Feedback and scheduling strategies in 802.16m Relays

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Venue:

IEEE 802.16m-08/033 Call for papers "Any parts of Section 11 (PHY) that are incomplete, inconsistent, empty, TBD, or FFS."

Base Contribution:

IEEE C802.16m-08/1104r1 or later revision

Purpose:

To be discussed and adopted by TGm

Feedback and scheduling strategies in 802.16m Relays

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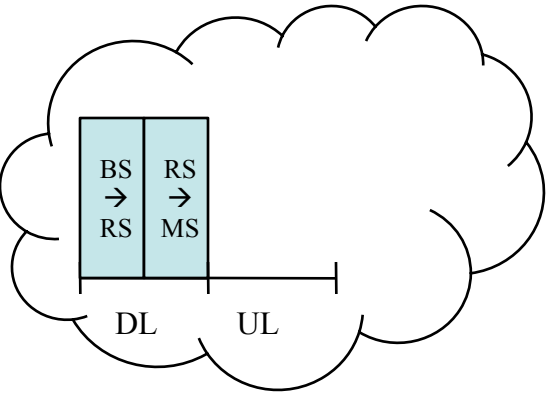
Overview

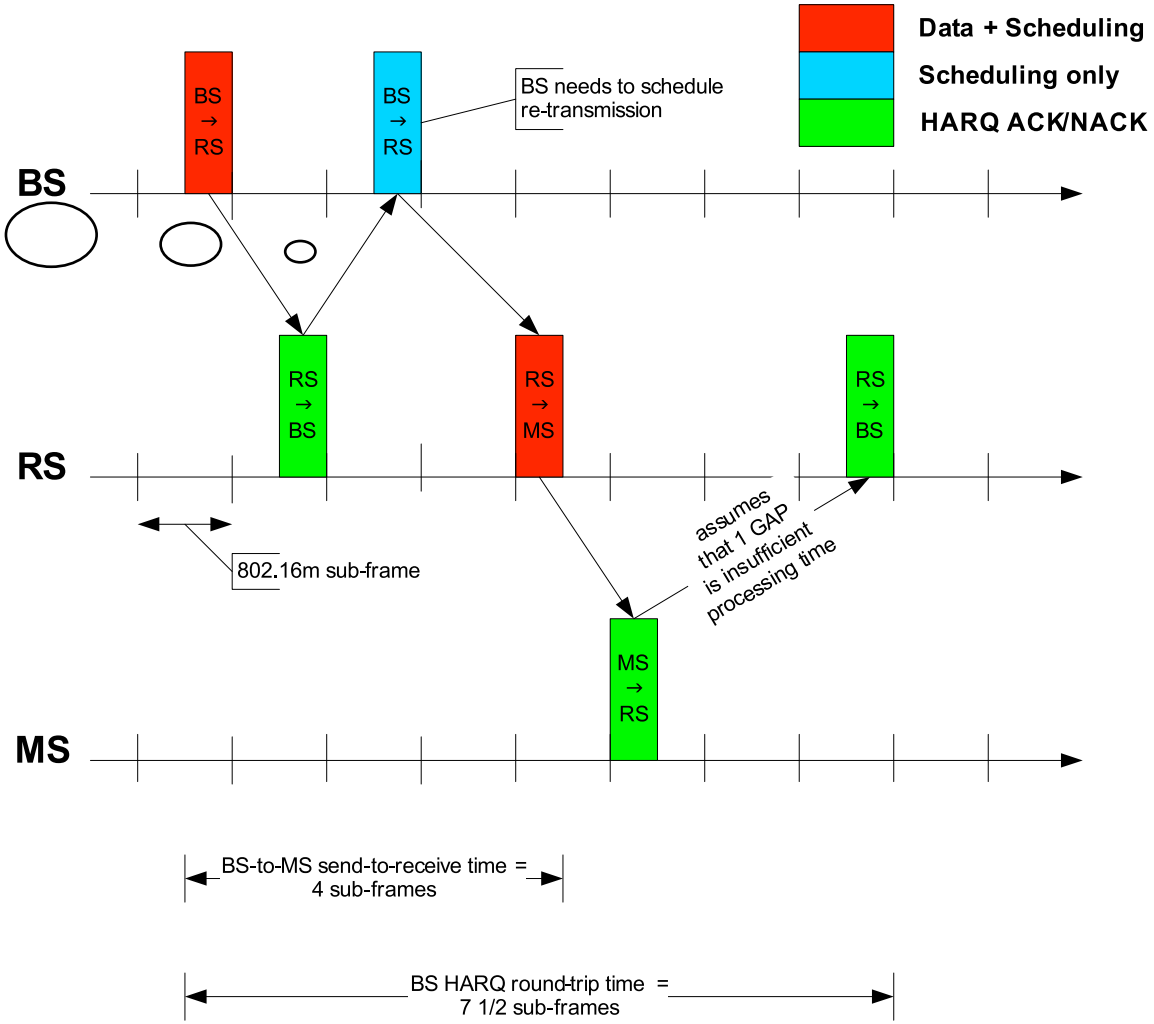
- Current SDD text lacks definition of HARQ scheduling and feedback for relays
  - And is uncertain about its frame structure
- This contribution shows several scheduling and HARQ ACK/NAK options:
  - Distributed / centralized scheduling
  - 2 or multi-hop / cooperative scheme
  - Relayed or direct feedback
- Proposes text to SDD

