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1 Contents

2 Intellectual Property Rights

3 Foreword

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

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

Version m.t.e

where:

m indicates [major version number]

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

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

4 Scope

This paper describes the diffrent issues related to synchronisation in UTRAN

5 References

[1] TS 25.401 “UTRAN Overall Description”

[2] TS 25.423 “UTRAN Iur Interface RNSAP

[3] TS 25.433 “UTRAN Iub Interface NBAP Signalling”

[4] TS 25.435 “UTRAN I_{ub} Interface User Plane Protocols for Dedicated Transport Channel Data Streams”

[5] TS 25.437 “I_{ub}/ I_{ur} Interface User Plane Protocol for DCH Data Streams”

[6] TR 25.931 “UTRAN Functions, Example on Signaling Procedure”

[7] EIA 422-A-78 “Electrical characteristics of balanced voltage digital interface circuits”.

6 Definitions, symbols and abbreviations

6.1 Definitions

6.2 Abbreviations

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

BFN	Node B Frame Number counter.
BSS	Base Station Subsystem
CFN	Connection Frame Number (counter)
CH	Channel
CN	Core Network
CRNC	Controlling RNC
CSN	Ciphering Sequence Number (counter)
DL	Down Link
DCH	Dedicated Channel
DPCH	Dedicated Physical Channel
DPCCH	Dedicated Physical Control Channel
DSCH	Downlink Shared Channel
DRNC	Drift RNC
FACH	Forward Access Channel
FDD	Frequency Division Duplex
GPS	Global Positioning System
HFN	Hyper Frame Number (counter)
HO	Handover
LTOA	Latest Time of Arrival
L1	Layer 1
L2	Layer 2
MAC	Medium Access Control
PCCPCH	Primary Common Control Physical Channel
PCH	Paging Channel
RACH	Random Access Channel
RAN	Radio Access Network
RFN	RNC Frame Number counter
RL	Radio Link
RNC	Radio Network Controller
RNS	Radio Network Subsystem
SFN	Cell System Frame Number counter.
SRNC	Serving RNC
SRNS	Serving RNS
TDD	Time Division Duplex
TOA	Time of Arrival
TOAWE	Time of Arrival Window Endpoint
TOAWS	Time of Arrival Window Startpoint
UE	User Equipment
UFN	UE Frame Number counter
UL	Up Link
UTRAN	UMTS Terrestrial Radio Access Network

7 Synchronisation

7.1 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.

7.2 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 Syncrhonisation. 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 Synchronisatoin is necessary 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 radio frame synchronisation which is used within neighbouring cells to minimise cross-interference (Node B-Node B, UE-UE, Node B-UE cross-interferences).

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

7.2.1 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 frame synchronisation between RNC and their Node Bs. 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). The usage over the CCH channels, e.g. FACH, is for the actual RNC-Node B Node Synchronisation procedure. When the procedure is used from SRNC over the DCH user plane, the usage is Round-trip-delay measurements. These could be used to determine offset values between RNCs and to find 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 a good Network synchronisation reference is used, the drift between nodes will be low, but will occur. If a Network synchronisation reference isn't available or is poor (as is the case in some transport network types), 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 drift between nodes. Therefore, a system can be deployed without Network synchronisation references (to all nodes or to some nodes).

7.2.2 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 (via Tcell) which can be used in the neighbour cell lists in order to speed up and simplify cell search done by UE at handover.

In the TDD mode Inter Node B Node Synchronisation is necessary to synchronise radio frames within neighbouring cells in order to minimise cross-interference (Node B-Node B, UE-UE, Node B-UE cross-interferences).

TDD may have several solutions for Inter Node B Node Synchronisation:

- Synchronization of Nodes B to an external reference via a standardized synchronization port.
- Synchronization of Nodes B on the air-interface, e.g. through Nodes B cross measurements or assisted by UEs.)

7.3 Time-of-day

Time-of-day handling is used for O&M functions like radio network event time-stamping. A prerequisite for Time-of-day handling is Network synchronisation of UTRAN and CN Nodes.

7.4 Counter names and definitions:

BFN Node **B** Frame Number counter. This is the Node B common frame number counter, often hard-coupled with the 'good' node oscillator. BFN is optionally frequency-locked to a Network sync reference.
BFN is free-running, not phase-locked to any other counter.
Range: 0 to 4095 frames, 12 bits.

