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Agenda Item:	**AH24: High Speed Downlink Packet Transmission**
Source:	**SONY Corporation**
Title:	**Reduction of DL channel quality feedback rate for HSDPA (revision of R1-01-231)**
Document for:	**Discussion**

1. Introduction

A concept of reducing the feedback rate for downlink channel quality is briefly presented at the last meeting in Boston [1]. This contribution presents system level simulation results to show that proposed scheme can be effectively used to reduce feedback rate of explicit DL channel quality report (thus reducing uplink load) without impacting the system throughput.

2. Estimation of DL channel conditions

The HS-DSCH being proposed utilizes adaptation of modulation and coding scheme in accordance with variation in downlink channel conditions. In FDD, the downlink channel condition can be estimated by a Node-B using explicit feedback information, such as CPICH SIR, from UE. The feedback information is needed from all UEs that are in HS-DSCH connected state, which implies that significant amount of uplink resources are needed if cell is loaded with HS-DSCH users. On the other hand, HS-DSCH is assumed to be associated with power controlled DL DPCH as in release 99 DSCH. This means that aside from explicit DL channel quality report, TPC commands that can be thought as relative channel quality report quantized into a single bit are also available for the estimation of DL channel conditions seen by UE. The use of TPC commands for estimation of DL channel quality has an advantage of having very short feedback delay. Conversely, disadvantages of using TPC commands are that channel quality derived from TPC commands do not necessary match with HS-DSCH quality if DPCH is in soft handover, and that TPC commands only provide relative quality respect to the target SIR.

The use of uplink resources can be suppressed by reducing the feedback rate of DL channel quality report and compensating the reduced feedback rate by estimation based on TPC commands as shown in Figure 1. TPC commands are used to fill the gap of explicit report as well as to compensate for feedback delay of the reported value. An extreme case is to set explicit reporting frequency to zero so that only TPC commands are used for DL channel quality estimation. The frequency of explicit report can made to be controlled by UTRAN. By allowing UTRAN to control the feedback rate of DL channel quality report, network will be able to make tradeoff between optimization of uplink resource usage and DL channel quality estimation accuracy. As examples, following scenario can be easily incorporated.

?? UTRAN may assign higher feedback rate for explicit DL channel quality report if UE's DPCH is in soft handover state to obtain better estimation accuracy
?? UTRAN may assign lower feedback rate for explicit DL channel quality report if uplink resources is limited

Using this scheme also enable UTRAN to disable explicit feedback report from UE, if serving Node-B is "smart" in a way that it can/want to estimate the DL channel conditions without explicit report

The proposed scheme can be implemented with an addition of downlink higher layer signaling that allows UTRAN to change/setup feedback rate for explicit C/I report. All other concepts are in line with current description of the technical report TR25.848.

