Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Handover and its network model for IEEE 802.16j**
Date Submitted	**2007-01-08**
Source(s)	Yong Sun, Dharma Basgeet, Zhong Fan, Paul Strauch Toshiba Research Europe Limited 32 Queen Square Bristol BS1 4ND Voice: +44 117 9060749 Fax: +44 117 9060701 Sun@toshiba-trel.com
Re:	This is a response to a Call for Technical Proposal regarding IEEE Project P802.16j http://ieee802.org/16/relay/docs/80216j-06_034.pdf
Abstract	This document proposes a network model for 802.16j relay with handover.
Purpose	This technical contribution is submitted IEEE 802.16j TG for consideration and further discussion.
Notice	This document has been prepared to assist IEEE 802.16. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein.
Release	The contributor grants a free, irrevocable license to the IEEE to incorporate material contained in this contribution, and any modifications thereof, in the creation of an IEEE Standards publication; to copyright in the IEEE's name any IEEE Standards publication even though it may include portions of this contribution; and at the IEEE's sole discretion to permit others to reproduce in whole or in part the resulting IEEE Standards publication. The contributor also acknowledges and accepts that this contribution may be made public by IEEE 802.16.
Patent Policy and Procedures	The contributor is familiar with the IEEE 802.16 Patent Policy and Procedures <http://ieee802.org/16/ipr/patents/policy.html>, including the statement "IEEE standards may include the known use of patent(s), including patent applications, provided the IEEE receives assurance from the patent holder or applicant with respect to patents essential for compliance with both mandatory and optional portions of the standard." Early disclosure to the Working Group of patent information that might be relevant to the standard is essential to reduce the possibility for delays in the development process and increase the likelihood that the draft publication will be approved for publication. Please notify the Chair <mailto:chair@wirelessman.org> as early as possible, in written or electronic form, if patented technology (or technology under patent application) might be incorporated into a draft standard being developed within the IEEE 802.16 Working Group. The Chair will disclose this notification via the IEEE 802.16 web site <http://ieee802.org/16/ipr/patents/notices>.

Handover and its network model for IEEE 802.16j

Yong Sun, Dharma Basgeet, Zhong Fan, Paul Strauch

Toshiba Research Europe Limited

Introduction

This document proposes handover and its network model for 802.16j relay mode in order to provide relay support for high efficient handover. This contribution is a response to Call for Technical Proposal of IEEE802.16j which was issued on 12th December 2006. This proposal is mainly targeting on 6.3.22 MAC layer handover procedures – 6.3.22.4 Mobile relay station handover, the section defines MAC constructs and signaling required for MRS (mobile relay station) handover. Other related subclauses are 6.3.5 Scheduling services and its followed subclauses. In this document, we will firstly discuss the handover of 802.16e [1]. Based on the discussion, the handover criteria and procedure suitable for 802.16j relay will be proposed.

Handover of IEEE 802.16e

[Handover is one of critical issues for mobile applications. Mobile WiMAX 802.16e supports seamless handover to enable the MS to switch from one base station to another at vehicular speeds without interrupting the connection. The handover process is defined in [1] as which an MS migrates from the air-interface provided by one BS to the air interface provided by another BS. It also specifies the functions to support higher layer handover between base stations or sectors.

There are three handover methods supported within the 802.16e standard – Hard Handover (HHO), Fast Base Station Switching (FBSS) and Macro Diversity Handover (MDHO). The hard handover is mandatory and others are optional. All techniques have been developed with the goal of keeping Layer 2 handover delays to less than 50 milliseconds [2].

The HHO is the simplest scheme for the practical operation since it is only based on signal strength from different BSs. For FBSS, the BS and MS maintain a list of BSs (diversity set), which are involved in FBSS with the MS. It requires MS continuously monitors the BSs in the diversity set and define an Anchor BS. The MS only communicates with the Anchor BS for uplink and downlink messages. Anchor update procedures are enable by communicating signal strength of the serving BS via the CQI channel. A FBSS handover begins with a decision by an MS to receive or transmit data from the Anchor BS that may change within the list. The MS reports the selected Anchor BS on CQICH or MS initiated HO request message. Fundamentally, the data is required to transmit simultaneously to all BSs of the diversity set. Similar operation of the diversity set, A MDHO begins when a MS decides to transmit or receive unicast messages and traffic from multiple BSs of the diversity set in the same time interval.

