
Agenda item: **AH32: HSDPA**

Source: **Motorola**

Title: **HS-DSCH Throughput of Open and Closed Loop Transmit Diversity**

Document for: **Discussion**

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1. SUMMARY

Recent contributions have examined link level error rate performance of TxAA on the High Speed Downlink Shared Channel (HS-DSCH). These contributions do not include the effects of link adaptation or hybrid ARQ (HARQ) techniques that are of interest for HSDPA.

We report on HS-DSCH throughput, providing link level (sub-chip resolution) simulation results comparing open loop and closed loop transmit diversity schemes when used with link adaptation and HARQ for a single path Rayleigh channel. We demonstrate that:

- Mode 2 TxAA on the HS-DSCH can provide significant throughput gains over both 1 antenna and STTD over a wide range of SNRs.

- The presence of link adaptation and HARQ reduce the benefit of STTD, such that it only improves capacity over 1 transmit antenna at higher SNRs. (Also it may be noted that multi user diversity also reduces the benefits of STTD [1]).

2. SIMULATIONS

Simulations of a single link with HARQ and link adaptation (AMC) were run with various transmit diversity configurations. We show the key simulation parameters used in Tables 1 and 2. STTD and TxAA mode 2 (1-bit gain, plus 3-bit phase) were simulated. The TxAA simulations assumed 0% or 4% feedback errors[1]. A simple one path channel model with i.i.d. Rayleigh fading for all rays is used for illustration. Additional results will be provided in future contributions.

Table 1. Important Simulation Parameters

Parameters	Value
Channel	1-Path Rayleigh
Mobile Speed	3 km/h
TxAA FB Error	0 or 4%
TxAA Verification	Ideal
Channel Estimation	Ideal
Pilot Power Fraction	10% Total
Overhead Power Fraction	10% Total
Walsh Codes	12 codes out of 16

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[1] Also, to simplify the simulations, we assumed that all feedback bits are transmitted in a single slot time, whereas the R'99 standard specifies 1-bit per slot.

Feedback Delays	Link Adaptation: measure in slot *n*; apply in slot (*n*+4) TxAA: measure in slot *n*; apply in slot (*n*+4) ARQ & Scheduling: 1st transmit in TTI *m* 2nd transmit in TTI (*m*+5)
Max Turbo Decoder Iterations	10
Turbo decoder Metric	MAP
HARQ	Repeat and Combine
Max # Repeats	10

We adapt the link using the modulation and coding schemes (MCS) shown in Table 2, below. The MCS levels are selected based on the receiver output SINR and are used with the delay shown above.

Table 2. MCS Table

MCS Level	SINR Range (dB)
R=1/4, 4QAM	-Inf < SINR < 0.5
R=1/2, 4QAM	0.5 < SINR < 4.0
R=3/4, 4QAM	4.0 < SINR < 5.5
R=1/2, 16QAM	5.5 < SINR < 7.5
R=5/8, 16QAM	7.5 < SINR < 9.5
R=3/4, 16QAM	9.5 < SINR < Inf

Simulation results are given in Figure 1. The average throughput (in bits/chip) is plotted against geometry. (Geometry is computed as Ior/(Ioc+No), where Ior is the total power received from the base station, Ioc is interference power, and No is thermal noise)[2]. Curves are given for 1 antenna, STTD, TxAA mode 2 with 0% feedback error, and TxAA mode 2 with 4% feedback error. We observe:

1. STTD provides is within a few percent of the capacity of a single transmit antenna for Ior/Ioc below 10 dB. Therefore, we can see that link adaptation and HARQ allow more efficient transmission, reducing the benefit of open loop transmit diversity.

2. TxAA provides significant capacity increases relative to 1 antenna and STTD over a wide range of SNR. Under error free conditions, we see as gains of 25 to 69% over STTD for Ior/Ioc ranging from –5 to 10 dB. With 4% feedback error, the gains range from 16 to 56% for the same geometry.

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[2] Ioc is modeled as thermal noise in these simulations.

