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Title: **Draft TR on " NodeB Synchronisation for TDD"**

NodeB Synchronisation for TDD is an agreed work item for Release 2000. The attached document is a draft for the TR to be issued on this topic.

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Technical Report

3rd Generation Partnership Project;
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(Release 2000)

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Contents

Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

This TR describes the solution recommended to enable the synchronisation of NodeBs in UTRA TDD beyond that included in Rel. 99.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.

[<seq>] <doctype> <#>[([up to and including]{yyyy[-mm]|V<a[.b[.c]]>}[onwards])]: "<Title>".

[1] 3G TS 25.123: "Example 1, using sequence field".

[2] 3G TR 29.456 (V3.1.0): "Example 2, using fixed text".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the [following] terms and definitions [given in ... and the following] apply.
Definition format

<defined term>*: <definition>.*

example: text used to clarify abstract rules by applying them literally.

3.2 Symbols

For the purposes of the present document, the following symbols apply:
Symbol format

<symbol> <Explanation>

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:
Abbreviation format

<ACRONYM> <Explanation>

4 Background and Introduction

NodeB synchronisation for TDD is a release 2000 work item that was agreed in RAN#7 plenary meeting. This work item involves the introduction of functionality to enable nodeBs to be synchronised.
This report identifies the required modifications within the UTRA layers 1/2/3. ~~Emphasis must be put on the fact that it is tried to reuse existing functionality as much as possible for enabling the nodeB synchronisation for~~

TDD . The methods described isare in addition to the Rel. 99 feature of the synchronisation port contained described in TS 25.402.

5 Motivation

Cell synchronisation is planned for UTRA TDD in order to fully exploit the system capacity. There are several factors, that have an impact on the system capacity. The most important ones are:

- Inter-slot interference: without frame synchronisation there could be leakage from an UL timeslot into a DL timeslot, especially crucial for the UE due to the potentially close distance between UEs and the near-far effect.
- neighbouring cell monitoring: In TDD mode, certain measurements have to be performed in certain parts of certain timeslots of neighbouring cells. Without cell synchronisation, the UE would have to synchronise itself before being able to perform the measurements.
- Handover: The TDD mode may use timing advance in order to align receptions from all UEs at the cell's receiver. After a handover, the UE has to start transmission in the new cell with a timing advance value as good as possible. With the assumption, that the TDD cells are synchronised to each other, the handover performance can be optimised.

6 Accuracy Requirements

Several issues have been identified as of key importance in determining the accuracy requirements that the solution for synchronisation between cells should fulfill:

1) Impact of Time Error on Inter Slot Interference
2) Impact of Time Error on Timing Advance Adjustment for handover
3) Impact of Cell Timing Adjustments on UE receive and tracking performance

The minimum requirementdetailed value for cell synchronisation accuracy in order to minimise the above impacts on the system performance has to be definedis not defined yet. A first estimate is ± 2.5 µs., but could be in the area of ±1...3 µs.

In addition to the above requirement, the chosen solution should provide the option, that the accuracy can be enhanced, e. g. via more frequent measurements.
It is advantageous to signal information about the synchronisation accuracy to the UE for handover, so that the UE can apply the proper timing advance procedure as described in section 7.3.

7 General Concept of Node B Synchronisation

7.1 General

The different solutions to achieve synchronisation in TDD can be grouped into two main classes:

- Synchronisation of nodes Bs to an external reference via the synchronisation port standardised for Rel. 99
- Synchronisation of cells or Node Bs via the air interface to be included in Rel. 2000

Each of these two methods has some advantages and some drawbacks, and also a solution shallmight be adopted that combines both techniques and furthermore allowsalso proprietary synchronisationmeans between a Node B and its cells.
It is however probable that whichever solution belonging to the second class is adopted, some new functionality will be needed on Iub.

~~In every solution the~~ The RNC shall be the master of the synchronisation process, since the measurements either performed by a~~one~~ cell ~~on another one,~~ or by a~~the~~ UE, shall be signaled to~~received~~ and processed by the RNC. This means that at least a procedure between~~from~~ the RNC and~~to~~ the node B is needed in order to transmit measurements and adjust the node B timing.

7.2 Layer 1 concepts

~~There are currently two concepts for performing synchronisation over-the-air. The first is based on measurements of neighbouring cells' SCH, the second is based on the transmission and measurements of a special burst on the RACH timeslot:~~

~~**SCH method:** The principal feature is based on each Node B occasionally monitoring neighbouring cell's Synchronisation Channel (SCH), measuring the Time of Arrival (TOA), confirming the identity, and sending this information to the controlling RNC.~~
~~**RACH method:**~~
The layer 1 concept method is based on using infrequent transmissions of synchronisation bursts in the PRACH time slots based on an RNC schedule. Such soundings between neighbouring cells facilitate timing offset measurements by the cells. The timing offset measurements are reported back to the RNC for processing. The RNC generates cell timing updates that are transmitted to the Node Bs and cells for implementation.

