TSG-RAN Meeting #9 *TSGRP#9(00)0371*
Hawaii, US, 20 - 22 September 2000

Title: **Agreed CRs to TS 25.402**

Source: **TSG-RAN WG3**

Agenda item: **5.3.3**

Tdoc_Num	Specification	CR_Num	Revision_Num	CR_Subject	CR_Category	WG_Status	Cur_Ver_Num	New_Ver_Num
R3-001861	25.402	007	1	Corrections to the UE state in section 9	F	agreed	3.2.0	3.3.0
R3-001985	25.402	008	2	Introduction of DOFF in TDD and CFN handling during hard handover	F	agreed	3.2.0	3.3.0
R3-001986	25.402	009	2	TDD intercell synchronisation	F	agreed	3.2.0	3.3.0

3GPP TAG RAN WG3 Meeting #14
Helsinki, Finland, 3 - 7 July, 2000

***Document* R3-001861**
e.g. for 3GPP use the format TP-99xxx
or for SMG, use the format P-99-xxx

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25.402	**CR**	**7r1**	Current Version:	3.2.0

GSM (AA.BB) or 3G (AA.BBB) specification number ↑ *↑ CR number as allocated by MCC support team*

For submission to:	RAN#9	for approval	X	strategic		*(for SMG*
list expected approval meeting # here ↑		for information		non-strategic		*use only)*

Form: CR cover sheet, version 2 for 3GPP and SMG *The latest version of this form is available from:* ftp://ftp.3gpp.org/Information/CR-Form-v2.doc

Proposed change affects: *(at least one should be marked with an X)*	(U)SIM		ME		UTRAN / Radio	X	Core Network	

Source:	R-WG3	**Date:**	July 3, 2000
Subject:	Corrections to the UE states in section 9		
Work item:			

Category:	F	Correction	X	**Release:**	Phase 2	
	A	Corresponds to a correction in an earlier release			Release 96	
(only one category	B	Addition of feature			Release 97	
shall be marked	C	Functional modification of feature			Release 98	
with an X)	D	Editorial modification			Release 99	X
					Release 00	

Reason for change:	This CR introduces some corrections to the UE states in section 9
Clauses affected:	9.2, 9.2.1, 9.2.2, 9.3.1A, 9.3.1

Other specs affected:	Other 3G core specifications		→ List of CRs:	
	Other GSM core specifications		→ List of CRs:	
	MS test specifications		→ List of CRs:	
	BSS test specifications		→ List of CRs:	
	O&M specifications		→ List of CRs:	

Other comments:	

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9 Usage of Synchronisation Counters and Parameters to support Transport Channel and Radio Interface Synchronisation

9.1 General

This subclause describes how the different synchronisation parameters and counters are computed and used in order to obtain Transport Channel (L2) and Radio Interface (L1) Synchronisation.

The parameters that need to be determined by the UE are CFN, OFF [FDD – and Tm].

The parameter that need to be determined by the UTRAN are [FDD – DOFF], Frame Offset and [FDD – Chip Offset].

Figure 19 summarises how these parameters are computed. A detailed description of the actions in each state is given in the sections 9.2 – 9.4, while some examples of corrections applied to synchronisation counters during UE state transitions are shown in section 9.5..

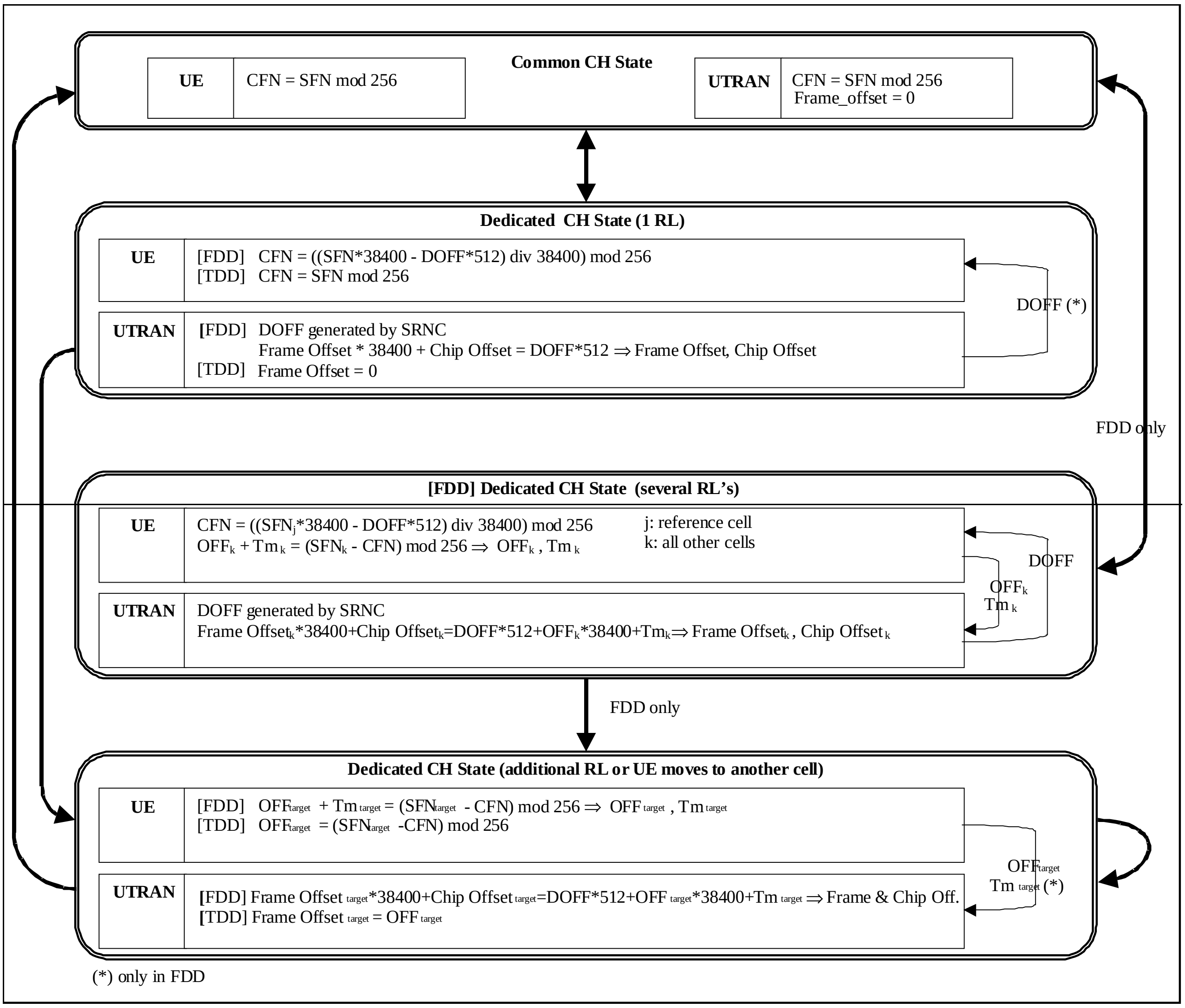

Figure 19: Calculations performed by UE and UTRAN

Figure 20 describes what offset parameters are signalled and used in the different nodes at Initial RL setup and at Handover (HO) in FDD. The rounding to closest 256 chip boundary is done in Node B. The rounded Frame Offset and

Chip Offset control the DL DPCH air-interface timing. The 256 chip boundary is to maintain DL orthogonality in the cell (the rounding to the closest 256 chip boundary is done in Node B to facilitate the initial UL chip synchronisation process in Node B).

