TSG-RAN Meeting #13 **_TSGRP#13(01) 0576_**
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Title: **Agreed CRs to TS 25.402**

Source: **TSG-RAN WG3**

Agenda item: **8.3.3/8.3.4/9.4.3**

RP Tdoc	R3 Tdoc	Spec	CR_Num	Rev	Release	CR_Subject	Cat	Cur_Ver	New_Ver	Workitem
RP-010576	R3-012419	25.402	026		R99	Notation of Time Instances	F	3.6.0	3.7.0	TEI
RP-010576	R3-012420	25.402	027		Rel-4	Notation of Time Instances	A	4.1.0	4.2.0	TEI

3GPP TSG-RAN WG3 Meeting #23
Helsinki, Finland, August 27th-31st 2001

TDoc R3-012419

CR-Form-v4

CHANGE REQUEST

⌘ **25.402 CR 026** ⌘ ev **-** ⌘ Current version: **3.6.0** ⌘

For ***HELP*** *on using this form, see bottom of this page or look at the pop-up text over the ⌘ symbols.*

Proposed change affects: ⌘ (U)SIM ☐ ME/UE ☐ Radio Access Network ☒ Core Network ☐

Title:	⌘	Notation of Time Instances		
Source:	⌘	R-WG3		
Work item code:	⌘	TEI	***Date:*** ⌘	2001-08
Category:	⌘	**F**	***Release:*** ⌘	R99

Use one of the following categories:
- ***F*** *(correction)*
- ***A*** *(corresponds to a correction in an earlier release)*
- ***B*** *(addition of feature),*
- ***C*** *(functional modification of feature)*
- ***D*** *(editorial modification)*

Detailed explanations of the above categories can be found in 3GPP TR 21.900.

Use one of the following releases:

2	*(GSM Phase 2)*
R96	*(Release 1996)*
R97	*(Release 1997)*
R98	*(Release 1998)*
R99	*(Release 1999)*
REL-4	*(Release 4)*
REL-5	*(Release 5)*

Reason for change:	⌘	At RAN WG3 meeting nr22, there was a decision on an uniform notation for time instances: Capital letters are to be used for this purpose. (This decision was made in Iub/Iur SWG at agenda item rb-2.5.3, when TDoc R3-012055 on TS25.435 was discussed). This CR provides the corresponding changes for TS25.402. In addition, an outdated "FFS" statement now removed.
Summary of change:	⌘	1) General alignment of notation: Capital letters 2) Removal of outdated "(FFS)" statement in section 4.3 3) Correction of typo in 8.3.4.4.2
Consequences if not approved:	⌘	Inconsistent notations between and inside RAN3 specifications. Backwards compatibility: Protocols are not affected at all, thus this change is backwards compatible. Isolated impact: Functions of UTRAN entities not affected, thus isolated impact is given.

Clauses affected:	⌘	4.3; 5; 6.1.1; 7.2; 8.3.4.4.2		
Other specs affected:	⌘	☒ Other core specifications ☐ Test specifications ☐ O&M Specifications	⌘	CR 027 25.402v4.1.0 REL-4
Other comments:	⌘			

How to create CRs using this form:

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1) Fill out the above form. The symbols above marked ⌘ contain pop-up help information about the field that they are closest to.

2) Obtain the latest version for the release of the specification to which the change is proposed. Use the MS Word "revision marks" feature (also known as "track changes") when making the changes. All 3GPP specifications can be downloaded from the 3GPP server under ftp://ftp.3gpp.org/specs/ For the latest version, look for the directory name with the latest date e.g. 2001-03 contains the specifications resulting from the March 2001 TSG meetings.

3) With "track changes" disabled, paste the entire CR form (use CTRL-A to select it) into the specification just in front of the clause containing the first piece of changed text. Delete those parts of the specification which are not relevant to the change request.

4.3 Node Synchronisation

Node Synchronisation relates to the estimation and compensation of timing differences among UTRAN nodes. FDD and TDD modes have different requirements on the accuracy of the timing difference estimation and on the necessity to compensate for these differences.

Two types of Node Synchronisation can be identified, "RNC-Node B" and "Inter Node B" Node Synchronisation. Their usage differs and the requirements differ between the FDD and TDD modes.

"RNC-Node B" Node Synchronisation allows to get knowledge of the timing differences between RNC and its Node Bs.

"Inter Node B" Node Synchronisation may be used in the TDD mode to compensate the timing differences among Node Bs in order to achieve a common timing reference. The purpose of having a common timing reference is to allow Intercell Synchronisation, which is used, within neighbouring cells to minimise cross-interference.

Positioning / Localisation functions may also set requirements on Node Synchronisation~~ (FFS)~~.

4.4 Transport Channel Synchronisation

The Transport Channel Synchronisation mechanism defines synchronisation of the frame transport between RNC and Node B, considering radio interface timing.

DL TBS transmission is adjusted to fit receiver by adjusting the DL TBS timing in upper node. UL TBS transmission is adjusted by moving the UL reception window timing internally in upper node.

4.5 Radio Interface Synchronisation

The Radio Interface Synchronisation relates to the timing of the radio frame transmission (either in downlink [FDD] or in both directions [TDD]). FDD and TDD have different mechanisms to determine the exact timing of the radio frame transmission and also different requirements on the accuracy of this timing.

In FDD Radio Interface Synchronisation is necessary to assure that the UE receives radio frames synchronously from different cells, in order to minimise UE buffers.

In TDD Radio Interface Synchronisation refers to the following two aspects:

- Intercell Synchronisation that is used to synchronise radio frames within neighbouring cells in order to minimise cells cross-interference, to allow frame wise hopping mechanisms among cells (e.g. Cell Parameter Cycling according to Ref. [12]) and to make procedures involving more cells (e.g. handover) easier and more efficient;
- Timing advance that is used between UE and UTRAN in order to minimise UE-cell interference.

4.6 Time Alignment Handling

The Time Alignment Handling procedure over Iu relates to the control of DL transmission timing in the CN nodes in order to minimise the buffer delay in SRNC. This procedure is controlled by SRNC.

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5 Synchronisation Counters and Parameters

This clause defines counters and parameters used in the different UTRAN synchronisation procedures.

The parameters used only by FDD has been indicated with the notation [FDD – parameter].

BFN	Node B Frame Number counter. This is the Node B common frame number counter. [FDD -BFN is optionally frequency-locked to a Network sync reference]. Range: 0 to 4095 frames.

RFN

RNC Frame Number counter. This is the RNC node common frame number counter. RFN is optionally frequency-locked to a Network sync reference.
Range: 0 to 4095 frames.

SFN

Cell System Frame Number counter. SFN is sent on BCH. SFN is used for paging groups and system information scheduling etc.
In FDD SFN = BFN adjusted with T_cell.
In TDD, if Inter Node B synchronisation port is used, SFN is locked to the BFN (i.e. SFN mod 256 = BFN mod 256).
Range: 0 to 4095 frames.

CFN

Connection Frame Number (counter). CFN is the frame counter used for the L2/transport channel synchronisation between UE and UTRAN. A CFN value is associated to each TBS and it is passed together with it through the MAC-L1 SAP. CFN provides a common frame reference (at L2) to be used e.g. for synchronised transport channel reconfiguration (see [2] [3]).

The duration of the CFN cycle is longer than the maximum allowed transport delay between MAC and L1 (in UTRAN side, between SRNC and Node B, because the L1 functions that handle the transport channel synchronisation are in the Node B).
Range: 0 to 255 frames. When used for PCH the range is 0 to 4095 frames.

Frame Offset

Frame Offset is a radio link specific L1 parameter used to map the CFN, used in the transport channel, into the SFN that defines the specific radio frame for the transmission on the air interface.

At the L1/L2 interaction, the mapping is performed as:

$$\text{SFN mod } 256 = (\text{CFN} + \text{Frame Offset}) \text{ mod } 256 \text{ (from L2 to L1)} \tag{5.1}$$

$$\text{CFN} = (\text{SFN} - \text{Frame Offset}) \text{ mod } 256 \text{ (from L1 to L2)} \tag{5.2}$$

The resolution of all three parameters is 1 frame. Frame Offset and CFN have the same range (0…255) and only the 8 least significant bits of the SFN are used. The operations above are modulo 256.

In the UTRAN, the Frame Offset parameter is calculated by the SRNC and provided to the node B.

OFF

The parameter OFF is calculated by the UE and reported to the UTRAN only when the UTRAN has requested the UE to send this parameter. In the neighbouring cell list, the UTRAN indicates for each cell if the Frame Offset is already known by the UTRAN or shall be measured and reported by the UE.

OFF has a resolution of 1 frame and a range of 0 to 255.

Five different cases are discerned related to the determination of the OFF value by the UE:

1. The UE changes from common channel state to dedicated channel state: 1 RL
   In this case OFF is zero.

2. [FDD -The UE changes from common channel state to dedicated channel state: several RL's
   OFF is in this case defined as being the difference between SFN of the candidate cells and the SFN of the camping cell. Again the UE sets OFF to zero for the cell to which the UE sends an UL RRC message (cell #1). For cells #2 to n, the UE sets OFF to the difference between the SFN of cell#2,n and the SFN of cell#1.
   This could be seen as if a virtual dedicated physical channel (DPCH) already is aligned with cell #1].

3. The UE adds another RL or moves to another cell in dedicated channel state.
   OFF is in this case defined as being the time difference between the CFN and the SFN of the cell in which the RL is to be added. In case this difference cannot be measured, a value as in [FDD - 13] [TDD - 14] shall be reported instead.

4. The UE is coming from another RAN and goes to dedicated channel state: 1 RL
   This case is identical to case 1).

5. [FDD - The UE is coming from another RAN or another frequency in the same RAN and goes to dedicated channel state: several RL's.
   This case is identical to case 2), with one exception: OFF will not be zero for the cell to which the UE sends an UL RRC message (the measurement information will be received via the CN in this case) but for a reference cell selected by the UE. All other reported OFF values will be relative to the SFN of this selected reference cell].

[FDD – DOFF$_{FDD}$] The DOFF$_{FDD}$ (FDD Default DPCH Offset value) is used to define Frame Offset and Chip Offset at first RL setup. The resolution should be good enough to spread out load over Iub and load in Node B (based on certain load distributing algorithms). In addition it is used to spread out the location of Pilot Symbol in order to reduce the peak DL power since Pilot symbol is always transmitting at the fixed location within a slot (the largest number of chips for one symbol is 512 chips).

The SRNC sends a DOFF$_{FDD}$ parameter to the UE when the new RL will make the UE change its state (from Cell_FACH state or other when coming from another RAN) to Cell_DCH state.

Resolution: 512 chips; Range:0 to 599 (<80ms).

[TDD – DOFF$_{TDD}$] The DOFF$_{TDD}$ (TDD Default DPCH Offset value) is used to define Frame Offset at first RL setup, in order to spread out load over /Iur and load in Node B (based on certain load distributing algorithms).

The SRNC sends a DOFF$_{TDD}$ parameter to the UE when the new RL will make the UE change its state (from Cell_FACH state or other when coming from another RAN) to the Cell_DCH state.

Resolution: 1 frame; Range: 0 to 7 frames.

[FDD – Chip Offset] The Chip Offset is used as offset for the DL DPCH relative to the PCCPCH timing. The Chip Offset parameter has a resolution of 1 chip and a range of 0 to 38399 (< 10ms).

The Chip Offset parameter is calculated by the SRNC and provided to the Node B.

Frame Offset + Chip Offset (sent via NBAP) are in Node B rounded together to closest 256 chip boundary. The 256 chip boundary is used regardless of the used spreading factor, also when the spreading factor is 512. The rounded value (which is calculated in Node B) controls the DL DPCH air-interface timing.

The "Frame Offset + Chip Offset" 256 chip boundary rounding rules for Node B to consider for each DL DPCH are:

1. IF (Frame Offset x 38 400 + Chip Offset) modulo 256 [chips] = {1..127} THEN round (Frame Offset x 38 400 + Chip Offset) modulo 256 frames down to closest 256 chip boundary.
2. IF (Frame Offset x 38 400 + Chip Offset) modulo 256 [chips] = {128..255} THEN round (Frame Offset x 38 400 + Chip Offset) modulo 256 frames up to closest 256 chip boundary.
3. IF (Frame Offset x 38 400 + Chip Offset) modulo 256 [chips] = 0 THEN "Frame Offset x 38 400 + Chip Offset" is already on a 256 chip boundary.

[FDD –Tm] The reported Tm parameter has a resolution of 1 chip and a range of 0 to 38399. The Tm shall always be sent by the UE.

Five different cases are discerned related to the determination of the Tm value by the UE:

1. The UE changes from common channel state to dedicated channel state: 1 RL
   In this case the Tm will be zero.

2. The UE changes from common channel state to dedicated channel state: several RL’s
Tm is in this case defined as being the time difference between the received PCCPCH path of the source cell and the received PCCPCH paths of the other target cells. Again the UE sets Tm to zero for the cell to which the UE sends an UL RRC message (cell #1). For cells #2 to n, the UE sets Tm to the time difference of the PCCPCH reception timing of cell#2,n from the PCCPCH reception timing of cell#1.
3. The UE adds another RL in dedicated channel state (macro-diversity)
Tm is in this case defined as being the time difference between "$T_{UETX} – T_o$" and the earliest received PCCPCH path of the target cell. T_{UETX} is the time when the UE transmits an uplink DPCCH frame, hence "$T_{UETX} – T_o$" is the nominal arrival time for the first path of a received DPCH.
4. The UE is coming from another RAN and goes to dedicated channel state: 1 RL
This case is identical to case 1.
5. The UE is coming from another RAN or another frequency in the same RAN and goes to dedicated channel state: several RL's
This case is identical to case 2, with one exception: Tm will not be zero for the cell to which the UE sends an UL RRC message (the measurement information will be received via the CN in this case) but for a reference cell selected by the UE. All other reported Tm values will be relative to the timing of the PCCPCH in this cell.

[FDD – T_cell]	T_cell represents the Timing delay used for defining the start of SCH, CPICH and the DL Scrambling Code(s) in a cell relative BFN. The main purpose is to avoid having overlapping SCHs in different cells belonging to the same Node B. A SCH burst is 256 chips long. SFN in a cell is delayed T_cell relative BFN. Resolution: 256 chips. Range: 0 .. 9 x 256 chips.
~~t~~T1	RNC specific frame number (RFN) that indicates the time when RNC sends the DL Node Synchronisation control frame through the SAP to the transport layer. Resolution: 0.125 ms; Range: 0-40959.875 ms.
~~t~~T2	Node B specific frame number (BFN) that indicates the time when Node B receives the correspondent DL Node Synchronisation control frame through the SAP from the transport layer. Resolution: 0.125 ms; Range: 0-40959.875 ms.
~~t~~T3	Node B specific frame number (BFN) that indicates the time when Node B sends the UL Node Synchronisation control frame through the SAP to the transport layer. Resolution: 0.125 ms; Range: 0-40959.875 ms.
~~t~~T4	RNC specific frame number (RFN) that indicates the time when RNC receives the UL Node Synchronisation control frame. Used in RNC locally. Not standardised over Iub.
TOAWS	TOAWS (Time of Arrival Window Startpoint) is the window startpoint. DL data frames are expected to be received after this window startpoint. TOAWS is defined with a positive value relative Time of Arrival Window Endpoint (TOAWE) (see Figure 10). A data frame arriving before TOAWS gives a Timing Adjustment Control frame response. The resolution is 1 ms, the range is: {0 .. CFN length/2 –1 ms}.
TOAWE	TOAWE (Time of Arrival Window Endpoint) is the window endpoint. DL data frames are expected to be received before this window endpoint (see Figure 10). TOAWE is defined with a positive value relative Latest Time of Arrival (LTOA). A data frame arriving after TOAWE gives a Timing Adjustment Control frame response. The resolution is 1 ms, the range is: {0 .. CFN length –1 ms}.

