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Title: Text proposal for TR 25.841 : Improvement of Power control for DSCH in soft handover

Document for: Discussion

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1. Introduction

In last Stocholm meeting, we proposed and discussed TFCI power control in split mode[1]. In split mode, TFCI2(TFCI for DSCH) is not transmitted from every cell in the active set when UE is in the soft handover region. Thus the reliability of TFCI cannot be guaranteed. To solve this problem, it is proposed that the power control for DSCH should be applied to the TFCI.

When the power control of DSCH is combined with SSDT, different power offsets are applied to TFCI. As DSCH power offset, TFCI power offset is adjusted by UE location(i.e. in the soft handover region or in the non-soft handover region), and it is also determined whether the cell transmitting DSCH is primary or non-primary cell. Therefore, three TFCI power offsets such as PO1, primary_PO1 and non-primary_PO1 are required. In this document, we propose text proposal for the TR 25.841.

2. Text proposal for TR 25.841

========================== text proposal ==========================

1 Scope

This document is the Technical Report for the DSCH power control improvement in soft handover, part of the Release 4 work item DSCH power controil improvement in soft handover".

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

?? References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.

?? For a specific reference, subsequent revisions do not apply.

?? For a non-specific reference, the latest version applies.

[1] 3G TS 25.214 (V3.2.0):

[2] 3G TR 25.849

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply.

Example: text used to clarify abstract rules by applying them literally.

3.2 Symbols

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

DCH	Dedicated Channel
DPCCH	Dedicated Physical Control Channel
FBI	Feedback Information
PDSCH	Physical Downlink Shared Channel
SSDT	Site Selection Diversity Transmision
SHO	Soft Handover
DSCH	Downlink Shared Channel
TFCI	Transport Format Combination Indicator

4 Background and Introduction

Under the study item "Radio Link Performance Improvement", the proposal for "DSCH power control improvement in soft handover" has been discussed in TSG RAN WG1 . Based on the progress in WG1 a work item was agreed in TSG RAN#9 under the name DSCH power control improvement in soft handover. In this technical report, the details of the proposed method are presented as well as the required changes in different specifications in TSG RAN specifications Additional technical report has been created to cover the WG3 part separately, see [2] for details on the Iur & Iub impacts.

This document also presents the proposed method about TFCI power control for DSCH in the soft handover region. Required changes on TFCI power control in specification are also described .

When TFCI field is on split mode, TFCI for DSCH(TFCI2) is not transmitted from every cell in the active set. It is determined by high layer signalling that the TFCI2 is transmitted from a cell. If the cell transmitting TFCI2 has weak power, then the quality of TFCI can not be guaranteed.

5 Changes over the Release –99 specification based equipment for the proposed method

This section covers the expected changes for the Release –99 based equipment to support the feature.

5.1 Changes with respect to Release 99

5.1.1 Required Changes in UE

At the UE side the new "capability" needed is to be able to do the normal soft handover even when sending the SSDT signalling in the uplink direction. This should not be a hardware issue; thus the incremental complexity is very small.

Both such a "normal" SHO combining and SSDT signalling are "mandatory" requirements for the UE in Release –99.

5.1.2 Required Changes in Node B

For the Node B side the proposed method is giving a possibility to improve the resulting performance in setting the DSCH power level and from Release –99 specification the added complexity is also very small as only the power control algorithm in the Node B (for DSCH and TFCI) would need to be modified.

In general it is also worth noting that this kind of item is optional in the Node B (or UTRAN in general).

5.2 Expected Gain with respect to Release 99

The performance improvements can be considered coming from the following case:

With the proposed method, The DSCH would be sent with more accurate power level, as UTRAN would utilise the information from the SSDT to see if the Node B/cell sending the DSCH is the strongest one. In the worst case with DSCH being sent from the weakest Node B, the DSCH power level could be 6-10dB below the desired power level.

