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Title: Uplink Outer Loop Power Control for TDD Mode.

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1 Introduction

TSG RAN WG1 has approved in principle a procedure for outer loop power control for TDD uplink dedicated channels. The implementation of this concept requires Layer 2/3 procedures; i.e. messaging between Node B and the RNC and between the RNC and the UE.

2 Background

The motivation for the proposed technique is found in the following contributions from TSGRANWG1.

- Tdoc R1-99576 [1] shows that power control schemes relying purely on open loop cannot be considered for uplink power control of dedicated channels.
- Tdoc R1-99972 [2] presents a modified version of the open loop schemes – weighted open loop power control, and shows that it outperforms the current (unweighted) open loop power control scheme.
- Tdoc R1–99A68 Text Proposal for 25.224 (Included as a working assumption in 3G TS 25.224 v1.0.1 [3])

3 Concept of operation

The UE's initial transmission power is decided in a similar manner as PRACH. After the synchronisation between NodeB and UE is established, the UE transits into open-loop transmitter power control (TPC).

3.1 UL Open Loop Power Control:

The transmitter power of UE shall be calculated by the following equation:

$$P_{UE} = \alpha L_{CCPCH} + (1-\alpha) L_0 + I_{BTS} + SIR_{TARGET} + \text{Constant value}$$

Where, P_{UE} : transmitter power level in dBm,
L_{CCPCH}: A measure representing path loss in dB (reference transmit power is broadcasted on BCH).
L_0: Long term average of path loss in dB
I_{BTS}: interference signal power level at cell's receiver in dBm, which is broadcasted on BCH

α: α is a weighting parameter which represents the quality of path loss measurements. α may be a function of the time delay between the uplink time slot and the most recent down link time slot.
SIR_{TARGET}: Target SNR in dB. A higher layer outer loop adjusts the target SIR.
Constant value: This value shall be set via Layer 3 message (operator matter).

4 Outer Loop Power Control

In order to satisfy the required reception quality (average FER, or average BER), the reference SIR value shall be updated through an outer loop process.

For connections with a CRC included in the format, the RNC shall derive a measure of average uplink error rate and shall take action when this average exceeds either of two thresholds:

- When the average estimated error rate exceeds a threshold representative of unacceptable performance
- When the average estimated error rate falls below a threshold, indicating unnecessarily good performance.

To make this decision, the RNC must be keyed off of the service whose error rate is monitored.

To support connections without an embedded CRC, the Node B shall derive an estimate of raw Bit Error Rate (into the FEC decoder) and, when either of the two thresholds is exceeded, it shall then send a message to the RNC containing the required information.

The RNC shall then derive a recommended change in target SIR
The RNC shall then send the change to the UE. The message shall contain

- UE identity
- Change in SIR Level (dB)

Ranges of Values
Average Error Estimate A 12 bit field should be more than sufficient for estimated Pre-FEC bit error rate; 8 bits for mantissa; 4 bits for exponent This could define a number in the format:

$$A.B \times 10^{-N}$$

where N can vary from 0 to 15 and A and B are decimal digits.
Other formats may be more convenient.

SIR change for the change in dB, a reasonable range is +/-4 dB in steps of 1/4 dB, but this can be changed for convenience.

5 A possible algorithm

5.1 Idealized version

The following algorithm was shown by simulation [4] to provide excellent results under the assumption that continuous correction was possible:

In outer loop, the RNC shall update the UE's reference SIR when UE receives a frame that includes an error detection code (CRC). If CRC result is not OK, the reference SIR shall be raised by SIR_{INC} dB. If CRC result is OK, the reference SIR shall be reduced by SIR_{DEC} dB. SIR_{INC} is 0.5 dB (tentative), and SIR_{DEC} is derived from the following equation:

$$SIR_{DEC} = SIR_{INC} \bullet FER_{TARGET} / (1 - FER_{TARGET}) ,$$

where FER_{TARGET} is the target frame error rate. Initial reference SIR (SIR_{INIT}) is dependent on services, and the maximum/minimum value of reference SIR is limited to SIR_{MAX}/SIR_{MIN} dB.

SIR_{INIT} ,SIR_{MAX}, and SIR_{MIN} are designated via Layer 3 message. The updates of the reference SIR may be conducted together for N_{ILD} frames when channel-interleaving depth is N_{ILD} frames.

5.2 Modified Version

To avoid continuous messaging between the RNC and the UE, the algorithm of section 5.1 should be modified. Criteria should be selected so that poor performance is corrected quickly, but acceptable performance is refined at a relatively slow rate.; e.g. no more than once per UE per 10 seconds. Preliminary simulation has shown this to be true, more detailed simulations are in the process of being completed.

Consider the following example, which is not optimized, but will serve as an illustration.
Assume

- The target Frame Error Rate (FER) is 1/100.
- One CRC check per 10 millisec TDD frame = 100 CRC observations per second

We expect, in steady state
1 frame error per second
10 frame errors per 10 seconds
Standard deviation = sqrt(10)=3.2
3 sigma deviation = 20 errors.

Therefore, if there are 20 or more errors within 10 seconds then the RNC should send a correction to increase target SIR. This should occur less than 1 per 100 observations (observation is performed once per 10-second interval), or 15 minutes.

Furthermore, if there are less than x errors in 10 seconds then the RNC should reduce the target SNR by a small amount (e.g. 1/4 dB). For x = 7, the probability of observing this condition is on the order of 1 in 100 observations.

This values identified in the previous exercise illustrate that corrections need be sent very rarely.

6 Conclusion

Since outer loop power control can be accomplished using periodic and/or threshold trigger measurements of CRC and/or BER. WG3 does not have to create new NBAP messages to accomplish this mechanism since existing NBAP dedicated measurements can be used to accomplish this. Additionally we believe that an FDD Outer loop power control (the need of which is FFS) can be accomplished in a similar manner.

7 References

[1] InterDigital, “Issues Regarding Open Loop Schemes for Uplink Power Control in TDD”, Tdoc R1-99576, Cheju, Korea, June 1999.

[2] InterDigital, “Performance of weighted open loop scheme for uplink power control in TDD

[3] TS 25.224 V1.0.1 Physical Layer Procedures (TDD).

[4] InterDigital, “Performance evaluation of combined outer loop / weighted open loop scheme for uplink power control in TDD”, R1-99973, July 1999.