LTOA	LTOA (Latest Time of Arrival) is the latest time instant a Node B can receive a data frame and still be able to process it. Data frames received after LTOA can not be processed (discarded). LTOA is defined internally in Node B to be a processing time before the data frame is sent in air-interface. The processing time (Tproc) could be vendor and service dependent. LTOA is the reference for TOAWE (see Figure 14).
TOA	TOA (Time of Arrival) is the time difference between the TOAWE and when a data frame is received. A positive TOA means that data frames are received before TOAWE, a negative TOA means that data frames are received after TOAWE. Data frames that are received after TOAWE but before LTOA are processed by Node B. TOA has a resolution of 125 µs. TOA is positive when data frames are received before TOAWE (see Figure 12). The range is: {0 .. +CFN length/2 –125 µs}. TOA is negative when data frames are received after TOAWE. The range is: {–125 µs .. –CFN length/2}.

6 Node Synchronisation

6.1 General

By Node Synchronisation it's generally meant the achievement of a common timing reference among different nodes. In UTRAN although a common timing reference among all the nodes could be useful, it is not required. In fact different nodes' counters (RFN and BFN), even if frequency-locked to the same network synchronisation reference, may be not phased aligned (see Figure 2).

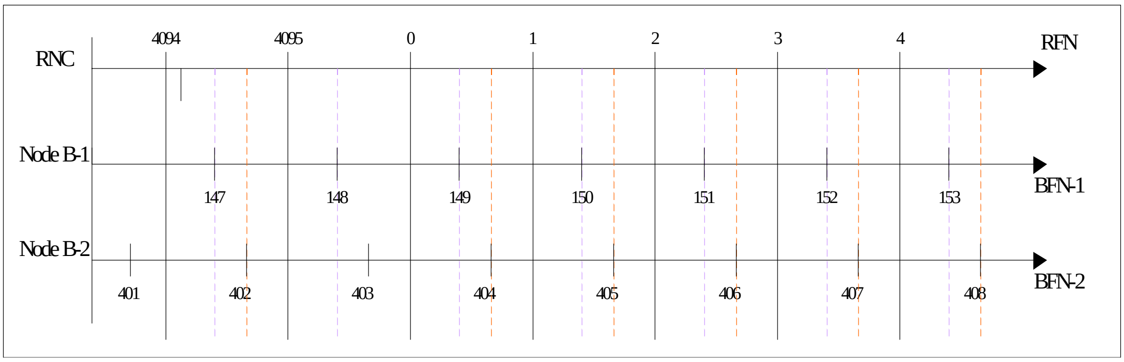


Figure 2: Timing of UTRAN counters

However in order to minimise the transmission delay and the buffering time for the DL transmission on the air interface, it can be useful to estimate the timing differences between RNC and Node Bs, without the need to compensate for the phase differences between RNC's and Node B's counters.

On the other hand the achievement of a common timing reference among Node B's may be used in TDD to support Cell Synchronisation.

For these reasons in UTRAN node synchronisation refers to the following two aspects:

- RNC-Node B Node Synchronisation;
- Inter Node B Node Synchronisation.

6.1.1 RNC-Node B Node Synchronisation

The Node Synchronisation between RNC and Node B can be used to find out the timing reference differences between the UTRAN nodes (RFN in RNC and BFN in Node B). The use is mainly for determining good DL and UL offset values for transport channel synchronisation between RNC and their Node B's. Knowledge of timing relationships between these nodes is based on a measurement procedure called RNC-Node B Node Synchronisation Procedure. The procedure is defined in the user plane protocols for Iub (DCH, DSCH, and FACH/PCH) and Iur (DCH).

When the procedure is used from SRNC over the DCH user plane, it allows finding out the actual round-trip-delay a certain service has (as the Node Sync Control Frames are transferred the same way as the DCH frames).

The procedure may also be carried out over a high priority transport bearer (beneficial when used between CRNC and Node Bs for the RNC-Node B Synchronisation purpose). Measurements of node offsets can be made at start or restart as well as during normal operation to supervise the stability of the nodes.

If an accurate Reference Timing Signal is used, the frequency deviation between nodes will be low, but could occur. If no accurate Reference Timing Signal is available, the local node reference oscillator must be relied upon. Then the RNC-Node B Node Synchronisation procedure can be used as a background process to find out the frequency deviation between nodes.

In the RNC-Node B Node Synchronisation procedure, the RNC sends a DL Node Synchronisation control frame to Node B containing the parameter ~~t~~T1. Upon reception of a DL Synchronisation control frame, the Node B shall respond with UL Synchronisation Control Frame, indicating ~~t~~T2 and ~~t~~T3, as well as ~~t~~T1 which was indicated in the initiating DL Node Synchronisation control frame (see Figure 3).

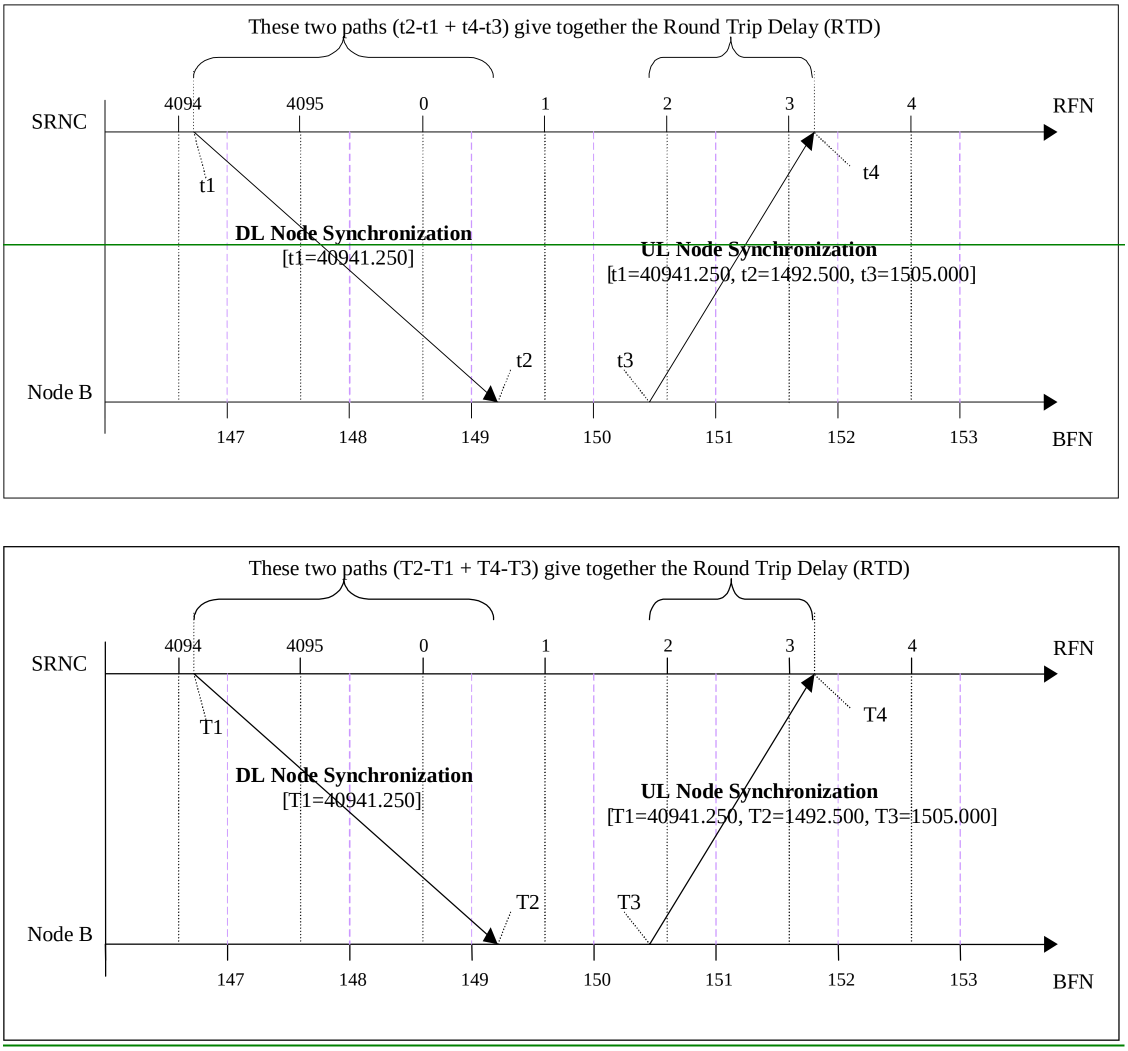


Figure 3: RNC-Node B Node Synchronisation

In case of macrodiversity with recombining in the DRNC, the DL Node Synchronisation control frame is duplicated in the DRNC on the different links, while the UL Node Synchronisation control frames received from all the Node B's are forwarded transparently to the SRNC (see Figure 4).

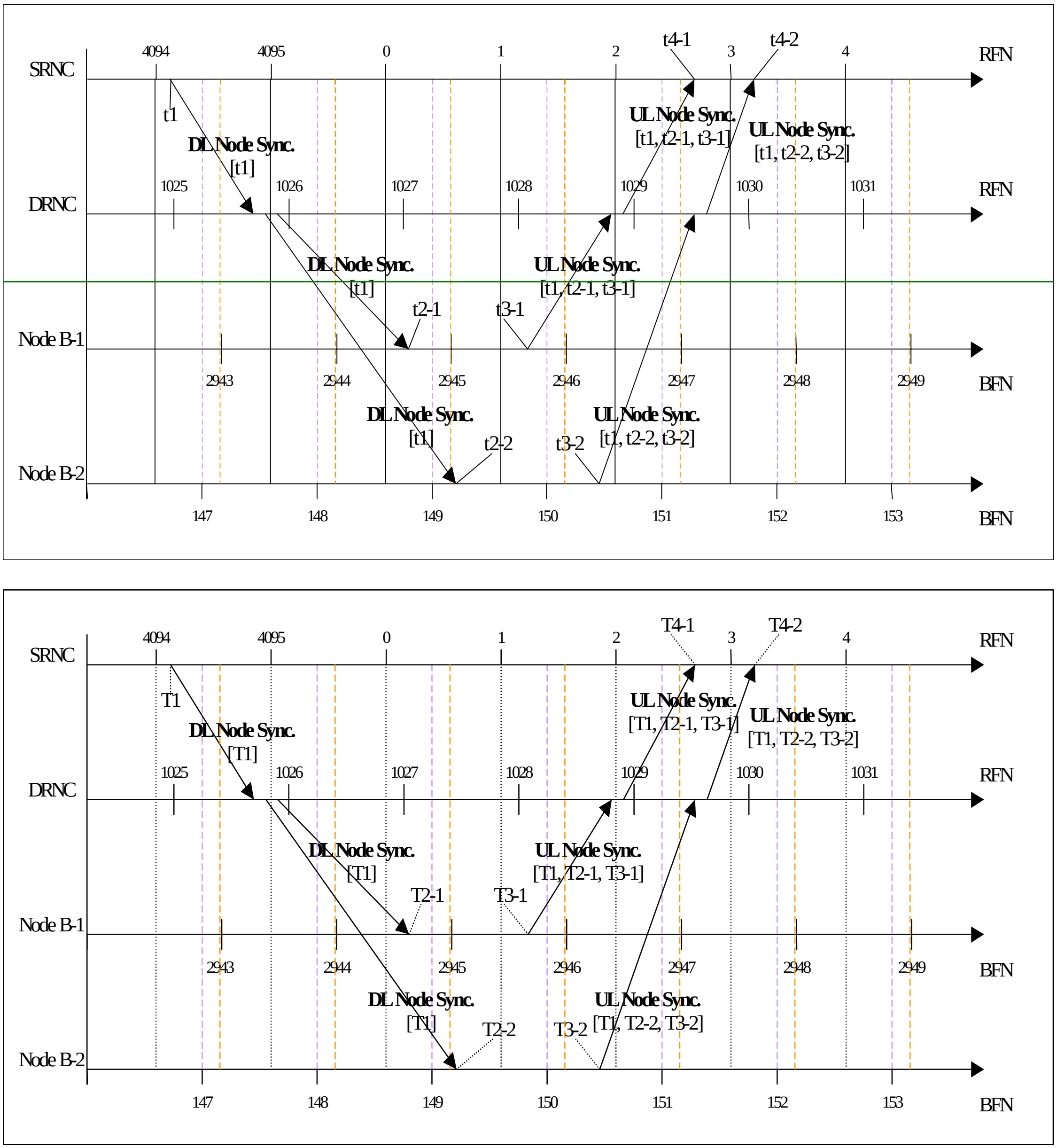


Figure 4: [FDD - RNC-Node B Node Synchronisation during soft handover with selection/recombining in the DRNC]

6.1.2 Inter Node B Node Synchronisation

In the FDD mode Inter Node B Node Synchronisation could be reached via the RNC-Node B Node Synchronisation in order to determine inter Node B timing reference relations.

This could be used to determine Inter-cell relationships (considering T_cell) which can be used in the neighbour cell lists in order to speed up and simplify cell search done by UE at handover.

In TDD Inter Node B Node Synchronisation is used to achieve a common timing reference among Node B's (see Figure 5), that allows to support Intercell Synchronisation.

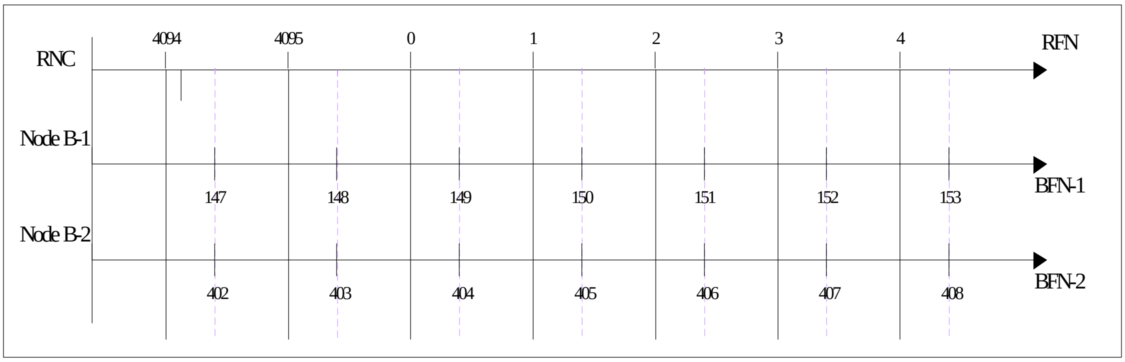


Figure 5: Synchronisation of BFNs through TDD Inter Node B Synchronisation

In TDD Inter Node B Node Synchronisation may be achieved via a standardised synchronisation port (see subclause 6.1.2.1) that allows to synchronise the Node B to an external reference.

6.1.2.1 TDD Node B Synchronisation Ports

This subclause defines the Node B input and an output synchronisation ports that can be used for Inter Node B Node Synchronisation. These synchronisation ports are optional.

The input synchronisation port (SYNC IN) allows the Node B to be synchronised to an external reference (e.g. GPS), while the output synchronisation port (SYNC OUT) allows the Node B to synchronise directly another Node B (see Figure 6).

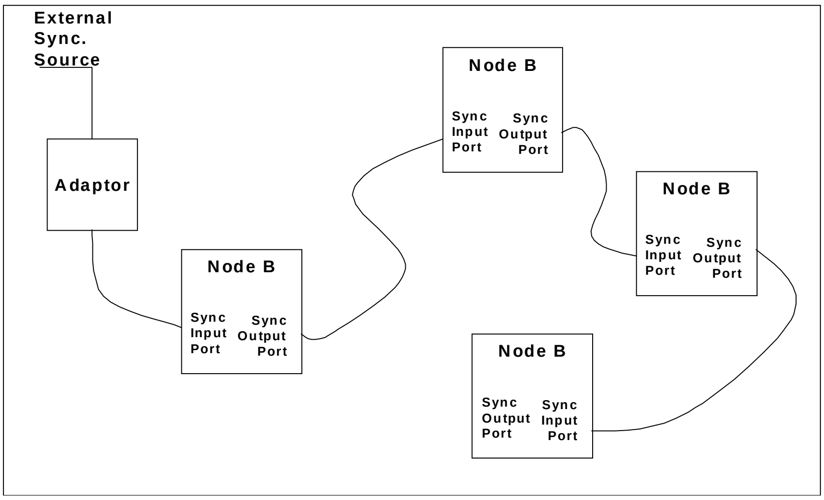


Figure 6: Usage of Synchronisation Ports

This allows connecting Node B's in a daisy chain configuration, so that a single external reference is enough and all remaining nodes B can be synchronised (e.g. in case of indoor operation).