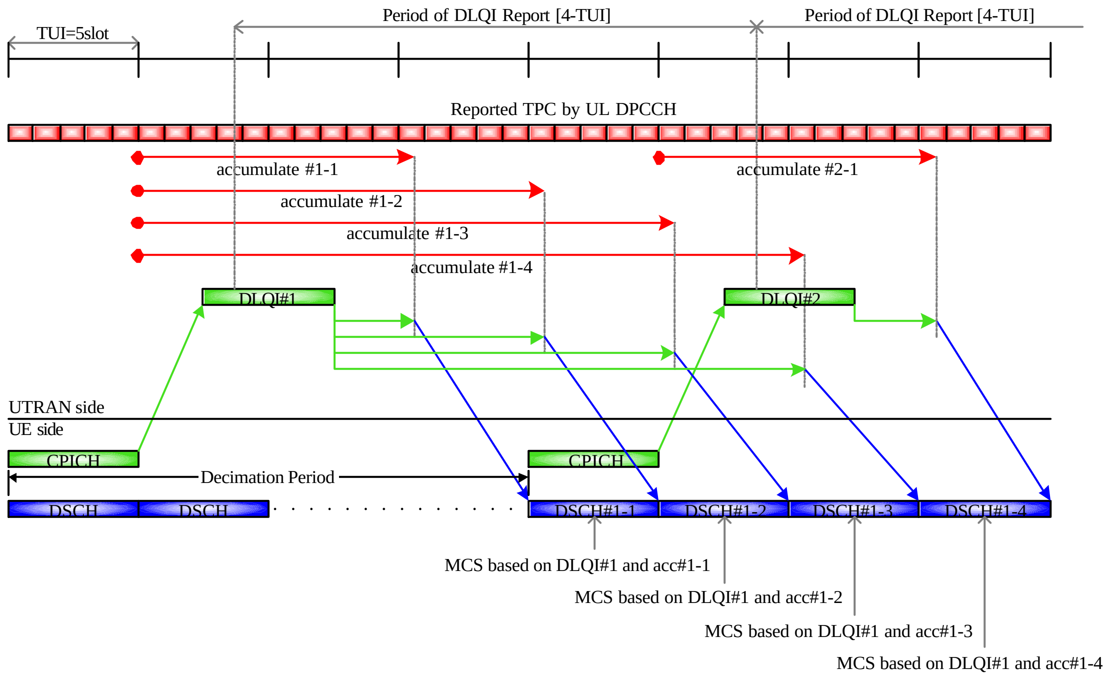

Figure 1 Reduction of DL Channel Quality Feedback Rate (TUI=5-slot)

3. Simulation Results

Dynamic system simulation is performed in accordance with [2] to evaluate the effectiveness of the proposed scheme. Simulation assumptions are provided in the Annex.

The following four schemes are investigated.

Baseline Performance

As a performance reference, HSDPA baseline scheme is evaluated. Baseline HSDPA utilizes explicit feedback report alone for the estimation of DL channel condition. When the reporting rate is reduced, Node-B simply uses the most recent reported value for MCS adaptation.

Table 1 shows the simulation results. As the feedback rate is reduced, actual channel condition is no longer correlated with reported value, causing severe degradation in throughput performance. HS-DSCH load also increases as average retransmission count increases due to inappropriate MCS assignments.

Table 1 Baseline HSDPA performance

MS speed=1, 3, 30km/h Sceduler=Max C/I TrBlk Size=24-byte H-ARQ=chase (up to 10-Tx)
HS-DSCH Ec/Ior=-1dB (Max) Tx-diversity=STTD MCS=1,2,3,4,6,7 TUI=3.33msec (5-slot)

deci. rate(TUI)	1 (No decimation)		12		24		48		96	
	OTA (kbps)	Load (%)	OTA (kbps)	Load (%)	OTA (kbps)	Load (%)	OTA (kbps)	Load (%)	OTA (kbps)	Load (%)
16 UE/sector	2,436	19.5	2,257	20.4	2,166	21.1	2,116	21.7	2,075	22.3
32 UE/sector	2,530	39.3	2,324	41.2	2,216	42.8	2,155	44.2	2,106	45.8
64 UE/sector	2,644	72.9	2,404	77.0	2,280	78.8	2,222	81.1	2,174	83.4
96 UE/sector	3,042	93.8	2,705	97.8	2,536	99.6	2,478	100.0	2,450	100.0

OTA: Over the Air Throughput Load: Ulilization of HS-DSCH resource

Performance with TPC compensation

A scheme with TPC command compensation is evaluated. When the feedback rate of explicit report is reduced, TPC bits are accumulated from the last CPICH SIR report and used to compensate for non-reported period. 4% error in TPC commands is simulated. Soft handover on DPCH is assumed and it is initiated if average CPICH RSCP is higher than –6dB from the best cell CPICH RSCP. Feedback rate for explicit channel quality is not changed from initial setup throughout the simulation.

Table 2 shows the simulation results. The degradation in throughput due to reduced explicit channel quality feedback rate is suppressed by significant amount. However, for the case with 64 UE/sector and feedback reporting of every 96-TUI, there still remains approximately 4% loss in throughput due to inaccurate channel quality estimation made for UEs with DPCH in soft handover.

Table 2 HSDPA performance with TPC compensation

MS speed=1, 3, 30km/h Sceduler=Max C/I TrBlk Size=24-byte H-ARQ=chase (up to 10-Tx)
HS-DSCH Ec/Ior=-1dB (Max) Tx-diversity=STTD MCS=1,2,3,4,6,7 TUI=3.33msec (5-slot)

deci. rate(TUI)	1(No Decimation)		12		24		48		96	
	OTA (kbps)	Load (%)	OTA (kbps)	Load (%)	OTA (kbps)	Load (%)	OTA (kbps)	Load (%)	OTA (kbps)	Load (%)
16 UE/sector	2,477	19.4	2,443	19.6	2,420	19.7	2,405	19.8	2,393	19.9
32 UE/sector	2,563	38.9	2,527	39.2	2,506	39.5	2,490	39.9	2,472	40.2
64 UE/sector	2,688	72.8	2,639	73.8	2,611	73.8	2,598	74.3	2,579	75.0
96 UE/sector	3,060	93.8	3,009	94.4	2,984	94.9	2,976	95.3	2,969	95.7

OTA: Over the Air Throughput Load: Ulilization of HS-DSCH resource

Performance with TPC compensation <u>with</u> handover control

In this scheme, feedback rate for explicit channel quality report is changed in accordance with DPCH soft handover state. TPC bits are accumulated from the last CPICH SIR report and used to compensate for non-reported period however, RNC algorithm to change feedback rate is incorporated. Following two RNC algorithms are evaluated. 4% error in TPC commands is simulated for both cases.

