Relay Frame Structure for IEEE 802.16m

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Re:
  TGm Call for Contributions, IEEE 802.16m-07/047, specifically on "16m Frame Structure with special attention to legacy support"

Abstract:
  Discussion on the 16m frame structure for enhanced relay support

Purpose:
  To discuss the frame structure in the 802.16m SDD

Relay in a cellular network using combined transmission
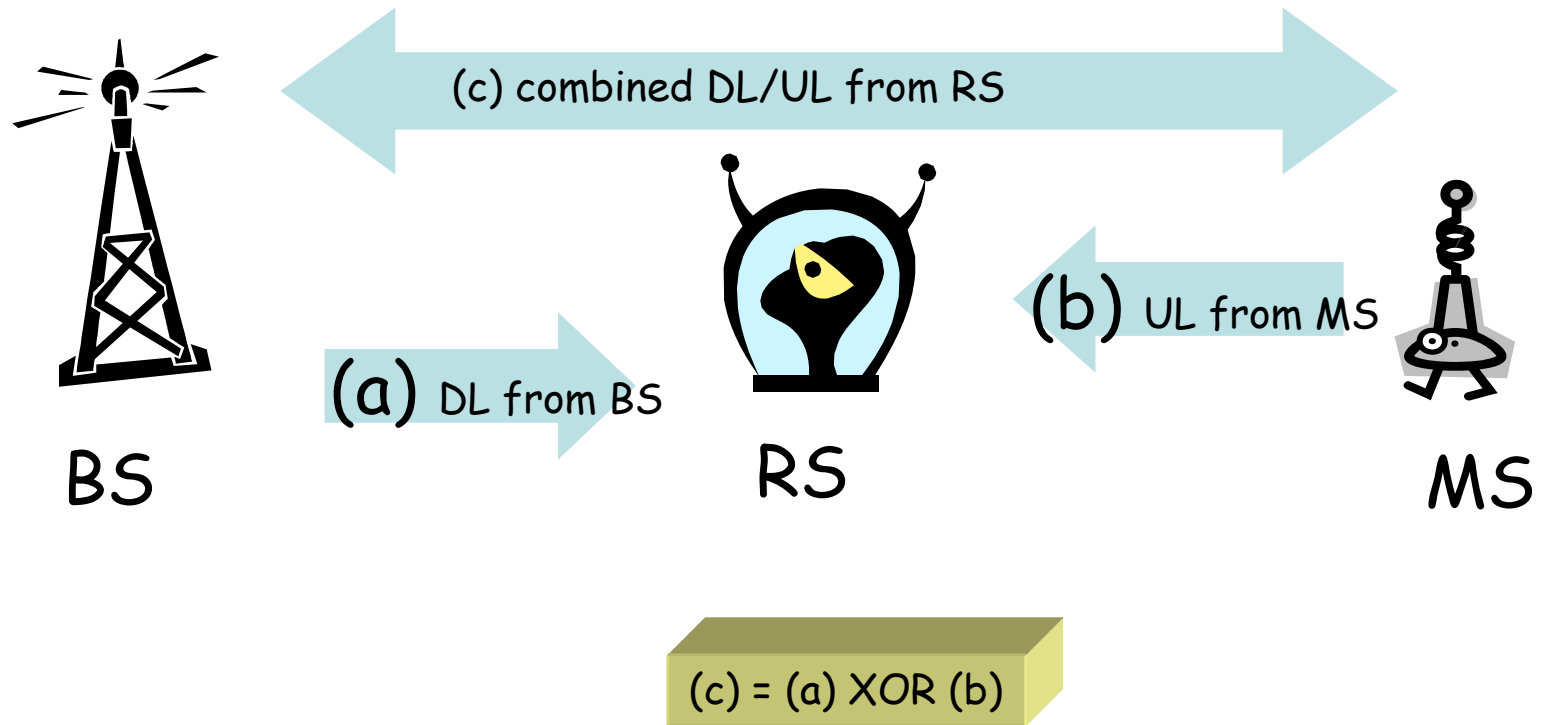
MSG & BS Scheduling

- Each MS maintains a MS Group (MSG) consisting of the neighboring MSs whose MSG report is decodable during UL sub-frame

- MS reports its MSG to BS periodically

- BS scheduler pairs the transmissions of a DL packet to MS2 and an UL packet from MS1, with MS1 in MS2's MSG, to maximize the possibility that combined transmission can be used if there is a retransmissions by relay

- MS1 & MS2 can be the same MS

MS Group (MSG)