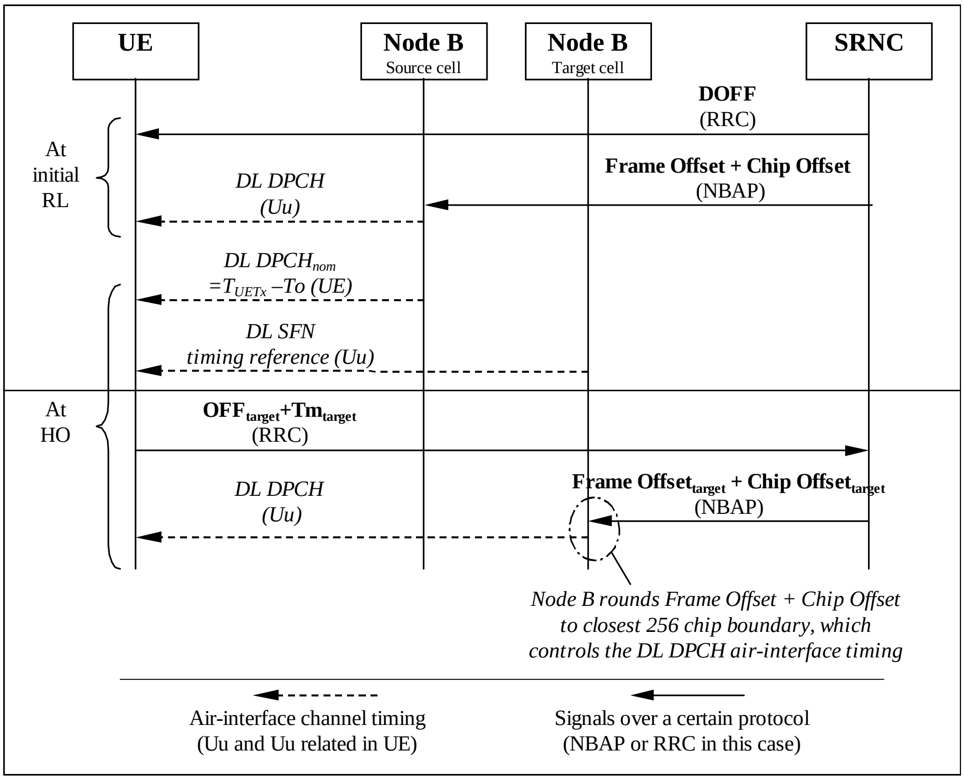

Figure 20: [FDD - Usage of Offset values at initial RL and at HO]

Figure 21 describes what offset parameters are signalled and used in the different nodes at Initial RL setup and at Handover (HO) in TDD.

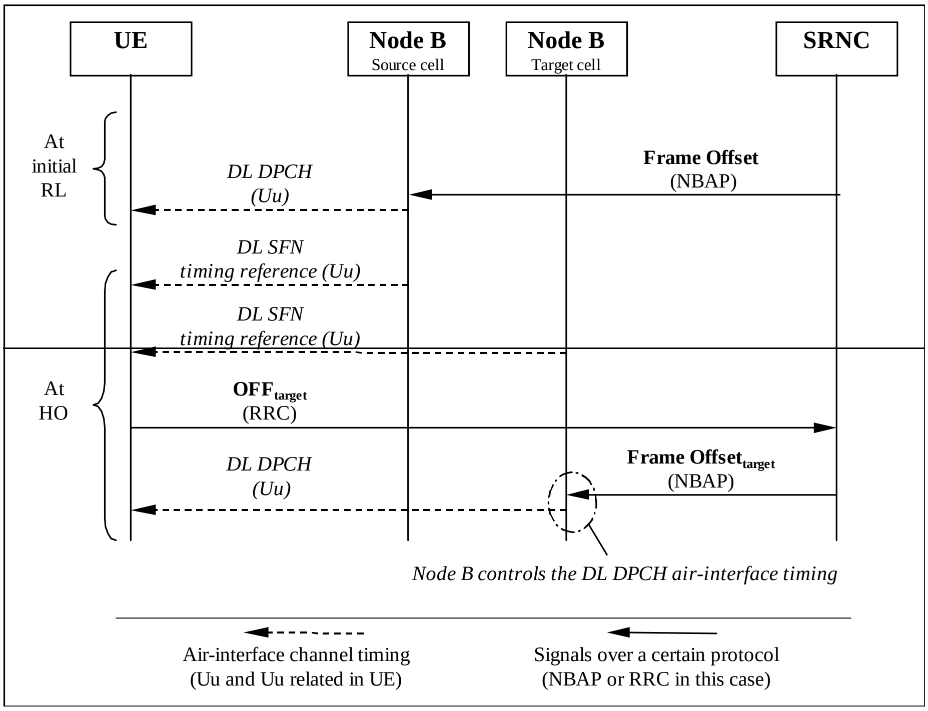

Figure 21: [TDD- Usage of Offset values at initial RL and at HO]

9.2 Calculations performed in the UTRAN

9.2.1 UE in CELL_FACH/PCH state ~~or CELL_DCH state with only stand-alone shared channels.~~

In CELL_FACH/PCH state ~~or CELL_DCH state with only stand-alone shared channels~~ the Frame Offset is set to 0 (for all common and shared channels).

9.2.2 UE changes from CELL_FACH/PCH state to CELL_DCH state: 1 RL

[FDD- 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 from formula (9.1).

$$\text{Frame Offset}*38400 + \text{Chip Offset} = \text{DOFF}*512 \qquad (9.1)$$

Frame Offset and Chip Offset are then signalled to the Node B controlling the serving cell.]

[TDD- In this case Frame Offset = 0.

Frame Offset is then signalled to the Node B controlling the serving cell.]

[TDD - Note that for all common and shared channels Frame Offset is set to 0 even during CELL_DCH state.]

9.2.3 [FDD - UE changes from CELL_FACH/PCH state to CELL_DCH state: several RL's]

Based on the received parameters from the UE for each cell_k (OFF_k and Tm_k) and the DOFF value generated in the SRNC, the SRNC calculates the Frame Offset_k and the Chip Offset_k. The Frame Offset_k and the Chip Offset_k are calculated from formula (9.2).

$$\text{Frame Offset}_k*38400 + \text{Chip Offset}_k = \text{DOFF}*512 + \text{OFF}_k*38400 + \text{Tm}_k \qquad (9.2)$$

NOTE: formula (9.3) is covering formula (9.1) since in the case described in section 9.2.2, OFF_k and Tm_k are both equal to zero.