Method#1:

Using CPICH RSCP that is assumed to be reported every 3,000msec:

?? Soft-handover is initiated if average CPICH of neighboring cell becomes larger than –6dB of current cell

?? If DPCH is in soft handover, then make UE to report CPICH SIR every TUI. Otherwise, use assigned feedback rate at call set-up.

This scheme is considered to be ideal since TPC compensation is only used for UEs with DPCH not in soft handover state.

Table 3 shows the simulation results. No throughput degradation due to reduced feedback rate is observed for this scenario. On the other hand, reduction in uplink resource used to transmit explicit channel quality report decreases as approximately 42% of users are in soft handover state and commanded to report CPICH SIR every TUI with this scheme.

Table 3 HSDPA performance with TPC and Handoff Control—method#1

MS speed=1, 3, 30km/h Sceduler=Max C/I TrBlk Size=24-byte H-ARQ=chase (up to 10-Tx)
HS-DSCH Ec/Ior=-1dB (Max) Tx-diversity=STTD MCS=1,2,3,4,6,7 TUI=3.33msec (5-slot)

deci. rate (TUI)	1 (No Decimation)		12		24		48		96	
	OTA (kbps)	Load (%)	OTA (kbps)	Load (%)	OTA (kbps)	Load (%)	OTA (kbps)	Load (%)	OTA (kbps)	Load (%)
16 UE/sector	2,472	19.4	2,468	19.4	2,466	19.4	2,465	19.4	2,463	19.4
32 UE/sector	2,577	38.4	2,572	38.5	2,573	38.5	2,573	38.5	2,573	38.5
64 UE/sector	2,691	72.7	2,686	72.8	2,686	72.8	2,686	72.8	2,686	72.9

OTA: Over the Air Throughput Load: Ulilization of HS-DSCH resource

Method#2:

Using CPICH RSCP that is assumed to be reported every 3,000msec:

?? Soft-handover is initiated if average CPICH of neighboring cell becomes larger than –6dB of current cell.

?? If UE is in soft handover <u>and</u> the difference between all active set average CPICH RSCP is within 3dB, then make UE to report CPICH SIR every TUI. Otherwise, use assigned feedback rate at call set-up.

Table 4 shows the simulation results. Approximately 23% of users are commanded to report CPICH SIR every TUI with this scenario. The degradation in throughput due to reduced explicit channel quality feedback rate is kept minimal (approximately 2% with feedback every 96-TUI) while maintaining reduction in uplink resource usage for feedback of channel quality.

Table 4 HSDPA performance with TPC and Handoff Control—method#2

MS speed=1, 3, 30km/h Sceduler=Max C/I TrBlk Size=24-byte H-ARQ=chase (up to 10-Tx)
HS-DSCH Ec/Ior=-1dB (Max) Tx-diversity=STTD MCS=1,2,3,4,6,7 TUI=3.33msec (5-slot)

deci. rate (TUI)	1(No decimation)		12		24		48		96	
	OTA (kbps)	Load (%)	OTA (kbps)	Load (%)	OTA (kbps)	Load (%)	OTA (kbps)	Load (%)	OTA (kbps)	Load (%)
16 UE/sector	2,471	19.4	2,452	19.5	2,438	19.5	2,436	19.6	2,434	19.6
32 UE/sector	2,577	38.4	2,552	38.7	2,535	38.9	2,530	39.1	2,523	39.2
64 UE/sector	2,690	72.7	2,658	73.7	2,646	73.7	2,641	73.9	2,634	74.2

OTA: Over the Air Throughput Load: Ulilization of HS-DSCH resource

Figure 2 shows the throughput performance comparison of each scheme as the feedback rate of explicit DL channel quality is reduced. The throughput comparison for 64 UE per sector is shown as an example. The benefit of using TPC commands to compensate for feedback rate reduction and incorporating variable feedback rate depending DPCH handoff state is clearly shown in the figure.