RFN **R**NC Frame Number counter. This is the RNC node common frame number counter, often hard-coupled with the 'good' node oscillator. RFN is optionally frequency-locked to a Network sync reference.
RFN is free-running, not phase-locked to any other counter.
Range: 0 to 4095 frames, 12 bits.

UFN **U**E Frame Number counter. This is the UE node common frame number counter, often hard-coupled with the 'good' oscillator.
UFN is frequency locked to UTRAN via air-interface SCH.
Range: 0 to 4095 frames, 12 bits.

SFN Cell **S**ystem Frame Number counter. This is the long counter in a Cell. SFN is sent on BCCH on Layer 1. SFN is used for paging groups and system information scheduling etc.
SFN = BFN adjusted with Tcell.
Range: 0 to 4095 frames, 12 bits.

CFN Connection Frame Number (counter).
CFN is used in Node B, RNC and UE for DCH and Common Transport Channels frame transport references.
Range: 0 to 255 frames, 8 bits.

HFN Hyper Frame Number (counter). This is the H number of most significant bits on top CFN to form a ciphering counter.

CSN Ciphering Sequence Number (counter). This is the total counter in a node for Ciphering purposes. CSN = [HFN, CFN].
Range: 0 to 2^{32}-1 frames, 32 bits.

7.5 Layer 2 Synchronisation

The L2 (or transport channel) 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 parameter.

In case of soft handover, the Frame_offsets of the different radio links are selected in order to have a timed transmission of the diversity branches in the air interface.

A L1-MAC primitive is defined to allow the L1 to indicate to L2 the necessity to adjust the timing of the DL transmission, in order to control and minimise the transmission delay. The primitive is carried in the user plane by Frame Protocol procedures within the UTRAN. This transport channel synchronisation mechanism is valid for all the transport channels, in FDD and TDD modes.

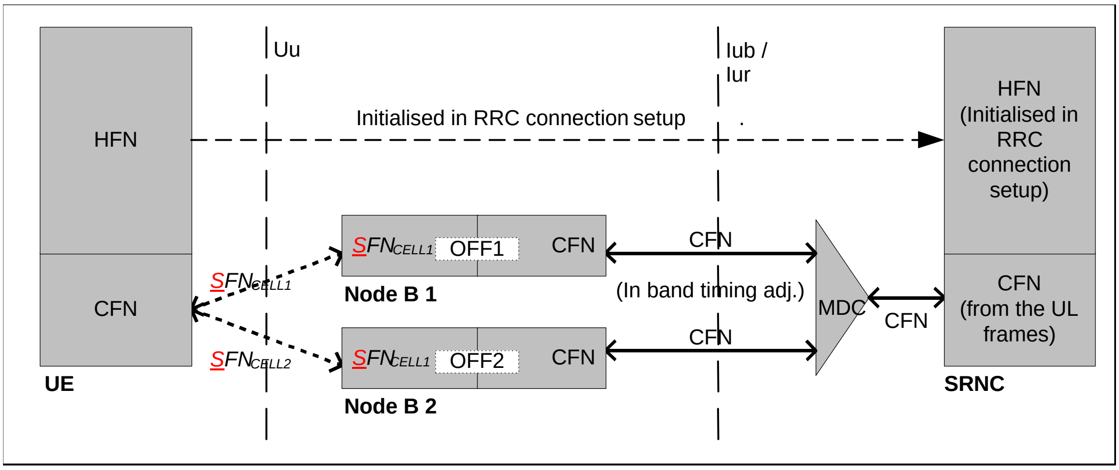


Figure 1: Layer 2 synchronisation

Note:The CFN used by the transport channel synchronisation mechanism may be extended to form a larger L2 counter (HFN, Hyper frame number), to be used for example for ciphering. The initialisation of this counter is done at RRC level and the parameter is not visible at lower layers.

The parameters related to L2 synchronisation are described in the following paragraphs.

7.5.1 CFN

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 for ciphering and synchronised transport channel reconfiguration, for example.

Since the CFN is mapped into one SFN and defines a specific frame for the transmission on the air interface, some L1-MAC primitives are defined to minimise 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), and, in general, to control the delays in the transport channel.

The duration of the CFN cycle shall be 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). Furthermore the CFN shall be shorter, or at most equal to the SFN. Currently the SFN is 12 bits long, and the proposal is to adopt 8 bits (2.56 seconds) for the CFN.

The range of CFN is 0…255 (integer value).

Note: WG3 is still studying the possibility to extend the CFN for the PCH to 12 bits, for long sleepmode paging.