Latency analysis

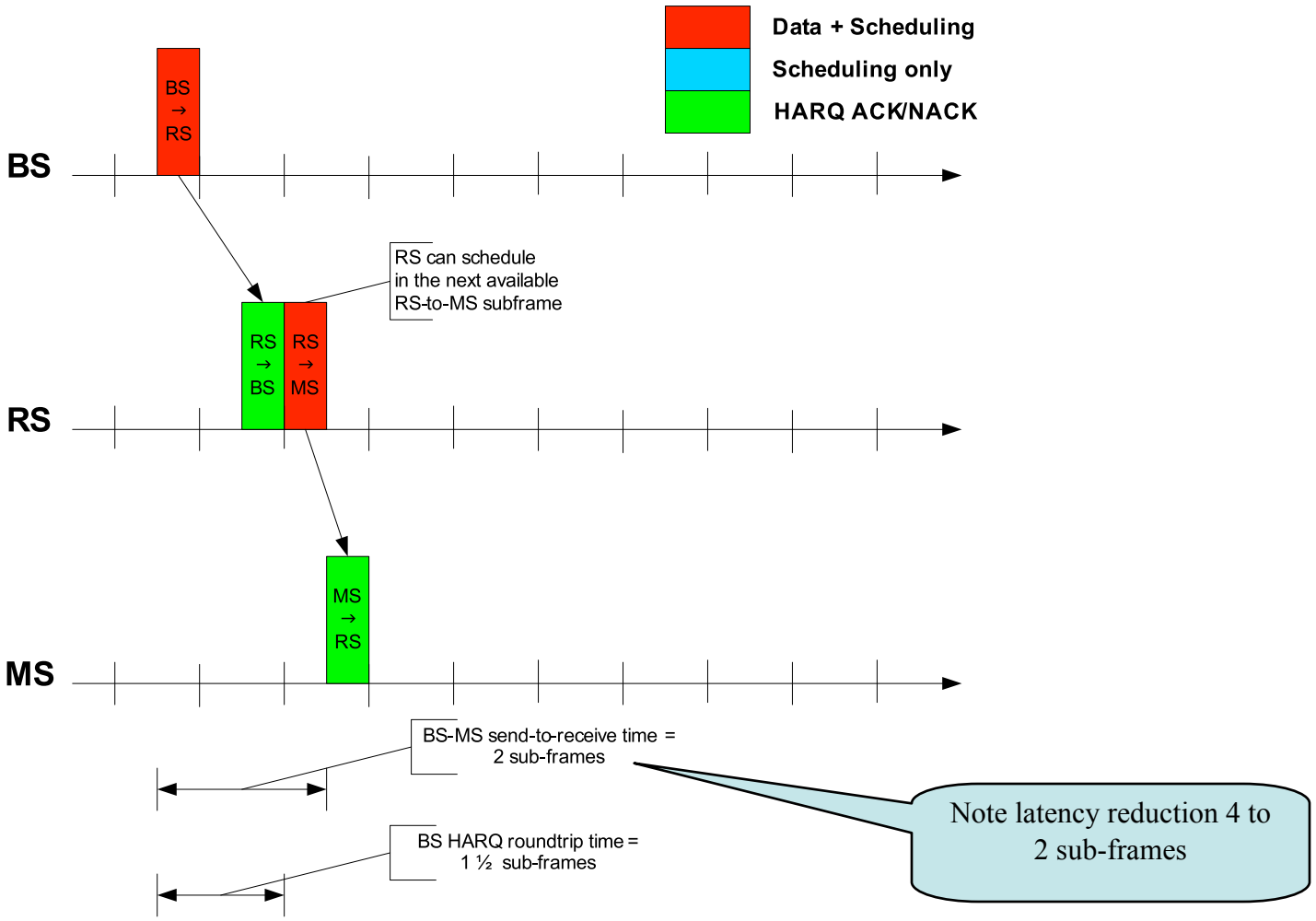
- We concentrate on the transmission of a single packet and highlight the three types of transmissions which can occur in connection with such getting a single data packet across successfully:
  - Sub-frames in which data and scheduling is sent.
  - Sub-frames in which scheduling only is sent (for our data of interest – other data is, presumably, transmitted)
  - ACK/NACK feedback.
- The analysis is TDD. Conclusions for FDD would be similar. The conclusions we bring are also independent of the choice of frame structure, although for the 3-hop case details will slightly vary.
  - 1/2 sub-frame is sufficient time for any required processing. This is likely optimistic, but is sufficient for our purposes. In particular, as processing delays increase, the differences between the schemes that we present will be accentuated. We do assume, however, that 1 relay-switching GAP is not sufficient for any processing.
  - UL and DL sub-frames alternate in TDD. Again, this tends to minimize delays associated with feedback and a different allocation will only accentuate the differences shown here. On the other hand, this will make our analysis for TDD and FDD the same as the delay to produce and send feedback will be identical for both.
  - The GAP which is used for the relay to switch between Tx and Rx is located in the middle of a sub-frame. This is for convenience, it does not affect our conclusions in any significant manner.

