3GPP TSG RAN WG 1 ***TSGR1#19 R1-01-0404***
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Agenda Item: Adhoc 26

Source: Nokia, Siemens

Title: Text proposal for WG 1 report on Tx diversity for multiple antennas on general issues

Document for: Discussion and approval

Summary:

The contents of this text proposal covers some general issues on Tx diversity with multiple antennas like introduction, goals and general complexity that need to be considered regardless of the specific method used. Some input was extracted from Tdoc R1-00-1040 and Tdoc R1-00-0867.

References

[1] Nokia, "Text proposal for extended closed loop mode 1 concept to Tx diversity TR", Tdoc R1-00-1040

[2] Nokia, "Recommended simulation parameters for Tx diversity simulations", Tdoc R1-00-0867

3G TR ab.cde V0.0.0(2000-07)

Technical Report

3rd Generation Partnership Project; Technical Specification Group Radio Access Network; RAN WG1 report on Tx diversity solutions for multiple antennas (Release ~~2000~~5)

Keywords

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Contents

Foreword

This Technical Specification 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:

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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.

1 Scope

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.

[<seq>] <doctype> <#>[([up to and including]{yyyy[-mm]|V<a[.b[.c]]>}[onwards])]: "<Title>".

[1~~1~~] 3G TS 25.211~~123~~ (V3.5.0): "Physical channels and mapping of transport channels onto physical channels (FDD)~~Example 1, using sequence field~~".

[2] 3G TR 25.214~~9.456~~ (V3.5~~1~~.0~~0~~): "Physical layer procedures (FDD)~~Example 2, using fixed text~~".

[3] 3G TS 25.221 (V3.5.0): "Physical channels and mapping of transport channels onto physical channels (TDD)".

[4] 3G TS 25.224 (V3.5.0): "Physical layer procedures (TDD)".

[5] Nokia. Recommended simulation parameters for Tx diversity simulations. TSG-R WG1 document, TSGR1#14(00)0867, July 4-7, 2000, Oulu, Finland, 5 pp.

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the [following] terms and definitions [given in ... and the following] apply.

Definition format

<defined term>*: <definition>.*

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

3.2 Symbols

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

Symbol format

<symbol> <Explanation>

3.3 Abbreviations

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

Abbreviation format

<ACRONYM> <Explanation>

4 Background and Introduction

[from Tdoc R1-00-1040:]

The standardization of 3rd generation WCDMA system has been going on in 3rd Generation Partnership Project (3GPP) since the end of 1998. The 3G systems bring a promise of much higher data rates and enhanced services when compared to 2G systems. As many of the proposed services, like wireless web browsing, are expected to be downlink-intensive it was recognized from the very beginning that improvement of downlink capacity is one of the main challenges.

Performance of radio system depends on various issues but one important factor is the available diversity (time, frequency, multipath etc.). Due to wide bandwidth WCDMA systems are especially effective in exploiting the multipath diversity existing in time dispersive radio environments. If little or no multipath diversity is available the performance can degrade quite considerably. One way of improving the situation is to utilize 2 or more receive and/or transmit antennas that effectively speaking introduce additional radio paths and thereby increase the available diversity. As receiver antenna diversity is implementation wise challenging especially for low cost terminals a lot of attention have been paid to various transmit diversity solutions to be employed on radio access network side.

During 1999 a great deal of effort was put on defining transmit diversity solutions for Rel.-99 of 3GPP WCDMA specifications. As a result two open loop techniques, Space Time Transmit Diversity (STTD) and Time Switched Transmit Diversity (TSTD), and closed loop solution based on Transmit Adaptive Array (Tx AA) concept with two different modes were standardized for FDD [1,2]. For TDD, TSTD and Block STTD open loop methods can be used on SCH and P-CCPCH, respectively, and closed loop methods on DPCH [3, 4]. All the Rel.-99 Tx diversity methods assume two transmit antennas.

Already during 1999 it was recognized that further performance improvements could be possible by increasing the number of transmit antennas. Yet, it was agreed that Tx diversity for more than 2 antennas will be studied ~~during 2000~~ for possible inclusion to Rel.-5~~00~~ of 3GPP specifications. The following chapters describe the proposed concepts, present the performance results, consider the impacts on UE and UTRAN implementation, and physical layer operation, and, finally, present issues related to backwards compatibility to Rel.-99 followed by conclusions.