Also, bear in mind that any extension of these must be legacy compatible. Therefore, it requires that the handover for 802.16j must meet all these definitions and conditions defined in 802.16e.

Handover issues for IEEE 802.16j

In 802.16j usage models definitions [3], there are three typical usage scenarios, which are fixed relay, nomadic relay and mobile relay. Also, in the mobile relay, there are further two different mobile relays been defined, namely, mobile vehicle usage and OTM (on-the-move) operation. The mobile RS applied to the mobile vehicle usage has been defined as MRS [4].

For MRS application, it is defined as that MS/SS devices are traveling together on the mobile vehicle and a mobile RS is mounted on the vehicle. If we assume that the MS/SS can only connect to its MRS, for handover issues, MRS can be treated as the same a MS since for MRS, the network only need to consider the MRS itself (no need to consider its MRS relayed MSs). Further to NRS, it is similar to FRS from handover point of view, since NRS is fixed when it is operated (it is switched off when it is moving).

Base on the above consideration, the network model defined in [1] and contribution [5], we are proposing a modified network model for 802.16j relay with handover issues as depicted in Figure 1.

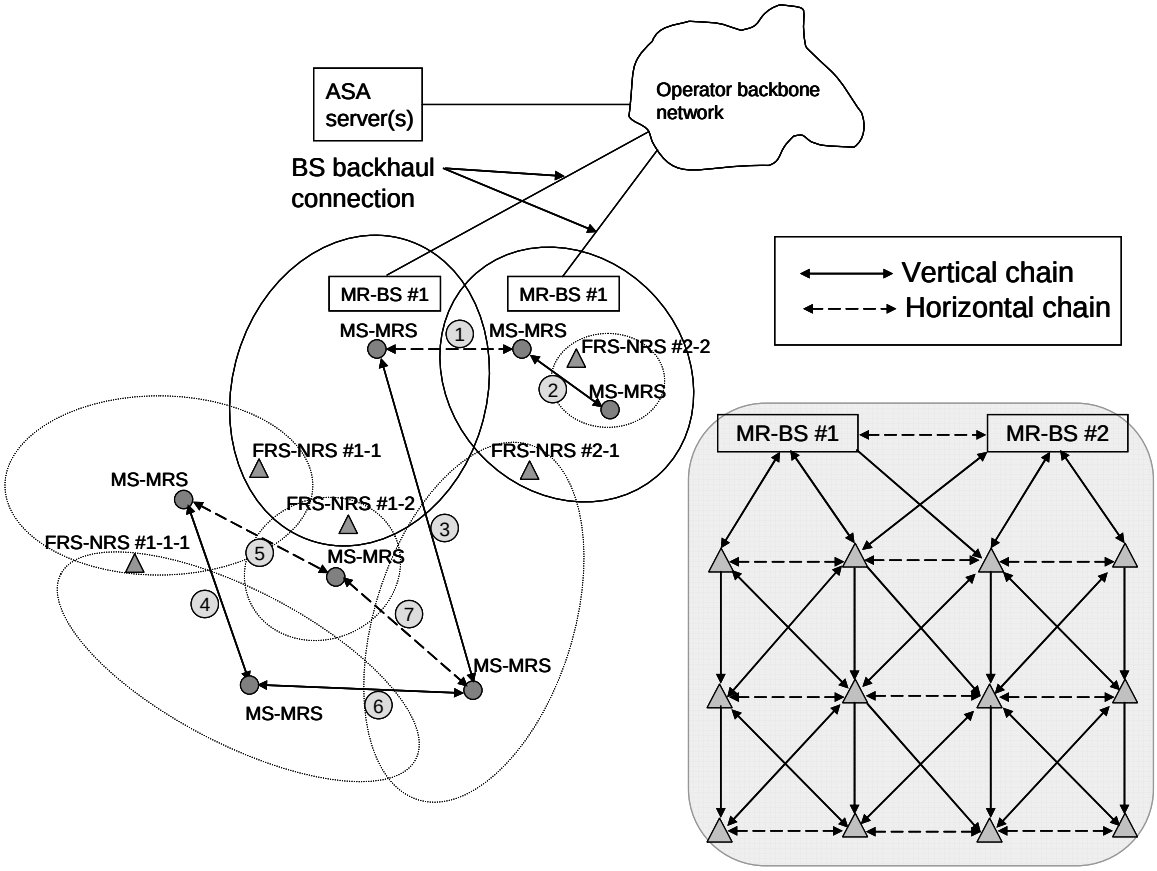


Figure 1: Network model example for 802.16j relay deployment

In the above figure, we define the RS number following its defined BS number, such as FRS-NRS #1-1 means a fixed RS or a nomadic RS number 1 with BS #1, etc. MS-MRS means MS or MRS.

Also as shown in the Figure 1, we propose all types of handover of relaying into seven categories as well in corresponding to [5] and these categories are defined in Table 1.Noted that the first category is the same as that defined in 802.16e, which should not have any modifications in 802.16j. Therefore, this document is concentrating the rest six categories.

Table 1: Seven handover categories of relay deployment

Handover categories	Definition	Comments
(1) BS-BS registration	Handover between two BSs without any relay	It is the same at that defined in 802.16e
(2) BS-RS network access	Handover between BS and its own RS	Registration is not required following the handover
(3) BS-RS registration	Handover between BS and a RS belongs to another BS	Registration is required following the handover
