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Title	A node entry process for IEEE 802.16j multihop relay networks
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Re:	Submitted in response to Call for Technical Proposals for IEEE 802.16j issued on 2006-10-15
Abstract	This contribution describes a network entry and node selection process as being defined in the IEEE 802.16j. It aims to select an optimal attachment point when an MS or RS enters into the network, such that the new node can achieve maximum end-to-end throughput, and the system can manage the resources efficiently.
Purpose	This contribution is about a network entry and node selection process to be considered for Section 6.3.9.16 Network entry and initialization.
Notice	
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Patent Policy and Procedures	

A node entry process for IEEE 802.16j multihop relay networks

IEEE 802.16j is the IEEE standardization Task Group defining Mobile Multihop Relay (MMR) Specification for Broadband Wireless Access Systems [1]. MMR is a promising solution to expand coverage and to enhance throughput and system capacity for IEEE 802.16 systems. It is expected that the complexity of relay stations (RS) will be considerably less than the complexity of legacy IEEE 802.16 base stations (BS). The gains in coverage and throughput can be leveraged to reduce total deployment cost for a given system performance requirement and thereby improve the economic viability of IEEE 802.16 systems. Also, relay functionality enables rapid deployment and reduces the cost of system operation. These advantages will expand the market opportunity for broadband wireless access.

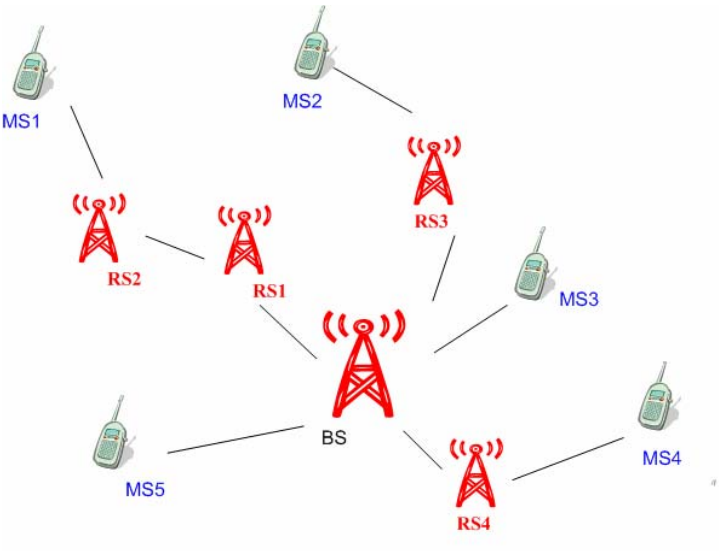

Figure 1. Network topology of MMR in IEEE 802.16j.

Figure 1 shows an example of network topology of IEEE 802.16j. An MS may attach to the BS directly or an RS. If the MS is attached to the BS, the downlink transmission is BS→MS and the uplink transmission is MS→BS. If the MS is attached to the RS, the downlink transmission is BS→RS→MS and the uplink transmission is MS→RS→BS. If multihop RS is being considered, the number of RS between the MS and BS may be more than one such that MS→RS→ …→RS →BS. When an MS enters into the BS cell, the BS will select an attachment point for the MS. The selection of attachment point will affect the performance of the MS, such as the end-to-end throughput and delay of the traffic of the MS. Also, this selection will affect the efficiency of the radio resource management of the system. We propose a network entry and node selection process for MS and RS. The proposed scheme conforms to the IEEE 802.16j specification in that there will be no change to IEEE 802.16e SS [3]. Our proposal only involves the changes of BS and RS. The target of the proposed scheme is to achieve good performance from the viewpoints of both system and individual components.

For the compatibility issues, the MS must maintain the process that has been prescribed in IEEE802.16e-2005 and IEEE802.16-2004 in “Section 6.3.9 Network entry and initialization” [2][3]. The flow chart of the network entry process for MS is shown in Figure 2 (Figure 55 in IEEE 802.16-2004 spec).