MSG2 has MS1, MS2, MS3

MS1

MS2

MS3
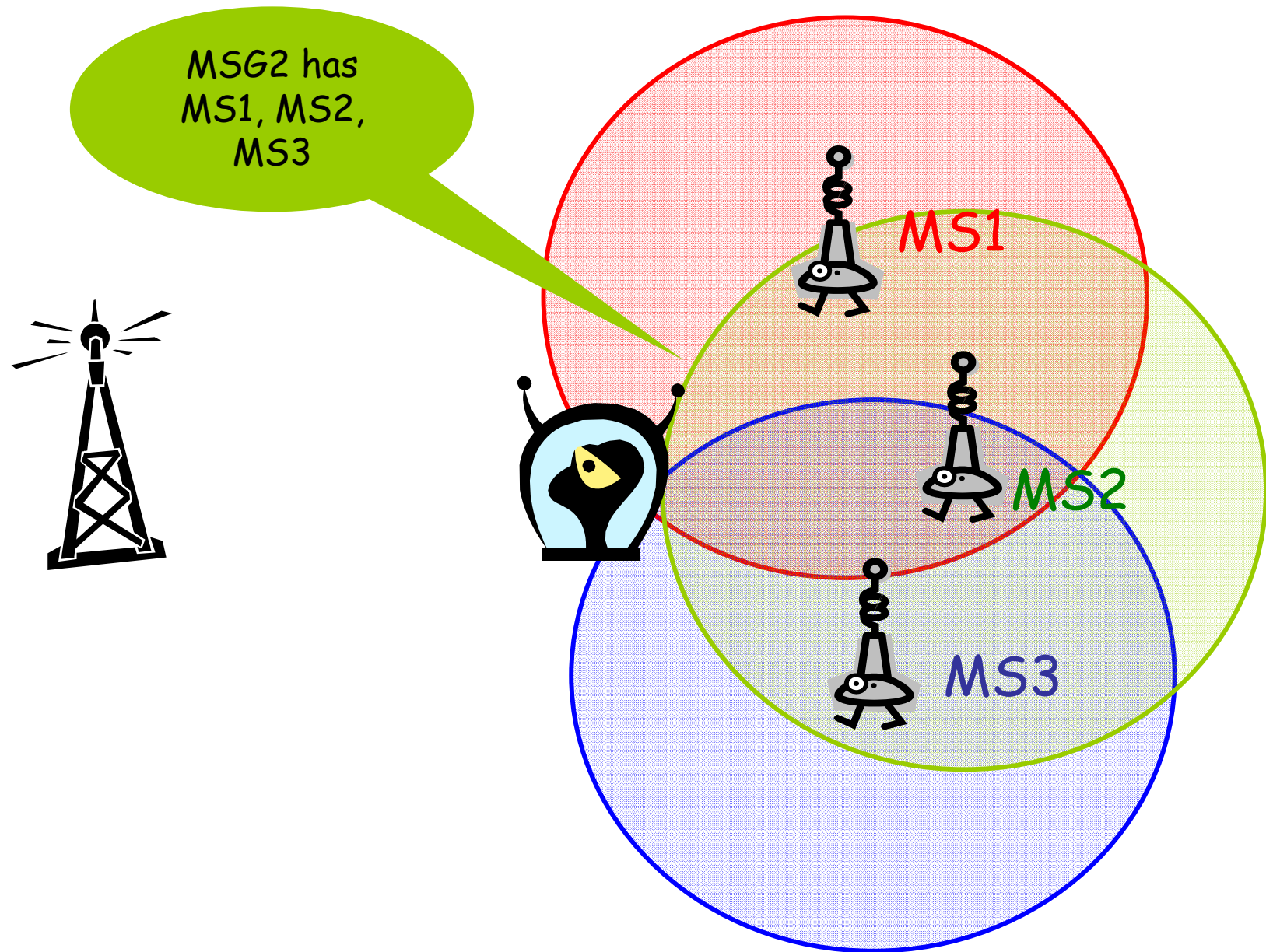
BS schedules based on MSG

BS schedules the two packets in the same frame

UL_MS1

DL_MS2

MS1

MS2

Relay sub-frame

MS1

MS2

RS multicasts the combined version of UL_MS1 & DL_MS2
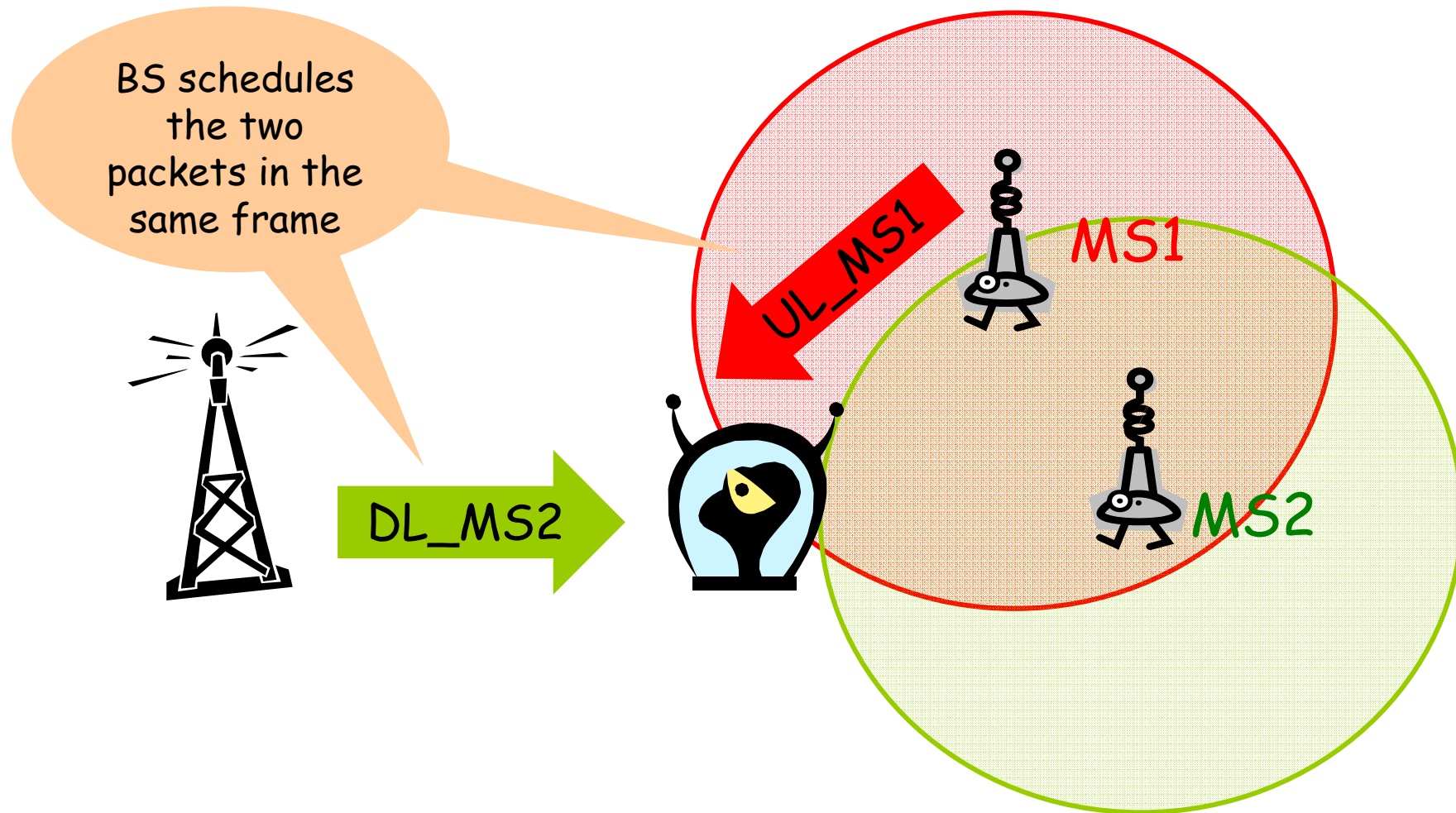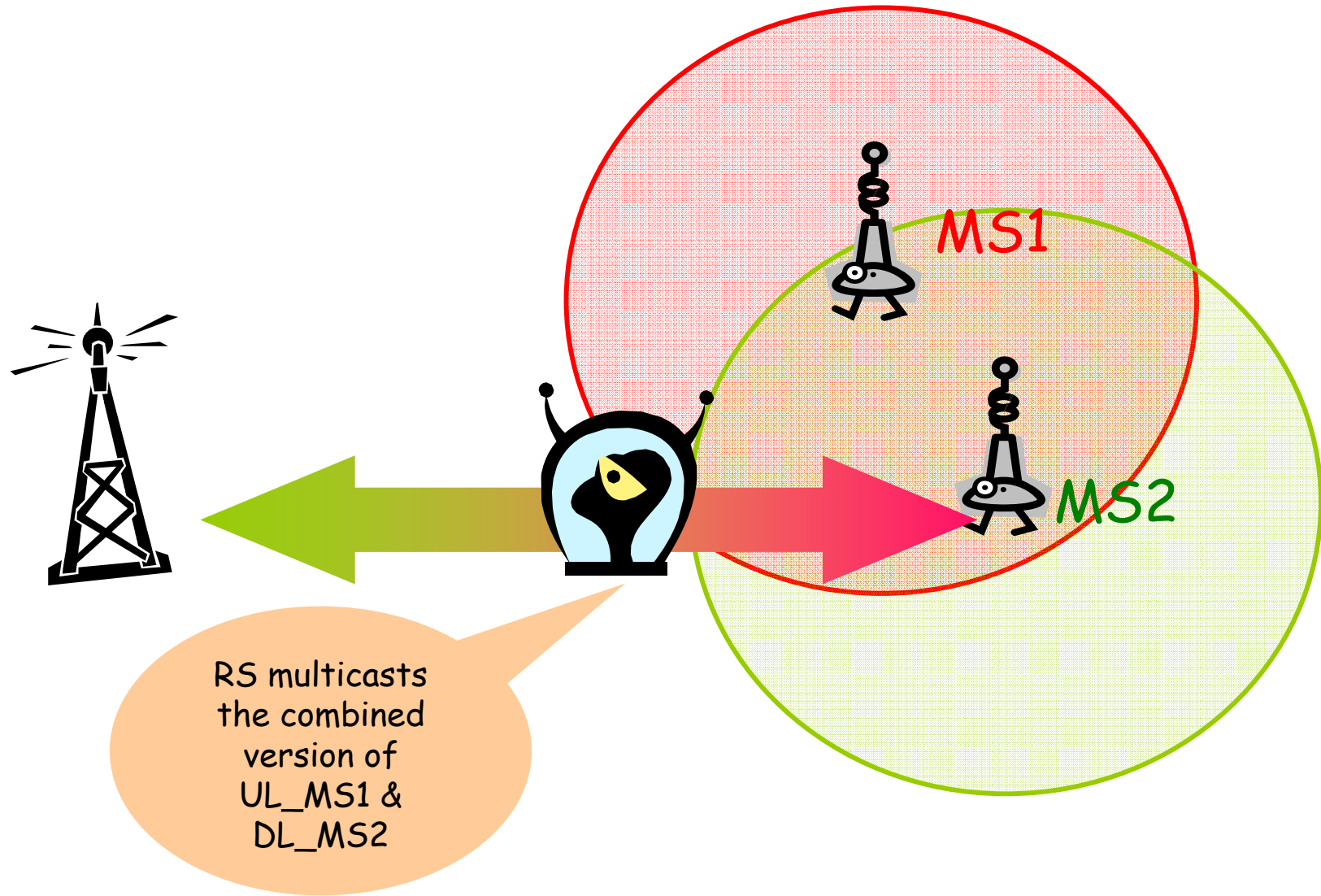
Co-operative relay support

- To support co-operative relay, the RS does not transmit a separated coded PHY packet
  - Instead, RS re-encodes the UL and DL packets and sends the XOR of the parity bits
  - BS/MS uses its own parity bits (not transmitted) to descramble the received parity bits, and decode the packets
- Receiver combines the information from both the source and RS (after de-scrambling) to decode the packet
- Co-operative relay with reduced RS BW consumption