(4) RS-RS vertical network access	Handover between RSs and the RSs are in vertical chain and the RSs belongs to the same BS	Registration is not required following a handover
(5) RS-RS horizontal network access	Handover between RSs and the RSs are in horizontal chain and the RSs belongs to the same BS	Registration is not required following a handover
(6) RS-RS vertical registration	Handover between RSs and the RSs are in vertical chain but the RSs belongs to different BSs	Registration is required following the handover
(7) RS-RS horizontal registration	Handover between RSs and the RSs are in horizontal chain but the RSs belongs to different BSs	Registration is required following the handover

As specified in the 802.16j PAR that subscriber station specifications are not changed. Under these definitions, the MSs are not supposed to aware of the existence of RSs. Also, MSs are not supposed to aware of any new aspects on BSs and RSs.

To all SSs and MSs, if we assumed that RSs are only recognized and treated as ‘BSs’, the RSs should have control information for MS to monitor. Since hard-handover (HHO) is mandatory, we start with HHO here for the 802.16j relaying mode.

For HHO, there are serving station, neighbor station, target access station and target serving station to be applied.

As defined in [4] , the serving station is only for MS and a serving station can be a BS or MR-BS (in original document it was ‘MMR-BS’). Here we propose the serving station should be also for RS including FRS, NRS and MRS. It is even important for the handover issue for a MRS.

Because the MSs cannot distinct MR-BS, BS and RS, we propose that each RS should have a RS indentifier which can be recognized as ‘BS identifier’ to any MS, even though it is recognized as RS identifier to any RS and MR-BS. With this, it is possible for any MS to monitor DL control information (i.e., DL-MAP, UL-MAP, and FCH) and DL broadcast messages. Here for this purpose, in this document, we introduce a virtual serving station, as shown in Figure 2, for clear description.

Noted that we define this ‘virtual serving station’, which in fact is a RS but the RS acts as a serving station to the MS it communicated (since the MS has no knowledge of a RS). It is corresponding to the serving station defined in [4], which is defined only for BS or MR-BS.