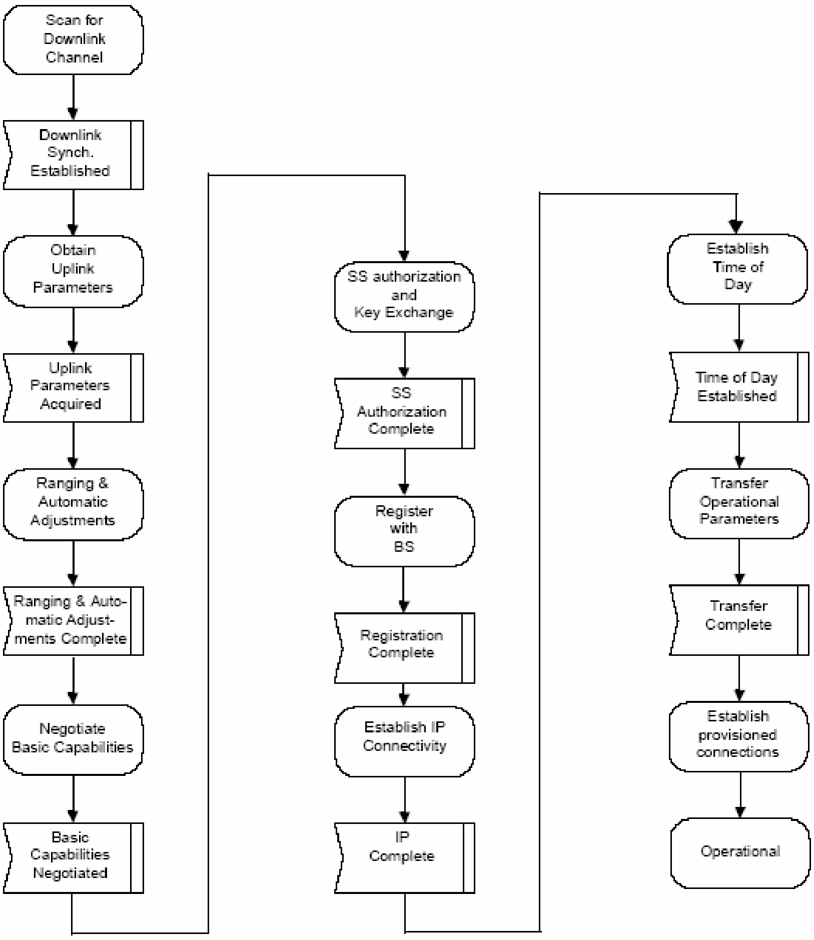

Figure 2. Network entry process for MS (indicated as “SS” in this flowchart).

Among those phases, ranging is very important for the MS attachment. Through the ranging process, the MS possibly optimizes its attachment point to get the best channel quality and maximum throughput. In this proposal, the network entry scenarios focus on ranging part.

Based on the network topology shown in Figure 1, one of the five scenarios may happen when an MS or RS enters into the network, depicted in Figure 3. The classification of the scenarios depends on whether BS or RS receive RNG-REQ from a new MS or RS and the number of RS receiving RNG-REQ. Some messages are defined in Table 1 in the network entry process, besides the standard messages in IEEE802.16e-2005, such as RNG-REQ and RNG-RSP.

Message symbol	Explanation	Remarks
SRVG-REQ	Serving Request	This message is sent from a RS to BS when the RS volunteers to be the attachment point of a new MS or a new RS.
SRVG-CNF	Serving Confirmation	This message is sent from a BS to a RS when the BS assigns this RS to be the attachment point of a new MS or a new RS.
SRVG-RJT	Serving Reject	This message is sent from a BS to a RS when the BS rejects the serving request from this RS. SRVG-RJT must indicate whether *forward* is enabled. A RS receiving SRVG-RJT with *forward* enabled must send RNG-RSP (abort) to the new MS or new RS on behalf of the BS.
SRVG-ACK	Serving Acknowledgement	This message is sent from a RS to BS, to acknowledge the receipt of the SRVG-CNF/ SRVG-RJT.

Table 1. Extended messages

The messages between a BS and an MS may be forwarded by more than one RS. We define two cases in the document, ***single RS case*** and ***multiple RS case***. In the ***single RS case,*** there is only one RS allowed in the forwarding path between the BS and MS, thus, the maximum number of hops in the end-to-end transmissions is two. The ***single RS case*** is the mandatory operation in IEEE 802.16j. In the ***multiple RS case,*** more than one RS is allowed in the forwarding path between the BS and MS, thus, the maximum number of hops in the end-to-end transmissions is larger than two. The ***multiple RS case*** is the optional operation in IEEE 802.16j. We will describe network entry process in the two cases in the following part of this document.

