R1-060646

3GPP TSG-RAN1 Ad Hoc

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Agenda Item:	**13.1.3**
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Title:	**Update on MIMO and HARQ interactions**
Document for:	**Discussion**

>THIS IS THE WAY

Update on MIMO and HARQ interactions

Nortel

February 2006

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Background and Introduction

> In the MIMO modes transmission, when packet in error, the basic Turbo coding based re-transmission can be employed.
  - Such a re-transmission can be based on Chase combing and/or incremental redundancy based coding combing (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 design 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 the 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.

> In this contribution a generalized decoder is proposed to improve STBC based HARQ performance at high mobile speed or alternatively if the re-transmission is from different Resource Blocks compared to the initial transmission

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

The Fundamental Limits of FEC Coding Gain*

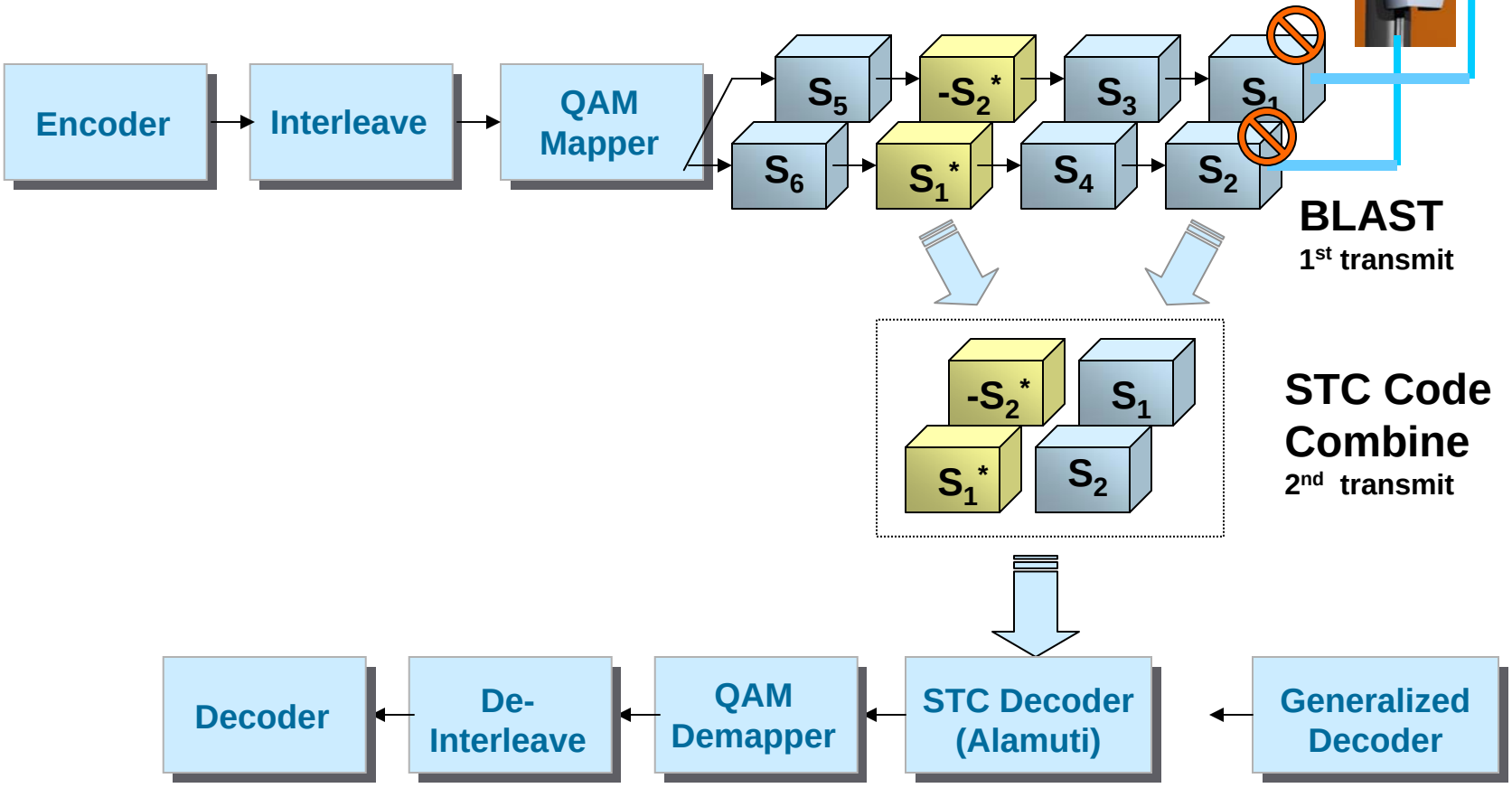
> FEC coding based incremental redundancy coding exploits coding gain when jointly to combine the code words of Turbo code as a lower code rate
  - However, such an additional coding gain is limited, e.g. for RCCC*

m=8	R = 1/4	R = 1/3	R = 1/2
Asymptotic coding gain	4.77 dB	4.77 dB	4.77 dB

> With MIMO case, additional SNR and space diversity gain can be obtained from space time block code (STBC) or quasi-orthogonal space time block code (QO-STBC)

***Sue Lin, Error Control Coding: Fundamentals and Applications Prentice Hall, 1983, p. 330**

STBC Based HARQ



Generalized STBC decoder

> When mobile speed is low, the well-known Alamuti STTD decoder can be used for STBC based HARQ