7.5.2 Frame_offset

Frame_offset is a radio link specific L1 parameter used to map the CFN, used in the transport channel, into the SFN transmitted between UE and UTRAN at L1.

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

SFN = CFN - Frame_offset (from L2 to L1) (1.1)

CFN = SFN + Frame_offset (from L1 to L2) (1.2)

The resolution of all three parameters is 1 frame. Frame_offset and CFN have the same range (8 bits, 0…255) and only the 8 least significant bits of the SFN are used. The operations above are modulo 256, i.e. 256 is added if the result is negative and subtracted if the result is above 255.

In the UTRAN, the Frame_offset parameter is calculated by the SRNC and provided to the node-B.

7.5.3 SFN

Each cell has a Cell System Frame Number. This SFN is broadcasted on the BCH. The SFN has a length of 12 bits.

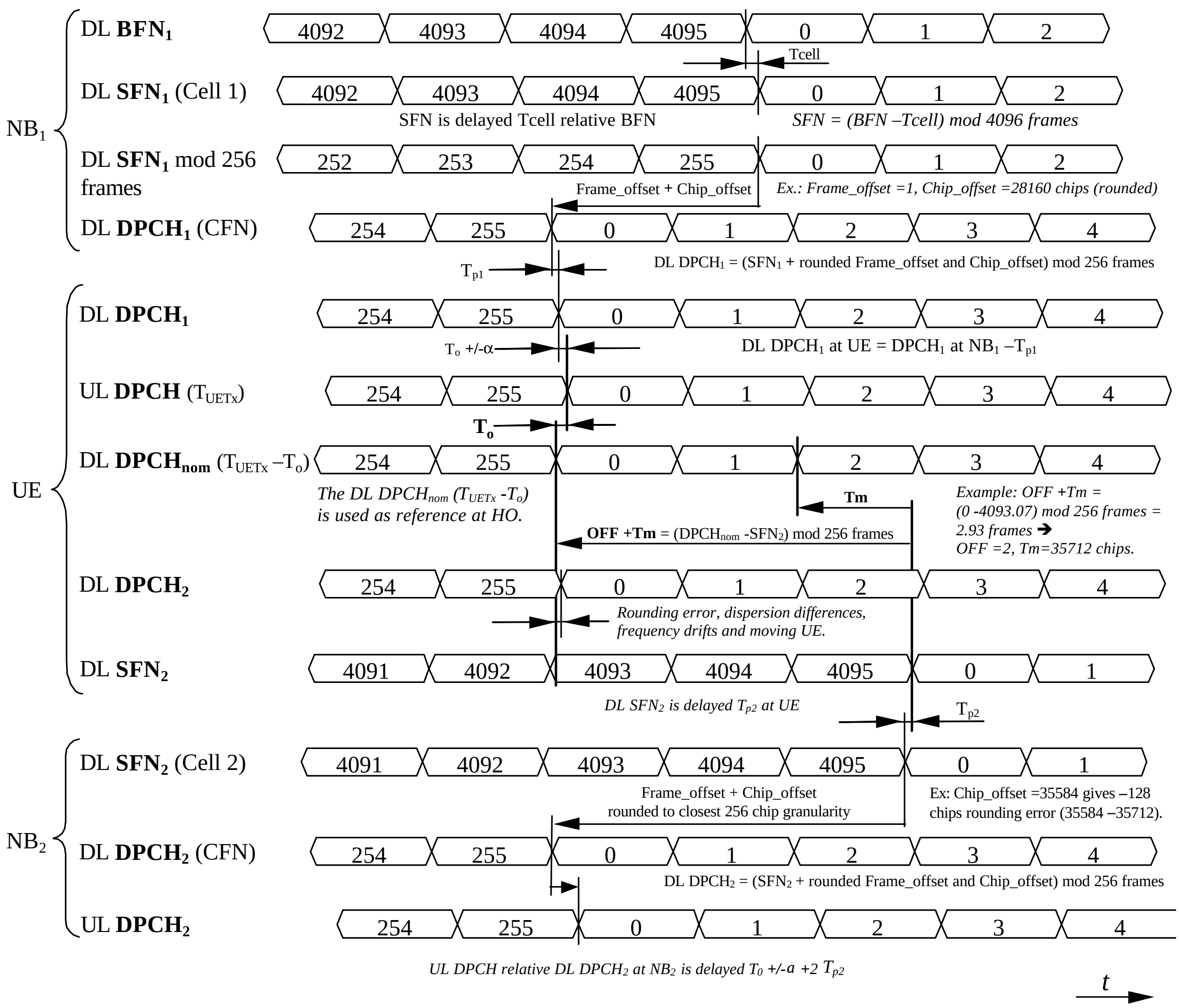
7.6 Radio Interface synchronisation

As shown above, the transport channel synchronisation mechanism defines the radio frame in which the TBS transmission shall be started. From this reference point, other parameters are used to define the exact timing of the radio frame transmission. Those parameters are the time slot for TDD and the Chip Offset for FDD.

