[Overview of the proposal for MS MAC handover procedure in an MR Network]

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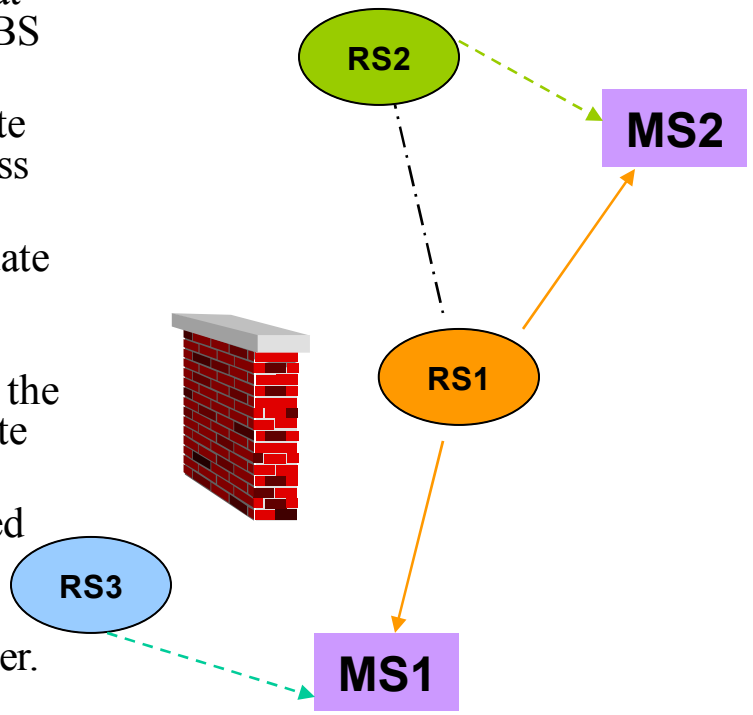
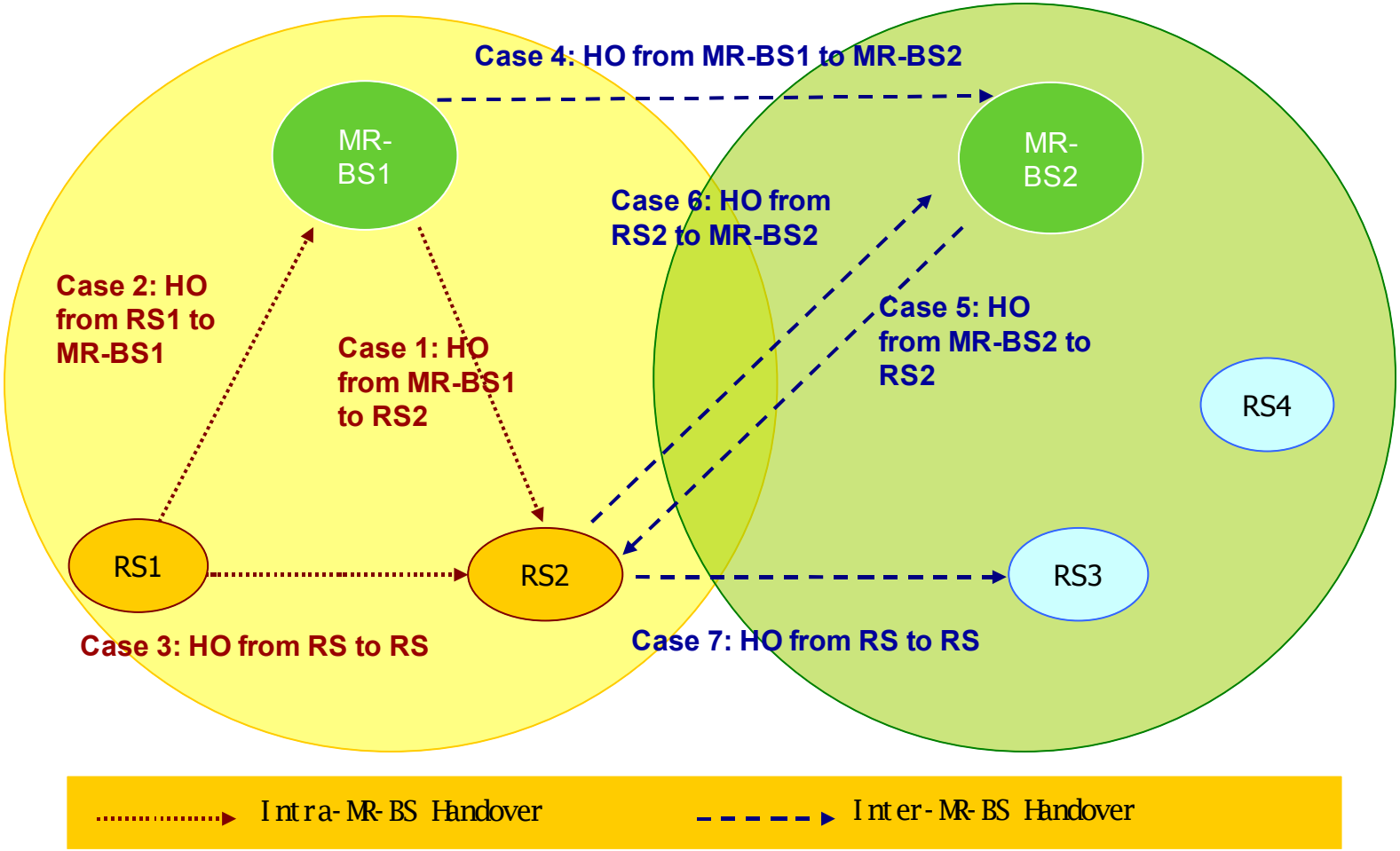
Purpose:
[This document provides an overview of the proposal on a MS MAC handover procedure for IEEE 802.16j network.]

Terminology

- **access station:** The station at the point of direct access into the network for a given MS. An access station can be a BS, RS, or MR-BS.
- **serving station**: For any MS, the serving station is the station with which the MS has most recently completed registration at initial entry or during a handover. A serving station can be a BS or MR-BS.
- **target access station**: A station which is the primary candidate for MS network access following a handover. The target access station can be an RS, BS, or MR-BS.
- **target serving station**: A station which is the primary candidate for MS registration following a handover. The target serving station can be a BS or MR-BS.
- **intra MR-BS HO:** handover between two RSs controlled by the same MR-BS or between an MR-BS and one of its subordinate RSs.
- **inter MR-BS HO:** handover between two RSs each controlled by different MR-BSs or between an MR-BS and an RS controlled by a different MR-BS.
- **infrastructure station (IS)**: A station which is not a subscriber. The infrastructure station can be a BS, MR-BS, or RS.
- **neighbor station**: For an MS, a neighbor is an access station whose downlink transmission over the access link can be received by the MS. For an infrastructure station, any other infrastructure station whose transmission over the relay link can be received by the infrastructure station.



Seven Handover Cases



Only Case 4 can be covered by the 802.16e MS MAC HO procedure without any additional activities among Infrastructure stations.

Handover in Synchronous System vs. Asynchronous System

Handover in a Synchronous Broadcast System:
Only MR-BS transmits all the broadcast control messages or RSs in the same MR-Cell transmit the same broadcast control messages with the ones from the MR-BS. Then, the MS considers these stations as the single BS. In this case, Intra MR-BS handover is transparent to the MS.

