An Framework for Multi-hop Path Management in MMR Networks

IEEE 802.16 Presentation Submission Template (Rev. 8.3)

Document Number:

IEEE S802.16j-07/161r1

Date Submitted:

1/15/2007

Source:

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Venue:

IEEE 802.16 Session #47, London, GB .

Base Document:

IEEE C80216j-07/161r1

Purpose:

To propose path management for IEEE802.16j

Path Management Framework

- Central Path management in MR-BS
- Path and connection database in MR-BS
- Forwarding in RS
- Forwarding database in RS

Path Management in MR-BS

- Path management :
  - is a functional entity inside MR-BS
  - controls the path management in its subordinate network, all connected RS and MS
  - incorporates database which stores all connection relevant data's
  - decides forwarding method for the connections
  - includes connection path setup, change and delete
  - sends path management related MAC messages to subordinates RS and MS

Path Management in RS

- RS contains and maintains forwarding database for MAC PDU forwarding
- Forwarding decision is taken according to :
  - database lookup
  - Header subheader information
- Forwarding database contains information like
  - Relation of incoming CID to outgoing CID
  - Relation of incoming CID to outgoing CID list
  - Type of forwarding method
- Forwarding databases are updated by information:
  - From MAC management PDU send by path management
  - Derived from received DSx management messages
  - From MAC header and subheader information elements

Forwarding methods

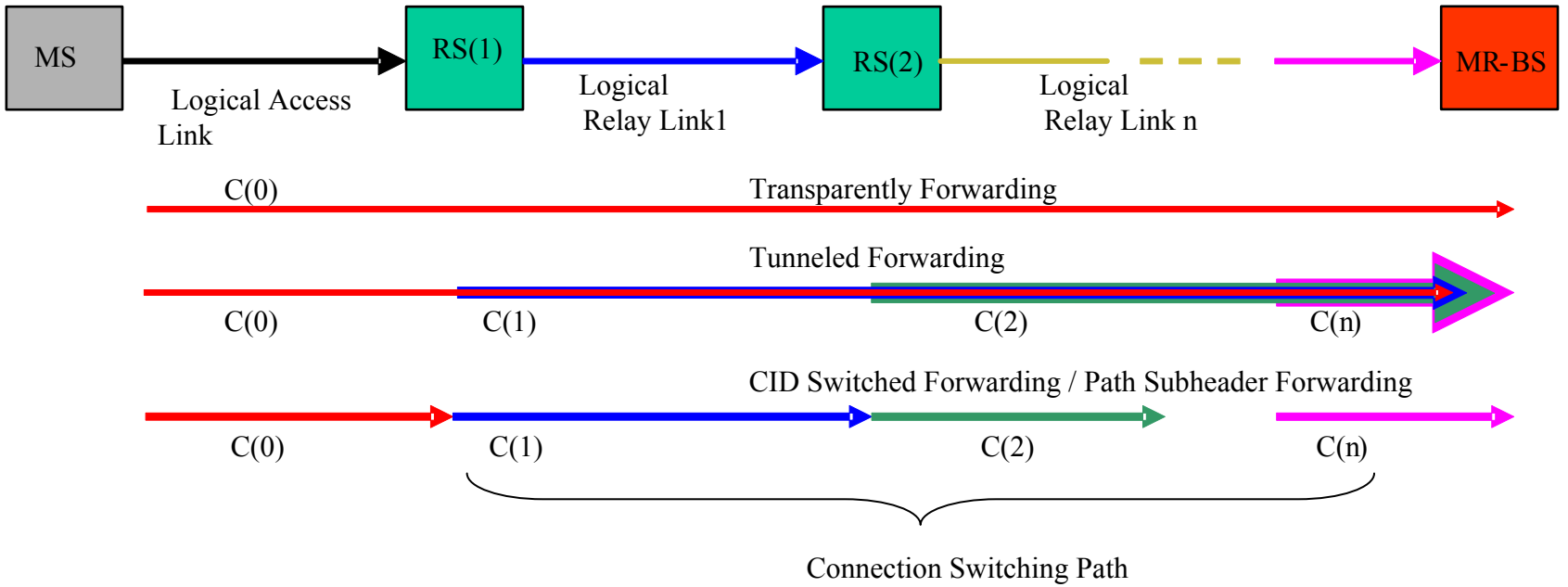
- CID mapping
  - CID may change from hop to hop
  - RS inserts the new CID value in the header and adapts further information fields in the header if necessary
  - Determination of the new CID is done by a forwarding database lookup.
- Transparent forwarding
  - CID keeps the same along the path between the logical communication endpoints
- Tunneled forwarding
  - CID may change from hop to hop
  - In uplink direction, relaying RS leaver header of received MAC PDU unchanged and prepends a new header
  - Inverse procedure in downlink direction
  - Determination of the new CID is done by a forwarding database lookup
  - The number of headers is given by the number of hops.
- Header subheader processing
  - CID may change from hop to hop
  - Path between the communication endpoints is defined by the CID in the MAC PDU header and a CID list in the subheader
  - Subheader insertion or removal at access RS
  - RS performs CID list wrap around in header and subheader
  - No database lookup in intermediate RS

