MMR Cell Path Discovery, Link Maintenance and Data Forwarding

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Purpose:

Technical contribution for MMR MAC layer functions on path discovery, maintenance & data forwarding

Highlights

- **MMR MAC layer functions focusing on**
  - Automatic relay path discovery
  - Relay Link maintenance
  - Data forwarding

- **Design Principle for low cost**
  - Minimize Relay link interface complexity (e.g., avoid introducing many new control messages)
  - Minimize the global distribution of MS’s information within a cell (e.g., keep RS agnostic to MS’s data)
  - “Hot Potato” relay to reduce delay and jitter (e.g., minimize per-MACPDU processing in RS)

Acronyms (IEEE 802.16j-06/014r1)

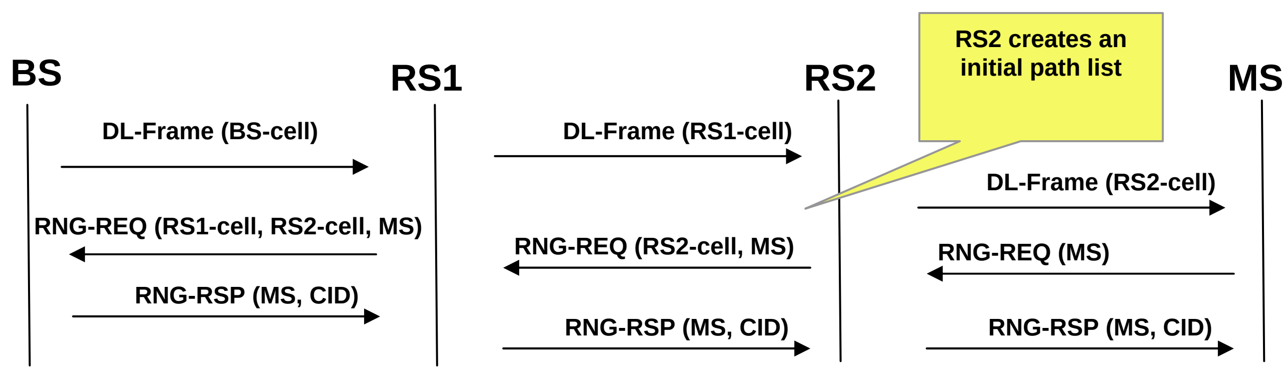
- **Cell:** . The radio coverage area of a particular station (e.g. BS, MMR-BS, or RS) where an MS can be serviced via access links
- **MMR Cell:** The radio coverage area of an MMR-BS cell and all of its subordinate RS cells
- **Relay link (R-link):** An 802.16j radio link between an MMR-BS and an RS or between a pair of RSs. This can be a relay uplink or downlink.
- **Relay uplink (R-UL):** Uplink from particular RS for upstream relay
- **Relay downlink (R-DL):** Downlink from particular RS for downstream relay
- **Relay path:** Concatenation of k consecutive relay links (k >= 1) between the MMR-BS and the designated access RS

Centralized routing vs. Distributed routing

- Centralized routing
  - Centralized radio resource scheduling at MMR-BS
  - Only MMR-BS stores routing database
  - MMR-BS assigns forwarding path in downstream data burst to a designated target
- Distributed routing
  - Distributed radio resource scheduling at MMR-BS and some RS
  - Every node stores routing database
  - MMR-BS only designates the target, each RS checks the destination against the local routing database to decide where the burst should go
- Hybrid routing
  - Based on radio resource scheduling schema, MMR cell can be organized as clusters of sub-tree
  - Cluster-head would determine the routing paths coordinately

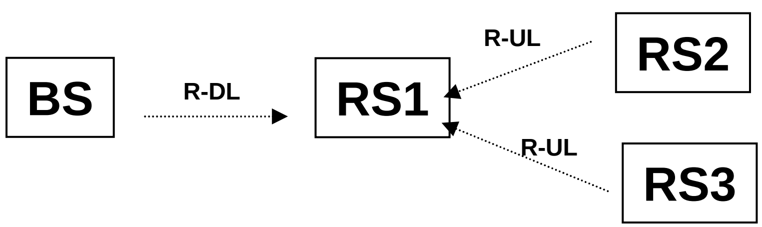
Example: Path Creation from Network Entry

