3GPP TSG RAN WG1 **TSGR1#15(00)1040**
Meeting #15
22-25th, August, 2000
Berlin, Germany

Agenda item:	6
Source:	Nokia
Title:	Text proposal for extended closed loop mode 1 concept to Tx diversity TR
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 extensions of the Rel.-99 closed loop mode 1 for multiple Tx antennas are presented.

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Technical Report

3rd Generation Partnership Project;
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RAN WG1 report on Tx diversity solutions for multiple antennas
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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).

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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.

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

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.-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

5.1 Closed loop mode 1 for > 2 Tx antennas

In the Rel.-99 closed loop mode 1 UE calculates the phase adjustment to be done at the UTRAN access point. This involves the calculation of the phase difference between the signals transmitted from the two antennas. When there are N Tx antennas, a straight forward extension of the mode 1 is to calculate the needed phase adjustment for each N-1 antennas with respect to the reference antenna and signal those adjustments back to the UTRAN. How fast this information can be communicated to UTRAN depends naturally on the number of antennas and the feedback bit rate. This in turn will determine the sensitivity of the performance to the UE speed, i.e. the performance will deteriorate faster as a function of UE speed if the feedback bit rate is low and N large. As it is not desirable to increase the feedback bit rate from 1500 bps as defined in Rel.-99 methods trying to enhance the performance given the restrictions in feedback signaling need to be studied.

In Rel.-99 closed loop mode 1 the filtering of the phase adjustments at the UTRAN access point is specified as simple (sliding window) averaging over two consecutive values. This could be denoted as R2F2T2 where R2 denotes the number of constellation sets due to rotation, F2 denotes the filter of length 2 and T2 denotes the 2 Tx antennas. This can be generalized to R2FNTM, that is rotation constellation set per antenna remains the same as in Rel.-99, length of the phase adjustment filter is N, and there are M Tx antennas.

In order to maintain the same rate of feedback as in the Rel.-99 mode 1, the weight of only one antenna is fed back in one slot. Hence, the actual memory of the filter is 3(N-1) slots. In case of 4 Tx antennas (M=4), let z_1, z_2, z_3 be the feedback for antennas 2,3,4 respectively, with antenna 1 being the reference antenna. Let N = 4 (R2F4T4). It is clear that in this example case the current antenna weight relies on feedback weights sent 9 slots in the past as illustrated in the Figure 1.

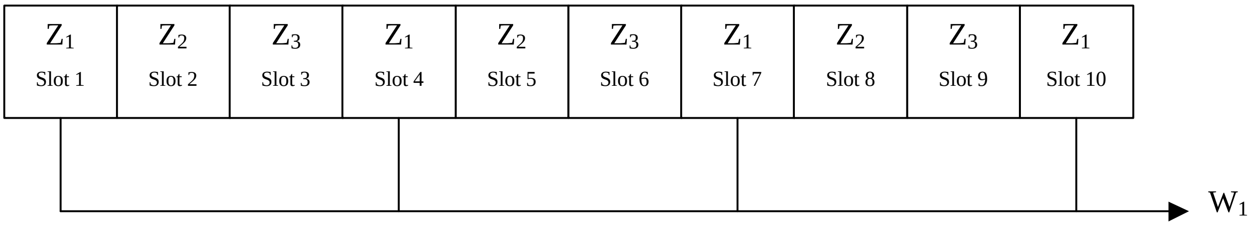

Figure 1. Filtering of the feedback commands.

The filter itself could be of various types but a simple solution is to use averaging as in the Rel.-99 mode 1.

6 Performance

6.1 Link level simulation assumptions

6.1.1 Closed loop mode 1 for > 2 Tx antennas

Basic link level simulation assumptions described in [5] were used.

