HARQ with Relays

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Purpose:

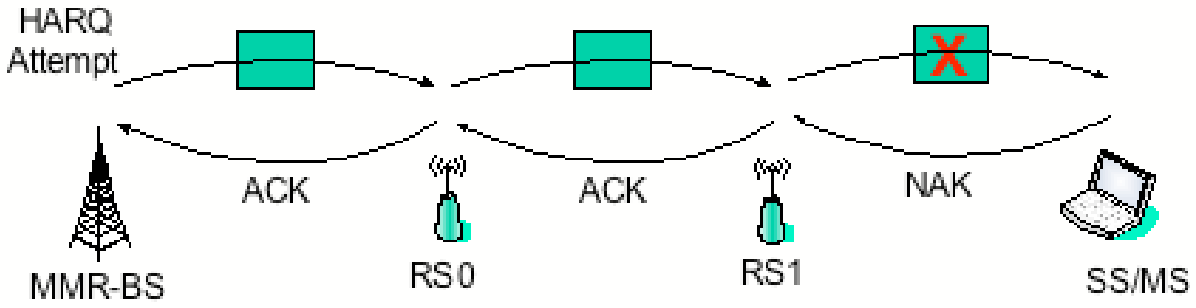
This contribution proposes HARQ procedure for relay.

Introduction

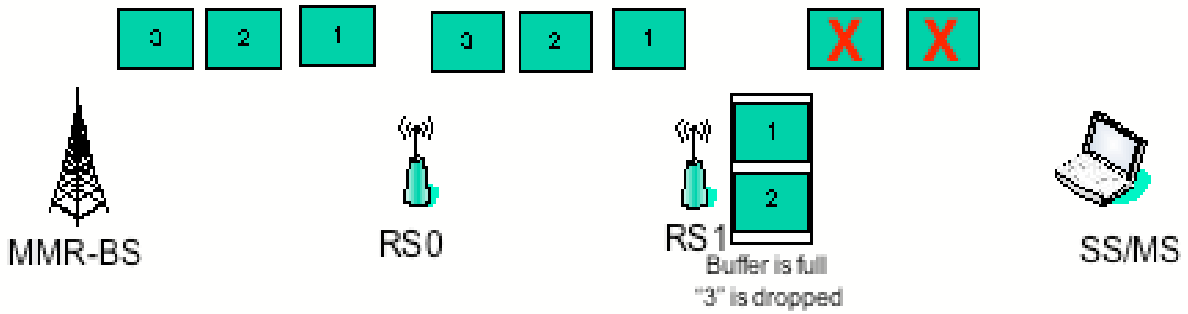
- This contribution proposes working of HARQ across relays
- End-to-end HARQ: A HARQ packet is relayed on all the links and ACK/NAK is relayed back to the originator, before the next HARQ packet is scheduled
  - Increased Latency: This would cause significant latency if the originator waits for a successful transmission of a HARQ packet over multiple links. With increased number of links, chances of error are also increased.
  - Spectrally Inefficient: Retransmission from the originator need to go over all the hops, even if the failure occurs only on the last link.
- Hop-by-hop HARQ: each hop (link) schedules HARQ packet independently and proceeds with the next HARQ packet (re)transmission after receiving ACK/NAK from the same link.
  - Preferable: provides better efficiency and reduced latency
- Hop-by-hop HARQ is discussed for centralized and distributed scheduling

HARQ Problems for Centralized Scheduling

- In centralized case, MMR-BS does all the MAP allocation and scheduling
- RS1 needs to retransmit, but MMR-BS does not know. Therefore, RS1 does not have bandwidth grant for retransmission