Decision of Forwarding Methods

- Path management in MR-BS selects an appropriate forwarding method for a connection according to the following constrains: *
  - QoS constrains of the connection
  - Type of connection (data or management)
  - Available resources in MMR

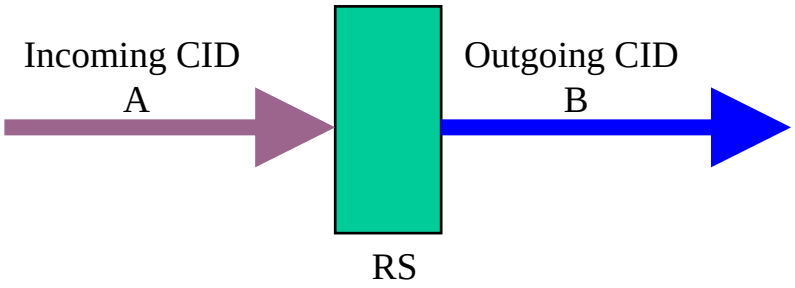
* Algorithms or configurations are implementation issues and not part of standard

Path management: Forwarding Methods



- MAC PDU forwarding
  - Forwarding table driven in RS
    - Transparent forwarding
    - CID switched forwarding
    - Tunneled forwarding
  - Header embedded path information

Forwarding Database Driven MAC PDU Forwarding (1/2)



Example of CID forwarding table in RS

Incoming CID	Outgoing CID	Action
A	B	*Translation*

- Each RS maintains a CID forwarding table for MAC PDU forwarding.
- CID Mapping between incoming and outgoing CIDs could be 1:1, M:1, 1:N and M:N.
- Action could be En-cap, De-cap, Translation etc.

Forwarding Database Driven MAC PDU Forwarding (2/2)

(1) En-Cap Action (Tunneling)

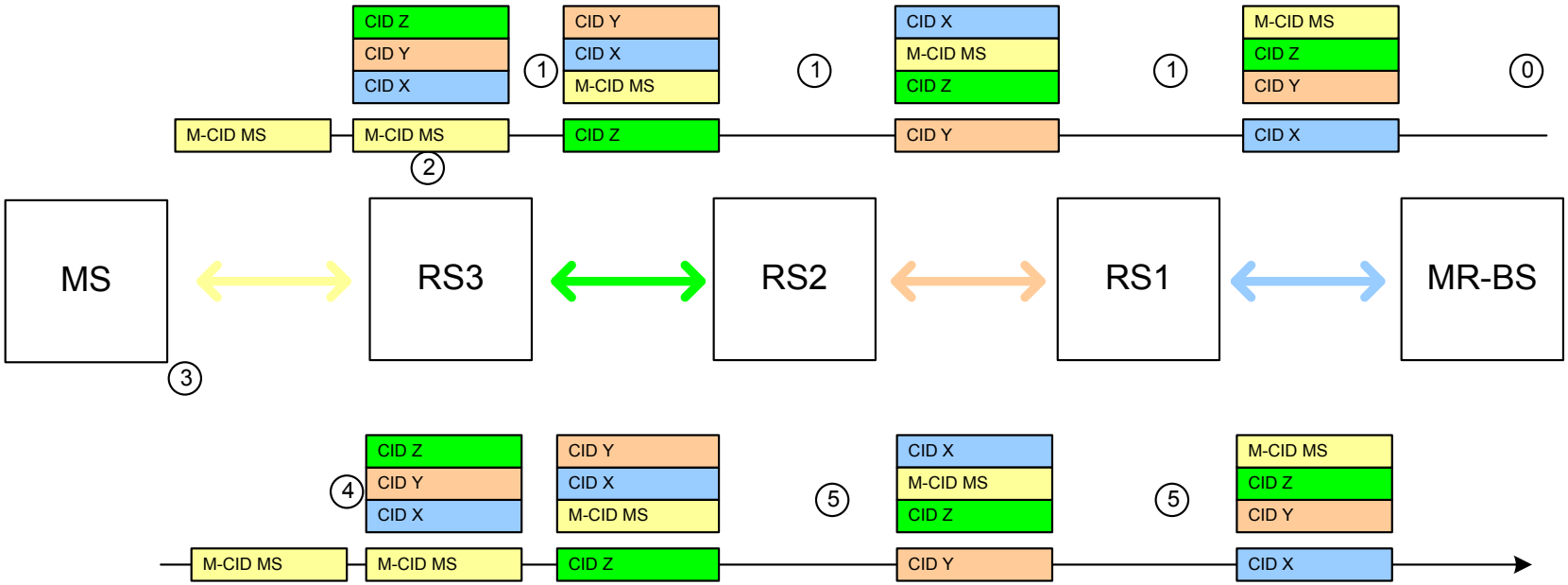
(2) De-Cap Action (Tunneling)

(3) Translation Action (CID mapping)