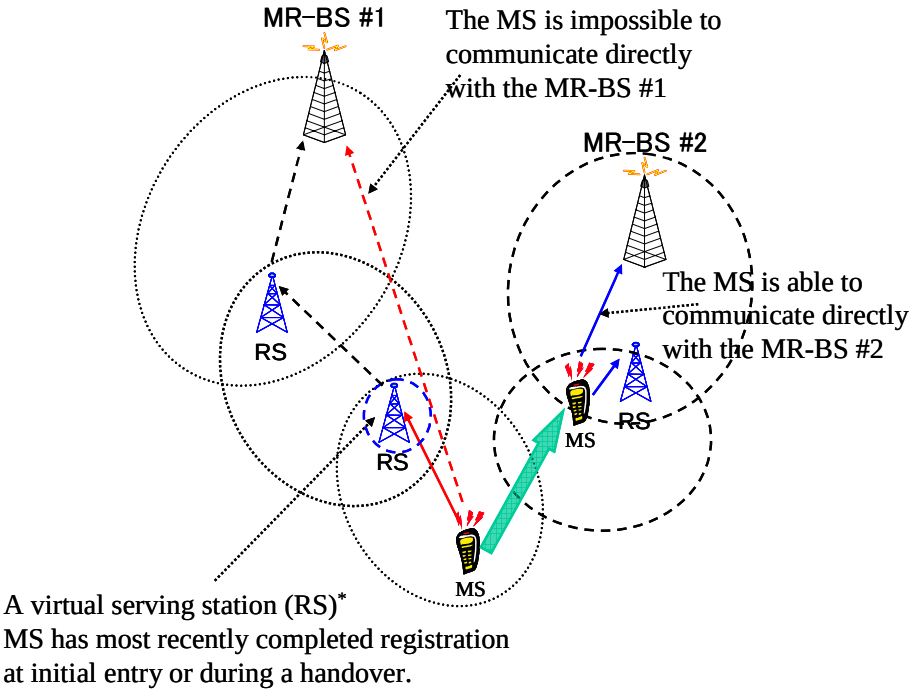


Figure 2: A virtual serving station for handover on a MS

As shown in the above figure, the virtual serving station is a station served as a serving station to the MS. However, to the MR-BS and its RSs, it is assumed that it is known that the station is a RS (assume that the MR-BS and the RSs have full knowledge of the topology) but it is not necessary for all RSs.

Therefore, it is blind to the MS beyond the virtual serving station, as to the MS, the initial entry registration is registered with the virtual serving station (as the MS can recognize).

In fact, the virtual serving station (RS) is not able to complete the registration, it will tack back to its BS (MR-BS #1). However, this kind of tracking-back precedure is not required to inform the MS. From another side, the MS is not able to have knowledge of RSs unless some modifications are applied on the MS(s).

For handover procedure, the MS will treat the virtual serving station as its serving BS, all other stations including other RSs and MR-BS #1 & #2 could be its neighbor stations (more strictly, they are treated as the 'neighbor BS' to the MS). MR-BS #1 & #2 could be the target anchor station or target serving station during the HO initiation. After the handover, the serving station should be the MR-BS #2 but also could be another virtual serving station (RS)

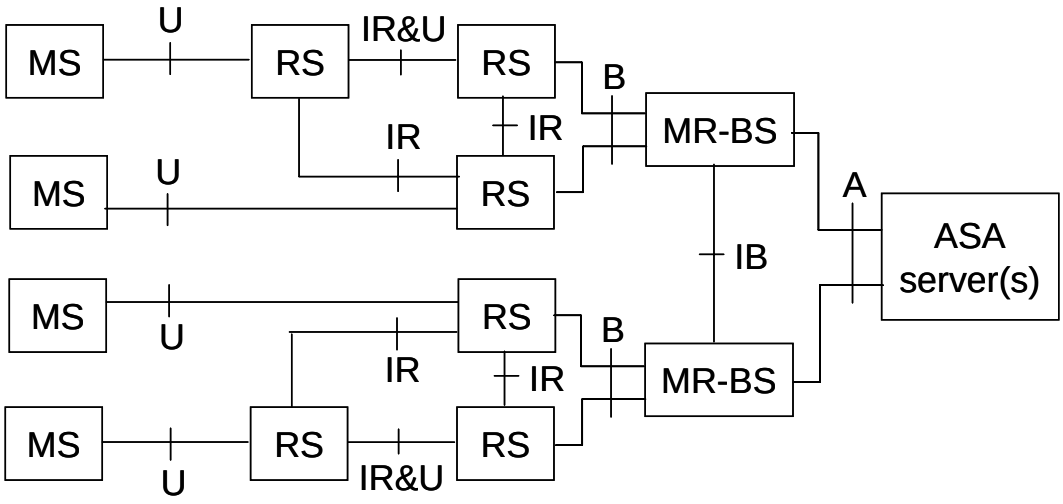
As also shown in the Figure 2, the virtual serving station is more important to a MS with no connection to the BS. However, even the MS has the connection with the BS (as that MR-BS #2), the MS might still require its handover and registration to the RS without knowing that it is a RS. Therefore, in any case, unless the MS has been modified, the virtual serving station needs to be well-defined for the 802.16j relay mode.

