TSG-RAN Working Group1 meeting #4
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Agenda Item **:**

Source **:** Nokia

Title **:** Updated Tx Transmit diversity complexity analysis

Document for **:** Discussion

Summary:

In this document it was studied how WCDMA terminal complexity is increased in the case of Downlink Tx diversity closed loop modes. Mode 1 (STD) does not add a lot of complexity to the terminal. Thus, the extra complexity is limited to two channel estimator units for each RAKE finger. On the other hand, we noticed in the analysis the fact that Dl Tx diversity modes 2 and 3 increases the number of fingers in the RAKE receiver introducing extra complexity to ASIC implementation. However, all the modes in question are still feasible from the real implementation point of view.

1. IMPLEMENTATION COMPLEXITY OF THE 3GPP DL TX DIVERSITY CLOSED LOOP MODES

1.1 Introduction

In the TSG-RAN Working Group1 #2 meeting in Yokohama, as a result of Ad Hoc #6, it was agreed that downlink Tx diversity closed loop modes (1,2,3) are defined to be mandatory for all kind of terminals. However, according to report from Ad Hoc #6 [1] it was concluded that for the terminal this is the working assumption requiring further studies.

Downlink Tx diversity schemes can generally be divided into two categories involving either open or closed loop mode. According to [1] the basic 3GPP merge proposal is following. The Space Time Transmit Diversity (STTD) is applied as the open loop mode and combined Selective Transmit Diversity (STD) and Transmit Antenna Array (Tx AA) is used in the closed loop mode.

The terminal complexity for STTD, which exploits the extra path diversity, do not increase significantly compared to non diversity mode. Basically, the channel estimation has to be made for both Tx antennas. Thus, two channel estimator units are required for each finger. One extra complex multiply and one extra complex add per symbol, per diversity path are required prior multipath combining. Consequently, the terminal complexity is quite comparable to ARIB's TDTD/PD based solution.

In the closed loop modes the BS's transmitter has some knowledge of the channel through a feedback loop from the terminal's receiver. In the mode 1 Tx antennas are switched based on antenna selection commands transmitted via uplink signaling from the terminal. Based on antenna measurements from the Primary CCPCH channel pilot symbols, the terminal selects the better transmit antenna and sends FBI to the BS for the next slot transmission. The mode 1 is actually ARIB's solution for a closed loop mode operation. Operation modes 2 and 3 utilize phase and/or amplitude weighting between the transmitted signals. It is stated in [1] that modes 2 and 3 provides better performance, especially in the slowly fading channel conditions and with correlated fading between the antenna branches. Unfortunately, the implementation complexity of the closed loop modes is increased compared to open loop mode.

In the last TSG-RAN Working Group1 #3 meeting in Nynäshamn, we submitted a paper describing the terminal implementation complexity with all three closed loop modes. One of the main conclusions was the fact that from RAKE implementation point of view mode 1 does not introduce a marked complexity increase. On the other hand, the modes 2 and 3 increased the complexity significantly. As a new input to implementation complexity discussion we would like to provide WG1 a description of our recent complexity study results since the very first results seemed to be a bit overestimated. The content of this paper is updated version of [2].

1.2 Complexity analysis

In this analysis, implementation complexity of a RAKE finger is evaluated in three different cases: 1) RAKE finger without Dl Tx diversity, 2) RAKE finger with closed loop mode 1, 3)

RAKE finger with closed loop modes 2 and 3 . Two Tx antennas are used for Dl Tx diversity operation.
Complexity is evaluated as the required silicon area in IC implementation.

a) Delay profile is the same from both antennas

Operations needed in RAKE receiver for different modes of Dl Tx diversity and relative complexity comparison are depicted in Table 1. It is assumed that the delay profile is the same for both antennas, so one finger is capable of following the transmission from both antennas. The results shows that the additional complexity with the mode 1 is 18 %. On the other hand, the difference in the implementation complexity between mode 1 and modes 2 and 3 is increased. Namely, the modes 2 and 3 requires more RAKE fingers in the terminal since the PCCPCH channel estimates cannot be used for dedicated channels. Thus, requiring separate fingers with channel estimators for PCCPCH and DPCH. The additional complexity resulted from determination of antenna specific weight factors is considered to be negligible.

Table 1. RAKE finger implementation complexity comparison

Operations	RAKE without Dl Tx diversity	RAKE with mode 1	RAKE with modes 2 and 3
Channel estimation	1 estimator/finger	2 estimators/finger	2 estimators/finger for PCCPCH processing. 1 estimator/finger for DPCH processing
Speed estimation	Used for channel estimation	Used for channel estimation and diversity mode selection decision	Used for channel estimation and diversity mode selection decision
Antenna verification	No	Yes	No
Relative complexity (Figures are based on area in ASIC implementation)	**100**	**118**	**135**

b) Different delay profiles from antennas

If different delay profiles are assumed for antennas, then basicly one finger can track only one antenna. In this case in mode 1, double channel estimators are not needed in fingers, resulting total complexity figure of **205** (separate fingers are needed for both antenna transmissions and

antenna verification is needed). In the case of modes 2 and 3, complexity figure is comparable to mode 1.

1.3 Conclusion

In this document, the results of the Dl Tx diversity complexity analysis from the terminal point of view are presented. The analysis indicated that mode 1 needs two channel estimator units for each RAKE finger. However, the additional complexity in terminal implementation is marginal, and therefore, STD mode can be easily implemented in terminal without any practical cost effect. However, one of the main conclusions in the implementation complexity analysis is the fact that Dl Tx diversity modes 2 and 3 increases the number of fingers in the RAKE receiver. The increase in implementation complexity is due to fact that separate RAKE finger units are needed both for PCCPCH and DPCH processing. On the one hand, the modes 2 and 3 appears to be a more complex solution from the terminal ASIC implementation point of view but on the other hand the modes in question are still feasible from the real implementation point of view. Therefore, we propose that closed loop modes 1, 2 and 3 should be a mandatory feature for all terminals.

REFERENCES

[1] Report from Ad Hoc #6: DL Tx diversity. TSG-R WG1 document, TSGR1#2(99)024, 22-25th, February, 1999, Yokohama, Japan, 14 pp.

[2] Nokia. Tx Transmit diversity complexity analysis. TSG RAN Working Group 1 #2 meeting, R1-99208, Yokohama, 4 pp.