802.16j-06/027: “Call for Technical Proposals regarding IEEE Project P802.16j”
Abstract	Text proposal to illustrate how to estimate the potential interference level before reusing the radio resources in IEEE 802.16j Multi-hop Relay system.
Purpose	Proposes the text to illustrate how to estimate the potential interference level before reusing the radio resources in IEEE 802.16j Multi-hop Relay system.
Notice	
Release	
Patent Policy and Procedures	

Reusing the Radio Resources in IEEE 802.16j Multi-hop Relay System

I. Introduction

In the multi-hop relay systems, the coverage extension and user throughput enhancement may be achieved at the expense of system capacity [1, 2]. It is because the duplicated user data is relayed several times and occupies multiple sub-carriers and/or symbol durations over the air, which may result in capacity degradation.

Previous simulation results showed that the capacity can be substantially improved by reusing the radio resources in different relay/access links [1-3]. Note that the radio resources considered in this contribution is the composite of the sub-carriers and symbol durations of each frame. This contribution provides a general description of reusing the radio resources in the multi-hop relay systems and proposes the mechanism to estimate the potential interference level before the reusing for IEEE 802.16j.

II. Reusing the Radio Resources in Multi-hop Relay Systems

As shown in Figure 1, consider an example with 2-hop relays, where MS_1, MS_2 and MS_3 are communicating with RS_1, RS_2 and RS_3, respectively.

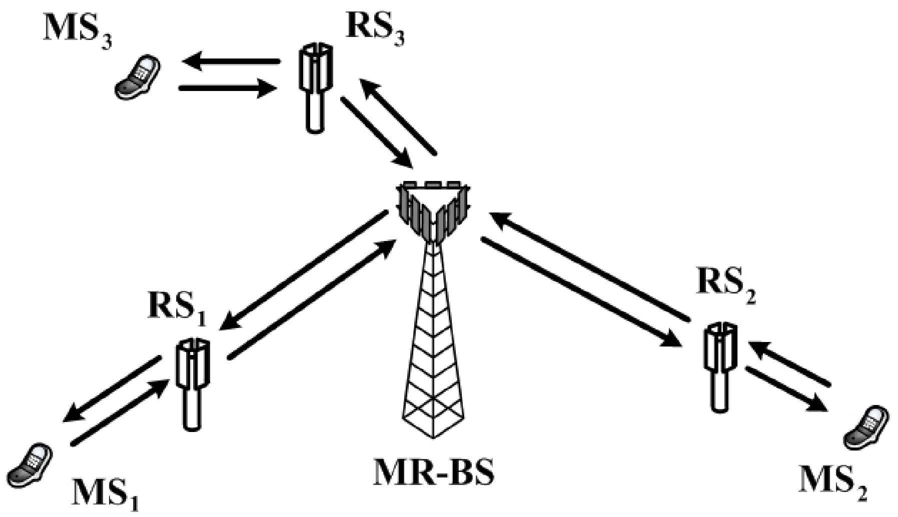

Fig.1 An example of 2-hop relay system

A straightforward idea is to schedule the data burst of the relay links (MR-BS↔RS_1, MR-BS↔RS_2, MR-BS↔RS_3) and access links (RS_1↔MS_1, RS_2↔MS_2, RS_3↔MS_3) be transmitted over different sub-carriers and/or symbol durations in each frame, which is shown as Figure 2. In Figure 2, T_{frame} is the frame duration, and specific sub-carriers and symbol durations can be allocated for each data burst. In this example, the data burst of each relay link (MR-BS↔RS_1, MR-BS↔RS_2, MR-BS↔RS_3) and access link (RS_1↔MS_1, RS_2↔MS_2, RS_3↔MS_3) are transmitted by different sub-carriers and/or symbol durations, and there will be no intra-cell interference. However, part of the sub-carriers and symbol durations are occupied for relaying the duplicated data, and the system capacity may be degraded.