With the definition of the virtual serving station and Figure 1 and Table 1, we can see that for any HO on the horizontal chain (including the category (1) BS-BS), 802.16j can easily adopt HO specified in the 802.16e specs, such that a handover begins with a decision for an MS/MRS to handover from a serving station to a target station and the decision may originate either at the MS or the serving station. In contrast, for the vertical chain (e.g., (4) and (6)), in the case that the hop number of the serving station link is great than that of targeting station link, it is the same as that of horizontal chain; in the case that the hop number of the serving station link is less than that of targeting station link, the HO decision should be made by RSSI, CINR, bandwidth and radio

resource re-use rate, etc. Consequently, for HO on the vertical chain, it is more like to be decided on the serving station, unless the MS has knowledge of the relay topology with modifications on MS.

For a specific case of full radio resource re-use in the relay, HO could be the same as that in 802.16e except of adding RSs (MS(s) do not need aware of either BS or RS(s)). It is more applicable to HHO since only CINR is required to make the handover decision at the MS(s). FBSS or FRSS can be easier applied as long as the MS/MRS and BS and RSs maintain a list of BSs and RSs that are involved in FBSS with the MS, as a RS can be treated as a virtual serving station. Furthermore, MDHO only needs to be modified for DL with RSs

A logical network reference model, control plane, for 802.16j relaying mode is also proposed and depicted in Figure 3, where we propose the message change between RSs under an MR-BS. The message change between RSs under different MR-BSs must go through the MR-BSs.



Reference point	Elements to be specified by IEEE 802.16j	Comments
U	PHY, MAC (including CS) operations, including message exchanges for mobility support	
IB	BS-to-BS messages	Transport protocol is not specified
IR	RS-to-RS messages	Transport protocol is not specified
A	Messages serving MS and RS (e.g. MRS) authentication and service authorization functions	Transport protocol is not specified
B	Messages serving MS and RS (e.g. MRS) authentication	Transport protocol is not specified

Figure 3: Logical network reference model, control plane, for 802.16j relaying mode

Summary and other recommendations

MSs' handover should be mainly controlled by either BS or RS in the relay mode. It could be different from 16e that MS could initiate and originate a target BS, instead, MS should employ feedback for BS/RS to make decision and/or negotiate through MOB_MSHO-REQ and MOB_BSHO-RSP. In addition, With considering system efficiency, the new threshold criteria should be set according to access link quality, relay gain, number of hops, latency, etc. (e.g., the H_Add Threshold, H_Delete Threshold included in DCD message, which was defined only based on CINR).

We suggest that the relay HO applications should be only considered while any mobiles with difficulties to connect to BS or any mobiles are losing connection to their BS. For those who can be connected to the BS but requires higher QoS, relay efficiency should be taken into account. For MS initiated HO, QoS is not always guaranteed in the 16j without negotiate with the BS. Handover might only guarantee the connection but not the performance.

Specific text change

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~Start text input~~~~~~

[Insert the following in subclause 6.3.22 at the end of the introduction]

A network model for 802.16j relay with handover issues is depicted in Figure xxx.