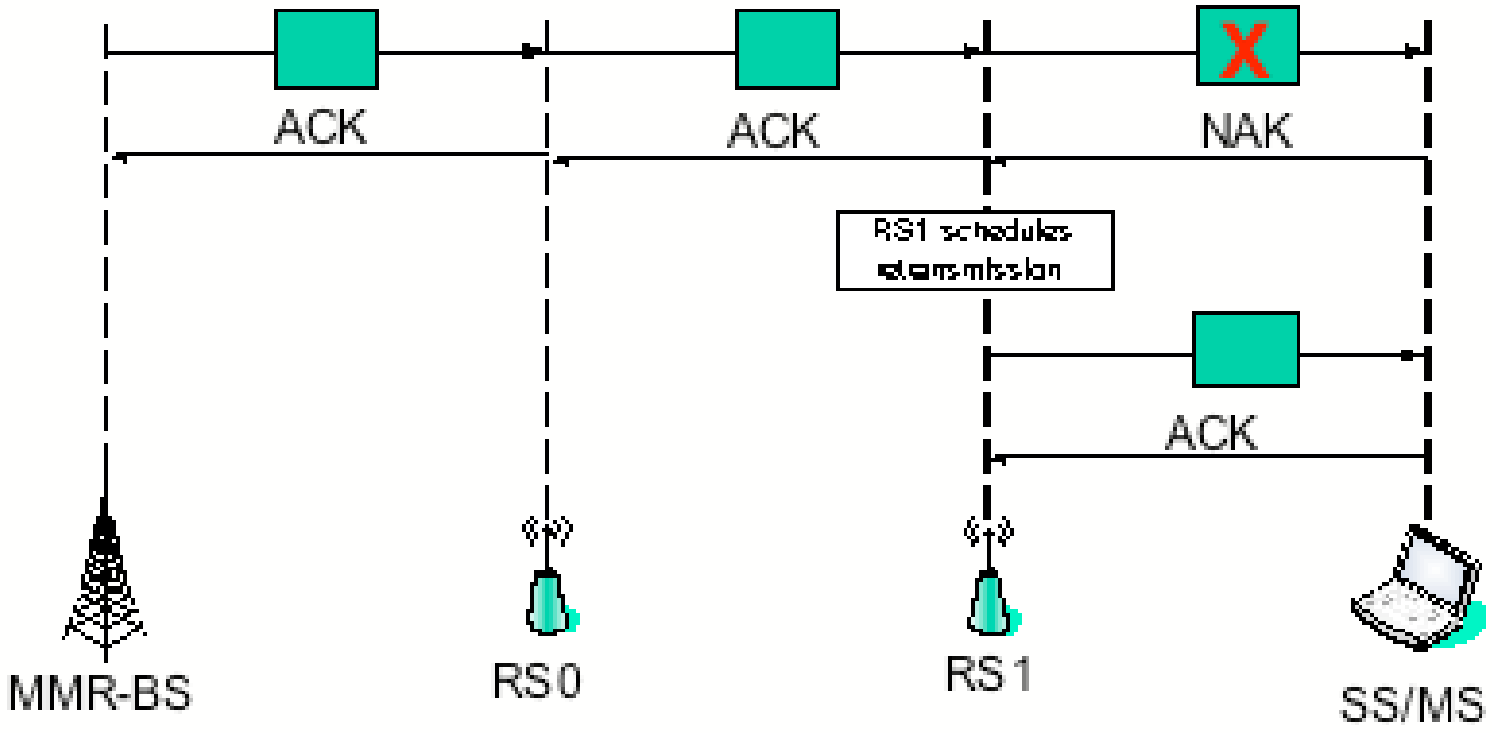


- Failures on a subsequent link, when there is less/no failures on the first link, could cause HARQ packet drop



