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Source: **Nokia Siemens Networks, Nokia**

Title: **Power control headroom reports for EUTRAN uplink**

Agenda item: **7.4.2**

Document for: **Discussion/Decision**

1. Introduction

In this contribution we address the topic of power control headroom reporting in E-UTRAN LTE Uplink. We propose that the UE measures the used power, and then reports the difference between this and the maximum UE transmission power. We also propose a flexible power control headroom reporting scheme which is based on a set of e-Node B configurable parameters, and can support both periodic and event-triggered signalling (but also a combination of these two reporting methods).

2. Power control headroom report

The latest agreement on the power control for PUSCH is summarized in [1]. Basically the power spectral density (PSD) is determined by; (i) an open loop power control (OLPC) component calculated at the UE, and (ii) a closed loop power control (CLPC) correction transmitted by the eNode-B. A similar approach (but using different OLPC parameters and independent closed loop commands) has been agreed for the PUCCH [2]. Given such a power control scheme, it is unknown by the eNode-B at which PSD level the different terminals are operating. Information on the PSD is important for performing correct radio resource management decisions at the eNode-B, especially when allocating the transmission format (bandwidth and modulation & coding) to the different terminals. Not knowing the PSD used by a certain terminal could e.g. cause the allocation of a too high transmission bandwidth (given the maximum eUE power capabilities), thus resulting in a lower SINR. Information on the PSD used at the eUE can be obtained from the power control headroom reports, provided that the eNode-B knows the transmission bandwidth used when the power measurement was performed. Information on the PSD is primarily critical for the PUSCH as the transmission format for this channel is adaptively adjusted. On the other hand, the transmission format on the PUCCH is more constant per user, i.e. constant bandwidth, MCS, etc. It is therefore suggested that the UE only measures the power control headroom for the PUSCH as this is the only case where such a measurement is needed before adjusting the allocated bandwidth and/or modulation and coding scheme.

Note: Alternatively to the power control headroom, the eUE could signal to the eNode-B the measured path-loss which is input to the OL standardized PC formula in [1]. Knowing the measured path loss at the eUE the eNode-B can easily calculate the PSD used at the terminal.

2.1 Definition of ‘Power Control Headroom’

In HSUPA the power control headroom is defined as the difference between the “nominal” maximum transmission power and the power measured at the UE. We propose to use the same measure in E-UTRAN uplink:

$$\text{Power Control Headroom} = 10\cdot\log_{10}(P_{MAX}) - 10\cdot\log_{10}(P_{MEASURED}),$$

where P_{MAX} is the maximum eUE Tx power, and $P_{MEASURED}$ is the measured eUE Tx power. The power control headroom is calculated per TTI. It is FFS whether the power control headroom should be averaged before being reported to the eNode-B, and whether the averaging should be done in linear or in logarithmic domain.

2.2 Proposed Power Control Headroom reporting scheme

We suggest the following criteria for sending a power control headroom report in the uplink:

1. A power control headroom report is transmitted after N closed loop PC corrections have been (correctly) received by the terminal.

2. After the OLPC component of the PSD is modified at the terminal (based on an updated path loss measurement), the eUE measures the power control headroom for M (consecutive) TTIs and afterwards transmits a power control headroom report.

3. The UE sends a power control headroom report if the difference between the current and the latest path loss measurement is higher than a given threshold (X dB).

4. A report is also triggered in case the power control headroom reaches a certain value, e.g. the eUE Tx power comes close (<Y dB) to its maximum possible value P_{MAX}.

5. A power control headroom report is in any case transmitted every P TTIs (periodic signaling).

6. However, the UE is not allowed to transmit a power control headroom report if the time elapsed from the last report is < K TTIs (this criteria is introduced to limit the signaling overhead).

Notice that standardizing the proposed criteria would allow the implementation of a variety of different reporting schemes by appositely tuning the parameters N, M, X, K, Y and P.

2.3 Signaling of Power Control Headroom Reports

Transmission of power control headroom measurement reports could be performed by means of either RRC or MAC signaling. Though this is mainly a RAN2 issue, we propose using MAC signaling to convey power control headroom reports from the eUEs to the eNode-B mainly due to the following two reasons: (i) MAC signaling is also used to report power headroom information in HSUPA, and (ii) MAC has been proposed as signaling protocol for the transmission of uplink buffer status reports in EUTRAN [3].

Whether power control headroom and buffer status reports should be signaled using a fixed size MAC header as in HSUPA or separate MAC messages should be used is FFS (shall be discussed in RAN2).

3. Conclusions

In this contribution we have addressed power control headroom reports in EUTRAN uplink. We have underlined the importance of power control headroom reports, especially in relation to the allocation of the uplink transmission bandwidth and MCS to the different users. We recommend RAN1 to reach an agreement on the following points:

- The power control headroom is measured and reported for the PUSCH only. No need to have power control headroom measured for the PUCCH as this channel is allocated constant bandwidth and MCS per user.

- The “power control headroom” per TTI is defined as $10 \cdot \log_{10}(P_{MAX}) - 10 \cdot \log_{10}(P_{MEASURED})$, where P_{MAX} is the maximum eUE Tx power and $P_{MEASURED}$ is the measured eUE Tx power. It is FFS whether the power control headroom should be averaged before being reported to the eNode-B, and whether the averaging should be done in linear or in logarithmic domain

- The standard should include the reporting rules and parameters described in Section 2.3. Notice that any of the reporting mechanisms can be deactivated by setting the corresponding parameter accordingly. The reporting parameters could be transmitted using the RRC protocol.

- Power headroom reports are transmitted in the uplink using MAC signaling (same used in HSUPA), but with the possibility to define separate reports for the power control headroom and the buffer status (to be discussed in RAN2).

4. References

[1] R1-073224 - “Way Forward on Power Control of PUSCH” - CATT, Ericsson, et al. - 3GPP TSG RAN WG1, meeting #49-bis, Orlando, USA, 25th - 29th June, 2007.

[2] R1-073209 - “Way Forward on Uplink Power Control of PUCCH” - CATT, Ericsson et al. - 3GPP TSG RAN WG1, meeting #49-bis, Orlando, USA, 25th - 29th June, 2007.

[3] R2-060829, “Buffer Reporting for E-UTRAN” - Nokia - 3GPP TSG RAN WG1, meeting #52, Athens, Greece, 27th - 31st March, 2006.