The parameters related to L1 synchronisation are described in the following paragraphs.

7.6.1 [FDD — General aspects]

The timing diagram shows an example with two cells connected to one UE where handover is done from source cell (Cell 1) to target cell (Cell 2).



α	1st received DL DPCH finger relative DL CFN_{nom}	T_{cell}	Specifies the SFN delay relative BFN
BFN	Node B Frame Number (counter)	T_m	Measured by UE at HO, the Tm has a range from 0 to 38399 chips.
CFN	Connection Frame Number (DPCH related)		
DPCH	Dedicated Physical Channel (CFN related)	T_o	Is a constant of 1024 chips, is the nominal difference between first received DPCH finger (DL CFN_{nom}) and T_{UETx} at UE.
HO	Handover		
NB_x	Node B (x=1:source, x=2:target)		
OFF	Offset with a range from 0 to 255 frames	T_{pX}	Propagation delay (one way), UE-Cell X
RFN	RNC Frame Number (counter)	T_{UETx}	The time when UE transmits an UL Dedicated Physical Channel.
RNC	Radio Network Controller		
SFN	System Frame Number (counter)		

Figure 2: Radio synchronisation timing diagram

SFN_1 is found in Cell 1 at NB_1 and SFN_2 at Cell 2 and NB_2. SFN_1 is sent T_{cell1} after the NB_1 reference BFN_1. CFN is the frame numbering that is related to each DL and UL Dedicated Physical Channel (DPCH). UL DPCH is sent from UE to both Cells (both NBs in this example). UL DPCH at NB_2 is shown to indicate the difference to the DL $DPCH_2$ at NB_2.

The new RL (DPCH) which is setup at HO will face some deviation from nominal position due to Tm rounding to Chip_offset boundary, Time dispersion, NB-UE frequency drift and UE movement.

Note: The frame number counters BFN, SFN and CFN (DPCH) are in the timing diagram seen as having a fractional part within each frame number in order to make it possible to express phase differences. Relations that can be positive or negative are expressed with a one-direction arrow. Delays, uncertainties and the constant To is expressed with bidirectional arrows. All time parameters are in expressions used with respective unit e.g. 10 ms and chips.

In UE dedicated state, OFF and Tm are measured according to the following equation:

$OFF + Tm = (T_{UETx} - T_o - SFN_{target}) \bmod 256$ frames.

Example: assume that OFF + T_m equals “2.93” frames as shown in Figure 2 as an example, then OFF = 2 and T_m = “0.93” which corresponds to T_m =35712 chips.

In other words (referring to Figure 2):

- How to determine T_m: Select a time instant 1) where a frame starts at DL $DPCH_{nom}$ (=T_{UETx} –T_o) e.g. at frame number 2, the time from that time instant to the next frame border of DL SFN_2 at UE 2) equals T_m (if these are in phase with each other, T_m is zero).
- How to determine OFF: The difference between the frame number selected for time instant 1) and the frame number after time instant 2) mod 256 frames equals OFF. Example: (2 –0) mod 256 is 2, another example could be (254 – 4092) mod 256.

7.6.2 [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. The details concerning rounding the Chip_offset value to Td are FFS.

7.6.3 [TDD — Time-slot]

The time-slot parameter indicates in which time-slot within the frame the transmission shall take place.

7.6.4 Synchronisation parameters from/to the UE

In order to obtain L1 and L2 synchronisation with the UTRAN, the UE reports and receives several parameters.

Note: Currently WG3 is assuming that the UE may report 2 separate parameters (Tm and OFF) when adding a RL. WG2 liaison “Response to LS on UE requirement to report OFF” (TSGR3#6(99)842) discussed in R3#6, indicated that WG2 has not yet taken a final decision if 1 or 2 separate parameters will be reported by the UE. If WG2 decides to only report 1 (combined) parameter, the description below will have to be change but no major consequences are foreseen.