6.2 Link level simulation results

6.2.1 Closed loop mode 1 for > 2 Tx antennas

Four different concepts were simulated:

- R2F2T2
  - ★ Closed loop mode 1 according to Rel.-99
  - ★ Feedback bit rate = 1500 bps
- 4-mode-1
  - ★ A benchmark reference case
  - ★ Feedback bit rate = 4500 bps
  - ★ Phase adjustment calculated separately for the three antennas as in Rel.-99 mode 1 and all the three feedback commands are signaled to UTRAN during 1 slot
- R2F2T4
  - ★ Feedback bit rate = 1500 bps
  - ★ Phase adjustment calculated separately for the three antennas as in Rel.-99 mode 1 and only one feedback command is signaled to UTRAN during 1 slot
  - ★ At UTRAN, two consecutive feedback commands per antenna are filtered (simple averaging)
- R2F4T4
  - ★ Feedback bit rate = 1500 bps
  - ★ Phase adjustment calculated separately for the three antennas as in Rel.-99 mode 1 and only one feedback command is signaled to UTRAN during 1 slot

- At UTRAN, four consecutive feedback commands per antenna are filtered (simple averaging)

Figures 2 and 3 show the results in AWGN channel. Figures 4-9 present the results in modified Ped. A and Vehicular A channels for R2F2T2 and R2F4T4.

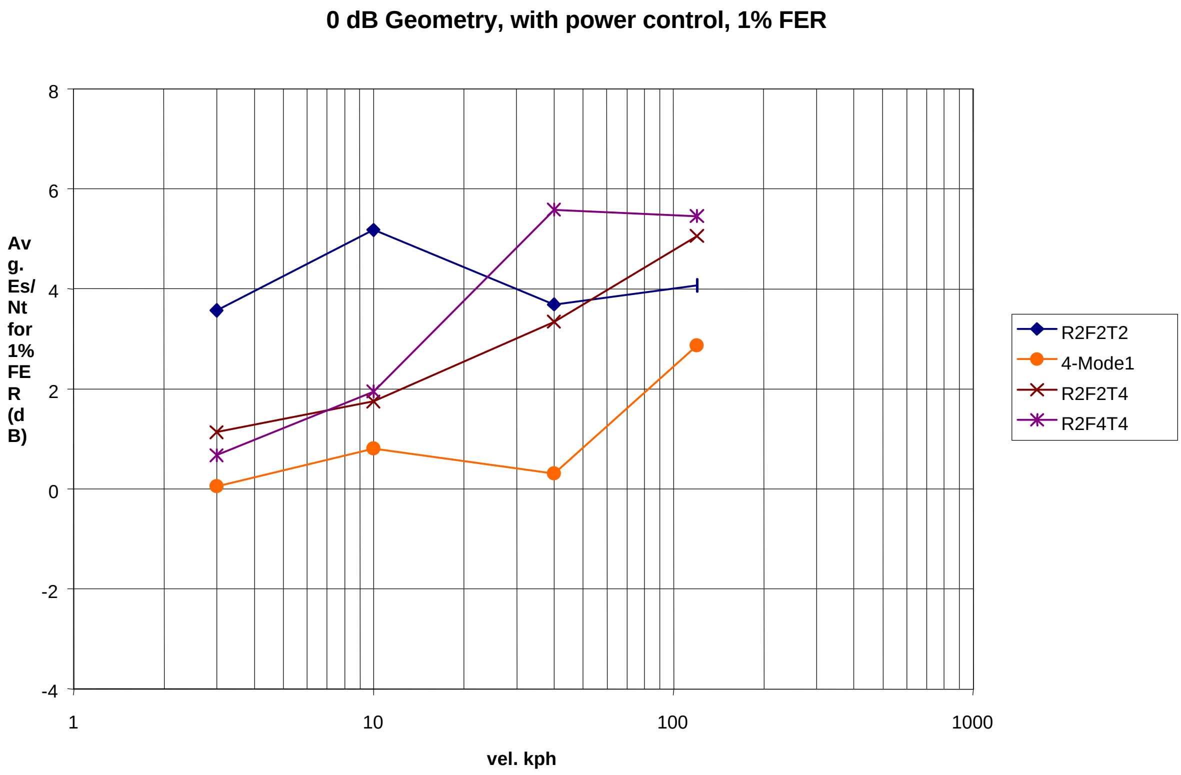

Figure 2. AWGN simulation results for 0 dB geometry and 1 % FER.

