Project	**IEEE 802.16j Mobile Multihop Relay Task Group**
Title	**MS Handover Support in Relay Mode**
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Source(s)	Gang Shen, Kaibin Zhang, Shan Jin Voice: 86-21-50551240-8194 Fax: 86-21-50554554 Email: gang.a.shen@alcatel-sbell.com.cn Alcatel, Research & Innovation 388#, Ningqiao Road, Shanghai, P. R. C.
Re:	IEEE 802.16j-06_027: "Call for Technical Proposals regarding IEEE Project P802.16j"
Abstract	The mechanism and procedures of MS HO with RS involved are proposed in this document
Purpose	This document is provided as the input for the IEEE802.16j.
Notice	
Release	
Patent Policy and Procedures	

MAC Handover Support in Relay Mode

1. Introduction

The document is to describe the intra / inter MMR-BS handover as an input for call for contribution of the IEEE 802.16j–06_027. The MS HO in MMR network can be classified into two categories, inter MMR-BS handover and intra MMR-BS handover. For inter MMR-BS handover, MS or RS handovers between two RSs controlled by different MMR-BSs or between an MMR-BS and an RS controlled by another different MMR-BS. For intra MMR-BS handover, MS handovers between two RSs controlled by the same MMR-BS or between an MMR-BS and one of its subordinate RSs. Since the access station and the target access station are both in the same MMR cell, the intra MMR-BS handover mechanism could be simplified. MS shall conduct IEEE802.16e-2005 compliant HO procedures for backward compatibility.

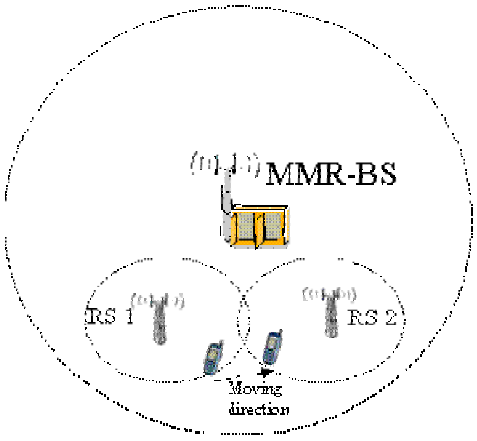

Figure1 Example of intra MMR-BS handover

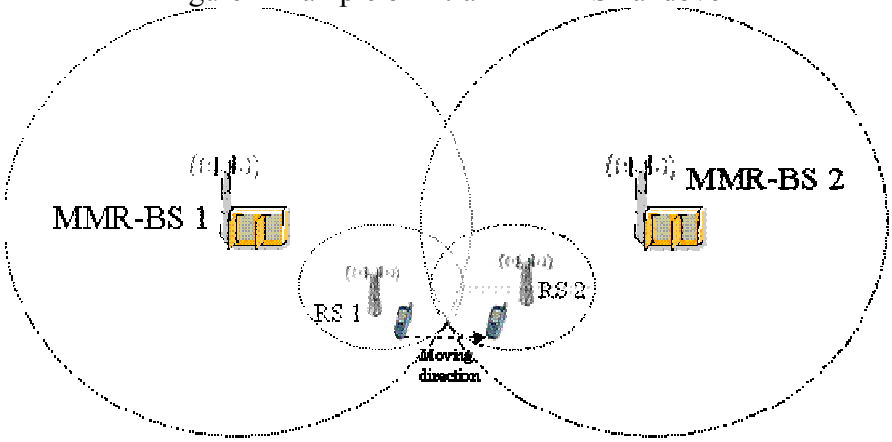

Figure2 Example of inter MMR-BS handover

2. Overview of the proposed solutions

Different relay frame structure definitions leads to different intra / inter MMR-BS handover procedures with high or low complexity. Handover strategies are given to suit supported relay frame structures. Generally there are two kinds of relay frame structures based on the different strategies of broadcast information transmission. The first one is uniform-broadcast info. frame structure, where the subordinate RS does not transmit the frame

header, or transmit the same frame header simultaneously as the serving station does. All MSs in MMR-cell get the preamble and MAP from the serving station directly. MS synchronizes to the same preamble before and after the intra-BS handover. Thus no actual handover procedure is performed in MS. For inter MMR-BS handover, MS performs a legacy 16e handover procedure. The second is different-broadcast info. frame structure, where the subordinate RS transmit its own frame header different from the serving station's. MS performs legacy 16e handover procedures and synchronizes to different preambles before and after the intra / inter-BS handover.