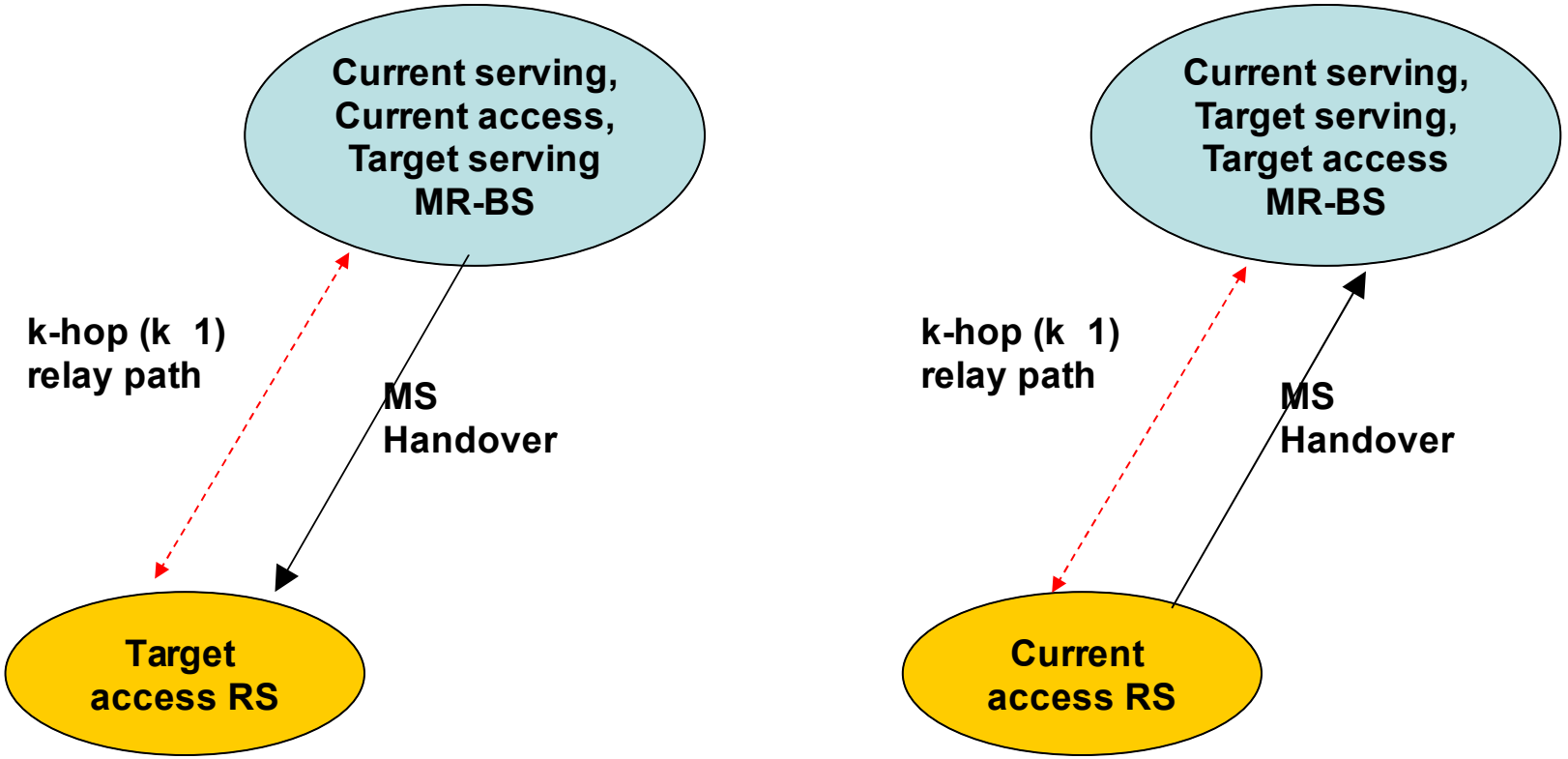
Handover in an Asynchronous Broadcast System: RS can transmit its own Preamble, DCD, UCD, UL-MAP, and DL-MAP. In this case, the MS recognizes an RS as a BS and thus needs to be aware of Intra MR-BS Handover and treat it same as regular 802.16e handover.

Objective and Assumptions

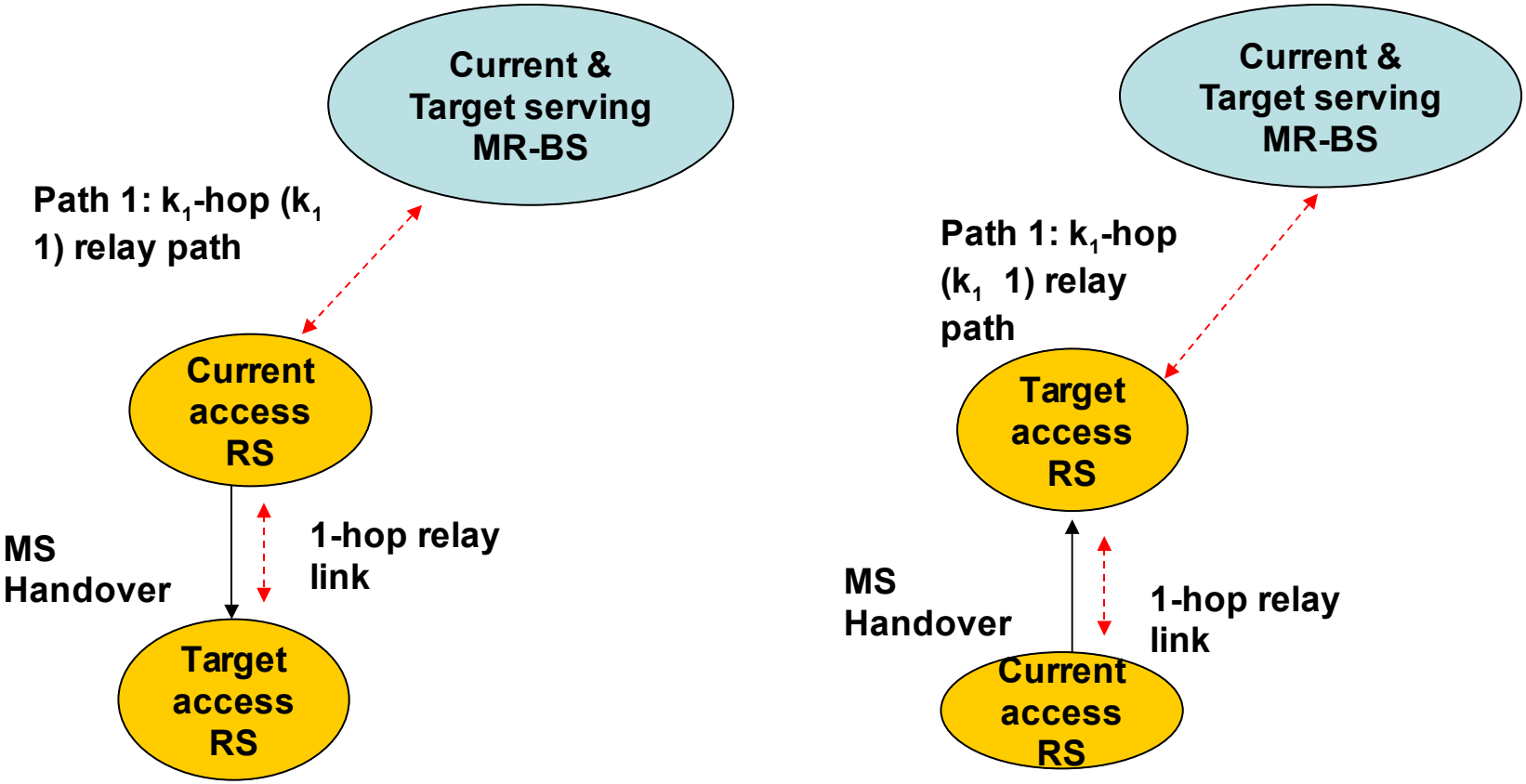
- Objective: To design a protocol for infrastructure stations for an asynchronous system, and thus to enable an 802.16e compliant MS to handover in an MR network following the 802.16e MAC handover procedure

- Assumptions
  - Centralized, distributed, and hybrid system are considered.
  - When a handover occurs, the current and target access stations may or may not be connected to each other directly via a 1-hop relay link
  - CIDs are globally managed by an MR-BS (i.e., CID is unique within an MR-Cell). Therefore, CIDs used by an MS remains the same after intra MR-BS handover.
  - Access station maintains information on MSs that are directly attached to it. The information includes MS MAC address and the associated SFIDs and CIDs, and the ARQ status if hop by hop ARQ is used.

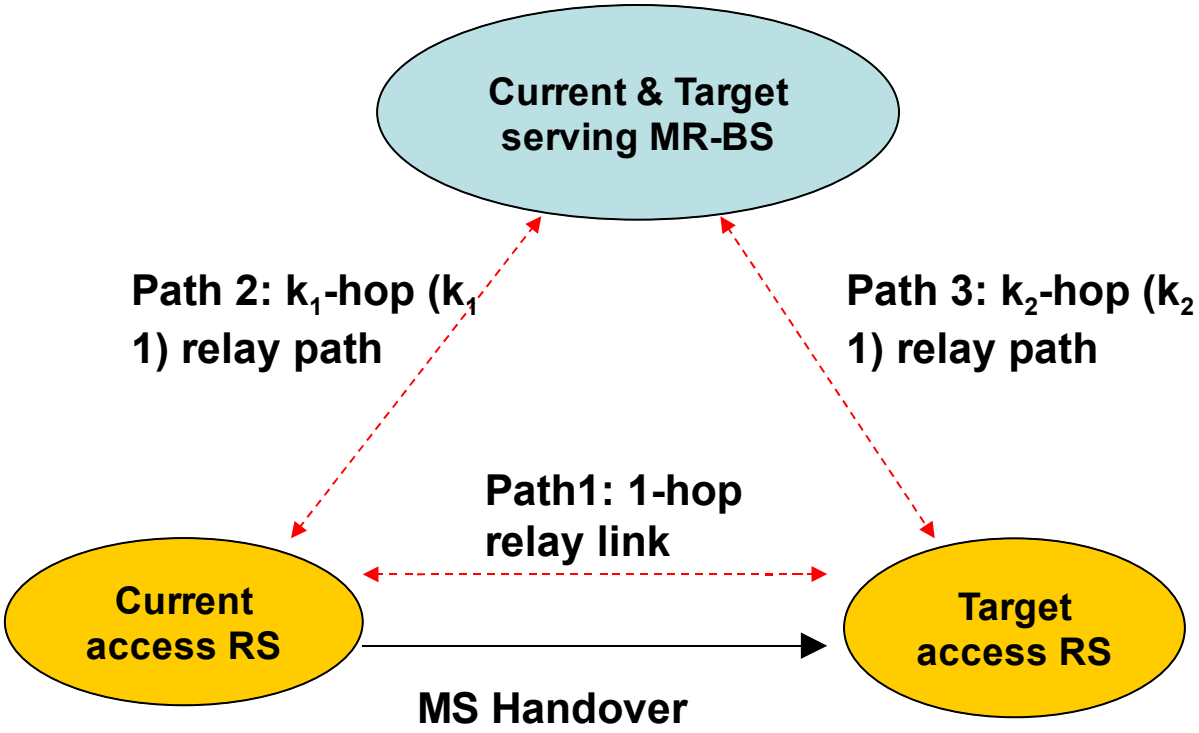
MAC management message exchanges for Handover Cases 1 and 2