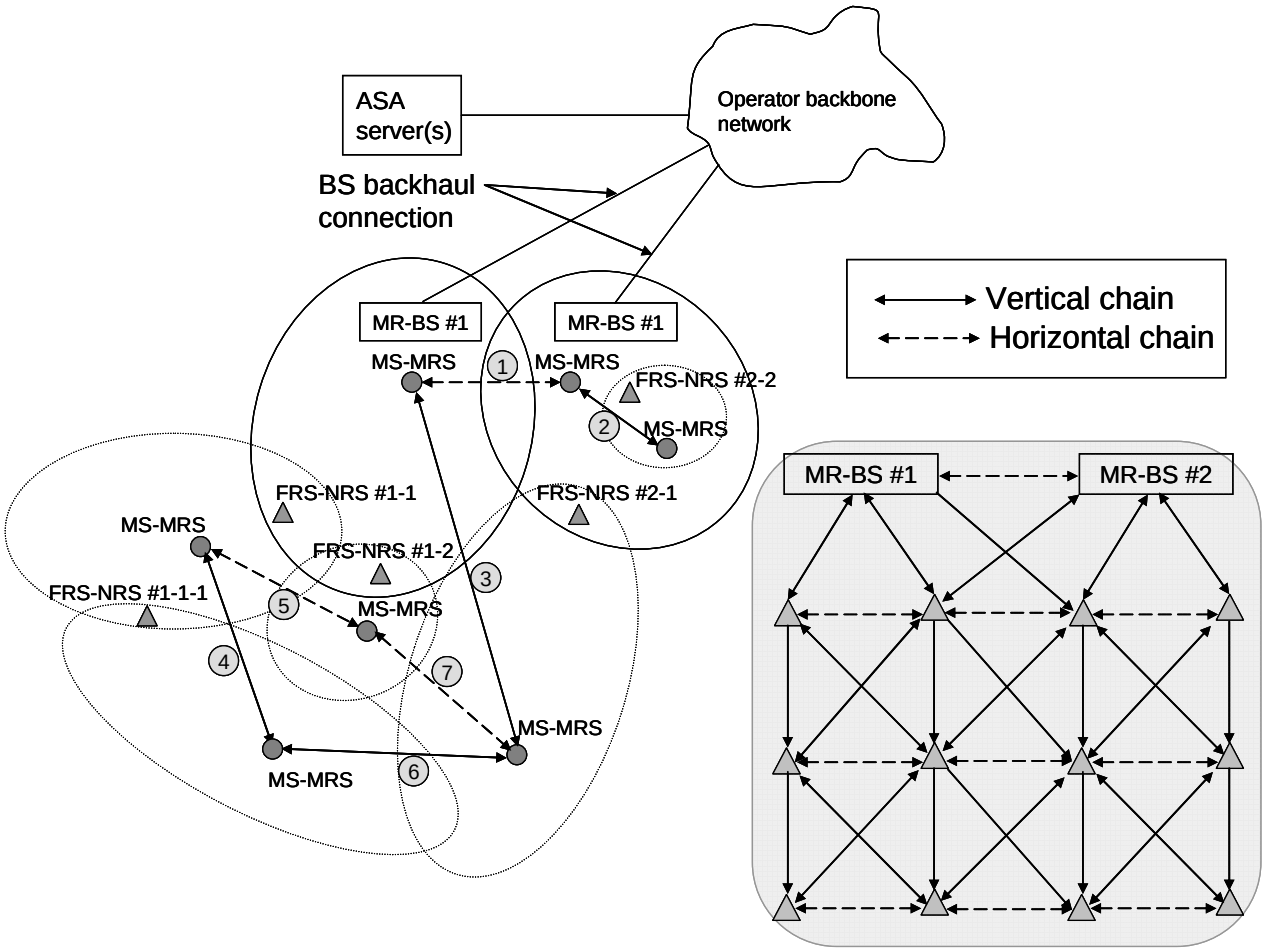


Figure xxx: Network model example for 802.16j relay deployment

In the above Figure xxx, the RS number is defined following its defined BS number, such as FRS-NRS #1-1 means a fixed RS or a nomadic RS number 1 with BS #1, etc. MS-MRS means MS or MRS.