The Node B starts the synchronisation to the external reference when a valid input synchronisation signal is detected at the input synchronisation port.

If a valid synchronisation signal is detected, the Node B regenerates that signal at its output synchronisation port.

The electrical characteristics of the synchronisation ports shall conform to RS422 [6] (output synchronisation port: subclause 4.1; input synchronisation port: subclause 4.2).

The synchronisation signal (illustrated in Figure 7) is a 100 Hz signal having positive pulses of width between 5 µs and 1 ms, except when SFN mod 256 = 0 (every 256th pulse), which has a pulse width between 2 ms and 5 ms. This signal establishes the 10 ms frame interval and the 2.56 s multiframe interval. The start of all frames in the cell of the node B is defined by the falling edge of the pulse. The required accuracy for the phase difference between the start of the 10ms frame interval is defined in [15]. The time delay from the falling edge of the signal at the SYNC IN port to the start of the transmitted radio frame shall not exceed 500ns.

The start of the 256 frame period is defined by the falling edge of the pulse corresponding to the frames where SFN mod 256 =0 (i.e. of width between 2 ms and 5 ms).

The synchronisation signal at the input port shall have frequency accuracy better than the one of the Node B.

The relative phase difference of the synchronisation signals at the input port of any Node B in the synchronised area shall not exceed 2.5 µs.

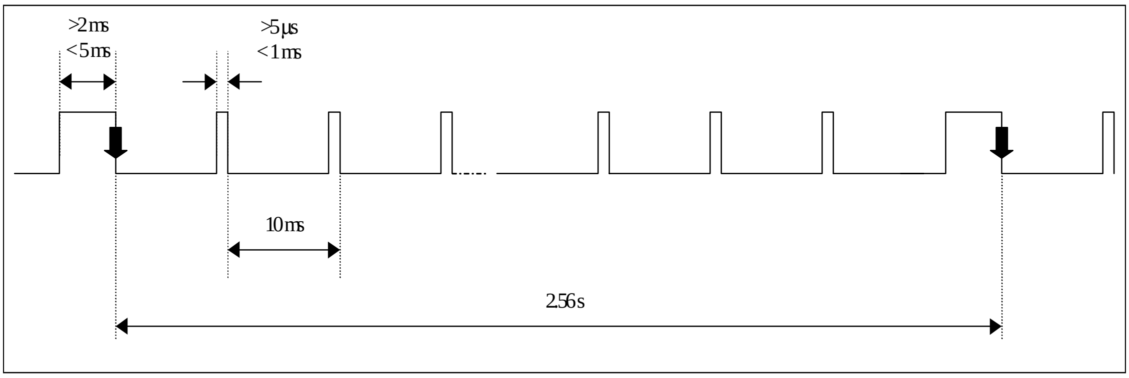


Figure 7: Synchronisation signal

Synchronisation by a GPS receiver

The signal transmitted by a Global Positioning System (GPS) satellite indicates the GPS time that provides an absolute time reference. This makes the GPS receiver suitable for Inter Node B Node Synchronisation.

Inter Node B Node Synchronisation is achieved by relating the synchronisation signal (at the input synchronisation port to the GPS signal. Since the period of this signal is 2.56 s, this implies that every 6400 frames the start of a 256 frame period coincides with an integer GPS second, i.e. a multiframe shall start when GPS time mod 64 = 0.

6.1.2.2 TDD Inter Node B Node Synchronisation procedure

Void.

7 Transport Channel Synchronisation

7.1 General

The Transport Channel (or L2) synchronisation provides a L2 common frame numbering between UTRAN and UE (frame synchronisation between the L2 entities). This frame number is the Connection Frame Number (CFN) and it is associated at L2 to every TBS and passed to L1: the same CFN is received on the peer side associated with the same TBS.

The CFN is not transmitted in the air interface for each TBS, but is mapped by L1 to the SFN of the first radio frame used for the transmission of the TBS (the SFN is broadcast at L1 in the BCH). The mapping is performed via the Frame Offset parameters (see Figure 8).

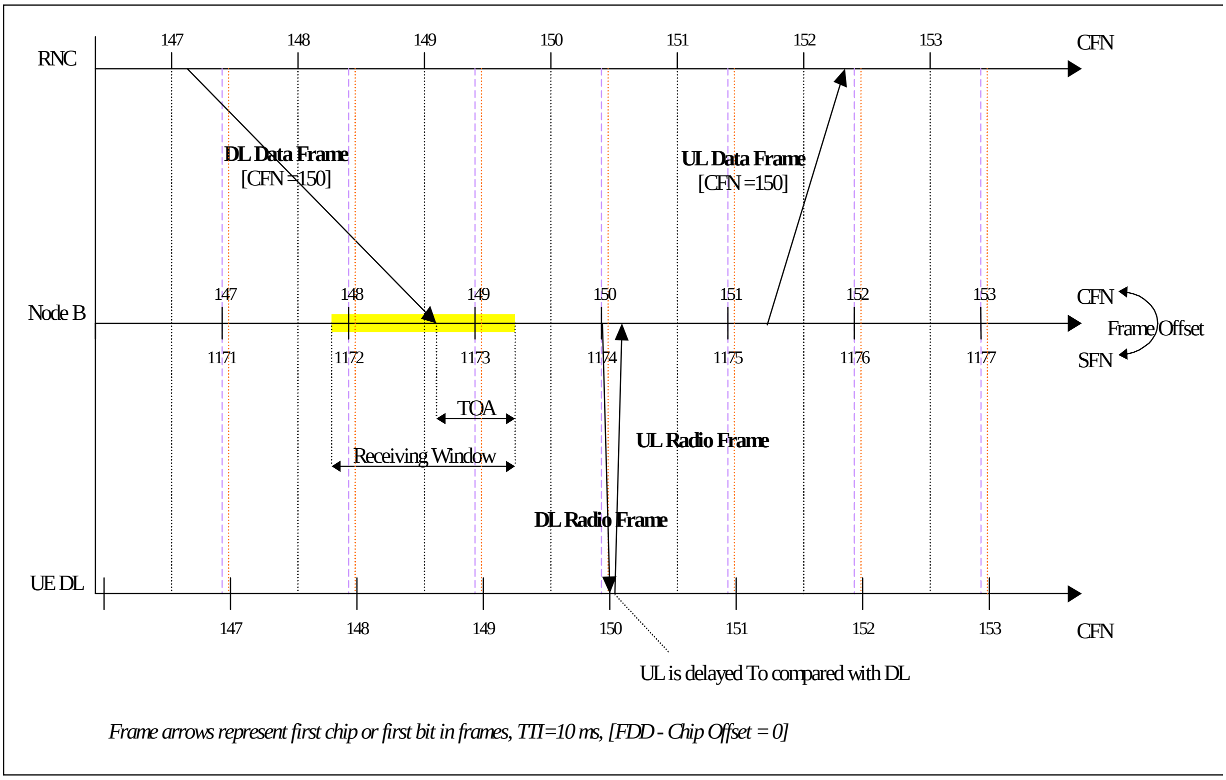


Figure 8: Transport Channel Synchronization

This transport channel synchronisation mechanism is valid for all downlink transport channels.

In case of soft handover (i.e. only for DCHs), the Frame Offsets of the different radio links are selected in order to have a timed transmission of the diversity branches on the air interface (see Figure 9).

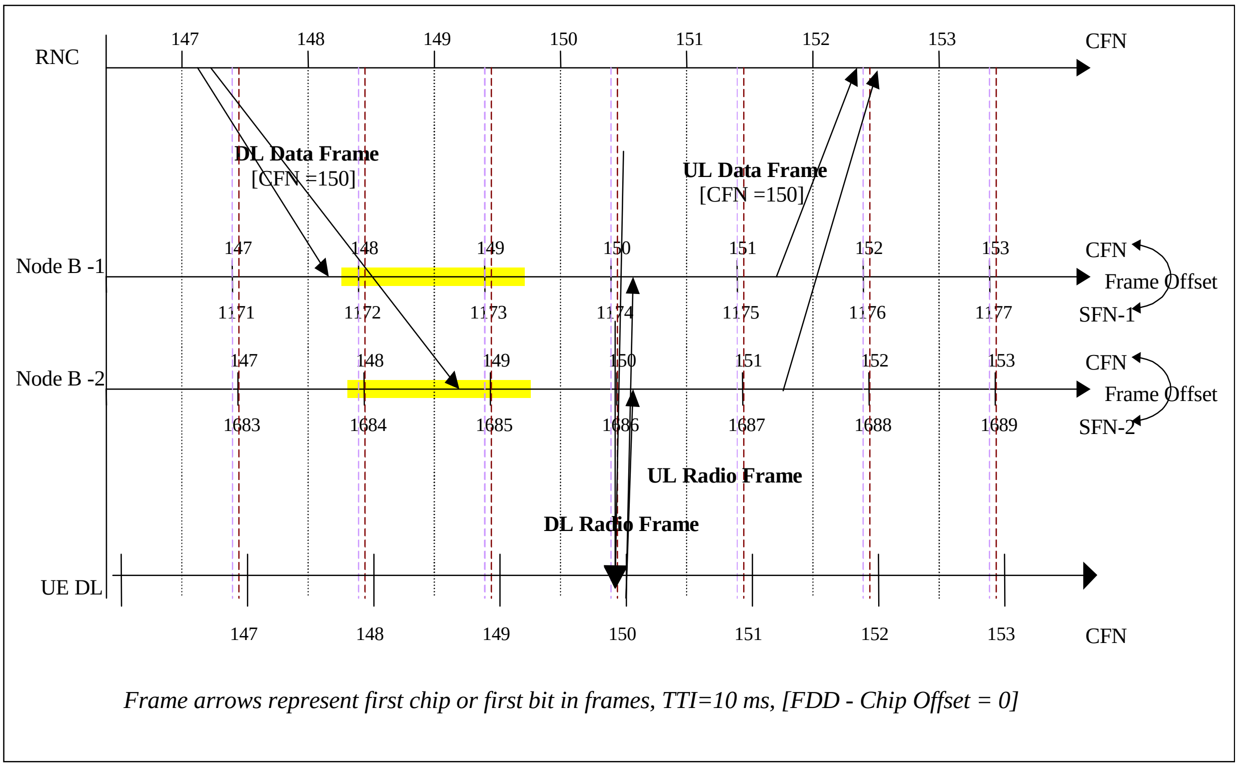


Figure 9: [FDD - Transport Channel Synchronisation during soft handover]

7.2 Timing adjustment and Time of Arrival monitoring on Iub/Iur interfaces

A receiving window is configured in Node B at Transport bearer Setup and Reconfiguration for DL frames (TOAWS and TOAWE). The purpose is to make it possible to supervise whether data frames are received in the window or not. When a frame is received outside that window, a response is sent to RNC by means of a Timing Adjustment Control frame containing the Time of Arrival information (TOA)(see Figure 10 and Figure 11). This allow the L1 to indicate to L2 (through the L1-MAC primitive carried by the Timing Adjustment Control frame) the necessity to adjust the timing of the DL transmission, in order to control and minimise the transmission delay and the buffering time for the transmission on the air interface (i.e. to ensure that the TBS does not arrive too much in advance respect to the transmission time).

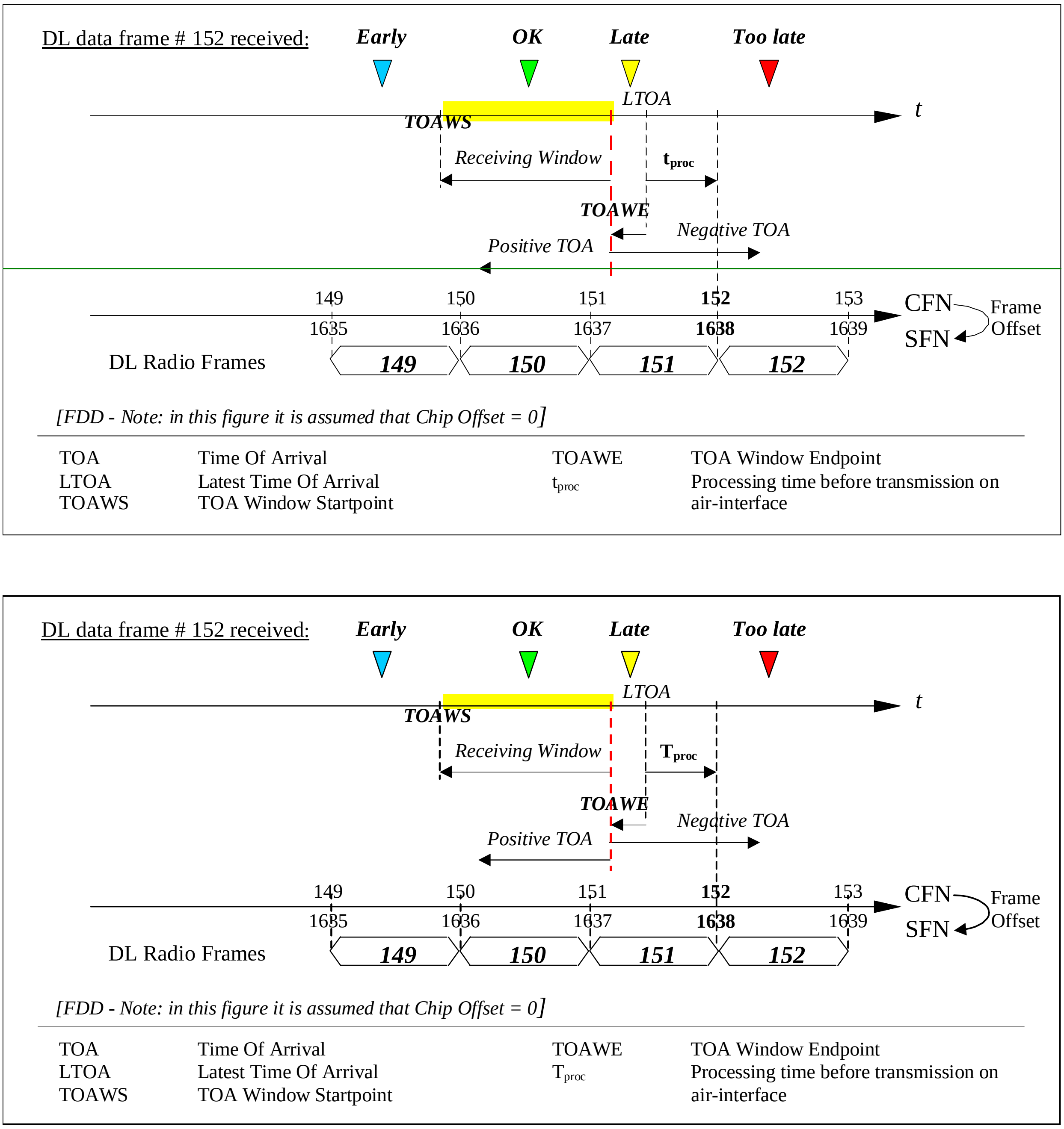


Figure 10: Illustration of TOAWS, TOAWE, LTOA and TOA

The window could be defined to have a margin before LTOA (TOAWE >0). This is to indicate to RNC that data frames are a bit late but they are still processed by Node B. In this case, data frames are received after TOAWE but before LTOA.

Using this window definition and supervising method, it is possible to determine the correct timing for sending data frames from the RNC over Iur/ Iub.

The window size and position is chosen with respect to expected data frame delay variation and different macro-diversity leg delays.