This corresponds also to a more or less non-power controlled case or random power controlled case as the associated DCH is not the basis for the power control commands generated by the UE.

By applying same method to the TFCI power control, TFCI would be sent with accurate power even in split mode.

6 DSCH Power Control Improvement

6.1 Fast DSCH power control combined with SSDT

In this section, the method for the DSCH power control improvement is described.

The proposed intends to allow the improvement of DSCH power control in soft handover by the use of the existing SSDT signalling in the uplink to determine whether DSCH power should follow the DCH (primary cell transmitting) or whether the DSCH power should be set with higher offset (or fixed value like for FACH (Forward Access Channel) for example) in case secondary cell is transmitting.

The SSDT has been specified in section 5.2.1.4 in [1] and according to the principle UE provides indication of the primary cell ID for in the uplink FBI field. This feature is considered as baseline feature and provided by all UEs (that can use dedicated channels) in the Release –99 as well. The intention with SSDT is that only the primary cell sends the DPDCH part of the downlink DCH, while DPCCH part is sent by the all Node Bs in the active set.

In the proposed enhancement, the UTRAN may activate the uplink SSDT signalling even the SSDT transmission is not necessary used on the downlink DCH. The Node Bs are given power offset value that is used whether the DSCH is sent from the Node B determined to be the primary Node B (or cell) or whether the Node B sending the DSCH is the secondary one. The primary/secondary status would be determined with sliding average for example over 10 frames with parameter given (over Iub) how many primary indications are needed to use the primary value power offset for DSCH.

The existing maximum/minimum power level values would be naturally valid, thus allowing to set the DSCH e.g. to be 6 dB over DCH but not to exceed the power level determined as being needed for example with FACH transmission.