For suitable target access station selection in intra / inter MMR-BS handover, MMR-BS should know the optimal path for each RS to BS. BS maintain the status and quality of relay links between RSs or RS and BS, where the status information is updated by RS network entry, periodic / requested RS neighbor station detection and report. Based on this status information, BS may know the optimal relay path for each RS. This process need not occur in conjunction with any other HO process. The RS topology relationship and path selection for each RS may be performed in RS under the distributed schemes.

Target access station selection is a key step for MMR-BS handover to decide a suitable path for a specified MS. MS / RS reports the link status information, and MMR-BS makes the final decision as to the selection. Generally 16e legacy handover decision is based on the access link quality. However, for multi-hop relaying, only access link quality is not enough for the suitable target access station selection. It shall be decided based on the whole path selection from MS to BS, including factors such as quality of radio link (CINR,…), MS power level, multi-hop bandwidth efficiency, QoS requirement, hop counts, traffic load and etc. As the MMR-BS knows the optimal path and path performance for each RS to BS, it just need consider the path combining MS-RS and the optimal RS-BS path, jointly evaluate the performance of two sections: MS-RS path section and the optimal RS-BS path section, or the performance of direct path from MS to RS without intermediate RS, and then select a specified RS or MMR-BS itself as access station to make the whole MS-BS path optimized. The path selection and target access station decision algorithms are beyond the scope of the standard.

2.1 Handover for uniform-broadcast info. frame structure

This section introduces intra / inter MMR-BS handover based on the frame structure schemes with synchronized broadcasting that the subordinate RS does not transmit the frame header, or transmit the same frame header simultaneously as the serving station does. In this case, all MS of a MMR cell synchronize with MMR-BS or RS and acquire the identical DL/UL MAP.

Intra MMR-BS HO

The intra MMR-BS HO process occurs between two RSs controlled by the same MMR-BS or between an MMR-BS and one of its subordinate RS. MS is not aware of this intra HO process. The candidate stations (MMR-BS and it subordinate RSs) shall monitor and measure the MS UL signal quality in terms of the UL data burst or ranging message from MS periodically or as requested by MMR-BS. The measurement results are reported to the serving station. Besides the link quality, the traffic load balance of the relay paths, hop counts, spectrum efficiency, MS power level and other factors may also be taken into account for the HO target access station selection. For saving bandwidth and decreasing the complexity, RS only reports the measurement results if the link quality is more than a threshold. The serving station shall make the MS intra MMR-BS HO decision based on the MS UL and the relay links measurement reports. Then, the serving station sends back the RNG_RSP message with time and power adjustment to the MS. MMR-BS may maintain a candidate set for HO convenience, where the candidate set includes a list of candidate stations that are the potential access stations close to a given MS. The access and relay link quality information are kept in the candidate set table for target access station selection.

The ranging procedure in the initialization process shall also use the same mechanism to identify the access station for initialized MS.

Inter MMR-BS HO

For inter MMR-BS HO, the target access station is located in the neighboring MMR cells. From the perspective of a MS, the process will be the same as the existing HO process defined in the clause 6.3.22.2 and 6.3.22.3 of IEEE802.16e-2005. The HO process is triggered by the MS or the MMR-BS in terms of the target scanning results. The only difference from the legacy procedure is the network reentry.

When MS sends ranging CDMA code to a candidate access stations in the target MMR cell, the target MMR-BS and/or its subordinate RSs may receive this ranging CDMA code. The candidate stations receiving the ranging code shall measure the MS UL link quality based on the received ranging signals, and report the measurement results to the target serving station. Based on the measurement results, the target serving station shall select the suitable target access station for the MS, and send back the RNG_RSP message with time and power adjustment to the MS.

The other HO procedures are the same as that defined in the clause 6.3.22.2 and 6.3.22.3.

2.2 Handover for different-broadcast info. frame structure

This section introduces intra / inter MMR-BS handover based on the frame structure schemes that the subordinate RS transmits its own frame header different from the serving station's, referring to the relay frame structure definition per 6.4.4.8. From the view of MS, it regards RS a BS as it receives different preambles. MS performs legacy 16e handover procedures and synchronizes to different preambles before and after the intra / inter-BS handover.