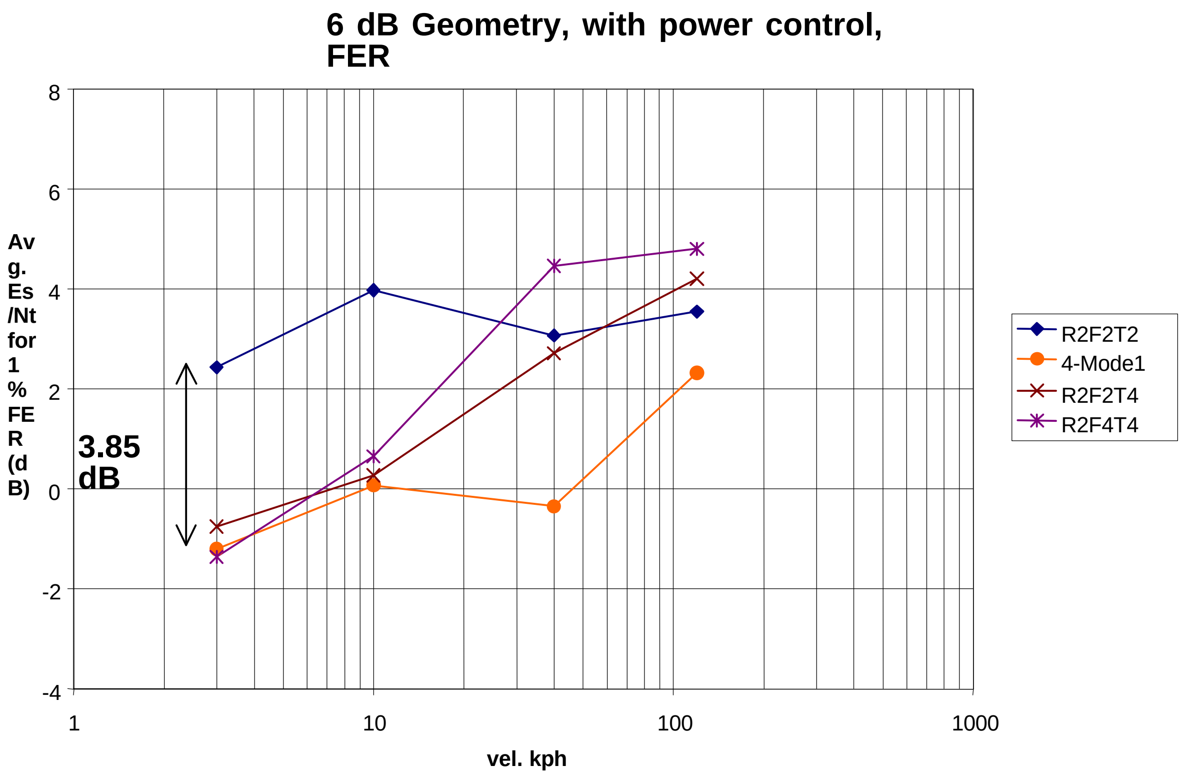

Figure 3. AWGN simulation results for 6 dB geometry and 1 % FER.

