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Source(s)	G.Q. Wang, Wen Tong, Peiying Zhu Hang Zhang, David Steer, Gamini Senarath, Derek Yu Nortel 3500 Carling Avenue Ottawa, Ontario K2H 8E9	Voice: 1-613-763-1315 [mailto:wentong@nortel.com]
	Yukihiro Takatani, Seishi Hanaoka Hitachi, Ltd. 292, Yoshida-cho, Totsuka-ku, Yokohama-shi, Kanagawa 244-0817, Japan	yukihiro.takatani.ee@hitachi.com seishi.hanaoka.kw@hitachi.com
	Kanchei (Ken) Loa, Yi-Hsueh Tsai, Shiann-Tsong Sheu, Hua-Chiang Yin, Yung-Ting Lee, Chih-Chiang Hsieh, Frank C.D. Tsai, Youn-Tai Lee, Heng-Iang Hsu Institute for Information Industry 8F., No. 218, Sec. 2, Dunhua S. Rd., Taipei City, Taiwan	Voice: +886-2-2739-9616 loa@iii.org.tw

Re:	Response to a call for contributions.
Abstract	Introducing R-link link status monitoring and reporting schema for relay path selection. Harmonization of IEEE C802.16j-06/248r2, C802.16j-07/079 and III.
Purpose	To make MMR-BS collectively acquire the current status of all relay links in MMR network
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MMR Relay Link (R-link) monitoring and reporting procedure for Multi-hop path selection

G.Q. Wang, Wen Tong, Peiying Zhu, Hang Zhang, Gamini Senarath,
David Steer, Derek Yu, Nortel
Yukihiro Takatani, Seishi Hanaoka, Hitachi, Ltd

1. Introduction

In 802.16j system, a multi-hop path selection is one of the important functionalities for the efficient usage of radio resource in the network. To be able to select an optimal relay path from BS to the access RS, MMR routing control system needs to collectively acquire global air link status within a cell. This contribution proposes to add the stability of link quality as a metric of multi-hop path selection.

2. Background

In IEEE 802.16e-2005 standard, there are mechanisms to measure and acquire the quality of radio link in physical layer. Examples of link quality parameters are shown in Table 1. These parameters can be used by BS for monitoring the status of BS-MS links, and for the purpose of handover, scheduling, and so on.

Table 1 Link quality parameters in IEEE 802.16e-2005 standard

Link quality parameter	Mechanism to report link quality parameters
RSSI mean	REP-RSP message
RSSI standard deviation	
CINR mean	
CINR standard deviation	
CQI value	fast-feedback channel (CQICH)

In general, the radio link quality changes in time (The word “link quality” is used here as a meaning of SINR or CINR level). A fluctuation of link quality may occur because of movement of nodes, environmental factors (radio noise, obstacles, weather condition, etc.), or system failure (node/card failure).

The example of 802.16j system is shown in Figure 1. The link quality between MMR-BS and RS1 slightly fluctuates in time, but the one between MMR-BS and RS2 dramatically changes. In this case the former link can be regarded as a stable radio link, and the latter one as a unstable radio link. Therefore it is appropriate to select the path via RS1.

In 802.16j system, a multi-hop path selection, which is defined as an optional functional requirement, is an important functionality for the efficient usage of radio resource in the network. To select an appropriate path, the stability of link quality should be considered.

