Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**A RS Clustering Scheme for IEEE 802.16j**
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Re:	IEEE 802.16j-06/027: "Call for Technical Proposals regarding IEEE Project P802.16j"
Abstract	This contribution proposes a RS clustering concept to enable multiple relay stations to transmit the same radio signal and behave like the traditional repeaters in the IEEE 802.16j Multi-hop Relay system
Purpose	Propose a RS clustering concept and clarify the corresponding MS mobility management mechanism for IEEE 802.16j
Notice	
Release	
Patent Policy and Procedures	

A RS Clustering Scheme for 802.16j

I. INTRODUCTION

In IEEE 802.16j, RSs (relay stations) are developed to provide user-throughput enhancement, coverage extension and/or capacity enhancement to IEEE 802.16e. Deployment of relays, however, may incur issues that are not encountered in IEEE 802.16e. For example, an MS (mobile station) may perform handover more frequently than in the IEEE 802.16e system due to a smaller RS coverage. Also, if RSs are configured to broadcast control signals such as preamble, FCH and MAP in a frame, over-the-air overhead might consume too large a part of the MR-BS's radio resource. This problem is particularly serious if the number of relays in an MR-cell (multi-hop relay cell) is large. Finally, if a predefined resource is allocated to a specific RS, the resource utilization in an MR-BS would lack of flexibility, and the system trucking efficiency would become lower. In this contribution, a clustering scheme of RSs is proposed for IEEE 802.16j to ease the above-mentioned issues.

II. PROBLEM DEFINITION

In IEEE 802.16j, RSs are developed to provide user throughput enhancement, coverage extension and/or capacity enhancement to IEEE 802.16. Some usage models of RSs were suggested in [1], including fixed infrastructure, in-building coverage, temporary coverage, and coverage on mobile vehicle. In real applications, deployment of RSs may be subject to limitation on the RS transmit power, geography of the service area, etc. For example, two or more RSs in the vicinity of each other may be deployed to provide throughput enhancement over a large urban area and/or to provide coverage extension to a large hole or in an underground. In addition, it would not be uncommon to deploy adjacent RSs along a tunnel or a highway in order to provide complete coverage. Figure 1 illustrates these deployment scenarios, including coverage and/or throughput enhancement (a) to a large urban area, (b) in a tunnel, (c) in an underground, and (d) along a highway.

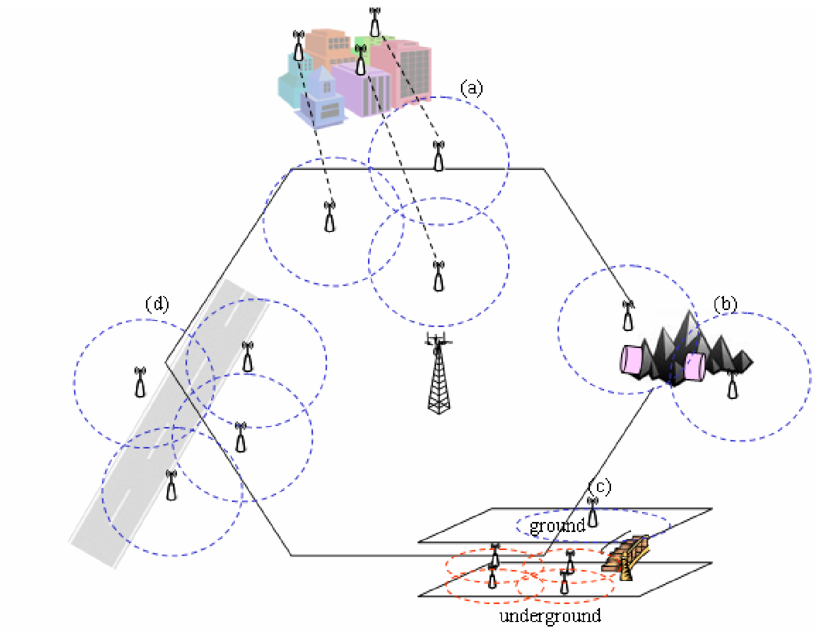

Figure 1. Deployment scenarios of RSs in IEEE 802.16j

Deployment of RSs may encounter issues that are not met in the traditional cellular systems, including frequent handovers, undue overhead and low system trunking efficiency. The issues are discussed in more detail as follows.