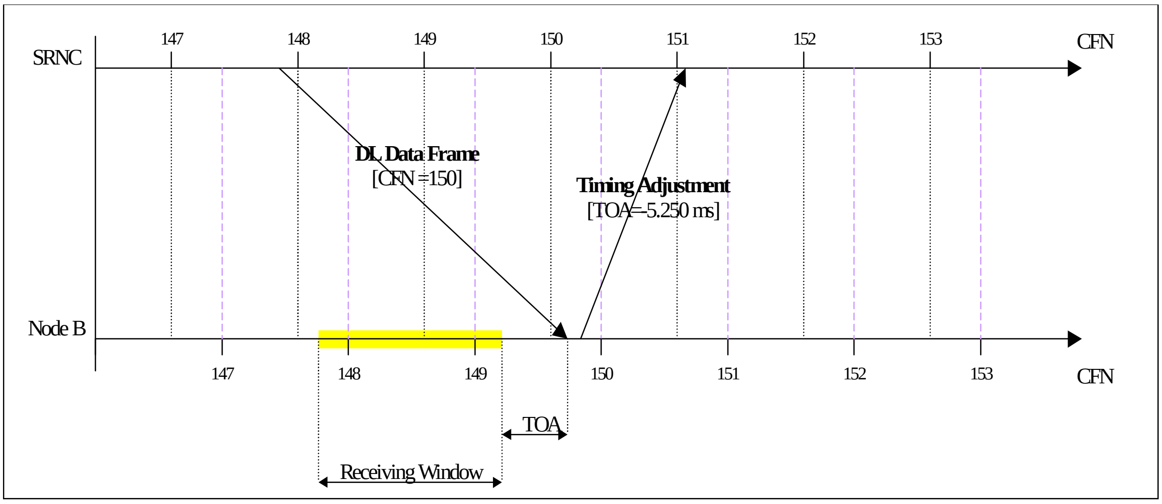


Figure 11: Timing Adjustment Procedure

In order to monitor the TOA when no DL data frames are sent, a synchronisation procedure is defined in the Iub/Iur frame protocols ([4],[5]). This procedure makes use of UL and DL Sync Control frames (see Figure 12 and Figure 13). The SRNC sends DL Sync Control frame containing the CFN in which the control frame should be received by the Node B. When the Node B receives the DL Sync Control frame, it always replies with an UL Sync Control frame containing the TOA , even if the DL Sync Control frame is received within the receiving window as in Figure 12.

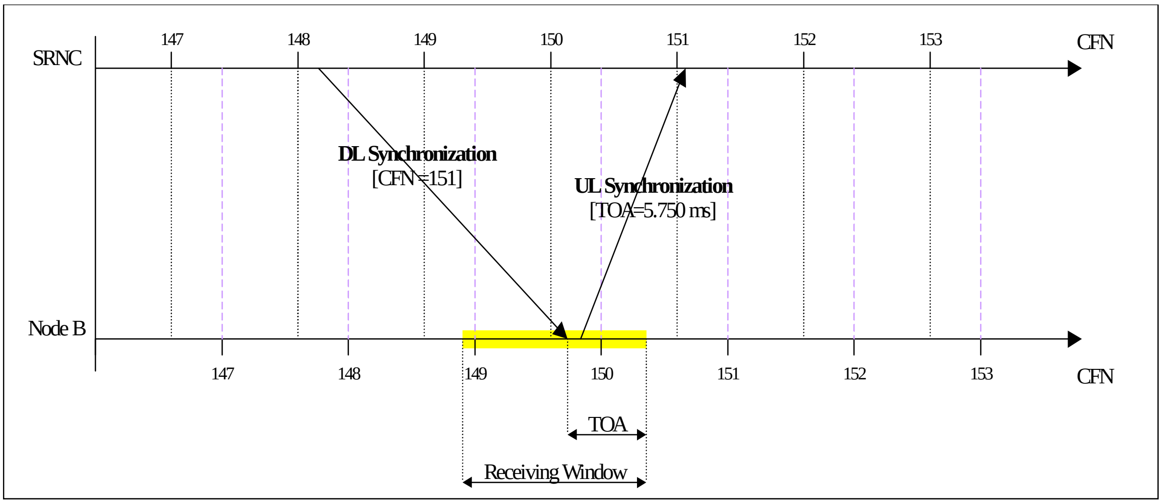


Figure 12: TOA monitoring through Frame Protocol Synchronisation Procedure (TOA >0)

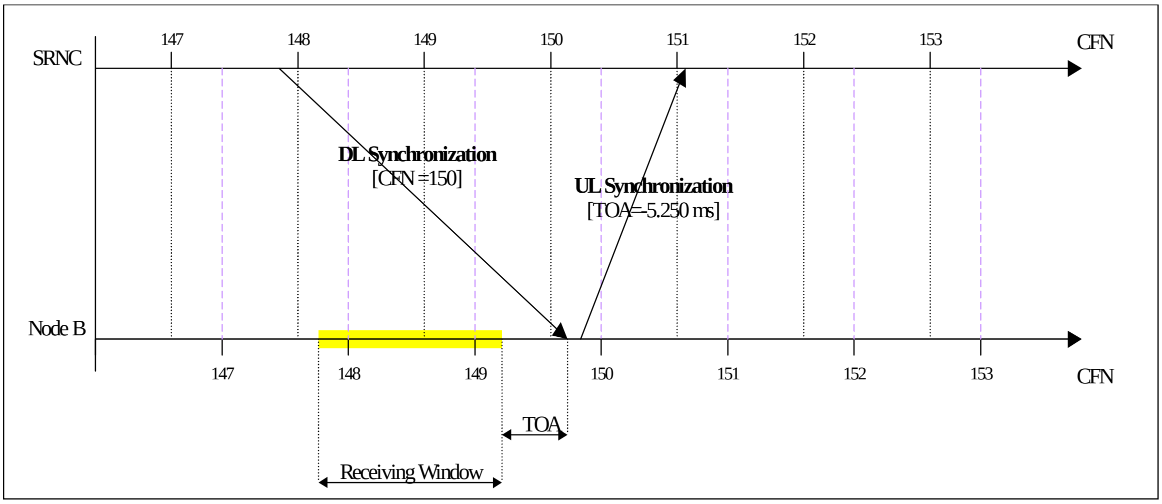


Figure 13: TOA monitoring through Frame Protocol Synchronisation Procedure (TOA <0)

In case of macrodiversity with recombining in the DRNC, the DL Synchronisation control frame is duplicated in the DRNC on the different links, while the UL Synchronisation control frames received from all the Node B's are forwarded transparently to the SRNC (see Figure 14).

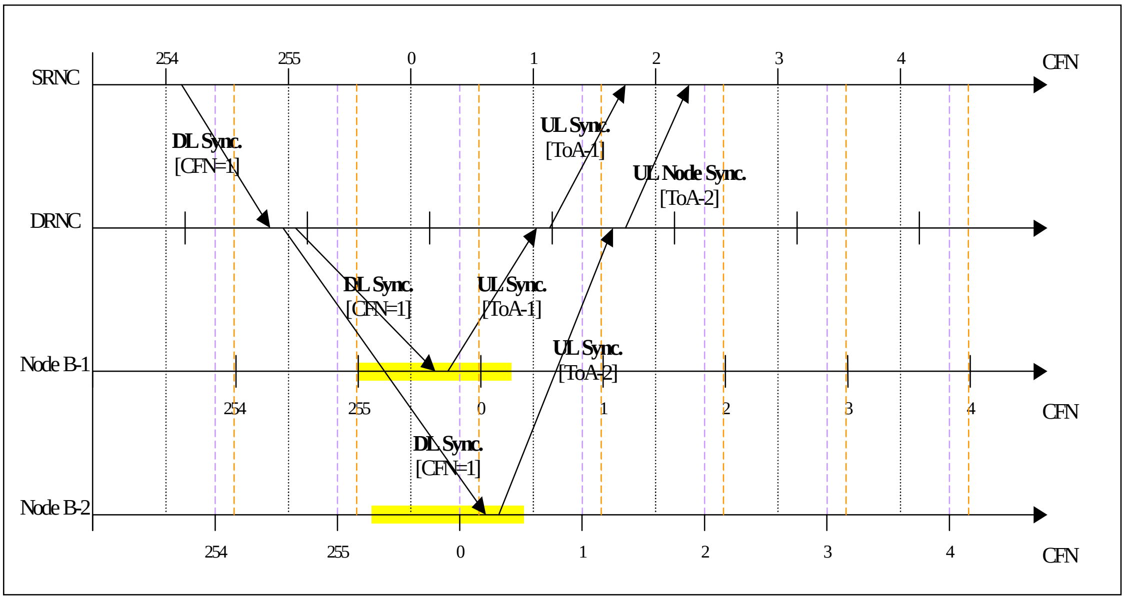


Figure 14: [FDD - TOA monitoring through FP Synchronisation Procedure during soft handover with selection/recombining in the DRNC]

Once the SRNC receives the two UL Synchronisation control frames containing TOA1 and TOA2, it may consider either TOA1 or TOA2 to advance or delay DL transmission (see Table 1).

8.3.4.4 Setting of timing advance value for target cell at handover

8.3.4.4.1 General

Since the uplink radio signals need to be adjusted only because of large enough distances between the UE and the cell transmission, certain cells will have a small enough radius that timing advance needs to not be used. In those cells the timing advance value in the UE is set to zero and UE autonomous adjustment of timing advance upon handover is disabled in the handover messages to the UE.

In these cells, where TA is not applied, the “RX Timing Deviation” measurement can be omitted if no other procedure (e.g. LCS) requires it.

8.3.4.4.2 Handover from TDD to TDD with synchronised cells

When two TDD cells are involved in handover and the two cells are sufficiently synchronised, a UE is able to measure the time offset between P-CCPCH reception of the two cells and, consequently, is able to autonomously correct its timing on handover without UTRAN assistance. However to improve the accuracy for the UE calculated timing advance, the SRNC can include an updated timing advance based on the timing deviation measured by the old cell in the messages triggering the handover in the UE. Note that this update shall apply in the old cell at the specified CFN if handover is performed on a later CFN or if the handover fails and falls back to the old cell. The UE shall use this new value as the basis for the UE autonomous update.

After a successful handover, a response message is transmitted in the new cell. In this message, if the UE auto~~mo~~nomously updated its timing advance it shall report the calculated timing advance value, which it is using for access to the new cell. By this way, the SRNC is informed as fast as possible about the absolute timing advance value in the UE, and it can correct the timing advance immediately or in the future based on this value, if necessary.

8.3.4.4.3 Handover from FDD to TDD, Handover from other systems to TDD, or Handover from TDD to TDD with unsynchronised cells

In these cases, since synchronisation between the handover cells is not possible, the new TDD cell must use a burst type with a large enough transmission window to allow the immediate transmission of data without the need of timing advance adjustment in the new cell, since timing adjustment can only be performed in these cells after the first uplink transmission.

3GPP TSG-RAN WG3 Meeting #23
Helsinki, Finland, August 27th-31st 2001

TDoc R3-012420

CR-Form-v4

CHANGE REQUEST

⌘ **25.402 CR 027** ⌘ ev **-** ⌘ Current version: **4.1.0** ⌘

*For **HELP** on using this form, see bottom of this page or look at the pop-up text over the ⌘ symbols.*

Proposed change affects: ⌘ (U)SIM ☐ ME/UE ☐ Radio Access Network ☒ Core Network ☐

Title:	⌘	Notation of Time Instances		
Source:	⌘	R-WG3		
Work item code:	⌘	TEI	***Date:*** ⌘	2001-08
Category:	⌘	**A**	***Release:*** ⌘	REL-4

Use one of the following categories:
- ***F*** *(correction)*
- ***A*** *(corresponds to a correction in an earlier release)*
- ***B*** *(addition of feature),*
- ***C*** *(functional modification of feature)*
- ***D*** *(editorial modification)*

Detailed explanations of the above categories can be found in 3GPP TR 21.900.

Use one of the following releases:

2	*(GSM Phase 2)*
R96	*(Release 1996)*
R97	*(Release 1997)*
R98	*(Release 1998)*
R99	*(Release 1999)*
REL-4	*(Release 4)*
REL-5	*(Release 5)*

Reason for change: ⌘

This CR is a mirror for REL-4 from CR026 for R99.

Background:
At RAN WG3 meeting nr22, there was a decision on an uniform notation for time instances: Capital letters are to be used for this purpose.
(This decision was made in Iub/Iur SWG at agenda item rb-2.5.3, when TDoc R3-012055 on TS25.435 was discussed).
This CR provides the corresponding changes for TS25.402, REL-4
In addition, an outdated "FFS" statement now removed.

Summary of change: ⌘

1) General alignment of notation: Capital letters
2) Removal of outdated "(FFS)" statement in section 4.3
3) Correction of typo in 8.3.4.4.2

Consequences if not approved: ⌘

Inconsistent notations between and inside RAN3 specifications.

Backwards compatibility:
Protocols are not affected at all, thus this change is backwards compatible.

Isolated impact:
Functions of UTRAN entities not affected, thus isolated impact is given.

Clauses affected: ⌘ 4.3; 5; 6.1.1; 7.2; 8.3.4.4.2

Other specs affected: ⌘
- ☒ Other core specifications ⌘ CR 026 25.402v3.6.0 R99
- ☐ Test specifications
- ☐ O&M Specifications

Other comments: ⌘

How to create CRs using this form:

Comprehensive information and tips about how to create CRs can be found at: http://www.3gpp.org/3G_Specs/CRs.htm. Below is a brief summary:

1) Fill out the above form. The symbols above marked ⌘ contain pop-up help information about the field that they are closest to.

2) Obtain the latest version for the release of the specification to which the change is proposed. Use the MS Word "revision marks" feature (also known as "track changes") when making the changes. All 3GPP specifications can be downloaded from the 3GPP server under ftp://ftp.3gpp.org/specs/ For the latest version, look for the directory name with the latest date e.g. 2001-03 contains the specifications resulting from the March 2001 TSG meetings.

3) With "track changes" disabled, paste the entire CR form (use CTRL-A to select it) into the specification just in front of the clause containing the first piece of changed text. Delete those parts of the specification which are not relevant to the change request.

4.3 Node Synchronisation

Node Synchronisation relates to the estimation and compensation of timing differences among UTRAN nodes. FDD and TDD modes have different requirements on the accuracy of the timing difference estimation and on the necessity to compensate for these differences.

Two types of Node Synchronisation can be identified, "RNC-Node B" and "Inter Node B" Node Synchronisation. Their usage differs and the requirements differ between the FDD and TDD modes.

"RNC-Node B" Node Synchronisation allows to get knowledge of the timing differences between RNC and its Node Bs.

"Inter Node B" Node Synchronisation may be used in the TDD mode to compensate the timing differences among Node Bs in order to achieve a common timing reference. The purpose of having a common timing reference is to allow Intercell Synchronisation, which is used, within neighbouring cells to minimise cross-interference.

Positioning / Localisation functions may also set requirements on Node Synchronisation~~ (FFS)~~.

4.4 Transport Channel Synchronisation

The Transport Channel Synchronisation mechanism defines synchronisation of the frame transport between RNC and Node B, considering radio interface timing.

DL TBS transmission is adjusted to fit receiver by adjusting the DL TBS timing in upper node. UL TBS transmission is adjusted by moving the UL reception window timing internally in upper node.

4.5 Radio Interface Synchronisation

The Radio Interface Synchronisation relates to the timing of the radio frame transmission (either in downlink [FDD] or in both directions [TDD]). FDD and TDD have different mechanisms to determine the exact timing of the radio frame transmission and also different requirements on the accuracy of this timing.

In FDD Radio Interface Synchronisation is necessary to assure that the UE receives radio frames synchronously from different cells, in order to minimise UE buffers.

In TDD Radio Interface Synchronisation refers to the following two aspects:

- Intercell Synchronisation that is used to synchronise radio frames within neighbouring cells in order to minimise cells cross-interference, to allow frame wise hopping mechanisms among cells (e.g. Cell Parameter Cycling according to Ref. [12]) and to make procedures involving more cells (e.g. handover) easier and more efficient;
- Timing advance that is used between UE and UTRAN in order to minimise UE-cell interference. In the 1.28Mcps TDD option, timing advance is provided by uplink synchronisation.

4.6 Time Alignment Handling

The Time Alignment Handling procedure over Iu relates to the control of DL transmission timing in the CN nodes in order to minimise the buffer delay in SRNC. This procedure is controlled by SRNC.

4.7 Uplink Synchronisation

In 1.28Mpcs TDD Uplink Synchronisation is performed at Layer 1 for PRACH and uplink DPCH. This procedure includes the establishment of UL synchronisation and maintenance of the UL synchronisation.

