In our opinion this document should describe architectural principles and give an overview of the architectural fundamentals. We believe that the level of detail of section 9 exceeds the one desired for an overall document on the UTRAN Architecture.

Furthermore the sections on UTRAN synchronisation aspects will need to be further detailed in the future taking into account also TDD synchronisation issues, and section on delay requirement (12.1) will increase significantly.

For these reasons we propose the creation of a new Technical Specification (UTRAN synchronisation principles & delay requirements). The content of sections 9 and 12.1 of TS 25.401 'UTRAN Overall Description' is proposed to be moved to this new TS.

The proposed table of content for the new TS is given in the following.

TS XX.XXX V0.0.1 (1999-04)

Technical Specification

3GPP

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Intellectual Property Rights

Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project, Technical Specification Group <TSG name>.
The contents of this TS may be subject to continuing work within the 3GPP and may change following formal TSG approval. Should the TSG modify the contents of this TS, it will be re-released with an identifying change of release date and an increase in version number as follows:

Version m.t.e

where:

m indicates [major version number]

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

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

1 Scope

This document describes the UTRAN synchronisation aspects and principles, as well as the UTRAN delay requirements.

2 References

This text block applies to ALL deliverables. The sub-division below applies optionally to TSs.
The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

[1] Merged UTRAN Architecture Description V0.0.2

[2] UMTS 23.10 : UMTS Access Stratum Services and Functions

Editor's Note : [1] is a temporary reference only to ease the definition of what should be in the different sections of this document.

3 Definition of UTRAN Synchronisation Aspects

This section describes a number of synchronisation principles grouped into three groups: Network Synchronisation, Frame Synchronisation and Node Synchronisation.

3.1 SYNCHRONISATION MODEL

The Synchronisation model includes nodes and interactions in UTRAN as well as points at interactions to Core Network (CN) and User Equipment (UE).
The objectives with the sync model are to describe where the interactions mainly take place and to define the following terms:

- Time Alignment handling
- Frame synchronisation
- Radio Interface Synchronisation handling
- Ciphering handling

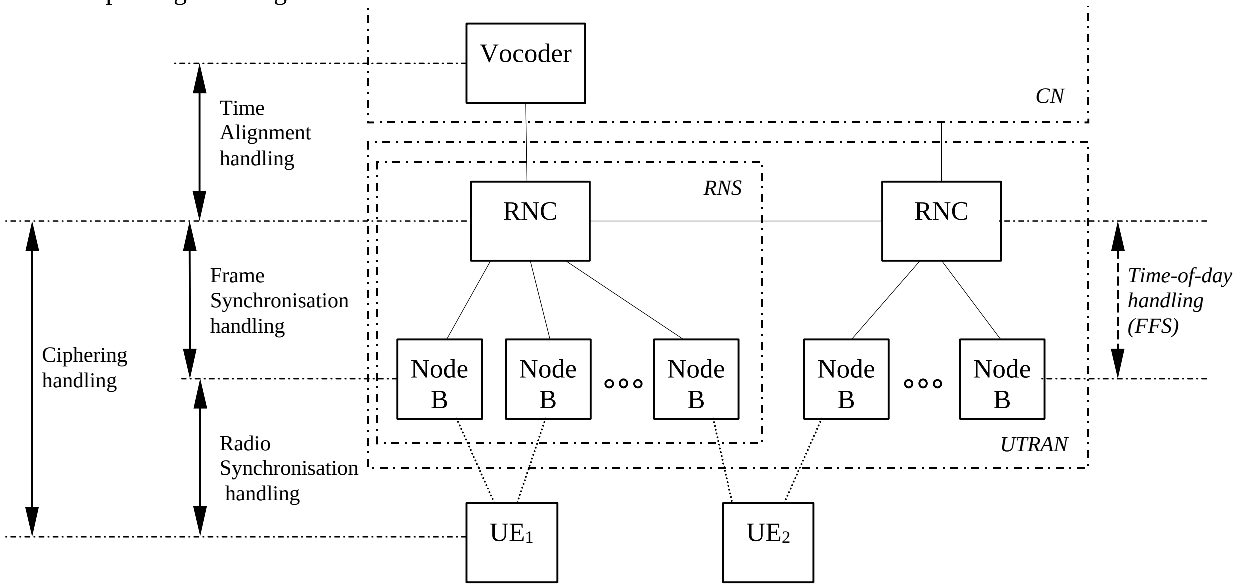

Figure 1. Synchronisation issues model.