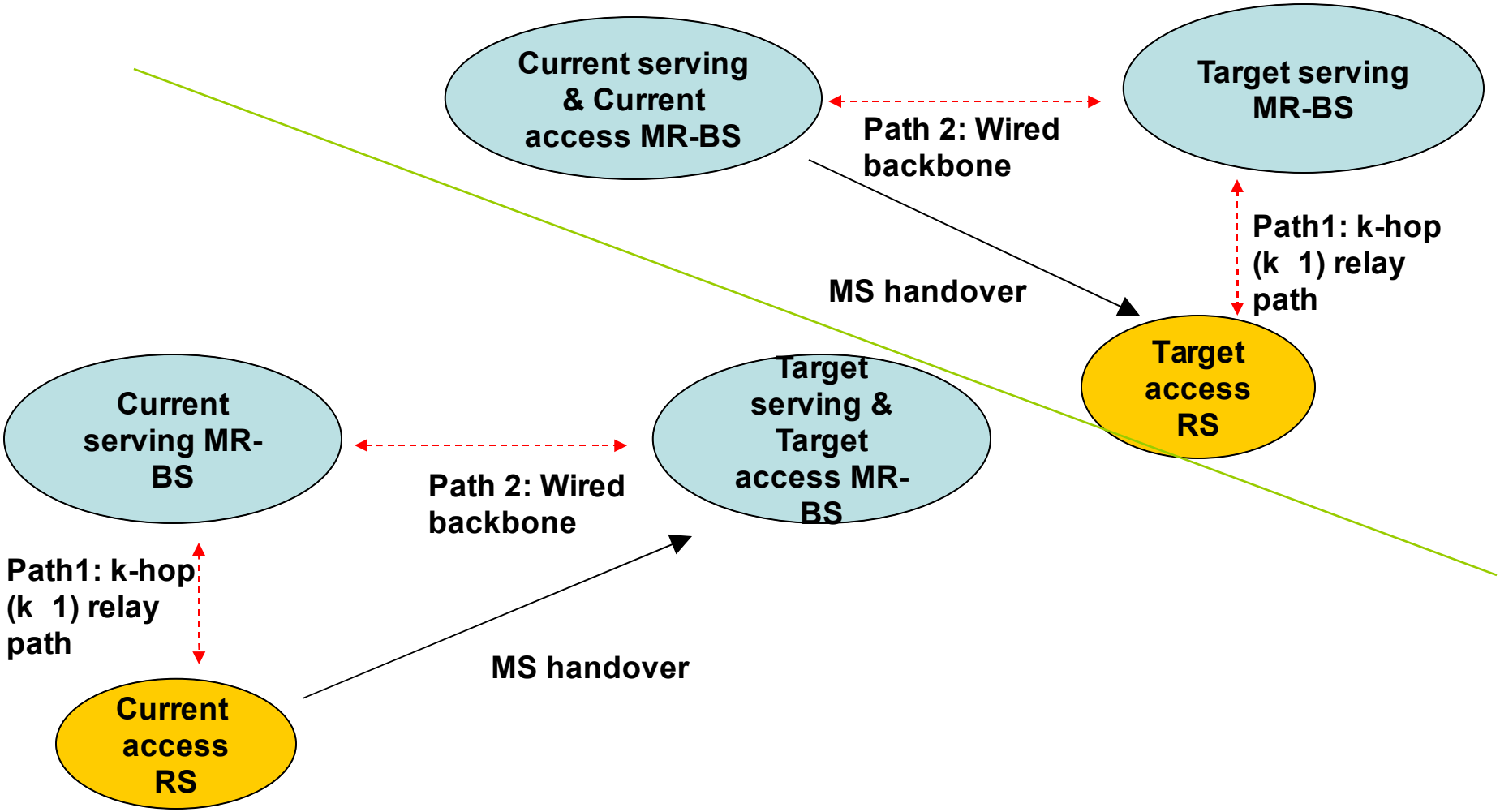
MAC management message exchanges for Handover Case 3



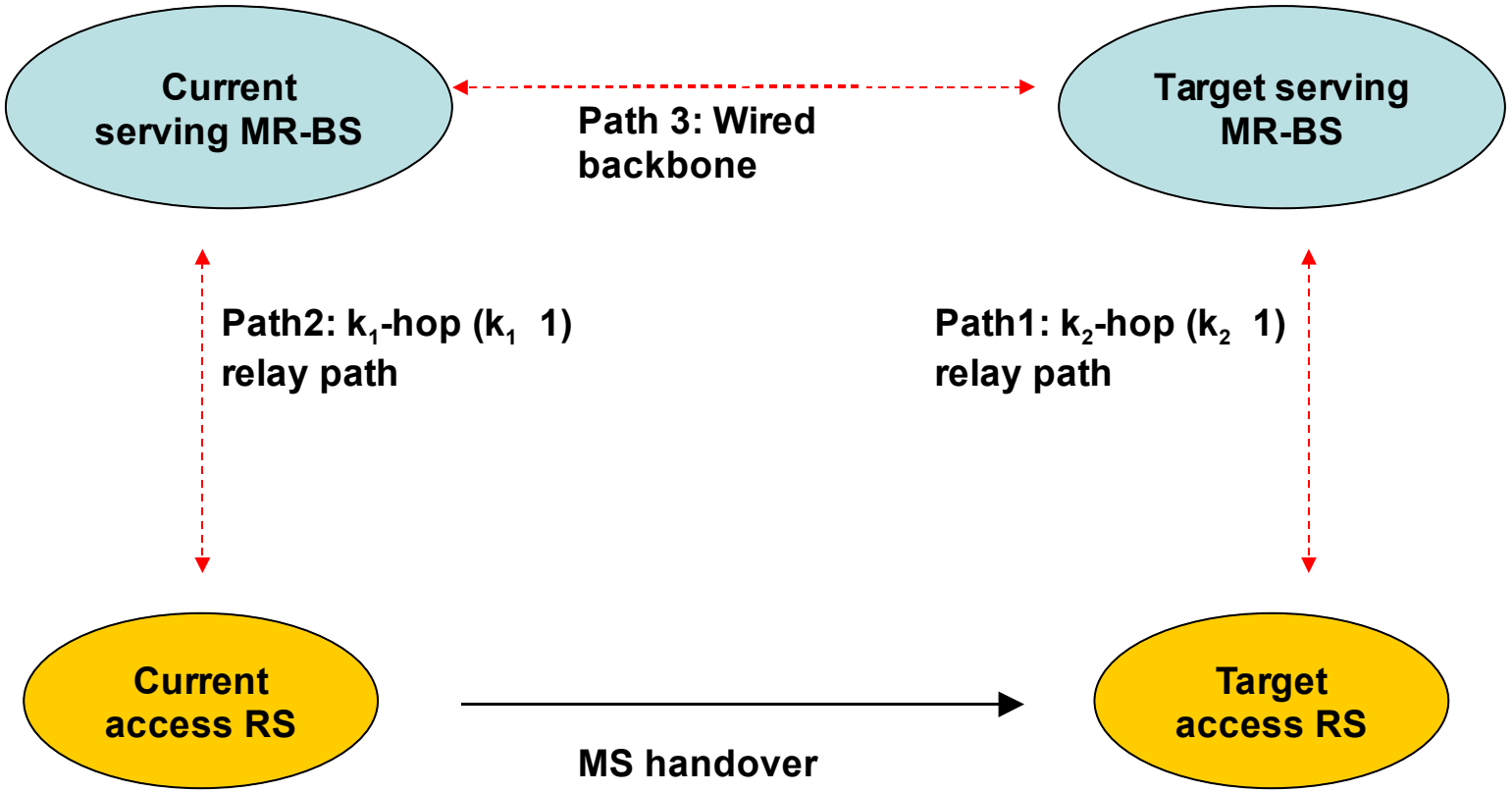
MAC management message exchanges for Handover Case 3



MAC management message exchanges for Handover Case 5 and Case 6



MAC management message exchanges for Handover Case 7



Handover Phases and New MAC Management Messages for Infrastructure Stations

New MAC Management messages	Related MS handover Phase	Functionality
NBR_ADVINFO-REQ NBR_ADV-INFO	Network Topology Advertisement	A NBR_ADV-INFO message is used to inform ISs' access link channel information over relay links. A NBR_ADVINFO-REQ message is used by RSs to request access link channel information of other ISs of interest.
ST_SCN-REQ, ST_SCN-RSP	MS scanning	These messages are used to coordinate an association for an MS at target access station(s).
HO_INFO-REQ, HO_INFO-RSP	Handover decision and initiation	These messages are used to pass the handover related information of potential target access station(s) to the current access station over relay links.
MS_INFO-REQ, MS_INFO-RSP	Handover execution	These messages are used to pass MS information to target (i.e., new) access and target serving station(s) when the actual handover to the target access station is performed.
HO_CPL	Termination	This message is used to notify successful handover to the current access and serving station(s) and to the target serving station.