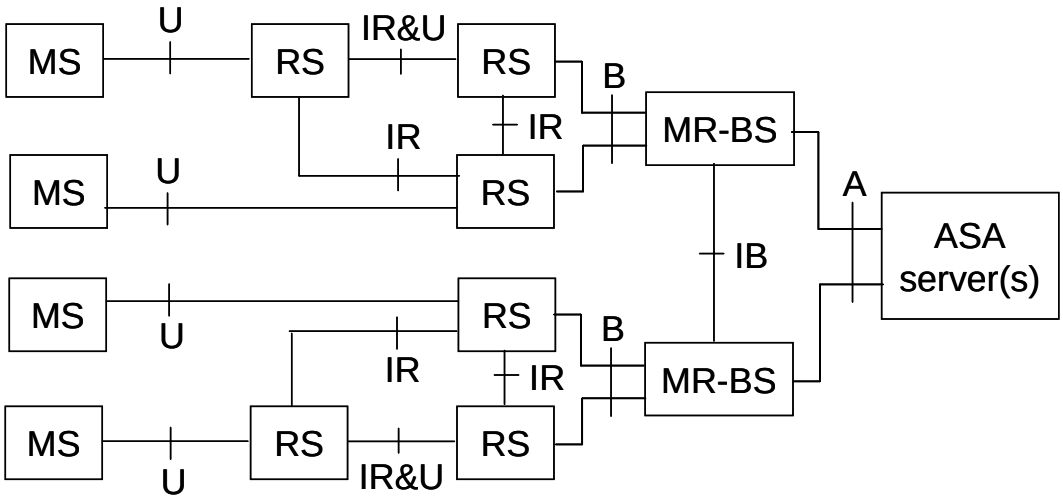
Two RSs are in a horizontal chain if they are at the same depth of the tree-topology, (i.e. same number of hops from the BS). Other wise, the two RSs are in a vertical chain.
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Also as shown in the Figure xxx, all types of handover of relaying are categorized into seven categories and these categories are defined in Table xxx. Noted that the first category is the same as that defined in 802.16e, which should not have any modifications in 802.16j.

Table xxx: Seven handover categories of relay deployment

Handover categories	Definition	Comments
(1) BS-BS registration	Handover between two BSs without any relay	It is the same at that defined in 802.16e
(2) BS-RS network access	Handover between BS and its own RS	Registration is not required following the handover
(3) BS-RS registration	Handover between BS and a RS belongs to another BS	Registration is required following the handover
(4) RS-RS vertical network access	Handover between RSs and the RSs are in vertical chain and the RSs belongs to the same BS	Registration is not required following a handover
(5) RS-RS horizontal network access	Handover between RSs and the RSs are in horizontal chain and the RSs belongs to the same BS	Registration is not required following a handover
(6) RS-RS vertical registration	Handover between RSs and the RSs are in vertical chain but the RSs belongs to different BSs	Registration is required following the handover
(7) RS-RS horizontal registration	Handover between RSs and the RSs are in horizontal chain but the RSs belongs to different BSs	Registration is required following the handover

A logical network reference model, control plane, for 802.16j relaying mode is also depicted in Figure yyyy, where the message change is between RSs under an MR-BS. The message change between RSs under different MR-BSs must go through the MR-BSs.



Reference point	Elements to be specified by IEEE 802.16j	Comments
U	PHY, MAC (including CS) operations, including message exchanges for mobility support	
IB	BS-to-BS messages	Transport protocol is not specified
IR	RS-to-RS messages	Transport protocol is not specified
A	Messages serving MS and RS (e.g. MRS) authentication and service authorization functions	Transport protocol is not specified
B	Messages serving MS and RS (e.g. MRS) authentication	Transport protocol is not specified

Figure yyyy: Logical network reference model, control plane, for 802.16j relaying mode

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~End of text input~~~~~~

References

[1] IEEE Standard for Local and metropolitan area networks, “Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems, Amendment 2: Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands”, IEEE, 28 February 2006.

[2] WiMAX Forum, “Mobile WiMAX – Part I: A technical Overview and Performance Evaluation”, WiMAX, Forum, June 2006.

[3] IEEE 802.16j-06/015, “Harmonized Contribution on 802.16j (Mobile Multihop) Usage Models”, 2006-09-05.

[4] IEEE802.16j-06/014r1, “Harmonized definitions and terminology for 802.16j Mobile Multihop Relay”, 2006-10-11.

[5] IEEE C802.16j-06/299r2, “Text proposal for handover cases in an MR Network”, 2006-11-16
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~