Each Frame Offset_k and Chip Offset_k are then signalled to the Node B controlling the cell_k.

9.2.4 UE in CELL_DCH state request to add a new RL or moves to another cell

[FDD-Based on the received parameters from the UE, the SRNC calculates the $\text{Frame Offset}_{target}$ and the Chip Offset_{target} with formula (9.3).

$$\text{Frame Offset}_{target}*38400 + \text{Chip Offset}_{target} = \text{OFF}_{target}*38400 + \text{Tm}_{target} \qquad (9.3)$$

$\text{Frame Offset}_{target}$ and $\text{Chip Offset}_{target}$ are then signalled to the Node B controlling the target cell.]

[TDD - In this case $\text{Frame Offset}_{target} = \text{OFF}_{target}$.

It is signalled to the Node B controlling the target cell.]

9.2.5 Handover from other RAN to UMTS

[FDD- Based on the definitions for OFF and Tm formula (9.1) can also be used when the UE enters the UTRAN from another CN and establishes one dedicated RL. The same is true for formula (9.2) when establishing one or more dedicated RL's.]

[TDD - When the UE enters the UTRAN from another CN and establishes one dedicated RL, OFF is 0.]

9.3 Calculations performed in the UE

~~This chapter describes which synchronisation parameters are computed and how the CFN is initialised in the UE in case of CELL_FACH/PCH state and CELL_DCH state.~~

9.3.1A UE in CELL_FACH/PCH state ~~or CELL_DCH state with only stand-alone shared channels.~~

In CELL_FACH/PCH state ~~or CELL_DCH state with only stand-alone shared channels the Frame Offset is set to 0, i.e.~~ the CFN is initialised with the values CFN = SFN for PCH and CFN = SFN mod 256 for all other common and shared channels. The CFN for all common and shared channels in the CRNC is increased (mod 256) by 1 every frame, except PCH, which CFN has the same range of the SFN.

9.3.1 UE changes from CELL_FACH/PCH state to CELL_DCH state: 1 RL

[FDD- Based on the received DOFF and the SFN of the cell in which the UE is source, the UE can initialise the CFN with the value given by formula (9.4)

$$CFN = ((SFN*38400 - DOFF*512) \text{ div } 38400) \bmod 256 \qquad (9.4)]$$

[TDD - The CFN is initialised with the value given by formula (9.5).

$$CFN = SFN \bmod 256 \qquad (9.5)]$$

After the initialisation, the CFN in the UE is increased (mod 256) by 1 every frame.

<u>[TDD - Note that for all common and shared channels CFN = SFN mod 256 even during CELL_DCH state.]</u>

9.3.1B [FDD - UE changes from CELL_FACH/PCH to CELL_DCH state: several RL's]

Based on the received DOFF and the SFN_j of the reference cell, the UE initialises the CFN with the value given by formula (9.6)

$$CFN = ((SFN_j*38400 - DOFF*512) \text{ div } 38400) \bmod 256 \qquad (9.6)$$

After the initialisation, the CFN in the UE is increased (mod 256) by 1 every frame.

The UE reports to the SRNC the parameters OFF_k and Tm_k for each $cell_k$ measured respect to the reference $cell_j$ determined by means of formula (9.7)

$$OFF_k + Tm_k = (SFN_k - CFN) \bmod 256 \qquad (9.7)$$

9.3.2 UE in CELL_DCH state request to add a new RL or moves to another cell

No special corrections to CFN are needed when moving from one cell to another.

However every time the UE enters a new cell (target cell), OFF_{target} might have to be reported.

[FDD - Tm_{target} is always reported. The target cell OFF_{target} is calculated using formula (9.8):

$$OFF_{target} + Tm_{target} = (SFN_{target} - CFN) \bmod 256 \qquad (9.8)$$

NOTE: OFF_{target} is calculated as the integer number of frames, Tm_{target} is the frame fractional part with the unit chips.]

[TDD - The target cell OFF_{target} is calculated using formula (9.9):

$OFF_{target} = (SFN_{target} - CFN) \bmod 256$ (9.9)]

9.4 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 RNSAP and NBAP Synchronised Radio Link Reconfiguration procedures.

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

9.5 Examples of synchronisation counters during state transitions

The example of Figure 22 shows the corrections applied to UTRAN synchronisation counters during multiple transitions from CELL_FACH/PCH state to CELL_DCH state before and after handover, without SRNS relocation.

