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Technical Report

3rd Generation Partnership Project (3GPP);
Technical Specification Group (TSG) RAN;

Node B Synchronisation for TDD (Iub/Iur aspects)
Release 2000

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3GPP

Postal address

Office address

Internet
secretariat@3gpp.org
Individual copies of this deliverable
can be downloaded from
http://www.3gpp.org

Contents

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Foreword

This Technical Report (TR) has been produced by the 3rd Generation Partnership Project (3GPP), Technical Specification Group RAN.

The contents of this TR are subject to continuing work within 3GPP and may change following formal TSG approval. Should the TSG modify the contents of this TR, it will be re-released with an identifying change of release date and an increase in version number as follows:

Version m.t.e

where:

m indicates [major version number]

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

y the third digit is incremented when editorial only changes have been incorporated into the specification.

1 Scope

The purpose of the present document is to help the TSG RAN WG3 group to specify the changes to existing WG3 specifications, needed for the introduction of the “Node B Synchronisation for TDD”. It is intended to gather all information in order to trace the history and the status of the Work Task in RAN WG3. It is not intended to replace contributions and Change Requests, but only to list conclusions and make reference to agreed contributions and CRs. When solutions are sufficiently stable, the CRs can be issued.

This TR describes agreed requirements related to the Work Task, and split the Work Task into “Study Areas” in order to group contributions in a consistent way.

It identifies the affected specifications with related Change Requests.

It also describes the schedule of the Work Task.

This document is a ‘living’ document, i.e. it is permanently updated and presented to all TSG-RAN meetings.

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.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

[1] RP-000055, Work Item Description: Node B Synchronisation for TDD

[2] TR 25.836, Node B Synchronisation for TDD (Release 2000).

[3] 3G TS 25.402: "Synchronisation in UTRAN, Stage 2".

[4] 3G TS 25.433: "UTRAN Iub Interface NBAP Signalling".

[5] 3G TS 25.423: "UTRAN Iur Interface RNSAP Signalling"

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply.

3.2 Symbols

3.3 Abbreviations

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

4 Introduction

4.1 Task Description

Node B synchronisation for TDD is a release 2000 work item described in [1], that was agreed at TSG-RAN#7 meeting. This work item enables the TDD Inter Node B Node Synchronisation via the air interface. This includes the synchronisation of cells among each other belonging to the same Node B or to neighbouring Node B.

4.2 Rationale for Node B Synchronisation for TDD

For the rationale for Synchronisation of Node B for TDD in the UTRAN refer to [2].

5 Requirements

For support of the TDD Node B synchronisation the following functionalities have to be provided:

- Synchronisation of the radio frame clock and multiframe clock between neighbouring cells
- Possibility to synchronise cells without external reference at each Node B
- Possibility to synchronise the TDD cells belonging to the same or to different Node B to an external clock (e.g. GPS) provided at a sync port.

6 Study Areas

This section gives a summary of areas that have been identified where work needs to be performed to complete the work item.

6.1 Over the air Cell Synchronisation mechanism

For cell synchronisation over the air interface 3 different synchronisation stages are distinguished:

- Initial synchronisation,
  The initial synchronisation is used when a TDD network is newly established and has to be synchronised. It is assumed that none of the cells is supporting traffic at this time.
- Steady-State phase,
  In the steady state phase the synchronisation mechanism during normal operation applies.
- Late-Entrant cells,
  Synchronisation mechanism for cells to be added to a synchronous network or cells recovering from loss of radio interface synchronisation.

6.1.1 Initial Synchronisation

Preliminary Phase:

1) There should be at least one cell in each RNC area (i.e. in the RNS) which is synchronised by an external reference (e.g. GPS). This cell should determine the local time modulo SFN period (40,96 sec.).

2) The RNC has to know at which of the cells the external reference is connected.

3) The RNC retrieves the reference timing signal from the cells with GPS. When receiving the response, the RNC adjusts its internal clock RFN (RNC Frame Number), compensating the Iub delay by subtracting half of the known round trip Iub delay.

4) Now the RNC proceeds by updating the timing of all the remaining cells in the RNS, instructing them to adjust their clocks. Each of the timing offsets is again adjusted by the Iub round trip delay for that cell. - The result is: All the cells are "roughly synchronised", with an inaccuracy corresponding to the uncertainty of the Iub interface signalling transmission time, which is likely to be more than 1 radio frame.