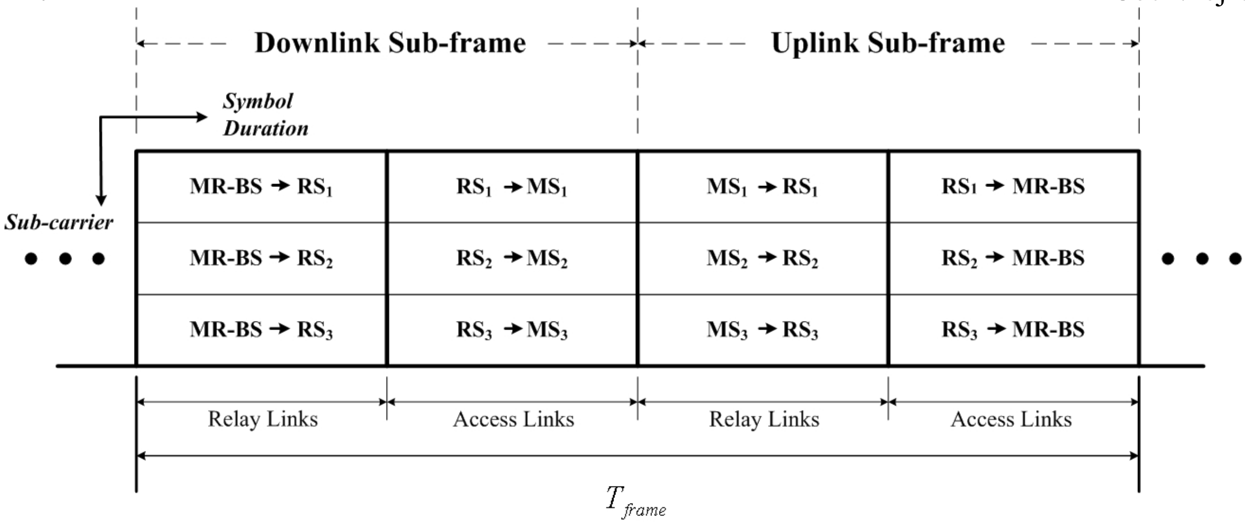

Fig.2 An example on frame structure for relay transmission

In order to improve the system capacity, a simple idea is to reuse the radio resources (i.e. the composite of sub-carriers and symbol durations) in different relay/access links. In Figure 3, the concept of resource allocation set, called Radio resources Reuse Group (RRG) is introduced to facilitate the resources reuse of radio links in the multi-hop relay system. For the relay/access links within the same RRG, they can transmit/receive the data burst over the same sub-carriers and the same symbol durations. For the links in different RRG, the sub-carriers can not be reused at the same time, which is illustrated in Figure 4.