---

5 Synchronisation Counters and Parameters

This clause defines counters and parameters used in the different UTRAN synchronisation procedures.

The parameters used only by FDD has been indicated with the notation [FDD – parameter].

BFN	Node B Frame Number counter. This is the Node B common frame number counter. [FDD -BFN is optionally frequency-locked to a Network sync reference]. Range: 0 to 4095 frames.
RFN	RNC Frame Number counter. This is the RNC node common frame number counter. RFN is optionally frequency-locked to a Network sync reference. Range: 0 to 4095 frames.
SFN	Cell System Frame Number counter. SFN is sent on BCH. SFN is used for paging groups and system information scheduling etc. In FDD SFN = BFN adjusted with T_cell. In TDD, if Inter Node B synchronisation port is used, SFN is locked to the BFN (i.e. SFN mod 256 = BFN mod 256). Range: 0 to 4095 frames.
CFN	Connection Frame Number (counter). CFN is the frame counter used for the L2/transport channel synchronisation between UE and UTRAN. A CFN value is associated to each TBS and it is passed together with it through the MAC-L1 SAP. CFN provides a common frame reference (at L2) to be used e.g. for synchronised transport channel reconfiguration (see [2] [3]). The duration of the CFN cycle is longer than the maximum allowed transport delay between MAC and L1 (in UTRAN side, between SRNC and Node B, because the L1 functions that handle the transport channel synchronisation are in the Node B). Range: 0 to 255 frames. When used for PCH the range is 0 to 4095 frames.
Frame Offset	Frame Offset is a radio link specific L1 parameter used to map the CFN, used in the transport channel, into the SFN that defines the specific radio frame for the transmission on the air interface. At the L1/L2 interaction, the mapping is performed as: SFN mod 256 = (CFN + Frame Offset) mod 256 (from L2 to L1) (5.1) CFN = (SFN - Frame Offset) mod 256 (from L1 to L2) (5.2) The resolution of all three parameters is 1 frame. Frame Offset and CFN have the same range (0…255) and only the 8 least significant bits of the SFN are used. The operations above are modulo 256. In the UTRAN, the Frame Offset parameter is calculated by the SRNC and provided to the node B.
OFF	The parameter OFF is calculated by the UE and reported to the UTRAN only when the UTRAN has requested the UE to send this parameter. In the neighbouring cell list, the UTRAN indicates for each cell if the Frame Offset is already known by the UTRAN or shall be measured and reported by the UE. OFF has a resolution of 1 frame and a range of 0 to 255. Five different cases are discerned related to the determination of the OFF value by the UE: 1. The UE changes from common channel state to dedicated channel state: 1 RL In this case OFF is zero. 2. [FDD -The UE changes from common channel state to dedicated channel state: several RL's OFF is in this case defined as being the difference between SFN of the candidate cells and the SFN of the camping cell. Again the UE sets OFF to zero for the cell to which the UE sends an UL RRC message (cell #1). For cells #2 to n, the UE sets OFF to the difference between the SFN of cell#2,n and the SFN of cell#1. This could be seen as if a virtual dedicated physical channel (DPCH) already is aligned with cell #1].

3. The UE adds another RL or moves to another cell in dedicated channel state.
   OFF is in this case defined as being the time difference between the CFN and the SFN of the cell in which the RL is to be added. In case this difference cannot be measured, a value as in [FDD - 13] [TDD - 14] shall be reported instead.

4. The UE is coming from another RAN and goes to dedicated channel state: 1 RL
   This case is identical to case 1).

5. [FDD - The UE is coming from another RAN or another frequency in the same RAN and goes to dedicated channel state: several RL's.
   This case is identical to case 2), with one exception: OFF will not be zero for the cell to which the UE sends an UL RRC message (the measurement information will be received via the CN in this case) but for a reference cell selected by the UE. All other reported OFF values will be relative to the SFN of this selected reference cell].

[FDD – DOFF$_{FDD}$]

The DOFF$_{FDD}$ (FDD Default DPCH Offset value) is used to define Frame Offset and Chip Offset at first RL setup. The resolution should be good enough to spread out load over Iub and load in Node B (based on certain load distributing algorithms). In addition it is used to spread out the location of Pilot Symbol in order to reduce the peak DL power since Pilot symbol is always transmitting at the fixed location within a slot (the largest number of chips for one symbol is 512 chips).

The SRNC sends a DOFF$_{FDD}$ parameter to the UE when the new RL will make the UE change its state (from Cell_FACH state or other when coming from another RAN) to Cell_DCH state.

Resolution: 512 chips; Range:0 to 599 (<80ms).

[TDD – DOFF$_{TDD}$]

The DOFF$_{TDD}$ (TDD Default DPCH Offset value) is used to define Frame Offset at first RL setup, in order to spread out load over /Iur and load in Node B (based on certain load distributing algorithms).

The SRNC sends a DOFF$_{TDD}$ parameter to the UE when the new RL will make the UE change its state (from Cell_FACH state or other when coming from another RAN) to the Cell_DCH state.

Resolution: 1 frame; Range: 0 to 7 frames.

[FDD – Chip Offset]

The Chip Offset is used as offset for the DL DPCH relative to the PCCPCH timing. The Chip Offset parameter has a resolution of 1 chip and a range of 0 to 38399 (< 10ms).

The Chip Offset parameter is calculated by the SRNC and provided to the Node B.

Frame Offset + Chip Offset (sent via NBAP) are in Node B rounded together to closest 256 chip boundary. The 256 chip boundary is used regardless of the used spreading factor, also when the spreading factor is 512. The rounded value (which is calculated in Node B) controls the DL DPCH air-interface timing.

The "Frame Offset + Chip Offset" 256 chip boundary rounding rules for Node B to consider for each DL DPCH are:

1. IF (Frame Offset x 38 400 + Chip Offset) modulo 256 [chips] = {1..127} THEN round (Frame Offset x 38 400 + Chip Offset) modulo 256 frames down to closest 256 chip boundary.

2. IF (Frame Offset x 38 400 + Chip Offset) modulo 256 [chips] = {128..255} THEN round (Frame Offset x 38 400 + Chip Offset) modulo 256 frames up to closest 256 chip boundary.

3. IF (Frame Offset x 38 400 + Chip Offset) modulo 256 [chips] = 0 THEN "Frame Offset x 38 400 + Chip Offset" is already on a 256 chip boundary.

[FDD –Tm]

The reported Tm parameter has a resolution of 1 chip and a range of 0 to 38399. The Tm shall always be sent by the UE.

Five different cases are discerned related to the determination of the Tm value by the UE:

1. The UE changes from common channel state to dedicated channel state: 1 RL
   In this case the Tm will be zero.

2. The UE changes from common channel state to dedicated channel state: several RL's
   Tm is in this case defined as being the time difference between the received PCCPCH path of the source cell and the received PCCPCH paths of the other target cells. Again the UE sets Tm to zero for the cell to which the UE sends an UL RRC message (cell #1). For cells #2 to n, the UE sets Tm to the time difference of the PCCPCH reception timing of cell#2,n from the PCCPCH reception timing of cell#1.

3. The UE adds another RL in dedicated channel state (macro-diversity)
   Tm is in this case defined as being the time difference between "$T_{UETX} – T_o$" and the earliest received PCCPCH path of the target cell. T_{UETX} is the time when the UE transmits an uplink DPCCH frame, hence "$T_{UETX} – T_o$" is the nominal arrival time for the first path of a received DPCH.

4. The UE is coming from another RAN and goes to dedicated channel state: 1 RL
   This case is identical to case 1.

5. The UE is coming from another RAN or another frequency in the same RAN and goes to dedicated channel state: several RL's
   This case is identical to case 2, with one exception: Tm will not be zero for the cell to which the UE sends an UL RRC message (the measurement information will be received via the CN in this case) but for a reference cell selected by the UE. All other reported Tm values will be relative to the timing of the PCCPCH in this cell.

[FDD – T_cell]	T_cell represents the Timing delay used for defining the start of SCH, CPICH and the DL Scrambling Code(s) in a cell relative BFN. The main purpose is to avoid having overlapping SCHs in different cells belonging to the same Node B. A SCH burst is 256 chips long. SFN in a cell is delayed T_cell relative BFN. Resolution: 256 chips. Range: 0 .. 9 x 256 chips.
~~t~~T1	RNC specific frame number (RFN) that indicates the time when RNC sends the DL Node Synchronisation control frame through the SAP to the transport layer. Resolution: 0.125 ms; Range: 0-40959.875 ms.
~~t~~T2	Node B specific frame number (BFN) that indicates the time when Node B receives the correspondent DL Node Synchronisation control frame through the SAP from the transport layer. Resolution: 0.125 ms; Range: 0-40959.875 ms.
~~t~~T3	Node B specific frame number (BFN) that indicates the time when Node B sends the UL Node Synchronisation control frame through the SAP to the transport layer. Resolution: 0.125 ms; Range: 0-40959.875 ms.
~~t~~T4	RNC specific frame number (RFN) that indicates the time when RNC receives the UL Node Synchronisation control frame. Used in RNC locally. Not standardised over Iub.
TOAWS	TOAWS (Time of Arrival Window Startpoint) is the window startpoint. DL data frames are expected to be received after this window startpoint. TOAWS is defined with a positive value relative Time of Arrival Window Endpoint (TOAWE) (see Figure 10). A data frame arriving before TOAWS gives a Timing Adjustment Control frame response. The resolution is 1 ms, the range is: {0 .. CFN length/2 –1 ms}.

TOAWE	TOAWE (Time of Arrival Window Endpoint) is the window endpoint. DL data frames are expected to be received before this window endpoint (see Figure 10). TOAWE is defined with a positive value relative Latest Time of Arrival (LTOA). A data frame arriving after TOAWE gives a Timing Adjustment Control frame response. The resolution is 1 ms, the range is: {0 .. CFN length –1 ms}.
LTOA	LTOA (Latest Time of Arrival) is the latest time instant a Node B can receive a data frame and still be able to process it. Data frames received after LTOA can not be processed (discarded). LTOA is defined internally in Node B to be a processing time before the data frame is sent in air-interface. The processing time (Tproc) could be vendor and service dependent. LTOA is the reference for TOAWE (see Figure 14).
TOA	TOA (Time of Arrival) is the time difference between the TOAWE and when a data frame is received. A positive TOA means that data frames are received before TOAWE, a negative TOA means that data frames are received after TOAWE. Data frames that are received after TOAWE but before LTOA are processed by Node B. TOA has a resolution of 125 µs. TOA is positive when data frames are received before TOAWE (see Figure 12). The range is: {0 .. +CFN length/2 –125 µs}. TOA is negative when data frames are received after TOAWE. The range is: {–125 µs .. –CFN length/2}.

6 Node Synchronisation

6.1 General

By Node Synchronisation it's generally meant the achievement of a common timing reference among different nodes. In UTRAN although a common timing reference among all the nodes could be useful, it is not required. In fact different nodes’ counters (RFN and BFN), even if frequency-locked to the same network synchronisation reference, may be not phased aligned (see Figure 2).

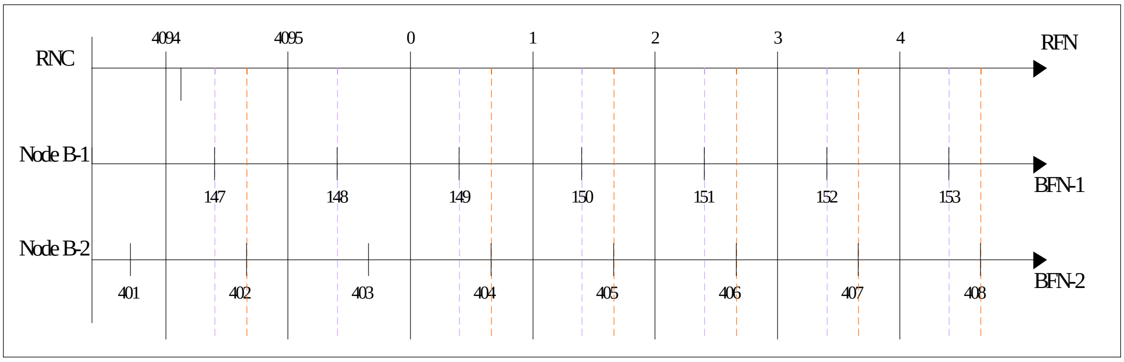


Figure 2: Timing of UTRAN counters

However in order to minimise the transmission delay and the buffering time for the DL transmission on the air interface, it can be useful to estimate the timing differences between RNC and Node Bs, without the need to compensate for the phase differences between RNC's and Node B's counters.

On the other hand the achievement of a common timing reference among Node B's may be used in TDD to support Cell Synchronisation.

For these reasons in UTRAN node synchronisation refers to the following two aspects:

- RNC-Node B Node Synchronisation;
- Inter Node B Node Synchronisation.

6.1.1 RNC-Node B Node Synchronisation

The Node Synchronisation between RNC and Node B can be used to find out the timing reference differences between the UTRAN nodes (RFN in RNC and BFN in Node B). The use is mainly for determining good DL and UL offset values for transport channel synchronisation between RNC and their Node B's. Knowledge of timing relationships between these nodes is based on a measurement procedure called RNC-Node B Node Synchronisation Procedure. The procedure is defined in the user plane protocols for Iub (DCH, DSCH, and FACH/PCH) and Iur (DCH).

When the procedure is used from SRNC over the DCH user plane, it allows finding out the actual round-trip-delay a certain service has (as the Node Sync Control Frames are transferred the same way as the DCH frames).

The procedure may also be carried out over a high priority transport bearer (beneficial when used between CRNC and Node Bs for the RNC-Node B Synchronisation purpose). Measurements of node offsets can be made at start or restart as well as during normal operation to supervise the stability of the nodes.

If an accurate Reference Timing Signal is used, the frequency deviation between nodes will be low, but could occur. If no accurate Reference Timing Signal is available, the local node reference oscillator must be relied upon. Then the RNC-Node B Node Synchronisation procedure can be used as a background process to find out the frequency deviation between nodes.

In the RNC-Node B Node Synchronisation procedure, the RNC sends a DL Node Synchronisation control frame to Node B containing the parameter ~~t~~T1. Upon reception of a DL Synchronisation control frame, the Node B shall respond with UL Synchronisation Control Frame, indicating ~~t~~T2 and ~~t~~T3, as well as ~~t~~T1 which was indicated in the initiating DL Node Synchronisation control frame (see Figure 3).

