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Re:	This is a response to Call for Technical Proposals regarding IEEE Project P802.16j.
Abstract	The document contains technical proposals for IEEE P802.16j that would provide protocols and signaling required for path management and routing in relay mode.
Purpose	The document is submitted for review by 802.16 Working Group members.
Notice	
Release	
Patent Policy and Procedures	

Link Adaptive Multi-hop Path Management for IEEE 802.16j.

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1 Introduction

This contribution covers the issues related to relay path management and routing defined in Table of Contents of Task Group Working Document[1]. It describes how multi-hop paths between a base station (MMR-BS) and relay stations (RSs) and between relay stations would be managed. In general, there are two main approaches to manage multi-hop paths among wireless stations, centralized and distributed. The proposed protocol takes a centralized approach where the MMR-BS builds and maintains the optimal tree structure, rooted at itself among the RSs under its control, based on a path metric determined from the radio link quality information collected from RSs (Fig. 1). User/control data can be forwarded along a path that is comprised of the tree edges.

The tree topology has been chosen over the others (e.g. mesh) because of the following reasons:

- We assume traffic between a pair of MSs through one or more RSs is not allowed. That is, all traffic should go through the MMR-BSs.
- With the centralized control of resources, network entry, scheduling, and so on, many control messages are expected to be sent to/from the MMR-BS.

With the network of MMR-BS and RSs in place, network entry for an MS may be performed via one or more RSs.

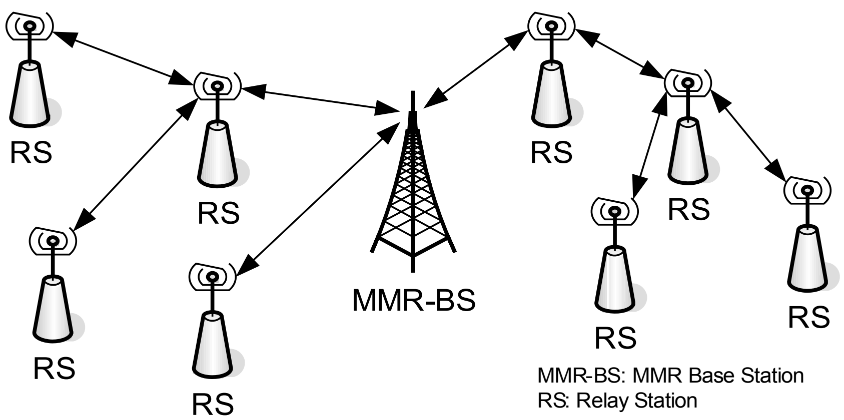

Figure 1 Tree-structured network topology

2 Overview of Proposed Solution

The tree-structured networks are built incrementally. Namely, a tree grows as a new RS is introduced in a network. An RS that is subject to enter the network connects to the MMR-BS either directly or through another RS (*6.3.9.16 Support for network entry and initialization in relay mode*). The entering RS should connect to a single MMR-BS or RS (i.e., a parent node). As a result, a tree-structured network topology would be formed as illustrated in Fig. 1. Introduction of a new RS into the existing network may lead to a situation which requires tree update as exemplified in Fig. 2. Upon network entry, the RS discovers neighbor RSs (*6.3.26 Relay station neighborhood discovery*), obtains their station IDs and determines the radio link quality. These data are sent to the MMR-BS to be used in the tree update operation. The MMR-BS updates a data structure that represents the optimal routing tree using a shortest path algorithm such as the Dijkstra's algorithm. Based on this tree information, the MMR-BS informs all RSs about their parent nodes so that they can re-establish links to other RSs or the MMR-BS. Routing of data would be made along the paths in the tree between the MMR-BS and an RS in accordance with resource allocation (*6.3.5 Scheduling services*).