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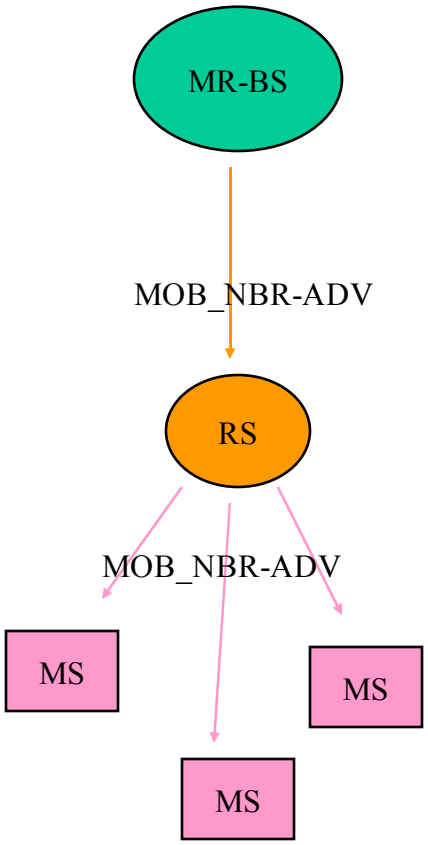
Network Topology Acquisition and MS Scanning

Network Topology Advertisement

- An access station (i.e. MR-BS or RS) periodically broadcasts a MOB_NBR-ADV message. The MOB_NBR-ADV message includes access link channel information of potential target access stations for all the MSs that are directly connected to the broadcasting access station.
- The access link channel information of those potential target access stations is obtained over the wired backbone in the legacy 802.16e network. However, it may be obtained over relay links and/or over wired backbone in an MR network.

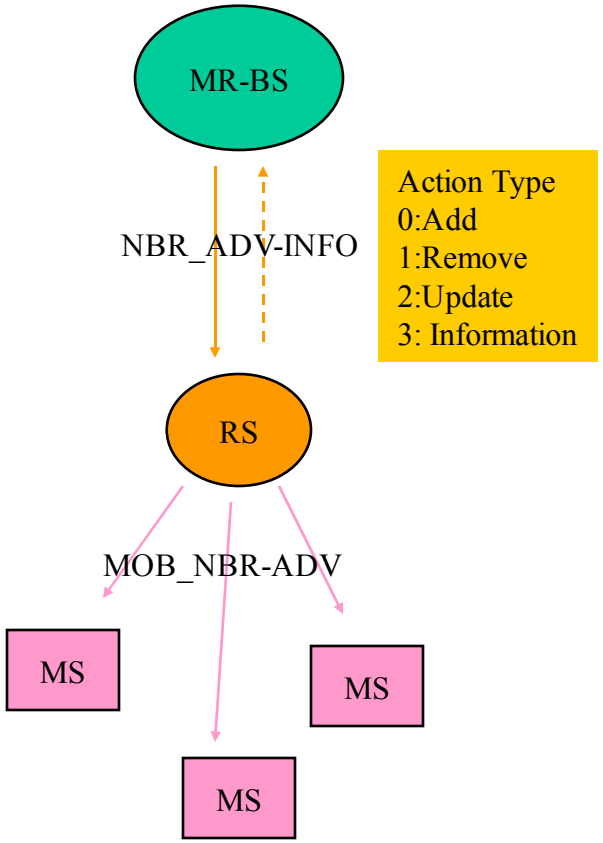
Network Topology Advertisement for simple RSs

- Assumption: An MR-BS owns all the necessary information (i.e., topology information and access link channel information) to generate a MOB_NBR-ADV message for individual subordinate RS.
- An MR-BS transmits a tailored MOB_NBR-ADV over relay links to individual subordinate RS in its own MR-Cell. Each RS simply broadcasts the received MOB_NBR-ADV to all the MSs located in its cell coverage.
- No new MAC management message is necessary.



Network Topology Advertisement for Distributed or Hybrid MR network – Alternative 1

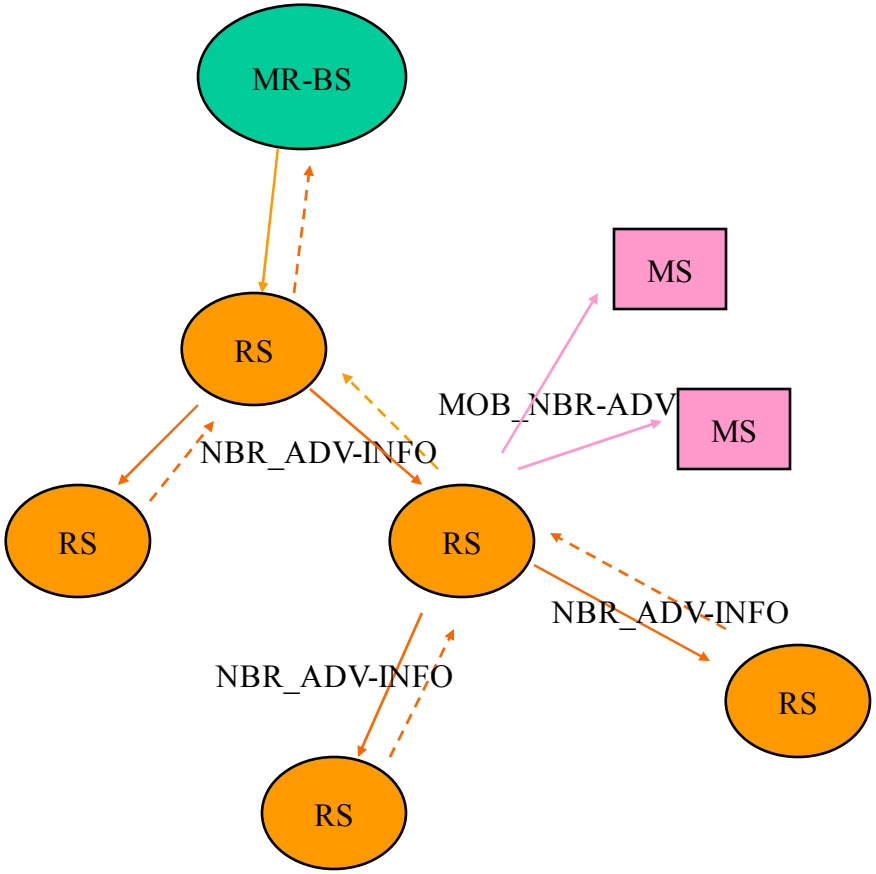
- Assumption: MR-BS is assumed to have some parameter values for its subordinate RSs but not other parameter values. (e.g., UCD/DCD Configuration)
- An RS informs the MR-BS of those parameter values by transmitting a new MAC management message, NBR_ADV-INFO.
- An MR-BS determines a list of ISs that will be included in each subordinate RS's MOB_NBR-ADV. Then, the MR-BS transmits a NBR_ADV-INFO message to each subordinate RS to inform it of the information about the determined list of ISs for its MOB_NBR-ADV message.
- Whenever there is a change in terms of the member of IS list in a MOB_NBR-ADV message broadcasted by a particular RS or in terms of any parameter value of any IS in the list, the MR-BS transmits a message NBR_ADV-INFO to update the affected RSs.
- The access station generates a MOB_NBR-ADV message based on the information collected from the received *NBR_ADV-INFO* messages.



Network Topology Advertisement for Distributed or Hybrid MR network – Alternative 2

- Assumption: An MR-BS owns some parameter values for its subordinate RSs but not other parameter values. (e.g., UCD/DCD Configuration)
- An RS informs the MR-BS of those parameter values by transmitting a new MAC management message, NBR_ADV-INFO.
- An RS is allowed to provide its upstream and downstream ISs with its own access link information using a NBR_ADV-INFO message. Hence, each RS can collect the information from its upstream and downstream stations without using multi-hop path to the MR-BS.
- To obtain access link information for ISs that are not upstream or downstream to the RS but are potential target access stations of MSs, the RS can send a new MAC management message, NBR_ADVINFO-REQ to the MR-BS with the identity of the ISs of interest.
- When an upstream RS receives the NBR_ADVINFO-REQ message from its downstream RS, it reads Requested_Station_ID parameter to see if it owns the information of any requested IS. If so, the upstream RS responds with a NBR_ADV INFO message to the downstream RS. After that, if there are other Requested_Station_ID(s) that it couldn't provide the information, it forwards the NBR_ADVINFO-REQ message to its upstream IS.