Non-cooperative 2-hop and centralized scheduling (Fig. 1)

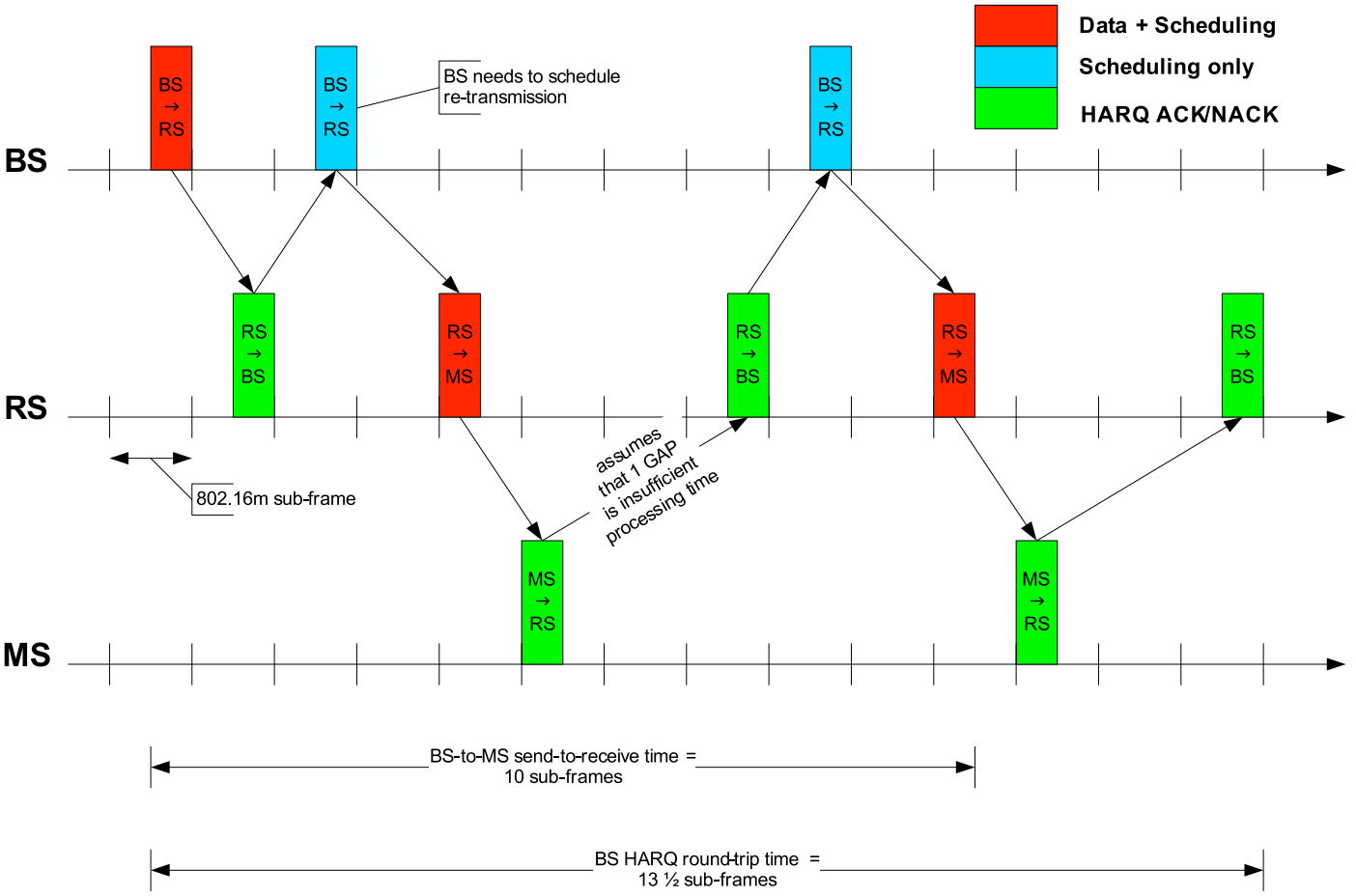