5 Descriptions of studied concepts

6 Performance

6.1 Link level simulation assumptions

6.1.1 Regular simulation assumptions

[from Tdoc R1-00-0867]

Table 1 lists the simulation parameters that should be used in the Tx diversity simulations.

Table 1. Recommended simulation parameters for multiantenna Tx diversity simulations.

Bit Rate	12.2 kbps
Chip Rate	3.84 Mcps
Convolutional code rate	1/3
Carrier frequency	2 GHz
Power control rate	1500 Hz
PC error rate	4 %
PC Step Size	1 dB per antenna
Channel model(s) and UE velocities	1-path Rayleigh: 3, 10, 40, 120 km/h Modified ITU Ped A: 3, 10, 40 km/h

	Modified ITU Veh. A: 10, 40, 120 km/h
CL feedback bit error rate	4 %
CL feedback delay	1 slot
TTI	20 ms
Downlink DPCH slot format	#10 or #11
Min. # of RAKE fingers for modified Vehicular A channel	5
Target FER/BlkER	1 %
Geometry (G)	-3, 0 and 6 dB
Common Pilot	-10 dB total
Correlation between antennas	0
Performance measure	$T_x E_b/I_{or}$
CL feedback rate	1500 Hz

The following notes should be taken:

1. Definition of Tx E_b/I_{or}

E_b = The average energy per information bit as measured at the base station. Defined after CRC attachment but before channel encoding.

I_{or} = The total power density of the base stations in soft handoff with the mobile, measured at the base station

2. Definition of Geometry (G)

Geometry, G, is defined as:

$$G ? \frac{average(R_x I_{or})}{I_{oc} ? N_o}$$

where,

$R_x I_{or}$ = The total power density of the base stations in soft handoff with the mobile, measured at the mobile station

I_{oc} = The interference power density at a mobile due to all the base stations not in soft handoff with the mobile

N_o = The thermal noise power spectral density

3. Power control step size

The power control step size is 1 dB per antenna. This means that when up/down command is received the tranmitter increases/decreases the Tx power per antenna by 1 dB which also results in 1 dB increase/decrease of the total Tx power.

4. Modeling of downlink channels

The only common channel modeled in downlink is the CPICH. The detailed implementation of the CPICH can vary but the total power allocated to it is 10 % of the total Tx power of the BS. This 10 % allocation needs to be valid only in the beginning of the simulation, i.e. the CPICH total power is kept fixed during the simulation. Thus, the change of the user signal power due to power control does not affect the total CPICH Tx power.

5. Modified ITU channel models

As all of the path delays of the ITU channel models will not be multiples of the the length of one chip the channel models will be modified. In case a path (ray) is between two channel delay samples, the following modification will be done:

?? The ray is split into two rays, one to the sample to the left and one to the sample to the right. The power of these new rays is such that the sum is equal to the original power, and the power of each of the new rays is proportional to the (1-normalised distance to the original ray). Finally, the power of all rays on one sample are added up and normalised to yield total channel power of 1.

Consider the example shown in the Figure 1. In this case a path of power P located between two delay samples (T_c = length of a chip in time) is split to two separate paths with power 0.75P at delay sample k and power 0.25P at delay sample k+1.

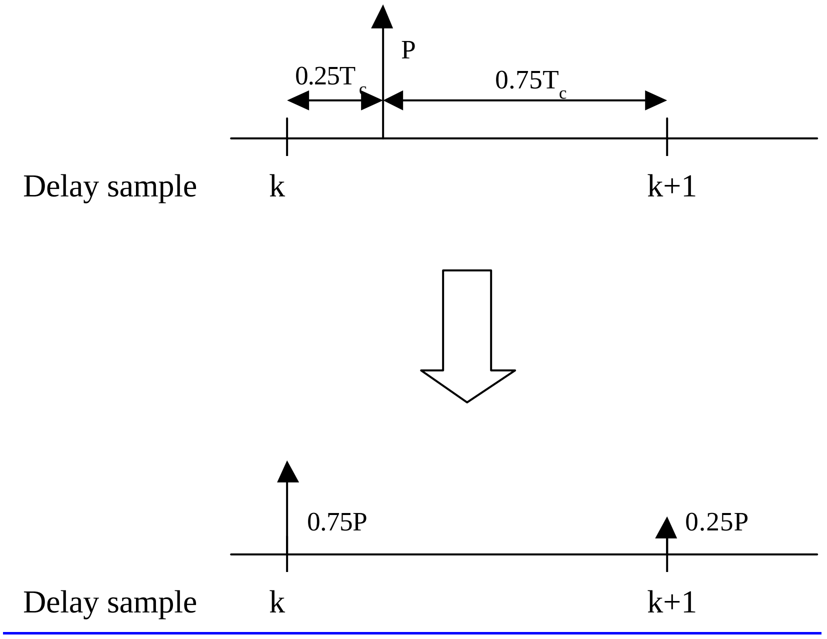

Figure 1. Example of a modification of one path.