The *Time-of-day* is an option FFS, used for OAM functions like radio network event time-stamping. Network synchronisation is a prerequisite for UTRAN and CN nodes.

3.1.1 Time Alignment handling

Time Alignment handling is the functionality to adapt to 10 ms framing (or to unit length e.g. 20 ms) i.e. to send and receive frames 'just-in-time' and thus minimizing the delay. TA is an issue between Vocoders and the Diversity handover unit (DHO) in RNC. TA could also be used for circuit switched services like data.

3.1.2 ~~FDD —~~Frame synchronisation

[Text to be added]

3.1.2.1 FDD — Frame synchronisation

Frame synchronisation is the functionality to secure that the same DL frames are sent in the involved Node Bs towards UE and that the same UL frames are combined in RNC (in the Diversity Handover unit, DHO).
This is done by managing Frame Offset values that could be set differently in DL and UL.
Frames are sent from RNC to Node Bs the DL Frame Offset value earlier compared with when they are to be sent in Node Bs towards UE.
Frames are combined in RNC the UL Frame Offset value later compared to when they are received by Node B.
Frame Offset values could be predefined in the system but could also be refined during operation. Frame Offset values are handled in RNC only. Refining the DL Frame Offset values requires Iub signalling from Node Bs to RNC and

contains the Frames discard rate and the Frames received too early rate in Node Bs. Refining the UL Frame Offset values requires no Iub signalling (RNC internal only).
The delay requirement for Voice is hard to fulfil. Therefore, Voice is transferred over the transport network using a Quality of Service (QoS) that has short buffers compared with e.g. packet data. This means that the Voice Frame Offset values could be shorter than those for packet data in order to have a chance to fulfil the Voice delay requirements.
Note : Due to TFI coordination in MAC layer, some situations could exist where the same frame offset would be required for different services. This will require further studies.]

3.1.2.2 TDD — Frame synchronisation

[Text to be added]

3.1.3 Radio Interface Synchronisation

[Text to be added]

3.1.3.1 FDD Radio Interface Synchronisation

Radio Interface Synchronisation is an issue mainly between UE and Node Bs. Radio Interface Synchronisation is used at addition of a new radio link (Soft-Handover, SHO) or when changing to another radio link (Hard-Handover, HHO). Radio Interface Synchronisation includes use cases like Establishment of first radio link, Inter-/Intra-RNS SHO and Inter-/Intra-frequency Hard-Handover which could be seamless or non-seamless.

3.1.3.2 TDD Radio Interface Synchronisation

[Text to be added]

3.1.4 Ciphering handling

Services transferred over the air-interface need ciphering for security reasons. The length of the ciphering counter is in the range of 2^{32}. The UE specific ciphering counter must be synchronised between UE and RNC.

3.1.5 Time-of-day handling

Time-of-day handling is optional and is FFS.

3.2 Network Synchronisation

The Network Synchronisation relates to the stability of the clocks in the UTRAN. The standard will specify the performance requirements on the radio interface. Also the characteristics on the UTRAN internal interfaces, in particular Iub, need to be specified.
Editor's note : The short-term stability (e.g. over a symbol or frame) of the Node B transmitter is an issue for the L1 EG. However, the long-term stability is related to the Node Synchronisation (see below), and may need to be specified taking the Node Synchronisation into account.

4 Synchronisation Aspects Common to FDD and TDD

[Text to be added]

5 FDD Synchronisation Aspects

[Text to be added]

~~3.3~~5.1 Radio interface synchronisation

This section firstly defines some physical channel timing parameters that are necessary for the radio interface synchronisation. See [7] for more details. Then the radio interface synchronisation procedure is described.
The following assumptions are considered:

- a Node B covers *N* cells, where *N* ³*1*;

- each Node B has a Reference Frame Number (RFN) which counts from *0* to *M-1* in Radio Frame intervals;
- each cell has a Frame Number (FN) which counts from *0* to *M-1* in Radio Frame intervals;
- the cell FN is broadcasted on the BCCH;
- cells are asynchronous among each others (Primary CCPCH are not synchronised).