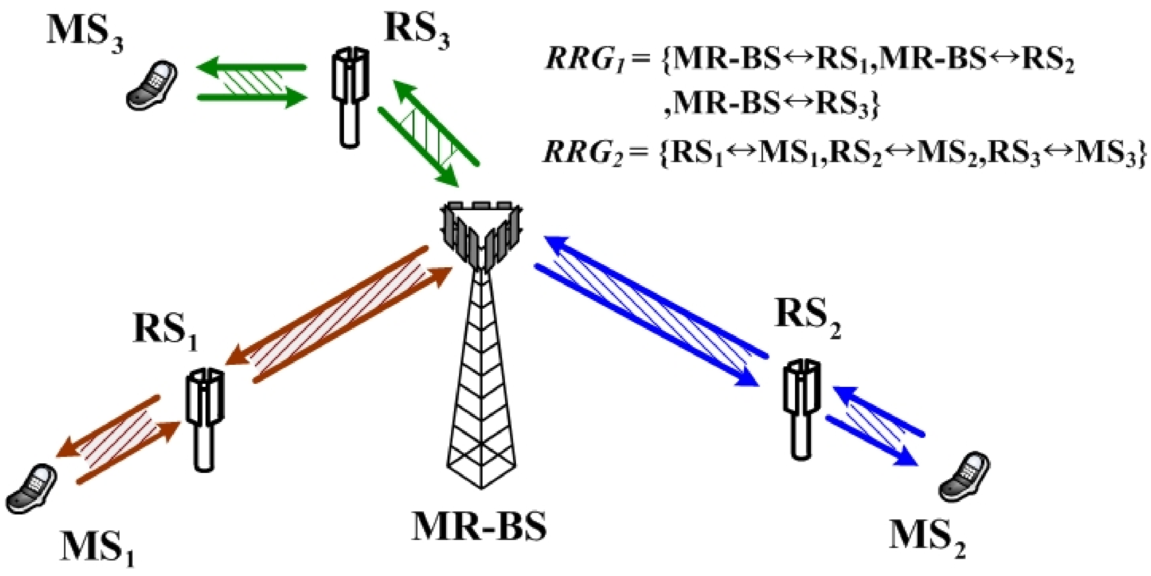

Fig.3 An example of reusing radio resources in 2-hop relay system

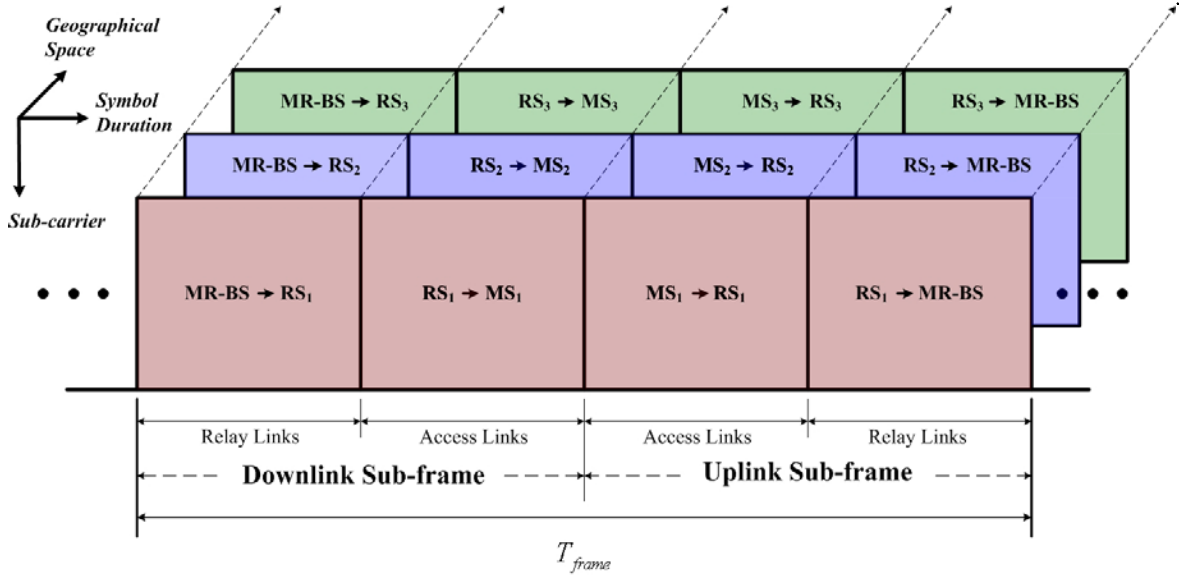

Fig.4 An example on frame structure for reusing radio resource

A fundamental criterion to determine the links for each RRG, i.e. the links which are allowed reuse the same radio resources or not, can be based on the potential mutual interference level. In other words, the system has to ensure the reuse of radio resources will not result in severe interfering scenario and damage on data transmission. Therefore, it will be necessary for each RS to report potential interference level of other RSs to its serving MR-BS, and the RSSI (Received Signal Strength Indicator) measurement on each RS can be a good estimate on potential interference.

The following texts are proposed to be included in the IEEE 802.16j specification to identify how to estimate the potential interference level by the RS scanning mechanism introduced in [4]. Note that for fixed and nomadic relay, such reporting may not be initiated very often, and there are two typical initiation scenarios: (1) when a new RS being deployed into the system and (2) the reuse scenario of the system (i.e. RRG members) needs to be reconfigured.

III. Text Proposal

---Start of the Text---

6.3.6.7 Relaying Support for Scheduling

6.3.6.7.1 Distributed Scheduling

[*Insert the following text in this section*]

The MR-BS can schedule the same region in each frame for different RSs so as to reuse the radio resources in subordinated relay or access links. In order to prevent the severe mutual interference between different relay/access links when reusing the radio resources, each RS have to report the RSSI measurement of all other stations in the same MR-cell before reusing the radio resources.