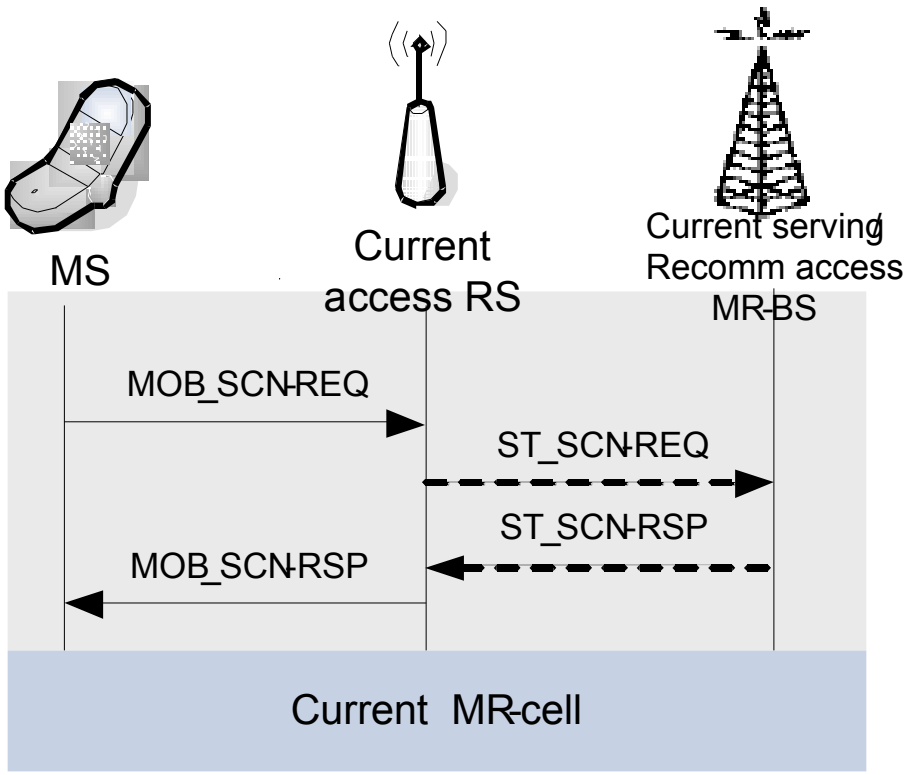
Network Topology Advertisement for Distributed or Hybrid MR network – Alternative 2

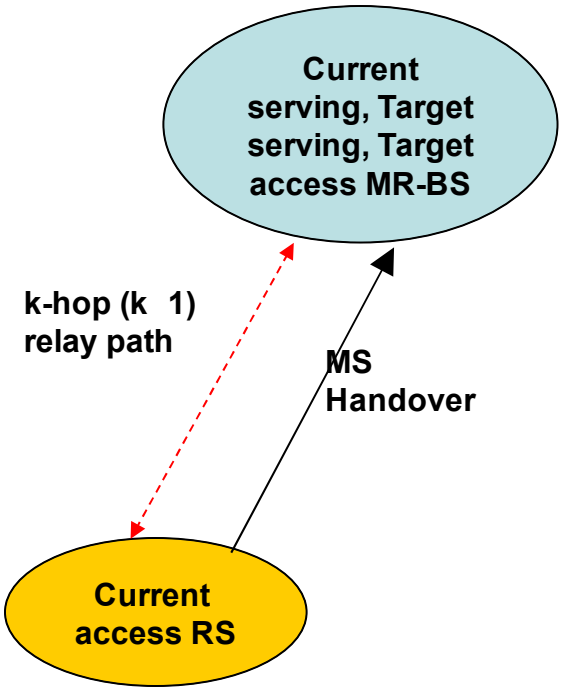


MS Scanning

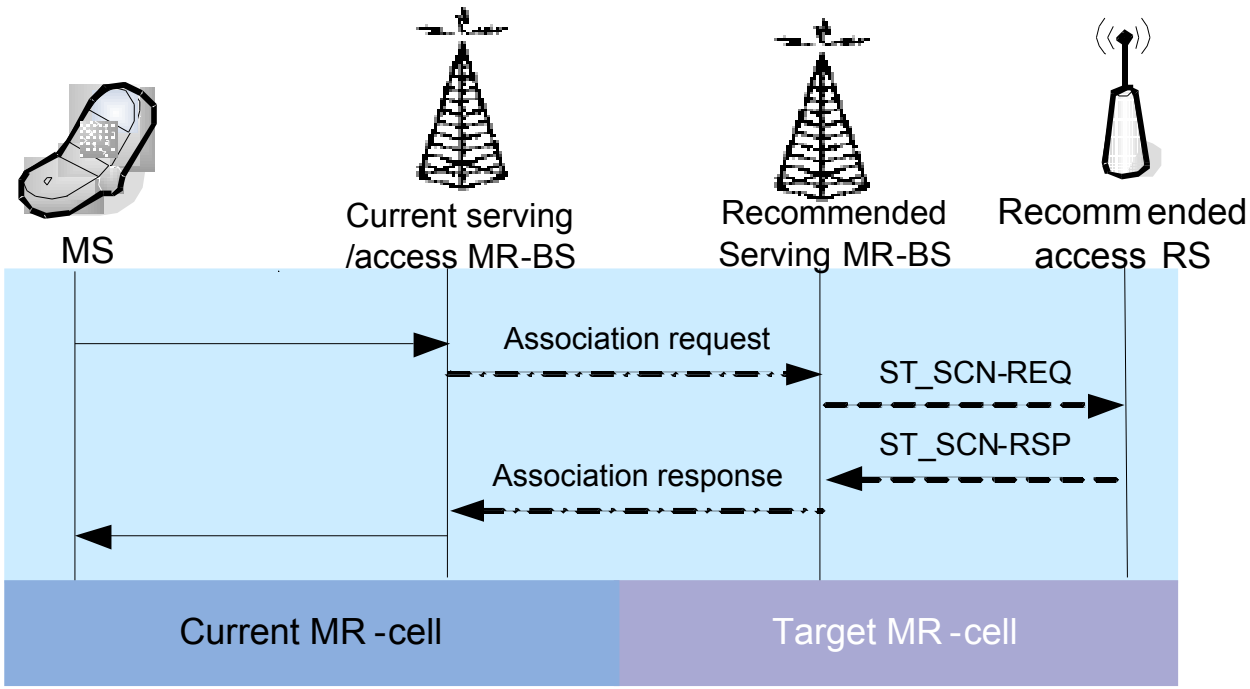
- An MS may receive an allocation of scanning intervals and a certain type of association with each potential target access station via a MOB_SCN-RSP message.
- Association levels 1 and 2 require coordination between the MS and the requested potential target access station. The coordination will be facilitated by the MS's current access station over the relay links and/or the backbone in 802.16j networks.
- Two new MAC management messages, *ST_SCN-REQ* and *ST_SCN-RSP,* are introduced for the coordination over the relay links.

An example of ST_SCN-REQ/RSP message exchange

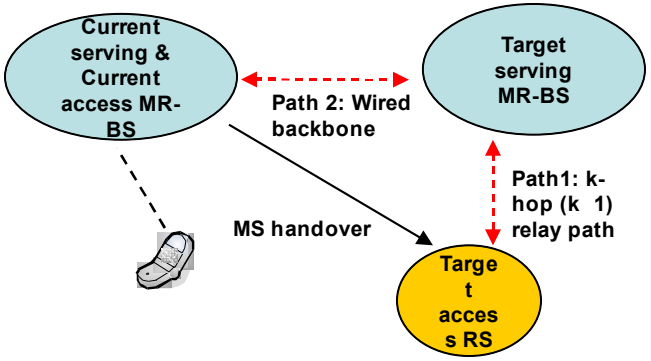




An example of ST_SCN-REQ/RSP message exchange



*This is an example flow when the MR-BS does not know the recommended RS's ranging allocation detail for the MS.



