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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 4)

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Foreword

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

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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. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[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".

[6] 3GPP TS 25.435: "UTRAN Iub interface user plane protocols for CCH data streams".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

Cell sync burst plan: A plan specifying for each cell in an RNS the times when to send or receive "cell sync bursts", and the parameters of these sync bursts.

Cell Sync bursts: Special CDMA bursts sent out and received by TDD cells in selected radio frames in a time slot which is normally used for the PRACH.

Re-use plan: Cell sync burst plan which allow "re-use" of synchronisation slots, i.e. two or more cells send their sync bursts at the same time.

Synchronisation slots: The time slots in selected radio frames where sync bursts are sent or received by certain cells in the RNS.

3.2 Symbols

None.

3.3 Abbreviations

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

FDD	Frequency Division Duplex
L1	Layer 1 (physical layer)
L2	Layer 2 (data link layer)
L3	Layer 3 (network layer)
MAC	Medium Access Control
P-CCPCH	Primary Common Control Physical Channel
PHY	Physical layer
PRACH	Physical Random Access Channel
RACH	Random Access Channel
RB	Radio Bearer
RNC	Radio Network Controller
RNS	Radio Network Subsystem
RNTI	Radio Network Temporary Identity
Rx	Receive
SCH	Synchronization Channel
SFN	Cell System Frame Number (counter)
SIR	Signal to Interference Ratio
SRNC	Serving Radio Network Controller
SRNS	Serving Radio Network Subsystem
TDD	Time Division Duplex
Ts	Timeslot
Tx	Transmit
U-	User-
UE	User Equipment
UL	Uplink
UMTS	Universal Mobile Telecommunications System
UTRA	UMTS Terrestrial Radio Access
UTRAN	UMTS Terrestrial Radio Access Network

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 half 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.

Frequency Acquisition Phase:

The frequency acquisition phase is used to bring cells of an RNS area to within frequency limits prior to initial synchronisation. No traffic is supported during this phase.

1) The cell(s) identified as reference cell, i.e. external reference clock is connected to, shall transmit continuously cell sync bursts in every time slot where possible.
2) All other cells are considered as unlocked (i.e. not in frequency lock) shall listen for transmission from other cells and perform frequency locking to any transmission received.

3) A cell shall signal completion of frequency acquisition to the RNC, as soon as it has locked its frequency to the received signal, fulfilling the Frequency Stability requirement set in TS 25.105.

4) If the cell(s) have received transmission request on instructing the frequency acquisition and the cell(s) have performed frequency locking, the cell(s) shall begin transmitting the specified code for frequency locking of other cells.

5) When the RNC has received completion of frequency acquisition signals from all cells the frequency acquisition phase is completed.

Initial Phase:

1) 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.

2) 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.

3) Steps 1 and 2 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.

4) 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.

6.2 Synchronisation Signalling aspects

6.2.1 Initial Synchronisation

This stage covers the "Preliminary Phase" where the Node B is roughly synchronised via Iub interface messages, and the "Initial Phase" where the radio interface timing of the cells is fine-tuned via radio for the first time.

6.2.1.1 Preliminary Phase

Iub signalling in the preliminary phase shall serve the following purposes:

- Reference cell identification: The CRNC shall be informed at which of the cells the external reference clock (GPS receiver) is connected.

- Reference time retrieval: For the initial adjustment, the reference time of a cell where a GPS receiver is connected has to be requested.

- Initial Synchronisation adjustment: The reference time has to be provided to the cells without the GPS receiver.

This implies the following signalling:

Reference Cell Identification:

The proposed solution to solve the first requirement is to add the information about the reference clock availability within the RESOURCE STATUS INDICATION message that is sent from the Node B to the RNC when a Local Cell becomes existing at the Node B.

At Cell Setup a ‘Reference SFN offset’ may be given to the cells where the reference clock is connected in order to separate the synchronisation bursts from different RNC areas.

Reference Time Retrieval:

For the reference time retrieval the DL Transport Channels Synchronisation procedure on the PCH frame protocol (see [6]) can be used. At this phase, a timing granularity of one radio frame is considered sufficient, which can be achieved by retrieval of the SFN which the Node B has derived from the external reference clock.

Initial Synchronisation Adjustment:

For the cells to adjust first the DL Transport Channels Synchronisation procedure on the PCH frame protocol shall be performed in order to determine the deviation from the reference SFN.

By means of the Synchronisation Adjustment procedure the Frame Adjustment value is then transmitted to the cells without GPS receiver.

Information elements required for Synchronisation Adjustment:

- Frame Adjustment value

6.2.1.1a Frequency Acquisition Phase

The frequency acquisition phase is used to bring cells of an RNS area to within frequency limits prior to initial synchronisation. No traffic is supported during this phase.

Reference Cell Transmission

The cell(s) identified as reference cell, i.e. external reference clock is connected to, shall transmit cell sync bursts according to the information given in the CELL SYNCHRONISATION INITIATION REQUEST message.