Header/Subheader driven Forwarding

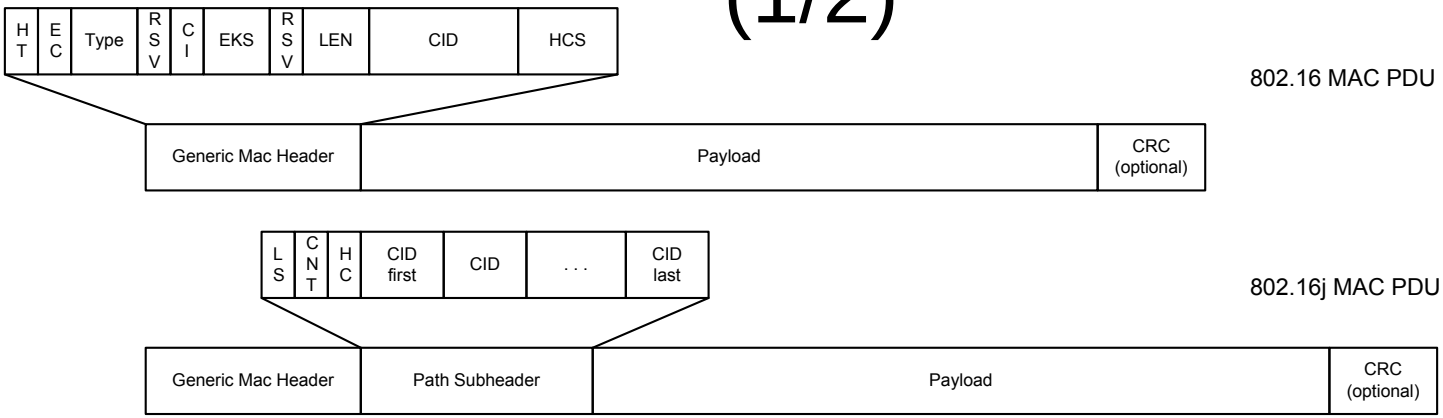
Example: MR-BS <-> MS management communication via 3 RS

MAC management communication : BS to MS, BS sends MAC management message to MS via management connection, (Basic, Primary or Secondary)



After network entry of MS, BS sends a first MAC management message to MS using a management CID of MS
0: MR-BS prepare MAC PDU with CID list in subheader according to topology database
1: RS performs CID list wrap around for downlink
2: RS3 stores stack, removes subheader to get an 802.16 compliant MAC PDU, and sends it to MS
3: MS sends reply MAC management message using its management CID
4: RS3 receives MAC PDU, perform a lookup in its stored CID list database, (using M-CIS MS as an index), builds subheader perform an uplink wrap around and sends MAC PDU to next hop
5: RS performs CID list wrap around for uplink
Management communication : Same CID's for downlink and uplink, access relay station (RS3) can "reuse" CID path list from downlink management path

MAC PDU Forwarding by Header and Subheader embedded Path Information (1/2)

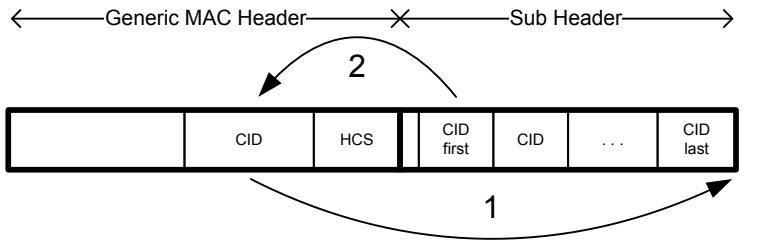


- MAC PDU contains path information
  - MAC PDU contains generic messages header as defined in 802.16e-2005
  - Message contains additional subheader as defined in 802.16e-2005 path subheader type and layout definition to be done in 802.16j
  - Path subheader contains: CID list which defines the connection path
  - and further information elements
    - CNT defines count of CID’s in list
    - HC defines hop count
    - LS List/Stack flag indicates if subheader shall be used as list (wrap around) or stack (shift-remove)

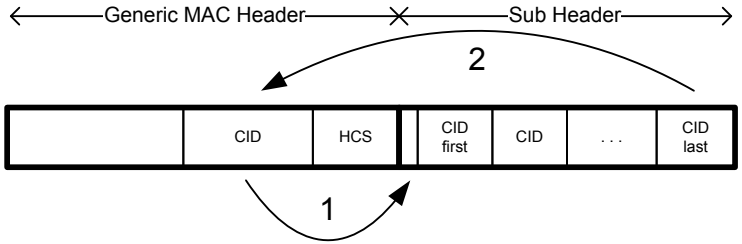
MAC PDU Forwarding by Header and Subheader embedded Path Information (2/2)

Per Hop Header Processing

MAC Messages with subheader CID list, List wrap around

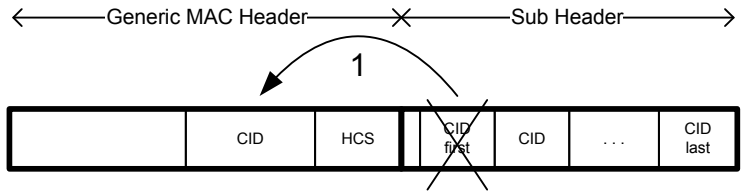


Downlink forwarding:
1. Append header CID at the end of the CID list
2. Remove first CID from list and set this as the new CID in header
3. Update subheader IE's and HCS