7.6.4.1 OFF

The reported OFF parameter has a resolution of 1 frame and a range of 0 to 255. OFF shall only be sent 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 bu the UE.

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 will be zero (is it even reported ?).
2. 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 camping cell and the SFN of the other candidate cells. 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 in dedicated channel state (macro-diversity)
   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.
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 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.

7.6.4.2 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.

Again five cases are discerned 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 the Tm will be zero (is it even reported ?).
2. The UE is 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 camping cell and the received PCCPCH paths of the other candidate 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 "optimum" 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 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.

7.6.4.3 DOFF

It is assumed that the SRNC sends a DOFF parameter to the UE when the new RL will make the UE change its state (from common channel state or other when coming from another RAN) to the dedicated channel state.

The DOFF parameter has a resolution of 512 chips and a range of 0 to 599 (<80ms). The maximum value is chosen in accordance with the largest interleaving period supported on Uu.

The DOFF value sent to the UE is determined by the SRNC based on certain (load distributing) algorithms.

7.7 Calculations performed in the UTRAN

This chapter describes how an SRNC can calculate the Frame_offset and Chip_offset based on the parameters received from the UE and available in the UTRAN.

7.7.1 UE in common channel state.

In common channel state (UE on RACH/FACH), the Frame_offset is set to 0.

7.7.2 UE changes state from common CH state to dedicated CH state: 1 RL

Based on the received parameters from the UE and the DOFF value generated in the SRNC, the SRNC calculates the Frame_offset and the Chip_offset:

Frame_offset*38400 +Chip_offset = DOFF*512 (4.1)

7.7.3 UE changes state from common CH state to dedicated CH state: several RL's

Based on the received parameters from the UE and the DOFF value generated in the SRNC, the SRNC calculates the Frame_offset and the Chip_offset. The Frame_offset and the Chip_offset are calculated from the following formula:

Frame_offset*38400 +Chip_offset = DOFF*512 + OFF*38400 + Tm (4.2)

Note [1]: note that formula (2) is covering formula (1) since in case 1, OFF and Tm are both equal to zero.

7.7.4 UE requests to add a new RL in dedicated CH state

Based on the received parameters from the UE, the SRNC calculates the Frame_offset and the Chip_offset with the following formula:

Frame_offset*38400 +Chip_offset = OFF*38400 + Tm (4.3)

7.7.5 Handover from other RAN to UMTS

Based on the definitions for OFF and Tm provided in chapter 3.1. and 3.2., formula (4.1) can also be used when the UE enters the UTRAN from another CN and establishes 1 dedicated RL. The same is true for formula (4.2) when establishing 1 or more dedicated RL's.

7.8 Calculations performed in the UE

7.8.1 First RL

Based on the received DOFF and the SFN of the cell in which the UE is camping, the UE can calculate the CFN with the following formula:

CFN = ((SFN*38400 + DOFF*512) div 38400)mod 256 (5.1)

Note: in case the UE is coming from another RAN, the SFN is not the SFN from the camping cell but the SFN from the reference cell.

In this case the OFF is set to 0.

7.8.2 Additional RL's

As long as the UE has one or more RL's established, the CFN will be increased (mode 256) by 1 every frame. Normally no special corrections are needed when moving from one cell to the other.

However every time the UE enters a new cell the Frame_offset, which might have to be reported in the OFF parameter, will have to be recalculated. The Frame_offset for the new cell is computed using the following formula:

OFF[new] = (CFN - SFN[new])mod 256 (5.2)

The difference OFF is calculated as the integer number of frames, with approximation to the lower integer number (*the exact definition of the difference is TBD*).

