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Title: Physical Layer Measurements in UTRA TDD mode

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1 Introduction

This document aims at defining the measurements necessary at a UE and UTRAN operating in TDD mode. The measurements are very similar to the ones used for FDD with the exception, that they have to take into account the TDMA component of TDD. Special care has been taken to align the given proposal with the ideas and specifications in WG 2.

In addition to the FDD-like measurements for cell selection/reselection and handover monitoring, we propose to support dynamic channel allocation (DCA) by measuring the timeslot specific interference. In chapter 2 the measurements are defined and discussed together with their complexity. Chapter 3 summarizes the proposal and in chapter 4 a text proposal for S 25.231 is given.

2 Measurements

2.1 Definitions

The purpose of this section is to introduce a common view of the terminology regarding measurement quantities. The terms defined are then used throughout this document and are also aligned with a corresponding input to WG2.

- **RSCP**:Received Signal Code Power, is the received power on one code in a specified timeslot.
- **ISCP**: Interference on Signal Code Power, is the interference on the received signal in a specified timeslot. Only the non-orthogonal part of the interference is included in this measurement. The midamble provides an ideal means for this measurement due to its cyclic correlation properties.
- **RSSI:** Received Signal Strength Indicator, the wide-band received power within the relevant channel bandwidth in a specified timeslot.
- **Observed Time Difference to UTRA cell**: The relative time difference in frame timing between the serving and the target cell at the UE. In case of a synchronized TDD target cell this is the propagation time plus synchronization inaccuracies.
- **RX timing deviation (at UTRAN only):** The difference of the time between arrival of the UL transmission and the arrival time of a signal with zero propagation delay
- **Total TX power (at UTRAN only):** The total power transmitted by the nodeB within the channel bandwidth in a specified timeslot

The following measurements are derived from the first three basic quantities:

- **SIR:** Signal to Interference Ratio, is defined as RSCP / ISCP
- **Ec/No:** The received signal code power divided by the total received power in the channel bandwidth, defined as RSCP/RSSI

2.2 Measurement concept

A set of functions is defined for the TDD mode in order to increase system capacity , these being power control, cell selection/re-selection, handover, dynamic channel allocation and timing advance.

All of these functions require measurements of the radio environment in the UE and UTRAN. However, in most cases measurements for one function can be reused for the others.

The UTRAN is in control of all these measurements. It can specify the measurement objects (e. g. timeslots, cells) as well as the measurements to be performed and how frequently they shall be reported. Therefore, the measurements can be adjusted to match specific needs such as the cell characteristic (indoor, micro, macro, ...) or the UE power consumption.

2.3 Measurements for cell selection/reselection and handover

The following measurements are foreseen for this purpose for UTRA cells:

1. **RSCP:** This is the Received Signal Code Power. In the UE it is based on measurements of the PCCPCH of neighbouring cells and can be implemented as correlation with the known midamble of these cells. Therefore, the complexity of this measurement is rather low. It indicates the receive power of the PCCPCH of a certain cell. Comparing the RSCP measurements of different target cells, the network can derive information, whether a certain cell is a useful handover candidate or not. The RSCP allows also pathloss calculations when knowing the TX power. RSCP is also measured for DPCH and PDSH/PUSCH in UE and UTRAN and can be used for SIR calculation for power control in the UE.
2. **Ec/No (for monitoring of FDD cells, only)**: This is defined as RSCP/RSSI on the primary CCPCH. This measurement is used for FDD cells only and the rationale has been given for FDD already. With Ec/No the UTRAN gets some basis to set initial downlink power. For TDD cells the No does not represent an approximation of the interference or load as in FDD. Therefore, we propose to use only RSCP for handover measurements of TDD cells.
3. **Observed time difference to UTRA cell**: This value describes the difference in propagation delay between the serving and the target cell as well as synchronization inaccuracies. It can be used for synchronized TDD-TDD handover and for ease of monitoring RSCP of target UTRAN cells.
4. **ISCP of own link:** This is the non-orthogonal interference on the serving timeslot(s). It is measured in the UE and UTRAN e. g. by means of correlation on the midamble due to the special cyclic properties of the latter. Together with RSCP it results in the **SIR** = RSCP/ISCP value for the serving link in a specific timeslot. The SIR provides quality information about the serving link to be used in the handover algorithm similar to RXQUAL in GSM and for DCA as described below. This value is also available in the UE and UTRAN for power control.
5. **Total TX power (at Utran only):** This value indicates the total transmit power of the nodeB in a certain timeslot. It is specified at the antenna connector and can be used for load control.