Other Cell Reception

All other cells are considered as unlocked (i.e. not in frequency lock) shall listen for transmission from other cells and perform frequency locking to any transmission received. For setting the parameters within the Node B to listen for transmission from other cells, the CELL SYNCHRONISATION INITIATION REQUEST message is used.

A cell shall signal completion of frequency acquisition to the RNC via a CELL SYNCHRONISATION REPORT message, as soon as it has locked its frequency to the received signal, fulfilling the Frequency Stability requirement set in TS 25.105, and the cell should automatically start acting like a reference cell i.e. to commence transmission cell sync bursts for frequency locking of other cells.

The process continues until the RNC has received completion of frequency acquisition signals from all cells at which point it sends a CELL SYNCHRONISATION TERMINATION REQUEST message to each cell to stop all transmissions.

6.2.1.2 Initial Phase

In the initial phase the CRNC will establish the "connectivity matrix", and in addition, the cells are for the first time brought into fine-synchronisation. For this purpose, each cell is instructed to transmit a sync burst at certain frame numbers (SFN), and to listen to the sync bursts of other cells for the rest of the time. During the initial phase any UE connections are disabled. The following procedures will have to be considered:

- Cell Sync Burst Instruction: Cells are instructed to transmit their cell sync burst at certain SFN numbers and to listen to other cell's sync bursts for the rest of the time.
- Cell Sync Bursts Measurement Report: The cells report on measured cell sync bursts
- Synchronisation Adjustment procedure

Cell Sync Burst Instruction:

It is assumed that within one procedure signalled via the Iub interface, cell sync burst transmission and reception (measurements) will be activated in parallel. I.e. the cell transmits the cell sync burst within the specified frame as well as measures for the rest of the time.

Information elements required:

- Time slot defines a PRACH timeslot where the cell sync burst shall be transmitted
- Start Frame (SFN)
- Repetition Period,
  This value must be large enough to allow all cells to send their sync bursts sequentially, with sufficient guard time in between. The typical guard time in this phase is several radio frames.
- Tx / Rx Cell Sync Burst Code
- Tx Power

Cell Sync Bursts Measurement Report:

Whenever a cell sync burst is detected the following parameters should be included within the cell sync burst measurement report:

Information elements required, for each sync burst received:

- SFN where the cell sync burst has been received

- Cell Sync Burst Timing:
  This is the arrival time of the cell sync burst within the radio frame. The resolution of this arrival time measurement shall be about 25 ns, equivalent to 1/8 chip; and since the range of this measurement is one radio frame, the measurement value will have 19 bits.

- Cell Sync Burst SIR:
  RSCP/Interference ratio

Synchronisation Adjustment:

For synchronisation adjustment during the initial phase the adjust timing indication with1/8 chip accuracy is proposed.

Information elements required:

- Frame Adjustment value:
  This indicates a required correction of the cell's SFN counter by an integer value.

- Timing Adjustment value:
  This indicates the "fine-tuning" of the frame start with a granularity of 1/8 chip. For the range of one radio frame, an 19-bit value is required.

6.2.2 Steady-State Phase

In the steady state phase each cell gets a cell sync burst plan which defines when cell sync bursts shall be transmitted and when cell sync bursts should be received. In this phase, the normal traffic is supported, i.e. the regular cell synchronisation monitoring and update is done in parallel to ongoing UE connections.

The following procedures have to be considered:

- Cell Sync Burst Instruction: Establishing a synchronisation schedule

- Cell Sync Bursts Measurement Report

- Synchronisation Adjustment procedure

Cell Sync Burst Instruction:

Defining the schedule consists of defining the transmission parameters and defining the receiving parameters. I.e. it is defined at which radio frames the cell shall transmit a sync burst and at which radio frames the cell shall receive sync bursts.

Information elements required:

- Time slot: This defines a PRACH timeslot to use

- For all SFN where the cell transmits a sync burst:

  - Cell Sync Burst Code

  - Cell Sync Burst Code Shift

  - Tx Power (for the bursts to transmit)

- For all SFN where the cell shall receive one or more sync bursts:

  - Cell Sync Burst Code

  - Cell Sync Burst Code Shift

The SFNs when to send or receive are not indicated explicitly but they are derived by the fact that the whole SFN period (4096 frames) is subdivided into several 'synchronisation cycles' of equal length L_{cycle}, and in each synchronisation cycle, there are N_{slot} synchronisation slots with an average distance of L_{cycle}/N_{slot}.

Cell Sync Bursts Measurement Report:

In this cell sync burst reports for each received code the signal time and power indicator should be considered. It is FFS, if the cell gets a table of the allowed codes and signal timings, so that a report is given only in case the threshold is exceeded.

Information elements required:

- For all SFN where cell sync bursts have been received
  - Cell Sync Burst Timing:
    This timing is the difference of the reception time of the respective cell sync burst from the expected "ideal" time, i.e. the burst would be received when the cells would be perfectly synchronised and the cell distance would be zero. The resolution of this measurement shall be about 25 ns, equivalent to 1/8 chip; and the range of this measurement shall be about ±5 μsec, which covers the small deviations in the steady state phase. This results in 9 bits resolution.
  - Cell Sync Burst SIR

Synchronisation Adjustment:

Beside the adjust timing value the Tx power for sync burst transmission may be adjusted.

