R1-060897

>BUSINESS MADE **SIMPLE**

STBC based HARQ with Simulation Comparison

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Background and Introduction

- In the MIMO modes transmission, when a packet is in error, the basic Turbo coding based re-transmission can be employed.
  - Such a re-transmission can be based on Chase combining and/or based on incremental redundancy coding combining (as per Rel5) to exploits the time-diversity.
- However, in the MIMO mode, we can exploit additional space-time diversity in the packet re-transmission.
  - The re-transmitted packet can be designed as a space time code words so that the receiver can treat the packet re-transmission as decoding a space time code, therefore, additional gain can be gained.
    - At Seoul meeting, we presented in R1-051426 the space time block coding based H-ARQ approach for two transmit antennas.
    - At Helsinki meeting, we further proposed in R1-060149 the orthogonality based retransmission for four transmit antennas.
    - At Denver meeting, a generalized decoder is proposed in R1-060646 to improve STBC based HARQ performance at high mobile speed or re-transmission is from different RB
- In this contribution, some simulation result are presented which show that STBC based HARQ provides extra gain over FEC based HARQ.

The Two Basic MIMO Transmission Modes

> STTD
  - Improve the reliability to link performance
  - Independent of MIMO channel matrix illness
  - Does not increase the user bit rate

> Spatial Multiplexing
  - Provides higher user bit rate
  - Sensitive to MIMO channel matrix illness

> The proposed H-ARQ strategy for MIMO transmission
  - Use Spatial multiplexing as *first* transmission to gain best bit rate
  - Second transmission built to form STBC for two antennas and double STTD (respectively QO-STFBC) for four antennas with the first transmission
  - The receiver exploits the orthogonal signal design and space diversity gain

H-ARQ Options for MIMO Transmission

> Option-1

- FEC based H-ARQ: rate compatible Turbo codes
- The redundant version is transmitted as different version of code words of Turbo code
- Combined packet decoding at receiver

> Option-2

- Symbol re-transmission: LMS based Chase combining
- Packet re-transmission and soft combined at receiver