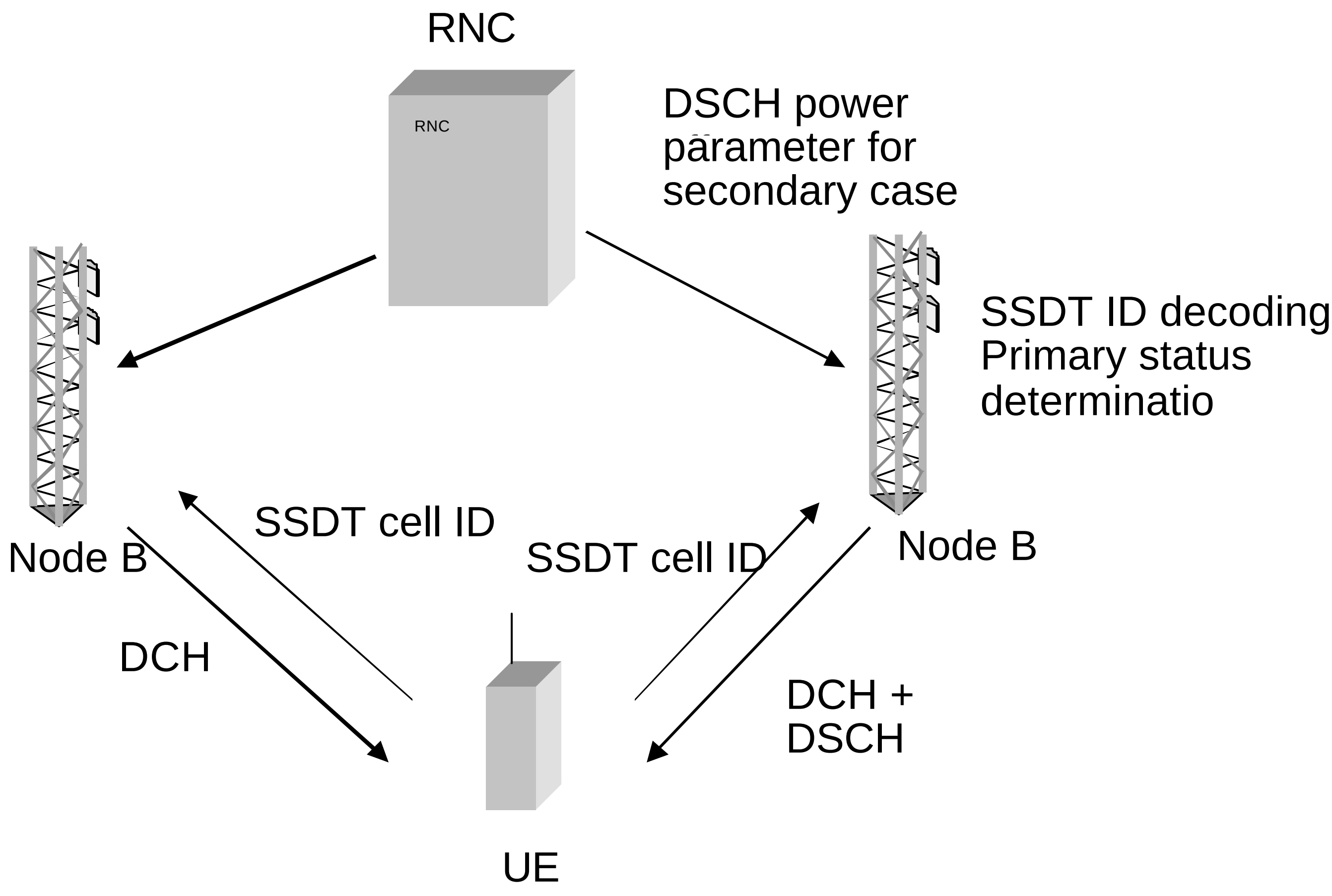

Figure 1. Concept of using SSDT signalling with DSCH power control

6.2 Other solutions.

The method presented in section 6.1 fits nicely in the R'4 context as it does not involve any hardware modification. However, it does not fully solve the PDSCH power control issue and has a number of drawbacks. In particular, the proposed method:

?? Only improves the performance in some very specific scenarios (unbalanced active set power distribution).

?? Could actually degrade the performance in some specific scenarios (balanced active set, error in cell selection)

?? Potentially decreases the average interference generated by PDSCH but does not necessarily provide additional capacity in power limited situation as the base station has to set aside the power required for fixed power or fixed offset PDSCH transmission in case the power control "mode" suddenly changes (switching between the two modes can not be predicted).

The following sub sections briefly presents two other possible solutions which are expected to provide additional gains (compared to solution in section 6.1) at the expense of potential HW modifications in the UE or Node B (compared to R'99). Those methods and their respective performance should be considered in more details in the context of releases beyond R'4.

6.2.1 Block error indication method

Description

The UE sends a 100 Hz, 1 bit, feedback to the network indicating whether any of the blocks in the previous frame has been received in error (based on CRC check). In case no TTI with CRC ended in the previous frame, the Node B knows it and discards the information sent by the UE. The information is sent by stealing one power control slot per frame on the associated DPCH.

Benefits

- ?? Does not require any change in the UE HW.

Drawbacks

- ?? Performance gain depends on transport channel configuration (CRC, TTI).
- ?? Since CRC is used for the outer loop and at least one transport channel is expected to include CRC integrity protection, CRC will, in principle, be available in most cases. However, depending on the TTI of the TrCH with CRC protection, the effective feedback rate could be 100 Hz (10 ms TTI), 50 Hz (20 ms TTI), 25 Hz (40 ms TTI) or 12.5 Hz (80 ms TTI).
- ?? Power control loop is not maintained when no data is sent over the PDSCH

6.2.2 SIR based method

Description

The UE derives an independent power control command based on the PDSCH symbols (non-coherent accumulation, PDSCH TFC is known in advance) and steals every 3, 5 or 15 slots of the associated DPCH UL power control stream to transmit the PDSCH power control commands. Alternatively, new UL slot structure could be defined.