Co-operative relay support

RS decodes the 1st sub-packets

UL packet encoder output

DL packet encoder output

RS transmits the XOR of the 2nd , 3rd , ... sub-packets
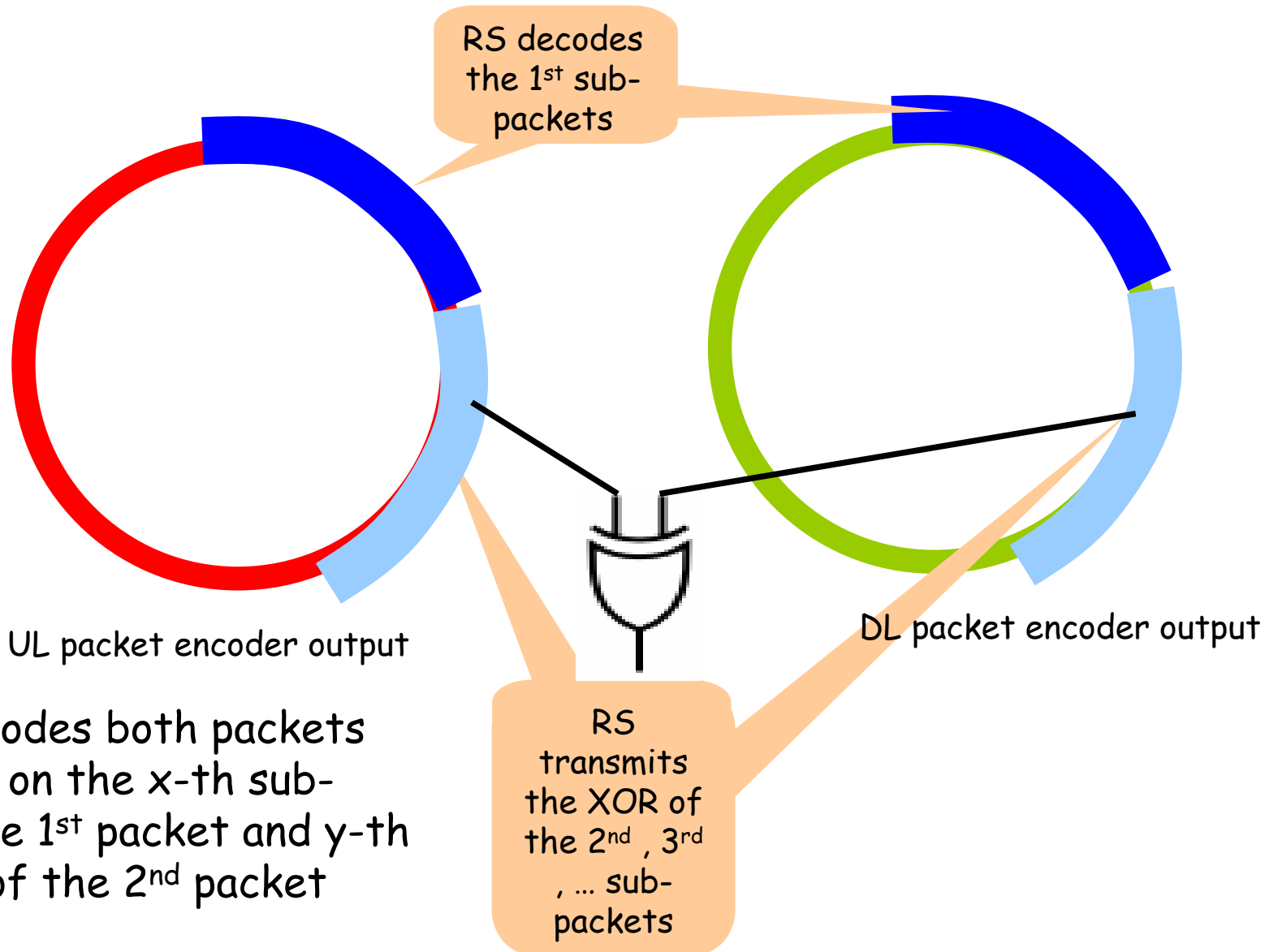
- Relay re-encodes both packets
- XOR is done on the x-th sub-packet of the 1st packet and y-th sub-packet of the 2nd packet
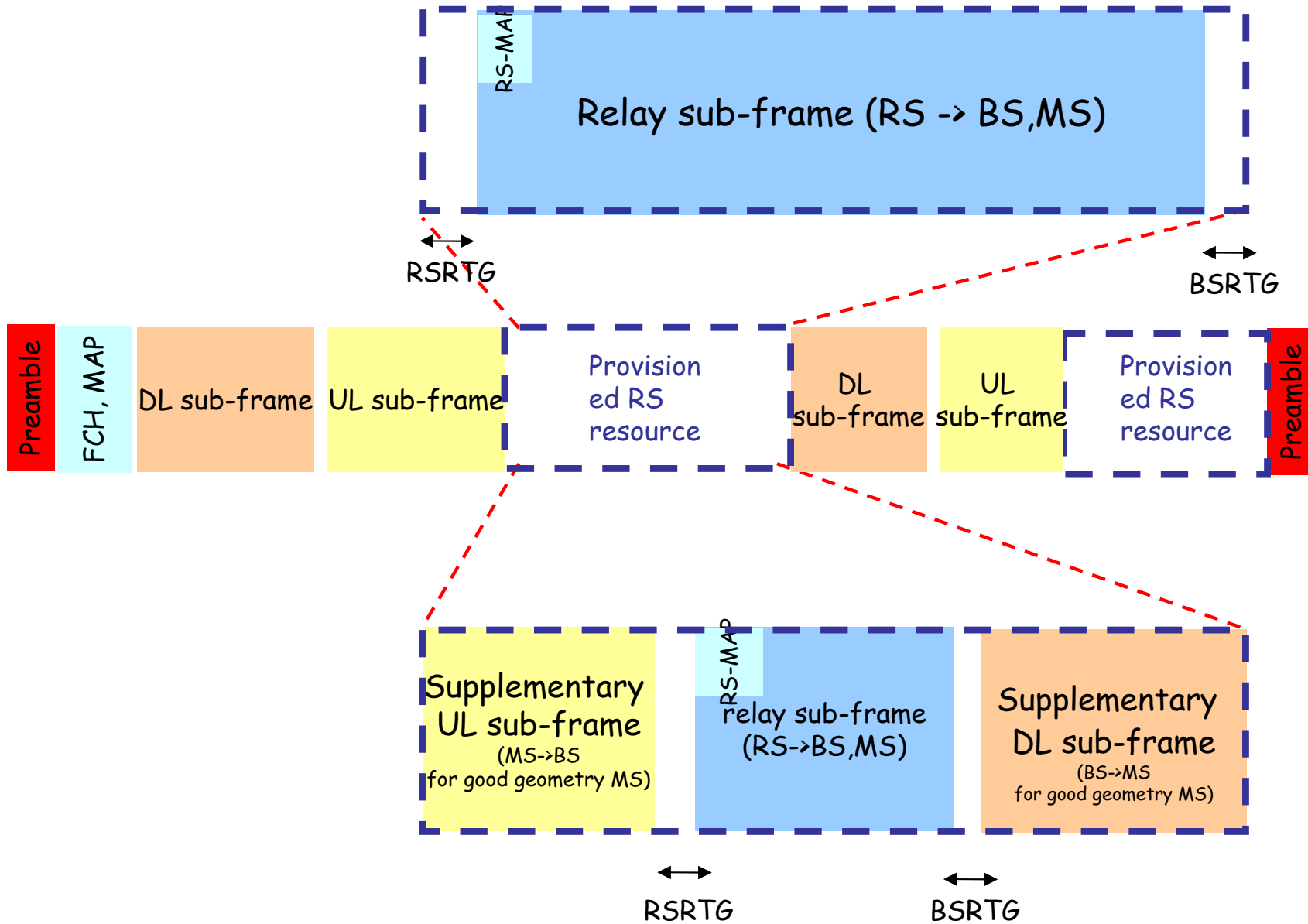
Proposed relay-sub-frame type A