Note : No assumptions have been made on the values of the Frame Number. The following alternatives are possible:

- *each cell has an independent FN;*
- *FN is unique inside each Node B;*
- *FN is unique inside each RNS;*
- *FN is unique in a PLMN.*

The physical channel timing parameters in a soft handover situation including two cells belonging to two different Nodes B (Cell i belonging to Node B1 and Cell j belonging Node B2) are described below and shown in Figure 2.

- $\mathbf{T_p}$: Propagation delay between cell and UE.
- $\mathbf{T_{cell}}$: This timing offset is used for the frame timing of SCH, Primary CCPCH and the starting phase of all down link Scrambling Codes in a cell. The main purpose is to avoid having overlapping SCHs in different cells belonging to the same Node B.
- $\mathbf{T_d}$: This timing offset is used for the frame timing of DPCHs and Secondary CCPCHs. It can be individually set up for each DPCH and Secondary CCPCH. The T_d values for the latter may be broadcast on BCCH, or known a-priori. The purpose of T_d is:
- In an originating/terminating cell, to distribute discontinuous transmission periods in time, and also to distribute Node B-RNC transmission traffic in time.
- At soft handover, to synchronise down link DPCHs to the same UE, in order to minimise the buffering requirements at the UE.

  Note that T_d can only be adjusted in steps of one DPDCH/DPCCH symbol (256 chips) in order to preserve downlink orthogonality.
- $\mathbf{T_m}$: This value is measured by the UE and reported to the RNC prior to soft handover. The RNC can then notify this value to the target cell, which then knows how to set T_d to achieve proper reception and transmission frame timing of the dedicated physical channel.