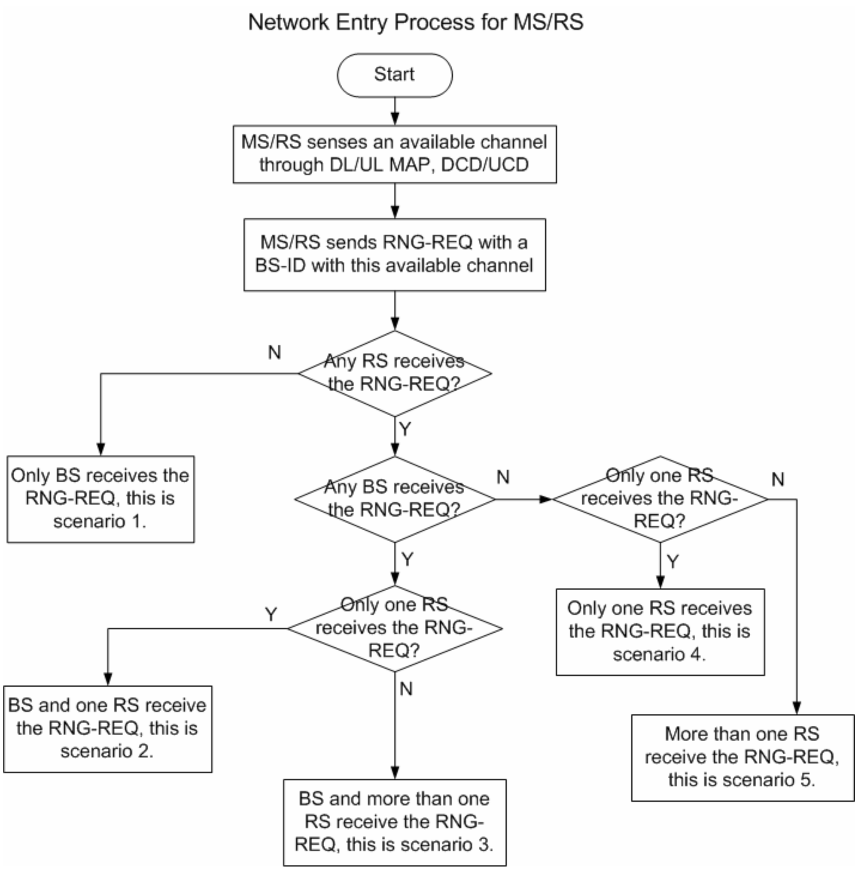

Figure 3. Network entry for MS/RS scenarios.

Single RS case

Figure 4 shows a generic scenario in the MS entry in the single RS case. The single RS case is the mandatory operation in IEEE 802.16j [1], where the maximum number of hops of end-to-end transmission between a BS and an MS is two. In this operation, only one RS is allowed to be in the forwarding path. The RS receiving the RNG-REQ with acceptable RSS (Received Signal Strength) volunteers to serve the MS, and sends a SRVG-REQ (Serving Request) to the BS. The BS will decide whether to accept or reject the entrance of the MS, as well as who will serve the MS, based on specific selection decision criteria. If the BS selects one of the RS to be the attachment point, the BS sends a SRVG-CNF (Serving Confirmation) to the RS, to confirm the serving request from the RS. This RS then sends a RNG-RSP (success) to the MS to confirm the attachment of the MS to the RS. The BS then sends a SRVG-RJT to other RS, to reject the serving request from those RS. Each RS acknowledges with an SRVG-ACK (Serving Acknowledgement) message. If the BS decides to serve the MS itself, the BS sends RNG-RSP to the MS. Then the BS sends a SRVG-RJT to all RS from which the BS received the SRVG-REQ earlier, to reject the serving request from those RS.