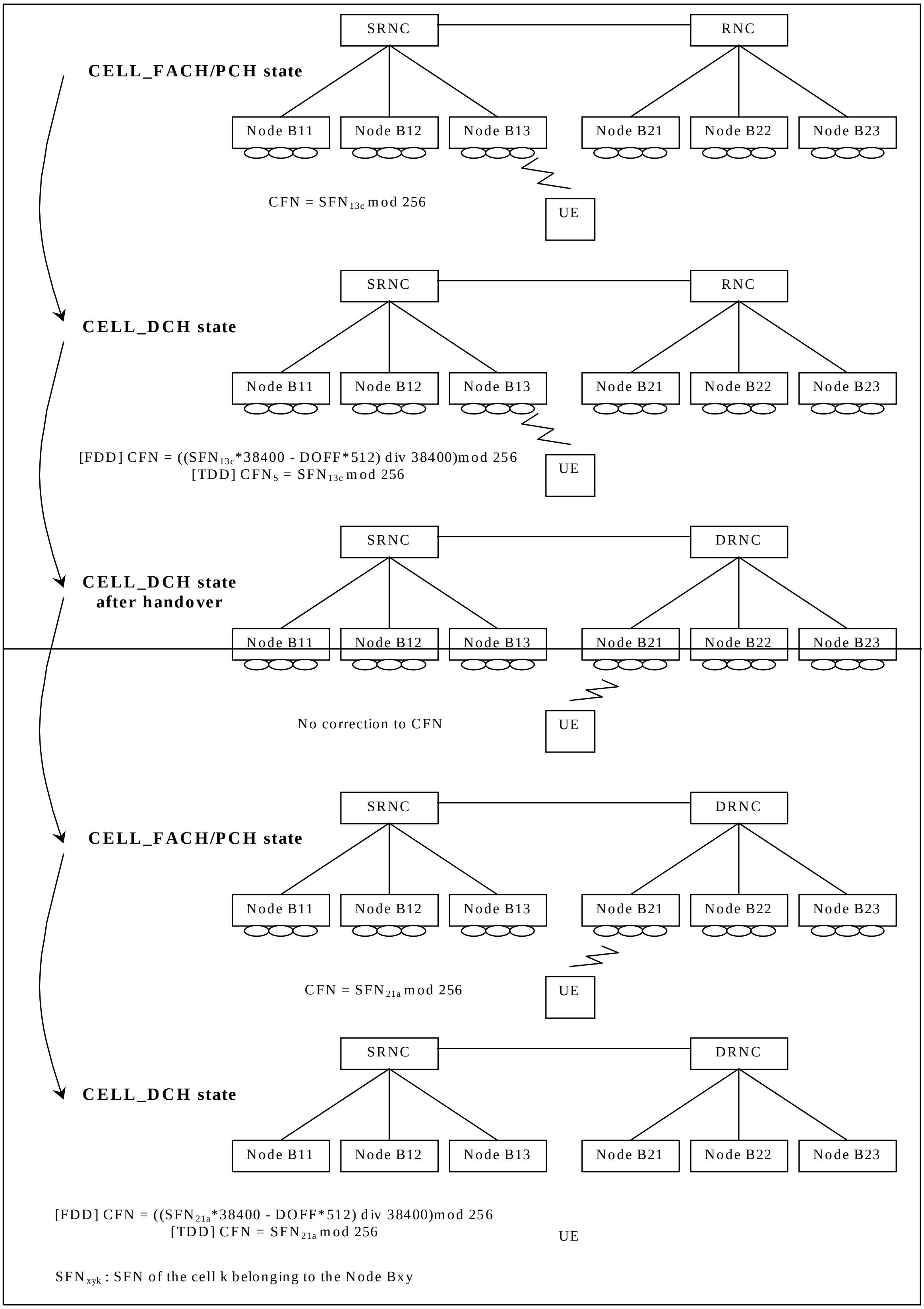

Figure 22: Example 1

The example of Figure 23 shows the corrections applied to UTRAN synchronisation during multiple transitions from CELL_FACH/PCH state to CELL_DCH state after cell reselection, without SRNC relocation.

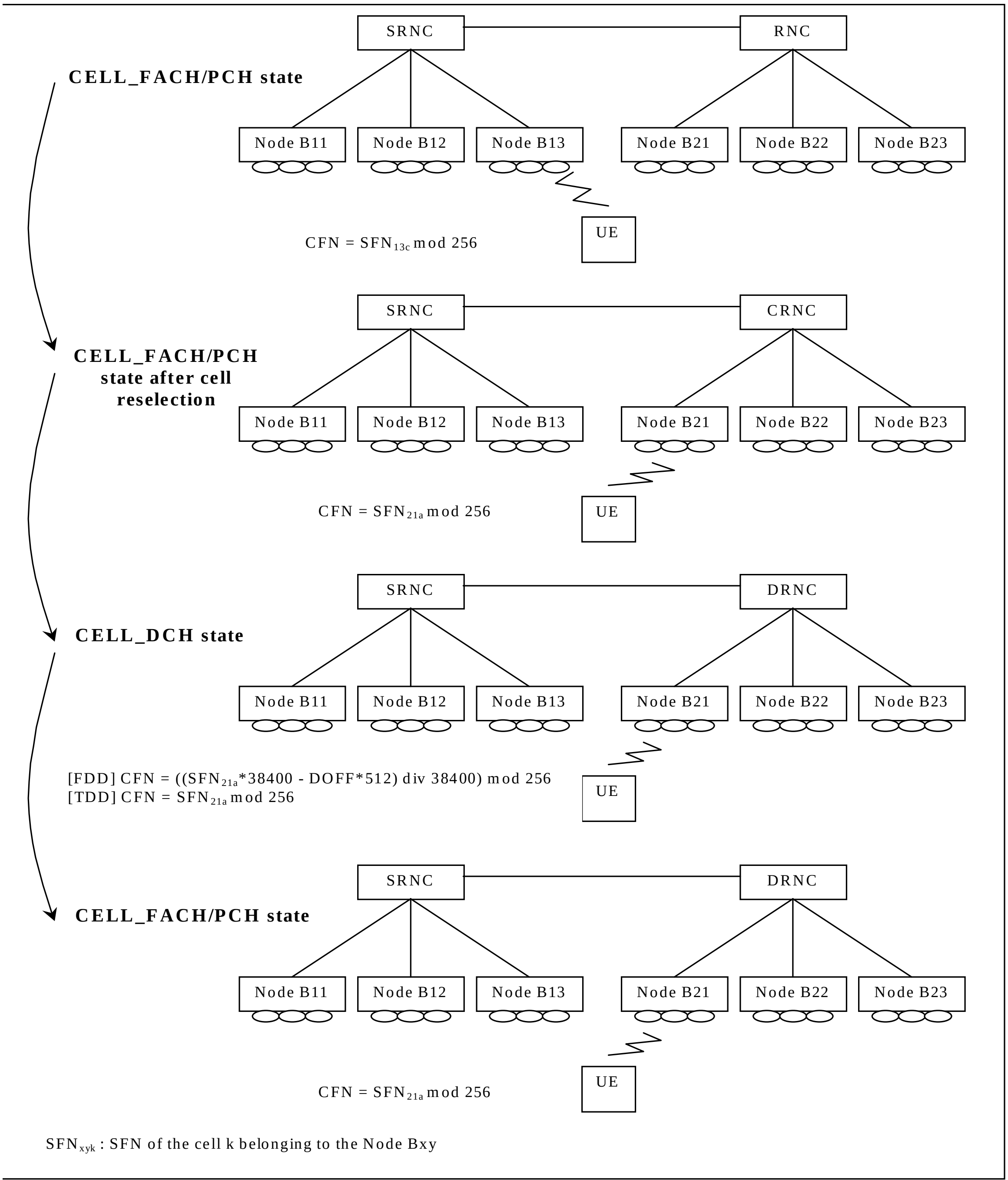

Figure 23: Example 2

The example of Figure 24 shows the corrections applied to UTRAN synchronisation counters during multiple transitions from CELL_FACH/PCH state to CELL_DCH state before and after handover and SRNS relocation (without UE involvement).