C80216j_06-219
Handover Decision and Initiation

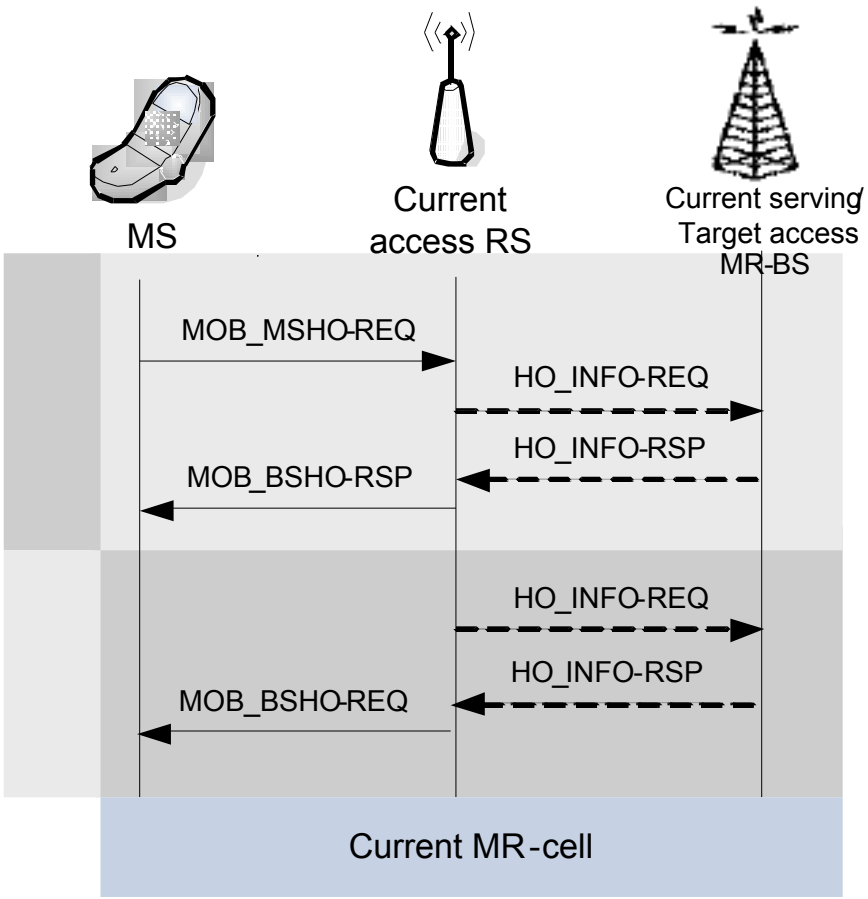
Handover Initiation and Decision

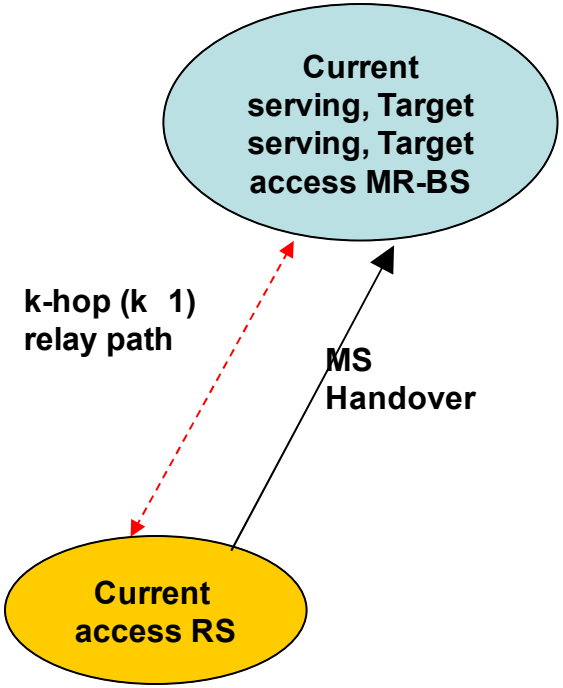
- An MS handover can be initiated either by the MS or by the access station (i.e., MR-BS or RS) through exchanging MOB_MSHO-REQ/MOB_BSHO-RSP or MOB_BSHO-REQ.
- Each message includes the information about possible target access stations for a particular MS.
- In 802.16j, the current access station obtains this information over relay links and/or backbone.

Handover Initiation and Decision

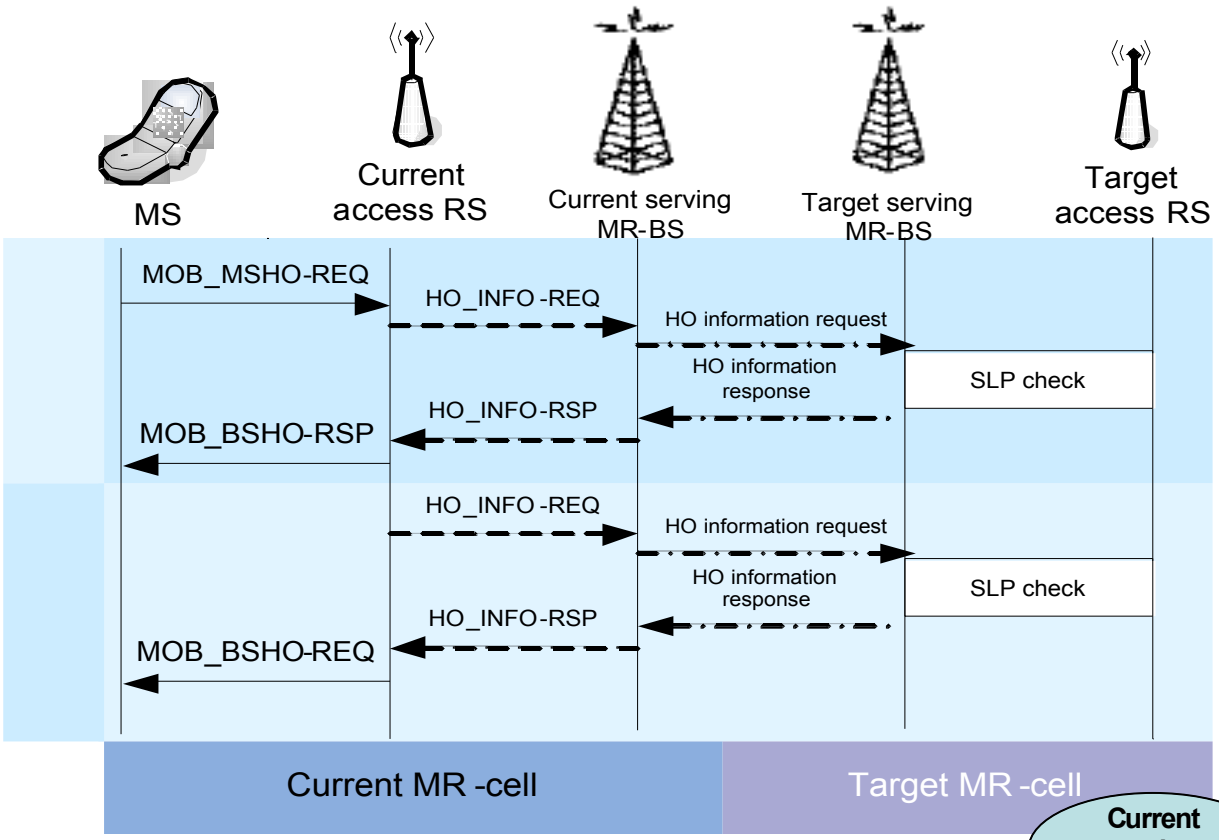
- In order for an RS to generate MOB_BSHO-RSP and MOB_BSHO-REQ messages, the RS obtains the necessary information by exchanging two new MAC management messages, *HO_INFO-REQ* and *HO_INFO-RSP* messages.
- An MR-BS is assumed to own the information about all of its subordinate RSs that is encoded in MOB_BSHO-RSP and MOB_BSHO-REQ messages.
- The target serving MR-BS may or may not have Service Level Prediction (SLP) information (when it is queried) for all of its subordinate RSs along the related relay path depending on the distribution of control functions between an MR-BS and its subordinate RSs.

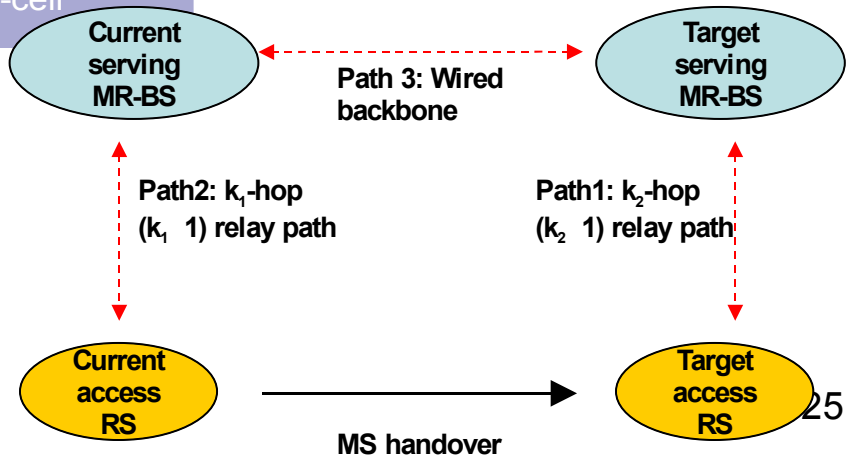
An example of HO_INFO-REQ/RSP message exchange