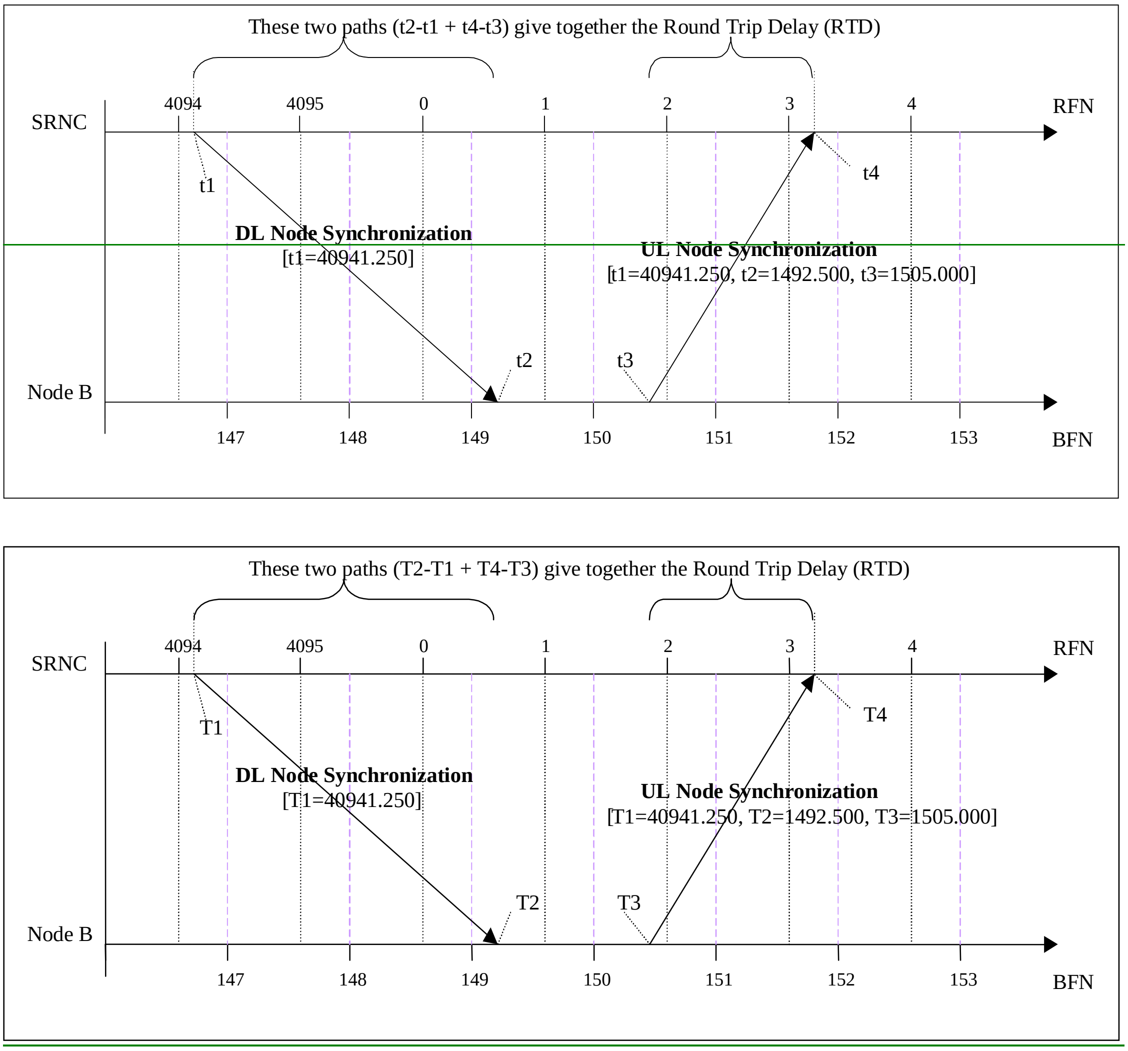


Figure 3: RNC-Node B Node Synchronisation

In case of macrodiversity with recombining in the DRNC, the DL Node Synchronisation control frame is duplicated in the DRNC on the different links, while the UL Node Synchronisation control frames received from all the Node B's are forwarded transparently to the SRNC (see Figure 4).

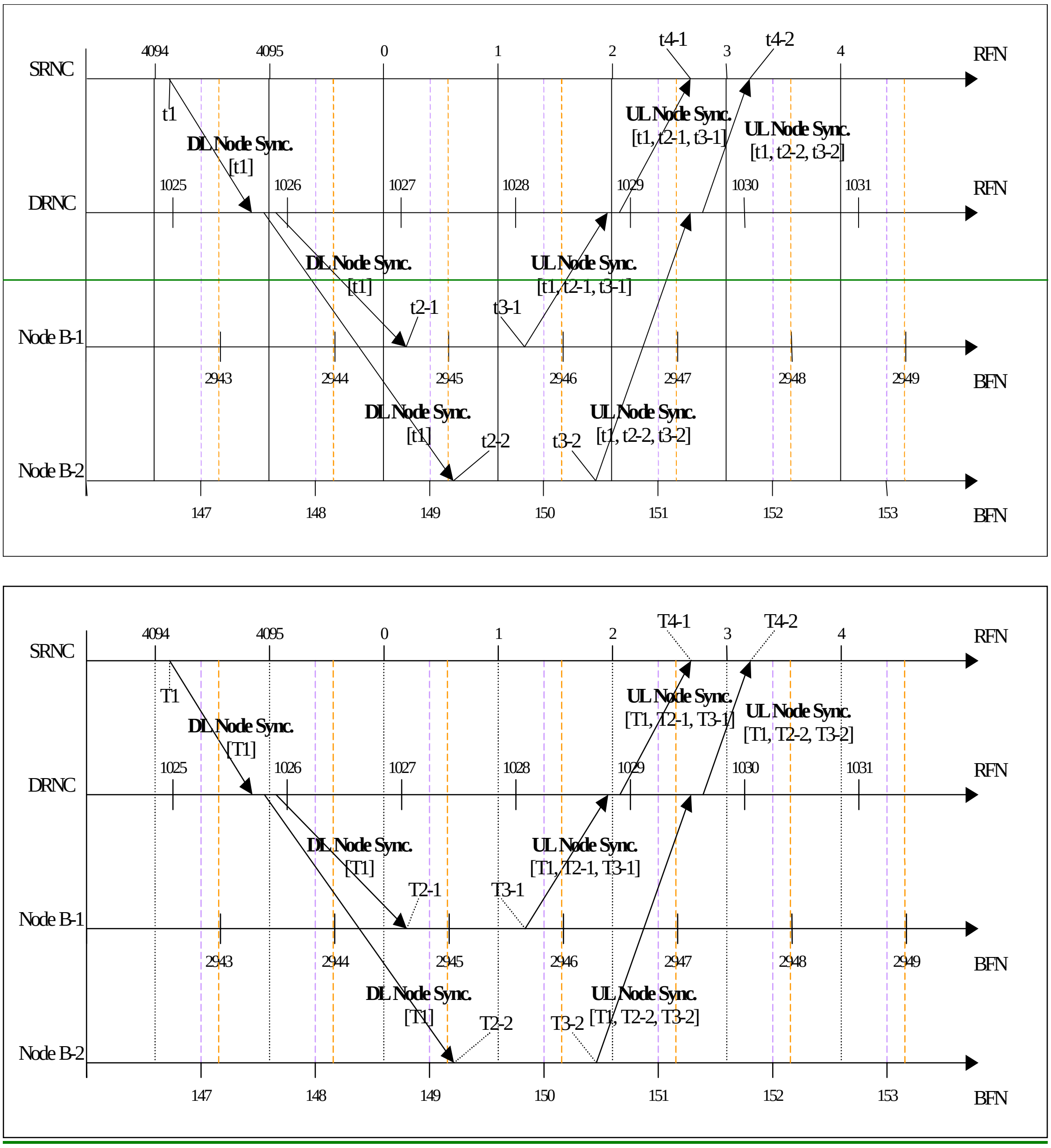


Figure 4: [FDD - RNC-Node B Node Synchronisation during soft handover with selection/recombining in the DRNC]

6.1.2 Inter Node B Node Synchronisation

In the FDD mode Inter Node B Node Synchronisation could be reached via the RNC-Node B Node Synchronisation in order to determine inter Node B timing reference relations.

This could be used to determine Inter-cell relationships (considering T_cell) which can be used in the neighbour cell lists in order to speed up and simplify cell search done by UE at handover.

In TDD Inter Node B Node Synchronisation is used to achieve a common timing reference among Node B's (see Figure 5), that allows to support Intercell Synchronisation.

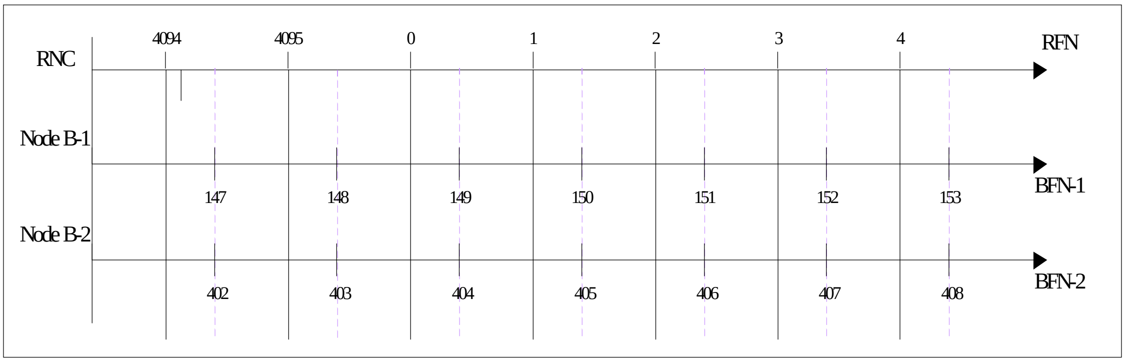


Figure 5: Synchronisation of BFNs through TDD Inter Node B Synchronisation

In TDD Inter Node B Node Synchronisation may be achieved via a standardised synchronisation port (see subclause 6.1.2.1) that allows to synchronise the Node B to an external reference.

Another option to achieve the Inter Node B Node Synchronisation in a TDD system is the synchronisation of cells or Node Bs via the air interface (see subclause 6.1.2.2).

6.1.2.1 TDD Node B Synchronisation Ports

This subclause defines the Node B input and an output synchronisation ports that can be used for Inter Node B Node Synchronisation. These synchronisation ports are optional.

The input synchronisation port (SYNC IN) allows the Node B to be synchronised to an external reference (e.g. GPS), while the output synchronisation port (SYNC OUT) allows the Node B to synchronise directly another Node B (see Figure 6).

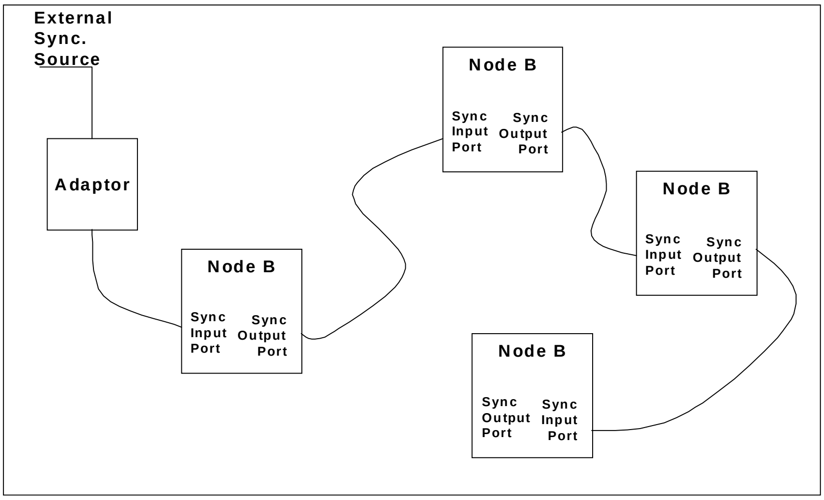


Figure 6: Usage of Synchronisation Ports

This allows connecting Node B's in a daisy chain configuration, so that a single external reference is enough and all remaining nodes B can be synchronised (e.g. in case of indoor operation).

The Node B starts the synchronisation to the external reference when a valid input synchronisation signal is detected at the input synchronisation port.

If a valid synchronisation signal is detected, the Node B regenerates that signal at its output synchronisation port.

The electrical characteristics of the synchronisation ports shall conform to RS422 [6] (output synchronisation port: subclause 4.1; input synchronisation port: subclause 4.2).

The synchronisation signal (illustrated in Figure 7a) is a 100 Hz signal having positive pulses of width between 5 µs and 1 ms, with the following exceptions:

- when (SFN mod 256 = 0) and not (SFN mod 4096 = 0), the pulse shall have a width between 2 ms and 3 ms;

This signal establishes the 10 ms frame interval, the 2.56 s multiframe interval, and the 4096 frames SFN period. The start of all frames in the cell of the node B is defined by the falling edge of the pulse. The required accuracy for the phase difference between the start of the 10ms frame interval is defined in [15].The time delay from the falling edge of the signal at the SYNC IN port to the start of the transmitted radio frame shall not exceed 500ns.

The start of the 256 frame period is defined by the falling edge of the pulse corresponding to the frames where SFN mod 256 =0 (i.e. of width between 2 ms and 3 ms, or between 4ms and 5 ms, respectively).

The start of the 4096 frame period is defined by the falling edge of the pulse corresponding to the frames where SFN mod 4096 = 0 (i.e. of width between 4 ms and 5 ms).

The synchronisation signal at the input port shall have frequency accuracy better than the one of the Node B.

The relative phase difference of the synchronisation signals at the input port of any Node B in the synchronised area shall not exceed 2.5 µs.

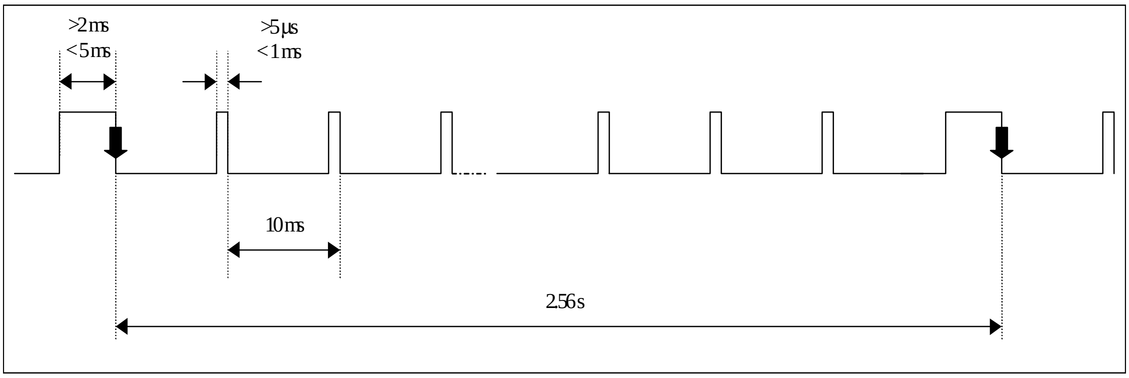


Figure 7: Synchronisation signal with 256 frames markers (Release 99)

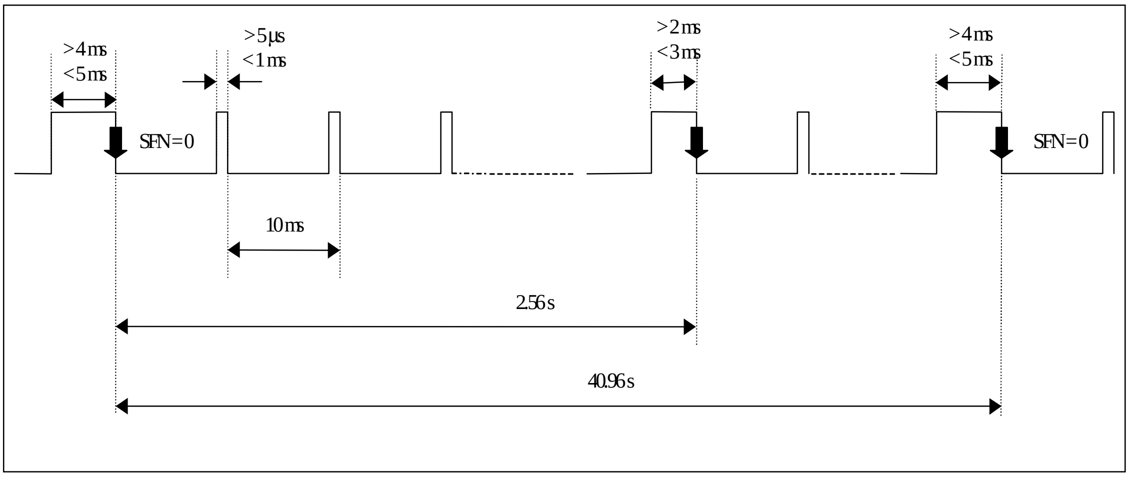


Figure 7a: Synchronisation signal with 256 and 4096 frames markers (Release 4)

Synchronisation by a GPS receiver

The signal transmitted by a Global Positioning System (GPS) satellite indicates the GPS time that provides an absolute time reference. This makes the GPS receiver suitable for Inter Node B Node Synchronisation.

Inter Node B Node Synchronisation is achieved by relating the synchronisation signal (at the input synchronisation port) to the GPS signal. Since the period of this signal is 2.56 s, this implies that every 6400 frames the start of a 256 frame period coincides with an integer GPS second, i.e. a multiframe shall start when GPS time mod 64 = 0.