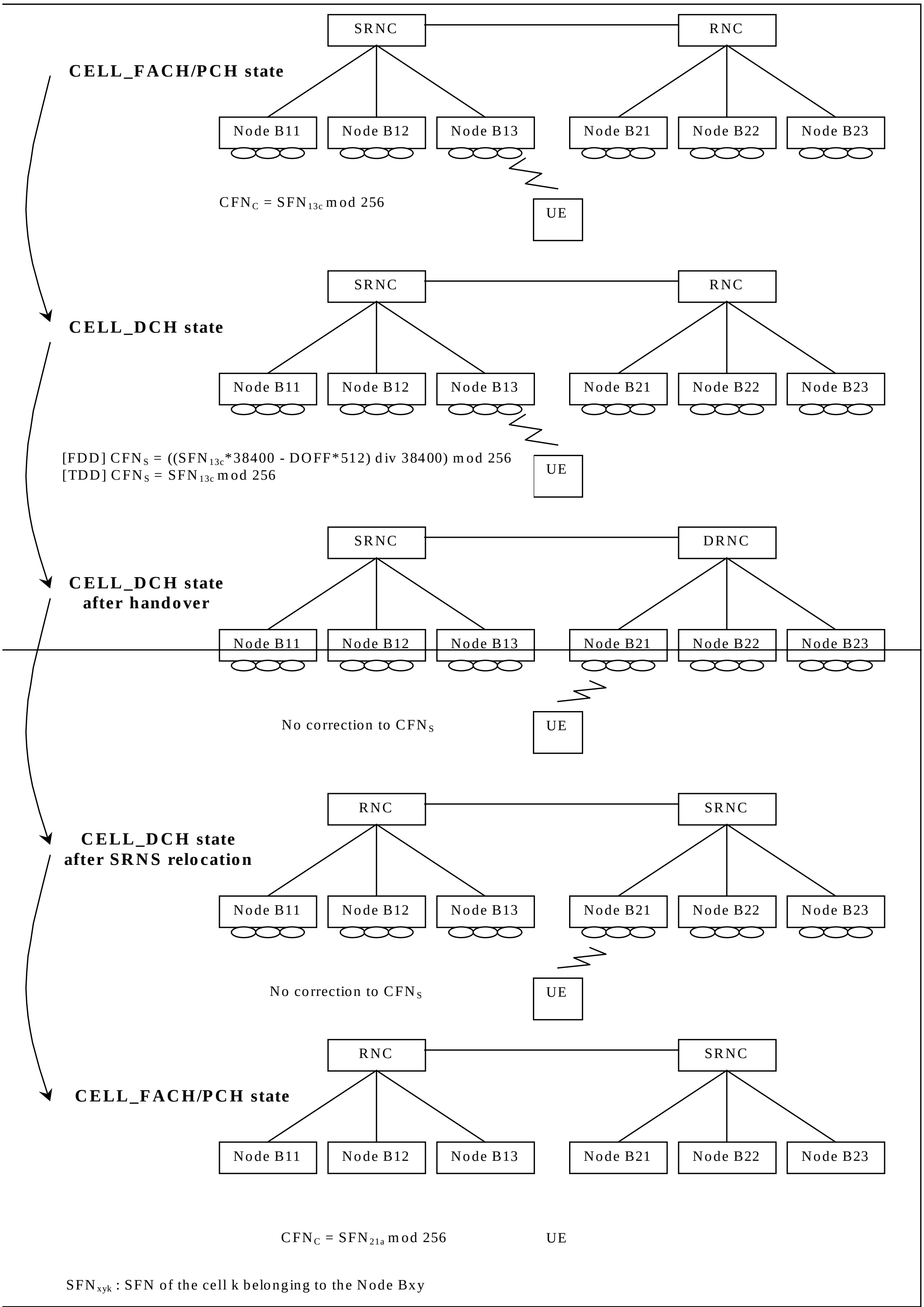

Figure 24: Example 3

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Helsinki, Finland, 3 - 7 July, 2000

Document ***R3-001985***
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25.402	**CR**	**8r2**	Current Version:	3.2.0

GSM (AA.BB) or 3G (AA.BBB) specification number ↑ *↑ CR number as allocated by MCC support team*

For submission to:	RAN#9	for approval	X	strategic		(for SMG use only)
list expected approval meeting # here ↑		for information		non-strategic		

Form: CR cover sheet, version 2 for 3GPP and SMG *The latest version of this form is available from:* ftp://ftp.3gpp.org/Information/CR-Form-v2.doc

Proposed change affects: *(at least one should be marked with an X)*	(U)SIM		ME		UTRAN / Radio	X	Core Network	

Source:	R-WG3	**Date:**	July 3, 2000
Subject:	Introduction of DOFF in TDD and CFN handling during hard handover		
Work item:			

Category:	F	Correction	X	**Release:**	Phase 2	
	A	Corresponds to a correction in an earlier release			Release 96	
(only one category	B	Addition of feature			Release 97	
shall be marked	C	Functional modification of feature			Release 98	
with an X)	D	Editorial modification			Release 99	X
					Release 00	

Reason for change:

FDD has introduced the parameter DOFF (Default DPCH Offset value) in order to spread out load on the Iub and load in Node B. In addition it is also used to spread out the location of the Pilot Symbol in order to reduce the peak DL power since Pilot symbol is always transmitting at the fixed location within a slot.
Currently in TDD there is no mechanism to achieve the same purpose, i.e. to spread out load over Iub/Iur and in the Node B when the TTI > 1, even if a kind of spreading is already given by the time slot structure of the TDD mode, that allows the SRNC not to send simultaneously Transport Block Sets that need to be transmitted in the same radio frame but in different time slots.
Therefore this CR proposes to introduce a similar parameter in TDD (named $DOFF_{TDD}$), as explained in Tdoc R3-001763
Furthermore it describes the different situations that may occur during hard handover and how the CFN is handled, as explained in Tdoc R3-001764.

Clauses affected: 3, 5, 8.2.1, 9.1, 9.2.2, 9.2.3, 9.2.4, 9.3.1, 9.3.1B, 9.3.2, 9.5

Other specs	Other 3G core specifications		→ List of CRs:	CR 442 to TS 25.331 CR 463 to TS 25.331
affected:	Other GSM core specifications		→ List of CRs:	
	MS test specifications		→ List of CRs:	
	BSS test specifications		→ List of CRs:	
	O&M specifications		→ List of CRs:	

Other comments:

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2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.
- For this Release 1999 document, references to 3G documents are for Release 1999 versions (version 3.x.y).

[1] 3G TS 25.401: "UTRAN Overall Description".

[2] 3G TS 25.423: "UTRAN I_{ur} Interface RNSAP Signalling".

[3] 3G TS 25.433: "UTRAN I_{ub} Interface NBAP Signalling".

[4] 3G TS 25.435: "UTRAN I_{ub} Interface User Plane Protocols for COMMON TRANSPORT CHANNEL Data Streams".

[5] 3G TS 25.427: "I_{ub}/I_{ur} Interface User Plane Protocol for DCH Data Streams".

[6] EIA 422-A-78: "Electrical characteristics of balanced voltage digital interface circuits".

[7] 3G TS 25.411: "UTRAN Iu Interface Layer 1".

[8] 3G TS 25.421: "UTRAN Iur Interface Layer 1".

[9] 3G TS 25.431: "UTRAN Iub Interface Layer 1".

[10] 3G TS 25.104: "UTRA (BS) FDD; Radio transmission and Reception".

[11] 3G TS 25.211: "Physical channels and mapping of transport channels onto physical channels (FDD)".

[12] 3G TS25.223 : "Spreading and modulation (TDD) " (already introduced by CR9r1).

[13] 3G TS25.215 : "Physical layer - Measurements (FDD)".

[14] 3G TS25.225 : " Physical layer - Measurements (TDD)".

3 Definitions, symbols and abbreviations

3.1 Definitions

No special definitions are defined in this document.

3.2 Symbols

No special symbols are defined in this document.

