TSG-RAN meeting #16 RP-020357
Marco Island, USA, June 4 – 7, 2002

# Status Report for WI to TSG

## Work Item Name: Beamforming Enhancements

**SOURCE:** Rapporteur **TSG: RAN** **WG: 1**

**E-mail address rapporteur: jussi.kahtava@nokia.com**

**Ref. to WI sheet:** RAN_work_items.doc

## Progress Report since the last TSG (for all involved WGs):

RAN1:
Definition of the measurement for best received cell portion was included.

RAN3, RAN4:
No progress

## List of Completed elements (for complex work items):

## List of open issues:

Requirements on the accuracy of measurements.
RAN3 checking of the Iub signalling requirements.

## Estimates of the level of completion (when possible):

40%

## WI completion date review resulting from the discussion at the working group:

12/2002 (TSG-RAN#18)

## References to WG's internal documentation and/or TRs:

[1] R1-02-0767, "TR25.887 V1.1.0", Rapporteur

# 3G TR 25.887 V1.1.0 (2002-05)

*Technical Report*

## 3rd Generation Partnership Project;
## Technical Specification Group Radio Access Network;
## Beamforming Enhancements
## (Release 6)

Beamforming Enhancements

<keyword[, keyword]>

***3GPP***

Postal address

3GPP support office address

650 Route des Lucioles - Sophia Antipolis
Valbonne - FRANCE
Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Internet

http://www.3gpp.org

# Contents

# Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

# Introduction

At RAN#13 plenary meeting, a work item on Beamforming was approved. Beamforming with dedicated pilot symbols or with S-CPICH has potential to improve system capacity. 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.

# 1 Scope

The scope of this TR is to define potential measurements for UTRA FDD and their performance requirements for efficient support of RRM in case beamforming is used in UTRAN.

# 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] TS25.133 : Requirements for support of radio resource management (FDD)

[2] TS 25.211 : Physical channels and mapping of transport channels onto physical channels (FDD)

[3] TS 25.213 : Spreading and modulation (FDD)

[4] TS 25.214 : FDD : Physical layer procedures

[5] TS 25.302 : Services provided by the Physical Layer

[6] TS 25.331 : Radio Resource Control (RRC) Protocol Specification

[7] TS 25.423 : UTRAN Iur Interface RNSAP Signalling

[8] TS 25.433 : UTRAN Iub Interface NBAP Signalling

[9] TS 25.435 : UTRAN interface User Plane Protocol for Common Transport channel Data Streams

# 3. Definitions, symbols and abbreviations

## 3.1 Definitions

**Beamforming antennas:** an array of antennas used to form one or several portions within a cell with controlled antenna radiation patterns.

**Cell portion:** A part of a cell that is covered by a specific beam antenna radiation pattern, which is can be created, e.g. by applying a specific weight vector on the beamforming antenna or using a grid of fixed beam directions.

**Flexible beamforming:** beamforming antennas where the uplink and downlink beams are formed by the application of weight vectors to the received and transmitted signals to control the relative phase between the signals applied at the antenna elements. The weight vectors, and hence beam directions, are flexible.

**Beamforming with grid of fixed beams:** beamforming antennas where the uplink and downlink beams are formed in such a way that the beam directions are fixed.

## 3.2 Symbols

## 3.3 Abbreviations

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

| | |
|---|---|
| BER | Bit Error Rate |
| BLER | Block Error Rate |
| Ec/No | Received energy per chip divided by the power density in the band |
| ISCP | Interference Signal Code Power |
| RL | Radio Link |
| RSCP | Received Signal Code Power |
| RSSI | Received Signal Strength Indicator |
| SIR | Signal to Interference Ratio |

# 4. Applicability of performance requirements and measurements.

The performance requirements and measurements outlined in this TR require the presence of beamforming antennas, as defined above, and therefore shall only apply where such beamforming antennas are present. This is because the application of the performance requirements and measurements to Node B’s which do not otherwise support beamforming antennas would add cost and complexity to these Node Bs.