Intra MMR-BS HO

This intra MMR-BS handover begins with a decision for a MS to handover. The decision may originate either at the MS, the serving station, or on the network. MS / RS is required to report the link quality it measured to the MMR-BS. MMR-BS makes the final decisions on the optimal path selection based on the reported link quality results from each RS, and the performance of corresponding RS-BS path. MMR-BS recommends MS the optimal target access station which is pretended as a BS ID for backward compatibility to MS. And MS takes RSs as a BS for intra MMR-BS handover, and conducts the legacy 16e handover procedures.

Inter MMR-BS HO

The inter MMR-BS handover is very similar to the above one. Both begin with a decision for a MS to handover. The decision may originate either at the MS, the serving station, or on the network. And MS conducts the legacy 16e handover procedures for backward compatibility. As MS handover to the access station in the neighbor BS cell, for the optimal path selection and handover target access station selection, the link quality information between MS and candidate access stations, and performance of the optimal path for each RS-BS in the neighbor BS cell is required. The serving station may achieve this information from the neighbor BS over backbone. And the optimal path between MS and neighbor BS can be calculated based on the information above. MMR-BS tells MS the optimal target access station, and MS conducts the legacy 16e handover procedures.

3. Proposed Text Changes

[Insert the sectiont and figure as follows]

6.3.22.2.10 HO process in MMR network

In terms of the whether the target access station is located at the same MMR cell as the serving station, the handover in MMR network can be classified into two categories, intra MMR-BS handover and inter MMR-BS handover. Handover strategies are given to adapt to supported uniform / different – broadcast relay frame structures.

6.3.22.2.10.1 HO process in MMR network under the uniform broadcast frame structure

There are several conditions required to enable the uniform broadcast frame structure, including:

- All candidate stations are frame time synchronized (frame start simultaneously for all MS)
- Subordinate RS does not send preambles or sends the same preambles as BS does.

Intra MMR-BS handover

The intra MMR-BS handover is different from the HO between non-MMR cells. The transition from one access station to another is performed without invocation of HO proedure described in 6.3.22.2. The following section defines the intra MMR-BS HO process in which an MSS migrates from the air interface provided by one access station to the air interface provided by the target access station within the same MMR cell. MMR-BS and other access stations shall cooperate to perform the following stages to support the intra MMR-BS handover:

- **Link quality measurement and report**
  For the handover, RS monitors and measures MS signal (e.g. RSSI, CINR,) within its coverage and estimates the link quality between the measured MS and itself. The measurement may be scheduled periodically or requested by the serving station or by itself. The measured signal is either ranging message or data burst. These measurement reports are forwarded to the serving station. For saving bandwidth and decreasing the complexity, RS only reports the measurement results if the link quality is more than a threshold. RS shall report BS the selected measurement results of the MS designated by the serving station. Besides the link quality, the traffic load balance of the relay paths, hop counts, spectrum efficiency, MS power level and other information may also be reported. MMR-BS may also receive ranging or data burst signals directly from MS and get the link quality between MS and itself. RS may use a new independent message or a existing message, to report the link measurement results. This process need not occur in conjunction with any following HO procedures.

- **Intra MMR-BS Handover Decision/ Selection of Target Access Station**
  The MMR-BS shall maintain a list of candidate stations. The list is called candidate set. An intra MMR-BS HO request may be triggered and sent to the serving station by a candidate access station or issued by the serving station based on the evaluation of the path performance. The serving station shall make the handover decision whether the MS handover from an existing access station to the target access station, where the decision is based on the MS UL and the relay links measurement reports. The HO decision-making may also include the link quality, load balance and other metrics to select an optimized path from the possible paths from MS to BS, refer to section 6.4.XX.

- **Adjustment to the Target Access Station**
  RNG_RSP or other messages i.e. PMC_RSP are sent to the MS for power level, timing advance adjustment to let MS adapt to the target access station. And updated UL&DL MAP is sent to the MS/RS to make it to communicate with the target access station at the specified frame.