An example of HO_INFO-REQ/RSP message exchange





C80216j_06-220
Handover Execution

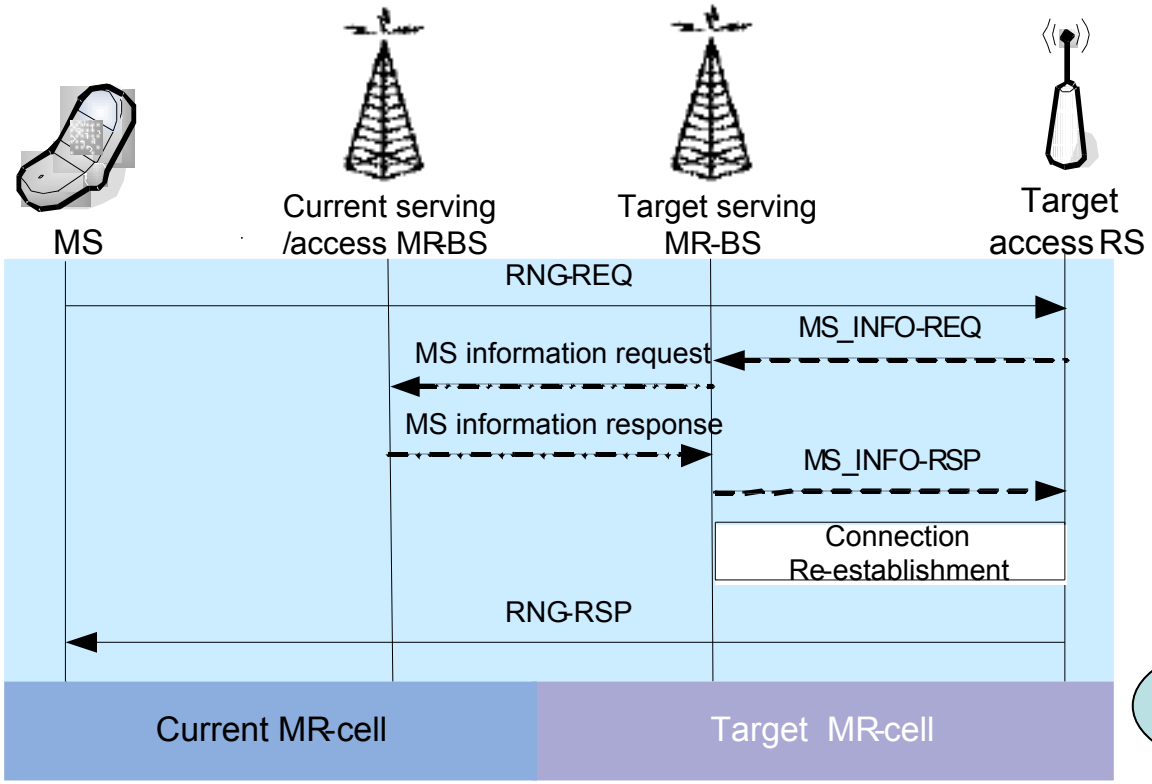
Network Entry/Re-entry for handover

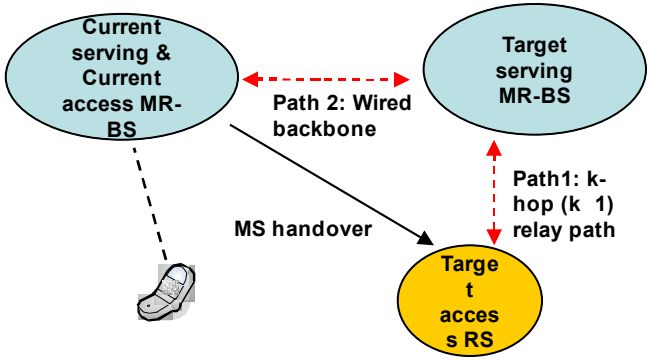
- MS network entry/re-entry due to handover in 802.16j systems is processed according to subclause 6.3.9.
- An MS can indicates a handover attempt by sending a RNG-REQ message which includes a serving BSID TLV and sets bit number 0 of the ranging purpose indication TLV to 1.
- Upon receiving such a RNG-REQ message, the target access station may request the MS information if it has not received yet.
- The MS information may need to be obtained over the relay links and/or over the wired backbone. Two new MAC management messages, MS_INFO-REQ/RSP, are used to exchange the information over relay links.
- The MS information needs to be delivered to target serving station as well as target access station.

Network Entry/Re-entry for handover

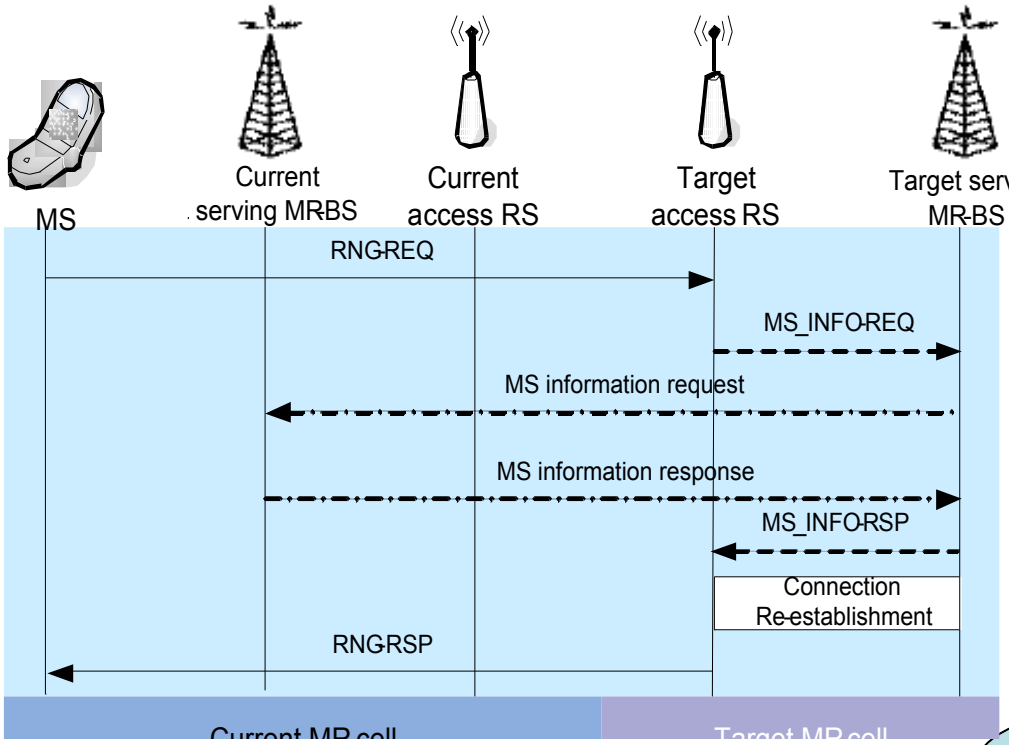
- Even though the current serving MR-BS possesses most of the MS information, if the continuity of hop by hop ARQ or SDU_SN enabled connections is to be maintained, then the ARQ status must be transmitted from the current access RS to the current serving MR-BS over the relay links.
- When receiving the MS information, if the target access station is an RS, existing connections needs to be re-established between the target serving MR-BS and the target access RS following the path management and routing procedure.
- In intra MR-BS handover, the bit # 0 – 7, 9, 10 of HO process optimization parameter in the RNG-RSP message can be set to 1 to omit some processes.
- The MS can continuously use the same CIDs before and after the intra MR-BS handover. Therefore, target access station simply notifies the MS of the same CIDs after intra MR-BS handover.

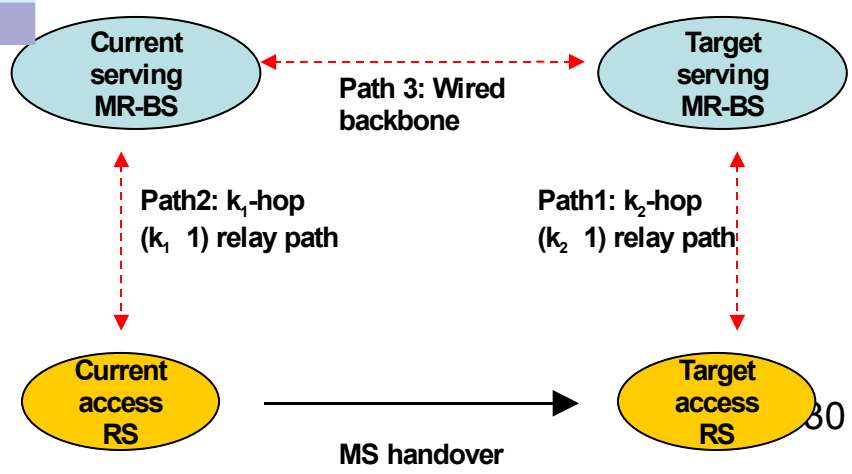
An example of MS_INFO-REQ/RSP message exchange