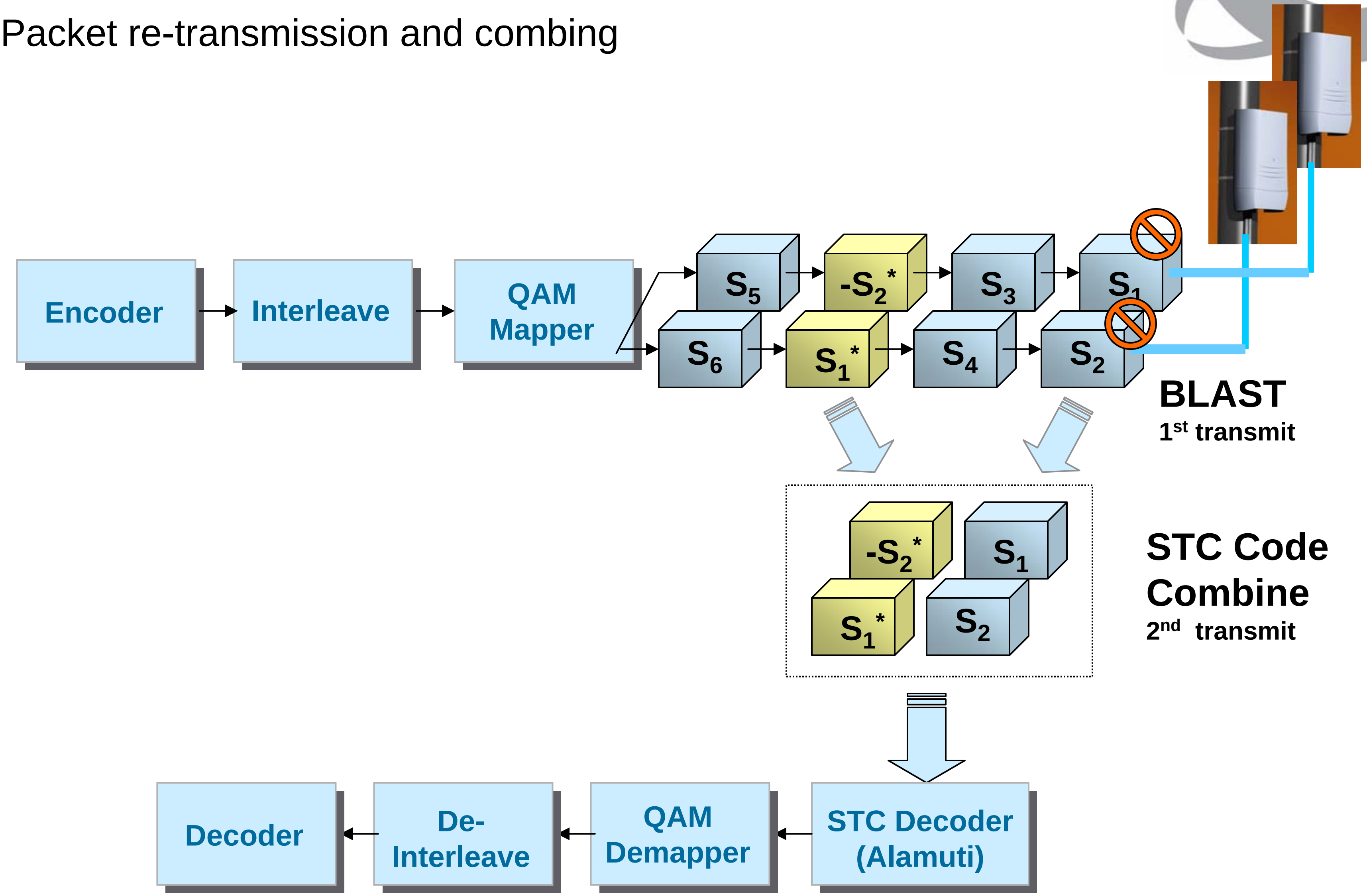
> Option-3

- Space time coding based retransmission
- Same Turbo code words same modulation symbol
- Different redundant version in terms of space time code

All the three approaches provide additional energy and time diversity

STBC Based HARQ for Two Antennas

Packet re-transmission and combing



Encoder → Interleave → QAM Mapper

S_5 $-S_2^*$ S_3 S_1

S_6 S_1^* S_4 S_2

BLAST

1st transmit

$-S_2^*$ S_1

S_1^* S_2

STC Code Combine

2nd transmit

STC Decoder (Alamuti) → QAM Demapper → De-Interleave → Decoder

Packet re-transmission formats

1. **Two transmit antennas case:**

	Tx-1	Tx-2
Time 1	S_1	S_2
Time 2	$-S_2^*$	S_1^*
Time 3	S_1	S_2
Time 4	$-S_2^*$	S_1^*