6. Number of RAKE fingers

As the ray splitting technique leads to a high number of channel taps in case of Vehicular A channel the minimum number of RAKE fingers that should be used in simulations has been set to 5.

6.2 Link level simulation results

6.3 System level evaluation

[from Tdoc R1-00-1040

System level evaluations are necessary to get the full understanding of e.g. impacts of different Tx diversity schemes on the cellular capacity. Generally speaking, however, decreased Tx E_c/I_{or} results in improved cellular performance. For example, when considering the cellular capacity, halving the Tx power roughly speaking doubles the capacity.

One issue to consider is the power allocated to CPICH and co-existence of terminals based on different specification releases. As such, the Tx power of the CPICH is not standardized, and it is up to the operator to define how much of the total BS power will be allocated to CPICH. As Rel.-99 terminals can utilize CPICH transmitted from 2 antennas some care must be taken when doing the network planning in case there are more than 2 Tx antennas. In Tx diversity simulations it has been assumed that the total CPICH power is 10 % of the BS power. That assumption may be too optimistic in a real deployment scenario due to existing Rel.-99 terminals. As a kind of worst case analysis you could define that when going from 2 to 4 Tx antennas the total Tx power of the CPICH will also be doubled. That would correspond to about 0.5 dB loss in Tx E_c/I_{or} performance when compared to the assumed 10 % CPICH power allocation. The worst case analysis does not account for the fact that increased CPICH power could improve channel estimation, weight calculation and weight verification performance.

7 Impacts to UE and UTRAN implementation

7.1 Impacts to UE implementation

7.1.1 General impacts to UE implementation

[from Tdoc R1-00-1040]

Main complexity increase comes from RAKE implementation as number of channel estimation units increases as a function of the number of Tx antennas. Yet, even in the case of 4 Tx antennas the complexity increase due to 4 channel estimators per finger is considered to be small when compared to the case of 2 Tx antennas with 2 estimators per finger.

When CPICH based channel estimation is used some kind of weight verification algorithm seems to be necessary. That holds also for Rel.-99 mode 1. Thus, additional complexity increase comes from the need to perform the verification for e.g. 4 antennas instead of 2. The complexity increase is considered to be small although more detailed analysis is needed for the more advanced verification algorithms.

Note that if the feedback rate is kept the same as in Rel.-99, short term calculation of the feedback commands requires about the same effort as in Rel.-99 based terminals. For concepts that exploit correlation between antenna elements additional complexity is needed for the long term analysis. This is regarded as small compared to the complexity needed for calculating the short term feedback commands.

7.2 Impacts to UTRAN implementation

7.2.1 General impacts to UTRAN implementation

[from Tdoc R1-00-1040]

If the number of Tx antennas is increased, the number of power amplifiers is increased accordingly. However, Tx power per amplifier can be lower as the total power is split between several amplifiers by which the PA requirements can be alleviated.

8 Impacts to physical layer operation

8.1 Definition of additional orthogonal pilot sequences

[from Tdoc R1-00-1040]

Additional orthogonal dedicated pilot sequences should be defined as many verification methods require the use of them. For dedicated pilot of length > 2 bits it is easy to do but the special case of length 2 bit pilot is more problematic. Some further studies on verification algorithms are needed.

CPICH used for weight calculation at UE should be transmitted from all of the Tx antennas. Furthermore, the CPICH from the different antennas should be orthogonal. Thus, additional orthogonal symbol sequences for Primary-CPICH should be defined or, alternatively, Secondary-CPICHs could be used.

9 Backwards compatibility to Release-99

109 Conclusions

History

Document history		
Date	**Version**	**Comment**
	0.0.0	
Editor for 3G TR xx.xxx is:		
Tel. : Fax : Email :		
This document is written in Microsoft Word version.		