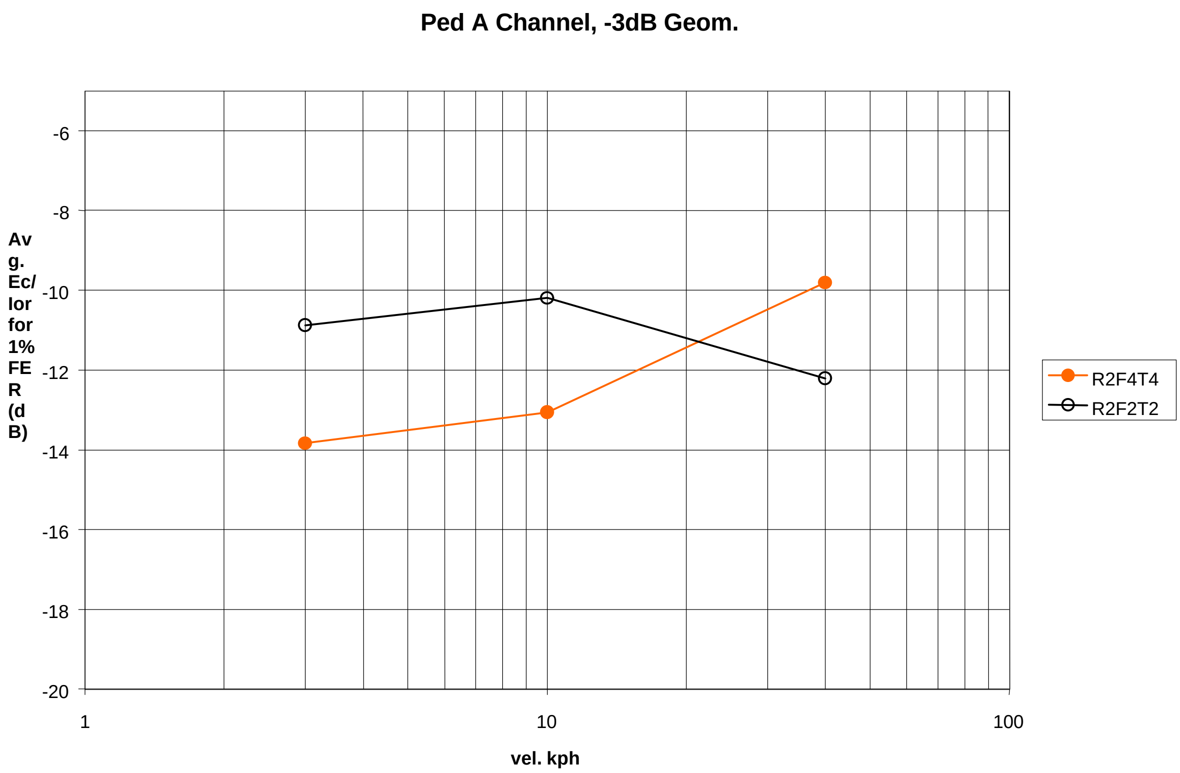

Figure 4. Simulation results for modified ITU Ped. A channel at –3 dB geometry.

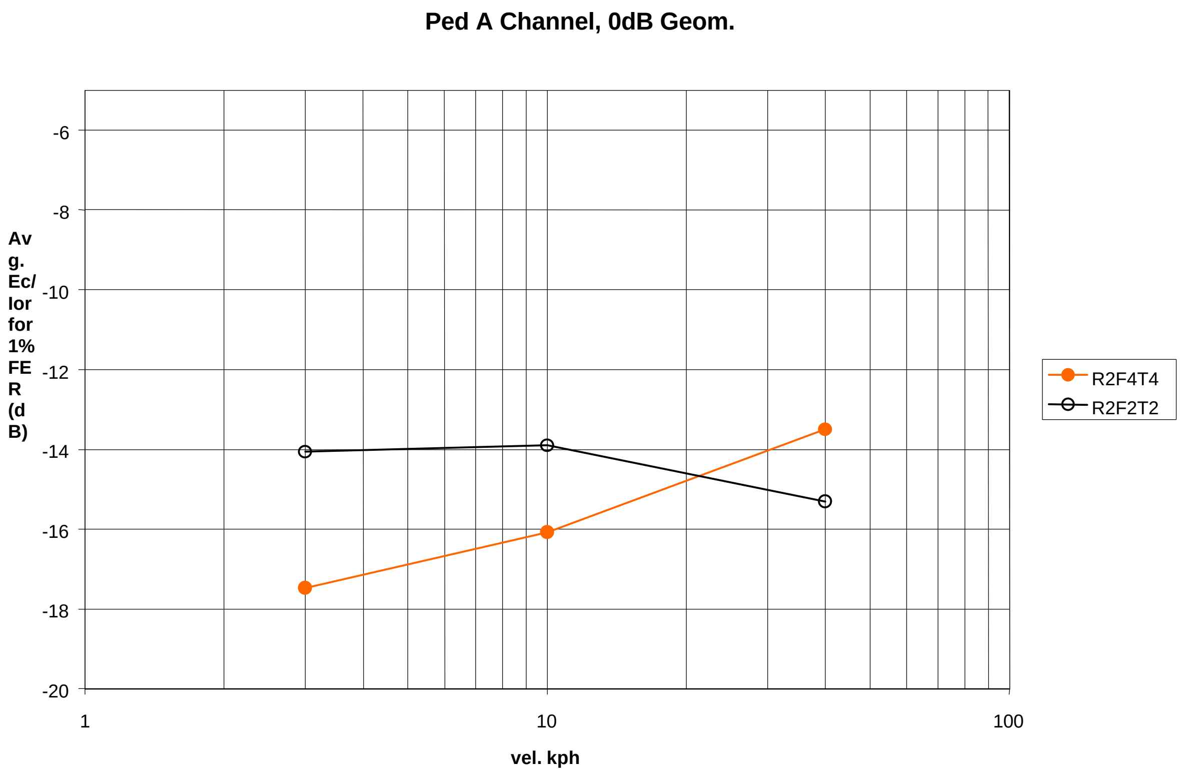

Figure 5. Simulation results for modified ITU Ped. A channel at 0 dB geometry.