2. **Four transmit antennas case:**

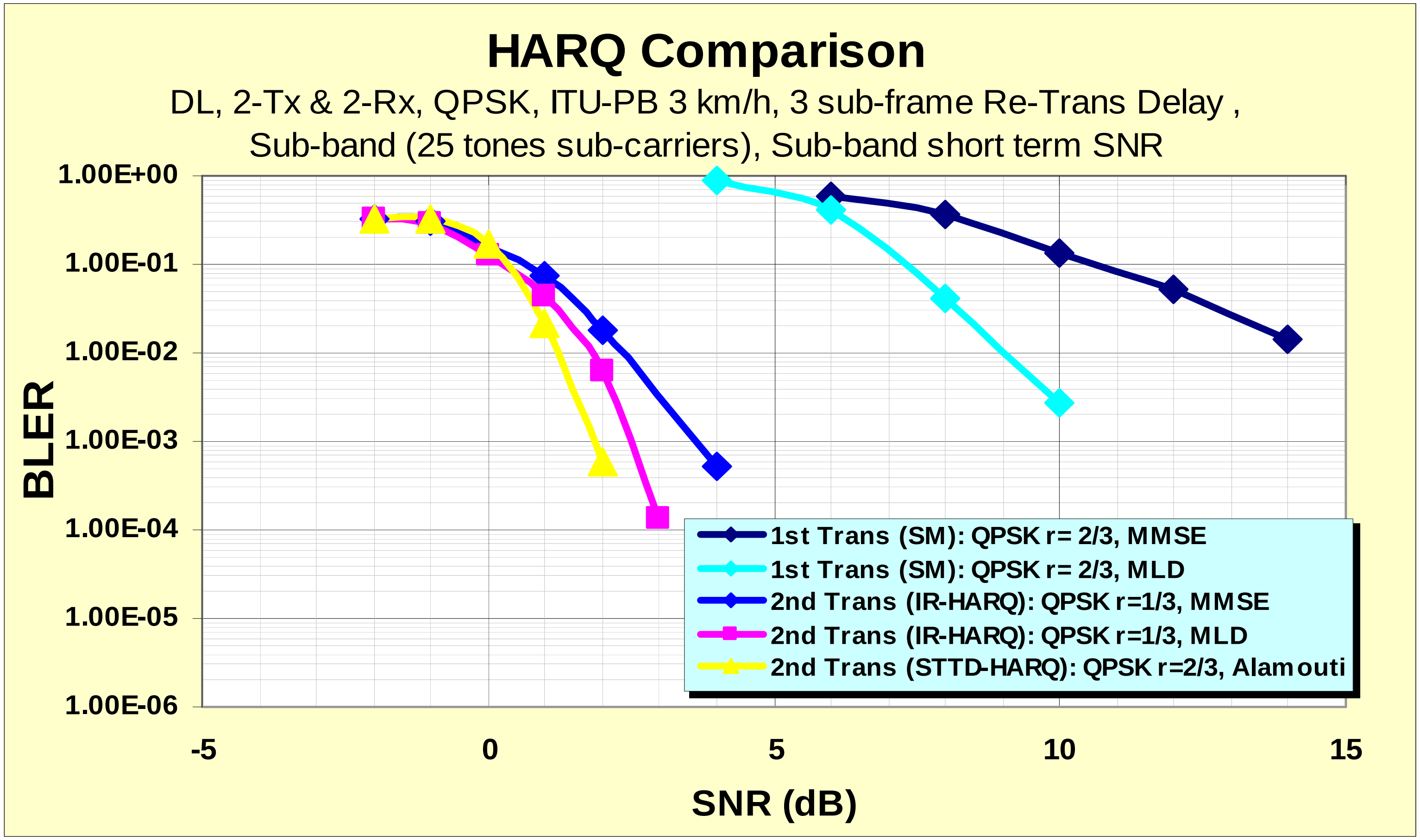
	Tx-1	Tx-2	Tx-3	Tx-4
Time 1	S_1	S_2	S_3	S_4
Time 2	$-S_2^*$	S_1^*	$-S_4^*$	S_3^*
Time 3	S_3	S_4	S_1	S_2
Time 4	$-S_4^*$	S_3^*	$-S_2^*$	$-S_1^*$

Simulation Assumption

- > LTE downlink, 10 MHz bandwidth, 1024 FFT
- > Two transmit antennas, two receive antennas
- > One localized VRB: 25 sub-carriers over 6 OFDM symbols
- > Encoding/decoding: Turbo code R=2/3
- > Coding block: 200 info bits for QPSK, 400 info bits for QAM-16
- > Channel: ITU-PB 3 km/h
- > SNR definition: short term sub-band SNR
- > Receiver:
  - Alamouti decoder for STBC based HARQ,
  - MLD and MMSE receiver for FEC-based IR HARQ