6.3.6.7.2 Centralized Scheduling

[*Insert the following text in this section*]

The MR-BS can designate the same region in each frame by DL-MAP IE and UL-MAP IE for different relay/access links so as to reuse the radio resources. In order to prevent the severe mutual interference between these relay/access links when reusing the radio resources, each RS have to report the RSSI measurement of all other stations in the same MR-cell before reusing the radio resources.

6.3.9 Network entry and initialization

6.3.9.16 Support for network entry and initialization in relay mode

[*Insert the following text in this section*]

In order to estimate the potential interference level when reusing the radio resources in different relay links, the newly deployed RS have to report the RSSI measurement on all other stations in the same MR-cell after the network entry. In order to initiate this measurement, the serving MR-BS has to reply the RLY_SCN-RSP message and include the Preamble_Index/Subchannel_Index of all other stations in the same MR-cell when it receives the RLY_SCN-REQ from the newly deployed RS. In addition, the MR-BS should also send the RLY_SCN-REQ with the parameter "Report mode" as 0b10 and include the Preamble_Index/Subchannel_Index of the newly deployed RS to all other RSs in the same MR-cell, so as to initiate an unsolicited scanning operation for existing RSs to estimate the potential interference level from the newly deployed RS. Note that each RS should report the RSSI measurement results to the serving MR-BS by RS_SCN-REP message.

6.3.25 Relay path management and routing

[*Insert the following text in this section*]

In order to reconfigure the reusing scenario of radio resources for each relay link, the MR-BS can send an unsolicited RLY_SCN-RSP message to each of its subordinated RS to perform the scanning operation and report the RSSI measurement results. The parameter "Report mode" should be set as 0b10 and the Preamble_Index/Subchannel_Index of all other stations in the same MR-cell should be included in the recommended list of RLY_SCN-RSP message, then each RS should report its measurement results to the serving MR-BS by the RLY_SCN-REP message.

[*The message formats of* RLY_SCN-REQ, RLY_SCN-RSP and RLY_SCN-REP *are specified in Appendix and referenced from* [4]]

--End of the Text--

References

[1] IEEE C802.16mmr-05/041r1, "System Performance of Relay-based Cellular Systems in Manhattan-like Scenario"

[2] IEEE C802.16mmr-06/004r1, "Reverse Link Performance of Relay-based Cellular Systems in Manhattan-like Scenario"

[3] IEEE C802.16mmr-06/003, "On the Throughput Enhancement of Fixed Relay Concept in Manhattan-like Urban Environments"

[4] IEEE C802.16j-06/167, "RS Network Entry, Topology Establishment and Initialization for IEEE 802.16j "

Appendix [4]

Relaying mode RS scanning request (RLY_SCN-REQ) message

An RLY_SCN-REQ message is transmitted by an RS to trigger the neighborhood discovery and determine their suitability as an association for attaching relaying network. The scanning type may be scanning or association (three levels) as the same as MS scanning process.

An RS shall generate RLY_SCN-REQ messages in the format shown in Table A.

Table A—RLY_SCN-REQ message format

Syntax	Size	Notes
RLY_SCN-REQ_Message_format(){	—	—
Management Message Type=xx	8 bits	—
Scan duration	8 bits	Units are in frames
Interleaving interval	8 bits	Units are frames
Scan Iteration	8 bits	In frames
N_Recommend_Station_Index	8 bits	Number of stations to be scanned or associated, which index that corresponds to the preamble index
For (j=0; j<N_Recommend_Station_Index; j++){	—	—
Preamble_Index/Subchannel Index	8 bits	This parameter defines the OFDMA PHY specific preamble
Scanning type	3 bits	0b000: Scanning without Association. 0b001: Scanning with Association level 0: association without coordination 0b010: Scanning with Association level 1: association with coordination. 0b011: Scanning with Association level 2: network assisted association 0b100–0b111: *Reserved*
}	—	—
Padding	variable	If needed for alignment to byte boundary
TLV encoded information	variable	—
}	—	—

Relaying mode RS scanning response (RLY_SCN-RSP) message

An RLY_SCN-RSP message shall be transmitted by the MR-BS in response to an RLY_SCN-REQ message sent by an RS. An MR-BS may transmit RLY_SCN-RSP to trigger the RS scanning report with or without scanning allocation. Four scanning type same as MS scanning may be used. The message shall be transmitted on the Basic CID.