- Frequent Handovers: In the IEEE 802.16e system, no handover will be triggered for an MS moving within the cell coverage. In an MR network, however, handover may be initiated when an MS moves across the boundary of RSs. Take Figure 2 as an example, an MS might trigger more than one handover when walking along path (a), (b) or (c). Too often handover happens would degrade the connection and network performance.

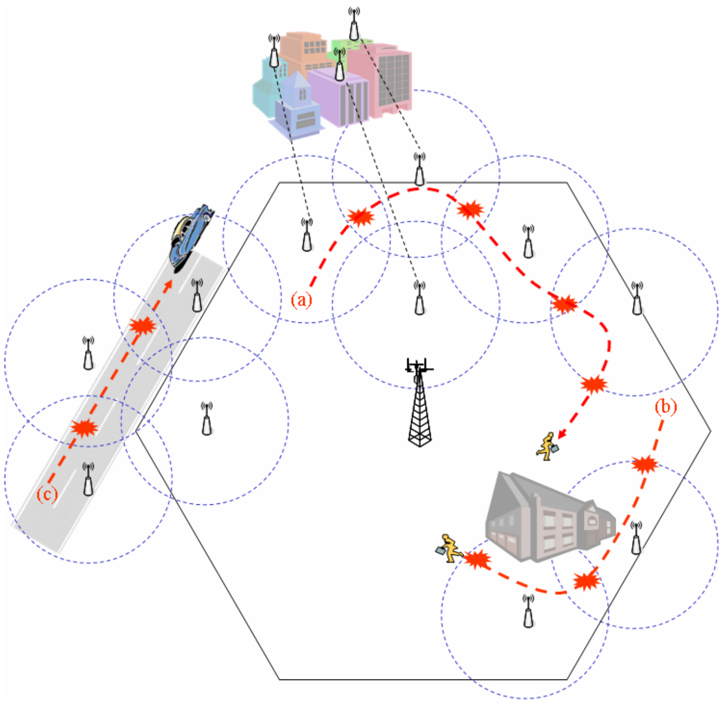

Figure 2. Example handover scenarios in MR-cell

- Undue overhead: In 802.16j, RSs may need to broadcast control signals such as Preamble, FCH and MAP for the application of coverage extension. Figure 3 illustrates the potential issue with one BS and six RSs in a MR-cell, where P and M stand for Preamble and MAP, respectively. As is obvious, the under overhead may eat up quite a part of the radio resource.

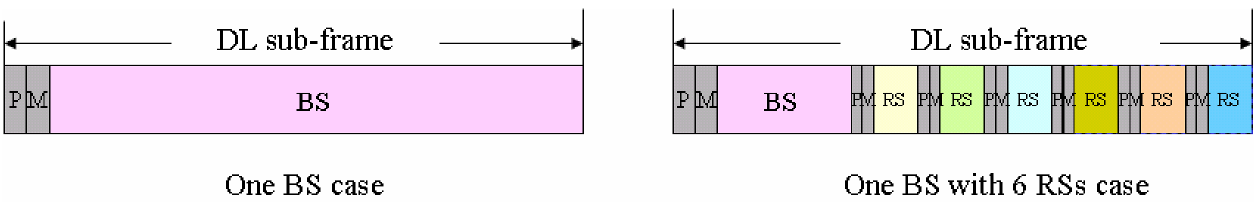

Figure 3. Overheads for six RSs in an MR-cell

- Low trucking efficiency: In IEEE 802.16j, radio resource may be allotted to RSs in a pre-determined and fixed way. In this case, an RS may starve for radio resource because a large number of MSs, while one other may leave its radio resource wasted due to not having enough number of MSs. That is, the radio resource of an MR-BS is fragmented and is not fully utilized, and that leads a lower trucking efficiency.

III. THE CONCEPT OF RS CLUSTERING

A set RSs is said to form a clustered-RS if they transmit the same down-link signals. (A single RS can be considered as a special clustered-RS which has only one member RS.) For the up-link, each member RS in a clustered-RS acts link a regular RS. The basic idea behind the clustering is that adjacent RSs could be clustered together as a clustered-RS that acts like a regular RS in the down-link to its associated MSs or RSs. Since the coverage of a clustered-RS is larger than the regular member RS, there would be a lower handover frequency. In addition, only one copy of control signal in a frame is needed for a clustered-RS, the overhead is thus reduced. Finally, the down-link radio resource of each member RS can be aggregated and shared by all the MSs under the clustered RS so that the trunking efficiency is improved.