Uplink forwarding:
1. Prepend header CID at the begin of the CID list
2. Remove last CID from list and set this as the new CID in header
3. Update subheader IE's and HCS

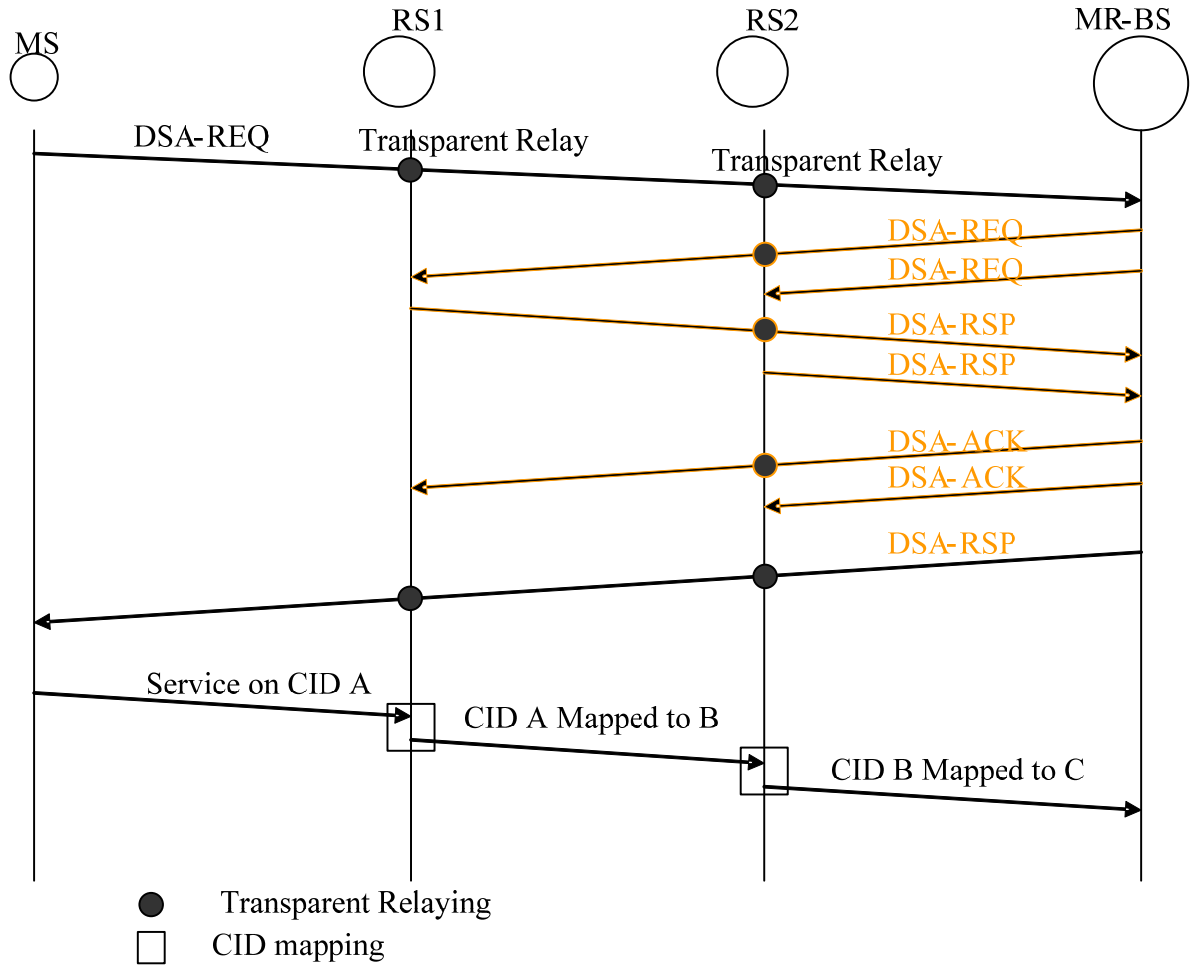
MAC Messages with subheader CID stack, Stack processing



Forwarding:
1.Remove first CID from list and set this as the new CID in header
2. Update subheader IE's and HCS

