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Source: **Nokia Siemens Networks, Nokia**

Title: **Closed loop power control corrections for PUSCH**

Agenda item: **6.4.2**

Document for: **Discussion/Decision**

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1. Introduction

In this contribution we address the meaning of closed loop power corrections for the PUSCH. We basically propose to only have specified accumulated power control corrections in order maximize the power control dynamic range from closed loop corrections, while minimizing the number of power control options and bits for power control in the UL grant (PDCCH).

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2. Interpretation of closed power control corrections

The agreement on the power control formula for PUSCH from [1] is summarized below:

- PC formula: P = min (Pmax , 10 log M + Po + α x PL + delta_mcs + f(delta_i))
    - UE obeys the power setting formulation based on the parameters signaled by the network
    - M is the number of assigned RBs (based on UL grant)
    - Po is a cell specific parameter that is broadcasted (default value)
    - α is cell specific path loss compensation factor (can be set to one to allow full path loss compensation)
    - PL is downlink pathloss calculated in the UE
    - delta_mcs is signaled by RRC (table entries can be set to zero)
        - MCS signaled in UL grant
    - delta_i is UE specific correction value included in the UL grant
        - Function f(*) signaled via higher layers
            - Only two possibilities
            - Accumulated vs. absolute value

As listed above, one of the open issues is the exact interpretation of the closed loop power control commands, as well as how many bits are used for each power control command. For the case with “absolute value”, the function, f(delta_i), only depends on the latest received closed loop correction (delta_i). If N bits are used for signaling the closed loop correction, then f(delta_i) can take log2(N) different values. As example, if N=2, then one possibility is to configure f(delta_i) to the following values; [-3dB, -2 dB, 1 dB, 3 dB].

If “accumulated value” is assumed, then the value of f(delta_i) depends also on previously received closed loop corrections. As an example, if we assume only a 1-bit closed loop power correction, then we have

$$f(delta\_i)=f\_old+P\_step*delta\_i, \quad (1)$$

where f_old is the old value of f(delta_i), P_step is the power control step size, and delta_i is taken values of -1 and +1 depending on the value of the received closed loop correction bit. Hence, with this approach the power is increased or decreased by P_step decibels whenever a new closed loop correction is received by the UE. Notice that the expression in (1) is just a simple example, which is easily extendable to the more general cases where different step-sizes are used for power-up and power-down, or to cases with multiple step up/down sizes in case several bits are used for each closed loop correction.

The advantage of using the approach with “accumulated values” is that 1-2 bits is estimated to be sufficient for the closed loop power correction. By sending several closed loop power control corrections, the UE Tx power can be adjusted over a larger dynamic range. On the contrary, using the approach with “absolute value”, the dynamic range and granularity from using closed loop commands is hard limited by the number of bits for each closed loop command, as well as the set values for f(delta_i).

The need for additional UE transmit power adjustments via closed loop power corrections is in practice expected to depend on many factors such as; QoS requirements for the users, cell load, interference from other cells, etc.. It is therefore desirable to have standardized a scheme which offers; (i) high Tx power dynamic range from using closed loop corrections, (ii) reasonable power control granularity, and (iii) a low number of bits from sending closed loop corrections. The scheme which best meets these design goals seem to be the solution with “accumulated values”, as it only requires few number of bits per closed loop correction (say 1-2 bits), it offers high dynamic range by sending several closed loop corrections, and it offers a reasonable power control granularity by choosing an appropriate power control step size.

As a specific proposal, we therefore suggest to only use 2 bits for closed loop corrections. As an example, the power control granularity for closed loop commands could be in steps of +/-1 and +/-3 dB.

3. Conclusions

In this contribution we have addressed the meaning of closed loop power control corrections for the PUSCH. Our recommendation is to only standardize accumulated closed loop corrections, where the value of the closed loop adjustment depends also on the previously received closed loop corrections. We furthermore suggest using 2-bits for each closed loop correction, assuming a power control granularity (step-size) of +/-1 and +/-3 dB.

4. References

[1] 3GPP Tdoc, R1-073224, “Way Forward on Power Control of PUSCH”, June 2007 (Orlando meeting)