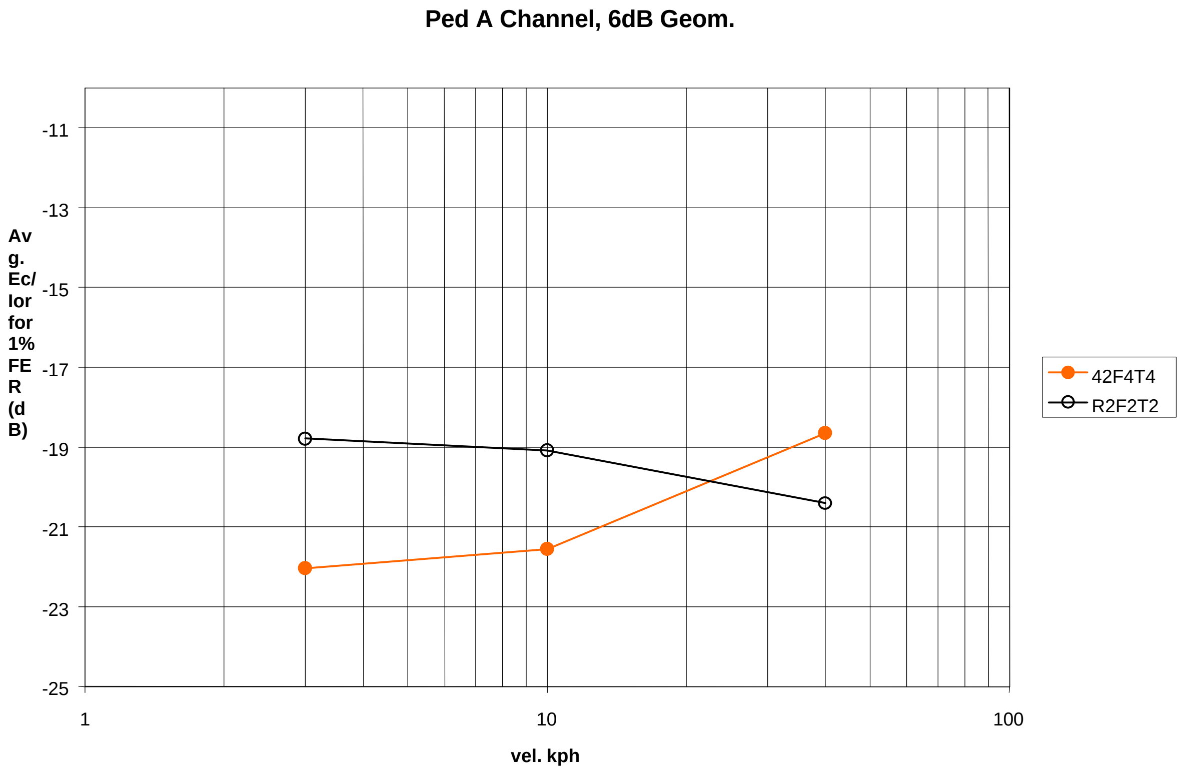

Figure 6. Simulation results for modified ITU Ped. A channel at 6 dB geometry.