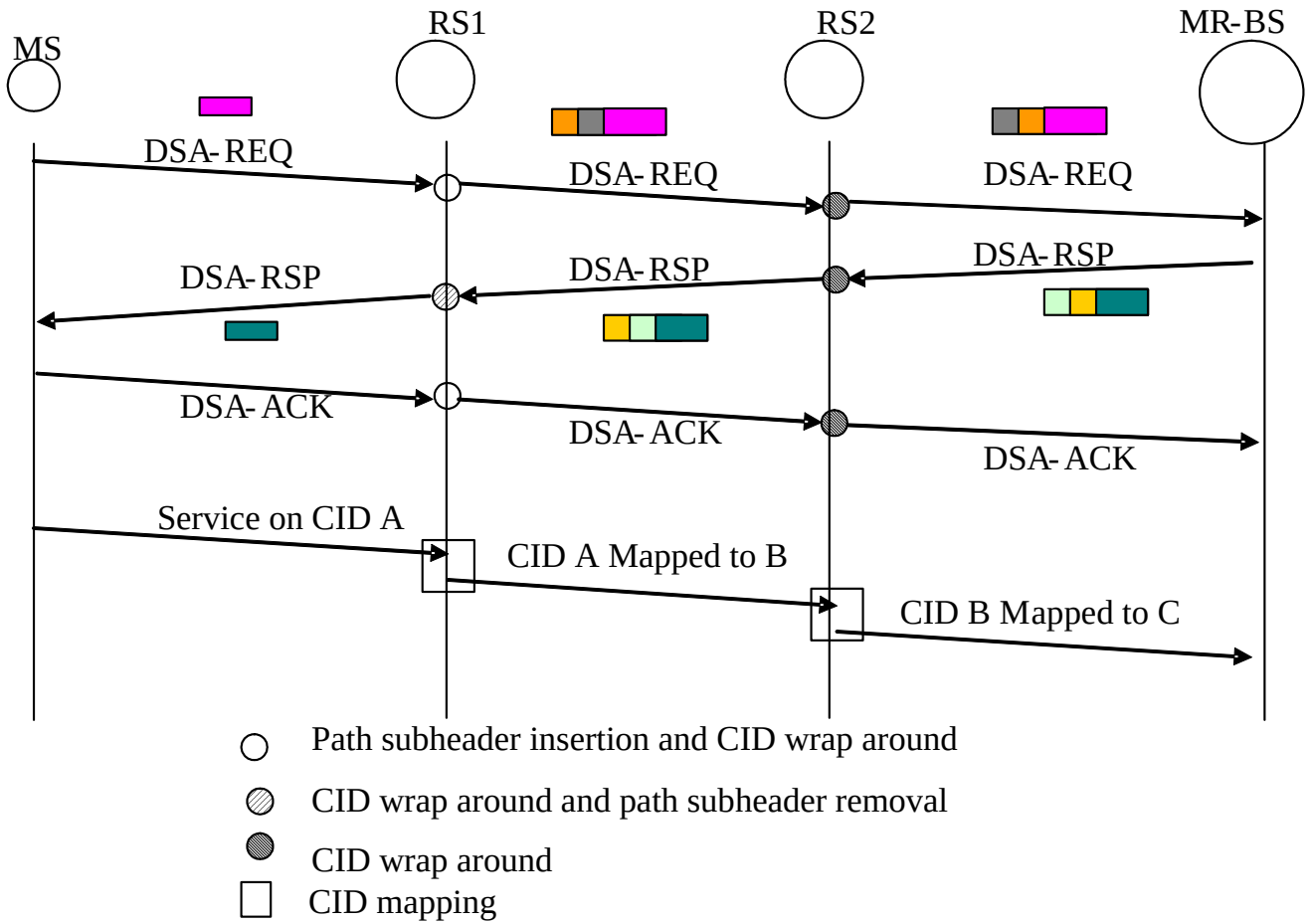
Example: Path setup 1/3

- Management message transport by transparent relaying
- Data path forwarding by CID mapping
- Optional intermediate connection setup