# 5. Performance requirements for beamforming related measurements

*[Requirements on the accuracy of the measurements for RRM support of beamforming are to be defined in this section.]*

*This section could be renamed to something like "Requirements on measurements for support of RRM for beamforming" and moved after the measurement section.*

# 6. Measurements for RRM support of beamforming

The following UTRAN measurements are proposed to be extended/added to provide support for RRM in case beamforming is used:

- Received total wide band power: The measurement is reported per cell portion.
- Transmitted carrier power: The measurement is reported per cell portion.

# 7. Overview of the changes required in the specification

## 5.1 RAN WG1

TS25.215 sections on received total wide band power and transmitted carrier power are updated to include description on beamforming antennas.

### 5.2.1 Received total wide band power

| | |
|---|---|
| **Definition** | The received wide band power, including noise generated in the receiver, within the bandwidth defined by the pulse shaping filter. In case of receiver diversity the reported value shall be linear average of the power in the diversity branches. The reference point for the Received total wide band power measurement shall be the output of the pulse shaping filter in the receiver. In case of beamforming antennas the total received wideband power shall be measured for each cell portion. |

### 5.2.2 SIR

| | |
|---|---|
| **Definition** | Signal to Interference Ratio, is defined as: (RSCP/ISCP)×SF. Measurement shall be performed on the DPCCH of a Radio Link Set. In compressed mode the SIR shall not be measured in the transmission gap. For PRACH, the measurement shall be performed on the PRACH control part.The reference point for the SIR measurements shall be the Rx antenna connector.<br><br>where:<br><br>RSCP = Received Signal Code Power, unbiased measurement of the received power on one code.<br>ISCP = Interference Signal Code Power, the interference on the received signal.<br>SF=The spreading factor used on the DPCCH or the control part of the PRACH. |

### 5.2.4 Transmitted carrier power

| | |
|---|---|
| **Definition** | Transmitted carrier power, is the ratio between the total transmitted power and the maximum transmission power. Total transmission power is the mean power [W] on one carrier from one UTRAN access point. Maximum transmission power is the mean power [W] on one carrier from one UTRAN access point when transmitting at the configured maximum power for the cell. Measurement shall be possible on any carrier transmitted from the UTRAN access point. The reference point for the transmitted carrier power measurement shall be the Tx antenna connector. In case of Tx diversity the transmitted carrier power for each branch shall be measured and the maximum of the two values shall be reported to higher layers, i.e. only one value will be reported to higher layers. In case of beamforming antennas the transmitted carrier power for each cell portion shall be measured and reported to higher layers. |

### 5.2.x Best received cell portion

| | |
|---|---|
| **Definition** | The measurement reports the cell portion with the highest measured SIR. |

## 5.2 RAN WG3

The measurements specified to support beamforming require some signalling support over the Iub in order to be useful. The Node-B beamforming capability is required to be known by the RNC. The possible modes are (“none”, “flexible beam”, “grid of fixed beams”). A capability of “none” means that beamforming antennas, as defined above, are not provided. This does not exclude the application of other non-standardised (uplink) schemes using antenna arrays which do not require support in the specifications. The following messages are suggested:

- Beamforming mode to apply: “none”, “flexible beam”, or “grid of fixed beams”.
- The average wideband power measurements (uplink and downlink) should be reported from the Node-B to the RNC over the Iub interface. Thus, a measurement message should be sent for each cell portion (1,2,…,*N*) in addition to the sector wideband measurement. The reporting of these measurements could be on request or periodic, as specified for the sector wideband measurements. If the beamforming mode is “none”, then only sector wideband measurements are reported.
- If the beamforming mode is “flexible beam” or “grid of fixed beams”, information should be added to the "Node-B configuration message", so that the RNC obtain information on the number of beams (*N*), in which the Node-B conducts wideband power measurements for RRM purposes.
- The beamforming specific Node-B measurements are intended for RRM purposes such as admission control (AC), packet scheduling (PS), etc. During a random access procedure, if beamforming is used in a Node-B, the RNC should therefore also know in which cell portion the new UE is located. This information is required in order to be able to make a decision on whether the UE can get a call accepted. The cell portion of the new UE is equivalent to the portion of the uplink where the highest SIR is received from that particular UE. This can be accomplished by introducing a new procedure during random access, e.g. before deciding on admission, the RNC asks the Node-B to perform a best cell portion measurement. Alternatively, this could be accomplished by adding the cell portion index to each random access message sent from the Node-B to the RNC.
- Similar action has to be taken during soft handover (SHO) where the RNC needs the information of which cell portion the UE belongs to. This information is needed in the AC in order to decide for available resources before the new radio link is created. This can be accomplished by e.g., asking the Node-B to perform a best cell portion measurement before deciding if the new link should be created.
- In addition to the special behaviour related to random access and SHO, there is also an issue for the RNC to signal to the Node-B in which cell portion to transmit a certain link to a certain UE. This requires an addition to the signaling scheme that is used in the present version of the specification.
- For scenarios where the Node-B uses beamforming mode “grid –of fixed beams” or “flexible beam” with one SCPICH assigned per beam, there are additional considerations. For this particular case, a UE transition from one beam to another require higher layer signalling, since the UE needs to get informed that it should use another

SCPICH. To be able to handle this the following signalling between Node-B and RNC is needed for the case where beamforming is applied with a SCPICH per beam:

- For each UE, the Node-B should measure the uplink received power of the of the pilot symbols in all the beams where a SCPICH is assigned. These measurements should be locally averaged in the Node-B before they are reported to the RNC. The length of the power averaging window is selected by the RNC. In order to reduce the Iub signalling load, we could chose to only report the strongest measurements to the RNC.

- Based on these measurements, the RNC determines whether a beam handover is needed or not. Hence, the beam handover algorithm can be implemented in coherence with the conventional sector handover algorithms.

## 5.3 RAN WG4

# Annex A (informative): Node B implementation aspects

Flexible beamforming generally requires a calibrated array in both uplink and downlink. In the uplink this means that the relative phase between the signals is controlled (to within some margin of error), from the antenna elements until the beams are formed by the application of the weight vector and summation. This may require special measures in the antenna network, feeder system and within the Node B itself (filters, mixers, LNAamplifiers etc.), depending where and how the application of the weight vector and summation is performed. In the uplink these measures would not be required in the absence of beamforming antennas, even in the case of alternative proprietary solutions for weighting and combining signals from an antenna array.

Similarly, flexible beamforming on the downlink requires that the relative phase between the signals is controlled (to within some margin of error), from the point where the signal to be transmitted in a beam is split in to one path per antenna (prior to application of the weight vector), until the antenna elements. This may require special measures in the antenna network, feeder system and within the Node B itself (filters, mixers, power amplifiers etc.) depending where and how the application of the weight vector is applied.

For cases where the beams are generated externally to the Node B, the above mentioned requirements do not apply.

# Annex B:
# Change history

| Change history | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Date** | **TSG #** | **TSG Doc.** | **CR** | **Rev** | **Subject/Comment** | **Old** | **New** |
| 23.11 | RAN1#22 | R1-01-1342 | | | Approved in RAN WG1 to be provided for TSG-RAN for information | 0.0.1 | 1.0.0 |
| 16.05 | RAN1#26 | R1-02-0767 | | | Approved in RAN WG1 to be provided for TSG-RAN for information | 1.0.0 | 1.1.0 |
| Rapporteur for 3GPP RAN TR 25.887 is: | | | | | | | |
| Jussi Kähtävä<br>Nokia-Japan Co., Ltd.<br>Tel. : +81 3 5759 7471<br>Fax : +81 3 5740 6833<br>Email : jussi.kahtava@nokia.com | | | | | | | |
| This document is written in Microsoft Word version 2000. | | | | | | | |