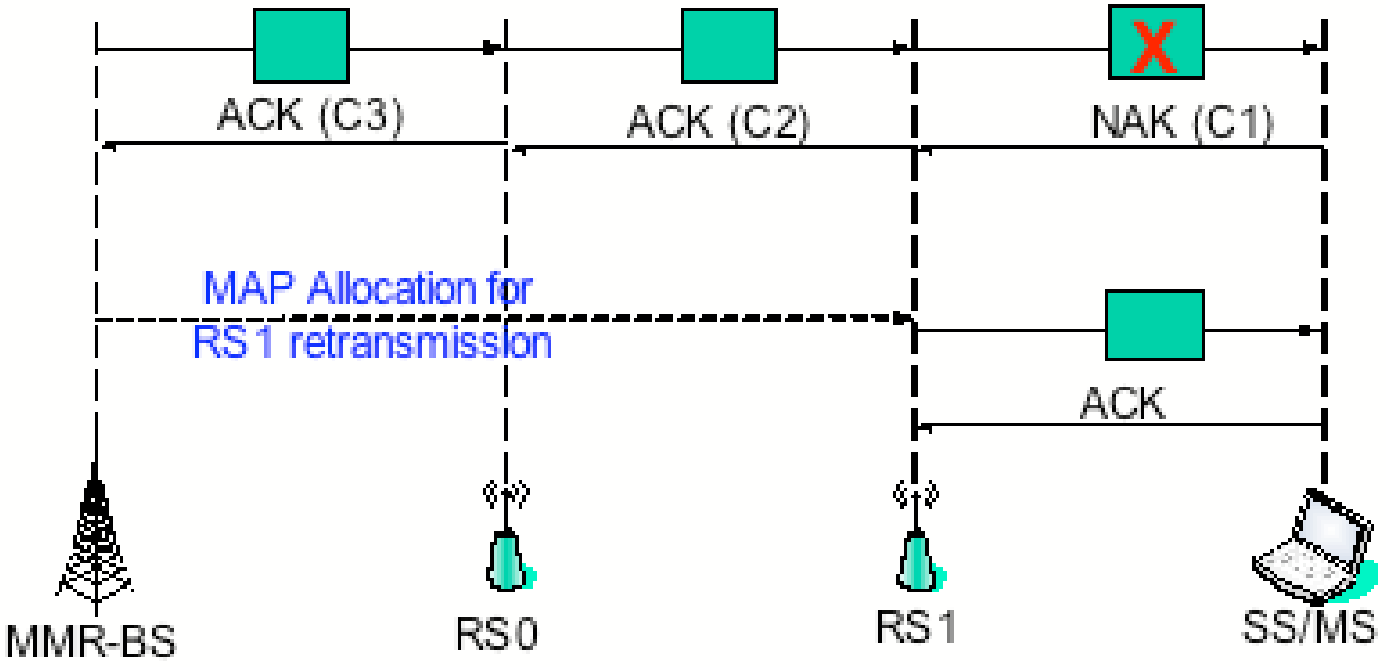
HARQ in Distributed Scheduling

- In distributed case, each RS does the MAP allocation and scheduling for its link
- RS1 schedules retransmission, independently of MMR-BS, after receiving NAK



DL HARQ Solution for Centralized Scheduling (1)

- RS1 sends Code C_2 to RS0 in the UL ACK Channel
- RS0 sends Code C_3 (Received Code + 1) to MMR-BS
- MMR-BS upon receipt of C_3 knows that HARQ packet is lost on 3rd hop. Therefore keep the resources reserved for 3rd hop onwards.



DL HARQ Solution for Centralized Scheduling (1)

In IEEE 802.16e-2005, On UL ACK Channel: ACK or NAK bit is encoded into a length 3 code-word over 8-ary alphabet for the error protection as shown in below.

ACK/NAK 1-bit symbol	**Vector Indices per Tile Tile(0), Tile(1), Tile(2)**
0 (ACK)	0, 0, 0
1 (NAK)	4, 7, 2

Table 1: ACK / NAK Encoding in 802.16e

Vector indices are defined in Table 2 [802.16e].