Information elements required:

- Timing Adjustment value:
  A range of ±5 μs with a resolution of 25 ns results in 9 bits to be adjusted.
- Tx Power adjustment
- SFN:
  Indicates the starting frame number the Timing Adjustment value shall apply.

6.2.3 Late-Entrant Cells

Late entrant cells (new cells being added without GPS receiver) or cells recovering from unavailability shall first be roughly synchronised via Iub interface messages. The Initial Synchronisation adjustment shall be performed as used in the preliminary phase.

A special cell sync burst shall then be transmitted in order for the new cell to find the synchronisation signals. The following procedures have to be considered:

- Initial Synchronisation Adjustment
- Common cell sync burst to transmit
- Configure receiver of new cell
- Cell Sync Bursts Measurement Report from the new cell

Pre-condition for the synchronisation procedure is an executed Cell Setup procedure. That means, the SCH is already transmitting which is not wanted until the cell is synchronised. The *Time Slot Status* IE is therefore proposed to be used within Cell Setup to disable the DL channels until the cell is synchronised. To enable the de-activated channels the *Time Slot Status* IE of the Cell Reconfiguration procedure shall be used.

Initial Synchronisation Adjustment:

- See Preliminary phase as used for Initial Synchronisation

Common cell sync burst to transmit:

This procedure should be performed for those cells which are in the "neighbourhood" of the new entrant cell. The common cell sync burst shall be transmitted from these cells only once, i.e. in a radio frame identified with a specified SFN-number. After that exceptional event, the schedule is continued as defined within the steady state: i.e. the cell resumes transmitting or receiving the defined cell sync bursts.

All this shall be done without service interruption of the existing cells.

Information elements required:

- Time slot: This defines a PRACH timeslot to use
- Tx Power (burst specific, related only to the common cell sync burst)
- Cell Sync Burst Code, common for all cells involved
- SFN, common for all cells involved

Configure receiver of new cell:

This procedure is performed with the new entrant cell: The measurement to be performed by the new cell is started by informing the cell about the sync burst to receive, and about the SFN of the frame in which this burst is transmitted by the neighbouring cells.

Information elements required:

- Time slot: This defines a PRACH timeslot to use
- Cell Sync Burst Code for late-entrant phase
- SFN when cell sync burst is transmitted in the late entrant phase

Cell Sync Bursts Measurement Report from the new cell:

On detection of the first common cell sync burst (which is assumed to originate from the "nearest" neighbour cell) the new cell re-initialises its frame clock, and restarts the frame counter with the pre-configured SFN. In addition the Node B shall send a synchronisation report to the RNC indicating that the frame counter has been adjusted. In case no measurement is reported by the new cell for a certain amount of time, the procedure for late-entrant cells shall start again.

At this point in time, the new entrant cell can be put into the "steady state" phase. However, before the new cell starts transmitting cell sync bursts only measurements shall be started on the regular cell sync bursts according to the schedule received for fine-adjustment purpose.

6.3 Synchronisation Instructions

6.3.1 Instruction definitions

According to the signalling aspects for cell synchronisation (see Ref. [2]), procedures are necessary to instruct the cells to transmit the cell sync bursts and to request measurements from the individual cells when a cell sync burst was received.

In order to avoid a high number of signalling messages to start the cell sync burst transmitting and then to start the common measurements on cell sync bursts, a combined procedure is proposed by which:

- the cells are instructed to transmit the cell sync burst and
- the measurements on cell sync bursts are started.

Further procedures are necessary for measurement reports, to terminate the started cell sync burst transmission and to cover the failure cases.

For the state transition phase from the Initial Phase to the Steady State Phase it is proposed to have a cell sync burst “reconfiguration” procedure in order to avoid a cell sync burst termination procedure and afterwards to restart the cell sync burst transmission and cell sync burst measurements.

In case a special cell sync burst shall be transmitted for late-entrant cells, the special cell sync burst shall be transmitted only once and no measurement is started. After this exceptional event the cell sync burst transmission and measurement reports in steady state phase shall proceed. It is therefore proposed that the cell sync burst “initiation” procedure applies for this exceptional case as used in the initial phase.

6.3.2 Information elements

Within the Cell Sync burst instruction definitions the transmission of cell sync bursts during the different phases have to be initiated and measurements are started in parallel. The following table summarises the information elements required within the individual synchronisation phases.