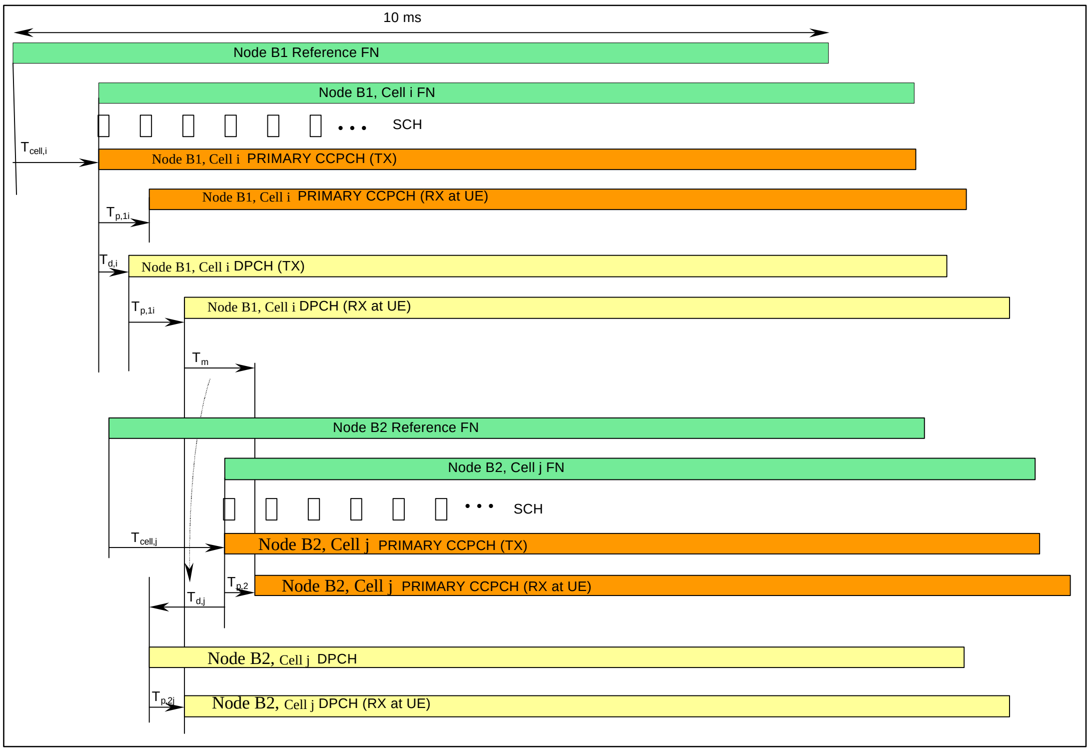

Figure 2. Physical channel timing parameters

The UE in active mode continuously searches for new cells on the current carrier frequency.
From the cell-search procedure, the UE knows the frame offset (T_m) between the Primary CCPCH frame-timing received from the target cell and the earliest received existing DPCH path (see Figure 2.).
When a soft handover is to take place, this offset (T_m) together with the frame offset between the DPDCH/DPCCH and the Primary CCPCH of the source cell ($T_{d,i}$), is used to calculate the required frame offset ($T_{d,j}$) between the DPDCH/DPCCH and the Primary CCPCH of the destination cell, i.e. the cell to be added to the active set (see Figure 3.).

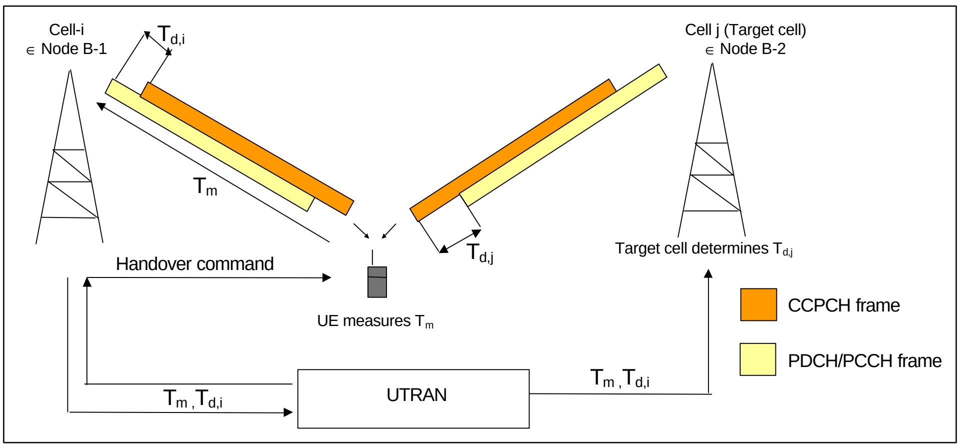

Figure 3. Radio interface downlink synchronisation (1)

This offset is chosen so that the frame offset between the DPDCH/DPCCH of the source and destination cells at the UE receiver is minimised.
Note that the propagation delay to the target cell is already compensated for in the setting of $T_{d,j}$ at the target cell. The DPCH signal from the target cell will reach the UE at the same time as the earliest received existing DPCH path. The only remaining error, besides frequency-drift and UE mobility related errors, is due to a (known) rounding error at the target cell in order to maintain down link orthogonality.
The overall radio interface downlink synchronisation mechanism is shown in Figure 4.

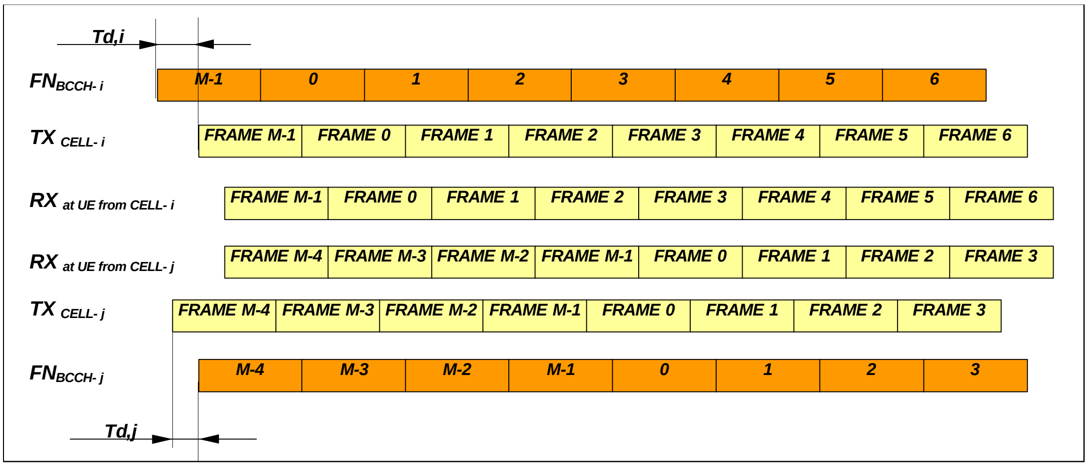

Figure 4. Radio interface downlink synchronisation (2)