Vector index	**Mn,8m, Mn,8m+1 , ... ,Mn,8m+7**
0	P0, P1, P2, P3, P0, P1, P2, P3
1	P0, P3, P2, P1, P0, P3, P2, P1
2	P0, P0, P1, P1, P2, P2, P3, P3
3	P0, P0, P3, P3, P2, P2, P1, P1
4	P0, P0, P0, P0, P0, P0, P0, P0
5	P0, P2, P0, P2, P0, P2, P0, P2
6	P0, P2, P0, P2, P2, P0, P2, P0
7	P0, P2, P2, P0, P2, P0, P0, P2

Table 2: Orthogonal Modulation Index in UL ACK Channel

DL HARQ Solution - UL ACK/NACK Encoding for Multi-Hop Relay

• The new sequences are defined in order to uniquely identify the failed link in multi-hop relay system.

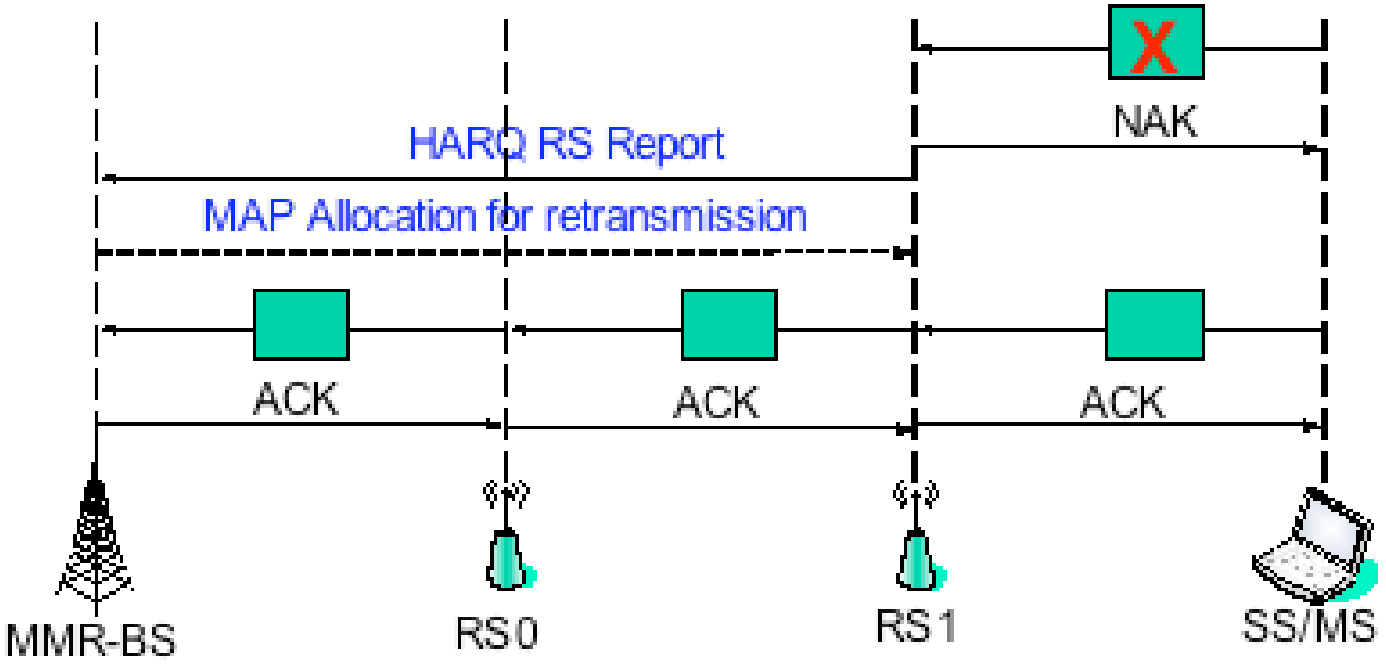
Sequences are generated by using the unused vector indices (1, 3 and 5) to generate a unique code, and the rest of the codes are generated using cyclic shifts of two sequences (4, 7, 2) and (3, 5, 1).