Benefits

- ?? Full fast inner loop power control solution fully correlated with the fading experienced by the PDSCH.

Drawbacks

- ?? Requires the introduction of a specific PDSCH power control decision algorithm in the UE. The complexity increase is not expected to be significant but might require HW changes.
- ?? In case new UL slot formats are defined the Node B HW might also have to be modified.
- ?? Power control loop is not maintained when no data is sent over the PDSCH.

6.3 TFCI Power control for DSCH

In this section, the power control of TFCI in the cell transmitting DSCH is presented when the TFCI is in split mode. The power control of DSCH is applied to the power control of TFCI in soft handover region.

6.3.1 Power control combined with SSDT

In this section, the power control of TFCI is described when the power control of DSCH is combined with SSDT.

The proposed method improves TFCI power control in soft handover by SSDT signalling in the uplink.SSDT signalling determines whether TFCI power should follow the DCH (primary cell transmitting) or whether the TFCI power should be set with higher offset (or fixed value like for FACH for example) in case secondary cell is transmitting.

SSDT has been specified in section 5.2.1.4 in [1], and UE provides the indication of the primary cell ID for in the uplink FBI field. UTRAN may activate the uplink SSDT signalling even the SSDT transmission is not necessary on the downlink DCH. Node Bs are given the power offset value of TFCI which is used whether the DSCH is sent from the Node B determined to be the primary Node B (or cell) or whether the Node B sending the DSCH is the secondary one. The primary/secondary status would be determined with same sliding average as the DSCH power control. And same parameter is used for the sliding window.

The existing maximum/minimum power level values would be naturally valid, thus allowing to set the TFCI e.g. to be 6 dB over DCH but not to exceed the power level determined as being needed for example with FACH transmission.

6.3.2 Power control with separate feedback

In this case, the power control of TFCI is similar to the Block error indication method or SIR based method. The power of TFCI is adjusted by the separate feedback for DSCH power control. DSCH power control on the section 6.2 is the issue beyond R4. Thus this method for TFCI power control would be considered in the context beyond R4.

7 Impacts to TSG RAN specifications

7.1 WG1

This section contains the draft changes to TSG RAN WG1 TS 25.214. Editing note: The revision marks in the section on WG1 specifications indicate the changes with reppect the TS 25.214 v.3.3.0 and should be detained to indicate the difference. Further work is to continue with draft CRs in WG1 on the issue based on the latest version of the 25.214..

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5.2 Downlink power control

The transmit power of the downlink channels is determined by the network. In general the ratio of the transmit power between different downlink channels is not specified and may change with time. However, regulations exist as described in the following subclauses.

Higher layer power settings shall be interpreted as setting of the total power, i.e. the sum of the power from the two antennas in case of transmit diversity.

5.2.1 DPCCH/DPDCH

5.2.1.1 General

The downlink transmit power control procedure controls simultaneously the power of a DPCCH and its corresponding DPDCHs. The power control loop adjusts the power of the DPCCH and DPDCHs with the same amount, i.e. the relative power difference between the DPCCH and DPDCHs is not changed.

The relative transmit power offset between DPCCH fields and DPDCHs is determined by the network The TFCI, TPC and pilot fields of the DPCCH are offset relative to the DPDCHs power by PO1, PO2 and PO3 dB respectively. The power offsets may vary in time. The method for controlling the power offsets within UTRAN is specified in [6]

The power of CCC field in DL DPCCH for CPCH is the same as the power of the pilot field.

UTRAN may use SSDT signalling to determine what power offset to use when more than one cell may be in the active set and TFCI is in split mode. This method is applied to the TFCI field in the cell transmitting PDSCH.

TFCI power offset value to be used depends on whether the cell transmitting PDSCH is determined to be a primary one or not. Power offset values for both cases, a cell being primary (*primary_PO1*) and a cell being non-primary (*non-primary_PO1*), are given by higher layers. The other cells that does not transmit PDSCH has general power offset(PO1).

