3GPP TSG RAN #21 **RP-03-0477**

Frankfurt, Germany
September 16-19, 2003

Title: **Discussion of scope of WI "Beamforming Enhancements"**
Source: **Alcatel**
Agenda Item: **8.2.3, Beamforming Enhancement**

---

1. Motivation

The scope of the WI "Beamforming Enhancements" was discussed at RAN1#33 meeting.

It was pointed out by several companies that so far no evidence (in the form of e.g. simulation results) has been given in order to demonstrate the feasibility/efficiency of the beam handover algorithms envisaged within the current scope of the WI and/or alternative beamforming solutions.

It was concluded by RAN1 that RAN should decide on how to proceed, e.g. to extend the scope of the WI "Beamforming Enhancements", to create a new WI, or to find a suitable SI (e.g. Radio Link Performance Enhancements).

2. Background

Within the current scope of the WI "Beamforming Enhancements", a beamforming solution coherent with conventional sector handover is envisaged for the beamforming mode using a grid of fixed beams [1]. In the case where a S-CPICH is assigned per beam, a UE transition from one beam to another requires higher layer signalling to inform the UE that it should use another S-CPICH as phase reference.

During the last RAN1#33 meeting, Alcatel informed RAN1 about technical concerns regarding this RNC-based beam handover solution [2]. RNC-based signalling will introduce a delay between determination of a beam and actual usage of this beam by Node B and UE. This delay is on the order of one to several seconds. In this time, the UE may have moved to a beam other than the beam determined as the best beam. Further, the use of uplink measurements to determine the best beam for downlink transmission is problematic, particularly for slowly moving or stationary UEs, as the uplink measurements may not be characteristic for the radio conditions encountered in downlink.

As a possible solution to overcome the drawbacks of beam handover, a fast beam selection mechanism was proposed in [2]. In this scheme, UE selects a best beam among a set of candidate beams to be used for downlink transmission, based on measurements of the S-CPICH signals of the candidate beams. To inform Node B about the selected beam, a beam identifier for the best beam is transmitted by UE within the FBI bits of the uplink DPCCH, similar as with R99/R4/R5 SSDT signalling.

3. Conclusion

Due to technical concerns regarding feasibility and efficiency of the beam handover solutions as currently envisaged within the scope of the WI "Beamforming Enhancements", we propose to extend the scope of the WI in order to include the identification of techniques for facilitating the use of beamforming in UTRAN in an efficient and cost effective way. A draft proposal of a respective WI sheet is presented in the

Appendix. The specifications possibly affected by the proposed extension of the scope of the WI are listed in this draft proposal.

Annex

R1-03-0739 [2] is attached.

References

[1] 3GPP TR 25.887, V1.0.0, 'Beamforming Enhancements (Release 5)', 2001-12.

[2] Alcatel, 'Fast Beam Selection,' 3GPP R1-03-0739, Aug. 2003.

Appendix – Proposal for WI Sheet

--------------- *Beginning of proposed WI Sheet* ---------------

3.3 Beamforming enhancements

Last distributed as: RAN_Work_Items_after_RAN_15 (originally RP-010711)

Work Item Description

Title: Beamforming Enhancements (originally Beamforming)

1 3GPP Work Area

X	Radio Access
	Core Network
	Services

2 Linked work items

None

3 Justification

Beamforming with dedicated pilot symbols or with S-CPICH has potential to improve system capacity. The efficiency and cost effectiveness of beamforming with dedicated pilot symbols or with S-CPICH could be enhanced by defining adequate beamforming techniques and signalling support. Also UTRAN RRM could be improved by defining support for measurements that take into account the possible use of beamforming with S-CPICH or with dedicated pilots only.

4 Objective

The objective of this work item is to identify techniques for facilitating the use of beamforming in UTRAN in an efficient and cost effective way. Further, ~~T~~this work item should define potential new measurements for UTRA FDD for efficient support of~~ of~~ RRM in case beamforming is used in UTRAN.