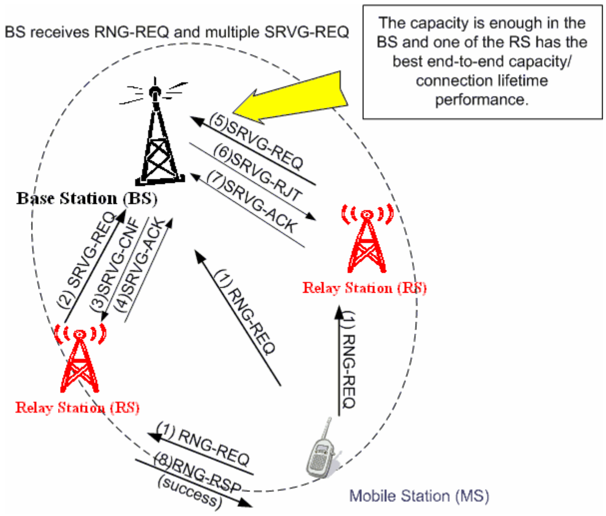

Figure 4. MS entry scenario in single RS case.

Figure 5 shows the sequence of messages that are exchanged during the network entry for MS in the single RS case.

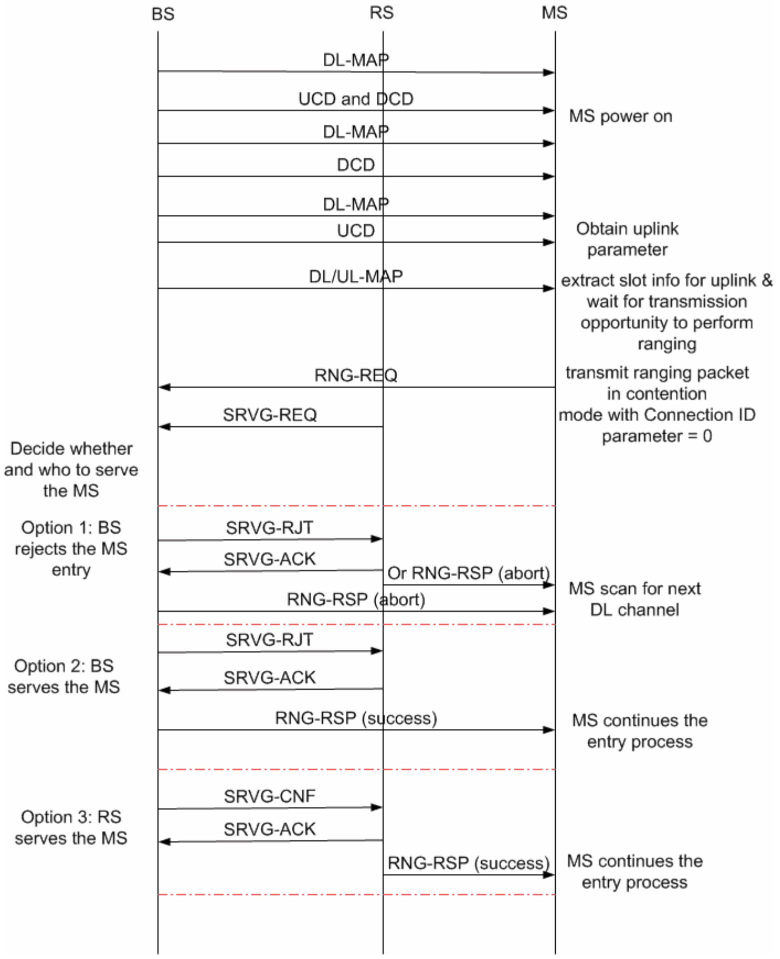

Figure 5. The message sequence of network entry for MS in single RS case.

The RS entry in single RS scenario is shown in Figure 6. When a new RS enters into the network, it scans multiple channels to identify the available BS cell to be connected. If there are more than one candidate BS cells, the new RS selects the BS cell according to specific selection criteria. Once a BS cell is selected, the RS sends RNG-REQ with the maximum power to the BS cell. If the RSS of the RNG-REQ is good enough, the BS sends RNG-RSP (success) to the RS to indicate that the RS can attach to the BS cell. Then the BS and RS start the follow-up procedures such as capability negotiation, authentication and register, etc.