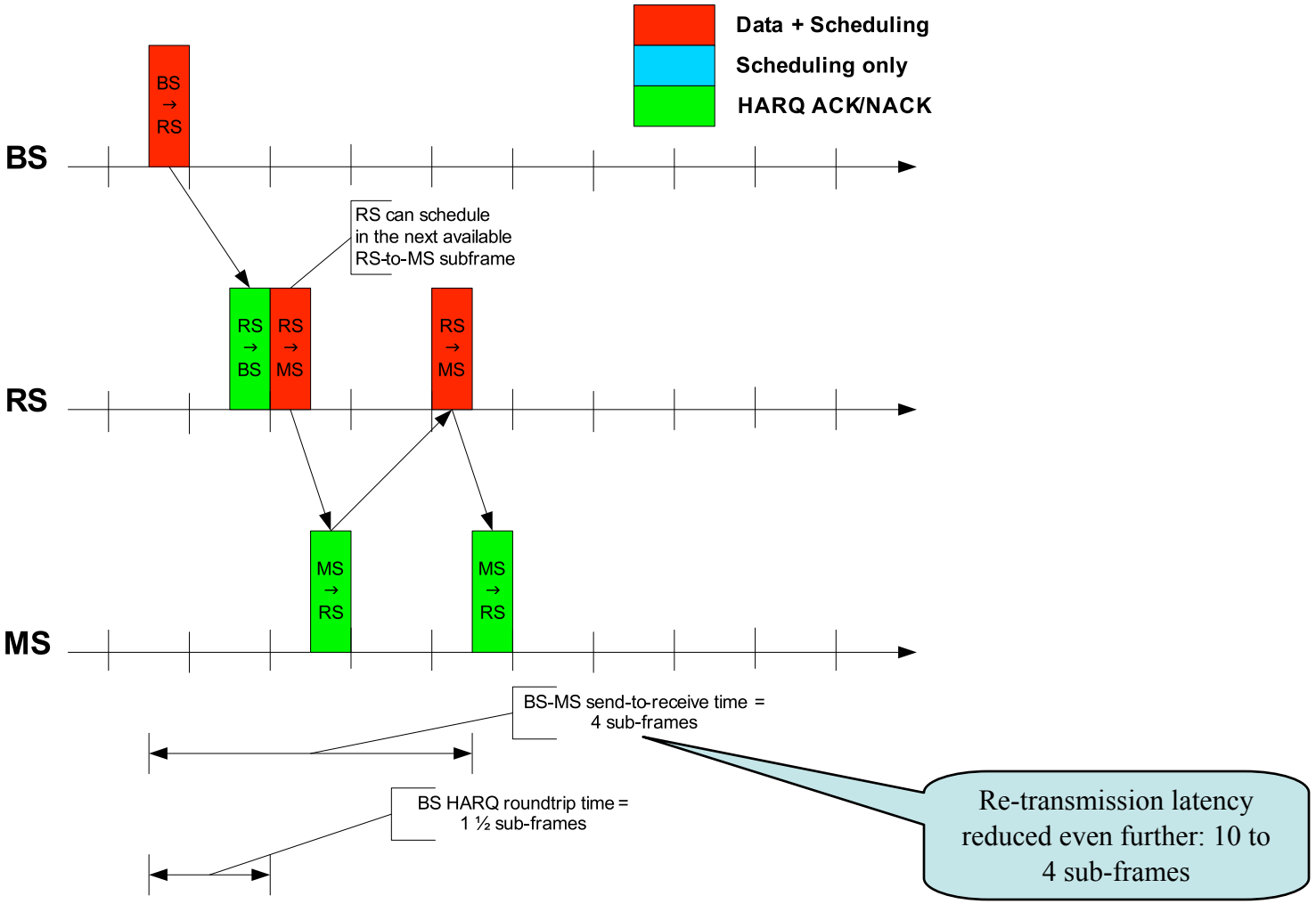
Non-cooperative 2-hop and distributed scheduling (Fig. 2)