For systems other than UTRA (GSM, PDC) the **RSSI** of the physical broadcast channel and the **observed time difference to** the non-UTRA target cell is measured.

2.4 Measurements for DCA

The following measurements are defined for DCA in the serving cell:

1. **ISCP on specified timeslots:** The ISCP is measured in UE and UTRAN e. g. by correlation with the midamble. Since such correlators will be needed for RSCP of neighbouring cells and for channel estimation in any case, the additional complexity for ISCP measurements is quite low. The timeslots, that have to be measured by the UE are specified in a list provided by the UTRAN. The ISCP values provide information about the inter-cell interference and therefore about the link quality to be expected in a certain timeslot. It is assumed, that the UTRAN measures ISCP on all UL timeslots.
2. **RSCP:** The RSCP is measured by the UE on the PCCPCH in order to calculate the pathloss and on the DPCH to calculate SIR (in connection with ISCP). Both provide quality estimates about the actual link, that can be used in a similar way as for handover. It is assumed, that the UTRAN measures RSCP on all uplink DPCHs.

The DCA tries to optimize TDD system performance by using measurements of interference in relevant timeslots and selecting the most suitable timeslots that require the least transmission power and best reuse efficiency. Another important parameter for this task is the pathloss which can be derived from RSCP on PCCPCH. While the nodeB measures continuously, for the UE two phases for measurements can be distinguished:

- **when connecting to TDD**: When connecting to TDD it is important to assign the most suitable resources for a UE's transmission needs. In order to save battery power, no DCA measurements are performed in idle mode. The UTRAN broadcasts a list of downlink timeslots, for which ISCP shall be measured by the UE's only when connecting to TDD. The UE can perform the ISCP measurements between the transmission of a RACH and the temporary allocation of an uplink signalling channel for call setup and measurement reporting.
- **when in connected mode**: In connected mode the UE monitors the link quality (e.g. SIR, BER) of the used timeslots. If quality falls below a certain threshold also the ISCP on all other timeslots specified by the network is measured and reported to UTRAN together with the quality values and pathloss loss indicator. That means the falling below a certain threshold triggers the periodic reporting to UTRAN. With these measurements the UTRAN can react on fluctuations of the interference in timeslots and reshuffle the timeslot allocation.

2.5 Measurements for timing advance (in UTRAN only)

In order to align the reception timing of the transmission from all UEs at the nodeB, each UE has to transmit with a specified timing advance. For this purpose the UTRAN has to measure the Rx timing deviation.

3 Summary of measurements in TDD mode

The following measurements are proposed in TDD mode for cell selection/reselection, handover monitoring and DCA:

1. RSCP
2. Observed time difference to UTRA cell
3. Ec / No (for monitoring FDD cells only)
4. ISCP in specified timeslots of the serving cell (partly available for power control already)
5. Total TX power of the nodeB

In addition, for inter-system handover, the RSSI and the observed time difference and for timing advance the Rx timing deviation shall be measured

4 Text Proposal for 25.231

It is proposed, that the following text replaces the existing text in 25.231. Therefore no revision marks are added.

In addition to the measurements described in detail above two sections are included in the text proposal, that describe the setting of compressed mode parameters, when monitoring TDD cells from FDD:

- 7.1.3.3.5. gives a general introduction similar to monitoring of FDD cells on other frequencies
- 7.1.3.3.5.1 describes the setting of compressed mode parameters without prior timing information. It is very similar to the chapter describing the monitoring of FDD cells on other frequencies in 7.1.3.3.4.1.
- 7.1.3.3.5.2 describes the case that timing information about the target TDD cell is available. In this case the compressed mode parameters are able to schedule the transmission gap to directly monitor the PCCPCH timeslot of the target TDD cell.

