TSG-RAN Working Group 1 #17 *R1-00-1467*
Stockholm, Sweden, 21-24 November 2000

Source: Editor

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

NodeB Synchronisation for TDD is an agreed work item for Release 4. The attached document is a draft for the TR to be issued on this topic.

3G TR 25.836 V0.1.20(2000-11)

Technical Report

3rd Generation Partnership Project;
Technical Specification Group Radio Access Network;
NodeB Synchronisation for TDD
(Release 42000)

Keywords
<keyword[, keyword]>

3GPP

Postal address

3GPP support office address
650 Route des Lucioles - Sophia Antipolis
Valbonne - FRANCE
Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Internet
http://www.3gpp.org

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>".

[11] 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. The method described is in addition to the Rel. 99 feature of the synchronisation port contained 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 requirement for cell synchronisation accuracy in order to minimise the above impacts on the system performance has been defined by WG 4 to be 3 ?s. The accuracy is defined as the maximum deviation in frame start times between any pair of cells that have overlapping coverage areas ~~has to be defined. A first estimate is ± 2.5 ?s. The final value is to be decided in WG 4.~~

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~~ In addition to proprietary means there are two ways to achieve cell synchronisation in a TDD system ~~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 described in this report for ~~to be included in~~ Rel. 4~~2000~~

~~Each of these two methods has some advantages and some drawbacks~~The solution described in this report allows a mixture of both schemes, i. e. some cells may be synchronised over the air, some via the synchronisation port.

In general, at least one time reference (e. g. GPS) is needed for each island of cells having connectivity to each other., and a solution shall be adopted that combines both techniques

The RNC shall be the master of the synchronisation process, since the measurements either performed by a cell or by a UE, shall be signalled to and processed by the RNC.
This means that at least aA new procedure facilitates the transmission of measurements and commands- between the RNC and the node B is needed in order to transmit measurements and as well as allows the adjustment of the node B timing. Details of this procedure can be found in TR 25.838.

7.2 Synchronisation ProcedureLayer 1 concepts

The layer 1 concept methodThe synchronisation procedure is based on using infrequent transmissions of cell synchronisation bursts in predeterminedthe 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. CEC sequences with multiple offsets are used as cell synchronisation bursts. The synchronisation procedure has two phases:

Initial Synchronisation

1. The RNC sends a request over the relevant Iub to the cell(s) with GPS reference for a timing signal. The RNC adjusts its clock appropriately, compensating for the known round trip Iub delay.
2. The RNC sends timing updates over the Iub to all the cells, apart from the one containing the GPS, instructing them to adjust their clocks towards its own timing. Each of the timing offsets is again adjusted by the Iub round trip delay for that cell.
3. At this point, none of the cells is supporting traffic so a large proportion of the time can be given over to achieving synchronisation. It is assumed that there is as yet no information available on which to base the generation of a re-use pattern for sync transmissions. Thus all cells are instructed to transmit their cell sync bursts in turn one after the other with *no re-use*, i. e. the same sync burst sequence and offset is used by all cells.
4. All cells listen for transmissions and those which successfully detect a cell sync burst report their timing and received S/(N+I) to the RNC over the relevant Iub. Knowing the schedule, the RNC is able to determine the cell which made the transmission and place a measurement entry in the relevant place in its measurement matrix. After all cells have made their transmissions, the RNC computes the set of updates which will bring the cells nominally into synchronisation.
5. Steps 3 and 4 are repeated several times (typically 10). This serves two purposes:-
   - ?? The rapid updates allow the correction of the clock frequencies as well as the clock timings to be adjusted in a short space of time. This rapidly brings the network into tight synchronisation.
   - ?? The S/(N+I) values are averaged over this period. This provides more accurate measurements (averaging over noise and fading) which can be used in the automatic generation of a re-use plan.
6. The S/(N+I) values are used, automatically, to plan a re-use pattern. This is performed as follows:-
   - ?? A matrix of minimal connectivity is computed on the basis of designating pairs of cells are minimal neighbours if either their estimated average S/(N+I) exceeds a threshold or if they have mutual neighbours.
   - ?? The set of cells is divided into partitions of cells. Each partition must satisfy the requirement that no pairs of cells within that partition are minimally connected. All cells within a partition transmit the same code offset in parallel.

Steady-State Phase

7. All of the cells in the same partition are arranged to transmit / receive in the same cell sync frames according to the above procedure and they transmit the same code offset in parallel. All cells report the reception times for all relevant code offsets back to the RNC.
8. At the end of each cycle, the RNC collates the information. In general there should always exist a path of bidirectional valid measurements that link every cell either directly or indirectly to the cell with UTC capability. However, the model is arranged such that only those cells which have such a path will be updated on any given occasion.
9. The process of partition transmissions and updating then continues indefinitely.