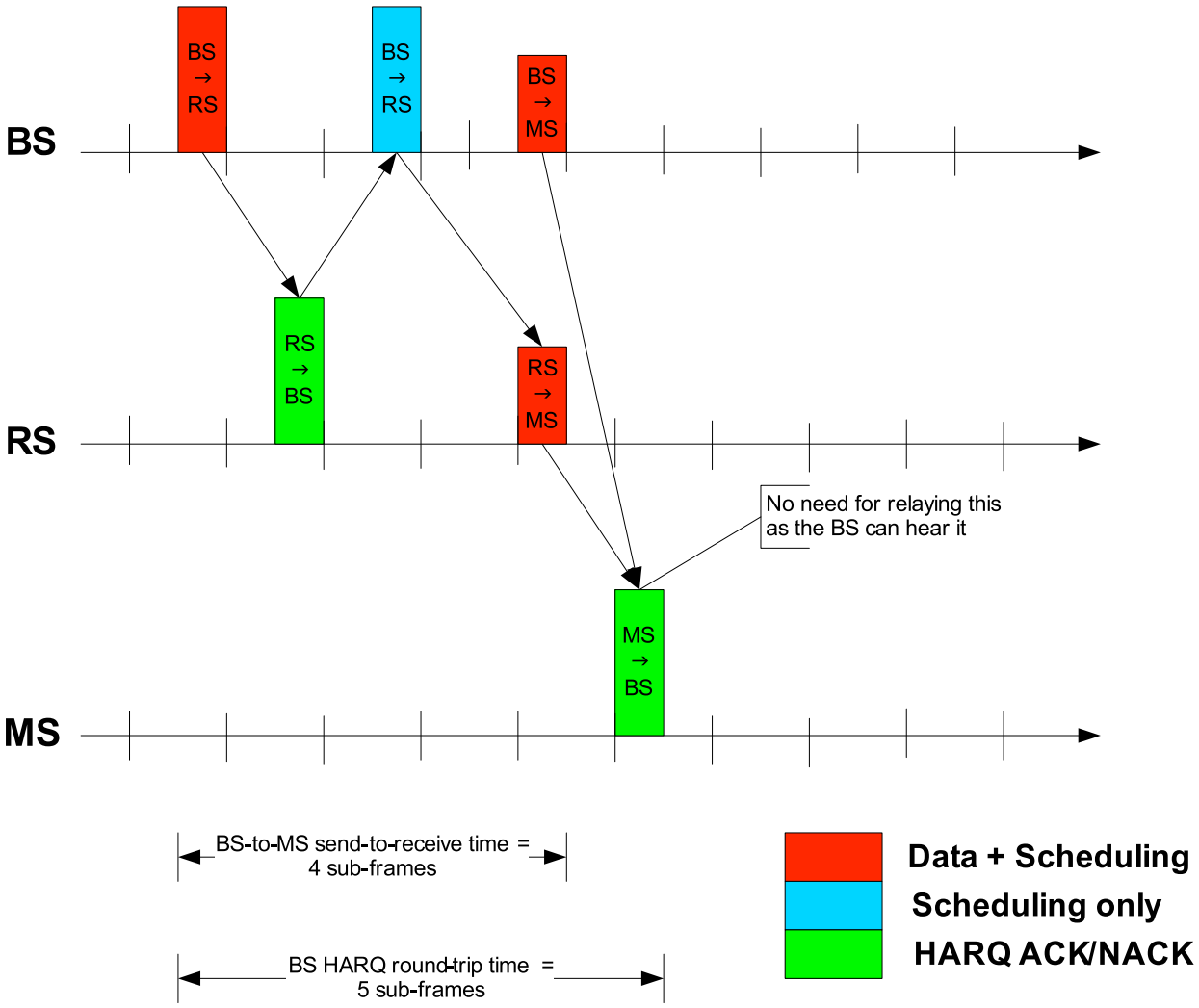
Non-cooperative 2-hop, re-transmissions to MS, centralized scheduling, relayed feedback (Fig. 3)



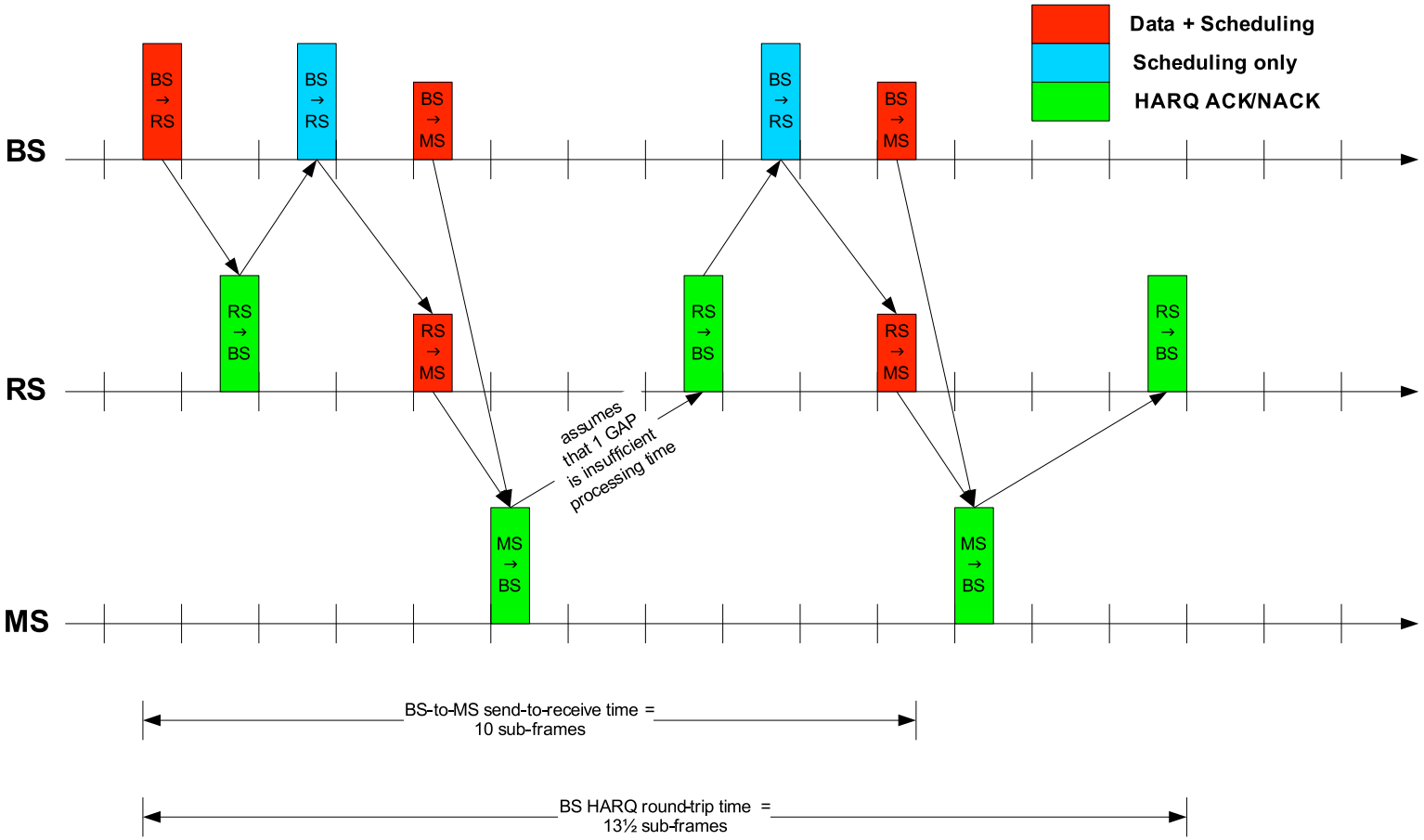
Non-cooperative 2-hop, re-transmissions to MS, distributed scheduling (Fig. 4)