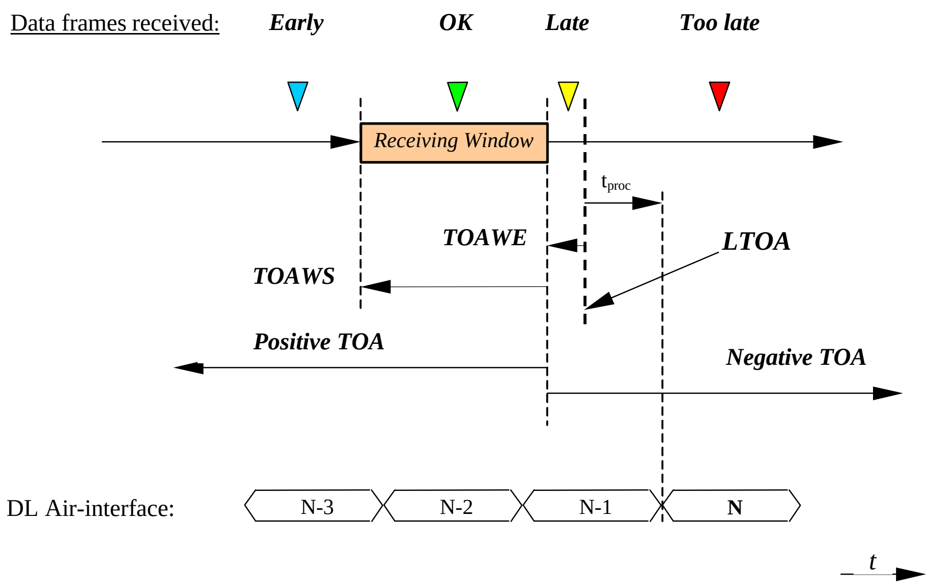
7.9 Timing adjustment in Iub/Iur interfaces

A receiving window is configured in Node B at Transport bearer Setup, Addition 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 frames are received outside that window, a response is sent to RNC called Timing Adjustment Control frame. This response contains Time of Arrival information (TOA). See Figure 3.

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.

Offset values, used for sending data frames from RNC over Iub, could therefore be refined by using this window definition and supervising method.

DL Sync Control frames will always give TOA as response, even if the DL Sync Control frame is received within the window. The purpose of Sync Control frames is to measure when frames are received for a certain transport bearer.



TOA	Time Of Arrival	TOAWE	TOA Window Endpoint
LTOA	Latest TOA	t_{proc}	Processing time before air-interface
TOAWS	TOA Window Startpoint		

Figure 3: Illustration of TOAWS, TOAWE, LTOA and TOA

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

The timing adjustment parameters are defined as follow:

- **Time of Arrival Window Startpoint (TOAWS)**
  TOAWS 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). A data frame arriving before TOAWS gives a Timing Adjustment Control frame response.
  The TOAWS is a CFN length parameter.
  The resolution is 1 ms, the range is: {0 .. CFN length/2 –1 ms}

- **Time of Arrival Window Endpoint (TOAWE)**
  TOAWE is the window endpoint. DL data frames are expected to be received before this window endpoint. TOAWE is defined with a positive value relative Latest Time of Arrival (LTOA). A data frame arriving after TOAWS gives a Timing Adjustment Control frame response.
  The TOAWE is a CFN length parameter.
  The resolution is 1 ms, the range is: {0 .. CFN length –1 ms}

- **Latest Time of Arrival (LTOA)**
  LTOA 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.

- **Time of Arrival (TOA)**
  TOA 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 (TOA+TOAWE>=0) are processed by Node B.
  When RNC measures data frame reception times to determine window position or to supervise data frame reception times, TOA could be added with TOAWE to make the measurements window position independent.
  TOA has a resolution of 125 µs.
  TOA is positive when data frames are received before TOAWE.
  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}.

7.10 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 CFN for the change by a suitable RRC message. The node B's are informed the *CFN* by NBAP RNSAP and NBAP Radio Link Reconfiguration procedures.

At indicated switch time UE and node B's change the L1 configuration.

7.11 [TDD — Frame Synchronisation]

In the UTRA TDD mode, the cells within the UTRAN are synchronized with respect to Radio Frame. This synchronization is achieved via a combination of absolute timing references such as GPS and/or GNSS, and simple adjustments commanded by the RNC’s which are made by cells reading the synchronization channel of neighboring cells.

For time alignment of the uplink radio signals from the UE to the UTRAN, timing advance can be applied whenever necessary. Timing advance is based on uplink burst timing measurements performed by the Node B L1, and on Timing Advance commands sent downlink to the UE. The details are FFS.

7.11.1 TDD synchronisation description

The method is based on the synchronisation of a number of node B (masters) to an external reference (e.g. GPS) via a standardised synchronisation port. The other nodes B are synchronised either to the reference or to already synchronised nodes B via the air interface.

The following assumptions are taken:

- Each node B may be synchronised through an external reference (e.g. GPS) connected to the synchronisation port;
- All the cells belonging to the same node B are synchronised among each others;
- All the nodes B that are synchronised through the external source become Reference; all the other nodes B are synchronised via the air through a master-slave mechanism;
- In order to get synchronised a node B shall listen at an active cell belonging either to a reference node B or to an already synchronised node B (that acts as a master of the synchronisation process for the unsynchronised node B, i.e. the slave Node B);
- All the nodes B that cannot listen to cells belonging to other nodes B shall be synchronised through their synchronisation port (i.e. they are References as well).