Initial Phase:

5) For the sync procedure it is useful to know which cells can “hear” each other. However, during the initial phase, it is assumed that there is 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. The same cell sync burst signal is used by all cells.

6) 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. 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 inter-cell connectivity matrix. After all cells have made their transmissions, the RNC computes the set of timing updates which will bring the cells nominally into synchronisation.

7) Steps 5 and 6 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 period 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.

8) The S/(N+I) values in the connectivity matrix are used by the RNC to plan a re-use pattern. This is performed as follows:-

- A matrix of minimal connectivity is computed where pairs of cells are labelled as “minimal neighbours” if either their estimated average S/(N+I) exceeds a threshold or if they have at least one neighbour in common.
- The set of cells is divided into partitions where cells which are in the same partition are sufficiently separated and can therefore be allowed to send the same cell sync burst at the same time. For this purpose each partition must satisfy the requirement that no pairs of cells within that partition are minimally connected.

6.1.2 Steady-State Phase

At this point, each cell gets a "cell synch burst plan" which tells the cell what to do whenever e.g. their SFN modulo 128 = 0. Based on that plan, they start transmitting or receiving cell sync bursts, respectively, and they report the relative time of cell synch burst reception, among others, to the RNC.

1. All 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 cell sync burst signal in parallel. All cells report the reception times for all relevant burst signals back to the RNC. In order to decrease the number of messages over Iub, the measurement reports may be sent only when a certain threshold is exceeded.

2. At the end of each cycle, the RNC collates the information. In general there should always exist a path of bidirectional valid measurements that links every cell either directly or indirectly to a cell with reference clock. However, the model is arranged such that only those cells which have such a path will be updated on any given occasion.

3. The process of partition transmissions and updating then continues indefinitely

6.1.3 Late-Entrant Cells

The scheme for introducing new cells into a synchronised RNS is as follows:

- There is a specialised sync transmission at regular intervals or event driven. A single common cell sync burst is transmitted in parallel by *all* cells which are synchronised in the system. The late entrant cell will correlate against the specialised sync transmissions. The late entrant cell will take the earliest reception as the timing of the system.

- Thus, at this point, the late entrant cell has obtained system time, subject to an unknown propagation delay between it and its nearest neighbour. At this time, the late entrant cell cannot tell which of its neighbours *is* the nearest. However, this level of synchronisation is good enough that from then on the late entrant cell can distinguish the overlaid normal sync transmissions unambiguously for the various code shifts.

- After this time the late entrant cell can measure the timings of sync transmissions received from specific cells and report these to the RNC. In turn, the RNC can give the late entrant cell its own schedules for cell sync burst transmission and reception. The RNC can then use the bi-directional sounding, which will then be available, to compute the true timing error and to instruct the cell to adjust its timing appropriately.

6.21 Neighbouring Cell Measurement

6.32 Synchronisation Adjustment

6.43 Synchronisation alarming

6.54 Delay Compensation

7 Agreements and associated agreed contributions

This section documents agreements that have been reached and makes reference to contributions agreed in RAN-WG3 with respect to this study item. This section is split according to the above mentioned Study Areas.

7.1 Neighbouring Cell Measurement

7.2 Synchronisation Adjustment

7.3 Synchronisation alarming

7.4 Delay Compensation

8 Specification Impact and associated Change Requests

This section is intended to list the affected specifications and the related agreed Change Requests. It also lists the possible new specifications that may be needed for the completion of the Work Task.

9 Backward Compatibility

In this section, the backward compatibility will be discussed.

10 Project Plan

10.1 Schedule

Date	Meeting	Scope	[expected] Input	[expected]Output

10.2 Work Task Status

	Planned Date	Milestone	Status
1.			
2.			

11 Open Issues

12 History

Document history		
V0.0.1	2000-07	First proposal
V0.1.0	2000-08	Version agreed at RAN3#15 (Berlin).
V.0.1.1	2000-11	Version including changes agreed at RAN3#17 (Chicago): • R3-003071
Rapporteur for 3GPP RAN TR 25.838 is:		
Johannes Lenhart, Siemens Tel.: +49 89 722 63697 Fax: +49 89 722 48511 Email: Johannes.Lenhart@icn.siemens.de		
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