~~3.4~~5.2 Frame Synchronisation

~~*Note : This whole section is applicable to FDD mode only.*~~

The methods for Frame Synchronisation describe how data units transmitted in radio frames over different macrodiversity branches can be combined in the receiver, while minimising the delay for the radio access bearer service.

Editor's note: The L1 EG has described how the radio frame transmission timing in two different cells can be set in order for the UE to receive the frames synchronously. What remains is to make sure the same data is transmitted in a given radio frame (avoiding combining of radio frames with different data contents in the UE) and how the same two data units are combined in the RNC. Questions to consider include:

Different (possibly unknown) delays on the AAL2 connections over Iur / Iub to different Node B's

Numbering of data units over Iur/Iub to relate them to certain radio frames

How to achieve initial numbering for an RRC connection and in a Node B at Radio Link / Branch Addition

Varying delay: buffer with margins or adapt to adjust delay?

Relation to a time alignment protocol over Iu for minimising the roundtrip delay for e.g. a speech service.

Furthermore, the specifications may need to consider a delay budget from reception at RNC to transmission from Node B, and include some requirements on the different nodes processing delay.

~~3.4.1~~5.2.1 General principles for frame synchronisation

The general principles for Frame Synchronisation are the following :

- each RNC has a Frame Number which count from *0* to *M-1* in Radio Frame.
- The RNC Frame Number is used to determine the stamp for downlink DCH Data Stream Frames transmitted either on the Iub or on the Iur.
- In order to ensure that DCH Data Stream Frames containing the same data are received by all the involved cells in time to be transmitted synchronously to the UE, the SRNC anticipates the transmission on each macrodiversity branch. This timing advance should be about the maximum downlink transfer delay (Downlink Offset).
- DCH Data Stream Frames that are not received in time to be transmitted synchronously to the UE are discarded.
- The cell FN is used to determine the stamp for uplink DCH Data Stream Frames transmitted on the Iub and Iur (in some proposals the Cell Frame Number is used to stamp uplink DCH Data Stream Frames).
- The RNC where selection/recombining takes place uses frame stamps of uplink DCH Data Stream Frames in order to combine correct frames.

These principles are shown in Figure 5.

