3GPP TSG RAN WG1#15 **TR1-00-1074**

Berlin, Germany, 22nd – 25th August, 2000

Agenda item:

Source: Samsung

Title: Proposed TR for Transmit diversity for more than 2 antennas

Document for: Discussion and approval

Summary:

Further enhancements of the Tx diversity solutions of Rel.-99 belong to a study item called “Radio link performance enhancements”. Before the new solutions can be incorporated to Rel.-00 TSG-R1 should agree on the inclusion of the new solutions and submit a technical report to RAN.

In this contribution a text input to the technical report on the proposed basis selection scheme for multiple Tx antennas are presented[1]-[4].

References

[1] R1-00-0506, “Proposal for the use of closed loop Tx diversity with more than 2 Tx antennas,” TSG-RAN WG1#12, Seoul, Korea, April 2000

[2] R1-00-0683, “Further simulation results of Tx diversity for more than 2 antennas,” TSG-RAN WG1#13, Tokyo, Japan, May 2000

[3] R1-00-0882, “Preliminary version of algorithm and Simulation results for Tx Diversity with more than 2 Tx Antennas,” TSG-RAN WG1#14, Oulu, Finland, July 2000

[4] R1-00-1073, “Performance results of basis selection transmit diversity for 4 antennas,” TSG-RAN WG1#15, Berlin, German, August 2000

3G TR ab.cde V0.0.0(2000-08)

Technical Report

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

Keywords

<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 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:

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.

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~~ (v3.3.0): "~~Example 1, using sequence field~~Physical channels and mapping of transport channels onto physical channels (FDD)".

[2~~2~~] 3G~~-~~ TS ~~R-~~25~~9~~.214~~456~~ (v3.3.0~~V3.1.0~~): "Physical layer procedures (FDD)~~Example 2, using fixed text~~".

[3] 3G TS 25.221 (v3.3.0): “Physical channels and mapping of transport channels onto physical channels (TDD)".

[4] 3G TS 25.224 (v3.3.0): "Physical layer procedures (TDD)".

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

[6] R1-00-0882, “Preliminary version of algorithm and Simulation results for Tx Diversity with more than 2 Tx Antennas,” TSG-RAN WG1#14, Oulu, Finland, July 2000

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

5 Descriptions of studied concepts

5.1 Basis selection scheme for > 2 Tx antennas

5.1.1 Tx antenna weights

In closed loop Tx diversity systems, the weights of transmit antennas are determined at a mobile station and fed back to the base station. These weights should result in as high SNR as possible at the mobile. The set of these weights may be viewed as a vector $w= [w_1\ w_2 \ldots w_i \ldots w_M]^T$, where w_i is a complex weight associated with the ith Tx antenna. For the maximum SNR at the mobile, the weights should maximize P below:

$$P = \underline{w}^H H^H H \underline{w}, \qquad (1)$$

when $H=[h_1\ h_2 \ldots h_i \ldots h_M]$ and M is the number of Tx antennas. The column vector h_i represents an estimated channel impulse response for the ith Tx antenna, and its vector length equals to the number of paths. The weight vector w information is periodically fed back to the base station. Note that the amount of feedback information and the implementation complexity increase with the number of Tx antennas. The efficient representation of a weight vector is desired to reduce the amount of feedback data and the implementation complexity. Furthermore, backward compatibility is desirable.

A weight vector with M elements may be represented as a linear sum of basis vectors, which span an M-dimensional space. Examples of basis vectors for 2-, 3-, 4-dimensional spaces are shown in Appendix A of [6]. Let's assume for explanation that 4 Tx antennas are used for Tx diversity. The optimal weight vector w_{opt} for this system has 4 elements and may be represented as a linear sum of four basis vectors, B_1, B_2, B_3, B_4, as follows:

$$\underline{w}_{opt} = c_1 \underline{B}_1 + c_2 \underline{B}_2 + c_3 \underline{B}_3 + c_4 \underline{B}_4 \qquad (2)$$

where $c_1,\ldots,c_4$ are complex coefficients associated with corresponding vectors. Assuming that $|c_1|>|c_2|>|c_3|>|c_4|$, we may approximate w_{opt} as

$$\underline{w}_{app\_1} \cong c_1 \underline{B}_1, \qquad (3a)$$

$$\underline{w}_{app\_2} \cong c_1 \underline{B}_1 + c_2 \underline{B}_2, \qquad (3b)$$

$$\underline{w}_{app\_3} \cong c_1 \underline{B}_1 + c_2 \underline{B}_2 + c_3 \underline{B}_3, \qquad (3c)$$