Proposed relay-sub-frame type A

Proposed relay-sub-frame type B

RS Preamble
RS-MAP
relay sub-frame (RS -> BS,MS)
Preamble

RSRTG

BSRTG

Preamble
FCH, MAP
DL sub-frame .... UL sub-frame
Provisioned RS resource
Preamble

RS Preamble
RS-MAP
relay sub-frame (RS->BS,MS)
Supplementary UL sub-frame (MS->BS for good geometry MS)
Supplementary DL sub-frame (BS->MS for good geometry MS)
Preamble

RSRTG

BSRTG

A TTG can be inserted if this BS supports legacy MS
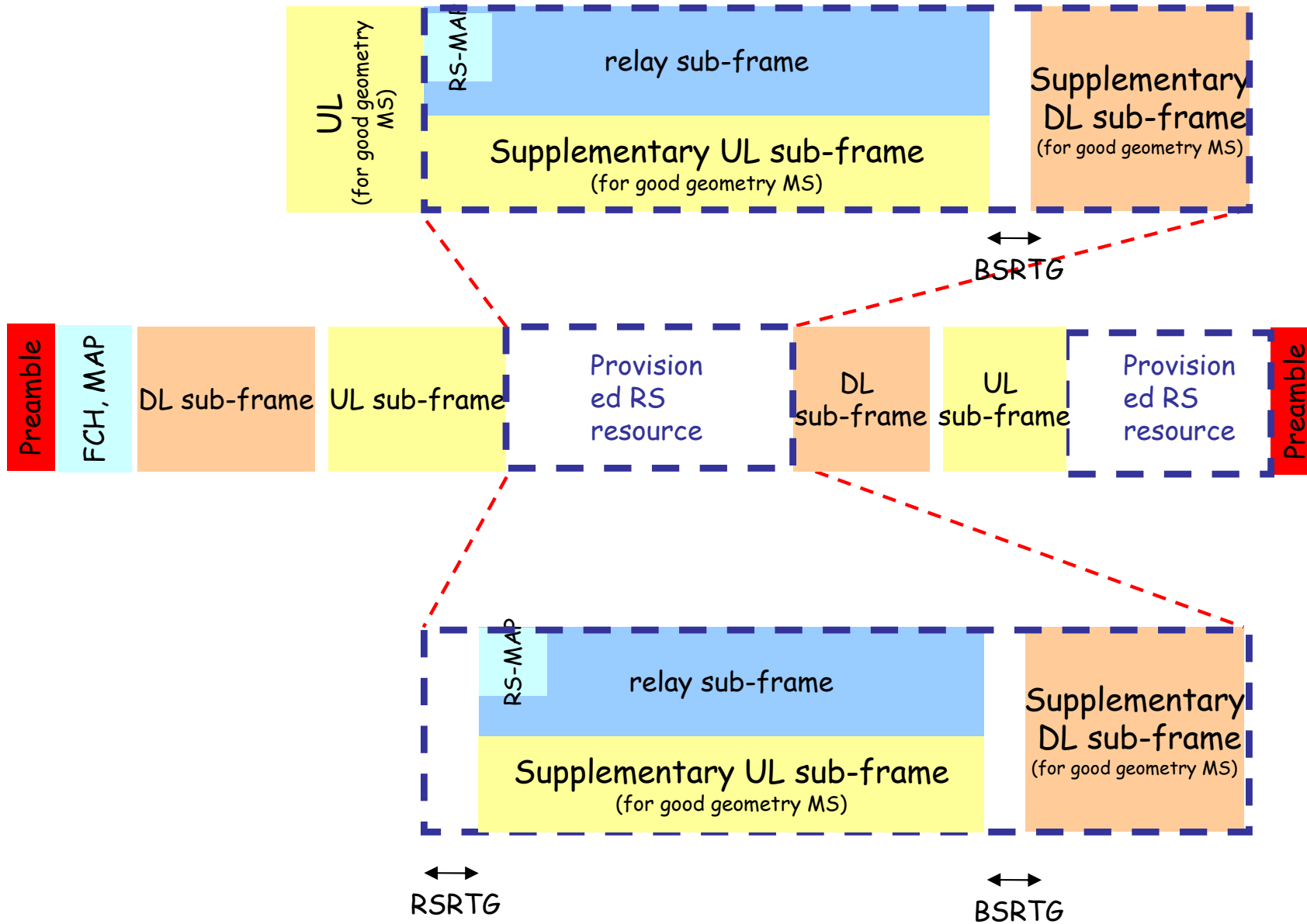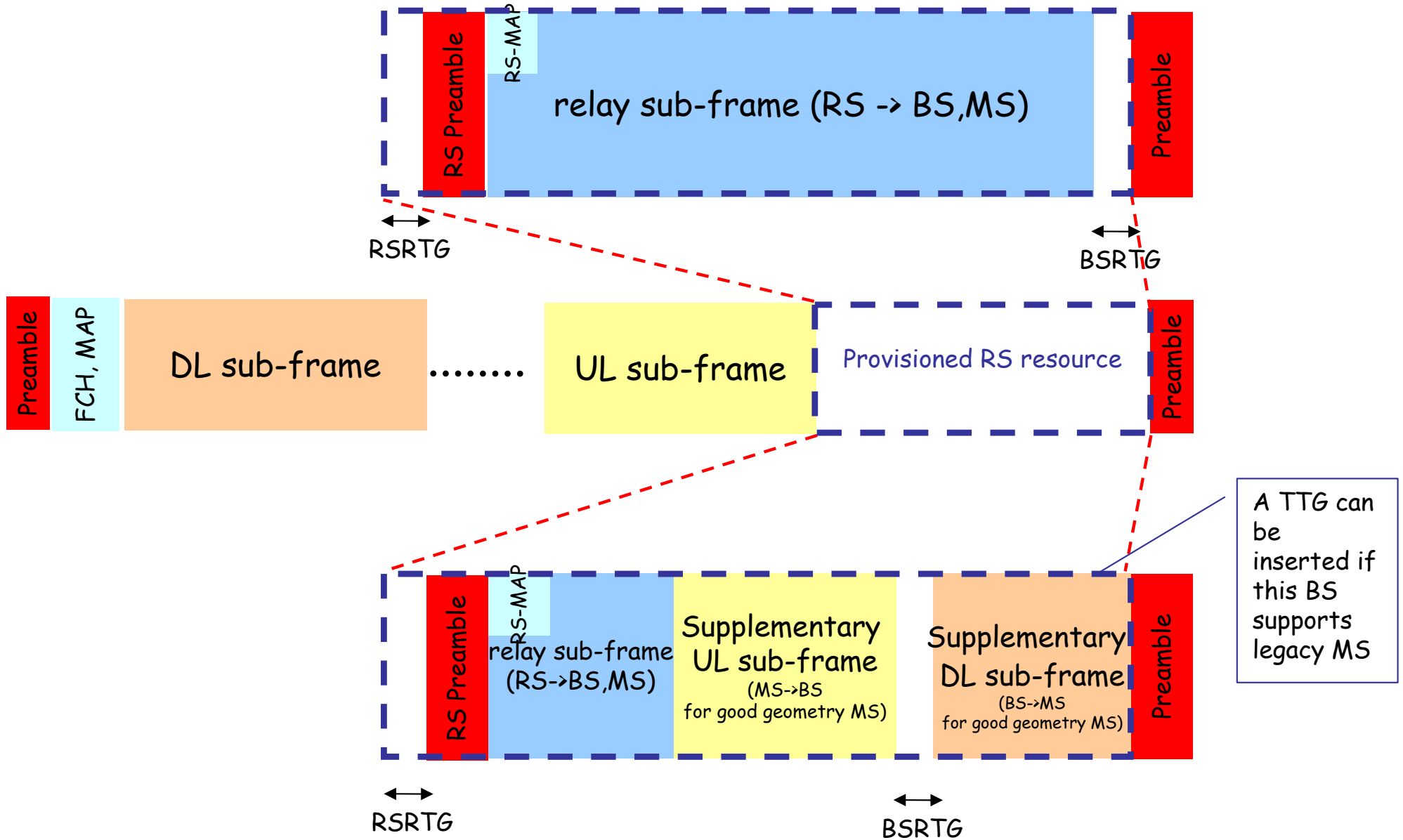
Proposed relay-sub-frame type B
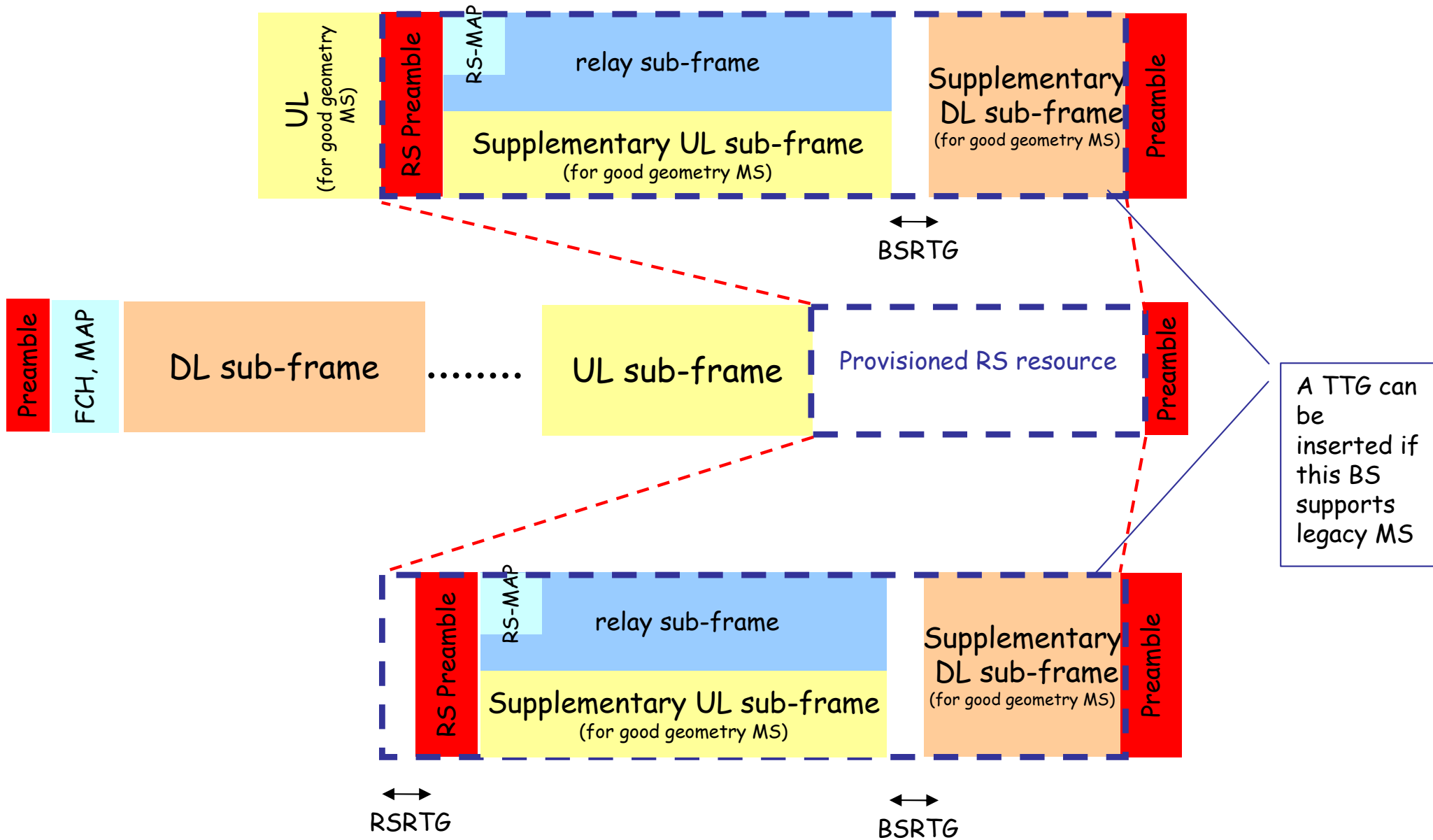
Proposed relay-sub-frame