5.1.2 Measurement from the cell selection monitoring set and reporting to higher layers

For intra system measurements the UE shall support measuring and reporting to higher layers any of the quantities:

1. Rx RSCP on PCCPCH,
2. Ec/No on CPICH (for FDD cells only),

For inter system (GSM/PDC) measurements the UE shall support measuring and reporting to the higher layers any of the quantities:

1. Receive signal strength (RSSI),
2. Observed time difference

of the physical broadcast channel of the target system (GSM/PDC). See section 8 for the definition of the quantities.

5.2.2 Measurements for cell reselection and reporting to higher layers

For intra system measurements the UE shall support measuring and reporting to the higher layers of the quantities:

1. Rx RSCP on PCCPCH,
2. Ec/No on CPICH (for FDD cells only),

For inter system (GSM/PDC) measurements the UE shall support measuring and reporting to the higher layers of the quantities:

3. Receive signal strength (RSSI),
4. Observed time difference to target cell

of the physical broadcast channel of the target system (GSM/PDC).

7.1.1 Cell Sets for handover preparation

7.1.1.2.1.3 TDD Cells

The handover monitoring set contains for each cell to monitor:

- The carrier center frequency information
- an information field for the cell parameters (t_{offset}, midamble code, scrambling code)
- the timeslot number of the PCCPCH
- Observed time difference of the target cell if available

Each UE has stored a 'cell parameter list' which maps the information field value value to one out of 128 sets of cell parameters. The list is common to all TDD systems and is described in TS 25.223.

7.1.3.3.5 Monitoring of TDD cell at the UE for the handover preparation from UTRA FDD to UTRA TDD

Upper layers may ask dual mode FDD/TDD UE to perform preparation of inter-frequency handover to TDD. In such case, the UTRAN signals to the UE the handover monitoring set, and if needed, the compressed mode parameters used to make the needed measurements. Setting of the compressed mode parameters defined in 7.1.3.3.2 for the preparation of handover from UTRA FDD to UTRA TDD is indicated in the following section. Measurements to be performed by the physical layer are defined in section 7.1.3.3.5.2.

7.1.3.3.5.1 Setting of the compressed mode parameters

When compressed mode is used for cell acquisition at each target TDD frequency, the parameters of compressed mode pattern are fixed to be:

TGL	TGD	TGP	PD

7.1.3.3.5.2 Setting of compressed mode parameters with prior timing information between FDD serving cell and TDD target cells

UTRAN or UE may have some prior knowledge of the frame timing difference between some FDD cells in UE's active set and some TDD cells in the handover monitoring set. When this information is acquired by the UE (e.g. after initial SCH detection) and on upper layer's command, the UE shall report it to the upper layers for verification of UTRAN's information, and feedback of this information from UTRAN to the other UE.

In this case with prior timing information the compressed mode parameters in chapter 7.1.3.3.2. are set in a way that takes into account the frame timing difference and the slot number of the PCCPCH in the target TDD cell. The position of the transmission gap allows directly the monitoring of the TDD cell's timeslot that contains the PCCPCH.

7.1.3.3.5.3 Measurements

The UE shall measure and report to the higher layers from the TDD cells, belonging to the handover monitoring set, any of the quantities:

1. Rx RSCP on PCCPCH
2. Observed time difference to target TDD cell

7.1.5 Measurements for the handover preparation from TDD at the UE

7.1.5.1.In general

In addition to the measurements described for neighbouring cells, the UE shall measure for the serving cell:
1. Rx ISCP on the DL timeslots assigned to the UE
2. Rx RSCP on the DPCH, PDSCH and PCCPCH

7.1.5.2.2 Monitoring of TDD cells

The UE shall measure and report to the higher layers from the cells on the same frequency, belonging to the handover monitoring set, any of the quantities:

1. Rx RSCP on PCCPCH
2. Observed time difference to target TDD cell

7.1.5.3 Measurements for the handover preparation from TDD to FDD at the UE

The UE shall measure and report to the higher layers from the FDD cells, belonging to the handover monitoring set, any of the quantities:

1. Ec/No on CPICH
2. Observed time difference to target FDD cell

7.1.6 Measurements for the handover preparation in TDD at the UTRAN side

For the handover preparation in a TDD cell the serving nodeB shall carry out any of the following measurements

1. Rx RSCP on DPCH and PUSCH
2. Rx ISCP on all uplink timeslots
3. Physical channel BER on DPCH and PUSCH
4. Total TX power in downlink

7.4 Measurements for DCA (for TDD only)

For DCA no measurements are performed in idle mode in the serving cell.

7.4.1 Measurements by the UE for DCA when connecting

<This chapter replaces chapter 6 in the existing 25.231>

With the initial access the UE immediately starts measuring the ISCP of time slots which are communicated on the BCH. The measurements and the preprocessing are done while the UTRAN assigns an UL channel for the UE for signaling and measurement reporting.

7.4.2 Measurements by the UE for DCA when in connected mode

In order to support DCA the UE shall measure and report to higher layers any of the quantities:

1. Rx ISCP on DL timeslots according to a list provided by the UTRAN
2. Rx RSCP on the serving DPCHs and PDSCH (for SIR calculation) and on the PCCPCH (for pathloss calculation)

7.4.3 Measurements by the UTRAN for DCA

The following measurements have to be performed for DCA at the UTRAN side and reported to higher layers:
1. Rx ISCP on all UL timeslots
2. Rx RSCP on all timeslots DPCH and PUSCH

7.7. Measurements for timing Advance by the UTRAN

The following measurement has to be performed by the UTRAN on PRACH, DPCH and PUSCH:

1. Rx Timing deviation

8 Radio link measurements for TDD

RSCP:
Definition:
Received Signal Code Power, is the timeslot specific received power on one code. UE measurements shall be possible on the PCCPCH,DPCH and PDSCH. UTRAN measurements shall be possible on PUSCH and on DPCH.
Purpose:
Handover evaluation, cell selection/reselection, DL and UL power control, calculation of SIR and pathloss.

ISCP
Definition:
Interference on Signal Code Power is the timeslot specific non-orthogonal interference on the received signal to be measured at UE and UTRAN..

Purpose:
This quantity is used for DCA and SIR calculation.

SIR
Definition:
Signal to Interference Ratio, is defined as the RSCP / ISCP. The measuring of SIR shall be possible both for the UE and UTRAN according to the measurement of RSCP and ISCP.
Purpose:
Power control, handover evaluation, initial power setting, DCA.

RSSI
Received Signal Strength Indicator, the wide-band received power within the channel bandwidth. UE and UTRAN measurements shall be possible for the relevant UTRAN channel bandwidth and for the other systems supported according to the applicable system DL bandwidth and channel structure.

Purpose:
Inter system (GSM/PDC) handover evaluation, Ec/No calculation.

Ec/No
Definition:
The received signal code power divided by the total received power in the channel bandwidth and is defined as RSCP/RSSI. The measuring of Ec/No shall be possible both for the UE and UTRAN according to the measurement of RSCP and RSSI.
Pupose:
Handover evaluation for FDD, initial power setting for FDD

Observed time difference to UTRA cell
Definition:

This value describes the differnce in propagation delay between the serving and the target cell as well as synchronization inaccuracies. It can be used for synchronized TDD-TDD handover and for ease of monitoring RSCP.
Pupose:
Handover evaluation.

Rx timing deviation
Definition:
The difference between the time of arrival of the UL transmission and the arrival time of a signal with zero propagation delay
Purpose:
Timing advance

Total TX power:
Definition:
The total power transmitted by the nodeB at the antenna connector within the channel bandwidth in a specified timeslot
Purpose:
Load control