Late entrant Node Bs

The scheme for introducing new nodeBs into a synchronized RNS is as follows:

1. There is a specialised sync transmission at regular intervals or event driven. A single common code (i.e. with the same, nominally zero, shift) is transmitted in parallel by *all* NodeBs which are synchronised in the system. The late entrant NodeB will correlate against the specialised sync transmissions. The late entrant NodeB will take the earliest reception as the timing of the system.
2. Thus, at this point, the late entrant NodeB has obtained system time, subject to an unknown propagation delay between it and its nearest neighbour. The late entrant NodeB cannot, at this time, tell which of its neighbours *is* the nearest. However, this level of synchronisation is good enough that from then on the late entrant NodeB can distinguish the overlaid normal sync transmissions unambiguously for the various code shifts.
3. After this time the late entrant NodeB can measure the timings of sync transmissions received from specific NodeBs and report these to the RNC. In turn, the RNC can give the late entrant NodeB its own schedules for sync transmission and to use one or more of these. The RNC can then use the bi-directional sounding, which will then be available, to compute the true timing error and to instruct the NodeB to adjust its timing appropriately.

~~WG1 Note: Details can be found in R1-00-074 and refinements thereof in R1-00-1349.~~

7.3 Potential Improvements for Handover~~Higher Layer concepts~~

~~In general, the RNC has overall control of the cell synchronisation procedure. The RNC sets up a scheduling plan. It instructs each cell when to transmit a sync burst in its PRACH slot and 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 GPS timing reference (UTC). Furthermore, different codes for the cell sync burst are used in neighbouring RNS.each RNS uses its own code for the synchronization burst.~~

For handover the UE may~~could~~ be provided with information about the synchronisation accuracy of the new cell 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~~ 3 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.~~ 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 for the example given 2~~4~~ µs or 8~~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 shall~~will~~ be used. The maximum timing inaccuracy will be twice the propagation delay.

The figures in the description above~~description above is~~ are just an example. The difference between small cells and large cells is whether TA has to be applied~~is needed~~ in these cells or not.
Higher layer signalling determines, whether TA is used in a cell or not and whether it shall be applied in a new cell after handover.
If the synchronisation accuracy is signalled in the handover phase, then the UE shall adjust its autonomously calculated TA value accordingly.
~~During the initial phase after handover it depends on the cell size and the synchronisation accuracy, whether TA is used or not with or without correction.~~

8 Impact on Interfaces

8.1 Uu Interface

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. In order to avoid these known losses of RACH transmissions, the UEs may be informed about timeslots that are blocked for cell sync burst transmissions. 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.
The cell sync codes to be used are **C**oncatenated periodically **E**xtended **C**omplementary sequences as described in more detail in R1-00-1351 (see Annex A). Different code offsets are used in order to preserve the correlation property of these sequences.
For handover the UE maycould 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. are described in detail in TR 25.838.
In the uplink these messages are:

?? Neighbouring cell measurements

?? Timing information

In downlink these are:

?? Timing adjustment commands

?? Transmit and receive schedule

8.3 Iur Interface

Each RNC area is synchronised individually to at least one reference UTC clock (e. g. GPS). 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 shallmay be required to have the capability to take into account the blocking of timeslots in up- and/or downlink.
It could shall support the synchronisation accuracy signalling mechanism and have the capability to of correcting its TA value forafter handover.

9.2 Node B

The cells shallhave to support the reception of the Cell Synchronisation Bursts as well as measure the reception time. In addition, the cells have to support the transmission of the Cell Synchronisation Burst.

Furthermore, the cells shall 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 shall~~has to~~ initialise, establish and maintain a connectivity plan. It shall~~has to~~ collect measurements and compute adjustment commands as well as support the necessary NBAP signalling. It may~~could~~ estimate the synchronisation accuracy between cells and signal the relevant information to the UEs for handover. All algorithms involved in the computation of timing updates and schedules ~~will~~are ~~be~~ proprietary.

10 Performance Analysis

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 0.04~~2~~ % of the RACH capacity.

11 Backward Compatibility

UTRAN: The synchronisation over the air in Rel. 4~~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.

Annex A

R1-00-1351.zip

History

Document history		
Date	**Version**	**Comment**
07.07.00	0.1.0	First draft
24.8.00	0.1.1	Second draft
22.11.00	0.1.2	Third Draft

Document history		
Date	**Version**	**Comment**
Editor for 3G TR 25.836 is: Stefan Oestreich		
Tel. : +49 89 722 21480 Fax: +49 89 722 24450 Email : stefan.oestreich@icn.siemens.de		
This document is written in Microsoft Word 97 version.		