- Auto path creation procedure
  - **Path creation using DL frame preamble (broadcast, downstream), initial ranging RNG-REQ (uni-cast, upstream) and RNG-RSP (broadcast, downstream)**
  - **Every RS is assigned a BS-ID and a MS-ID**
  - **Every BS/RS transmits DL frame preamble using their assigned IDCell (Cell ID)**
  - **Routing path can be identified by an array of IDcell , or BS-ID.**
  - **New node starts initial ranging by sending RNG-REQ to the selected access RS**
  - **For the received RNG-REQ, the access RS stores new-node's MS-ID into routing table, and creates a path list in RNG-REQ with its IDcell as first entry, and further relay RNG-REQ upstream**
  - **Along the upstream path, from the received RNG-REQ, the RS stores the new path list and new-node's MS-ID into routing table. RS then appends its own IDcell into path list (if such a path does not exist before) and further relay RNG-REQ upstream .**
  - **After receiving RNG-REQ, the BS stores the final path list and new-node's MS-ID into routing table, and sends RNG-RSP back to new node with assigned Basic CID.**
  - **Along the downstream path, RS intercepts RNG-RSP. If the MS-ID is matched with a direct attachment, RS puts new-node's Basic CID into routing table and further relay RNG-RSP downstream; If MS-ID is not matched, RS simple drops RNG-RSP.**
  - **For path maintenance, three approaches can be used to determine whether to keep or to remove a node from the path: periodical RNG-REQ, MOB_MSHO_REQ and REP-REQ/RSP**



MMR Cell Link Maintenance

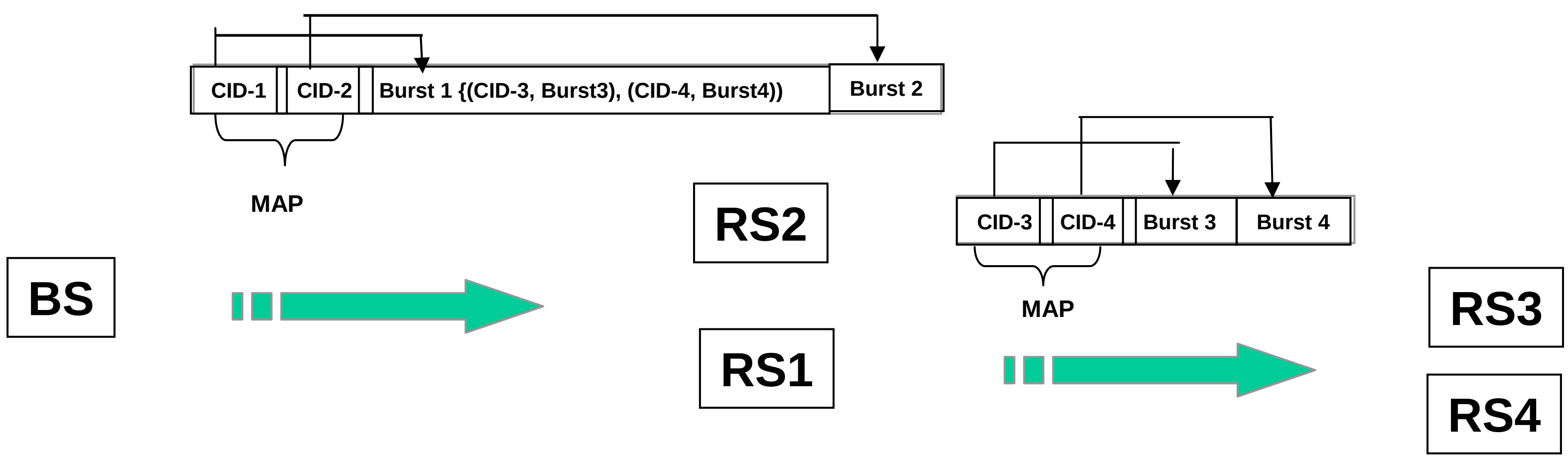
- **R-Link monitoring and reporting procedure**
  - Current .16e only supports MS monitoring and reporting R-DL situation to BS
  - .16j requires each RS to monitor and to report both R-DL (from successor node) and R-UL situation (from child nodes) back to BS
  - BS can use globally acquired link information for relay path maintenance (fault detection & fault isolation) and path selection
  - BS could utilize REP-REQ/REP-RSP to detect RS failure
  - When RS received REP-REQ, it should send per-link REP-RSP (if any) back to BS
  - Alternatively, RS could send REP-RSP in an unsolicited fashion.
  - new R-link TLV in REP-RSP indicating the link type (i.e., R-DL or R-UL), and link-source indicating which R-link was measured



Example: Tunneled Data Burst Forwarding (1)