5 Service Aspects

None/Text

6 MMI-Aspects

None/Text

7 Charging Aspects

None/Text

8 Security Aspects

None/Text

9 Impacts

Affects:	USIM	ME	AN	CN	Others
Yes			X		
No	X	X		X	X
Don't know					

10 Expected Output and Time scale (to be updated at each plenary)

New specifications						
Spec No.	Title	Prime rsp. WG	2ndary rsp. WG(s)	Presented for endorsement at plenary#	Approved at plenary#	Comments
New TR	Beamforming Enhancements	TSG RAN WG1	TSG RAN WG4	TSG RAN#18	TSG RAN#19	

Affected existing specifications				
Spec No.	CR	Subject	Approved at plenary#	Comments
TS 25.133		Requirements for Support of Radio Resource Management (FDD)	TSG RAN#20	
TS 25.433		UTRAN Iub Interface NBAP Signalling	TSG RAN#20	
TS 25.215		Physical layer measurements (FDD)	TSG RAN#20	
TS 25.214		Physical layer procedures (FDD)	TSG RAN#	
TS 25.331		RRC Protocol	TSG RAN#	
TS 25.423		UTRAN Iur Interface RNSAP Signalling	TSG RAN#	
TS 25.306		Radio UE capability	TSG RAN#	

11 Work item raporteurs

Jussi Kähtävä, Nokia.

12 Work item leadership

TSG-RAN WG1

13 Supporting Companies

TSG-RAN

14 Classification of the WI (if known)

	Feature (go to 14a)
	Building Block (go to 14b)
X	Work Task (go to 14c)

14a The WI is a Feature: List of building blocks under this feature

14b The WI is a Building Block: parent Feature

14c The WI is a Work Task: parent Building Block

UTRAN Improvement Feature

--------------- *End of proposed WI Sheet* ---------------

3GPP TSG RAN WG1 #33 **R1-03-0739**

New York, USA
August 25-29, 2003

Agenda Item: **6.2, Beamforming Enhancements**
Source: **Alcatel**
Title: **Fast Beam Selection**
Document for: **Discussion**

Abstract

We discuss a novel fast beam selection technique for the beamforming mode using a "grid of fixed beams". In this scheme, UE selects a best beam among a set of candidate beams to be used for downlink transmission, based on measurements of the S-CPICH signals of the candidate beams. To inform Node B about the selected beam, a beam identifier for the best beam is transmitted by UE within the FBI bits of the uplink DPCCH, similar as with R99/R4/R5 SSDT signalling. This scheme avoids some drawbacks of RNC-based beam handover as envisaged in the TR 25.887.

1. Introduction

In this contribution, we consider the beamforming mode using a "grid of fixed beams" [1]. Beamforming with dedicated pilot symbols or with secondary common pilot channel (S-CPICH) has potential to improve system capacity. In the case where a S-CPICH is assigned per beam, a UE transition from one beam to another requires to inform the UE that it should use another S-CPICH as phase reference.

In TR 25.887 [1], a solution coherent with conventional sector handover is envisaged for 3GPP Release 5. In this 'beam handover' algorithm, the 'best beam' for downlink transmission is determined by RNC based on uplink measurements. RNC informs both UE and Node B on the beam to be used by means of higher layer signalling.

Two fundamental problems of RNC-based beam handover can be identified:

- Use of uplink measurements may result in inaccurate determination of the best beam for downlink transmission due to different small scale fading states in uplink and downlink (e.g. pedestrian or stationary users) and due to mismatch in the beam pointing directions in uplink and downlink.
- RNC-based signalling will introduce a delay between determination of a beam and actual usage of this beam by Node B and UE. This delay is on the order of one to several seconds. In this time, the UE may have moved in a way that a beam other than the beam determined as the best beam would be optimum. As illustrated in Fig. 1 and Table 1, the time to traverse a best beam region can be on the order of a few seconds if the UE is close (within a few 100 meters) to Node B site and the UE velocity is moderate-to-high (> 50km/h).

A further drawback of beam handover is the requirement to implement a grid of fixed beams also in uplink, in order to enable the necessary uplink measurements.

For beamforming using a "grid of fixed beams", a fast beam selection scheme avoiding the above described drawbacks is proposed in the next section.