In general, at each start of a GPS second indicating the GPS time in seconds, the associated full SFN (the 12 bits value) can be derived as: SFN = (GPS time * 100) mod 4096. If the synchronisation port signal shall be derived from GPS, the special pulses for the 256 frames period and the 4096 frames period shall be present in the synch port signal when SFN mod 256 = 0 or SFN mod 4096 = 0, respectively, where the SFN in these equations is linked to the GPS time by the said equation.

Backward compatibility to Release 99

The Release 4 synchronisation port definition is backward compatible with the R99 synch port in the following sense: It is possible to feed a Release 99 Node B with the Rel.4 synchronisation port signal. This results from the fact that the Rel.4 synch port pulses defined for SFN mod 256 = 0 and those defined for SFN mod 4096 = 0 both meet the pulse width tolerance defined for SFN mod 256 = 0 in Release 99. So the Rel.99 Node B will recognise these two classes of Release 4 pulses as valid Release 99 pulses for definition of the 256 frames multiframe start. The Rel.99 Node B will, however, ignore the differences between the 256 frames period pulse and the 4096 frames period pulse: The result is the 256 frames multiframe synchronisation as specified for Release 99.

The opposite scenario, however, i.e. connecting a Release 99 synchronisation port signal (without the 4096 frames marker) to a Release 4 Node B, shall be excluded. This would cause confusion for the "synchronisation via radio interface" procedure. The TDD cells in Rel.4 shall be either "reference" cells where the SFN is fully synchronised to an external reference, or they shall be "non-reference" without any external, local frame clock reference.

6.1.2.2 TDD Inter Node B Node Synchronisation procedure

The Node B synchronisation procedure is an optional procedure based on transmissions of cell synchronisation bursts in predetermined PRACH time slots according to an RNC schedule. Such soundings between neighbouring cells facilitate timing offset measurements by the cells. The measured timing offset values are reported to the RNC for processing. The RNC generates cell timing updates that are transmitted to the Node B and cells for implementation.

The synchronisation procedure has four phases to bring a network into a synchronised operation, the preliminary phase, the frequency acquisition phase, the initial phase and the steady-state phase. The procedure for late entrant cells is slightly different and is described separately.

For synchronisation via the air interface it has to be considered that as long as a cell is not synchronised the cell may interfere the neighbouring cells. This applies especially in case of late entrant cells where first the new cell has to be setup before the synchronisation procedure starts. By this Cell Setup procedure the SCH is already transmitting. The RNC shall therefore disable the downlink time slots on Cell Setup procedure by means of the *Time slot Status* IE. When the cell synchronisation has been performed the downlink time slots shall be enabled by means of the Cell Reconfiguration procedure.

6.1.2.2.1 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 receiver). The cells with reference timing shall initialise their SFN counter so that the frame with SFN=0 starts on January 6, 1980 at 00:00:00.
2) The RNC has to be informed at which of the cells the external reference clock is connected. Therefore, a ‘Reference Clock availability’ indicator is added 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.
3) 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.
4) The RNC has to retrieve the reference time from the cells with the reference clock. For the reference time retrieval the DL Transport Channels Synchronisation procedure on the PCH frame protocol (see [4]) shall be used. The Node B shall consider the SFN derived from the synchronisation port and the Reference SFN offset given by the RNC.
5) Now the RNC proceeds by updating the timing of all the remaining cells in the RNS, instructing them to adjust their clocks. Therefore, 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. The RNC then sends an CELL SYNCHRONISATION ADJUSTMENT message to all the cells for SFN update, apart from the one(s) containing the reference clock. The cells shall adjust SFN and frame timing accordingly.

6.1.2.2.1A 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.

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 according to the information's given in the CELL SYNCHRONISATION INITIATION REQUEST message.

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. For setting the parameters within the Node B to listen for transmission from other cells, the CELL SYNCHRONISATION INITIATION REQUEST message is used.

3) When a cell has detected that it has locked its frequency to within 50 ppm of the received signal, it shall signal completion of frequency acquisition to the RNC.

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.

6.1.2.2.1B Initial Synchronisation

The procedure for initial synchronisation is used to bring cells of an RNS area into synchronisation at network start up. No traffic is supported during this phase.

1) For the sync procedure it is useful to know which cells can “hear” each other. Therefore, all cells are instructed to transmit their cell sync bursts in turn one after the other. The same cell sync burst code and code offset is used by all cells.

2) Each cell shall listen for transmissions from other cells. Each cell shall report the timing and received SIR of successfully detected cell sync bursts to the RNC.

3) Upon reception of a CELL SYNCHRONISATION ADJUSTMENT message the cell shall adjust its timing accordingly. The timing adjustment shall be completed before the CELL SYNCHRONISATION ADJUSTMENT RESPONSE message is sent. It shall be implemented by adjusting the timing and/or tuning the clock frequency.

4) Steps 1 to 3 are repeated as often as necessary in order to reach the minimum synchronisation accuracy defined in [16]. This serves the purpose to bring the network into tight synchronisation.
   The SIR value within the cell sync burst reports is used by the RNC to define the schedule for the steady-state phase. I.e. to define when which cells transmit a cell sync burst and when which cell sync bursts shall be received. Cells which are sufficiently separated can be allowed to send the same cell sync burst at the same time. Cells which are not sufficiently separated have to use different cell sync codes and code offsets for distinctions.

6.1.2.2.2 Steady-State Phase

The steady-state phase allows to reach and/or maintain the required synchronisation accuracy. With the start of the steady-state phase traffic is supported in a cell. The steady-state phase starts with the Cell Synchronisation Reconfiguration procedure (see [3]) which defines the synchronisation schedule. I.e. each cell gets the information when to transmit a cell sync burst and when the individual cell sync bursts from the neighbouring cells shall be measured.

For definition of the SFN when the cell shall transmit or receive cell sync bursts, the SFN period is divided into cycles that have the same schedule. Within each cycle the Frame numbers for the cell sync bursts are calculated by the number of repetitions per cycle and by an offset. Code and code offset are used to identify the individual cell sync bursts.

1) The cell shall transmit a cell sync burst and measure cell sync bursts from neighbouring cells according to the information's given in the CELL SYNCHRONISATION RECONFIGURATION REQUEST message. Reception times for all relevant codes and code offsets shall be reported to the RNC with the CELL SYNCHRONISATION REPORT message.

2) Upon determination of an error in timing, the RNC adjusts the cell timing by means of the CELL SYNCHRONISATION ADJUSTMENT message. The timing adjustment shall be started at the beginning of the frame with the SFN given in the command. It shall be completed by the next cell sync slot. Timing adjustments shall be implemented via gradual steps at the beginning of a frame. The whole adjustment shall be implemented with maximum stepsize of one sample per frame.

3) Step 1 and 2 continue indefinitely

6.1.2.2.3 Late-Entrant Cells

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

1) Late entrant cells (new cells being added without reference clock) or cells recovering from unavailability shall first be roughly synchronised. Therefore, 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. The RNC then sends a CELL SYNCHRONISATION ADJUSTMENT message to the late-entrant cells for SFN update.

2) Frequency acquisition of the late entrant cell is started by instructing the late entrant cell first to listen to the regular schedule of cell sync bursts of the surrounding cells. The transmission schedule of the surrounding cells shall be signalled to the late entrant cell within the CELL SYNCHRONISATION INITIATION REQUEST message. Frequency locking is reported using the CELL SYNCHRONISATION REPORT message.

3) In addition or instead of a regular schedule a single common cell sync burst is transmitted in parallel by cells which are synchronised in the system and which are preferably the ones surrounding the late-entrant cell. The single cell sync burst is initiated by means of the CELL SYNCHRONISATION INITIATION REQUEST message to the surrounding cells.

4) The late entrant cell shall correlate against the cell sync burst according to the measurement information within the CELL SYNCHRONISATION INITIATION REQUEST message. The reception window shall be +/- 3 frames around the SFN frame given in the measurement information. The late entrant cell shall take the earliest reception as the timing of the system and adjusts its own timing and SFN number accordingly.

5) Thereafter, the late entrant cell shall start regular measurements after the reception of a CELL SYNCHRONISATION RECONFIGURATION REQUEST message and it shall report the timing of the measured cell sync bursts to the RNC. In turn, the late entrant cell receives its own schedules for sync transmissions and receptions and enters the steady-state phase.

7 Transport Channel Synchronisation

7.1 General

The Transport Channel (or L2) synchronisation provides a L2 common frame numbering between UTRAN and UE (frame synchronisation between the L2 entities). This frame number is the Connection Frame Number (CFN) and it is associated at L2 to every TBS and passed to L1: the same CFN is received on the peer side associated with the same TBS.

The CFN is not transmitted in the air interface for each TBS, but is mapped by L1 to the SFN of the first radio frame used for the transmission of the TBS (the SFN is broadcast at L1 in the BCH). The mapping is performed via the Frame Offset parameters (see Figure 8).

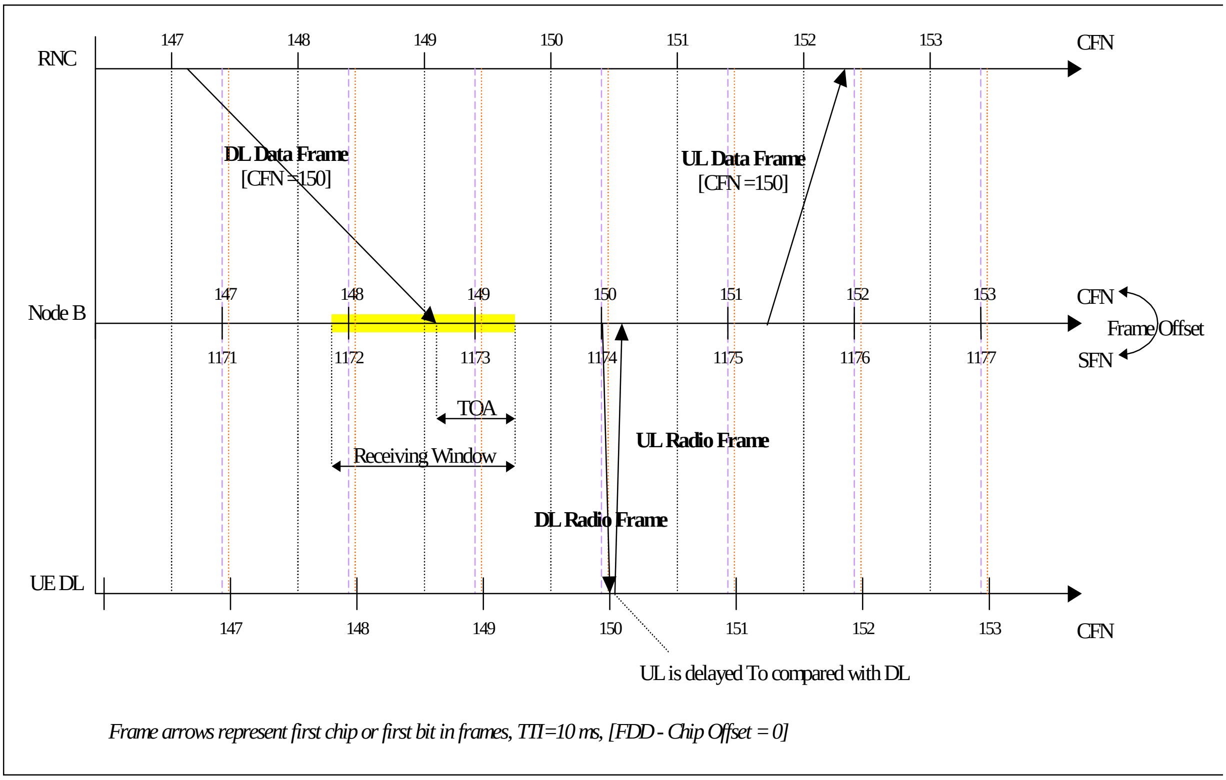


Figure 8: Transport Channel Synchronisation

This transport channel synchronisation mechanism is valid for all downlink transport channels.

In case of soft handover (i.e. only for DCHs), the Frame Offsets of the different radio links are selected in order to have a timed transmission of the diversity branches on the air interface (see Figure 9).

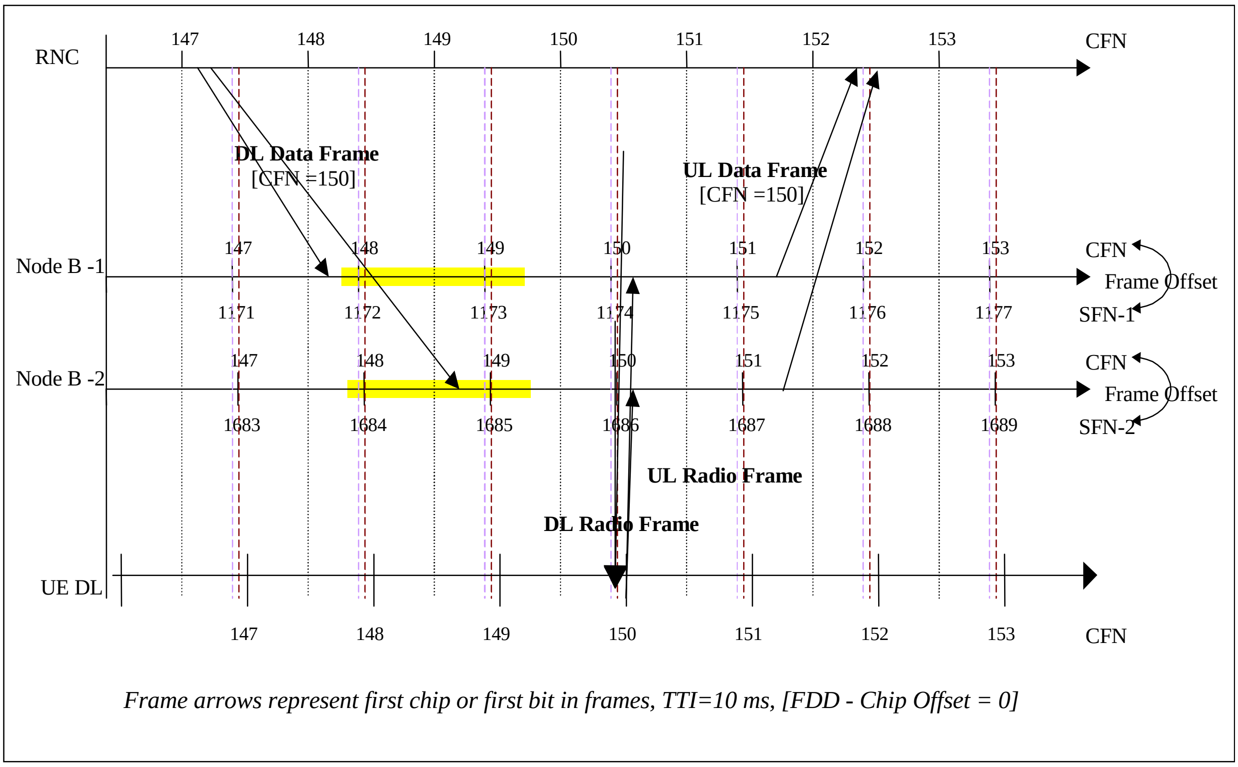
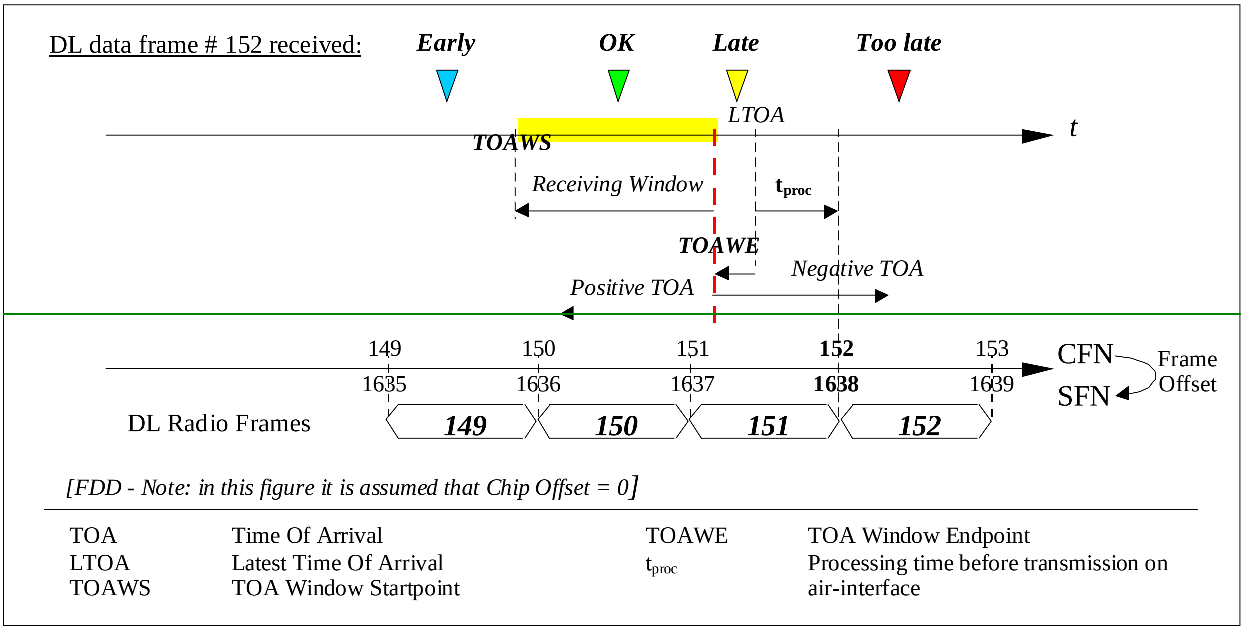


Figure 9: [FDD - Transport Channel Synchronisation during soft handover]

7.2 Timing adjustment and Time of Arrival monitoring on Iub/Iur interfaces

A receiving window is configured in Node B at Transport bearer Setup and Reconfiguration for DL frames (TOAWS and TOAWE). The purpose is to make it possible to supervise whether data frames are received in the window or not. When a frame is received outside that window, a response is sent to RNC by means of a Timing Adjustment Control frame containing the Time of Arrival information (TOA)(see Figure 10 and Figure 11). This allow the L1 to indicate to L2 (through the L1-MAC primitive carried by the Timing Adjustment Control frame) the necessity to adjust the timing of the DL transmission, in order to control and minimise the transmission delay and the buffering time for the transmission on the air interface (i.e. to ensure that the TBS does not arrive too much in advance respect to the transmission time).