3.3 Abbreviations

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

ACK	(time alignment) acknowledgement
BFN	Node B Frame Number (counter)
CFN	Connection Frame Number (counter)
CH	Channel
CN	Core Network
CRNC	Controlling RNC
DL	Down Link
DCH	Dedicated Channel
$DOFF_{FDD}$	FDD Default DPCH Offset value
$DOFF_{TDD}$	TDD Default DPCH Offset value
DPCH	Dedicated Physical Channel
DPCCH	Dedicated Physical Control Channel
DRNC	Drift RNC
DSCH	Downlink Shared Channel
FACH	Forward Access Channel
FDD	Frequency Division Duplex
GPS	Global Positioning System
HO	Handover
LTOA	Latest Time of Arrival
L1	Layer 1
L2	Layer 2
MAC	Medium Access Control
~~MDC~~	~~Macro Diversity Combiner~~
NACK	(time alignment) negative acknowledgement
PCCPCH	Primary Common Control Physical Channel
PCH	Paging Channel
PDU	Packet Data Unit
PUSCH	Physical Uplink Shared Channel
RAB	Radio Access Bearer
RACH	Random Access Channel
RAN	Radio Access Network
RFN	RNC Frame Number (counter)
RL	Radio Link
RNC	Radio Network Controller
RNS	Radio Network Subsystem
RRC	Radio Resource Control
SFN	Cell System Frame Number (counter)
SRNC	Serving RNC
SRNS	Serving RNS
TBS	Transport Block Set
TDD	Time Division Duplex
TOA	Time of Arrival
TOAWE	Time of Arrival Window Endpoint

TOAWS	Time of Arrival Window Startpoint
TTI	Time Transmission Interval
UE	User Equipment
UL	Up Link
USCH	Uplink Shared Channel
UTRAN	UMTS Terrestrial Radio Access Network

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 SFN is locked to the BFN (i.e. SFN=BFN).
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 ~~common channel~~Cell_FACH state or other when coming from another RAN) to Cell_DCH ~~the dedicated channel~~ 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.

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.

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.

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.

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 14). 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 14). 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 8). 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}.

8 Radio Interface Synchronisation

8.1 General

This subclause describes the Radio Interface Synchronisation for FDD and TDD.

8.2 FDD Radio Interface Synchronisation

8.2.1 General

FDD Radio Interface Synchronisation assures that UE gets the correct frames when received from several cells. The UE measures the Timing difference between its DPCH and SFN in the target cell when doing handover and reports it to SRNC. SRNC sends this Time difference value in two parameters Frame Offset and Chip Offset over Iub to Node B. Node B rounds this value to the closest 256 chip boundary in order to get DL orthogonality (regardless of used spreading factor). The rounded value is used in Node B for the DL DPCH.

$DOFF_{FDD}$ is selected by the SRNC considering the interleaving period (e.g. 10, 20, 40 or 80ms) when entering in dedicated state from common channel state.

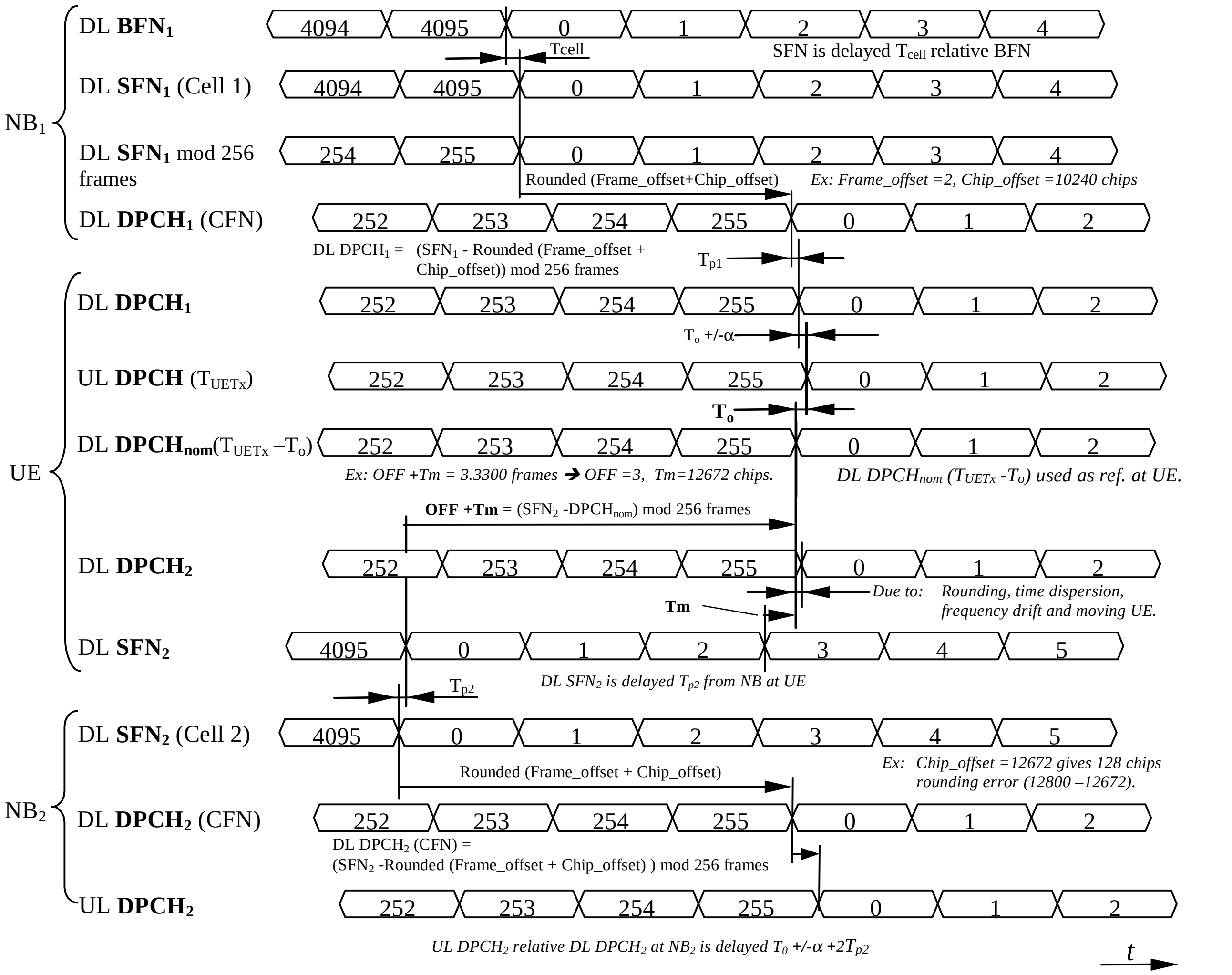
Services are scheduled by using $DOFF_{FDD}$ in order to average out the Iub traffic load and the Node B processing load. $DOFF_{FDD}$ (FDD Default DPCH Offset value) is only used when setting up the first RL in order to initialise Frame Offset and Chip Offset and to tell UE when frames are expected.

UE uses the UL DPCH as it is a more defined time instant compared with DL DPCH.