The former assumptions are shown in Figure 4.

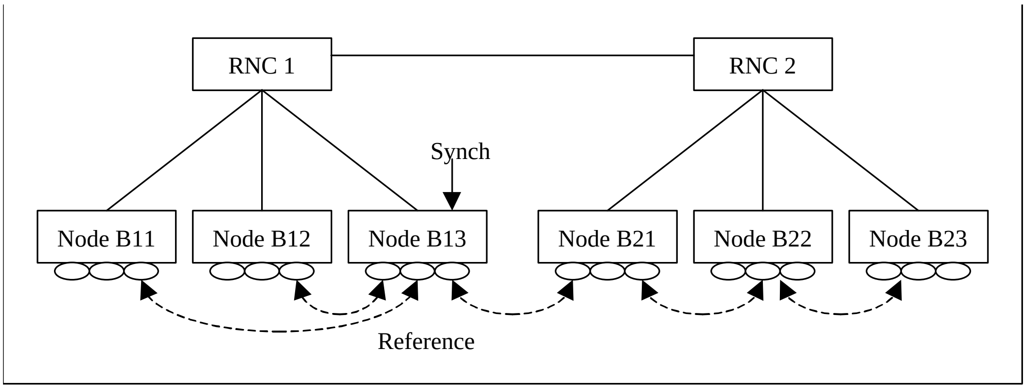


Figure 4: TDD synchronisation

In this example Node B13 is the only Reference, i.e. it is the only one that is synchronised through an external source. Node B11, Node B12 and Node B21 can listen at least to one cell of Node B13. This means that they can get synchronised over the air directly to the Reference Node B. On the contrary Node B22 can listen only to a cell belonging to Node B21. This means that it can get synchronised only to Node B21 that acts as a master for B22 (second hierarchical level of synchronisation), while node B23 can get synchronised only to Node B22 that acts as a master for B23 (third hierarchical level of synchronisation).

7.11.2 Frame Synchronisation

This kind of synchronisation is necessary to ensure that the uplink/downlink switching points be positioned at the same time instant at least in adjacent cells (see Figure 5)

This requirement is necessary to avoid that a receiving UE can be saturated by a transmitting UE in a neighbouring cell.

In addition it automatically ensures that the slots of different cells are synchronised, i.e. they do not overlap at the UE.

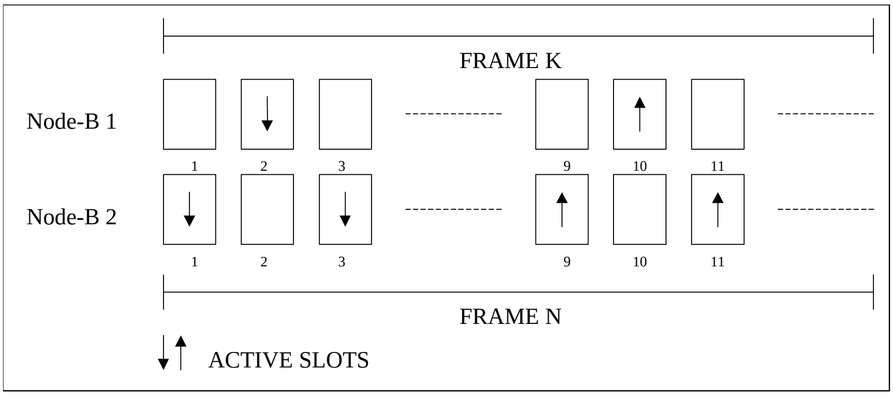


Figure 5: Frame synchronisation

Optionnal Input and Output synchronisation ports can be used to obtain this synchronisation.

7.11.3 Multi Frame Synchronisation

This kind of synchronisation may be required to keep more efficient and faster all procedures involving a switch from one Node-B to another, such as searching for new Base Stations, locking to new Base Stations or handover.

This Multi Frame Synchronisation is however FFS.

Note that a prerequisite for Multi Frame Synchronisation is that frames are synchronised.

For Multi Frame Synchronisation it is required that the frame numbers in neighbouring cells are time aligned, i. e. in Figure 5 would mean N=K.

7.12 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.

8 TDD Synchronisation port

This section defines the Node B input and an output synchronisation ports.

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.