- **Candidate Set initialization/update**

MMR-BS may maintain a candidate set for HO convenience, where the candidate set includes a list of candidate stations that are the potential access stations close to a given MS. The access and relay link quality information are kept in the candidate set table for target access station selection. MMR-BS can evaluate and select the optimal path for a specified MS based on the performance information saved in the candidate sets. The candidate set shall be created when a specified MS power on or network entry / reentry and shall be updated periodically or as requested by the serving MMR-BS. There are two thresholds used decide whether to add or delete a station to or from the candidate set. The RSs or MMR-BS with the better link quality (e.g. CINR is above the C_Add threshold) with MS shall be selected by the serving station to be included into the candidate set. If the quality of the access link between a candidate station and the MS is less than C_Delete Threshold. All access stations in the candidate set are required to monitor the UL signal strength of the specified MS and report the measurement results to the serving station periodically or response to the report request. The other relay stations outside of the candidate set may also be requested to report the link quality with specified MS by the serving station, so that the serving station can check if there are any candidate stations that satisfy the criteria to be included into candidate set.

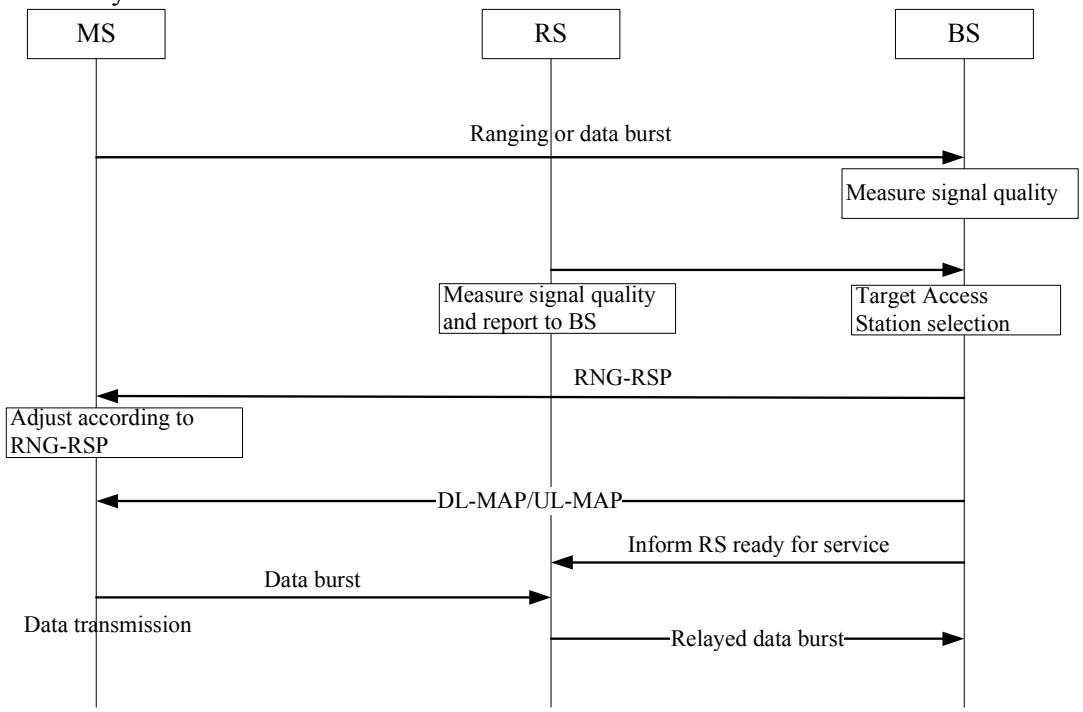

Figure xx - Example Intra MMR-BS HO Process

Inter MMR-BS handover

The inter MMR-BS handover, MS handovers between two RSs controlled by different MMR-BSs or between an MMR-BS and an RS controlled by another different MMR-BS. Thus MS conducts legacy 16e handover procedures from the serving MMR cell to the neighbor MMR cell with preamble change per 6.3.22.2. At network entry / reentry, MS conducts ranging and neighbor RS monitor and report the link qualities to the serving BS. Only ranging requests with the strong signal level measured at RS are forwarded to BS. The forwarded ranging request is exactly the same as the original one. Other weaker ranging requests are omitted by RS. MMR-BS may also receive ranging signals directly from MS and get the link quality between MS and itself, if the signal can reach the MMR-BS.Then MMR-BS evaluates and decides the handover target access station, and send RNG_RSP message for MS adjustment, where the procedures are the same as the above intra MMR-BS handover.