Figure 4 shows an example MR network incorporating the concept of RS clustering, where the solid line connecting two clustered-RSs says that they have a direct communication between them. In this example, Clustered-RS1 consists of RS-1 and RS-2, Clustered-RS2 consists of two RS-5 and RS-6, and Cluster-RS3 and Cluster RS-4 are the single-element clustered-RSs. Note that RS-4 cannot be clustered with RS-5 and RS-6 as a new clustered-RS because they don't have same mater clustered-RS.

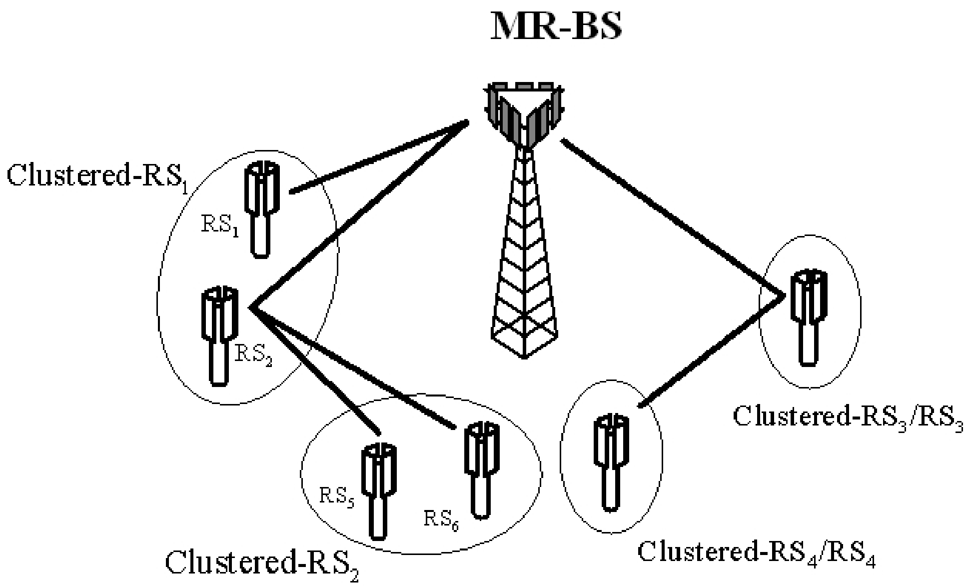

Figure 4. An example MR-network with RS clustering

IV. THE MOBILITY MANAGEMENTS FOR RS CLUSTERING

For Clustered-RS1, RS1 and RS2 will transmit the same preamble and MAP. Besides, the ranging channel is shared by RS1 and RS2. Under this design, MS behaves like roaming in a Clustered-RS1's cell and doesn't initiate the HO procedures when associating from RS1 to RS2. A MS CDMA periodic ranging process with aggregated ranging sub-channel allocation [2] can be employed to handle the RS reselection during Clustered-RS1's coverage. On the other hand, when MS moves from Clustered-RS1's coverage into Clustered-RS2's coverage, due to a Clustered-RS can be seen as a legacy BS, the conventional MAC layer handover procedures can be applied for this scenario. By the way, only inter-Clustered-RS needs initiating the handover procedures and this will reduce the handover frequency for MR network.

V. PROPOSED TEXT

---Start of Text---

6.3.6.7 Relaying Support for Scheduling

6.3.6.7.2 Centralized Scheduling

[*Insert the following text in this section of [3]*]

The MR-BS shall schedule the same down-link data to the RSs in a clustered RS by using DL-MAP IE.

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 of [3]*]

In order to evaluate the possibility of clustering a new coming RS into a clustered-RS, the new RS should report RSSI measurements of other RSs that are subordinated to the same MR-BS after the network entry. When the MR-BS receives the RLY_SCN-REQ from the new RS, it should reply the RLY_SCN-RSP message and include the Preamble_Index/Subchannel_Index of itself and all its subordinated RSs in the recommended list. Then the new RS should report the RSSI measurement results to the MR-BS by RS_SCN-REP message.