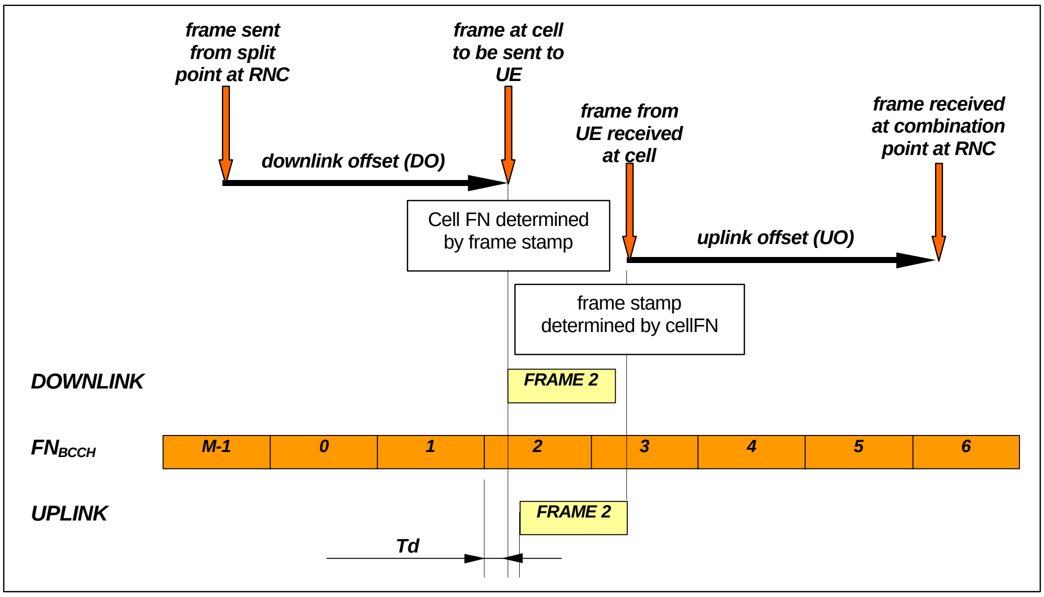

Figure 5. Frame stamping and uplink/downlink offsets handling

~~3.4.2~~5.2.2 UE Frame Number definition

A cell in WCDMA system has its own specific frame numbering (FN_{CELL}), broadcast in the BCCH. FN_{CELL} of different Cells are not synchronised. The range of this frame number is 0-71, and one cycle lasts 720 ms (this is the current assumption in the SMG2-UMTS L1 EG)

The UE (acting as a master) sets its own reference for frame numbering (*UEFN, UE Frame Number*), composed by at least a *Connection Frame Number* (*CFN*) of the same range of the FN_{CELL} (0..71).

Note: The cycle of the CFN is selected to be equal to the cycle of the FN_{CELL}, and will change if the latter changes. Furthermore, the CFN is synchronous with the received DPDCH/DPCCH.

~~3.4.3~~5.2.3 CFN-CELL FN Offset

Let's consider the case of a UE connected to Cell i belonging to Node B1, that is entering in soft handover with Cell j belonging Node B2.

From the cell-search procedure, the UE knows the frame offset (T_m) between the Primary CCPCH frame-timing received from the target cell and the earliest received existing DPCH path.

Furthermore, the UE measures the difference between its own *CFN* and the FN_{CELL} broadcast by the target cell:

$$OFF_j = CFN_{UE} - FN_{CELL-j}$$

When a soft handover is to take place, T_m is used to calculate the required offset ($T_{d,j}$) between the DPDCH/DPCCH and the Primary CCPCH of the destination cell, i.e. the cell to be added to the active set. This offset is chosen so that the frame offset between the DPDCH/DPCCH of the source and destination cells at the UE receiver is minimised.

Both T_m and OFF_j are included sent by the UE to UTRAN before the soft handover. The use of offset OFF_j is explained in Section 5.2.4.

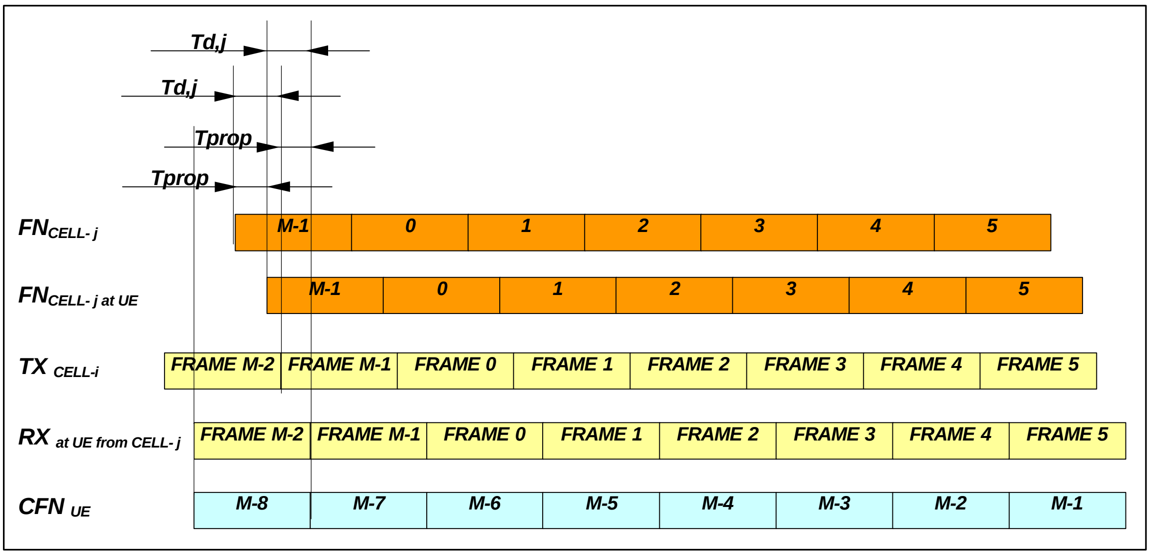

Figure 6. Offsets among Frame Counters

Note : If the network already knows the relation between the different FNCELL, then the UE does not need to report the OFF.