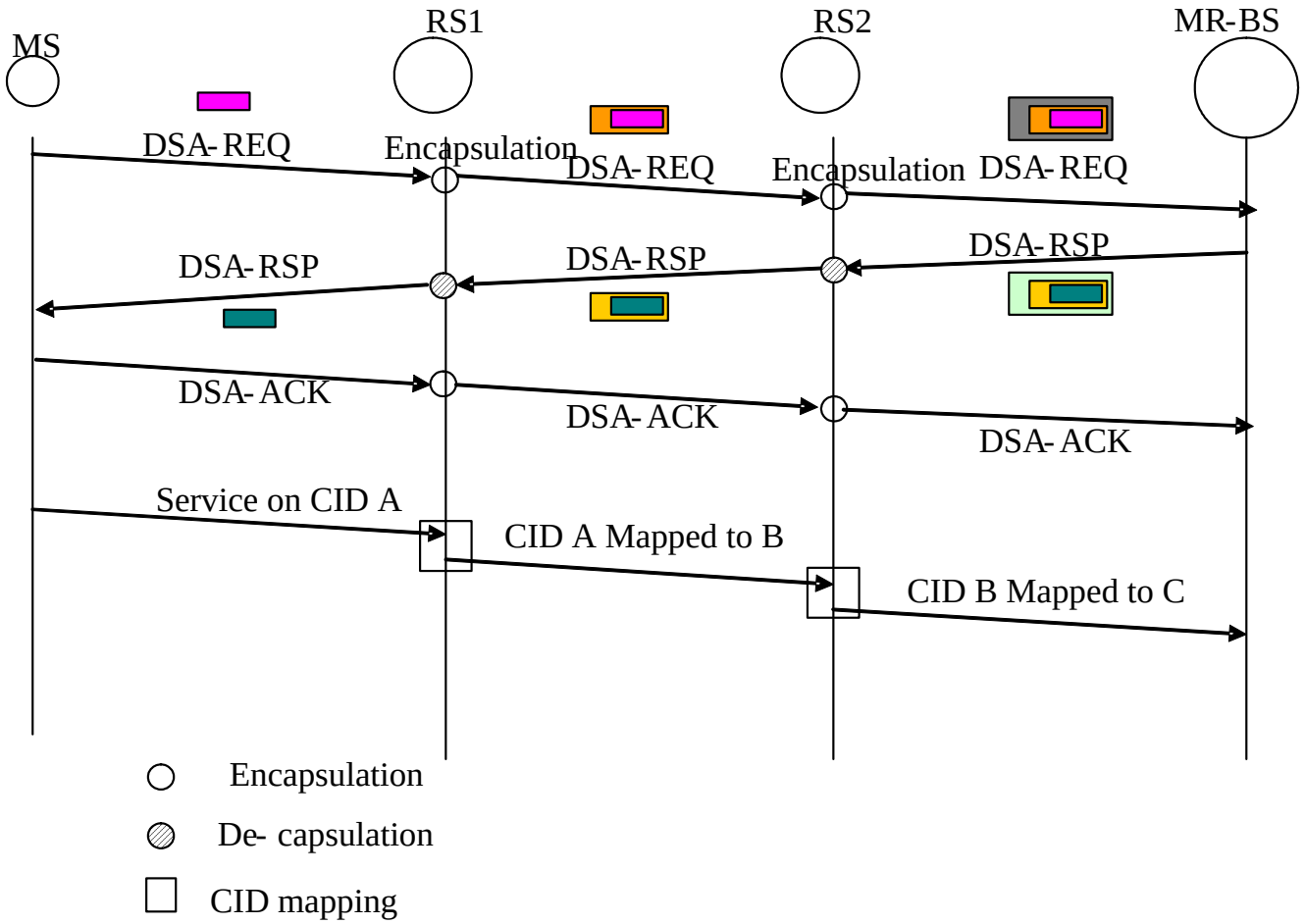
Example: Path Setup 2/3

- Management message transport by header/subheader forwarding
- Data path forwarding by CID mapping



Example: Path Setup 3/3

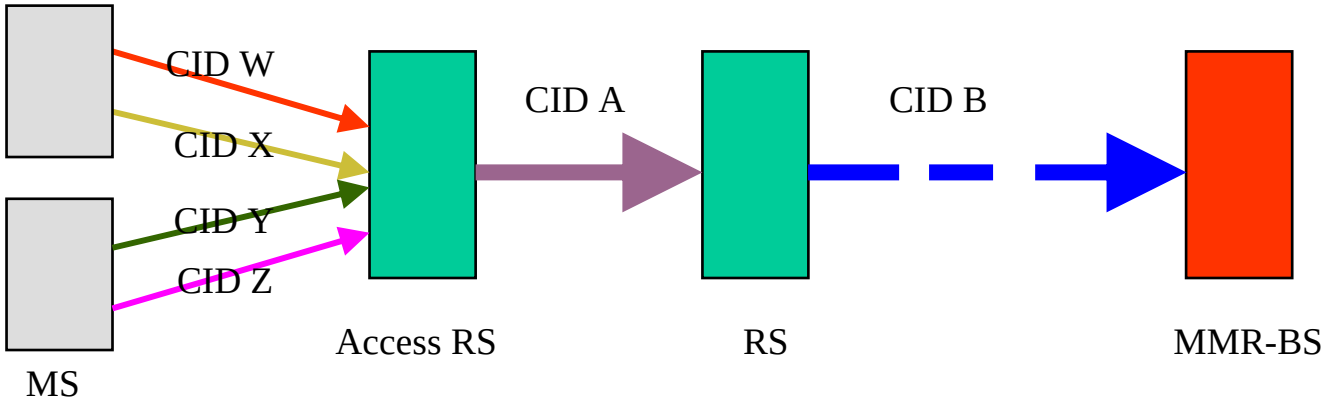
- Management message transport by tunneling
- Data path forwarding by CID mapping



Recommendation on MAC PDU forwarding

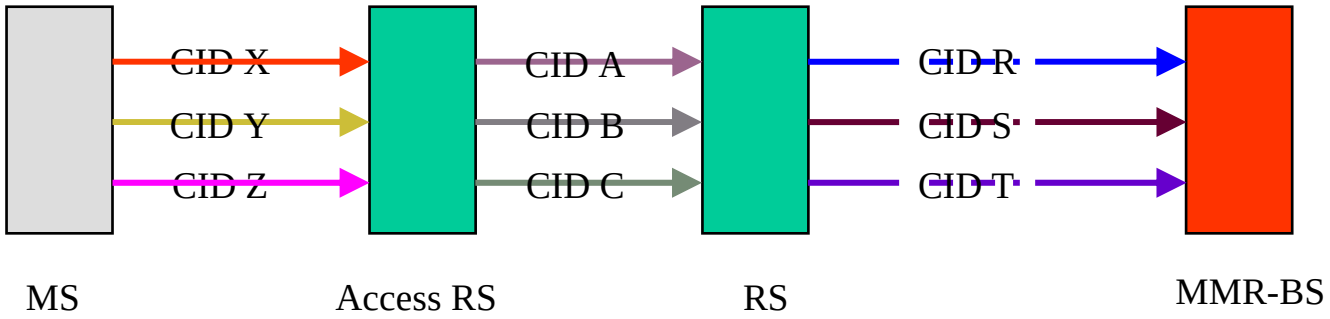
- Table driven in RS
  - More suitable for data connections
- Embedded path information
  - More suitable for management connections
    - Fast forwarding, no forwarding table lookup
    - No path setup or configuration messages, receiving RS in downlink can reuse path information for uplink send
    - Receiving RS or MR-BS can use receive path information for originator determination