SSDT commands sent by the UE are averaged in UTRAN side over one or more frames. The averaging window length parameter as the number of frames to average over, *SSDT_aveg_window*, and the parameter for the required number of received primary SSDT commands, *SSDT_primary_commands*, during the averaging window for declaring primary status are given by higher layers. If the number of primary commands received during the averaging window is less than the parameter *SSDT_primary_commands*, then an offset given for the non-primary case is used.

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5.2.1.4 Site selection diversity transmit power control

5.2.1.4.1 General

Site selection diversity transmit power control (SSDT) is an optional macro diversity method in soft handover mode.

Operation is summarised as follows. The UE selects one of the cells from its active set to be ‘primary’, all other cells are classed as ‘non primary’. The main objective is to transmit on the downlink from the primary cell, thus reducing the interference caused by multiple transmissions in a soft handover mode. A second objective is to achieve fast site selection without network intervention, thus maintaining the advantage of the soft handover. In order to select a primary cell, each cell is assigned a temporary identification (ID) and UE periodically informs a primary cell ID to the connecting cells. The non-primary cells selected by UE switch off the transmission power. The primary cell ID is delivered by UE to the active cells via uplink FBI field. SSDT activation, SSDT termination and ID assignment are all carried out by higher layer signalling.

UTRAN may also command UE to use SSDT signalling in the uplink although cells would transmit the downlink as without SSDT active. The downlink operation mode for SSDT is set by higher layers. UTRAN may use the SSDT information for the PDSCH power control as specified in section 5.2.2.

5.2.1.4.1.1Definition of temporary cell identification

Each cell is given a temporary ID during SSDT and the ID is utilised as site selection signal. The ID is given a binary bit sequence. There are three different lengths of coded ID available denoted as "long", "medium" and "short". The network decides which length of coded ID is used. Settings of ID codes for 1-bit and 2-bit FBI are exhibited in table 3 and table 4, respectively.

Table 3: Settings of ID codes for 1 bit FBI

ID label	ID code "long"	"medium"	"short"
a	000000000000000	(0)0000000	00000
b	101010101010101	(0)1010101	01001
c	011001100110011	(0)0110011	11011
d	110011001100110	(0)1100110	10010
e	000111100001111	(0)0001111	00111
f	101101001011010	(0)1011010	01110
g	011110000111100	(0)0111100	11100
h	110100101101001	(0)1101001	10101

Table 4: Settings of ID codes for 2 bit FBI

ID label	ID code (Column and Row denote slot position and FBI-bit position.) "long"	"medium"	"short"
a	(0)0000000 (0)0000000	(0)000 (0)000	000 000
b	(0)0000000 (1)1111111	(0)000 (1)111	000 111
c	(0)1010101 (0)1010101	(0)101 (0)101	101 101
d	(0)1010101 (1)0101010	(0)101 (1)010	101 010
e	(0)0110011 (0)0110011	(0)011 (0)011	011 011
f	(0)0110011 (1)1001100	(0)011 (1)100	011 100
g	(0)1100110 (0)1100110	(0)110 (0)110	110 110
h	(0)1100110 (1)0011001	(0)110 (1)001	110 001

ID must be terminated within a frame. If FBI space for sending a given ID cannot be obtained within a frame, hence if the entire ID is not transmitted within a frame but must be split over two frames, the first bit(s) of the ID is(are) punctured. The relating bit(s) to be punctured are shown with brackets in table 3 and table 4.

5.2.1.4.2 TPC procedure in UE

The TPC procedure of the UE in SSDT is identical to that described in subclause 5.2.1.2 or 5.2.1.3 in compressed mode.

5.2.1.4.3 Selection of primary cell

The UE selects a primary cell periodically by measuring the RSCP of CPICHs transmitted by the active cells. The cell with the highest CPICH RSCP is detected as a primary cell.