6.3.22 MAC layer handover procedures

[*Insert the following text in this section of [3]*]

When RS clustering scheme is adopted in MR network, a MS CDMA periodic ranging process with aggregated ranging sub-channel allocation specified in 6.3.10.3.4.2 can support the MS mobility management for intra-Clustered-RS scenario and the MAC layer handover procedures could be omitted in this case. For inter-Clustered-RS scenario, the MAC layer handover procedures specified in 6.3.22.1~6.3.22.2 could be used to handle the MS mobility management.

6.3.25 Relay path management and routing

[*Insert the following text in this section of [3]*]

In order to reconfigure the clustering of RSs, the MR-BS can send an unsolicited RLY_SCN-RSP message to each subordinated RS for reporting the RSSI measurement. The parameter "Report mode" in RLY_SCN-RSP should be set as 0b10, and each RS should report the measurement by the RLY_SCN-REP message to the MR-BS.

[*The ranging process and related message formats for Clustered-RS are specified in Appendix and referenced from* [2]]

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

---End of Text---

VI. REFERENCES

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

[2] IEEE 802.16j-06/172, "Ranging process for IEEE 802.16j"

[3] IEEE 802.16j-06/017r2, "Table of Contents of Task Group Working Document"

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

Appendix [2] [4]

In the aggregate raging sub-channel allocation, the relaying support for OFDMA based ranging shall take the following actions:

—When receiving a Ranging Code or an RNG-REQ message, the RS shall send an RLY_RNG-REP message to the MR-BS. This message contains its RSID, required adjustments and status about received Ranging Code (or RNG-REQ message).

—The MR-BS shall identify the received RLY_RNG-REP messages from its subordinate RSs by checking the Ranging Code (or RNG-REQ) and frame number to see if they are coming from the same user's ranging request during a period of time (timer T49).

—The MR-BS shall select a suitable station from these candidate access stations as the ranging target and response with an RNG-RSP message based on the target station's PHY parameters. This Ranging Response message contains the needed adjustments (e.g. time, power, and possibly frequency corrections) and a status notification or contains a valid basic CID after success adjustments.

The ranging and adjustment processes given in Figure D, Figure E, Figure F, and Figure G shall be followed by superordinate RS and MR-BS.

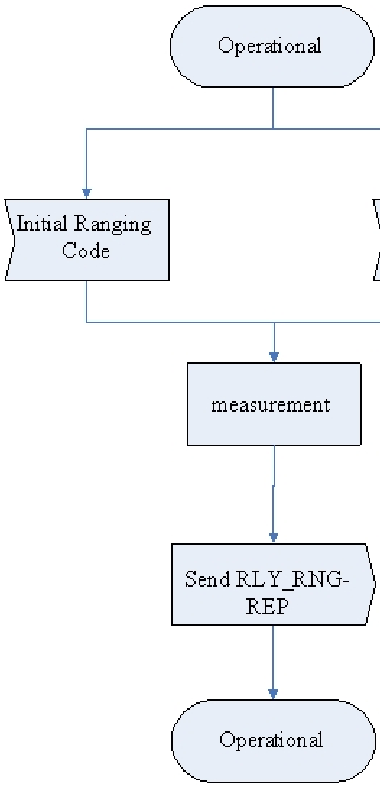

Figure D: CDMA initial ranging process with aggregate ranging sub-channel allocation (access RS)