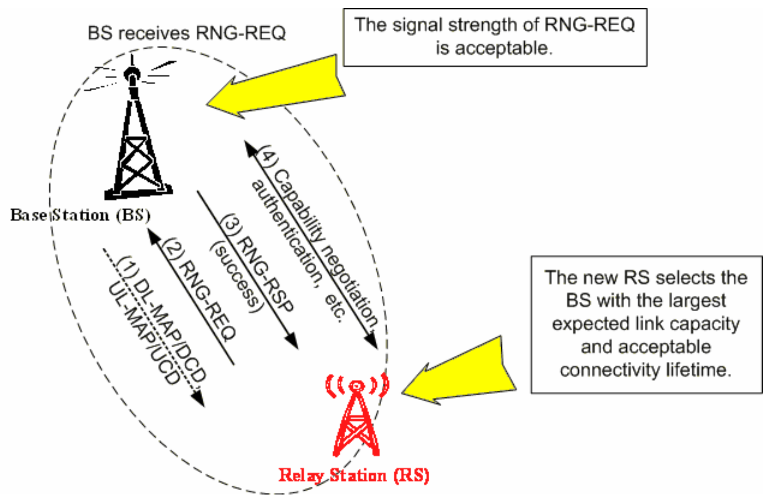

Figure 6. RS entry scenario in single RS case.

Figure 7 shows the message sequence in RS entry process in single RS case.

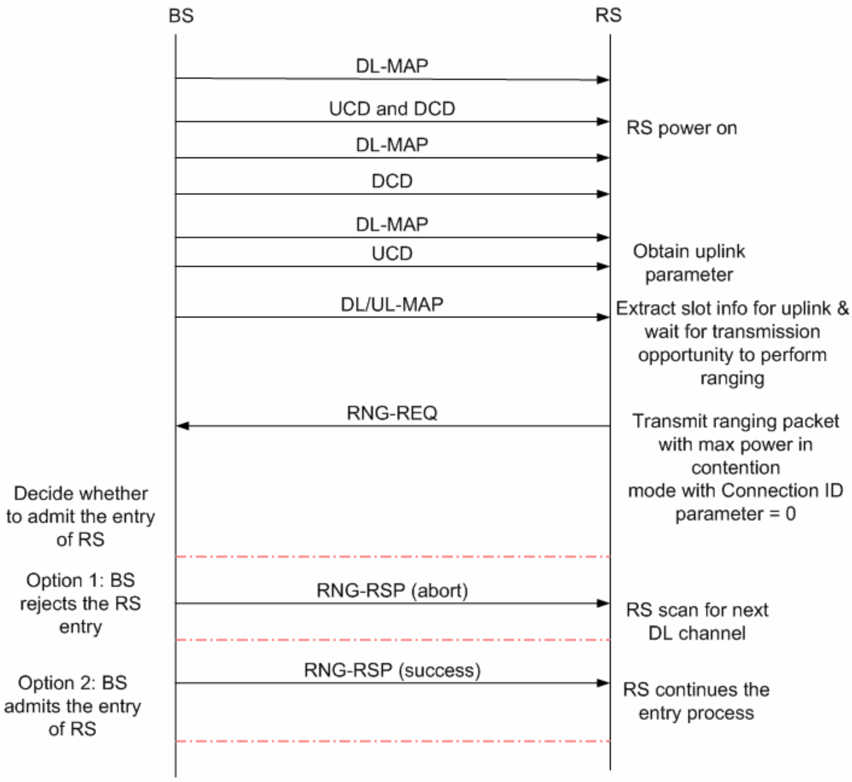

Figure 7. The messages sequence in RS entry in single RS case.