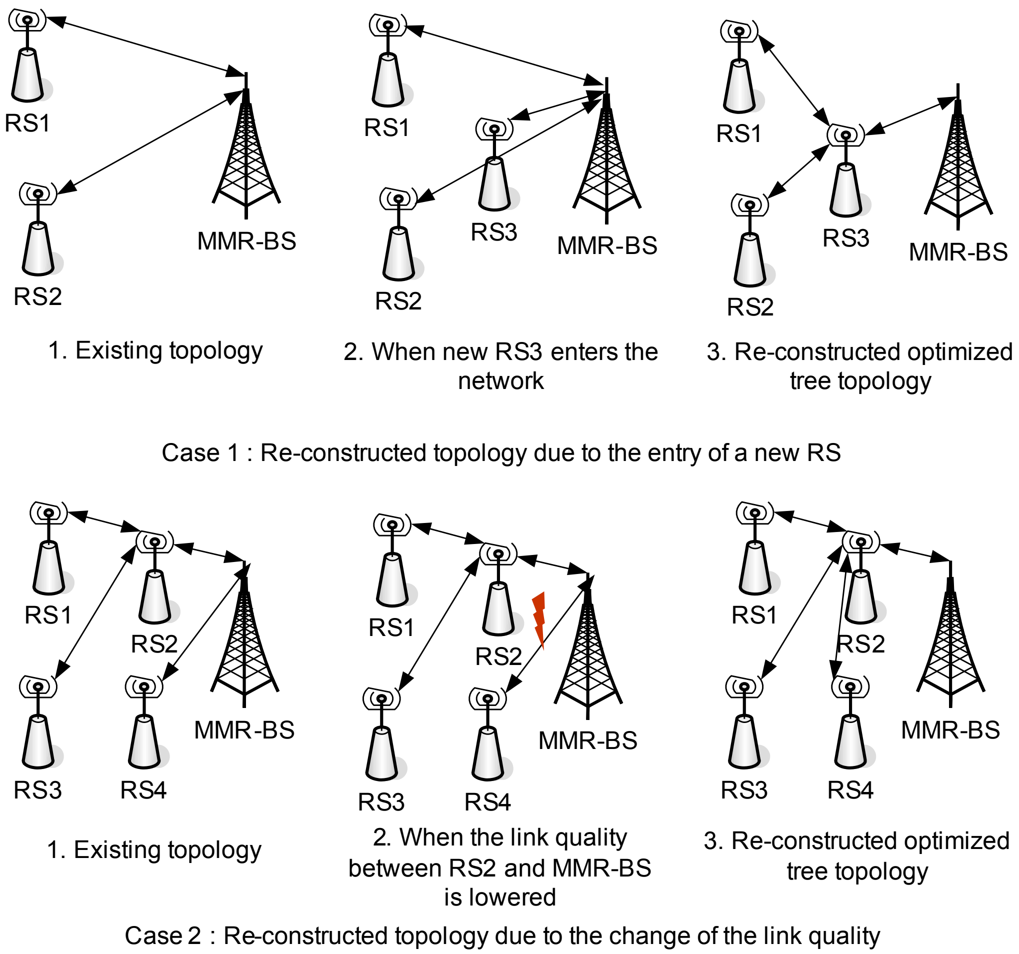

Figure 2 An example of tree re-construction into an optimal tree

3. Text Proposals

[*Insert the following text after 6.3.25 Relay path management and routing*:]

6.3.25.1 Path management

6.3.25.1.1 Tree-based path management

The tree-based path management determines minimum cost paths using link cost derived from the values of link quality. The minimum cost paths determined in this way are used for updating connections among RSs. The tree update operation may be performed periodically or on-demand when a certain tree update criteria are met in order to minimize the interruption of on-going data transmissions and the overhead associated with it.

6.3.25.1.1.1 Neighbor station information report

The station IDs of neighbor RSs and the CINR values obtained in the *Relay station neighborhood discovery* operation are inserted in a *neighbor CINR report message* and sent to the MMR-BS on the CQICH. Procedures for the allocation of CQICH and *neighbor CINR report* are illustrated in Fig. 3.

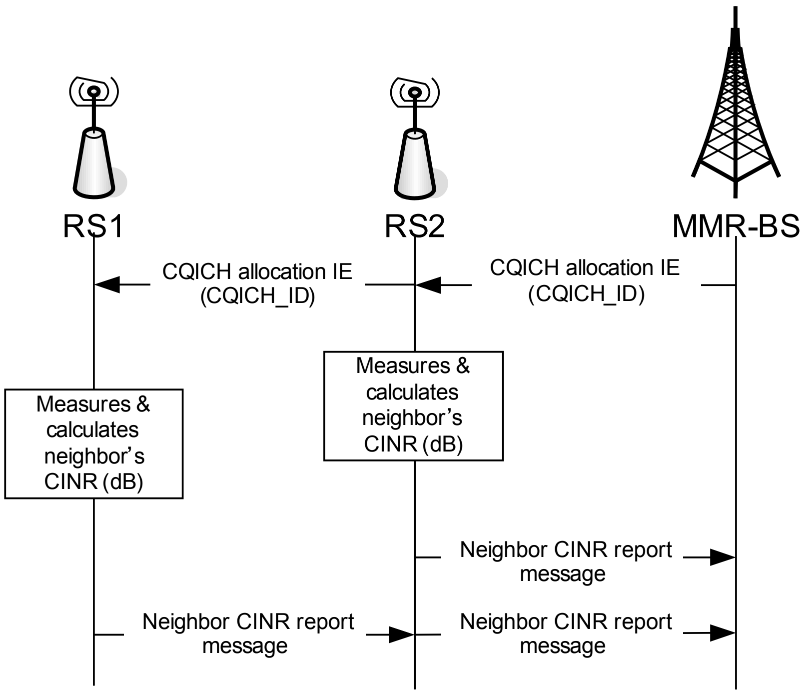

Figure 3 Procedures for the allocation of CQICH and *neighbor CINR report*

6.3.25.1.1.2 Optimal tree calculation

The MMR-BS collects the radio link quality and station ID information using the operations defined in *6.3.25.1.1.1 Neighbor station information report* in order to compute an optimal tree. It converts the CINR values into link costs and builds a graph structure that represents the complete network topology. The MMR-BS generates a spanning tree which consists of the optimal paths from the MMR-BS to all RSs in terms of radio link quality.