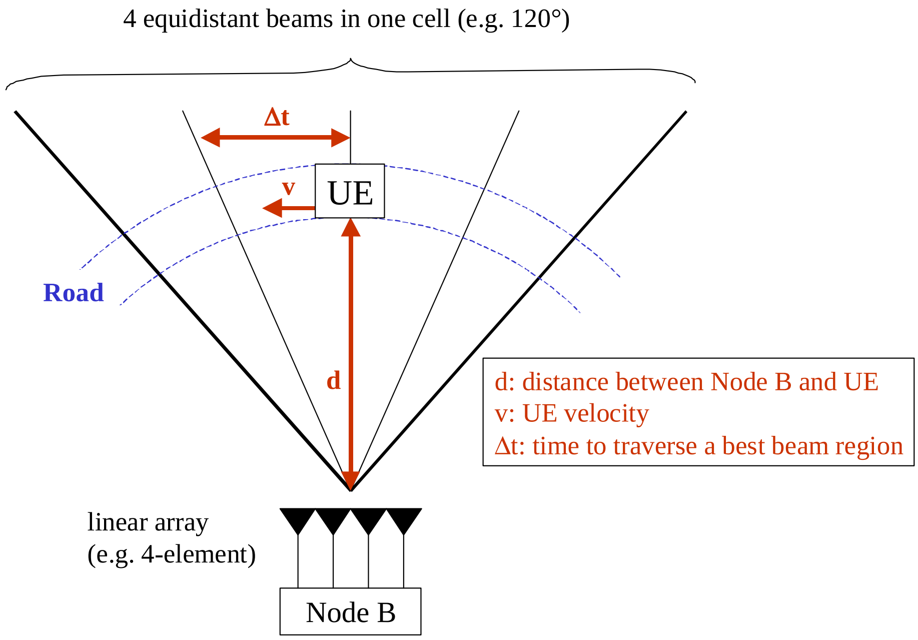

Figure 1: Possible beamforming scenario with UE traversing beams orthogonally.

Table 1: Time πd/6/v to traverse a best beam region depending on distance d between Node B and UE and UE velocity v, when UE moves on a circle around a Node B covering three 120° cells and applying four equidistant beams per 120° cell.

v \ d	100m	1000m	2000m
10 km/h	18.8s	188.5s	377.0s
50 km/h	**3.8s**	37.7s	75.4s
100 km/h	**1.9s**	18.8s	37.7s

2. Fast Beam Selection

Instead of using RNC-based beam handover, we propose to make use of UE-based fast beam selection. In this scheme, UE determines the best beam to be used for downlink transmission based on S-CPICH measurements, for example, received signal code power (RSCP) of S-CPICH.

Fast Layer 1 signalling shall be used to indicate the selected beam to Node B. The selected beam is transparent for RNC.

As this Layer 1 signalling shall be introduced with no or only minor changes of the R99/R4/R5 specifications, we propose to use a similar mechanism as the Layer 1 signalling used for Site Selection Diversity Transmission (SSDT) [2]. In this scheme, RNC informs Node B and UE about candidate beams for downlink transmission and it assigns identifiers to these beams, allowing UE to signal to Node B the identifier of the beam selected for downlink transmission. The beam identifiers are transmitted by UE within the FBI bits of the uplink DPCCH.

As opposed to the R99/R4/R5 SSDT scheme, it is envisaged to use only one beam (or Radio Link) for downlink DPCCH transmission. This is possible in (intra-Node B) beamforming case as Node B can produce a single power control command for the UE (as opposed to the SSDT macro-diversity case, where UE receives a different power control command from every Node B in the active set). In the macro-diversity case, where more than one Node B contributes to the candidate beams several solutions for using DPDCH/DPCCH are possible (ffs).

An example of the proposed fast beam selection mechanism is illustrated in Figure 2. In this example, Node B uses three sectors, each covering 120°. In each sector, Node B uses a grid of (here two) fixed beams for transmission. For that purpose Node B uses multiple Tx antennas in each sector (here 4-element linear arrays). In every beam, Node B radiates a S-CPICH to be used as basis for measurements and as phase reference by the UE. UE performs measurements with a number of candidate S-CPICH signals, the candidates being signalled from RNC. Based on these S-CPICH measurements, UE decides which beam should be used by Node B for transmission to the UE. In analogy to SSDT terminology, we call this beam the 'primary beam', and all other candidate beams 'non-primary'. At a pre-defined time after receipt of the Layer 1 signalling message transmitted by UE to indicate the primary beam, Node B starts using this beam for transmission of data (here DPDCH, but also PDSCH or HS-PDSCH/HS-SCCH could be used) and control information (DPCCH). UE is aware of the beam transition timing and starts using the S-CPICH of the selected beam as phase reference accordingly. In the non-primary beams, the transmission of data is switched off (DPDCH OFF). In Figure 2, also the transmission of DPCCH is switched off in the non-primary beams (DPCCH OFF). Note that in Figure 2 only downlink transmission from Node B to UE is illustrated. In the uplink, Node B is free to use beam patterns different from those used on downlink in order to receive/process the signals transmitted by UE (e.g. fixed beamforming, user-specific beamforming, or any other signal combining technique).