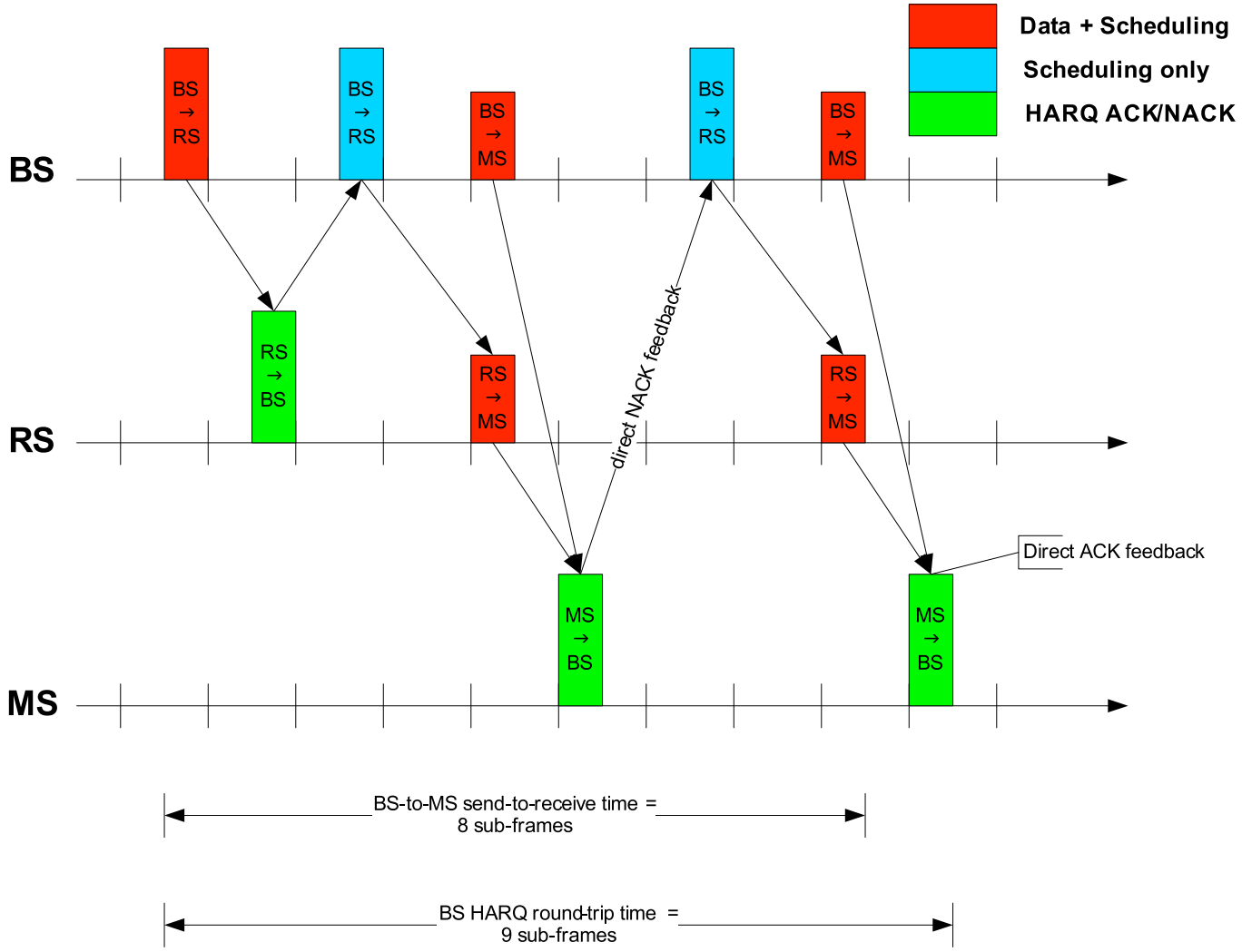
Cooperative 2-hop, centralized scheduling, direct feedback (Fig. 5)