Link Distance/Depth	**ACK/NAK 1-bit symbol**	**Vector Indices per Tile Tile(0), Tile(1), Tile(2)**	**Code #**
Any Distance	0 (ACK)	0, 0, 0	C_0
1	1 (NAK)	4, 7, 2	C_1
2	1 (NAK)	3, 5, 1	C_2
3	1 (NAK)	7, 2, 4	C_3
4	1 (NAK)	5, 1, 3	C_4
5	1 (NAK)	2, 4, 7	C_5

Table 3a: ACK / NAK Encoding for multi-hop relay in 802.16j

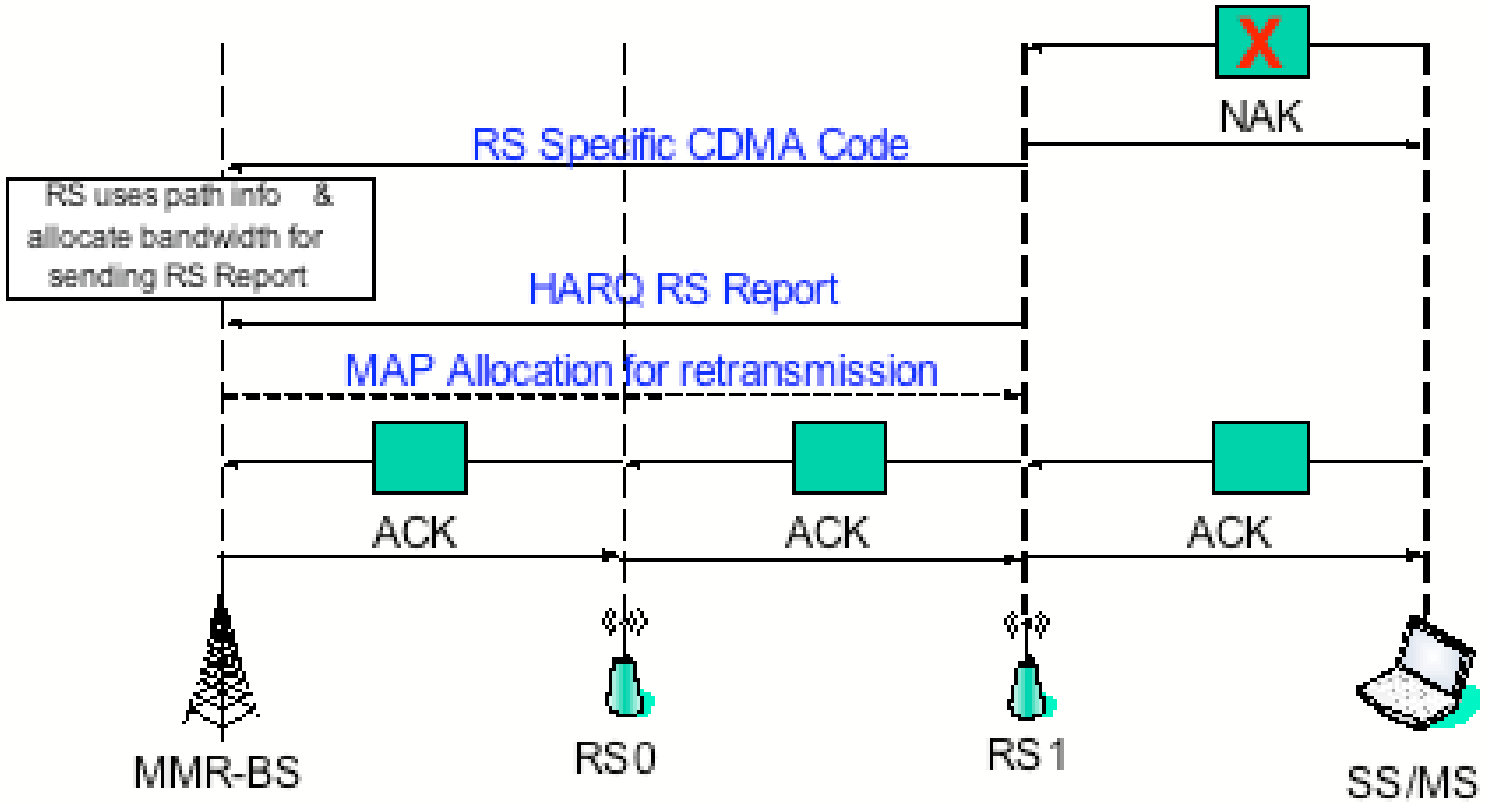
UL HARQ Solution for Centralized Scheduling