~~3.4.4~~5.2.4 Use of frame numbers in uplink and downlink transmission

In UL transmission, each Node-B receiving the TBS calculates the corresponding CFN based on known FN_{CELL} and *OFF*, and includes it in the header of the Iub/Iur data frame carrying the TBS.

$$CFN = FN_{CELL-j} + OFF_j \quad (\text{modulo } 72)$$

The MDC unit in SRNC (and optionally in DRNC) combines uplink TBS with the same CFN.
If the *UEFN* is used for encryption, UE ciphers the UL transport block sets (TBS) accordingly to the *UEFN* of the first frames used for their transmission. SRNC deciphers them with the same *UEFN*.
In downlink transmission, SRNC numbers the DL TBS with the connection specific *CFN* in the Iur/Iub data frame header.
In order to ensure that TBS containing the same data are received by all the involved cells in time to be transmitted synchronously to the UE, the SRNC anticipates the transmission on each macrodiversity branch. This timing advance should be about the maximum downlink transfer delay (Downlink Offset). The exact time when SRNC shall transmit the DL Iub/Iur frame in the queue for transmission with the TBS and a specific CFN is defined by a DL Offset handling procedure (see Section 5.2.5 Timing adjustment in Iub/Iur interfaces).
Every cell transmits the TBS starting from:

$$FN_{CELL-j} = CFN - OFF_j$$

$T_{d,j}$ is used to set the required frame offset between the DPDCH/DPCCH and the Primary CCPCH of cell j, so that the transmission on the air-interface is synchronised.
If the *UEFN* is used for encryption, SRNC ciphers the DL TBS accordingly to the *UEFN* (of the first frames to be used for their transmission).
Note that, due to the transmission and processing delay, SRNC receives the UL TBS with CFN = X after that the DL TBS with CFN = X has been sent.

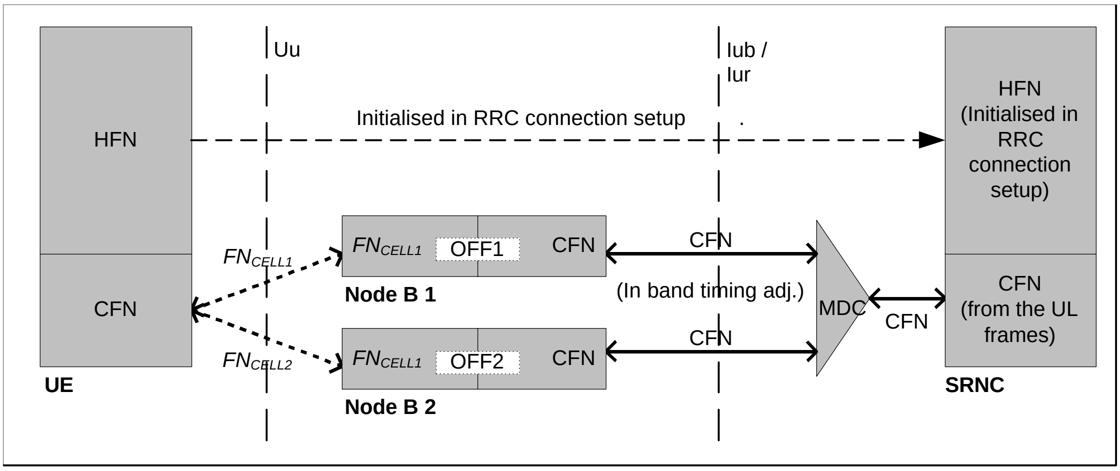

Figure 7. UE-UTRAN synchronisation

~~3.4.5~~5.2.5 Timing adjustment in Iub/Iur interfaces

Downlink Offset values are found 'on-the-fly' according to current traffic situation either at connection set-up or when a diversity leg is needed. A certain margin can be added in both the UL and DL offsets to cope with a possible increase of transmission delay (ex: new link added).
The Link Offset values could be adjusted during the connection based on *Frame discard rate and Too early frame arrival rate* (at Node B and at SRNC respectively), in order to adapt to the current traffic situation.
Note : In case of speech connection with vocoder in CN, a frequent time adjustment shall be prevented in order to avid frame-slips. This is done setting a margin in the uplink/downlink link offset as shown in the next subchapter.