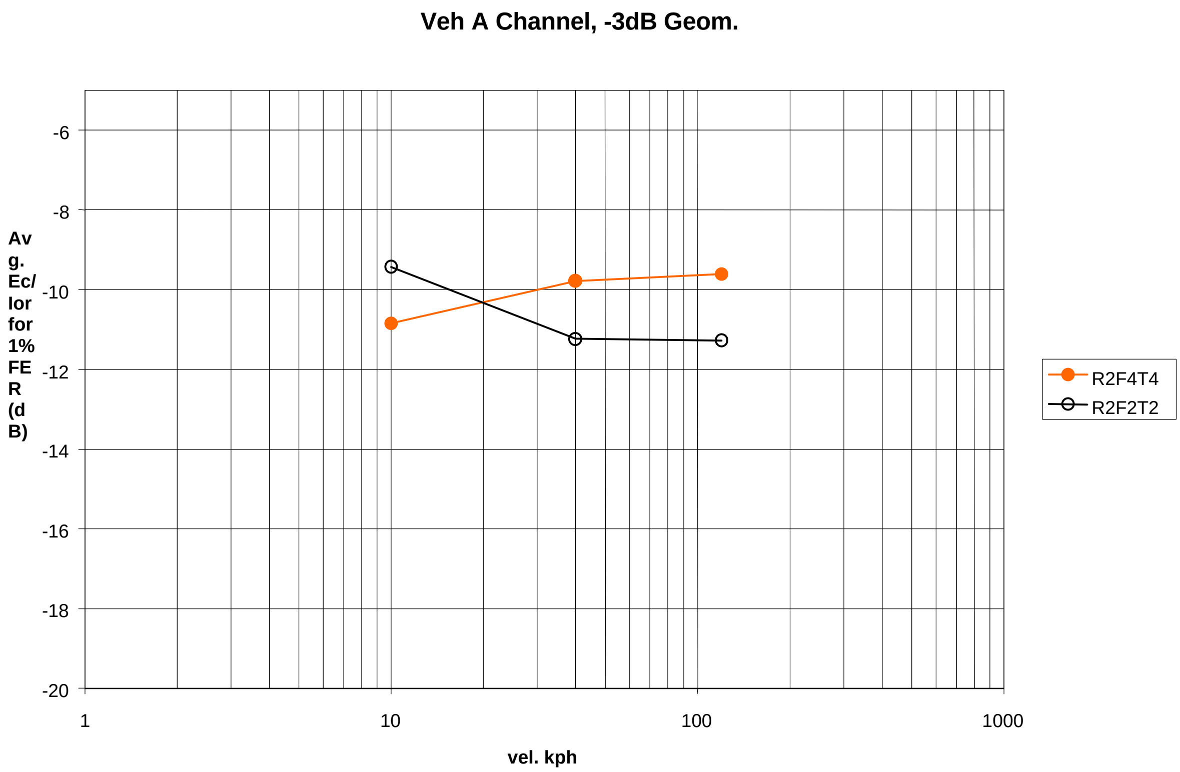

Figure 7. Simulation results for modified ITU Veh. A channel at –3 dB geometry.

Figure 8. Simulation results for modified ITU Ped. A channel at 0 dB geometry.