The handover reference is the time instant T_{UETx} -To, which is called DL $DPCH_{nom}$ in the timing diagram.

T_{cell} is used to skew cells in the same Node B in order to not get colliding SCH bursts, one SCH burst is 1/10 of a slot time.

The timing diagram in Figure 17 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 DPCH$_{nom}$	T$_{cell}$	Specifies the SFN delay relative BFN
BFN	Node B Frame Number (counter)	T$_m$	Measured by UE at HO, T$_m$ 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 DPCH$_{nom}$) and T$_{UETx}$ at UE.
HO	Handover		
NB$_x$	Node B (x: 1=source, 2=target)		
OFF	Offset with a range from 0 to 255 frames	T$_{pX}$	Propagation delay (one way), UE to 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 17: FDD Radio Interface Synchronisation timing diagram

SFN$_1$ is found in Cell 1 at Node B$_1$ and SFN$_2$ at Cell 2 and Node B$_2$. SFN$_1$ is sent T_cell$_1$ after the Node B$_1$ 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 Node B's in this example). UL DPCH at Node B$_2$ is shown to indicate the difference to the DL DPCH$_2$ at Node B$_2$.

The new RL (DL DPCH$_2$) which is setup at the HO will face some deviation from nominal position due to the rounding of Frame Offset and Chip Offset to 256 chip boundary in Node B. Also Time dispersion, Node B-UE frequency drift and UE movement affects this phase deviation.

The nominal DL DPCH timing at UE is T$_o$ before the T$_{UETX}$ time instant, which could be expressed:

$$\text{DL DPCH}_{nom} = T_{UETX} - T_o \qquad (8.1)$$

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

$$\text{OFF} + \text{Tm} = (\text{SFN}_{target} - \text{DL DPCH}_{nom}) \bmod 256 \text{ frames [chips]} \qquad (8.2)$$

NOTE: OFF has the unit Frames and Tm the unit Chips.

Example: assume that OFF + T_m equals "3.3300" frames (as given as an example in Figure 19).
Then OFF = 3 and T_m = "0.33" which corresponds to T_m = 12672 chips.

In other words (referring to the timing diagram in Figure 19):

- How to determine T_m at UE: Select a time instant 1) where frame N starts at DL SFN_2 e.g. frame number 3, the time from that time instant to the next frame border of DL $DPCH_{nom}$ 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 starting at instant 2) mod 256 frames equals OFF.
  Example: (3 –0) mod 256 = 3, another example is (1 –254) mod 256 = 3.

9 Usage of Synchronisation Counters and Parameters to support Transport Channel and Radio Interface Synchronisation

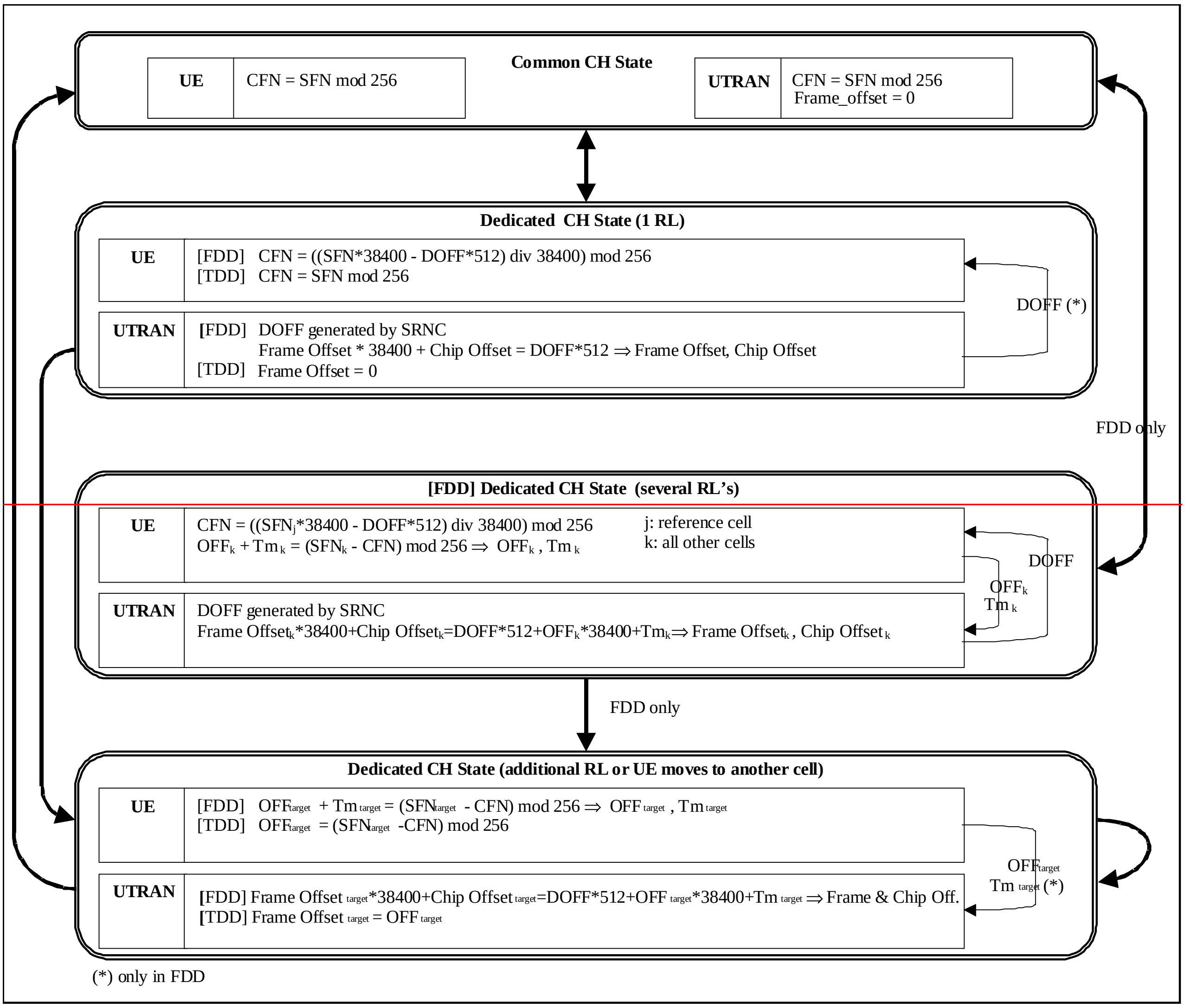
9.1 General

This subclause describes how the different synchronisation parameters and counters are computed and used in order to obtain Transport Channel (L2) and Radio Interface (L1) Synchronisation.

The parameters that need to be determined by the UE are CFN, OFF [FDD – and Tm].

The parameter that need to be determined by the UTRAN are [FDD – $DOFF_{FDD}$], [TDD – $DOFF_{TDD}$], Frame Offset and [FDD – Chip Offset].