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 propagation delay between the input and output synchronisation ports shall not exceed [FFS] ns.

The electrical characteristics of the synchronisation ports shall conform to RS422 [7] (output synchronisation port: section 4.1; input synchronisation port: section 4.2).

Note: The detailled signal layout of such ports as described below is FFS.

The synchronisation signal (illustrated in Figure 6) is a 100 Hz signal having positive pulses of width between 5 µs and 1 ms, except for frame 0 (every 72nd pulse), which has a pulse width between 2 ms and 5 ms. This signal establishes the 10 ms frame interval and the 720 ms multiframe interval.

The start of a frame is defined by the falling edge of the pulse.

The start of the multiframe is defined by the falling edge of the pulse corresponding to frame 0 (i.e. of width between 2 ms and 5 ms).

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

The relative phase difference of the synchronisation signals at the input port of two neighbouring nodes B shall not exceed [FFS] µs.

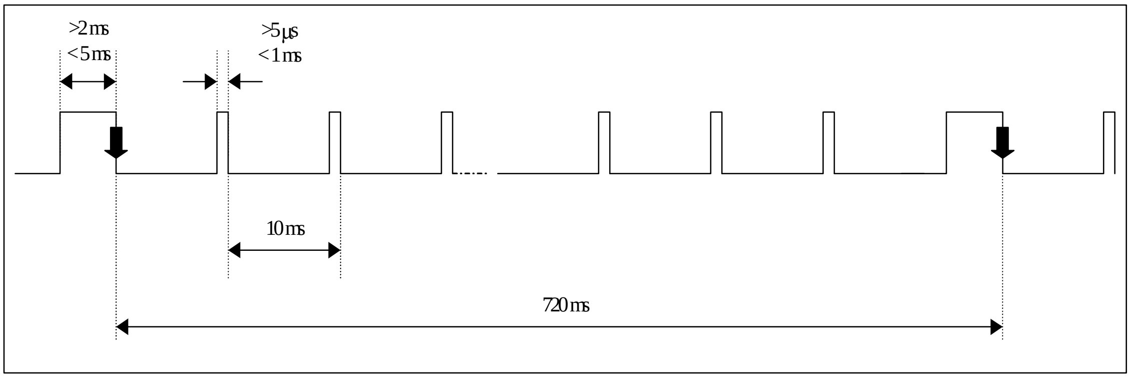


Figure 6: Synchronisation signal

8.1 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 frame and multiframe synchronisation of UTRAN.

UTRAN is frame synchronised by relating the start of the first frame of a multiframe to the GPS time. Since the duration of a radio multiframe is 720 ms, this implies that every 18 seconds the start of a UTRAN multiframe coincides with an integer GPS second (see Figure 7).

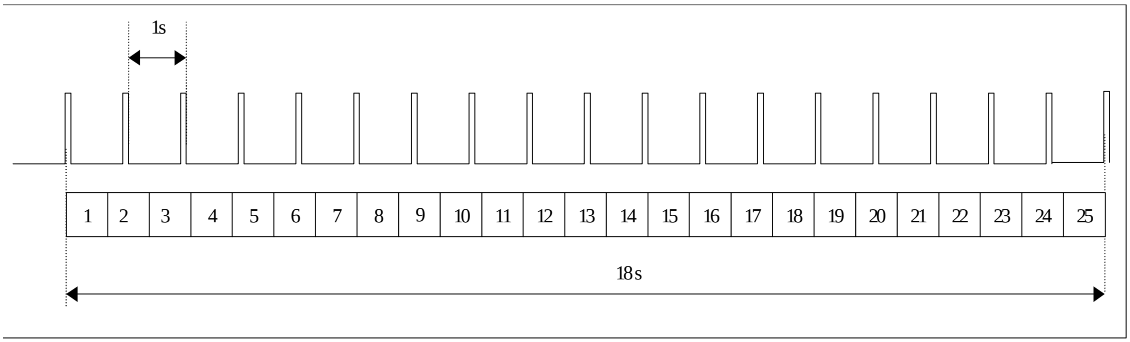


Figure 7: Relation between UTRAN and GPS timing

The start of a UTRAN multiframe coincides with the start of a GPS second each time T_{GPS} mod 18 = 0.

9 Annex A Document Stability Assessment Table

Section	Content missing	Incomplete	Restructuring needed	Checking needed	Editorial work required	Finalisation needed	Almost stable	Stable
1								
2								
3								
4								
5								
6								
7								
8								

10 History

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