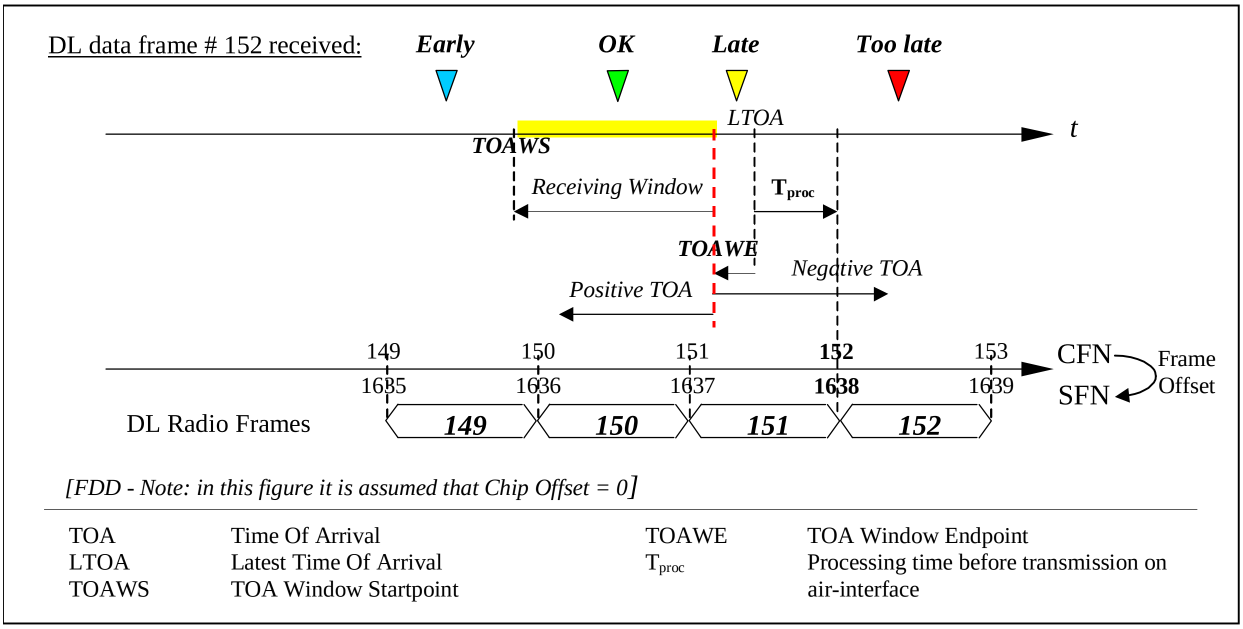


Figure 10: Illustration of TOAWS, TOAWE, LTOA and TOA

The window could be defined to have a margin before LTOA (TOAWE >0). This is to indicate to RNC that data frames are a bit late but they are still processed by Node B. In this case, data frames are received after TOAWE but before LTOA.

Using this window definition and supervising method, it is possible to determine the correct timing for sending data frames from the RNC over Iur/ Iub.

The window size and position is chosen with respect to expected data frame delay variation and different macro-diversity leg delays.

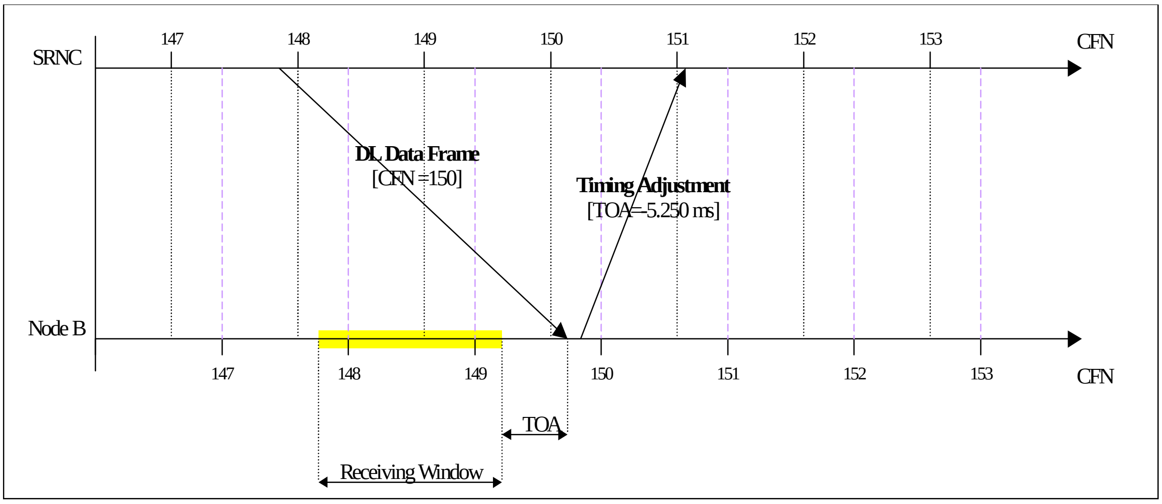


Figure 11: Timing Adjustment Procedure

In order to monitor the TOA when no DL data frames are sent, a synchronisation procedure is defined in the Iub/Iur frame protocols ([4],[5]). This procedure makes use of UL and DL Sync Control frames (see Figure 12 and Figure 13). The SRNC sends DL Sync Control frame containing the CFN in which the control frame should be received by the Node B. When the Node B receives the DL Sync Control frame, it always replies with an UL Sync Control frame containing the TOA , even if the DL Sync Control frame is received within the receiving window as in Figure 12.

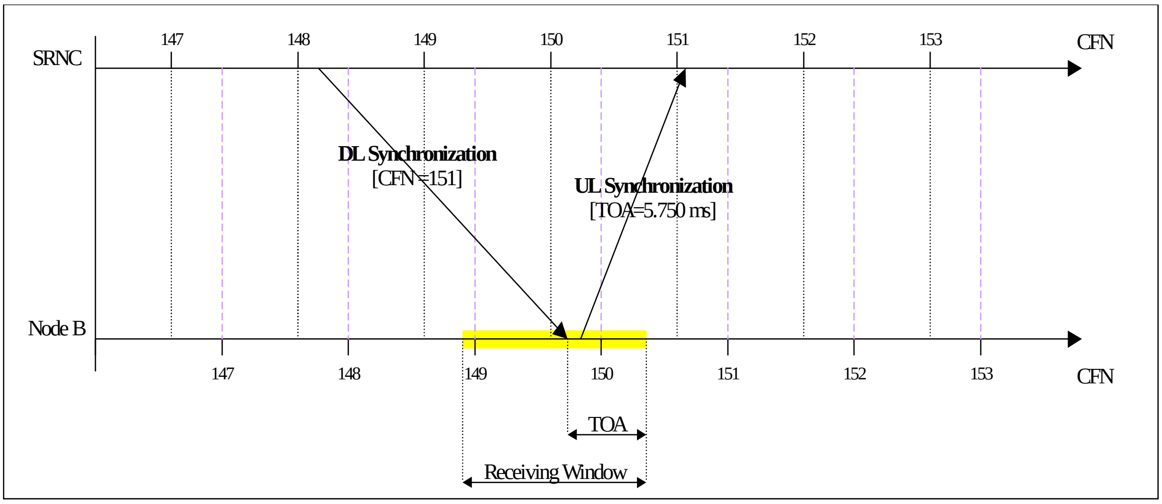


Figure 12: TOA monitoring through Frame Protocol Synchronisation Procedure (TOA >0)

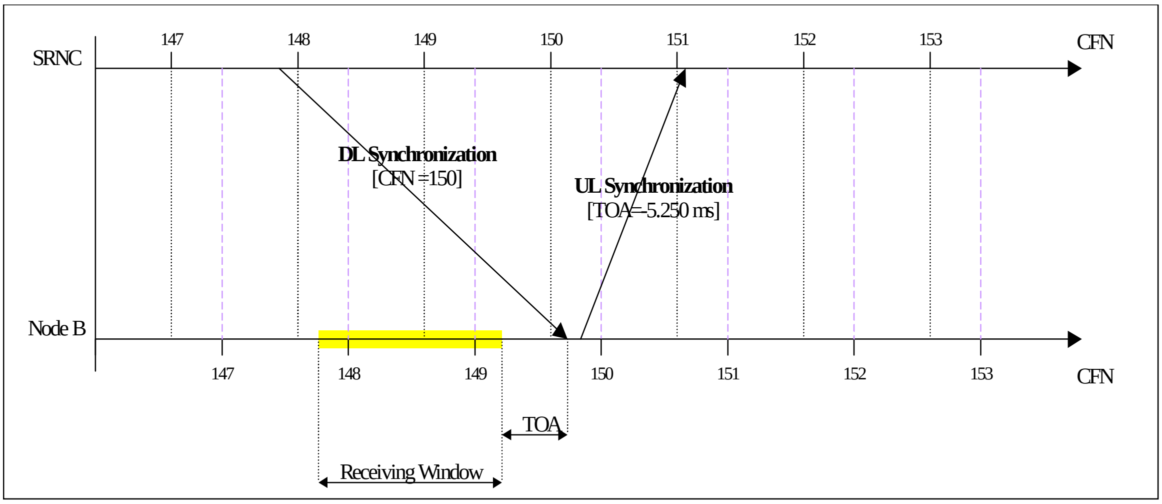


Figure 13: TOA monitoring through Frame Protocol Synchronisation Procedure (TOA <0)

In case of macrodiversity with recombining in the DRNC, the DL Synchronisation control frame is duplicated in the DRNC on the different links, while the UL Synchronisation control frames received from all the Node B's are forwarded transparently to the SRNC (see Figure 14).

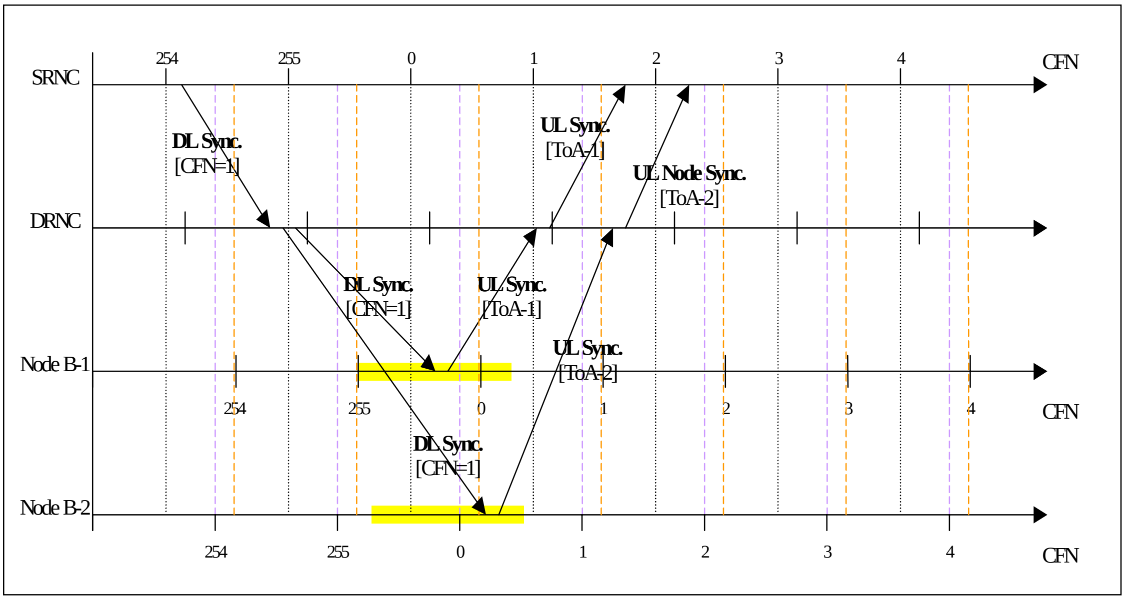


Figure 14: [FDD - TOA monitoring through FP Synchronisation Procedure during soft handover with selection/recombining in the DRNC]

Once the SRNC receives the two UL Synchronisation control frames containing TOA1 and TOA2, it may consider either TOA1 or TOA2 to advance or delay DL transmission (see Table 1).

8.3.4.4 Setting of timing advance value for target cell at handover

8.3.4.4.1 General

Since the uplink radio signals need to be adjusted only because of large enough distances between the UE and the cell transmission, certain cells will have a small enough radius that timing advance needs to not be used. In those cells the timing advance value in the UE is set to zero and UE autonomous adjustment of timing advance upon handover is disabled in the handover messages to the UE.

In these cells, where TA is not applied, the “RX Timing Deviation” measurement can be omitted if no other procedure (e.g. LCS) requires it.

8.3.4.4.2 Handover from TDD to TDD with synchronised cells

When two TDD cells are involved in handover and the two cells are sufficiently synchronised, a UE is able to measure the time offset between P-CCPCH reception of the two cells and, consequently, is able to autonomously correct its timing on handover without UTRAN assistance. However to improve the accuracy for the UE calculated timing advance, the SRNC can include an updated timing advance based on the timing deviation measured by the old cell in the messages triggering the handover in the UE. Note that this update shall apply in the old cell at the specified CFN if handover is performed on a later CFN or if the handover fails and falls back to the old cell. The UE shall use this new value as the basis for the UE autonomous update.

After a successful handover, a response message is transmitted in the new cell. In this message, if the UE auto~~mo~~nomously updated its timing advance it shall report the calculated timing advance value, which it is using for access to the new cell. By this way, the SRNC is informed as fast as possible about the absolute timing advance value in the UE, and it can correct the timing advance immediately or in the future based on this value, if necessary.

8.3.4.4.3 Handover from FDD to TDD, Handover from other systems to TDD, or Handover from TDD to TDD with unsynchronised cells

In these cases, since synchronisation between the handover cells is not possible, the new TDD cell must use a burst type with a large enough transmission window to allow the immediate transmission of data without the need of timing advance adjustment in the new cell, since timing adjustment can only be performed in these cells after the first uplink transmission.