3. CONCLUSIONS

- Transmit diversity techniques need to be evaluated in the presence of link adaptation and hybrid ARQ.

- The need for open loop diversity appears to be significantly less in HSDPA due to its use of link adaptation, hybrid ARQ, and multiuser diversity.

- TxAA can provide significant capacity gains for HSDPA for a single path Rayleigh.

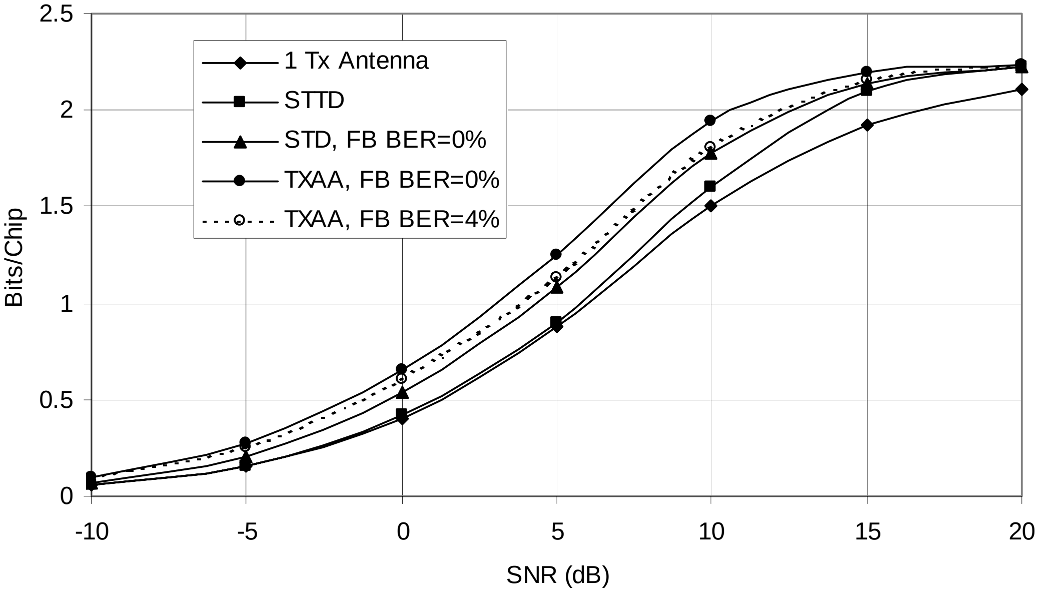
- As has been pointed out in [2-5], some care is needed when the DPCCH is in soft handoff, since the HS-DSCH does not use soft handoff. The performance of TxAA under soft handoff will be addressed in future contributions.

- System level studies of TxAA as applied to HSDPA are currently being developed by Motorola for different traffic models and for mixed voice and data services.

4. REFERENCES

[1] Motorola. “System performance with IR and STTD for multi-path channels,” TSG-R1 document, TSGR1#23(02)0038, Espoo, Finland, January 08-11 2002
[2] Texas Instruments. “Closed-loop transmit diversity (TxAA) solution for HSDPA,” TSG-R1 document, TSGR1#23(02)0049, Espoo, Finland, January 08-11 2002
[3] Motorola. “Closed Loop Transmit Diversity for DSCH during SHO,” TSG-R1 document, TSGR#24(02)00392, Orlando, USA, February 18-22, 2002
[4] Samsung. “DSCH Tx Diversity Operation in SHO Region”. TSG-R1 document, TSGR1#16(00)1270, October 12, 2000, Busan, Korea.
[5] NEC. “Closed Loop Mode Transmit Diversity for DSCH in Soft Handover,” TSG-R1 document, TSGR1#19(01)0276, February 27 – March 2, 2001, Las Vegas, USA.

Figure 1: Link simulation results comparing TxAA and STTD


1 Tx Antenna
STTD
STD, FB BER=0%
TXAA, FB BER=0%
TXAA, FB BER=4%
Bits/Chip
SNR (dB)