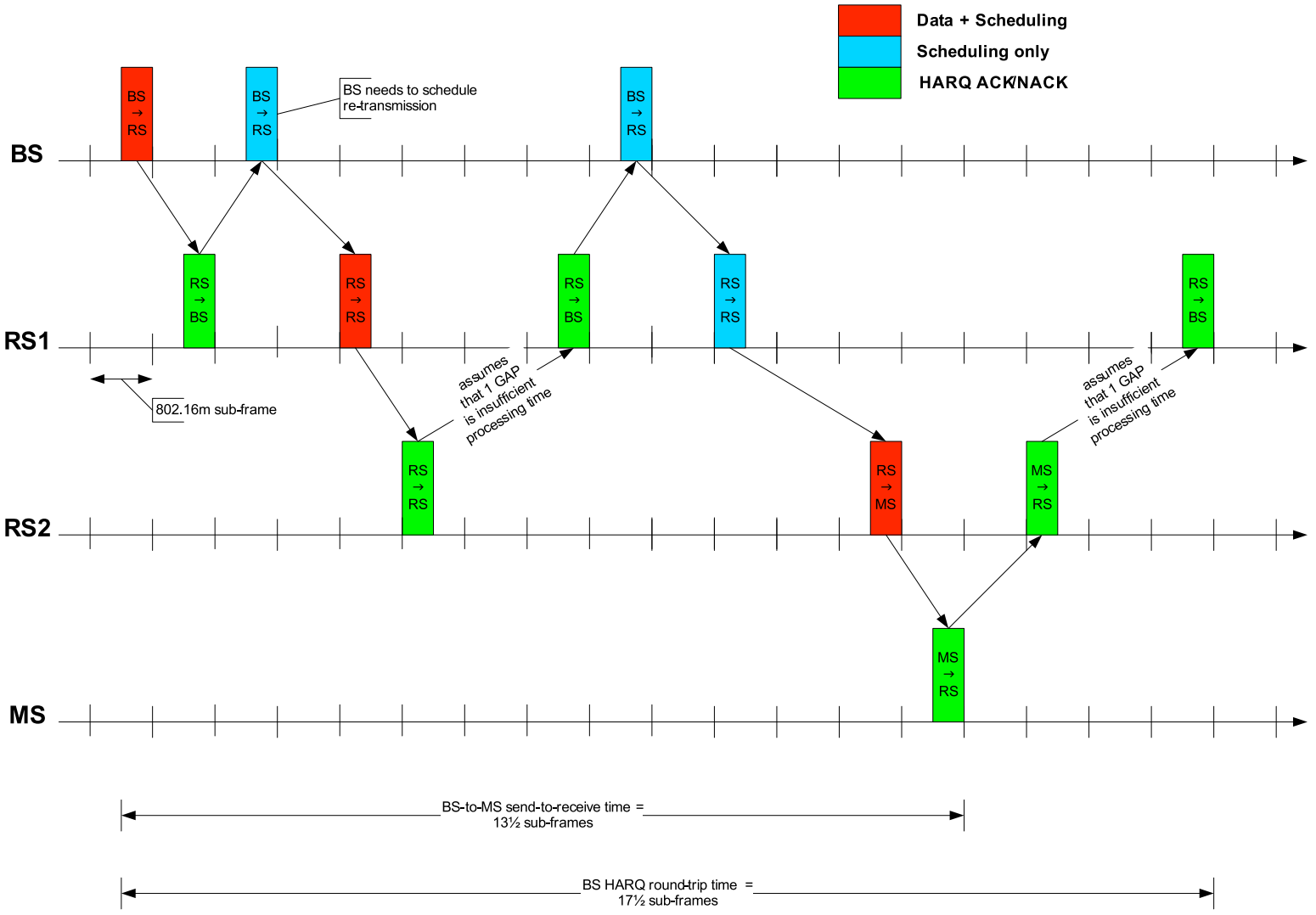
Cooperative 2-hop, centralized scheduling, relayed feedback, with retransmissions (Fig. 6)