Table 1: Information elements for Initial Phase and Late-Entrant cells

	Initial Phase	Frequency Acquisition Phase	Late-Entrant Cells	
Cell Synchronisation Initiation Request			**Special Cell Sync Burst to transmit**	**Special Cell Sync Burst measurement from new cell**
Cell sync burst transmission initiation	SFN (Start Frame)	SFN (Start Frame)	SFN (Special Sync Burst to transmit)	
	Repetition Period	Repetition Period		
	Tx Cell Sync Burst Code	Tx Cell Sync Burst Code	Tx Cell Sync Burst Code	
	Tx Cell Sync Burst Code Shift	Tx Cell Sync Burst Code Shift	Tx Cell Sync Burst Code Shift	
	Tx Power	Tx Power	Tx Power	
Cell sync burst measurement initiation	Rx Cell Sync Burst Code	Rx Cell Sync Burst Code		SFN (when cell sync burst is transmitted)
	Rx Cell Sync Burst Code Shift	Rx Cell Sync Burst Code Shift		Rx Cell Sync Burst Code
	Report characteristics	Report characteristics		Rx Cell Sync Burst Code Shift
				Report characteristics

In the steady-state phase the synchronisation schedule defines a number of cells transmitting each a cell sync burst at the same time, which shall be measured from another number of cells. The individual cell sync bursts are distinguished by different cell sync codes and cell sync code shifts.

To define the SFN where to transmit/receive, the SFN period is divided into cycles, that have the same schedule. Within a cycle each cell receives for each slot an individual set of parameters for the cell sync bursts to transmit/receive.

Table 2: Information elements for Steady-State Phase

	Steady-State Phase
Cell Synchronisation Reconfiguration Request	
Cell sync burst schedule	Number of cycles per SFN period
	Number of repetitions per cycle
Cell sync burst transmission reconfiguration	Sync Frame number per cycle to transmit
	Tx Cell Sync Code
	Tx Cell Sync Code shift
	Tx Power
Cell sync burst measurement reconfiguration	Sync Frame number per cycle to receive
	For all simultaneous receptions
	Rx Cell Sync Code
	Rx Cell Sync Code shifts
	Report characteristics

Table 3: Information elements for Cell Synchronisation reports

	Initial Phase	Steady-State Phase	Late-Entrant Cells	Frequency Acquisition
Cell Synchronisation Report	SFN where cell sync burst has been received	SFN where cell sync burst has been received	NULL	NULL
	Cell Sync Burst Timing			
	Cell Sync Burst SIR	For all simultaneous receptions		
		Cell Sync Burst Timing [8 bits]		
		Cell Sync Burst SIR		

For Late-Entrant Cells and Frequency Acquisition Phase the CELL SYNCHRONISATION REPORT message is only sent once without reporting parameters or measurements to indicate that the phase is completed.

6.4 Synchronisation Adjustment

6.4.1 Adjustment procedure definitions

The purpose of Synchronisation Adjustment procedure is to allow the CRNC to adjust the timing of the radio transmission of a cell within a Node B for time alignment.

6.4.2 Adjustment elements

Synchronisation adjustment will be handled differently during the individual synchronisation phases. The following table indicates the required information elements.

Table 4: Information elements for Synchronisation Adjustment procedure

	Initial Phase	Steady-State Phase	Late-Entrant Cells
Synchronisation Adjustment	Frame Adjustment value	Timing Adjustment value [9 bits for a range of ±5 μs]	
	Timing Adjustment value [19 bits for a range of one radio frame]	Tx Power adjustment	
		SFN, indicates starting frame number when Timing Adjustment value shall apply	

6.5 Synchronisation alarming

For Node B synchronisation only the Cell Synchronisation procedures and the Synchronisation Adjustment procedures are necessary. Calculating the timing adjustment between neighbouring cells is to be performed within the CRNC. The Node B is only informed about cell sync bursts to transmit and about measurements to be performed. For cell sync burst measurements thresholds may be defined to inform the RNC about synchronisation deviations. Thus, a specific alarming procedure is not necessary.

6.6 Backward compatibility/Coexistance synchronisation methods

In R99 Node Bs are synchronised via the synchronisation port only (see [3]). This synchronisation port signal provides a 256 frames multiframe clock which allows for synchronisation of the last 8 bits of the Cell System Frame Number (SFN) of the cells of the Node B.

In Rel. 4 the Node Bs may be synchronised either via the synchronisation port or via the air interface. Synchronisation via the air interface requires an extension of the synchronisation port that all 12 bits of the SFN are provided. Based on this basic functions following application cases exist:

Table 5: Synchronisation coexistance cases

	Node B synchronisation	Node B	RNC	
1.	Sync port (SFN mod 256=0)	R99	R99 Rel. 4	Synchronisation method via sync port as defined for R99 Synchronisation method via sync port as defined for R99
2.	Sync port (SFN mod 4096=0)	Rel. 4	R99 Rel. 4	No procedures within the RNC are provided. The synchronisation is therefore only based on synchronisation via the sync port. Since the Synchronisation via the air interface may be cell based, the reference clock has to be provided to all cells within the Node B, same as for R99 Node B. Synchronisation via air interface applies

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 Synchronisation Instructions

7.1.1 EP for Cell Sync Burst instructions

Following Class 1 procedures shall be defined for cell sync burst instruction settings:

Elementary Procedure	Message	Successful Outcome	Unsuccessful Outcome
		Response message	Response message
Cell Sync Burst Initiation	CELL SYNCHRONISATION INITIATION REQUEST	CELL SYNCHRONISATION INITIATION RESPONSE	CELL SYNCHRONISATION INITIATION FAILURE
Cell Sync Burst Reconfiguration	CELL SYNCHRONISATION RECONFIGURATION REQUEST	CELL SYNCHRONISATION RECONFIGURATION RESPONSE	CELL SYNCHRONISATION RECONFIGURATION FAILURE

For report of the measured cell sync bursts, for terminating the started cell sync burst transmission and for failure cases, the following class 2 EPs shall be defined:

Elementary Procedure	Message
Cell Sync Burst Reporting	CELL SYNCHRONISATION REPORT
Cell Sync Burst Termination	CELL SYNCHRONISATION TERMINATION REQUEST
Cell Sync Burst Failure	CELL SYNCHRONISATION FAILURE INDICATION

7.1.2 Cell Sync Burst instruction procedures

7.1.2.1 Cell Synchronisation Initiation

This procedure is used by a CRNC to request the transmission of cell sync bursts and/or to start measurements on cell sync bursts in a Node B.

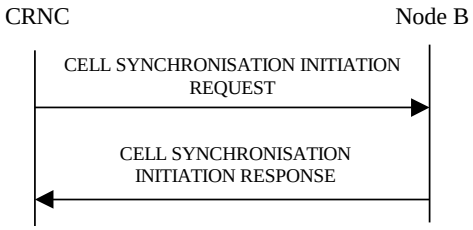

Figure 1: Cell Synchronisation Initiation procedure: Successful Operation

The procedure is initiated with a CELL SYNCHRONISATION INITIATION REQUEST message sent from the CRNC to the Node B using the Node B control port.

Upon reception, the Node B shall initiate the requested transmission according to the parameters given in the request and start the measurement on cell sync bursts if requested.

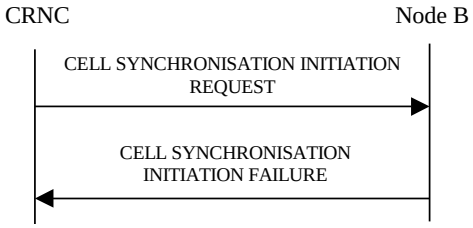

Figure 2: Cell Synchronisation Initiation procedure: Unsuccessful Operation

If the requested transmission or measurement on cell sync bursts cannot be initiated, the Node B shall send a CELL SYNCHRONISATION INITIATION FAILURE message sent over the Node B control port. The message shall include the *Cause* IE set to an appropriate value.

7.1.2.2 Cell Synchronisation Reconfiguration

This procedure is used by a CRNC to reconfigure the transmission of cell sync bursts and/or to reconfigure measurements on cell sync bursts in a Node B.

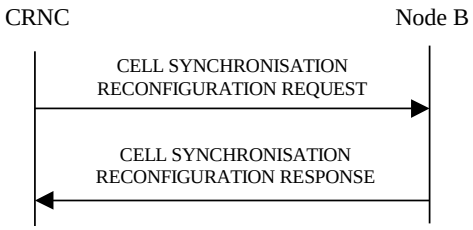

Figure 3: Cell Synchronisation Reconfiguration procedure: Successful Operation

The procedure is initiated with a CELL SYNCHRONISATION RECONFIGURATION REQUEST message sent from the CRNC to the Node B using the Node B control port.

Upon reception, the Node B shall reconfigure the cell sync burst transmission and/or measurements according to the parameters given in the request.

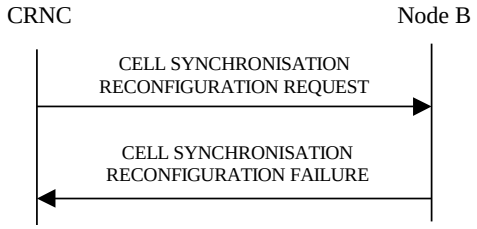

Figure 4: Cell Synchronisation Reconfiguration procedure: Unsuccessful Operation

If the Node B cannot reconfigure the requested transmission or measurement on cell sync burst, the CELL SYNCHRONISATION RECONFIGURATION FAILURE message shall be sent to CRNC. The message shall include the *Cause* IE set to an appropriate value.

7.1.2.3 Cell Synchronisation Reporting

This procedure is used by a Node B to report the result of cell sync burst measurements requested by the CRNC with the Cell Synchronisation Initiation or Cell Synchronisation Reconfiguration procedure.

Figure 5: Cell Synchronisation Reporting procedure: Successful Operation

If the requested synchronisation measurement reporting criteria are met, the Node B shall initiate a Cell Synchronisation Reporting procedure. The CELL SYNCHRONISATION REPORT message shall use the Node B control port.

7.1.2.4 Cell Synchronisation Termination

This procedure is used by the CRNC to terminate a cell synchronisation previously requested by the Cell Synchronisation Initiation procedure.