These vectors w_{app_1}, w_{app_2}, w_{app_3}, may be viewed as the projections of w_{opt} into 1-dim, 2-dim, and 3-dim subspaces. w_{app_3} is more accurate representation of w_{opt} than w_{app_1} and w_{app_2}.

5.1.2 Representation of weight vectors

The conventional representation of the vector w_{opt} may require $(M-1)*N_c$ bits, where N_c bits are required to represent each element of w_{opt}. This representation indicates that the transmission of $(M-1)*N_c$ bits at 1500Hz is required to support Tx diversity with M Tx antennas. The reason for $(M-1)*N_c$ not $M*N_c$ is that one of M Tx antennas may be viewed as reference and the relative weights for other antennas are required. To reduce the required number of bits, we propose to feedback information on the approximated vector, instead of w_{opt}. The representation of the approximated vector includes the specification of basis vectors and associated coefficients. When there are *M* Tx antennas and the approximation is made in a *S*-dimensional subspace, there are ${}_{M}C_{S}$ combinations for selecting *S* basis vectors among *M* vectors and the required number of bit to specify the basis vector combination is $\lceil \log_2({}_{M}C_{S}) \rceil$.

5.1.3 Feedback protocol structure

In the simulation, we consider the two cases for antenna selection: **Case 1)** 2 antenna selection (*M*=4, *S*=2), it noted as 4C2 and **Case 2)** 3 antenna selection (*M*=4, *S*=3), it noted as 4C3. In both cases, 2bit representation for each element (phase only) is used (N_c = 2). The required number of feedback information per signaling word is: **Case 1)** 5 bits, and **Case 2)** 6bits. For detail simulation scheme, we can refer section 6.2.1. The considered frame format of feedback information is:

(Case 1: 2 best selection among 4 antenna and combine all 2 with received phase information)

slot	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
FBI	S_1	S_2	S_3	P_1	P_2	S_1	S_2	S_3	P_1	P_2	S_1	S_2	S_3	P_1	P_2

S_i: Antenna selection bits

P_i: Phase difference with respect to the coefficient associated with the first basis vector

(Case 2: 3 best selection among 4 antenna and combine all 3 with received phase information)

slot	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
FBI	S_1	S_2	P_{11}	P_{12}	P_{21}	P_{22}	S_1	S_2	P_{11}	P_{12}	P_{21}	P_{22}	S_1	S_2	P_{11}

S_i: Antenna selection bits

P_{ij}: Phase difference with respect to the coefficient associated with the first basis vector

6 Performance

6.1 Link level simulation assumptions

6.1.1 Basis selection for > 2 Tx antennas

Basic link level simulation assumptions described in [5] and additional assumptions descried Table 1 were used.

Table 1. Additional simulation parameters.

Comparing output	*Ec/Ior*
Modulation	*QPSK*
Physical channel rate	*30ksps*
Number of antennas	*Release 99: 2, Release 2000: 4 (New)*
Total FSM bits	*Release 99* — *Mode2: 4bits* *Release 2000* — *Case I (4C2): 5bits* *Case II (4C3): 6bits*
Slot format	*#10 (6,2,0,24,8)*
Channel estimation	*WMSA – 4slots (1,4,4,1)*
MPI modeling	*All noncoherent except self (Fig1 and 2)* *Coherent and noncoherent (Fig 3 and 4)*

6.2 Link level simulation results

6.2.1 Basis selection for > 2 Tx antennas

Release 99 scheme and two other schemes are simulated as in Table 2.