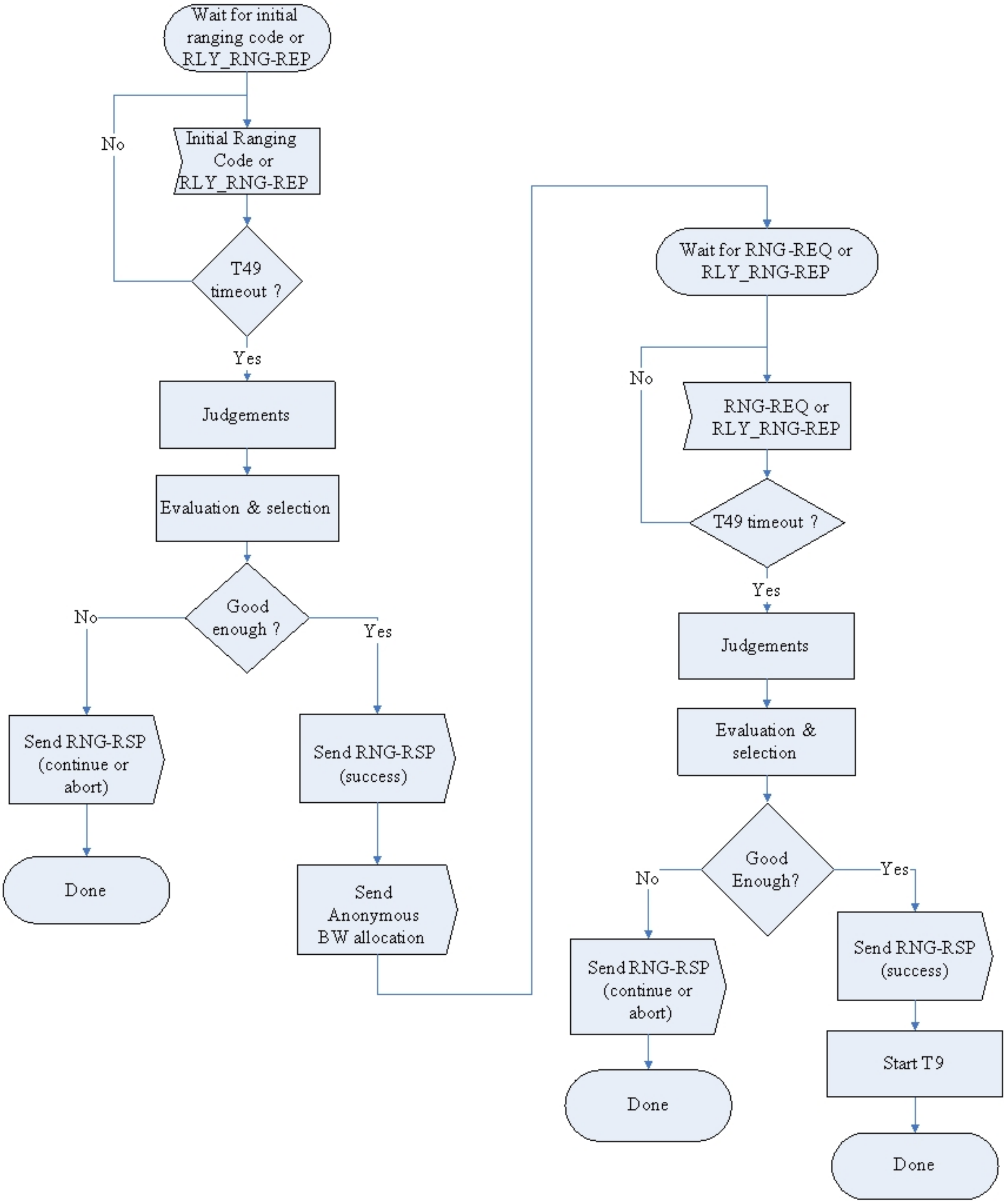

Figure E: CDMA initial ranging process with aggregate ranging sub-channel allocation (MR-BS)

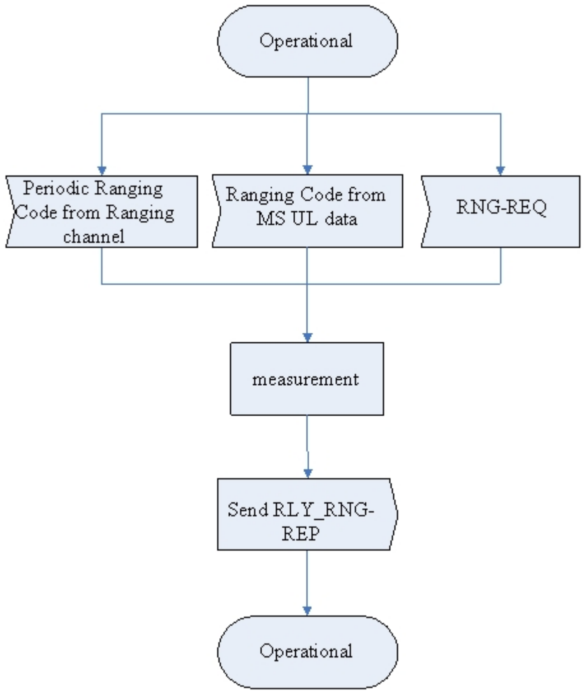

Figure F: Periodic CDMA ranging process with aggregate ranging sub-channel allocation (access-RS)