Figure 6: Cell Synchronisation Termination procedure: Successful Operation

This procedure is initiated with a CELL SYNCHRONISATION TERMINATION REQUEST message, sent from the CRNC to the Node B using the Node B control port.

7.1.2.5 Cell Synchronisation Failure

This procedure is used by the Node B to notify the CRNC that a synchronisation burst transmission or synchronisation measurement procedure can no longer be supported.

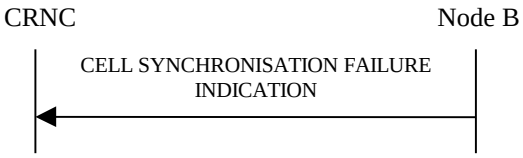

Figure 7: Cell Synchronisation Failure procedure: Successful Operation

This procedure is initiated with a CELL SYNCHRONISATION FAILURE INDICATION message, sent from the Node B to the CRNC using the Node B control port.

7.1.3 Cell Sync Burst instruction message definitions

7.1.3.1 CELL SYNCHRONISATION INITIATION REQUEST

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Discriminator	M		9.2.1.45		–	
Message Type	M		9.2.1.46		YES	reject
Transaction ID	M		9.2.1.62		–	
C-ID	M		9.2.1.9		YES	reject
Cell Sync Burst Repetition Period	M		9.2.3.4J		YES	reject
Time Slot Information		1..15			GLOBAL	reject
>Time Slot	M		9.2.3.23		–	
Cell Sync Burst Transmission Initiation Information		0..1			GLOBAL	reject
>CSB Transmission ID	M		9.2.3.4N			
>SFN	M		9.2.1.53A		–	
>Cell Sync Burst Code	M		9.2.3.4G		–	
>Cell Sync Burst Code shift	M		9.2.3.4H			
>Initial DL transmission Power	M		DL Power 9.2.1.21		–	
Cell Sync Burst Measurement Initiation Information		0..1			GLOBAL	reject
>CSB Measurement ID	M		9.2.3.4I			
>Cell Sync Burst Code	M		9.2.3.4G		–	
>Cell Sync Burst Code shift	M		9.2.3.4H			
>Synchronisation Report Type	M		9.2.3.18E		–	
>SFN	O		9.2.1.53A		–	
>Synchronisation Report Characteristics	M		9.2.3.18D		–	

7.1.3.2 CELL SYNCHRONISATION INITIATION RESPONSE

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description	Criticality	Assigned Criticality
Message Discriminator	M		9.2.1.45		–	
Message Type	M		9.2.1.46		YES	reject
Transaction ID	M		9.2.1.62		–	
Criticality Diagnostics	O		9.2.1.17		YES	ignore

7.1.3.3 CELL SYNCHRONISATION INITIATION FAILURE

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description	Criticality	Assigned Criticality
Message Discriminator	M		9.2.1.45		–	
Message Type	M		9.2.1.46		YES	reject
Transaction ID	M		9.2.1.62		–	
Cause	M		9.2.1.6		YES	Ignore
Criticality Diagnostics	O		9.2.1.17		YES	Ignore

7.1.3.4 CELL SYNCHRONISATION RECONFIGURATION REQUEST

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Discriminator	M		9.2.1.45		–	
Message Type	M		9.2.1.46		YES	reject
Transaction ID	M		9.2.1.62		–	
C-ID	M		9.2.1.9		YES	reject
Time Slot	M		9.2.3.23		YES	reject
Number of cycles per SFN period	M		9.2.3.7B		YES	reject
Number of repetitions per cycle period	M		9.2.3.7C		YES	reject
Cell Sync Burst Transmission Reconfiguration Information		0 .. < maxnoofCellSyncBursts >			Global	reject
>CSB Transmission ID	M		9.2.3.4N		–	
>Sync Frame number to transmit	M		Sync Frame number 9.2.3.18C		–	
>Cell Sync Burst Code	O		9.2.3.4G		–	
>Cell Sync Burst Code shift	O		9.2.3.4H		–	
>DL transmission Power	O		DL Power 9.2.1.21		–	
Cell Sync Burst Measurement Reconfiguration Information		0..1			YES	reject
>Cell Sync Burst Measurement Information		1 .. <maxnoofCellSyncBursts>			GLOBAL	reject
>>Sync Frame number to receive	M		Sync Frame number 9.2.3.18C		–	
>>Cell Sync Burst Information		1..< maxnoofreceptionsperSyncFrame>			–	
>>>CSB Measurement ID	M		9.2.3.4I		–	
>>>Cell Sync Burst Code	M		9.2.3.4G		–	
>>>Cell Sync Burst Code shift	M		9.2.3.4H		–	
>Synchronisation Report Type	O		9.2.3.18E		YES	reject
>Synchronisation Report Characteristics	O		9.2.3.18D		YES	reject