WG1 Note: Details ~~on these two methods~~ can be found in R1-00-074. ~~(RACH method) and R1-00-471 (SCH method), respectively.~~

7.3 Higher Layer concepts

In general, the RNC has overall control of the cell synchronisation procedure. The RNC sets up a scheduling plan. ~~In the case of the RACH method i~~It instructs each cell when to transmit a sync burst in its PRACH slot and when to perform measurements.
~~In the case of the SCH method the RNC instructs each cell when to perform measurements.~~
All measurement results are processed within the RNC and timing update commands are then sent to the individual cells or Node Bs.
It is currently assumed, that there is no communication between neighbouring RNC areas and that each RNC area has its own timing reference (UTC). Furthermore, each RNS uses its own code for the synchronization burst.

For handover the UE is provided with information about the synchronisation accuracy so that it can apply the proper timing advance value and procedure in the new cell:

1. In large cells and low sync accuracy (± 2.5 us), HO will be done without TA, so that the maximum timing error would be twice the propagation delay, e. g. 6 us or 24 chips for 1 km radius. TA would only be useful for a cell larger than 1.5 km in radius. It might be advantageous to transmit a special burst type 3.
2. In large cells with medium sync accuracy (e. g. ± 0.5 us) HO will be performed with TA autonomously calculated by the UE. However, the UE will correct the calculated TA value for the sync inaccuracy. The maximum timing error would be 4 s or 16 chips. For an estimation window of 57 chips this is be tolerable. Even the TA step size is 4 chips. The correction value is calculated in the RNC and signalled to the UE before handover execution.
3. In large cells with high sync accuracy (+- 100 ns) autonomous TA calculation in the UE will be used after HO. The maximum timing inaccuracy will be 400 ns.

In cases 1-3 the UE shall apply TA wirh the value received in a TA command in the new cell.

In small cells no TA will be used. The maximum timing inaccuracy will be twice the propagation delay.

8 Impact on Interfaces

8.1 Uu Interface

8.1.1 SCH method

The impact of the SCH method on the Uu Interface is the measurement of neighbouring cells' SCH code in downlink timeslots or in addition to other uplink data. It is highly desirable that the UE performance be unaffected by these losses, and that they not be required to be signalled. However analysis must be done to determine this fact, and it may be necessary to provide such signalling. The need, or non-need of this signalling is under study.

8.1.2 RACH method

The RACH method has There is an impact in the transmitting as well as in the receiving cell.
In the transmitting cell, a RACH timeslot is blocked during synchronisation burst transmission. In the receiving cell the Synchronisation Burst is interfered by PRACH bursts as well as it generates interference for these. It is highly desirable that the UE performance be unaffected by these losses, and that they not be required to be signalled the blocking of the RACH timeslots. However analysis must be done to determine this fact, and it may be necessary to provide such signalling. The need, or non-need of this signalling is under study.

In addition to the blocking of timeslots, the Synchronisation Burst itself has to be defined.
For handover the UE shall be provided with information about the synchronisation accuracy so that it can apply the proper timing advance value and procedure in the new cell as described in section 7.3.

8.2 Iub Interface

The messages between a NodeB and the RNC have to be standardised.
In the uplink these are:

- Neighbouring cell measurements

In downlink these are:

- Timing adjustment commands
- Transmit (RACH method only) and receive schedule

8.3 Iur Interface

Each RNC area is synchronised individually to at least one reference UTC clock. This automatically ensures synchronisation between RNC areas. Therefore, no communication over Iur is necessary for cell synchronisation between RNC areas.

9 Impact on network elements

9.1 UE

The UE may be required to have the capability to take into account the blocking of timeslots in up- and/or downlink.
It shall have the capability of correcting its TA value after handover.

9.2 Node B

The cells have to support the reception of the Synchronisation Burst ~~and/or the SCH sequence~~ as well as measure the reception time. In addition, ~~for the RACH method~~ the cells have to support the transmission of the Synchronisation Burst.
Furthermore, the cells have to provide means for adjusting their timing and optionally the clock rate on command. The changes in the NBAP protocol have to be supported.

9.3 RNC

The RNC has the control of the whole algorithm. It has to initialise, establish and maintain a connectivity plan. It has to collect measurements and compute adjustment commands as well as support the necessary NBAP signalling. It shall estimate the synchronisation accuracy between cells and signal the relevant information to the UEs for handover. All~~The~~ algorithms involved will be proprietary.

10 Performance Analysis

~~10.1 Simulations for the SCH method~~

~~To be supplied~~

~~10.2 Simulations for the RACH method~~

A performance analysis is included in Tdoc R1-00-0074. There it is shown, that it is possible, to fulfill the accuracy requirements for support of LCS. The resource stealing for this is in the order of 0.5 % of the RACH capacity. The resource stealing neccesary for the minimum requirements is considerably lower and in the order of 0.02 % of the RACH capacity. ~~To be supplied~~

11 Backward Compatibility

~~To be supplied~~
UTRAN: The synchronisation over the air in Rel. 2000 can be used in addition to and in combination with the synchronisation via the sync port in Rel. 99. Therefore, backward compatibility is ensured for the UTRAN.

UE: The Rel. 99 UE's are affected by the blocking of RACH resources in certain timeslots, i. e. these UEs are not aware, that their RACH transmission in certain timeslots cannot be successful. However, this is not regarded as a problem, since the algorithms involved in the RACH transmission have to cope with a RACH failure in any case.

History

Document history		
Date	**Version**	**Comment**
07.07.00	0.1.0	First draft

Document history		
Date	**Version**	**Comment**
24.8.00	0.1.1	Second draft

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