One relay path per Relay Station

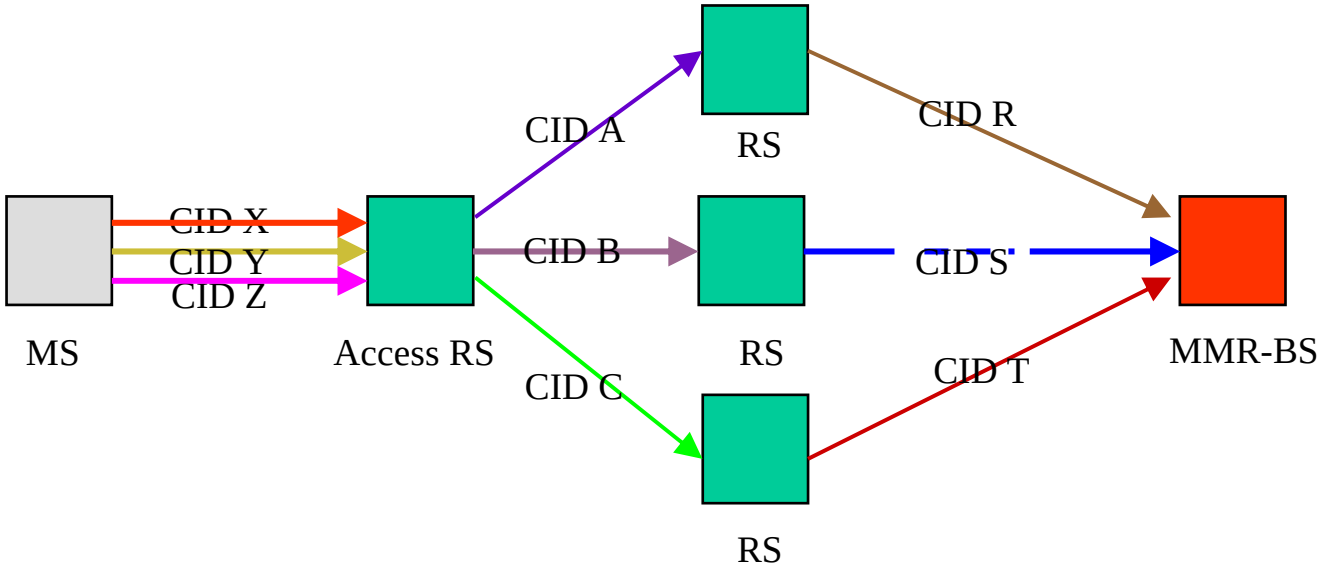


- All traffic from one RS will be carried over one relay path
- Multiple services mapped to one connection in each relay link
- Simple to implementation
- Less resource consumption
- Better performance on mobile RS
- Problems to handle different QoS constrains on data connections

One relay path per service(1/2)



Same physical relay path and different logical relay paths



Different physical and logical relay paths

Summary

- Central Path management in MR-BS
- Forwarding in RS driven by path management in MR-BS
- Several forwarding mechanisms configured by path management according to connection constrains
- Forwarding in RS according to forwarding database and/or header/subheader information

Backup Slides

Combination of both, connection sharing on relay links

- Rationales
  - Satisfy all QoS requirements from access link
  - Reduce amount of connections on relay links
- Connection sharing on relay links for
  - Management connections
    - Management connections from MS are transported via management connection of RS
      - MS basic CID via RS basic CID
      - MS primary management CID via RS primary management CID
      - MS secondary management CID via RS secondary management CID
  - BE (best effort) data connections from MSs may be merged on one RS BE connection
  - Several non-BE data connection from access links may by be merged to one or more RS connection according to QoS constrains
    - N number of data connections on access link
      M number of data connections on relay link
      N >= M >= 1

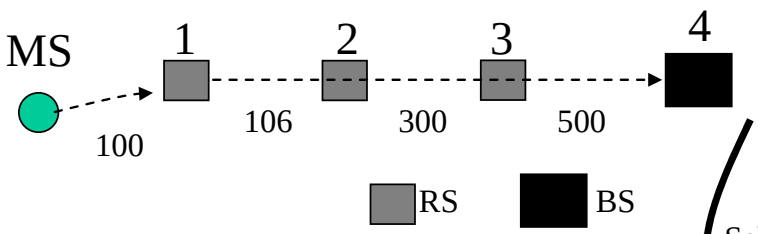
Example: Connection Reduction on Relay Link