Table 2. Scheme description

Scheme	Description
2-mode-2	• Closed loop mode 2 according to Rel.99 • Number of Tx antennas = 2 • Feedback bit rate = 1500 bps • Total bits of FSM = 4bits: 1bit for gain, 3bits for phase
4C2	• Number of Tx antennas = 4 • Feedback bit rate = 1500 bps • 2 best antenna selection among 4 transmit antenna • Total bits of FSM = 5bits: 3bits for selection, 2bits for phase
4C3	• Number of Tx antennas = 4 • Feedback bit rate = 1500 bps • 3 best antenna selection among 4 transmit antenna • Total bits of FSM = 6bits: 2bits for selection, 4bits for phase

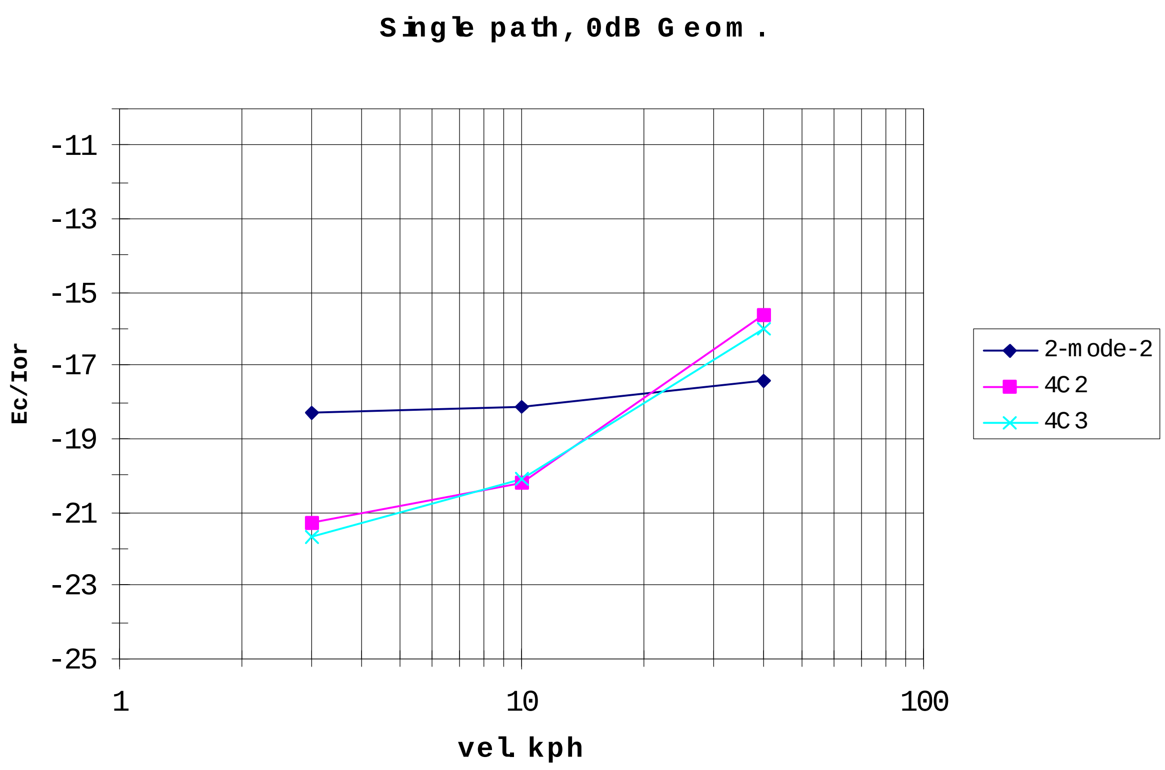

Figure 1. Single path simulation results for 0 dB geometry and 1 % FER.