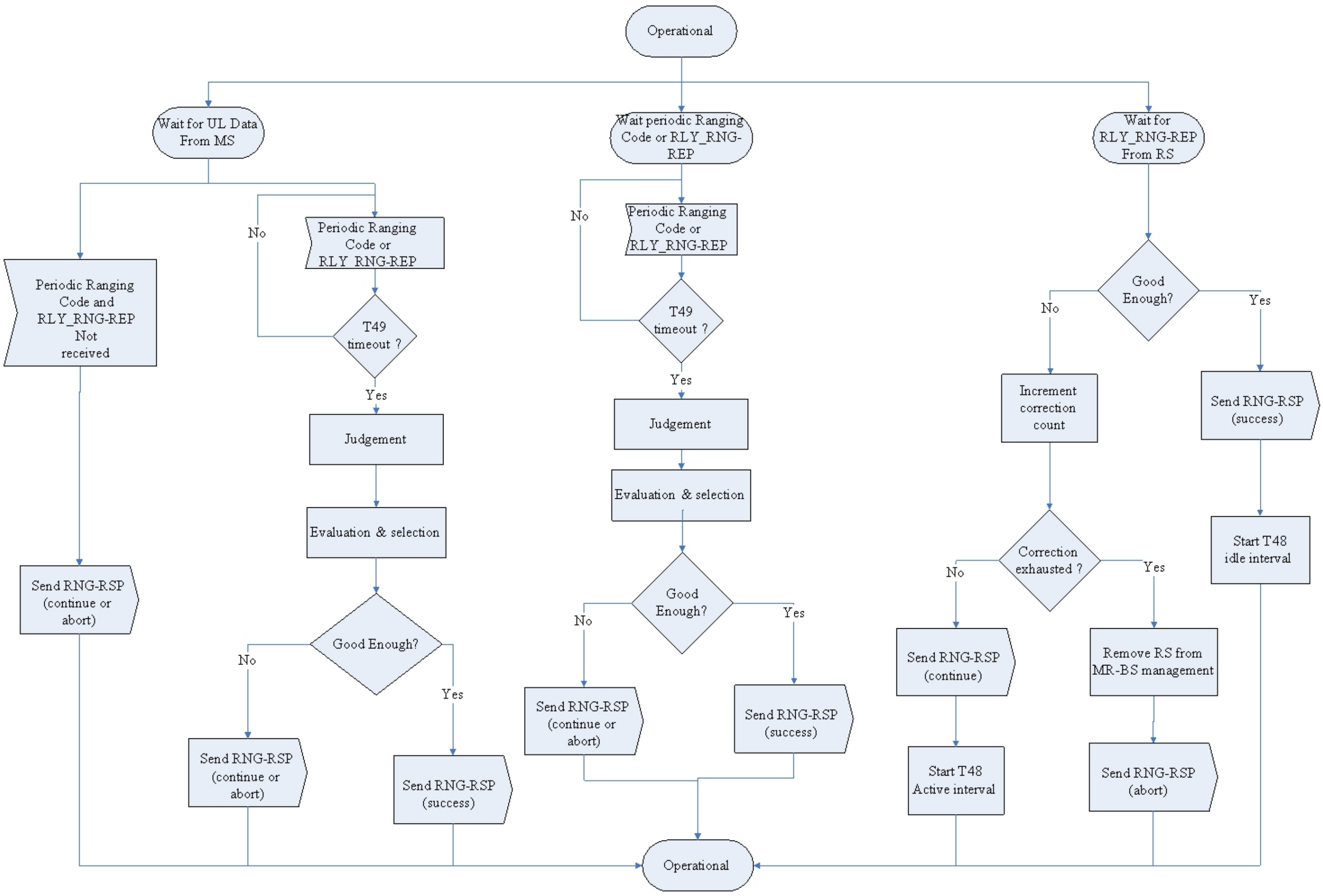

Figure G: Periodic CDMA ranging process with aggregate ranging sub-channel allocation (MR-BS)

Relaying mode RS ranging report (RLY_RNG-REP) message

After receiving a Ranging Code or RNG-REQ message, RS shall transmit an RLY_RNG-REP message to report the ranging results to MR-BS. The message shall be transmitted on the Primary Management CID.