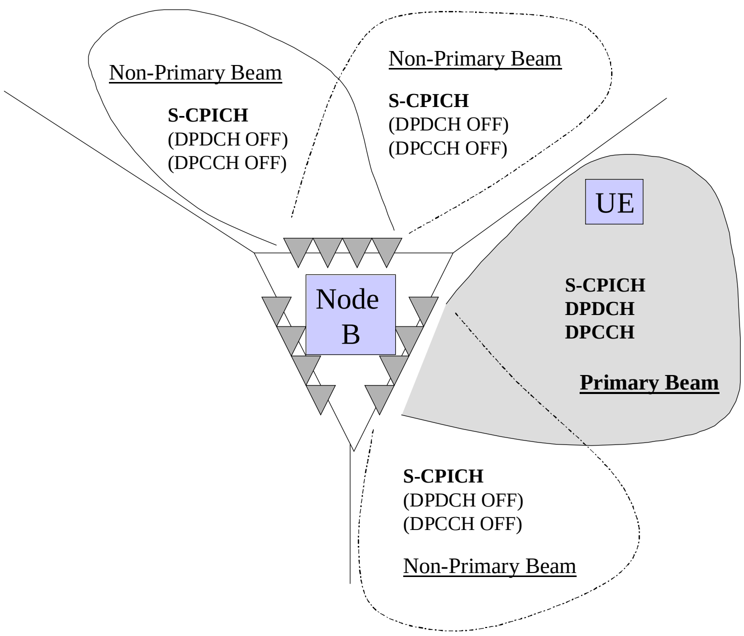

Figure 2: Example of downlink transmission scenario with proposed fast beam selection mechanism. To each beam a S-CPICH is assigned.

3. Summary and Conclusions

We propose a fast beam selection mechanism, particularly suitable for beamforming with a grid of fixed beams. In this scheme, UE selects a best beam among a set of candidate beams to be used for downlink transmission, based on measurements of the S-CPICH signals of the candidate beams. To inform Node B about the selected beam, a beam identifier for the best beam is transmitted by UE within the FBI bits of the uplink DPCCH, similar as with R99/R4/R5 SSDT signalling. Identifiers for the candidate beams are assigned by RNC, and signalled to Node B and UE by means of higher layer signalling.

The proposed scheme has the following advantages:

- Measurements for beam selection are carried out in downlink, thus avoiding bias due to differences in small scale fading states and beam pointing directions in uplink and downlink.
- Low latencies due to Layer 1 signalling of selected beam, making it possible to timely react to UE movements.
- Similar Layer 1 signalling mechanism as used with R99/R4/R5 SSDT, keeping moderate the implementation effort in UE and Node B.
- No grid of fixed beams needed in uplink, thus avoiding uplink calibration in Node B.
- Beam selection is transparent for RNC, thus reducing RNC complexity.

We propose to consider the presented fast beam selection scheme as a possible beamforming enhancement of UTRA/FDD. The major impact of the proposed fast beam selection scheme on the current 3GPP specifications is summarized in the Appendix.

Appendix -- Impact on Specifications

The major impact on the current 3GPP UTRA/FDD specifications to be expected from the proposed fast beam selection transmission scheme (FBST) is summarized in the table below. In this table, the term 'beam' is equivalent with transmission using the same complex-valued antenna weight vector as used for the transmission of the S-CPICH assigned to the beam.