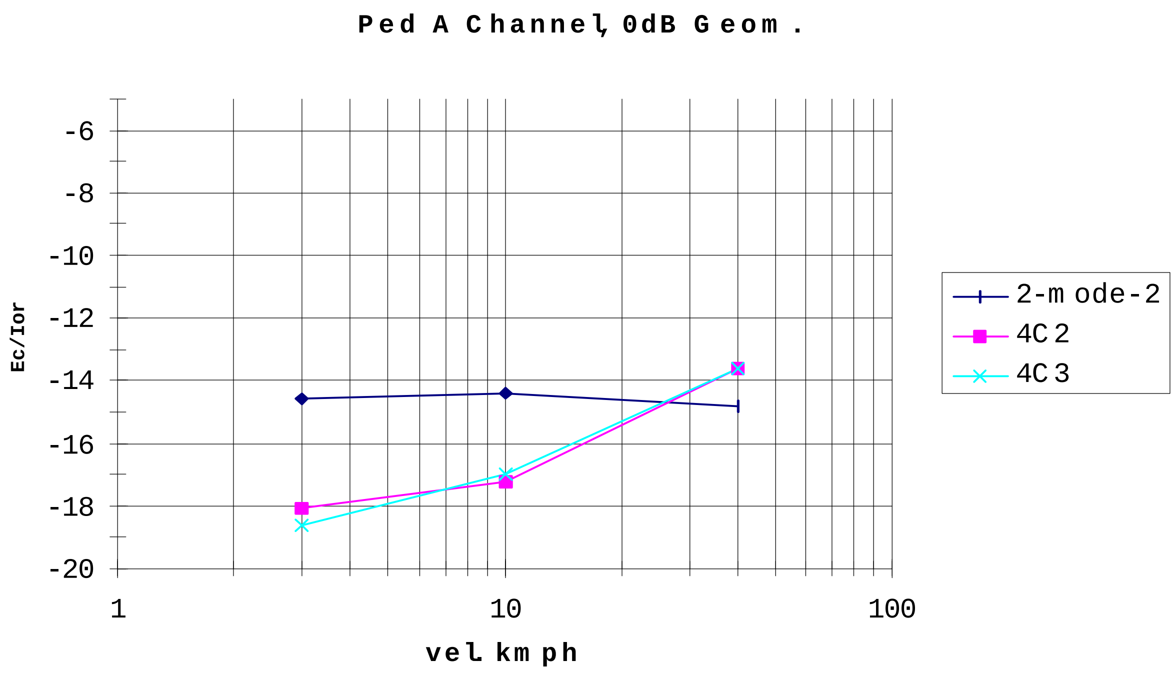

Figure 2. Simulation results for modified ITU Ped. A channel at 0 dB geometry.