Range bound	Explanation
maxnoofCellSyncBursts	Maximum number of cell sync bursts per cycle
maxnoofreceptionsperSyncFrame	Maximum number of cell sync burst receptions per Sync Frame

7.1.3.5 CELL SYNCHRONISATION RECONFIGURATION RESPONSE

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description	Criticality	Assigned Criticality
Message Discriminator	M		9.2.1.45		–	
Message Type	M		9.2.1.46		YES	reject
Transaction ID	M		9.2.1.62		–	
Criticality Diagnostics	O		9.2.1.17		YES	ignore

7.1.3.6 CELL SYNCHRONISATION RECONFIGURATION FAILURE

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description	Criticality	Assigned Criticality
Message Discriminator	M		9.2.1.45		–	
Message Type	M		9.2.1.46		YES	reject
Transaction ID	M		9.2.1.62		–	
Cause	M		9.2.1.6		YES	Ignore
Criticality Diagnostics	O		9.2.1.17		YES	Ignore

7.1.3.7 CELL SYNCHRONISATION REPORT

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Discriminator	M		9.2.1.45		–	
Message Type	M		9.2.1.46		YES	ignore
Transaction ID	M		9.2.1.62		–	
Cell Synchronisation Information		*1..* <maxCellinNodeB >			EACH	ignore
>C-ID	M		9.2.1.9		YES	ignore
>CHOICE *Synchronisation Report Type*					YES	ignore
>>*Initial Phase* or *Steady-State Phase*					–	
>>>Cell Sync Burst Measured Information		1 .. <maxnoofCellSyncBursts>			–	
>>>>SFN	M		9.2.1.53A		–	
>>>>Cell Sync Burst Information		1..<maxnoofreceptionsperSyncFrame>			–	
>>>>>CHOICE Cell Sync Burst Availability Indicator	M				–	
>>>>>>Cell Sync Burst Available					–	
>>>>>>>Cell Sync Burst Timing	M		9.2.3.4L		–	
>>>>>>>Cell Sync Burst SIR	M		9.2.3.4K		–	
>>>>>>Cell Sync Burst not Available			NULL		–	
>>Late-Entrant Cell			NULL		–	
>>Frequency Acquisition			NULL		–	

Range bound	Explanation
maxCellinNodeB	Maximum number of Cells in a Node B
maxnoofCellSyncBursts	Maximum number of cell sync bursts per cylce
maxnoofreceptionsperSyncFrame	Maximum number of cell sync burst receptions per Sync Frame

7.1.3.8 Synchronisation Report Characteristics

The Synchronisation Report Characteristics IE defines how the reporting on measured cell sync bursts shall be performed.

Different methods shall apply for the measured cell sync burst reports. In the frequency acquisition phase the measurement report shall be sent when the frequency locking is completed. In the initial phase and for the measurement on late-entrant cells an immediate report after the measured frame is expected.

In the steady-state phase measurement reports may be given after every measured frame, after every SFN period or only when the requested threshold is exceeded.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Synchronisation Report characteristics type	M		ENUMERATED (Frame related, SFN period related, Cycle length related, Threshold exceeding, Frequency Acquisition completed, ...)	
Threshold exceeding	C-Threshold exceeding			Applies only to the Steady State Phase
>Cell Sync Burst Threshold Information		1 .. <maxnoofCellSyncBursts>		
>>Sync Frame number to receive	M		Sync Frame number 9.2.3.18C	
>>Cell Sync Burst Information		1..<maxnoofreceptionsperSyncFrame>		
>>>Cell Sync Burst Code	M		9.2.3.4G	
>>>Cell Sync Burst Code shift	M		9.2.3.4H	
>>>Cell Sync Burst Arrival Time	O		Cell Sync Burst Timing 9.2.3.4L	
>>>Cell Sync Burst Timing Threshold	O		9.2.3.4M	

Range bound	Explanation
maxnoofCellSyncBursts	Maximum number of cell sync burst per cycle
maxnoofreceptionsperSyncFrame	Maximum number of cell sync burst receptions per Sync Frame

7.2 Synchronisation Adjustment

7.2.1 EP for Synchronisation Adjustment

Following Class 1 procedure shall be defined for Synchronisation Adjustment:

Elementary Procedure	Message	Successful Outcome	Unsuccessful Outcome
		Response message	Response message
Synchronisation Adjustment	SYNCHRONISATION ADJUSTMENT REQUEST	SYNCHRONISATION ADJUSTMENT RESPONSE	SYNCHRONISATION ADJUSTMENT FAILURE

7.2.2 Synchronisation Adjustment procedure

The purpose of Synchronisation Adjustment procedure is to allow the CRNC to adjust the timing of the radio transmission of a cell within a Node B for time alignment.

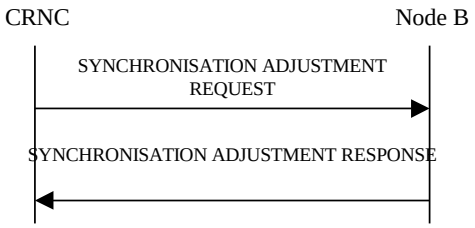

Figure 1: Synchronisation Adjustment – Successful Case

This procedure is initiated with a SYNCHRONISATION ADJUSTMENT REQUEST message sent by the CRNC to the Node B control port.