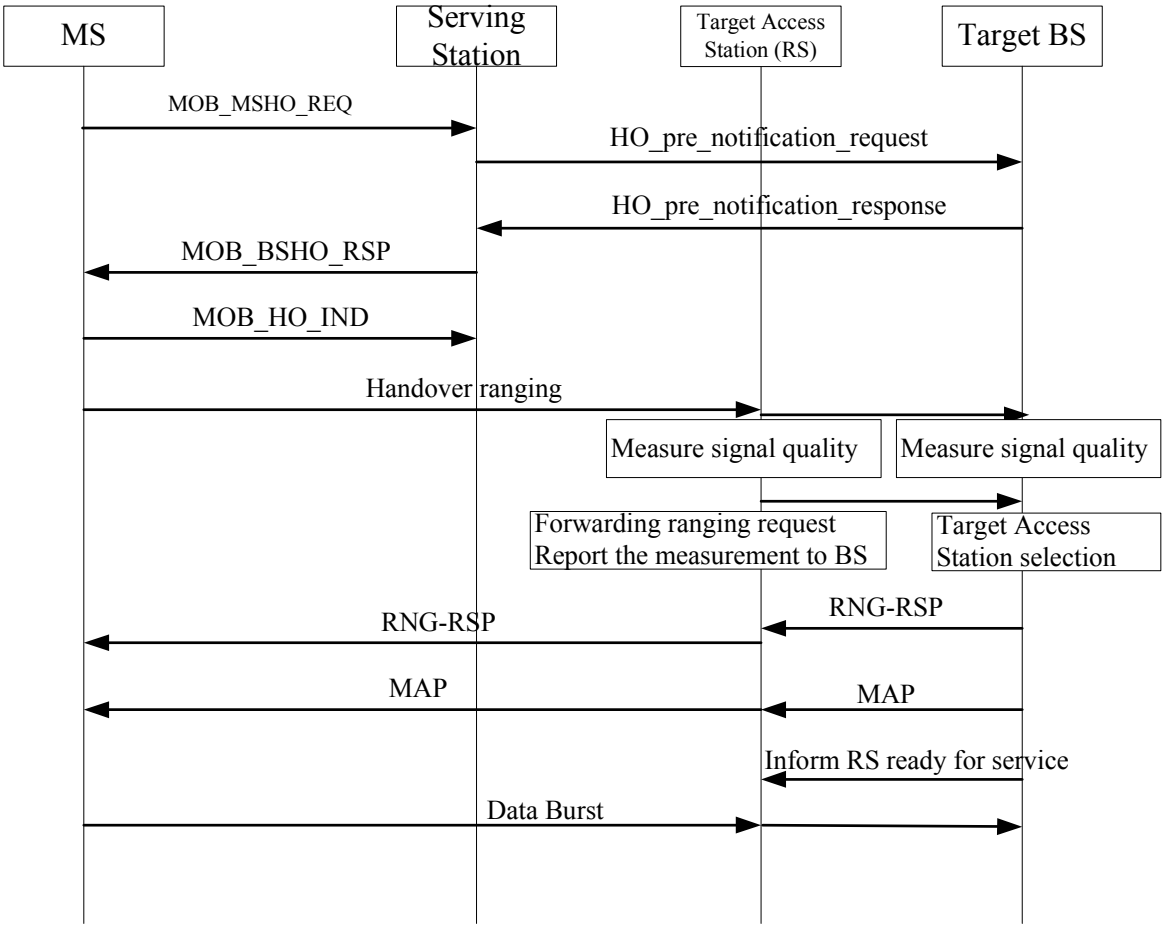

Figure xx. Inter MMR-BS HO Process

6.3.22.2.10.2 HO process in MMR network under the different-broadcast frame structure

There are several conditions required to enable the different broadcast frame structure, including:

- Subordinate RS has its own preamble different from that of the serving MMR-BS.

Intra MMR-BS handover

For intra MMR-BS handover, MS handovers between two RSs controlled by the same MMR-BS or between an MMR-BS and one of its subordinate RSs. As RS has its own preambles different from the serving stations's, MS conducts legacy 16e handover procedures in this intra MMR-BS handover.