- Relay sub-frame from RS may contain:
  - RS-MAP
  - Combined HARQ retransmissions to BS, MS
  - DL HARQ retransmissions to MS
  - UL HARQ retransmissions to BS
  - RS HARQ ack/nak to BS, MS
- The need for relay may vary from time to time based on BS, MS HARQ ack/nak
  - Fixed RS resource is provisioned per frame
  - Provisioned RS resource can be used for
    - relay sub-frame
    - DL/UL transmission for good geometry MS's if relayed traffic is small

In the provisioned RS time duration:
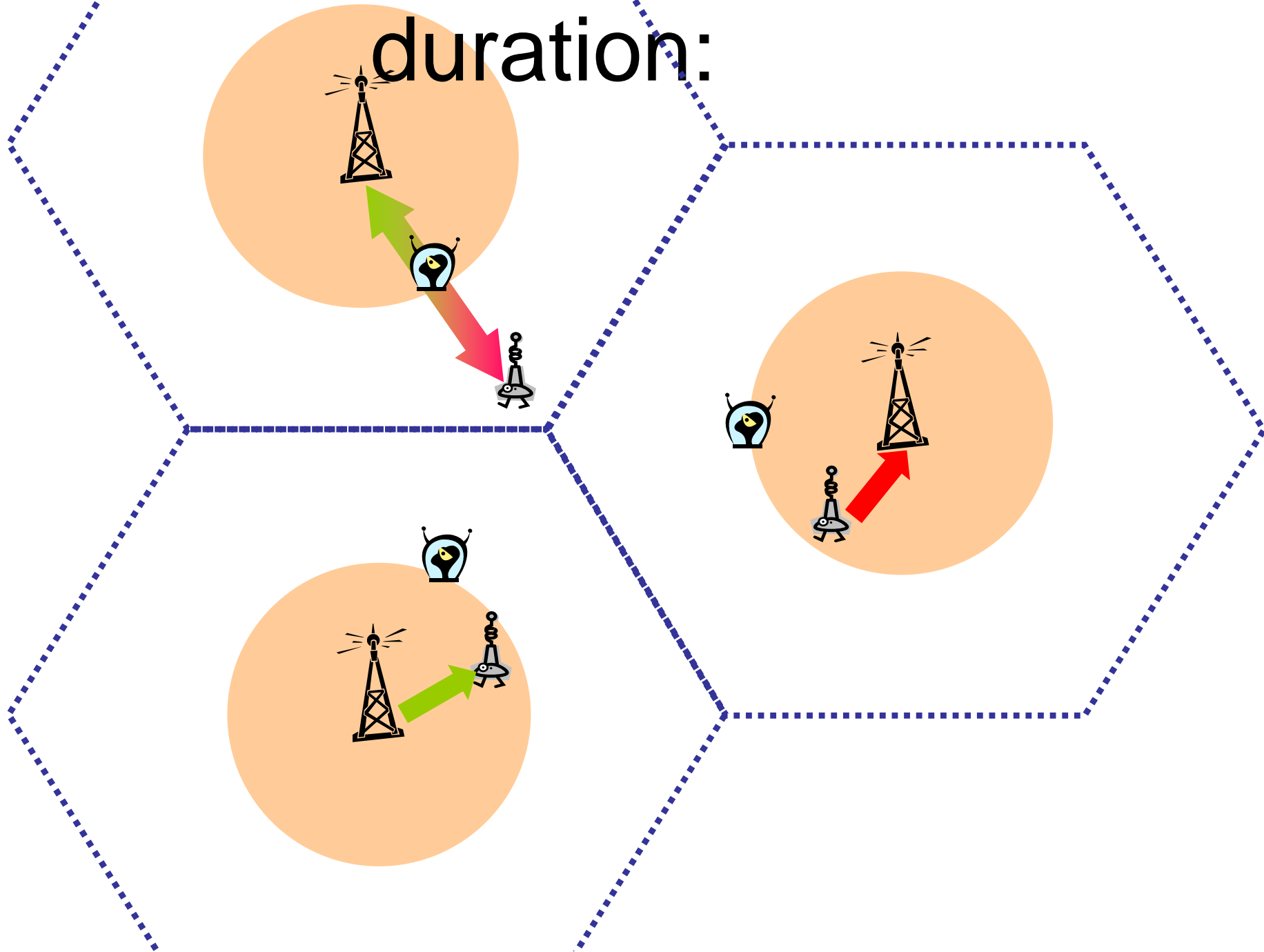
Example HARQ time line
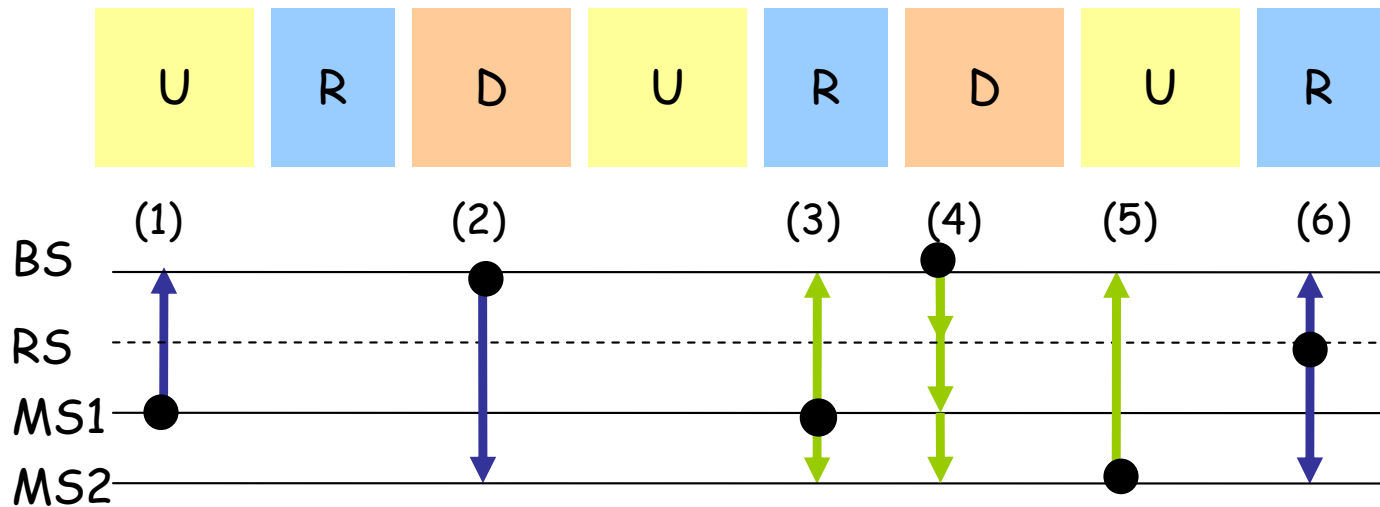
(1) UL burst from MS1 to BS
(2) DL burst from BS to MS2
(3) UL/DL HARQ ack/nak from RS
(4) UL HARQ ack/nak from BS, and the delivery of resource assignment of relay sub-frame (based on (3))
(5) DL HARQ ack/nak from MS2, and UL HARQ ack/nak from MS2 (MS2 only acks those UL bursts nak by BS if MS2 cannot decode its own DL burst)
(6) Combined HARQ retransmission from RS (based on (4), (5))

Data

Control

sender
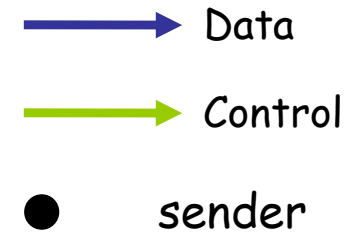
Numerical results

- Assumptions:
  - Each UL/DL packet uses the same amount of resource
  - 1 HARQ retransmission (from either source or RS)
  - Pr=0.99, probability of RS decodes a DL/UL packet in the 1st HARQ transmission