Multiple RS case

Figure 8 shows a generic scenario in the MS entry in multiple RS case. The RS receiving the RNG-REQ with acceptable RSS (Received Signal Strength) volunteers to serve the MS, and sends a SRVG-REQ (Serving Request) to the BS. When a parent RS receives a SRVG-REQ from its child RS, the parent RS forwards the SRVG-REQ until it reaches the BS. The BS will decide whether to accept or reject the entrance of the MS, as well as who will serve the MS, based on specific selection decision criteria. If the BS selects one of the last hop RS to be the attachment point, the BS sends a SRVG-CNF (Serving Confirmation) to the RS, to confirm the serving request from the RS. When a RS receives a SRVG-CNF from the BS or its parent RS, and this RS is not the one who initiated the SRVG-REQ, the RS forwards the SRVG-CNF to its child RS until it reaches the last hop RS. The last hop RS then sends a RNG-RSP (success) to the MS to confirm the attachment of the MS to the RS. The BS then sends a SRVG-RJT to other RS, to reject the serving request from those RS. Each RS acknowledges with an SRVG-ACK (Serving Acknowledgement) message. If the BS decides to serve the MS itself, the BS sends RNG-RSP to the MS. Then the BS sends a SRVG-RJT to all RS from which the BS received the SRVG-REQ earlier, to reject the serving request from those RS. The forwarding path of SRVG-RJT is the same as that of the SRVG-CNF described earlier.

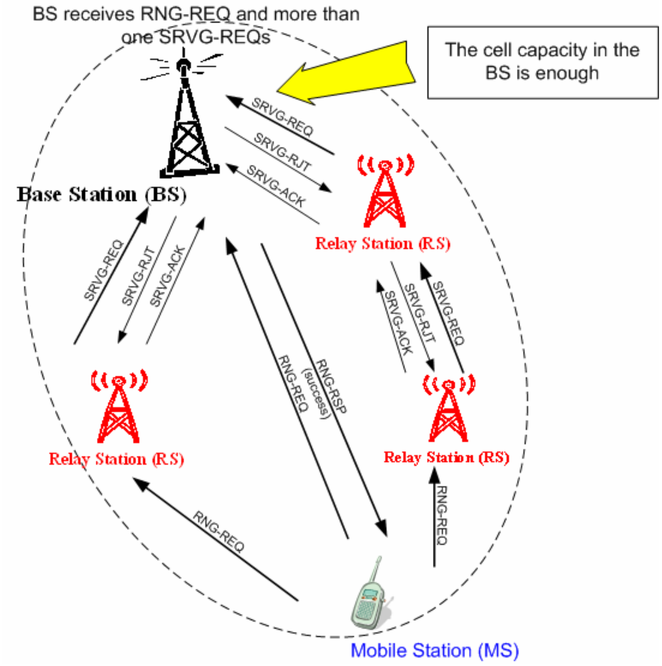

Figure 8 MS entry in multiple RS scenario.

In the multiple RS case, the RS entry process is similar to the MS entry as shown in Figure 8. The scenario of RS entry in multiple RS case is shown in Figure 9.

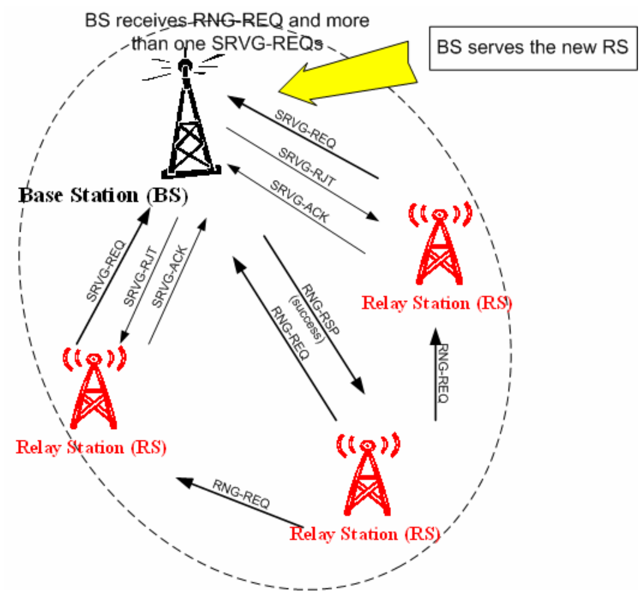

Figure 9 RS entry in multiple RS scenario.

Figure 10 shows the generic message flow for MS and RS entry in multiple RS scenario. In this message flow, option 1 is only for MS entry; options 2 and 3 are for both MS and RS entry.