Upon reception, the Node B adjusts its timing according to the parameters given in the message. When the synchronisation adjustment is successfully done by the node B the node B shall respond with a SYNCHRONISATION ADJUSTMENT RESPONSE.

The Node B shall adjust its timing in the frame numbers in between two cell sync occations. If the SYNCHRONISATION ADJUSTMENT REQUEST message includes the *SFN* IE, the Node B shall use the indicated SFN as the starting number.

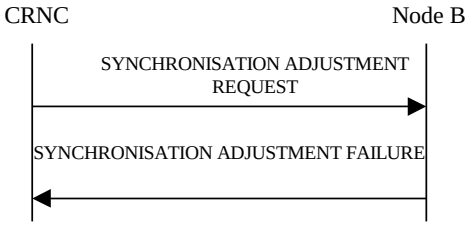

Figure 2: Synchronisation Adjustment – Unsuccessful Case

If the Node B cannot perform the indicated synchronisation adjustment due to hardware failure or other problem it shall send the SYNCHRONISATION ADJUSTMENT FAILURE as a response.

7.2.3 Synchronisation Adjustment message definitions

7.2.3.1 SYNCHRONISATION ADJUSTMENT REQUEST

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Discriminator	M		9.2.1.45		–	
Message Type	M		9.2.1.46		YES	ignore
Transaction ID	M		9.2.1.62		–	
Cell Adjustment Information		1.. <maxCellinNodeB>			EACH	ignore
>C-ID	M		9.2.1.9		–	
>Frame Adjustment value	O		9.2.3.5C		–	
>Timing Adjustment value	O		9.2.3.22a		–	
>DL Transmission Power	O		9.2.1.21		–	
>SFN	O		9.2.1.53A		–	

Range bound	Explanation
MaxCellinNodeB	Maximum number of Cells in a Node B

7.2.3.2 SYNCHRONISATION ADJUSTMENT RESPONSE

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Discriminator	M		9.2.1.45		–	
Message Type	M		9.2.1.46		YES	ignore
Transaction ID	M		9.2.1.62		–	
Criticality Diagnostics	O		9.2.1.17		YES	Ignore

7.2.3.3 SYNCHRONISATION ADJUSTMENT FAILURE

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Discriminator	M		9.2.1.45		–	
Message Type	M		9.2.1.46		YES	ignore
Transaction ID	M		9.2.1.62		–	
CHOICE *cause level*	M				YES	ignore
>General					–	
>>Cause	M		9.2.1.6		–	
>Cell specific					–	
>>Unsuccessful Cell Information Response		1.. <maxCellinNodeB>			EACH	ignore
>>>C-ID	M		9.2.1.9		–	
>>>Cause	M		9.2.1.6		–	
Criticality Diagnostics	O		9.2.1.17		YES	Ignore

Range bound	Explanation
MaxCellinNodeB	Maximum number of Cells in a Node B

8 Specification Impact and associated Change Requests

It is expected that Node B Synchronisation for TDD (Iub/Iur aspects) affects the NBAP [4] specification and the Synchronisation in UTRAN Stage 2 [3]. Since it is assumed that each RNC area is synchronised individually to at least one reference clock, this ensures automatically synchronisation between RNC areas. Therefore, no communication over Iur is necessary.

8.1 Impact on TS 25.402

Beside the existing synchronisation via the synch port, the mechanism of the synchronisation over the air interface is introduced.

In addition, the synchronisation port signal specification is enhanced, to include the 4096 frames marker.

Table 6: List of change requests for 25.402

3G TS/TR	Title	CR number
3G TS 25.402	Introduction of Cell Synchronisation for TDD	CR016
	Synchronisation port signal extension	CR017

8.2 Impact on TS 25.433

In the NBAP specification the Cell Synchronisation function is introduced. This includes also the mapping and introducing of the Cell Synchronisation function to the individual Cell Synchronisation procedures.

On existing procedures the Resource Status Indication procedure and the Audit procedure has been modified in order to notify the availability and operation of the reference clock connected to a cell. Within the Cell Setup procedure a offset parameter is added in order to separate the reference SFN between RNS's.

Table 7: List of change requests for 25.433

3G TS/TR	Title	CR number
3G TS 25.433	NBAP Procedure modifications due to cell synchronisation	CR361
	Introduction of NBAP Cell Synchronisation function for TDD	CR360

9 Backward Compatibility

The synchronisation over the air interface in Rel.4 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.

Annex A (informative): Change history

Change history							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
03/2001	11	RP-010153	-	-	Approved at TSG RAN #11 and placed under Change Control	2.0.0	4.0.0
12/2001	14	RP-010866	001	-	Introduction of the Frequency Acquisition Phase and updates of IEs, EPs, and messages	4.0.0	4.1.0