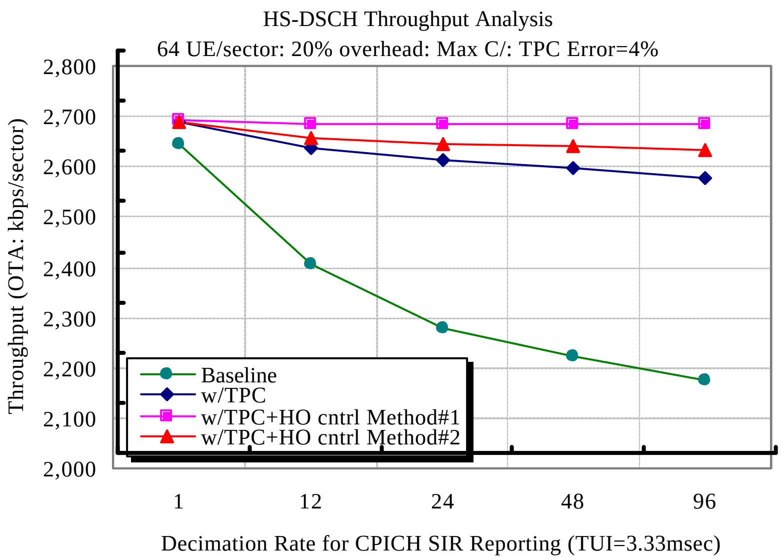

Figure 2 HSDPA Throughput Performances Comparison (64 UE/sector)

4. Conclusion

Throughput performance for HSDPA under reduced downlink channel quality feedback rate is presented. It is shown that using TPC commands to estimate channel condition change and allowing UTRAN to control the feedback rate depending on the handover state of DPCH, reporting rate for explicit downlink channel quality can be reduced without impacting the system capacity. It is also suggested that allowing UTRAN to control the channel quality feedback rate gives flexibility to network so that tradeoff can be made between uplink capacity and channel quality estimation accuracy.

It is recommended that the concept above be considered for HSDPA and reflected in the technical report TR25.848.

5. Reference

[1] SONY: "Use of TPC for DL channel Quality Estimation", TSGR1#18(01)0074, Jan. 2001

[2] TR25.848: "Physical Layer Aspects of High Speed Downlink Packet Access", TSGR1#18(01)0186, Jan. 2001

[3] SONY: "Delay on Control Information for HS-DSCH", TSGR1#17(00)1378, Nov. 2000

[4] Ericsson: "Comments and discussion of HSDPA proposal", TSGR1#17(00)1434, Nov. 2000

[5] Motorola: "Evaluation Methods for High Speed Downlink Packet Access", TSGR1#14(00)0909, July 2000

Annex: Simulation Assumptions

Table 5 Modulations and Coding Parameters

Parameter				
Transport CH	Number of TrCH		1	
	TTI (TUI)		5-slot	
	Transport Block Size		24-byte	
	CRC Attachment		Per Code Block	
AMCS	Mode	Modulation	Coding Rate	Num TrBlk
	MCS1	QPSK	R=1/4	1
	MCS2	QPSK	R=1/2	2
	MCS3	QPSK	R=3/4	3
	MCS5	16QAM	R=1/2	4
	MCS6	16QAM	R=3/4	6
	MCS7	64QAM	R=3/4	9

Table 6 System Simulation Parameters

Parameter	**Explanation/Assumption**	**Comments**
Cellular layout	19-cell, 3-sector sites	
Site to Site distance	2800 m	
Antenna pattern	As in [5]	
Propagation model	$L = 128.1 + 37.6\ Log_{10}R$	R in kilometers
Tx-diversity	2-Tx antenna, STTD	
CPICH power	-10 dB	
Other channels	- 10 dB	
Power allocated to HS-DSCH	Max. 80 % of total cell power	
Number of Code allocated to HS-DSCH	Max. 20	SF=32--Fixed
Slow fading	As modelled in UMTS 30.03, B 1.4.1.4	
Std. deviation of slow fading	8 dB	
Correlation between sectors	1.0	
Correlation between sites	0.5	
Correlation distance of slow fading	50 m	
Carrier frequency	2000 MHz	
BS antenna gain	14 dB	
UE antenna gain	0 dBi	
UE noise figure	9 dB	
Max. # of retransmissions	10	
Fast HARQ scheme	Chase combining	N=4-TUI
BS total Tx power	Up to 44 dBm	
Active set size	3	Maximum size
Fast Cell Selection	Yes. Based on CPICH RSCP	delay = 4 TUI
UE Mobility	1, 3, 30km/h	With equal probability

Table 7 Packet Traffic Model Parameters

Process	**Random Variable**	**Parameters**

Packet Calls Size	Pareto with cutoff	? =1.1, k=4.5 Kbytes, m=2 Mbytes, μ = 25 Kbytes
Time Between Packet Calls	Geometric	μ = 5 seconds
Packet Inter-arrival Time (open- loop)	Geometric	μ = MTU size /peak link speed (e.g. [1500 octets * 8] /2 Mbps = 6 ms)