3GPP TSG-RAN WG1 RAN49 **R1-072403**
Location **Kobe Japan**
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Agenda item: **7.10**

Source: **Broadcom Corporation, InterDigital Communications Corporation, Nortel**

Title: **Consideration of Differential Feedback for SU-MIMO**

Document for: **Discussion**

1 Introduction

Codebook based approach was adopted in 3GPP-LTE meetings as a method moving forward regarding precoding. It is important that the feedback required to transmit precoding matrix information from receiver to the transmitter is minimized. In submissions [1-4], it was proposed that 4-5 bit codebooks are used for 4 transmit (Tx) antenna cases. However, link level simulations show that up to 2 dB loss in performance occurs as a result of such a coarse resolution codebook. In submission [5] it was shown that for the same codebook resolution, i.e. 6-bit codebook, it is possible to achieve performance results close to ideal (floating point codebook). In submission [6] it was shown that the differential codebook approach also reduces loss and decreases the required feedback significantly. Similar conclusions were presented in submission [7].

Precoding techniques are proposed for low mobility scenarios in order to reduce 3GPP-LTE feedback overhead requirements. In the low mobility scenarios channel variations are slow due to low Doppler frequencies in which case differential codebook update techniques provide a viable solution. If channel coefficients are changing slowly, it is not necessary to update the precoding matrices so that the full resolution of the matrix is required. It is sufficient only to send partial (differential) update information to the precoding transmitter. Differential feedback can be reset every certain period of time or aperiodically using full resolution to avoid error accumulation.

All differential techniques rely upon a recursion to update the precoding matrix at the transmitter. Functionally, an equation that describes the relationship is:

$$V_k = F\left(V_{k-1}, \Delta_k\right)$$

where V_k is the transmit precoding matrix at time = *k*, and Δ_k is the (delta) channel feedback information at time = *k*. The value of Δ_k (i.e. differential precoding matrix feedback) to be applied at time *k* depends on the channel state information at time = *k* and *k-1*. It also depends on the differential technique being used. In general Δ_k functionally relates the previous precoding matrix at time *k-1*, to time *k*.

The differential precoding matrix feedback Δ_k is used to track the changes in the channel, and adapts the channel to achieve good beamforming gain while reducing feedback. When channel conditions change slowly, the variation of the precoding matrix change is also small. It is this property that makes the differential techniques attractive.

One can observe that when channel conditions are changing slowly, then Δ_k usually has a very small dynamic range. This property lowers the requirement for the codebook resolution that achieves close to ideal performance. For the same performance when compared to the full update codebook approach, the differential update codebook approach significantly reduces the required feedback, or with the same feedback requirement the differential codebook approach yields up to 2 dB better performance than the full update codebook approach (for 4 Tx antenna precoding systems).

2 Proposal

We propose that a differential feedback approach is considered as a candidate for the precoding feedback technique. The differential feedback technique should be analyzed in system level simulations with realistic scheduling. The performance should be compared to the full update codebook approach and reduction in feedback or gain in performance should be quantified.

3 References

[1] R1-070878 NEC Group - Codebook design for EUTRA MIMO

[2] R1-070936 Panasonic - MMO Codebook Design for MU/SU-MIMO

[3] R1-062650 Texas Instruments - Codebook design for E-UTRA MIMO Pre-coding

[4] R1-063373 Nokia - Linear Precoding Design for 4Tx Antennas

[5] R1-070800 Broadcom - Compact Codebook for Unitary Precoding MIMO w/Support for Rank Reduction

[6] R1-071103 Interdigital – Binary Differential Feedback Scheme for Downlink MIMO Precoding for E-UTRA

[7] R1-070707 Nortel – Differential Codebook for LTE Downlink Closed Loop MIMO