6.3.25.1.1.3 Transmission of tree optimization message

If the shortest path tree has changed, the MMR-BS should inform the RSs such that they could change their connections to another RS or to the MMR-BS. The MMR-BS broadcasts to all RSs a list of RSs that are subject to change their parent nodes using a *tree optimization message*. In the *tree optimization message*, the station IDs of the RSs that are subject to change their parent nodes, the station IDs of the target stations, the *RS network re-entry optimization parameter* that specifies the processes that can be omitted from the *RS network re-entry.*

6.3.25.1.1.4 Network re-entry

Upon receiving the *tree optimization message*, the RS performs the *RS network re-entry* operation to connect to a new parent node only if it has been informed to do so (Fig. 4). Since a re-entering RS must have performed the network entry, the RS can skip some of its processes such as RS basic capability REG/RSP, RS registration REQ/RSP and address acquisition by checking the *RS network re-entry optimization parameter* in order to accelerate the *RS network re-entry.*

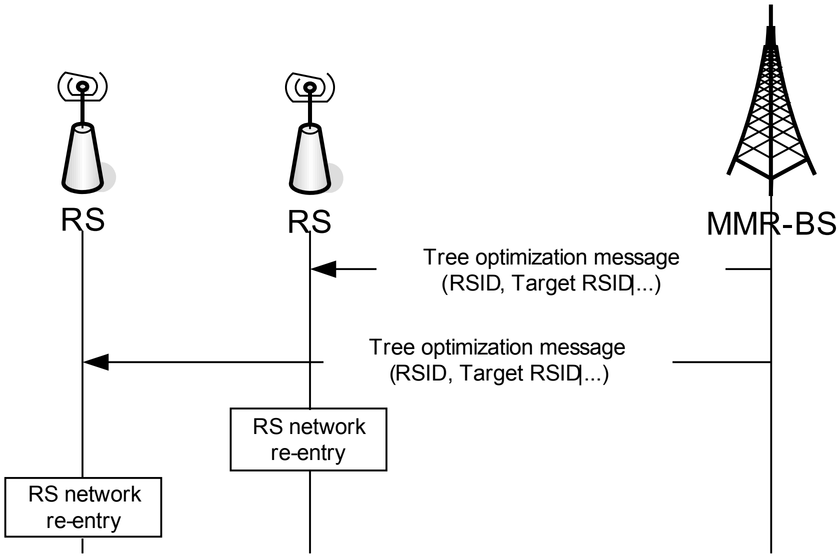

Figure 4 Procedures for the tree optimization and RS network re-entry

[*Insert the following text after 6.3.2.3.75 MAC management messages*:]

6.3.2.3.75 Neighbor CINR report message

The station IDs of neighbor RSs and the CINR values obtained in the *Relay station neighborhood discovery* operation are inserted in a *neighbor CINR report message* and sent to the MMR-BS on the CQICH.

Syntax	Size	Notes
Neighbor_CINR_Report_Message_Format() {		
Management Message Type=75	**8 bits**	
Frame number	**8 bits**	**8 LSB of the frame number**

N_reports	8 bits	The number of report elements that the RS sends to the MMR-BS
For(i=0; i<N_reports; i++) {		
Measurement indication	4 bits	Bit #0- Report CINR Bit #1~3-*Reserved*
Neighbor station ID	48 bits	
CINR	7 bits	
}		
TLV Encoding Information	variable	TLV specific
}		

[***Insert the following text after 6.3.2.3.80 MAC management messages***:]

6.3.2.3.80 Tree optimization message

The MMR-BS broadcasts to all RSs a list of RSs that are subject to change their parent nodes using a *tree optimization message* with the station IDs of the RSs that are subject to change their parent nodes, the station IDs of the target stations and the *RS network re-entry optimization parameter* specified.

Syntax	Size	Notes
Tree_Optimization_Message_Format() {		
Management Message Type=80	8 bits	
Broadcast relay symbol	4 bits	
Frame Offset	4 bits	
N_Station	8 bits	
For(i=0; i<N_RS; i++) {		
RS network re-entry optimization	3 bits	Bit #0: Omit the RS Basic Capability REQ/RSP process Bit #1: Omit the RS registration REQ/RSP process Bit #2: Omit the address acquisition process
Station ID	48 bits	
Target station ID	48 bits	
}		
TLV Encoding Information	variable	TLV specific
}		

4. Reference

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

[2] IEEE Std. 802.16e-2005, “IEEE Standard for Local and metropolitan area networks, Part 16: Air Interface for Fixed Broadband Wireless Access Systems”

[3] IEEE 802.16j-06/015,“Harmonized Contribution on 802.16j (Mobile Multihop Relay) Usage Models”

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