An example of MS_INFO-REQ/RSP message exchange





C80216j_06-221
Termination, Drop, Cancellation

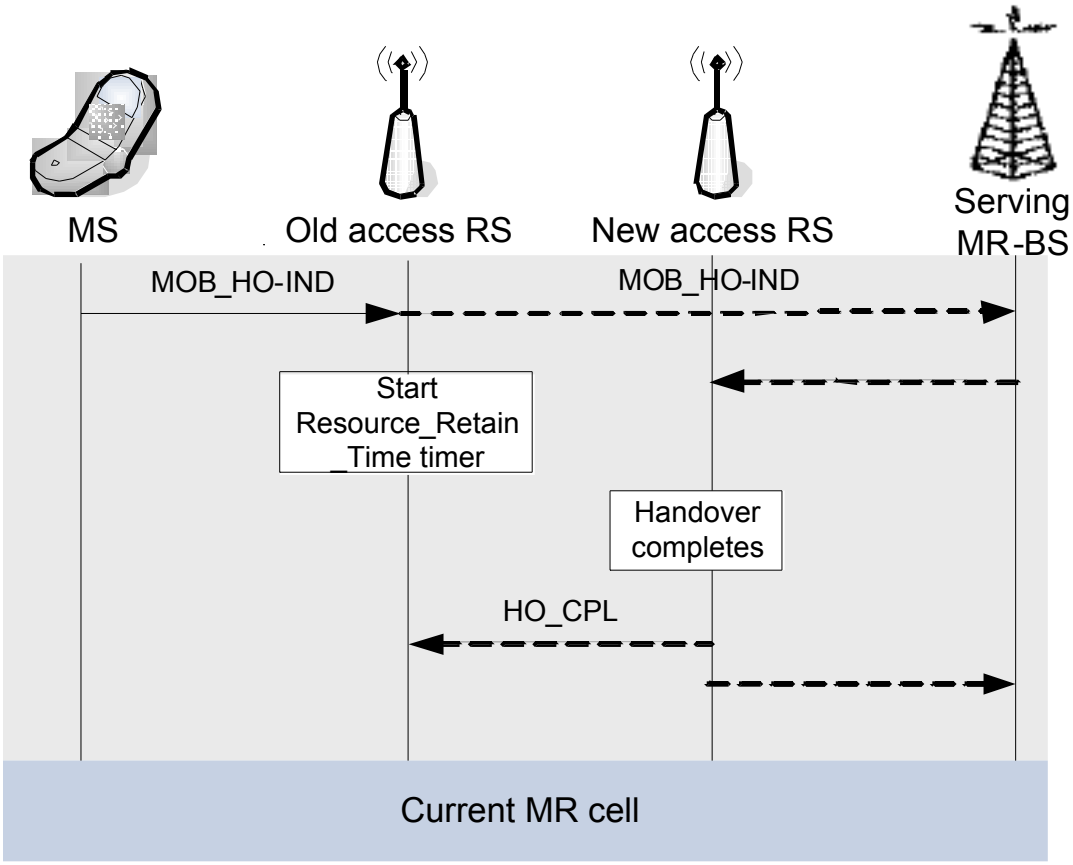
Termination

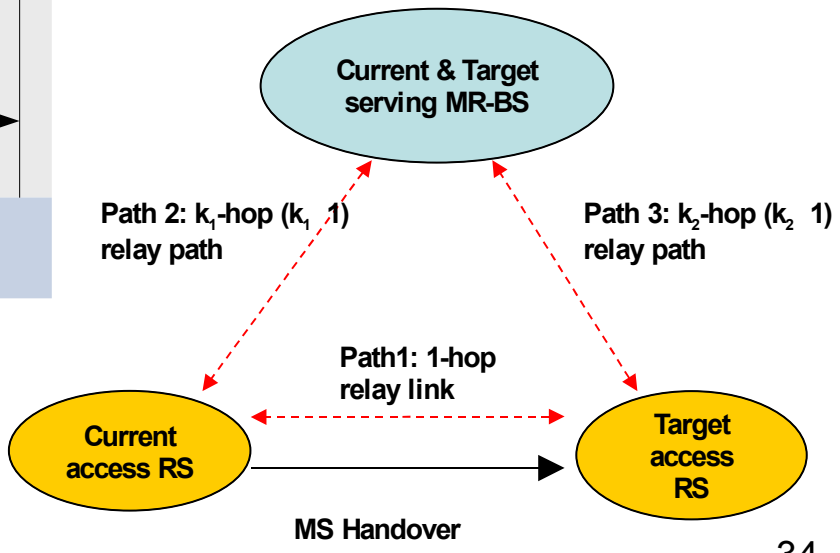
- During the handover process, the MS sends its current access station a MOB_HO-IND (HO_IND_type = 0b00) to release it.
- Upon receipt of MOB_HO-IND, the old serving station (only for inter MR-BS HO) and the old access station starts Resource_ Retain_Time timer.
- For an intra MR-BS HO, the MR-BS doesn't have to starts Resource_Retain_Time timer.
- In IEEE 802.16e-2005, the successful MS network attachment at the target BS is informed to the old serving BS over the backbone. Similarly, a new MAC management message *HO_CPL* is designed. This message is used to inform the old access/serving stations and the target serving station of the successful MS network attachment at the target access station.
- If Resource_Retain_Time timer expires or HO_CPL is received, the MS MAC information is removed.

Cancellation and Drop

- Cancellation: If the current access station is an RS and it receives a *MOB_HO-IND* message with HO_IND_type = 0b01 (indicating the handover cancellation), the *MOB_HO-IND* message is forwarded to the current serving MR-BS. The normal operation communication can be resumed.
- Drop: If the access station is an RS and it detects a drop, the access station reacts as if it receives MOB_HO-IND with BS release (HO_IND_type = 0b00).

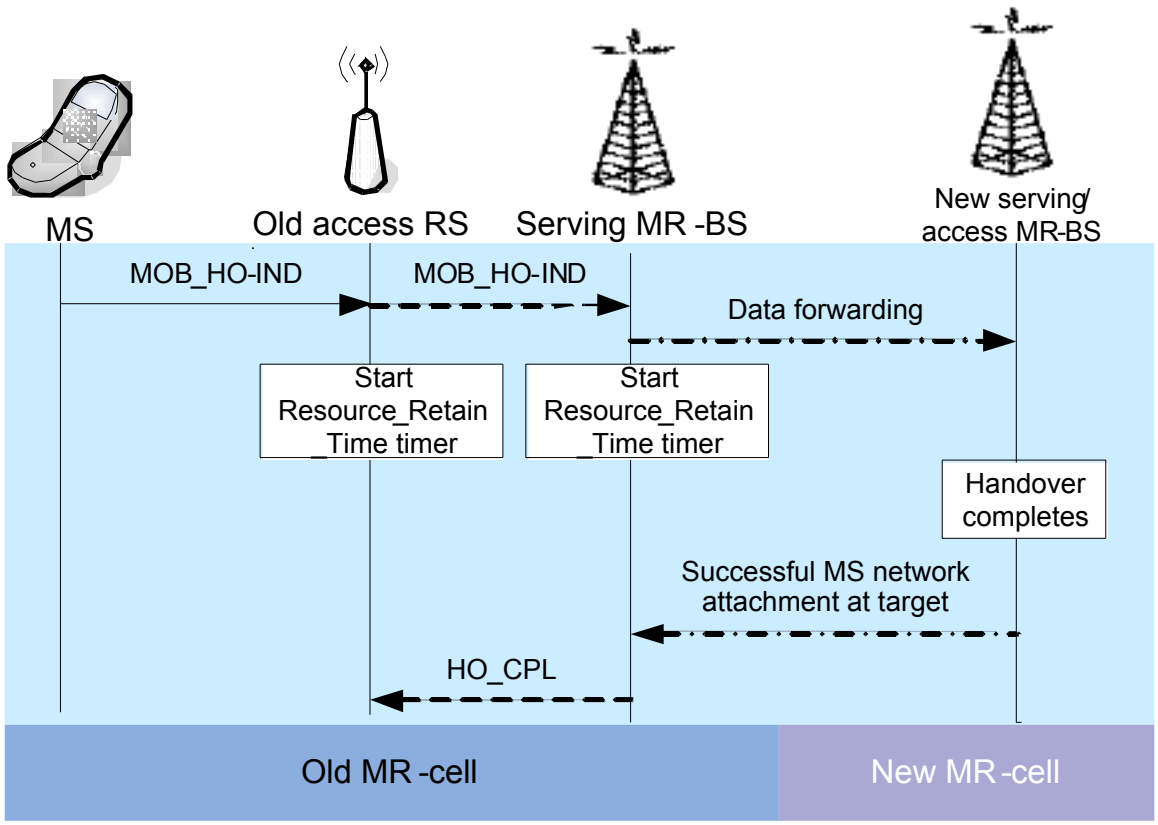
An example of termination procedure

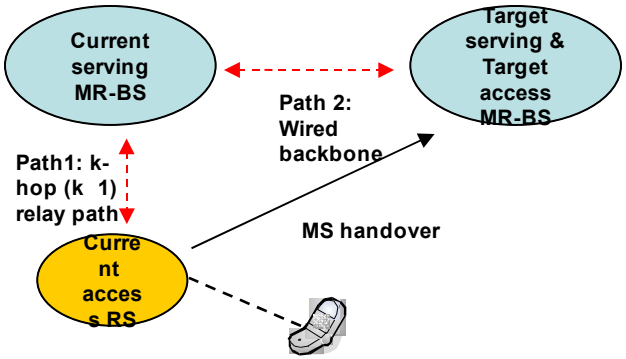




***This flow is an example when a direct 1-hop relay link exists between the current and the target access RSs.**

An example of termination procedure





Handover Contribution Summary

Phase	Contributions
Network Topology Advertisement	C80216j_06-218
MS scanning allocation	
MS Cell Reselection	
Handover decision and initiation	C80216j_06-219
Network entry/re-entry	C80216j_06-220
Termination	C80216j_06-221

New control message formats are defined and their exchange procedure for each handover phase for cases 1, 2, 3, 5, 6, 7 are tabulated in each contribution.