- RS1 sends HARQ RS Report to MMR-BS, indicating the RS and HARQ packet
- MMR-BS allocates MAP for the retransmission on the failed link, and onwards.
- If a RS is reaching its buffer capacity, it sends HARQ RS Report indicating to stop HARQ packet transmission. Once RS recovers, it sends indication to resume the transmission.



How to send HARQ RS Report?

- Define an extended subheader for HARQ RS Report
- If there is an avail. bandwidth, RS sends the subheader using it
- It is possible that the RS may not have any available bandwidth. In this case, it requests bandwidth using CDMA ranging code. (refer to C80216j-06_189 Bandwidth Allocation for Relay contrib)

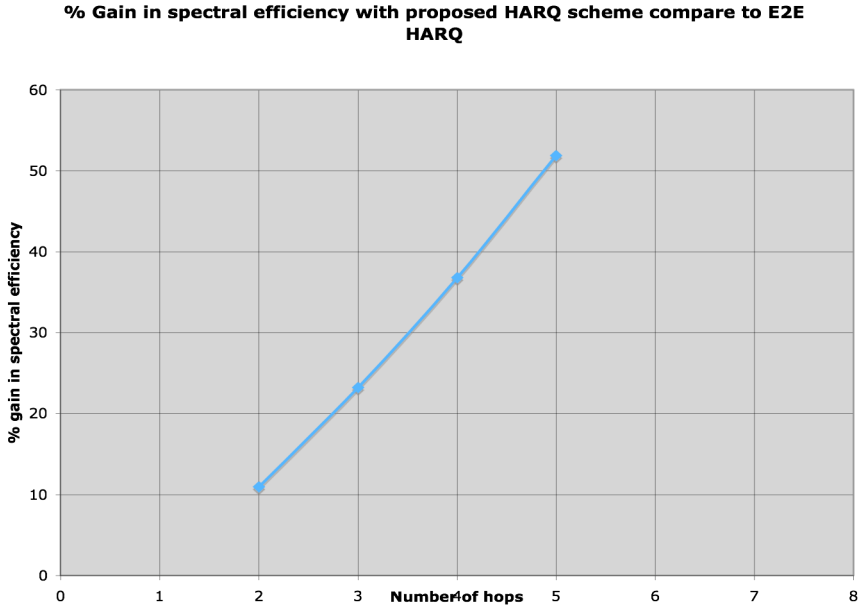


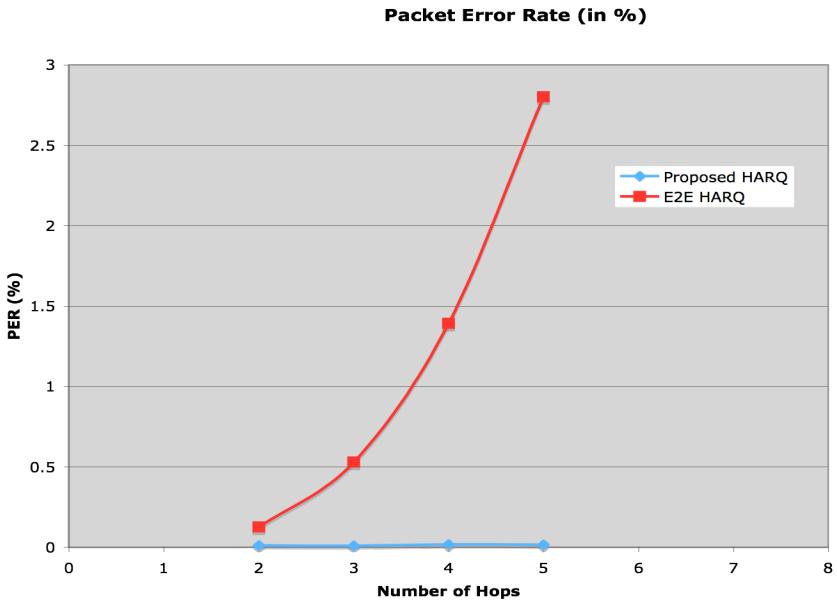
Simulation Parameters

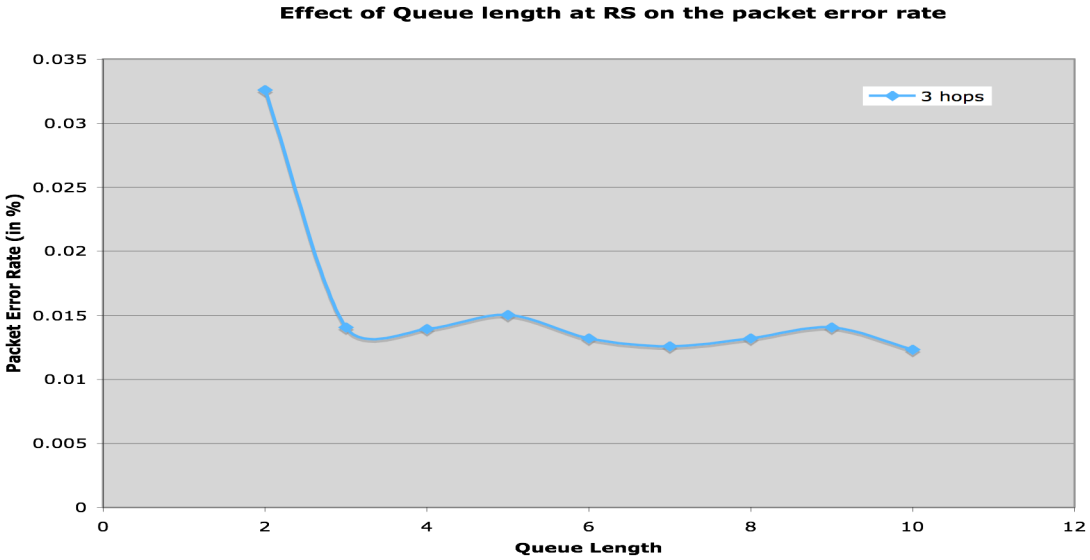
- Comparison of proposed HARQ scheme and end-to-end HARQ in case of centralized scheduling.

Scheduler	Round Robin (goes through HARQ Channels of MSs)	HARQ_DL_ACK_DELAY	1 frame
No of HARQ Channels scheduled per MS in one frame	2	HARQ_NEXT_RETRANS_DELAY	3 frames
No of MS in system	20	MAX_RETX_COUNT	4
No of HARQ Channels per MS	6	UL and DL overhead for resource request	10 bytes
Total HARQ Channels available in one frame	15	Resource Request latency at RS	3 frames
Frame Duration	5 ms	Queue Length at RS	variable
Simulation Duration	60000 frames	No of Hops	variable
Error generation	Uniform random error generation with BLER of 10 %	Flow control	supported

Simulation results







Conclusion

- Hop by hop HARQ is suggested for better throughput and low latency
- Described a problem for retransmission scheduling from a RS in the case of centralized scheduling
- Proposed a solution by sending new orthogonal code sequence in the UL ACK Channel for DL HARQ
- Proposed a solution by sending HARQ RS Report to MMR-BS for UL HARQ
- Allows retransmission only on the effected links, thus, it is bandwidth efficient
- Provide minimum propagation delay
- Works on top of the existing HARQ mechanism
- Doesn't modify MS behavior
- Provides corresponding spec changes in C80216j-06_197.doc