5.2.1.4.4 Delivery of primary cell ID

The UE periodically sends the ID code of the primary cell via portion of the uplink FBI field assigned for SSDT use (FBI S field). A cell recognises its state as non-primary if the following conditions are fulfilled simultaneously:

- the received primary ID code does not match with the own ID code;
- the received uplink signal quality satisfies a quality threshold, Qth, a parameter defined by the network;
- and when the use of uplink compressed mode does not result in excessive levels of puncturing on the coded ID. The acceptable level of puncturing on the coded ID is less than (int)N_{ID}/3 symbols in the coded ID, where N_{ID} is the length of the coded ID.

Otherwise the cell recognises its state as primary.

The state of the cells (primary or non-primary) in the active set is updated synchronously. If a cell receives the last portion of the coded ID in uplink slot j, the state of cell is updated in downlink slot (j+1+T_{os}) mod 15, where T_{os} is defined as a constant of 2 time slots. The updating of the cell state is not influenced by the operation of downlink compressed mode.

At the UE, the primary ID code to be sent to the cells is segmented into a number of portions. These portions are distributed in the uplink FBI S-field. The cell in SSDT collects the distributed portions of the primary ID code and then detects the transmitted ID. The period of the primary cell update depends on the settings of the code length and the number of FBI bits assigned for SSDT use as shown in table 5.

Table 5: Period of primary cell update

code length	The number of FBI bits per slot assigned for SSDT	
	1	2
"long"	1 update per frame	2 updates per frame
"medium"	2 updates per frame	4 updates per frame
"short"	3 updates per frame	5 updates per frame

5.2.1.4.5 TPC procedure in the network

In SSDT, a non-primary cell can switch off its DPDCH output (i.e. no transmissions).

The cell manages two downlink transmission power levels, P1, and P2. Power level P1 is used for downlink DPCCH transmission power level and this level is updated as the same way specified in 5.2.1.2 or 5.2.1.3 in compressed mode regardless of the selected state (primary or non-primary). The actual transmission power of TFCI, TPC and pilot fields of DPCCH is set by adding P1 and the offsets PO1, PO2 and PO3, respectively, as specified in 5.2.1.1. P2 is used for downlink DPDCH transmission power level and this level is set to P1 if the cell is selected as primary, otherwise P2 is switched off. The cell updates P1 first and P2 next, and then the two power settings P1 and P2 are maintained within the power control dynamic range. Table 6 summarizes the updating method of P1 and P2.

Table 6: Updating of P1 and P2

State of cell	P1 (DPCCH)	P2 (DPDCH)
non primary	Updated by the same way as specified in 5.2.1.2 or 5.2.1.3 in compressed mode	Switched off
primary		= P1

5.2.2 PDSCH

The PDSCH power control can be based on the following solutions, which are selectable, by the network:

- Inner-loop power control based on the power control commands sent by the UE on the uplink DPCCH.
- Slow power control.

UTRAN may use the SSDT signalling to determine what power offset to use for PDSCH with respect to the associated downlink DCH when more than one cell may be in the active set.

The PDSCH power offset value to be used with respect to the associated DCH depends on whether the cell transmitting PDSCH is determined to be a primary one or not. The power offset values for both cases, a cell being primary (*primary_DSCH_pow*) and a cell being non-primary (*non-primary_DSCH_pow*), are given by higher layers.

The SSDT commands sent by the UE are averaged in UTRAN side over one or more frames. The averaging window length parameter as the number of frames to average over, *SSDT_aveg_window*, and the parameter for the required number of received primary SSDT commands, *SSDT_primary_commands*, during the averaging window for declaring primary status are given by higher layers. If the number of primary commands received during the averaging window is less than the parameter *SSDT_primary_commands*, then an offset given for the non-primary case is used.

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3. Reference

[1] TSG R1-00-1429, Power control of TFCI field for DSCH in soft handover, LG Electronics.