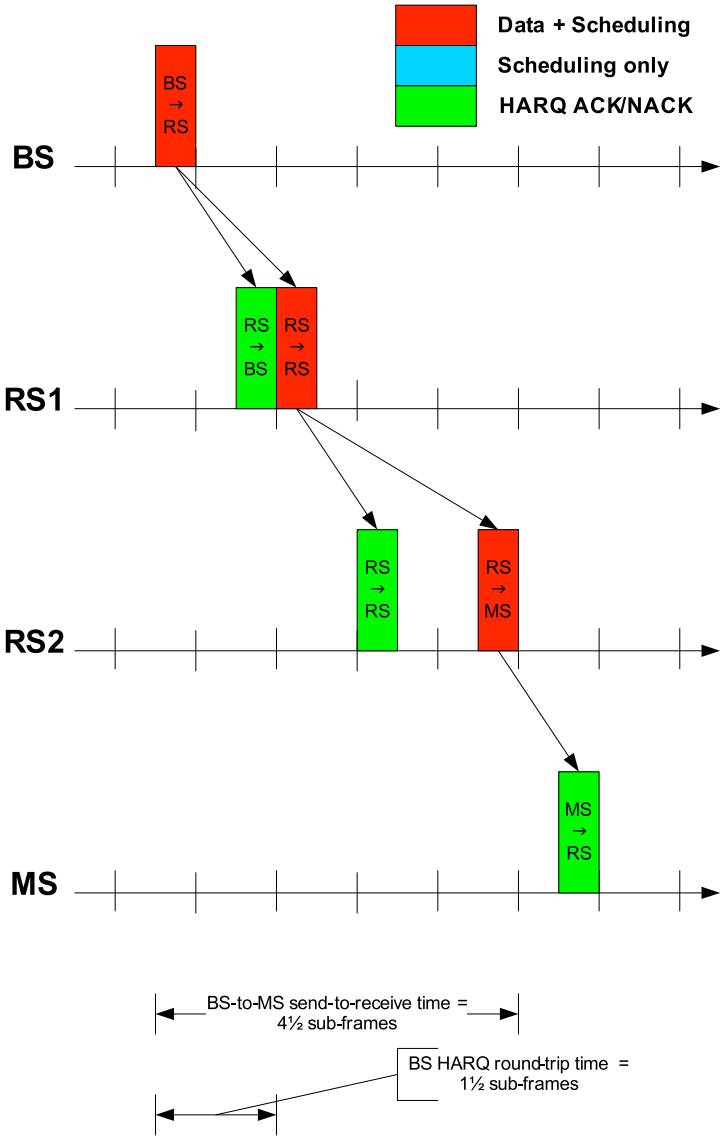
Cooperative 2-hop, centralized scheduling, direct feedback with retransmissions (Fig. 7)



Non-Cooperative 3-hop, centralized scheduling, relayed feedback & scheduling, no retransmissions to MS (Fig. 8)



Non-cooperative 3-hop, distributed scheduling (Fig. 9)



Distributed scheduling → Low latency

Fig.	Conditions	BS-MS latency	HARQ latency (@ BS)	Comments
1	Non-Coop 2-hop, centralized schedule, 2-hop feedback, ACKs only	4	7 ½	
2	Non-Coop 2-hop, distributed schedule, ,ACKs only	2	1 ½	1→2 reduces latency & overhead
3	Non-Coop 2-hop, centralized schedule, 2-hop feedback, NACKs present	10	13 ½	
4	Non-Coop 2-hop, distributed schedule, NACKs present	4	1 ½	3→4 reduces latency & overhead even more
5	Coop, centralized schedule, direct feedback, ACKs only	4	5	
6	Coop, centralized schedule, 2-hop feedback, MS NACK present	10	13 ½	
7	Coop, centralized schedule, direct feedback, MS NACK present	8	9	6→7 Direct feedback reduces latency & overhead for CS
8	Non-Coop 3-hop, centralized schedule, relayed feedback & scheduling, 3-hop feedback, ACKs only	13 ½	17 ½	
9	Non-Coop 3-hop, distributed schedule, ACKs only	4 ½	1 ½	8→9 distributed scheduling has greatest impact here

Latency isn't all

- Very difficult to control inter-cell and inter-RS interference with distributed scheduling
- Cooperative relaying (BS, RS → MS) has been shown to enhance performance
- 2-hop (possibly with relayed feedback) necessary for coverage extension

Relay Scheduling Options

- Centralized:
  - Allows BS-RS cooperation on same resources
  - Easier inter-cell and inter-relay interference control
  - Longer latency
- Distributed:
  - Non-cooperative mode only
  - Difficult to coordinate cells, relays
  - Short latency
- Cooperative relays suitable for:
  - Throughput enhancement
  - in latency non critical applications or where interference control requires centralized scheduling anyway
  - Where BS-MS and RS-MS links are comparable
- Non-cooperative relays suitable for:
  - Coverage extension
  - In latency critical applications when interference control allows distributed scheduling
- Direct feedback suitable for:
  - Latency reduction when uplink budget allows it

Resulting in that…

- we need, as appropriate:
  - Both centralized & distributed scheduling
  - Relayed and direct feedback
  - Cooperative relaying
- We could use hard switches to select between the two, but:
  - Mobiles move, changing their link conditions
  - Inter-cell (-Relay) interference conditions change rapidly
- Therefore we propose that the above options will be dynamically selectable by the BS
  - TP for SDD attached in contribution

Thank You!