3GPP Specification	Expected Impact
TS 25.211	The ID of beam selected by UE shall be signalled on uplink DPCCH. The exact signalling structure needs to be defined. No changes of R99/R4/R5 DPCCH format required if e.g. FBI S-field of uplink DPCCH is used for signalling of selected beam ID.
TS 25.214	A paragraph on transmit power control with FBST has to be added. This paragraph has similarity with §5.2.1.4 of [2] and contains the following items: • <u>Definition of temporary beam identification:</u> Each candidate beam is given a temporary ID during FBST and the ID is utilised as beam selection signal. The ID is given a binary bit sequence. Similar settings for ID codes and number of FBI bits per slot could be used as with R99/R4/R5 SSDT, cf. §5.2.1.4.1.1 of [2]. • <u>TPC procedure in UE:</u> The UE shall generate TPC commands to control the

	network transmit power and send them in the TPC field of the uplink DPCCH based on the downlink signals from the primary beam as selected by the UE. This procedure is similar as with R99/R4/R5 SSDT, cf. §5.2.1.4.2 of [2]. • Selection of primary beam: The UE selects a primary beam periodically by measuring e.g. the RSCP of S-CPICHs transmitted by the candidate beams. The beam with the highest S-CPICH RSCP is detected as a primary beam. This procedure is similar as with R99/R4/R5 SSDT, cf. §5.2.1.4.3 of [2]. • Delivery of primary cell ID: The UE periodically sends the ID code of the primary beam via portion of the uplink FBI field assigned for FBST use (e.g. FBI S field). A beam recognises its state as non-primary if certain conditions are fulfilled. These conditions need to be defined. Otherwise the beam recognises its state as primary. The state of the beams (primary or non-primary) in set of candidate beams shall be updated synchronously. The exact timing relations need to be defined. At the UE, the primary ID code to be sent to the beams is segmented into a number of portions. These portions are distributed in e.g. uplink FBI S-field. The beam in FBST collects the distributed portions of the primary ID code and then detects the transmitted ID. The period of the primary beam update depends on the defined settings of the code length and the number of FBI bits assigned for FBST use. This procedure is similar as with R99/R4/R5 SSDT, cf. §5.2.1.4.4 of [2]. • TPC Procedure in the network: In FBST, a non-primary beam can switch off its DPDCH/PDSCH/HS-PDSCH/HS-SCCH output and its DPCCH output (i.e. no transmissions). R99/R4/R5 SSDT is confined to transmission of DPDCH/DPCCH. FBST should be applicable also to PDSCH/HS-PDSCH/HS-SCCH. With R99/R4/R5 SSDT, DPCCH is transmitted in every cell of active set. With FBST, we can distinguish between Intra-Node B case (all candidate beams transmitted from same Node B) and Inter-Node B case (candidate beams transmitted from at least two Node Bs). In Intra-Node B case, DPCCH can be switched off for a non-primary beam. In Inter-Node B case, several solutions for transmission of data and control information are possible (ffs). A definition of the TPC procedure in the network is required, likely different from the procedure of R99/R4/R5 SSDT.
TS 25.215	The UE measurement abilities in §5.1.1 of [3] need to be extended to include the measurements necessary for FBST. For example, UE could select the beam having largest received signal code power (RSCP) of S-CPICH in the set of candidate beams. In this case, the definition of RSCP of CPICH in §5.1.1 of [3] must be adapted so as to distinguish between

	RSCP of P-CPICH and RSCP of S-CPICH.
TS 25.133	The measurement performance for UE in §9.1 of [4] need to be extended to include the measurements necessary for FBST. For example, UE could select the beam having largest received signal code power (RSCP) of S-CPICH in the set of candidate beams. In this case, the measurement performance of RSCP of CPICH in §9.1 of [4] must be adapted so as to distinguish between RSCP of P-CPICH and RSCP of S-CPICH.
TS 25.331	RRC signalling for activation and termination of fast beam selection, and for ID assignment of candidate beams.
TS 25.423	RNSAP signalling for activation and termination of fast beam selection, and for ID assignment of candidate beams.
TS 25.433	NBAP signalling for activation and termination of fast beam selection, and for ID assignment of candidate beams.

References

[1] 3GPP TR 25.887, V1.0.0, ‘Beamforming Enhancements (Release 5)’, 2001-12.

[2] 3GPP TS 25.214, V5.5.0, ‘Physical Layer Procedures (FDD) (Release 5),’ 2003-06.

[3] 3GPP TS 24.215, V5.4.0, ‘Physical Layer – Measurements (FDD) (Release 5),’ 2003-06.

[4] 3GPP TS 25.133, V5.7.0, ‘Requirements for Support of Radio Resource Management (FDD) (Release 5),’ 2003-06.