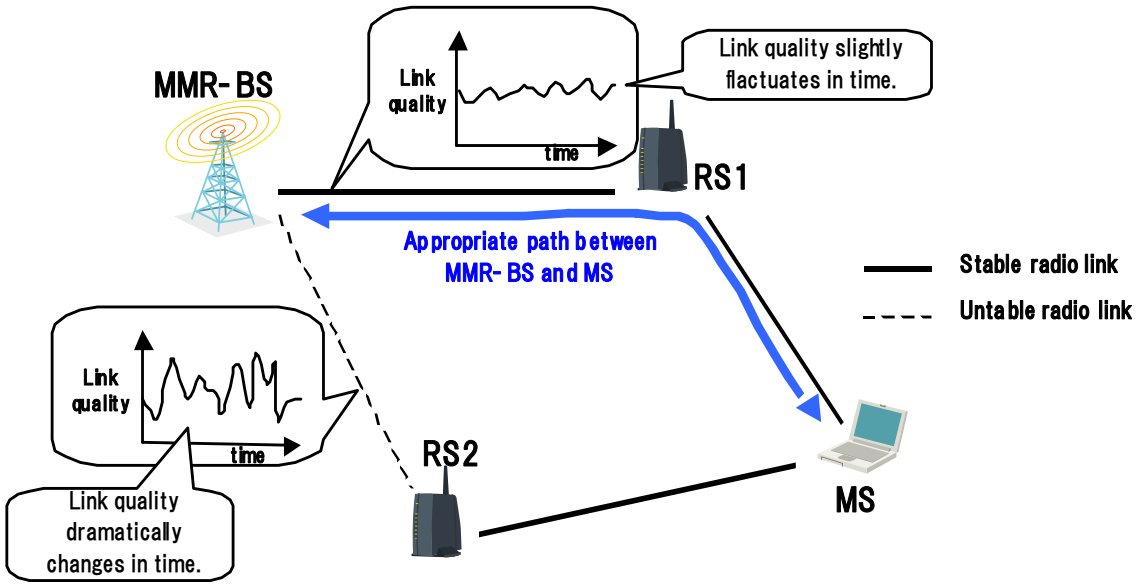

Figure 1 An appropriate path selection based on stability of link quality in 802.16j system

As indicated in Table 1, 802.16e-2005 has defined two ways to monitor and report the access link quality status: MS can use REP-RSP message or CQICH channel to report the measured link metrics to BS. The following sections propose link status report/procedure extensions to R-link quality metrics (both R-DL and R-UL). The extensions include new TLV and procedures to report link status and to select the relay path with the associated link metrics.

3. Proposed Method

We propose to add the stability of link quality as a metric of multi-hop path selection. There are advantages considering it:

Less frequent path changes: It can reduce the control overhead occurring by path changes.
Less data loss: It can avoid data loss by a sudden decrease of link quality.
Link quality for backup relay path purpose (reliability)

In order to get information regarding the stability of link quality, following methods are proposed:

Using a fast-feedback channel (CQICH)
Using REP-RSP messages (In case that CQICH cannot be used) with newly introduced R-link TLV

In these methods, no change of MS specification is required.

3.1. Calculating the stability of link quality using a fast-feedback channel (CQICH)

In the centralized scheduling, MMR-BS allocates CQICH to RSs and MSs (Figure 2). Allocation of CQICH for RSs is performed in the relay zone and the one for MSs in the access zone. RSs and MSs report CQI to MMR-BS, and MMR-BS maintain the history of CQI. Based on this information, it calculates the stability of link quality which is used for the multi-hop path selection. The algorithm of calculating the stability of link quality is out of this contribution.