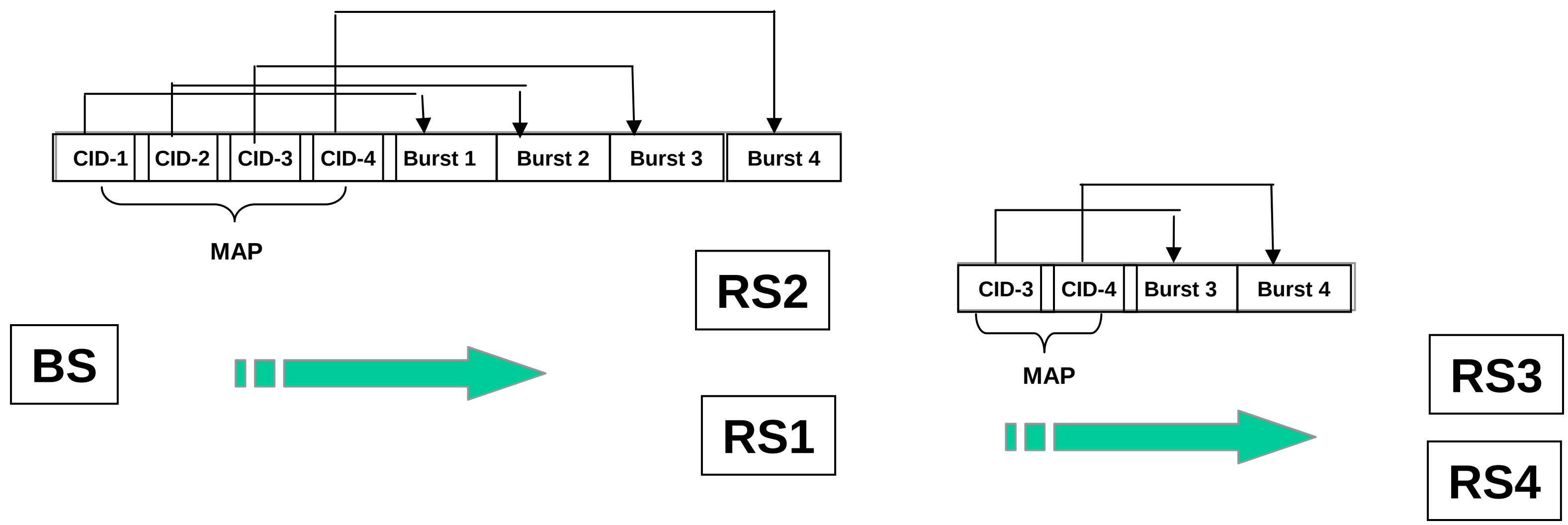
- **Centralized routing**
  - Basic CID used as unicast tunnel CID in DL-MAP_IE (802.16-2004)
  - Or, Basic CID is used as tunnel CID in MACPDU header (and sub-header)
  - BS builds the data bursts with embedded tunnel CID (and the associated MAC PDU) along a given path
  - Tunneled burst targets to each access RS and its subordinate tree.
  - For the received frame, by checking tunnel CID, RS would determine:

    (1) process it (2) further relay (3) drop it
  - new spec for RS



Example: Tunneled Data Burst Forwarding (2)

- **Distributed Routing**
  - Basic CID used as unicast tunnel CID in DL-MAP_IE (802.16-2004)
  - BS only needs to specify the designated target
  - Tunneled burst is relayed to each access RS, which contains the MAC PDUs either targeting to the RS, or targeting to all MS attached to this RS
  - For received frame, by checking burst CID and the routing table, RS would determine: (1) process it (2) further relay (3) drop it
  - new spec for RS



Summary

1. **Utilize 802.16e network entry procedure to create routing path**
2. **Only a few new TLVs to be introduced**
3. **New spec focus on RS functional behavior for those new TLVs**
4. **In centralized routing, only BS stores the routing table, but data forwarding with some overhead**
5. **In distributed routing, RS needs to intercept some mgmt messages to acquire children's Cell ID list, MS-ID and Basic CID (e.g., RNG-REQ/RSP)**
6. **Path maintenance can be done via periodical ranging, MOB_MSHO_REQ and REP-REQ**
7. **Basic CID is used for tunneled data burst (No need to populate MS's transport CID to RS along the relay path)**
8. **Downstream data forwarding at designated burst level reduces delay and jitter (No need to decode MAC PDU individually)**
9. **Minimum change to 802.16-2005**