The format of the RLY_SCN-RSP message is depicted in Table B.

Table B—RLY_SCN-RSP message format

Syntax	Size	Notes
RLY_SCN-RSP_Message_format(){	—	—
Management Message Type=xx	8 bits	—
Scan duration	8 bits	Units are in frames. When scan duration is set to zero, no scanning parameters are specified in the message. When RLY_SCN-RSP is sent in response to RLY_SCN-REQ, setting scan duration to zero to deny RLY_SCN-REQ.
Report mode	2 bits	0b00: No report 0b01: Periodic report 0b10: Event-triggered report 0b11: *Reserved*
Reserved	6 bits	Shall be set to zero
Report period	8 bits	Available when the value of Report Mode is set to 0b01. Report period in frames.
Report metric	8 bits	Bitmap indicating metrics on which the corresponding triggers are based: Bit 0: CINR mean Bit 1: RSSI mean Bit 2: Relative delay Bit 3: MR-BS RTD; this metric shall be only measured on MR-BS. Bits 4–7: *Reserved*; shall be set to zero.
If (Scan duration != 0) {		
Start frame	4 bit	—
Reserved	1 bits	Shall be set to zero
Interleaving interval	8 bits	Duration in frames
Scan iteration	8 bits	—
Padding	3 bits	Shall be set to zero
N_Recommended_Station_Index	8 bits	Number of stations to be scanned or associated, which index that corresponds to the preamble index
For (j=0; j<N_Recommend_Station_Index; j++){	—	—
Preamble_Index/Subchannel Index	8 bits	This parameter defines the OFDMA PHY specific preamble
Scanning type	3 bits	0b000: Scanning without Association. 0b001: Scanning with Association level 0: association without coordination 0b010: Scanning with Association level 1: association with coordination. 0b011: Scanning with Association level 2: network assisted association 0b100–0b111: *Reserved*
If (Scanning type = = 0b010) or (Scanning type= = 0b011 {	—	—
Rendezvous time	8 bits	Units are frame
CDMA code	8 bits	From initial ranging codest
Transmission_opportunity offset	8 bits	Units are transmission opportunity
}	—	—

}	—	—
}	—	—
Padding	variable	If needed for alignment to byte boundary
TLV encoded information	variable	—
}	—	—

Relaying mode RS scanning report (RLY_SCN-REP) message

RS shall transmit an RLY_SCN-REP message to report the scanning results to MR-BS after scan duration. The message shall be transmitted on the Primary Management CID.

The format of the RLY_SCN-REP message is depicted in Table C.

Table C—RLY_SCN-REP message format

Syntax	Size	Notes
RLY_SCN-REP_Message_format(){	—	—
Management Message Type=xx	8 bits	—
Report metric	8 bits	Bitmap indicating metrics on which the corresponding triggers are based: Bit 0: CINR mean Bit 1: RSSI mean Bit 2: Relative delay Bit 3: MR-BS RTD; this metric shall be only measured on MR-BS. Bits 4–7: *Reserved*; shall be set to zero.
N_Recommend_Station_Index	8 bits	Number of stations to be scanned or associated, which index that corresponds to the preamble index
For (j=0; j<N_Recommend_Station_Index; j++){	—	—
Preamble_Index/Subchannel Index	8 bits	This parameter defines the OFDMA PHY specific preamble
If (Report metric[Bit 0]==1)	—	—
Station CINR mean	8 bits	—
If (Report metric[Bit 1]==1)	—	—
Station RSSI mean	8 bits	—
If (Report metric[Bit 2]==1)	—	—
Relative delay	8 bits	—
}	—	—
TLV encoded information	variable	Optional
}	—	—