Note : It is FFS if additional functionality should be introduced to improve the initial setting of DL offset values. (e.g. some background protocols)

~~3.4.6~~5.2.6 Initial synchronisation of the first dedicated branch

The *CFN* and FN_{CELL} of the cell into which the RRC connection setup request was sent are synchronised (the *CFN* is set in UE to the same cycle as the FN_{CELL}). SRNC estimates the timing to send the first DL control frame, with a given *CFN*, in the new user plane. The correct DL transmission time is estimated by the SRNC (or a predefined value is used) taking into account the assumed transmission and processing delays in the UTRAN. Timing adjustment procedure on the control frames stream is then used to converge to the exact timing. Other solutions are FFS.
In case of connection using transcoder in the CN, a margin can (shall) be added to both the DL and UL offset in order to face possible variation of the transmission delay in the interfaces without causing frame slips. Margin in DL is created delaying/buffering DL data in RNC before sending the frames to the Node B, while margin in UL is created delaying/buffering the UL data before sending the transcoder frame to the CN.
Note : It is FFS if additional functionality should be introduced to improve the initial setting of DL offset values. (e.g. some background protocols)

~~3.4.7~~5.2.7 Initial synchronisation of a additional soft handover branches

The initial synchronisation of a new branch is achieved using the timing adjustment procedure described above and applied to the Iub/Iur frames that are sent before the beginning of the DL data transmission in the new Uu port. The initial timing assumed by SRNC can be the timing used for the existing branch(es).
If the transmission delay for the new branch is higher that in the existing ones, the timing advance request from Node B can be fulfilled using increasing the UL and DL margin, if any (e.g. in case of connection using transcoder in the CN).
Note : It is FFS if additional functionality should be introduced to improve the initial setting of DL offset values. (e.g. some background protocols)

~~3.4.8~~5.2.8 Maintaining offset

UE measures the offset also in the active Radio Links, and if changed, reports the new value to the UTRAN.

~~3.4.9~~5.2.9 Synchronisation of L1 configuration changes

When a synchronised L1 configuration change shall be made, the SRNC commands the related node B's to prepare for the change. When preparations are completed and SRNC informed, serving RNC decides appropriate change time. SRNC tells the UEFN for the change by a suitable RRC message. The node B's are informed the *CFN* by NBAP Channel reconfiguration messages (name not yet agreed in SMG2 ARC) and/or RNSAP Radio Link Reconfiguration messages.
At indicated switch time UE and node B's change the L1 configuration.

~~3.5~~5.3 Node Synchronisation

This describes how a common timing reference can be achieved between the UTRAN nodes.
Editor's note : It is likely that the method for Frame Synchronisation will depend on a numbering of the Iub/Iur DCH frames. Then there may be a need for the UTRAN nodes (RNC and Node B) to have a common timing reference. Avoiding dependence to an external system to provide this means that there is a need for UTRAN specific solutions. If the Network Synchronisation above is very good, the drift between different nodes is slow, but will occur. Therefore, some kind of protocols over Iur and Iub need to be specified to detect and correct a possible misalignment of the Node Synchronisation. The needed accuracy need to be identified.
The architecture may have several solutions: separate synchronisation node, hierarchical synchronisation relation between RNCs and RNC-Node B, mutual synchronisation between RNCs etc.
Positioning / Localisation functions may also set requirements on this Node Synchronisation.
[TDD - Node Synchronisation and Frame synchronisation are used within neighbouring cells to minimise cross-interference (Node B-Node B, UE-UE, Node B-UE cross-interferences)].

6 TDD Synchronisation aspects

[Text to be added]

7 UTRAN delay requirements

7.1 FDD delay requirements

The maximum transmission delay of a diversity branch and the maximum processing delay introduced by single UTRAN network elements shall be defined.

7.2 TDD delay requirements

[Text to be added]

History

Document history		
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