The format of the RLY_RNG-REP message is depicted in Table A.

Table A—RLY_RNG-REP message format

Syntax	Size	Notes
RLY_RNG-REP_Message_format(){	—	—
Management Message Type=74	8 bits	—
BSID	48 bits	BSID of access RS
Ranging type	2 bits	0b00: receiving a Ranging Code 0b01: receiving a RNG-REQ with MAC address 0b10: receiving a RNG-REQ with Basic CID 0b11: *Reserved*
Padding	6 bits	Shall be set to zero
If (Ranging type==0b00) {	—	—
N_Received_Ranging _Code	8 bits	Number of Ranging Code received in this frame number
For (j=0; j<N_Received_Ranging_Code; j++){	—	—
Ranging Code attributes	32 bits	Bits 31:22 – Used to indicate the OFDM time symbol reference that was used to transmit the ranging code. Bits 21:16 – Used to indicate the OFDMA subchannel reference that was used to transmit the ranging code. Bits 15:8 – Used to indicate the ranging code index that was sent by the SS. Bits 7:0 – The 8 least significant bits of the frame number of the OFDMA frame where the SS sent the ranging code.
Timing adjust	32 bits	Tx timing offset adjustment (signed 32-bit). The time required to advance subordinate station transmission so frames arrive at the expected time instance at the superordinate station. Units are PHY specific (see 10.3).
Power Level Adjust	8 bits	Tx Power offset adjustment (signed 8-bit, 0.25 dB units) Specifies the relative change in transmission power level that the subordinate station is to make in order that transmissions arrive at the superordinate station at the desired power. When sub-channelization is employed, the subscriber shall interpret the power offset adjustment as a required change to the transmitted power density.
Offset Frequency Adjust	32 bits	Tx frequency offset adjustment (signed 32-bit, Hzunits) Specifies the relative change in transmission frequency that the subordinate station is to make in order to better match the superordinate station. (This is fine-frequency adjustment within a channel, not reassignment to a different channel.)
Ranging Status	4 bits	Used to indicate whether uplink messages are received within acceptable limits by superordinate station. 1 = continue, 2 = abort, 3 = success, 4 = rerange
}	—	—
}	—	—
If (Ranging type==0b01) {	—	—
N_Received_RNG-REQ	8 bits	Number of RNG-REQ message received in this frame number
For (j=0; j<N_Received_RNG-REQ; j++){	—	—
TLV encoding	variable	RNG-REQ management message encodings
}	—	—
}	—	—

If (Ranging type==0b10) {	—	—
N_Received_RNG-REQ	8 bits	Number of RNG-REQ message received in this frame number
For (j=0; j<N_Received_RNG-REQ; j++){	—	—
Timing adjust	32 bits	Tx timing offset adjustment (signed 32-bit). The time required to advance subordinate station transmission so frames arrive at the expected time instance at the superordinate station. Units are PHY specific (see 10.3).
Power Level Adjust	8 bits	Tx Power offset adjustment (signed 8-bit, 0.25 dB units) Specifies the relative change in transmission power level that the subordinate station is to make in order that transmissions arrive at the superordinate stationat the desired power. When subchannelization is employed, the subscriber shall interpret the power offset adjustment as a required change to the transmitted power density.
Offset Frequency Adjust	32 bits	Tx frequency offset adjustment (signed 32-bit, Hzunits) Specifies the relative change in transmission frequency that the subordinate station is to make in order to better match the superordinate station. (This is fine-frequency adjustment within a channel, not reassignment to a different channel.)
Ranging Status	4 bits	Used to indicate whether uplink messages are received within acceptable limits by superordinate station. 1 = continue, 2 = abort, 3 = success, 4 = rerange
TLV encoding	variable	RNG-REQ management message encodings
}	—	—
}	—	—
Padding	variable	Optional
}	—	—

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 B.

Table B—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 C.

Table C—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 D.

Table D—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
}	—	—