> A more generalized STBC decoder can be used if mobile speed is high or if re-transmission is from different resource block (RB).

$$\begin{bmatrix} r_{1,t_1} \\ r_{2,t_1} \\ r_{1,t_2}^{*} \\ r_{2,t_2}^{*} \end{bmatrix} = \begin{bmatrix} h_{11,t_1} & h_{12,t_1} \\ h_{21,t_1} & h_{22,t_1} \\ h_{12,t_2}^{*} & -h_{11,t_2}^{*} \\ h_{22,t_2}^{*} & -h_{21,t_2}^{*} \end{bmatrix} \begin{bmatrix} s_1 \\ s_2 \end{bmatrix}$$

$$\vec{r} = H\vec{s}$$

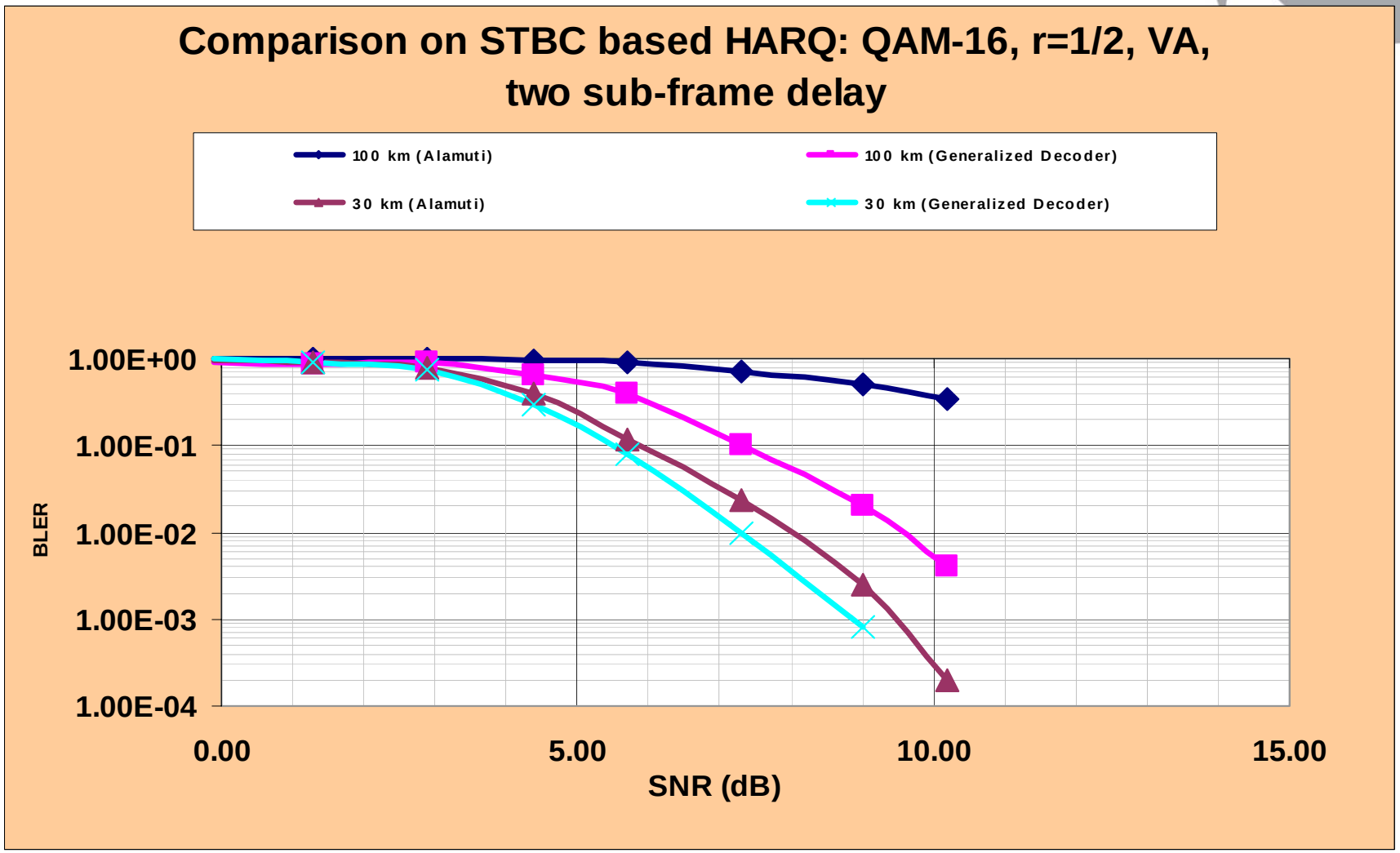
$$\vec{s} = \left(H^{*}H\right)^{-1} H^{*}\vec{r}$$

If

$$h_{11,t_1} = h_{11,t_2}$$
$$h_{12,t_1} = h_{12,t_2}$$
$$h_{21,t_1} = h_{21,t_2}$$
$$h_{22,t_1} = h_{22,t_2}$$

Then we have Alamuti solution

STBC based HARQ comparison



Conclusions

- For spatial multiplexing based systems, the gain from incremental FEC based retransmission is limited.
- For the two transmit antenna case, STBC based H-ARQ is able to introduce additional orthogonality and hence significant SNR gains associated with it. It can be applied for both localized and distributed transmission.
- A generalized decoder can be used at UE to improve its STBC based HARQ performance when mobile speed is high or alternatively if re-transmission is from different Resource Blocks compared to the initial transmission
- 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