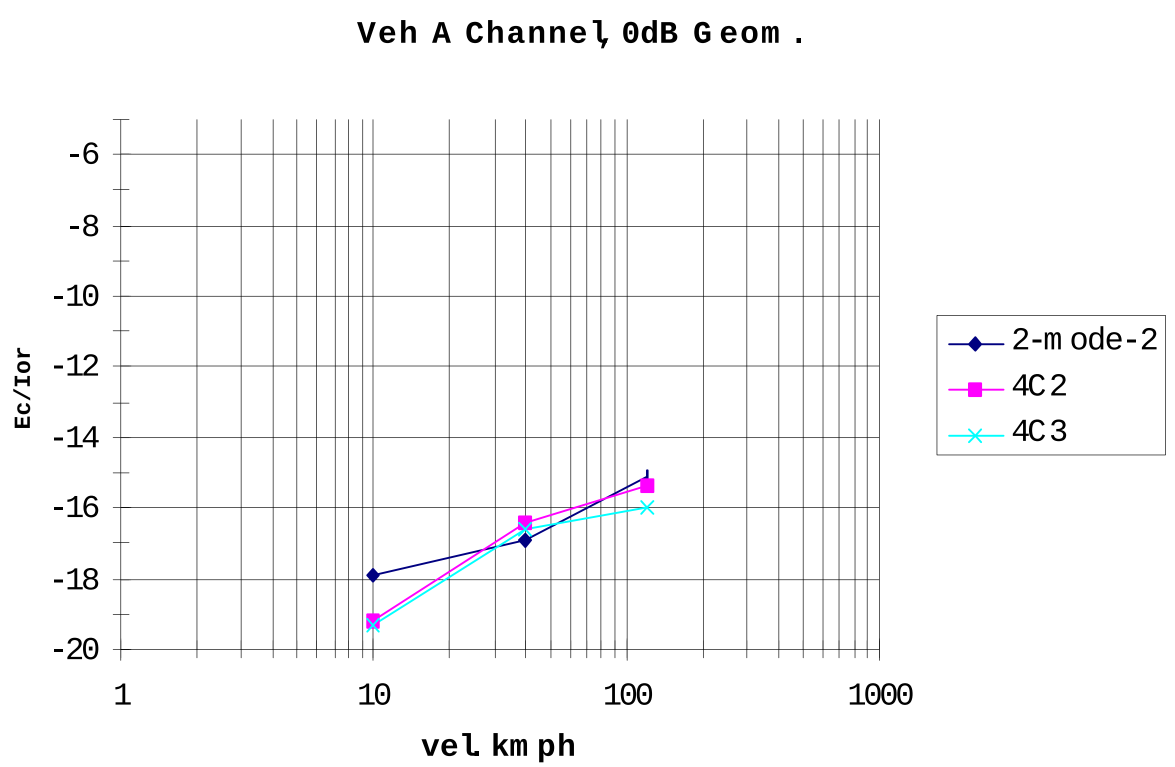

Figure 3. Simulation results for modified ITU Veh. A channel at 0 dB geometry.

In these simulation results, we compared “2-mode-2” scheme, “4C2” scheme, and “4C3” scheme. The “2-mode-2” scheme is closed loop Tx diversity mode 2 of two antennas in Rel 99. And the “4C2” and “4C3” schemes are the basis selection methods of closed loop Tx diversity for more than two antenna. In the “4C2” scheme, the UE selects two antennas among four antennas. As a consequence, the UE selects three antennas in “4C3” scheme.

The results of Fig.1., single path case, show that the new scheme has 2.7dB@ FER=1% gain for 4C2 and 3.0dB@ FER=1% for 4C3 over the Release 99 Tx diversity Mode 2 when the UE speed is 3km/h.

As shown in Fig.2, the “modified ITU pedestrian A” channel model is used. The multipath model is “noncoherent”. When compared to “2-mode-2” scheme, performance gains of “4C2” scheme and “4C3” scheme are 3.5dB and 4dB, respectively. The cross-over point between “2-mode-2” scheme and other schemes is about 25km/h.

In Fig.3, these schemes are compared in the “modified ITU vehicular A channel”. As the same as in Fig.2, the “noncoherent” multipath model is used. The suggested “4C2” and “4C3” scheme have better performance (approximately 1.3dB) in low speed than that of the “2-mode-2” scheme. If, however, the velocity is higher than 30km/h, performance is similar for three schemes.

6.3 System level performance

7 Impacts to UE and UTRAN implementation

7.1 Impacts to UE implementation

7.1.1 Basis selection scheme for > 2 Tx antennas

In order to obtain feedback weight in UE, it is necessary to perform the matrix operation in Eq. (1). In general, it is known that the searching is one of the efficient methods to calculate the weight for antennas. If the number of antenna is limited by selection, then the complexity of calculation could be reduced.

In detail, the number of multiplication of Eq. (1) is proportional to M^2+M if the weight for each antenna is transmitted, where M denotes the number of antenna. It is worth noting that the (M^2+M) is for only one weight vector. Thus the resultant number of multiplication is proportional to (size of weight vector set)* (M^2+M). Note that the size of weight vector set is L^M, where $L=2^{Nc}$ is the possible number of weight vector per antenna.

If the weight for the reference antenna is set to one, then the number of multiplication is proportional to (size of weight vector set)*(M(M-1)+M-1), where the size of weight vector is L^{M-1}.

If the number of transmit antenna is reduced to S, then the number of multiplication reduces to (size of weight vector set)*(S(S-1)+S-1). In this case, the size of weight vector set reduces to ${}_MC_S*L^{S-1}$ due to the reduced number of antenna.

For example, in case of M=4, S=2, N_c=2, the number of multiplication of the proposed scheme is proportional to 6*4*3=72 while that of the full representation with reference antenna is 4^3*(12+3)=64*15=960. Note that in case of M=2, N_c=4 (3GPP Mode 2), the number of multiplication is 16*3=48.

7.2 Impacts to UTRAN implementation

8 Impacts to physical layer operation

9 Backwards compatibility to Release-99

~~9~~10 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.		