- Assumption:
  - 50 MS are connected to one RS
  - Every MS has 4 connections:
    - 2 management connections, basic and primary management
    - 2 Data connections, one BE for Web browsing, one rtPS for VoIP
- One relay path per service would result in:
  50 * 4 = 200 connections on relay link
- Path reduction:
  - Management connections of MS are relayed over the management connection of RS, no additional connections
  - All BE connections of MS are relayed over one BE relay connection, only one additional connection
  - rtPS connections of MS are relayed over one or little bit more rtPS connections on relay link, depending on the QoS constrains of the rtPS connections
- Totally 2 (or little bit more) additional connections on relay link

Backup_CID Mapping Message

Syntax	Size	Notes
CID_MAP_Message_format(){	--	CID mapping message
Management Message Type=80	8 bits	--
N_RS	4 bits	Number of RS to relay the service
For(j=0; j<N_RS; j++){	--	--
RS ID	24 bits	Identify RS
Action	3 bits	Indicate RS how to relay the ingress CID 000: CID Translate 001: CID Encap 010: CID Decap 011: Reserved 100: CID Header Wrap 101: CID Header Stack 110: CID Header Add List 111: Reserved
Outgress CID	16 bits	CID that to be put into the header of MAC PDU which is carried on the ingress CID. Only for action 000, 001.
}		
TLV encoded information	variable	--
Padding	variable	If needed for alignment to byte boundary
}		

Backup_Route and CID mapping



BS Routing Table

Src	Dest	Count	Next	Bandwidth	Delay	Other Metrics
1	4	..	2	..	..	..
2	4	..	3	..	..	..
3	4	..	4	..	..	..

Select Route: 1->2->3->4 according to resource and requirement
Allocate CIDs for access link and relay link
Route-to-CID binding

CID Path: 106, 300, 500

RS2 CID Forwarding Table

	In CID	Out CID	Action	Next Hop
From RS1	106	300	Mapping	RS3

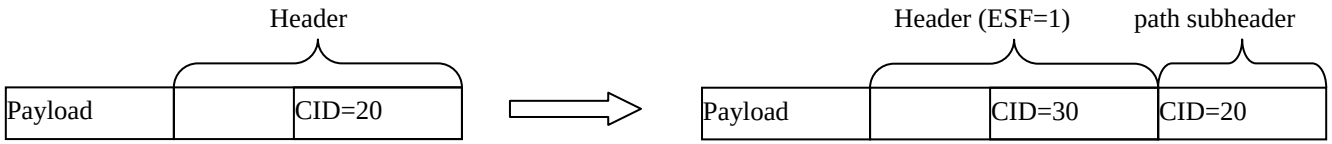
RS1 CID Forwarding Table

	In CID	Out CID	Action	Next Hop
From MS	100	106	Mapping	RS2

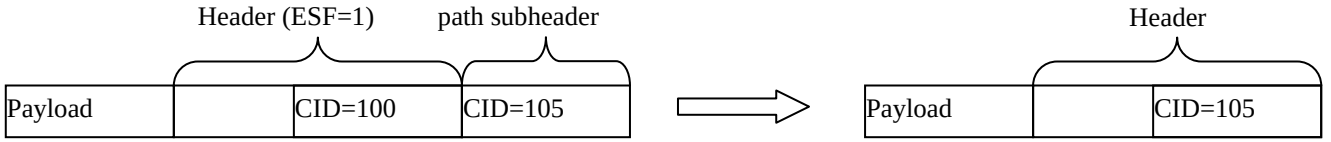
Backup Slides_Slide 5

- Piggyback mode:
  - Need DSA-RSP message extension (with ESF=1)
- Separate mode
  - No modification to DSA-RSP
  - Need a new-defined CID mapping message

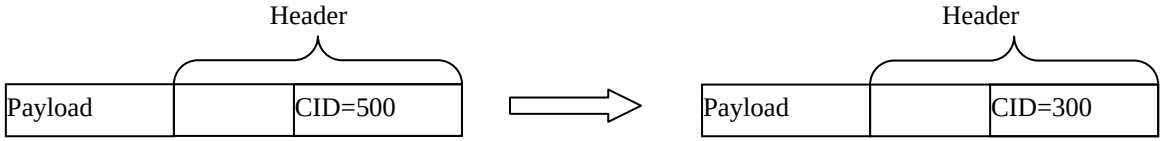
Backup_Slide 7



En-cap



De-cap



En-cap

Backup Slides_Slide 7

- Typically, for control/management message
  - Access RS would take en-cap/de-cap action to relay uplink/downlink control/management message
  - Intermediate RS would take translate action
- Typically, for data message
  - Access RS would take translate action
  - Intermediate RS would take translate

Backup-DSA_RSP Extension

Type	Length	Value	Scope

[145/146].47	variable:
	6n
		Compound:
		For(j=0; j<N_RS; j++){
		24bits: RS_ID
		8bits: Action
		16bits: OutgressCID
		}
		
		Action: Indicate RS how to relay the ingress CID
		0x00: CID Translate
		0x01: CID Encap
		0x02: CID Decap
		0x03: Reserved
		0x04: CID Header Wrap
		0x05: CID Header Stack
		0x06: CID Header Add List
		0x07~0xFF: Reserved
			DSx-REQ
			DSx-RSP
			DSx-ACK