  - Pm=0.1, probability of BS/MS decodes a UL/DL packet in the 1st HARQ transmission
  - 2-bit Ack from a DL MS
    - 00: ack for its DL packet d0
    - 01: ack for an UL packet u1 and nak for d0
      - u1 paired/grouped with d0
    - 10: ack for an UL packet u2 and nak for d0
      - u2 grouped with d0
    - 11: none of the ack above

Effects from MSG reliability, DL/UL=1

MSG reliability	Saved BW/ RS BW	Saved BW/ Total BW
0.9	40.10%	18.80%
0.8	35.64%	16.71%
0.7	31.19%	14.62%
0.6	26.73%	12.53%
0.5	22.28%	10.45%

- MSG reliability: probability of MS2 decoding UL packets from MS1, given MS1 in the MSG of MS2

- BS pairs a DL MS2 with an UL MS1

Effects from BS scheduling decision, DL/UL=3

x DL MSs grouped with an UL MS based on MSG reports	y remaining DL MSs	MSG reliability	Saved BW/ RS BW	Saved BW/Total BW
1	2	0.6	13.37%	6.27%
2	1	0.6	19.59%	9.18%
3	0	0.6	22.48%	10.54%
1	2	0.9	20.05%	9.40%

- When DL/UL ratio is high, BS may group multiple DL MSs with less number of UL MSs to improve MSG reliability
- Grouping applied to the case with low MSG reliability can perform better than the case with high MSG reliability and pairing

- BS schedules x+y=3 DL packets, and one UL packet (from MS0)
- MS0 is in the MSGs of x DL MSs
- MS0 is not in the MSG of y DL MSs