- **MS Link quality monitor by candidate station**

Access station and candidate access stations that can hear MS signal shall monitor and measure the link quality from MS. This link quality monitoring and measurement may be controlled by BS in centralized control scheme or by RS itself in distributed control scheme. It is scheduled periodically or requested by messages. RSs shall report the measurement reports to BS for optimal path selection. RS may be required to check the link quality to determine whether it is necessary to report to BS. If the link quality is bad, RS shall not report the measurement results to BS for bandwidth saving. A threshold may be defined for decision whether RS need to report the measurement results. The RS Link quality monitor process need not occur in conjunction with any flowing HO process.

- **Cell Reselection**

Cell reselection process is the same as the legacy one as per 6.3.22.2.1, as subordinate RSs send preambles different from BS, and act as BSs to MS. MS scans and/or associates with one or more neighbor stations and evaluates the performances for handover target access station selection, where these stations could be BS or its subordinate RSs.

- **Initialize a legacy handover procedure**

This intra MMR-BS handover begins with a decision for a MS to handover. The decision may originate either at the MS, the serving station, or on the network. RS shall not originate a handover. The HO may proceed with a notification through either MOB_MSHO-REQ or MOB_BSHO-REQ messages.

When MOB_MSHO-REQ is sent by a MS, the MS may indicate one or more candidate access stations. This MOB_MSHO-REQ message shall be relayed to the serving station, if its access station is a RS. Serving station evaluates the candidate access stations for optimal target access station selection to decide whether RS or BS, or which RS is required for a specified MS access relaying in the initialization or the handover process. This optimal path selection is based on the comparison of possible paths comprising MS-RS, and RS-BS, where the optimal path selection for each RS is referred as above session. Target selection metrics may include but not limited to quality of radio link (CINR,…), MS power level, multi-hop bandwidth efficiency, hop counts, QoS requirement, traffic load. Target access station is selected based on whole path evaluation instead of the access link only, as it is not enough to only consider the quality and statuses of MS access link for path selection. Considering both optimal RS-BS path, and MS-RS link quality report, BS make a decision as to the optimal target access station selection to make the whole path from MS to BS optimal. The selected candidate access

station information may be included into MOB_BSHO-RSP message. This message shall be relayed to the MS, if its access station is a RS.

When MON_BSHO-REQ is sent by a BS, the BS may perform handover target access station selection described as above before the message submission, and indicate one or more candidate access stations in the message.

- **Complete the legacy handover process**

MS performs synchronization to target, ranging, and network re-entry per 6.3.22.2.2 and 6.3.22.2.3. If the handover target is RS, MS just takes it as a BS to conduct legacy handover process, except that all messages shall be forwarded by RS to the MS or BS.