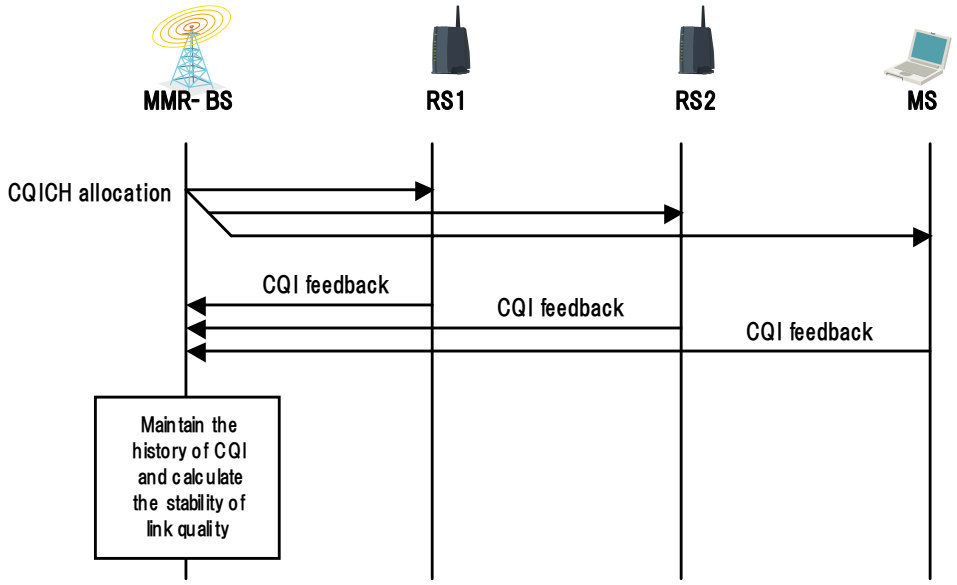

Figure 2 Using a fast-feedback channel (CQICH): Centralized scheduling

In the distributed scheduling, MMR-BS and RSs allocate CQICH to neighboring RSs and MSs (Figure 3). Allocation of CQICH for RSs is performed in the relay zone and the one for MSs in the access zone. MMR-BS and RSs collect CQI from neighboring nodes and maintain the history of CQI. Based on this information, they calculate the stability of link quality which is used for the multi-hop path selection. The algorithm of calculating the stability of link quality is out of this contribution.

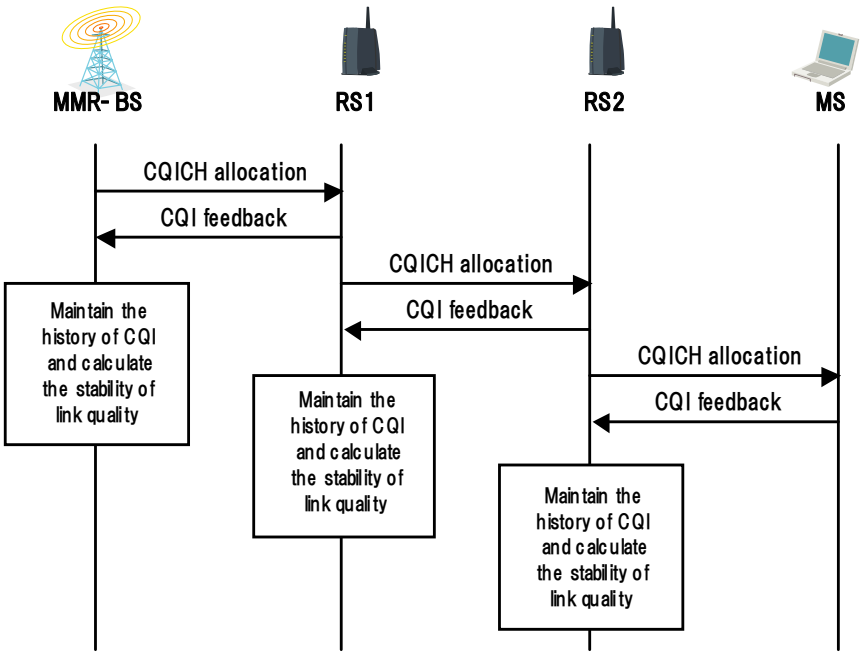

Figure 3 Using a fast-feedback channel (CQICH): Distributed scheduling

3.2. Calculating the stability of link quality using REP-RSP messages

If the fast-feedback channel (CQICH) cannot be used, REP-RSP messages may be used, alternatively.

In the centralized scheduling, MMR-BS sends REP-REQ to RSs and MSs, requesting a RSSI standard deviation or a CINR standard deviation, and RSs and MSs send REP-RSP to MMR-BS (Figure 4).
While MS only reports single Down-Link status (from BS to MS, as defined in 802.16e-2005) to the BS, each designated RS should report multiple link status including both R-DL (from BS or ancestor RS to the designated RS) and R-UL (from the successor RS to the designated RS) to the BS. The REP-RSP issued from each RS should indicate the link direction (i.e., R-DL or R-UL), and the link end point (i.e., who is the adjacency of the measured links).
RS shall report the measured channel conditions (both R-DL and R-UL) to MMR BS via either polling way (REP-REQ/RSP) or unsolicited way (REP-RSP).

MMR-BS may use the value of a RSSI standard deviation or a CINR standard deviation directly as an index of the stability of link quality.

With the collectively acquired link status, MMR BS would effectively schedule the radio resource, select the optimized path for the relay, and route the traffic to an alternative path when a failure case occurred.