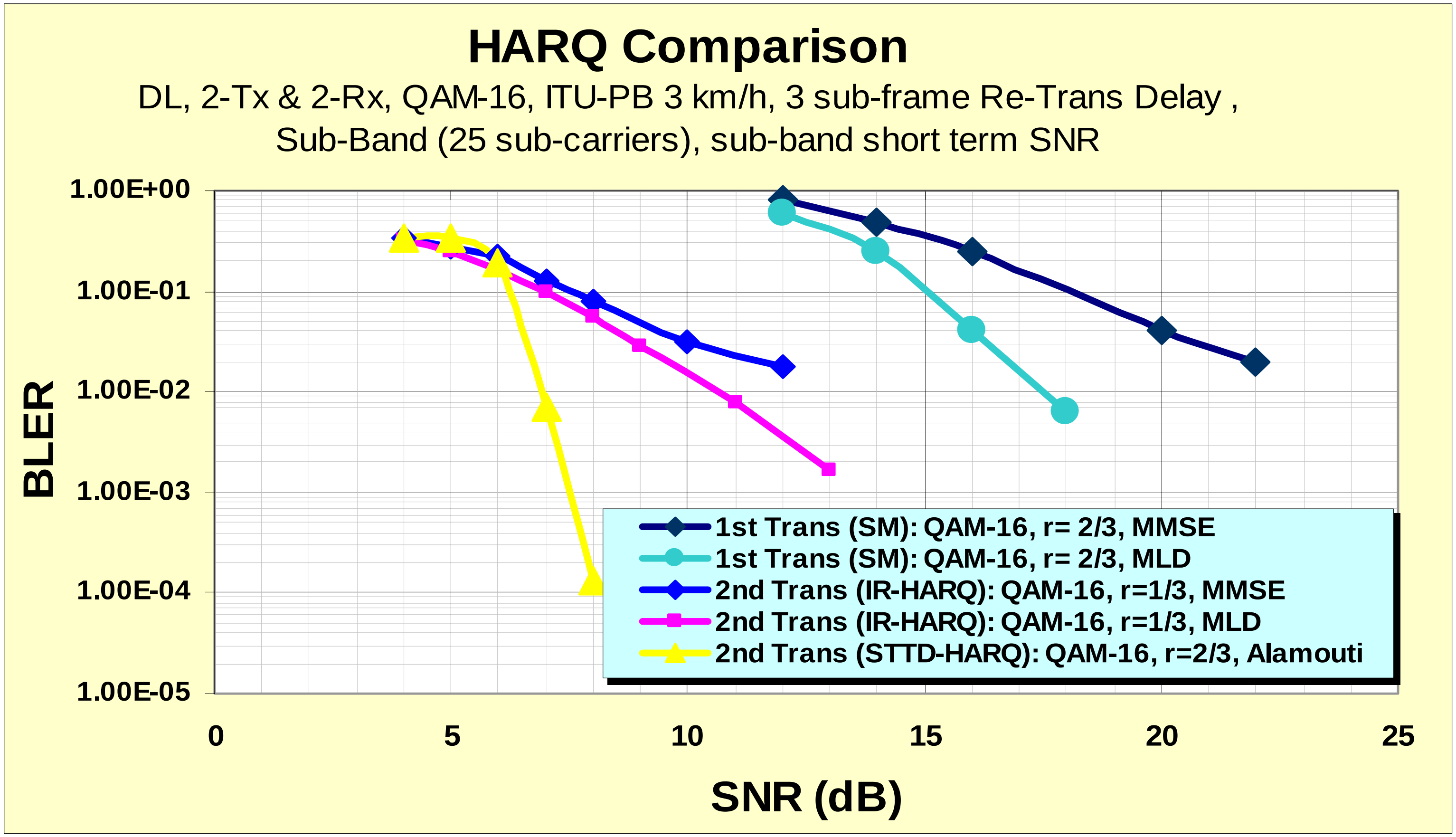
HARQ Comparison

PQSK modulation



HARQ Comparison (cont)

QAM-16 modulation



Simulation Observation

> For QPSK modulation, STBC based HARQ has 0.7 to 1.5 dB gain (10^{-2} BLER) over FEC-based IR HARQ using MLD and MMSE receivers, respectively.

> For QAM-16 modulation, STBC based HARQ has 4 to more than 6 dB gain (10^{-2} BLER) over FEC-based IR HARQ using MLD and MMSE receivers, respectively.

> The gain of FEC-based IR HARQ is limited by relatively flat channel and insufficient time diversity, while STBC based HARQ provides extra gain from orthogonality.

Conclusions

> For spatial multiplexing based systems, the gain from incremental FEC based retransmission is limited, especially for users with low mobility and small bandwidth.

> For the two transmit antenna case, STBC based H-ARQ is able to introduce additional orthogonality and hence extra SNR gains associated with it.

> STBC based H-ARQ with Alamouti decoder requires less complexity than FEC based retransmission with MMSE or MLD Rx.

> We recommend RAN1 to consider the adoption of the orthogonality principle for H-ARQ retransmission using STBC based HARQ for two transmit antennas and Double-STTD / QO-STFBC based HARQ for four transmit antennas

- Packet re-transmission format for 2-transmit and 4-transmit