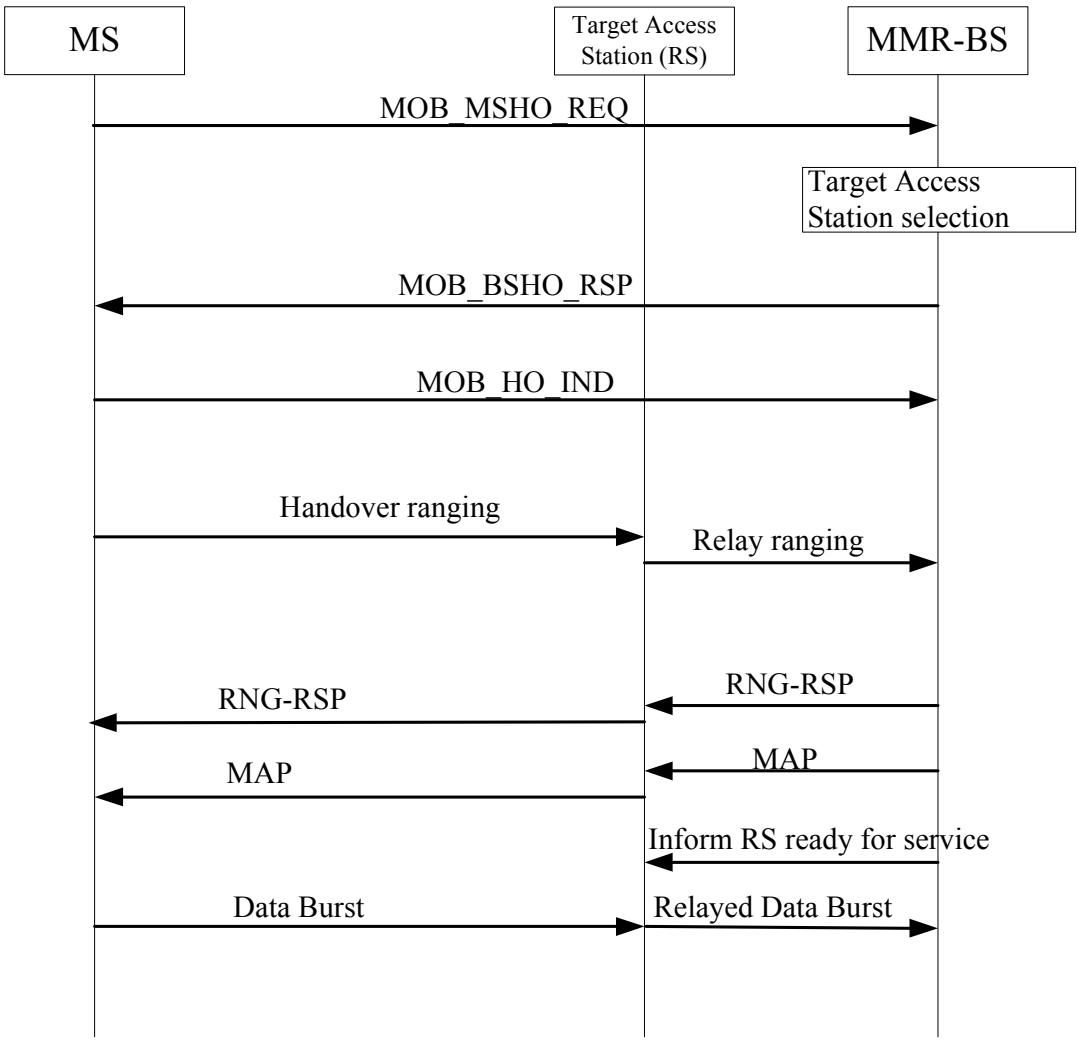

Figure xx, Example of Intra MMR-BS Handover from MMR-BS to RS

Inter MMR-BS handover

For inter MMR-BS handover, MS or RS handover between two RSs controlled by different MMR-BSs or between an MMR-BS and an RS controlled by a different MMR-BS. MS performs legacy handover procedures

for current cell to neighbor cell. Handover target access station selection is performed in the legacy HO decision period. The following stages shall be performed to support the intra MMR-BS handover:

- **Cell Reselection**

Cell reselection process is the same as the legacy one. Subordinate RSs within neighbor BS cell are taken as BS for MS. MS scans and/or associates with one or more neighbor stations and evaluates the performances for handover target selection.

- **Candidate access link quality monitor**

In the cell reselection, MS conduct performance evaluation for each candidate access station. This link quality information shall be sent to the serving station with / without relaying. Serving station may obtain RS- neighbor BS link status and also the optimal path for each RS to neighbor BS through the exchange of backbone message. Target access station is selected based on whole path evaluation instead of the access link only. Considering RS-neighbor BS path quality and statuses from the neighbor BS, and MS-RS link quality report from MS, BS make a decision as to the optimal target access station selection to make the whole path from MS to BS optimal. The selected candidate access station information may be included into MOB_BSHO-RSP message. This message shall be relayed to the MS, if its access station is a RS.

- **Complete the legacy handover process**

MS performs synchronization to target, ranging, and network re-entry. If the handover target is RS, MS just takes it as a BS to conduct legacy handover process, except that all messages shall be forwarded by RS with two or more hops to the MS or BS.