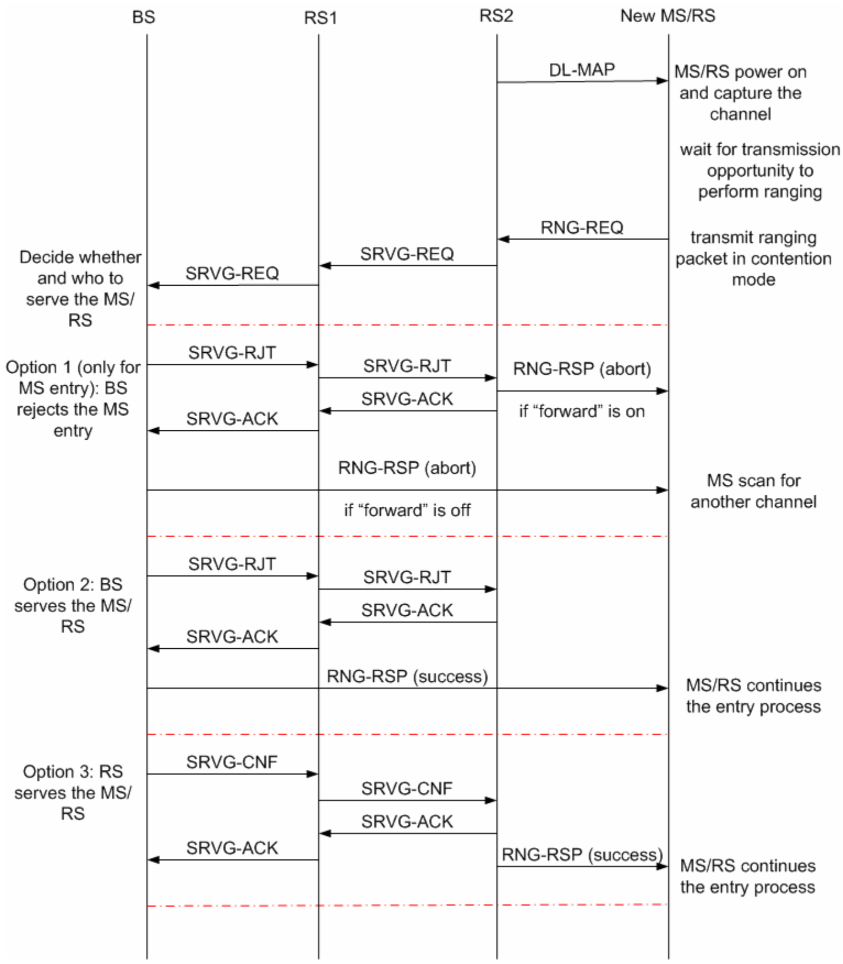

Figure 10 The messages sequence in MS/RS entry in multiple RS case.

The message format of RS-SRVG_IE is designed as Table 2, which defines the content of extended messages in Table 1.

Syntax	Size	Notes
RS-SRVG_IE(LAST) {	*variable*	
TYPE	3 bits	0x0 = SRVG-REQ 0x1 = SRVG-CNF 0x2 = SRVG-RJT 0x3 = SRVG-ACK 0x4…0x7 = reserved
NetEntry MAC Address	48 bits	The MAC address of the new MS
LAST	1 bit	0 = More RS-SRVG_IE in the list 1 = Last RS-SRVG_IE in the list
LAST HOP MOBILITY INFO	5 bits	0x0 = speed 0 0x1 = speed 1 0x15 = speed 15 0x16 = angle 0 0x31 = angle 15
LAST HOP INITIAL DISTANCE	4 bits	0x0 = distance 0 0x15 = distance 15
LAST HOP LINK CAPACITY	4 bits	Map to modulation type
FORWARD	1 bits	0x0 = not forward RNG-RSP(fail) 0x1 = forward RNG-RSP(fail)
}		

Table 2. RS-SRVG_IE format

References:

[1] “P802.16j - Amendment to IEEE Standard for Local and Metropolitan Area Networks - Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems - Multihop Relay Specification”, March 2006.

[2] “Part 16: Air Interface for Fixed Broadband Wireless Access Systems”, IEEE Std 802.16-2004, October 2004.

[3] “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 and Corrigendum 1”, IEEE Std 802.16e-2005, February 2006.