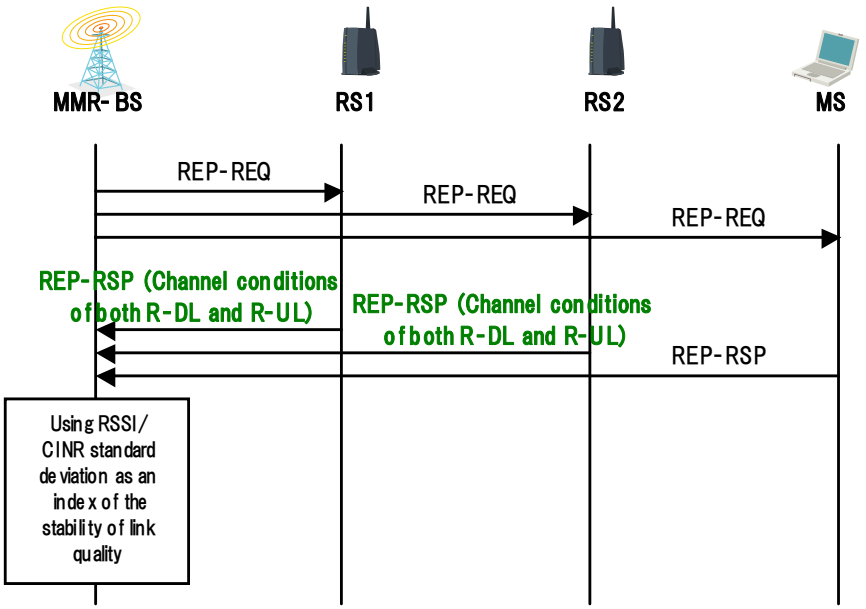

Figure 4 Using REP-RSP messages: Centralized scheduling

In the distributed scheduling, MMR-BS and RSs send REP-REQ to neighboring RSs and MSs, requesting a RSSI standard deviation or a CINR standard deviation (Figure 5). They receive REP-RSP from neighboring RSs and MSs. They may use the value of a RSSI standard deviation or a CINR standard deviation directly as an index of the stability of link quality.

Each designated RS should report multiple link status including both R-DL (from BS or ancestor RS to the designated RS) and R-UL (from the successor RS to the designated RS) to the BS.

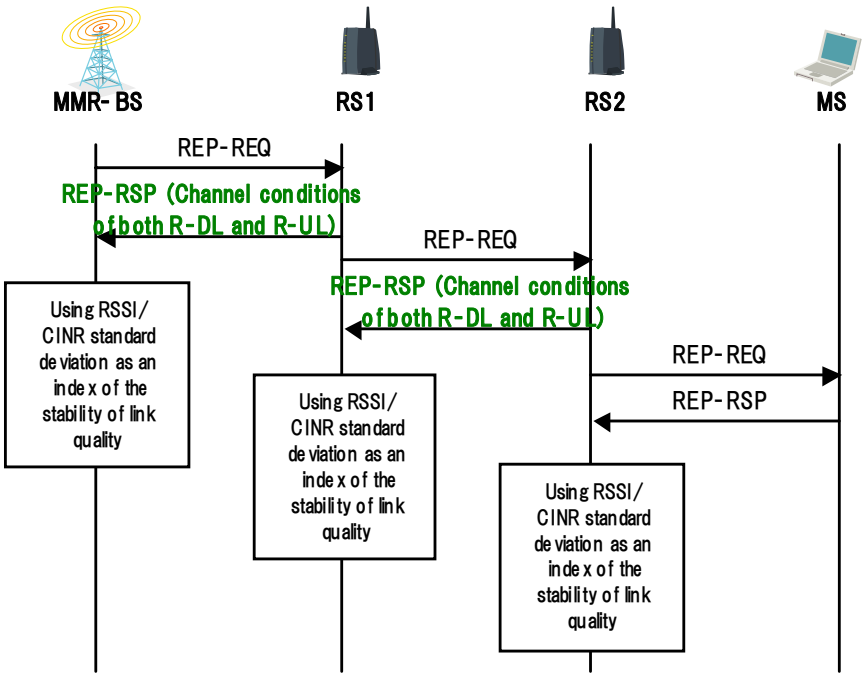

Figure 5 Using REP-RSP messages: Distributed scheduling

4. Proposed text changes

6.3.25 Relay path management and routing

[Insert the following text]
6.3.25.x R-link monitoring and report procedure for relay path management

The stability of link quality shall be considered as a metric of multi-hop path selection. In order to get information regarding the stability of link quality, following methods may be used:

Using a fast-feedback channel (CQICH)
Using REP-RSP messages (In case that CQICH cannot be used) with R-link TLV

In the centralized scheduling, MMR-BS may allocate CQICH to RSs and MSs. Allocation of CQICH for RSs is performed in the relay zone and the one for MSs in the access zone. RSs and MSs report CQI to MMR-BS, and MMR-BS may maintain the history of CQI. Based on this information, it calculates the stability of link quality which is used for the multi-hop path selection. The algorithm of calculating the stability of link quality is out of this standard.
In the distributed scheduling, MMR-BS and RSs may allocate CQICH to neighboring RSs and MSs. Allocation of CQICH for RSs is performed in the relay zone and the one for MSs in the access zone. MMR-BS and RSs collect CQI from neighboring nodes and maintain the history of CQI. Based on this information, they

calculate the stability of link quality which is used for the multi-hop path selection. The algorithm of calculating the stability of link quality is out of this standard.

If the fast-feedback channel (CQICH) cannot be used, REP-RSP messages may be used, alternatively.

In the centralized scheduling, MMR-BS may send REP-REQ to RSs and MSs, requesting a RSSI standard deviation or a CINR standard deviation, and RSs and MSs may send REP-RSP to MMR-BS. MMR-BS may use the value of a RSSI standard deviation or a CINR standard deviation directly as an index of the stability of link quality.

In the distributed scheduling, MMR-BS and RSs may send REP-REQ to neighboring RSs and MSs, requesting a RSSI standard deviation or a CINR standard deviation. They receive REP-RSP from neighboring RSs and MSs. They may use the value of a RSSI standard deviation or a CINR standard deviation directly as an index of the stability of link quality.

[Insert the following text]

6.3.18.3 Relay station DL/UL CINR report operations

Unlike MS which only reports single Down-Link status (from BS to MS, as defined in 802.16e-2005) to the BS, each designated RS should report multiple link status including both R-DL (from BS or ancestor RS to the designated RS) and R-UL (from the successor RS to the designated RS) to the BS. The REP-RSP issued from each RS should indicate the link direction (i.e., R-DL or R-UL), and the link end point (i.e., who is the adjacency of the measured links). For report on an R-DL link, the R-link direction is set as “Downlink”; otherwise the R-link direction is set as “Uplink”. As well the R-link source should be set as the IDCell code of the link end point from the adjacent node. For RS, the REP-RSP (see 11.12 for the TLV encodings) includes R-link TLV which contains R-link direction and R-link source end point

RS shall report the measured channel conditions (both R-DL and R-UL) to MMR BS via either polling way (REP-REQ/RSP) or unsolicited way (REP-RSP).

Link-source and Link-direction TLV format

Link-source and Link-direction is defined as one-byte TLV. Link-source is the source end of the measured link, which is represented by IDcell code of the source node. In 802.16-2005, ID cell is defined as 5-bit integer. Here Link-direction is defined as 2-bit size.

Name	Type	Length	Value
R-Link	xxx	1 byte	8-bit Integer

Syntax	Size	Notes
R-link {		
Direction	2 bits	0b00/11 = Reserved 0b01 = Uplink 0b10 = Downlink
Reserved	1 bit	
Source	5 bits	IDcell code of the source end
}		

5. References

[1] IEEE standard 802.16e-2005, "IEEE Standard for Local and metropolitan area networks, Part 16: Air Interface for Fixed Broadband Wireless Access Systems"
[2] IEEE 802.16j-06/013r3, "Multi-hop Relay System Evaluation Methodology (Channel Model and Performance Metric)"
[3] IEEE 802.16j-06/014r1, "Harmonized definitions and terminology for 802.16j Mobile Multihop Relay"
[4] IEEE 802.16j-06/015, "Harmonized Contribution on 802.16j (Mobile Multihop Relay) Usage Models"
[5] IEEE 802.16j-06/016r1, "Proposed Technical Requirements Guideline for IEEE 802.16 Relay TG"
[6] IEEE 802.16j-06/017r2, "Table of Contents of Task Group Working Document"
[7] IEEE 802.16j-06/026r2, "P802.16j Baseline Document"
[8] IEEE 802.16j-06/248r2, "R-link TLV for MMR relay link monitoring and reporting procedure"
[9] IEEE 802.16j-07/079, "A new metric for multi-hop path selection"