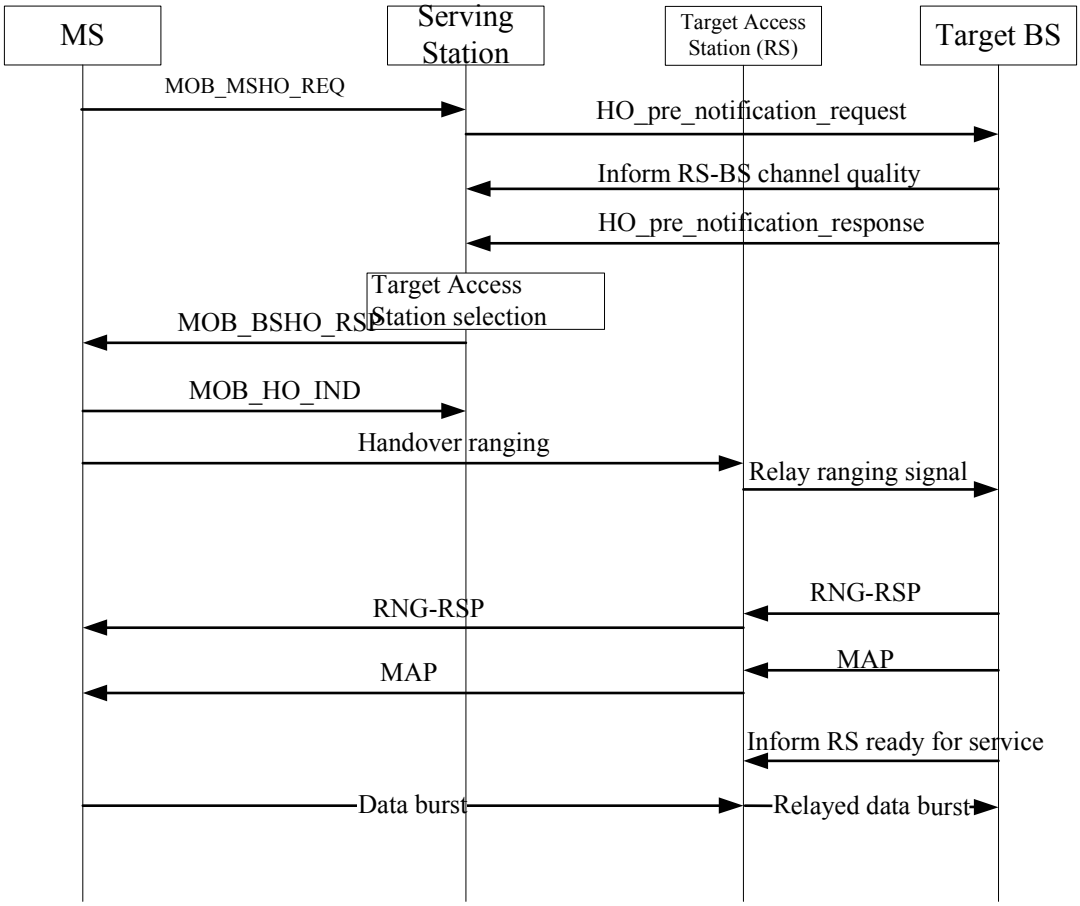

Figure xx, Example of Inter MMR-BS Handover

6.3.2.3 MAC management messages

[Insert the following text into this section]

RS Link Quality Measurement (RS_LQM) message

RS is required to measure the link quality between MS and itself periodically or requested by MMR-BS or RS. RS may report the measurement results to the MMR-BS. These information shall be used for the optimal target access station selection.

The format of the RS_LQM message is depicted as follows Table.

Table — RS_LQM message

Syntax	Size	Notes
RS_LQM_Message_format(){	—	—
Management Message Type=xx	8 bits	—
RS ID	48 bits	Relay station identification.
Number_of_MS	8 bits	Number of MSs measured by this RS
For(j=0;j<Number_of_MS; j++){	—	—
Ranging Code		Optional, CDMA code, only used in the MS initialization and link measurement
MS CID	16 bits	Optional, to identify MS, used except MS initialization and link measurement
Number_of_Metrics	8 bits	Number of metrics measured for a specified MS
Measurement Metrics	8 bits	Bitmap indicating measurement metrics: Bit 0: CINR mean Bit 1: RSSI mean Bit 2: Power level Bit 3: Timing advance Bit 4: Frequency Bits 5–7: Reserved
If (Measurement metric[Bit 0]==1)	—	—
Station CINR mean	8 bits	—
If (Measurement metric[Bit 1]==1)	—	—
Station RSSI mean	8 bits	—
If (measurement metric[Bit 2]==1)	—	—
Power level	8 bits	—
If (measurement metric[Bit 3]==1)	—	—
Timing advance	8 bits	—
If (measurement metric[Bit 3]==1)	—	—
Frequency	8 bits	—
TLV encoded information	variable	Optional
}	—	—
}	—	—

References

[1] IEEE 802.16j-06_016r1, "Proposed Technical Requirements Guideline for IEEE 802.16 Relay TG"
[2] IEEE 802.16j-06_017r2, "Table of Contents of Task Group Working Document"
[3] IEEE C802.16j-06_005r1, "Handover Schemes in IEEE802.16j"