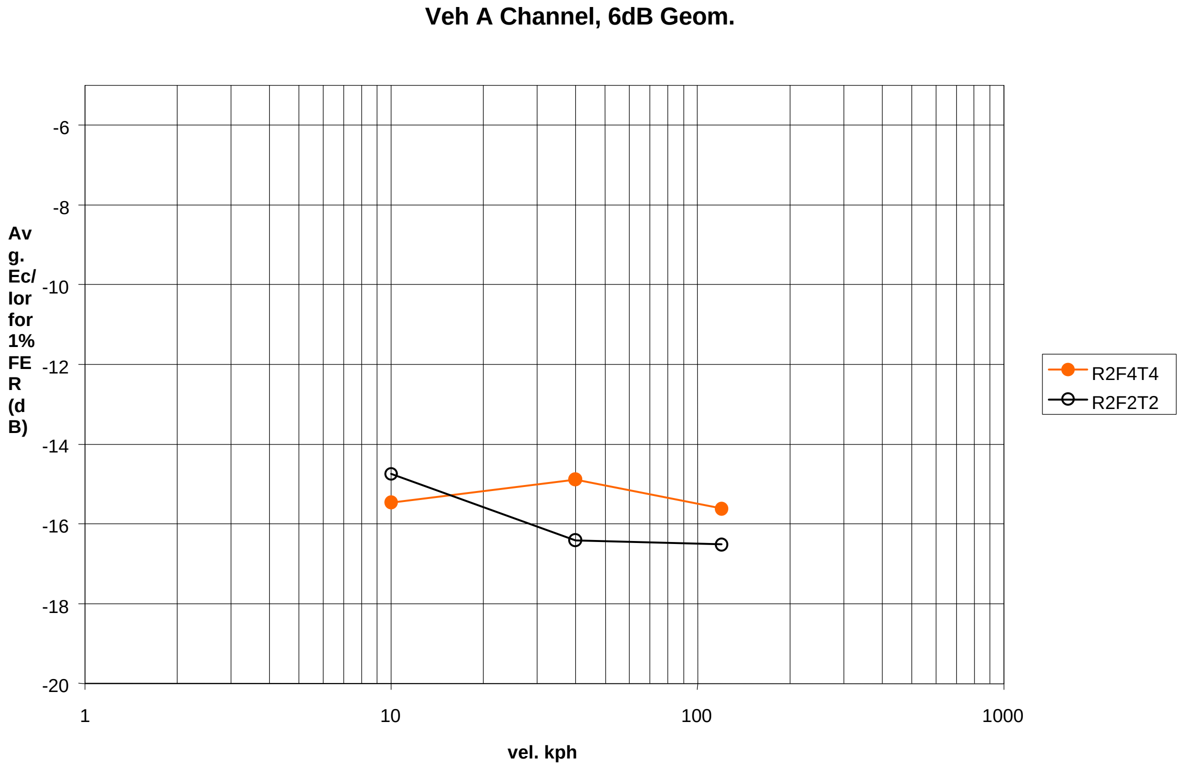

Figure 9. Simulation results for modified ITU Ped. A channel at 6 dB geometry.

In general, the performance improvement of up to 4 dB in AWGN channel over the R2F2T2 at low UE velocities seems to be achievable. The best performance over the simulated velocity range is achieved with the benchmark reference case, 4-mode-1, at the expense of higher uplink signaling load.

When the feedback bit rate is limited to 1500 bps, there is a trade-off between feedback command filter length and UE speed. At low speeds the R2F4T4 provides better performance than R2F2T4. Already at speeds around 7-8 km/h the R2F2T4 outperforms R2F4T4. Note that R2F4T4 gives similar performance as 4-mode-1 at the speed of 3 km/h.

For UE speeds up to 10 km/h the gains of R2F4T4 over R2F2T2 in modified ITU pedestrian A are still quite high ranging approximately between 2 and 3.5 dB. At a speed of around 20 km/h there is a cross over point after which the R2F2T2 starts to outperform the R2F4T4.

In modified ITU vehicular A channel the gain of R2F4T4 over R2F2T2 is still at least 1 dB at speed of 10 km/h despite greatly increased path diversity. At higher speeds R2F2T2 outperforms R2F4T4.

The simulation results presented above assume ideal weight verification at UE. Note that whether verification is actually needed depend e.g. on the channel estimation method. If only dedicated pilot is used no verification is needed. If the bit rate is low then channel estimation utilizing strong CPICH tend to produce better results than dedicated pilot based channel estimation. Thus, it seems that some kind of verification algorithm is needed, though.

There will inevitably be some performance loss if a realistic verification algorithm is applied at UE. Preliminary results for advanced verification methods for R2FNTM concepts have shown good results. More work is needed to assess the actual loss due to imperfect verification, though.

6.3 System level performance

System level simulations would be required to get the full understanding of e.g. impacts of different Tx diversity schemes on the cellular capacity. Generally speaking, however, decreased Tx Ec/Ior 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 Ec/Ior 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 Closed loop mode 1 for > 2 Tx antennas

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, calculation of the feedback commands requires about the same effort as in Rel.-99 based terminals.

7.2 Impacts to UTRAN implementation

7.2.1 Closed loop mode 1 for > 2 Tx antennas

R2FNTM concepts bring some additional requirements for the base station transmission. If N increases, i.e filter length for each antenna signal is longer, the number of Tx signal constellation points are also increased. Therefore, in addition to longer filter memory, higher phase resolution is needed for the signal presentation. Signals to be generated will be increased to M.

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 Closed loop mode 1 for > 2 Tx antennas

R2FNTM based methods require some straightforward definitions on how the feedback for different antennas is mapped to uplink slots, how the end of frame adjustments are done and how the compressed mode operation is defined.

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

9.1 Closed loop mode 1 for > 2 Tx antennas

As Rel.-99 closed loop mode 1 is one instance (i.e. R2F2T2) of R2FNTM solutions there is no backwards compatibility problems. Note, though, that it could be possible to define R2FNT2 for Rel.-00 in case other filtering schemes as the one defined in Rel.-99 show better performance in case of 2 Tx antennas ! In that case UTRAN would use different weight filter depending whether the UE is based on Rel.-99 or Rel.-00.

~~9~~10 Conclusions

History

Document history		
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	0.0.0	
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