Figure 19 summarises how these parameters are computed. A detailed description of the actions in each state is given in the sections 9.2 – 9.4, while some examples of corrections applied to synchronisation counters during UE state transitions are shown in section 9.5..



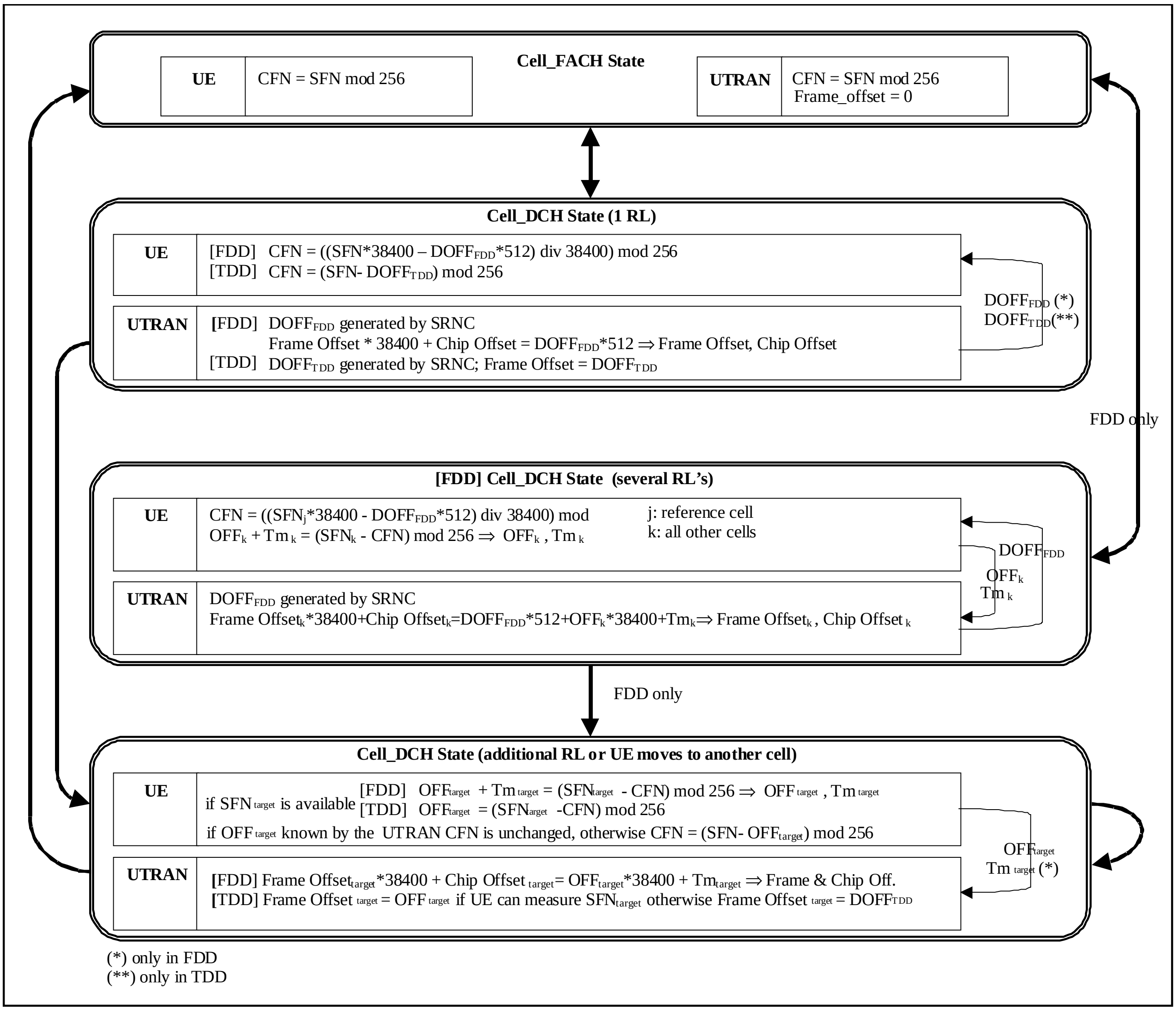
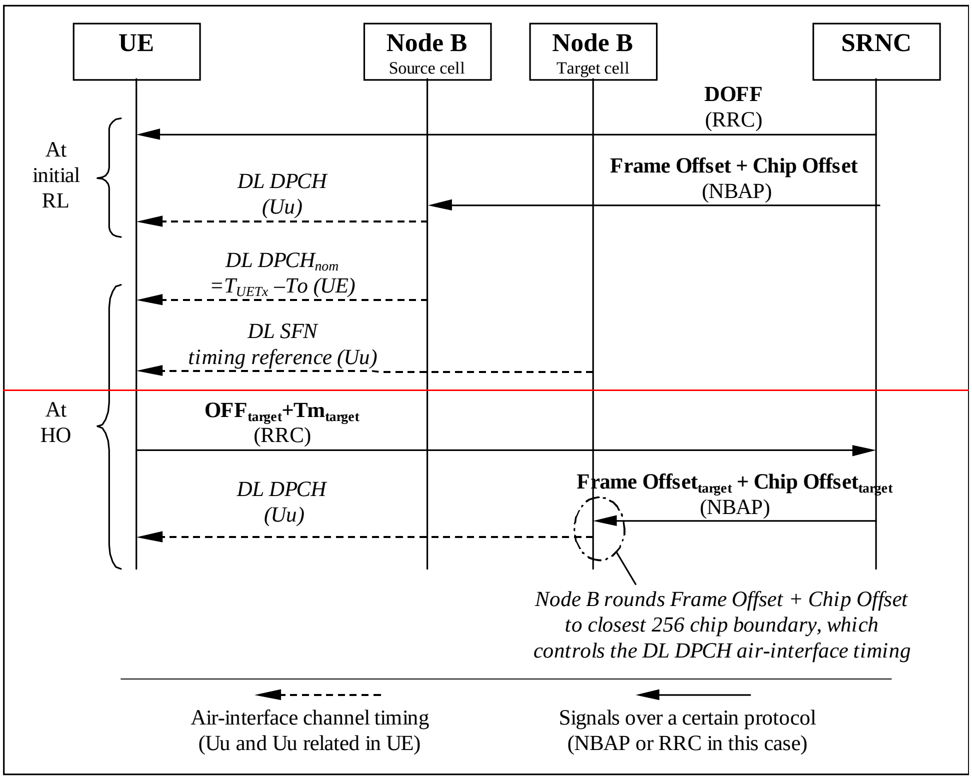


Figure 19: Calculations performed by UE and UTRAN

Figure 20 describes what offset parameters are signalled and used in the different nodes at Initial RL setup and at Handover (HO) in FDD. The rounding to closest 256 chip boundary is done in Node B. The rounded Frame Offset and Chip Offset control the DL DPCH air-interface timing. The 256 chip boundary is to maintain DL orthogonality in the cell (the rounding to the closest 256 chip boundary is done in Node B to facilitate the initial UL chip synchronisation process in Node B).



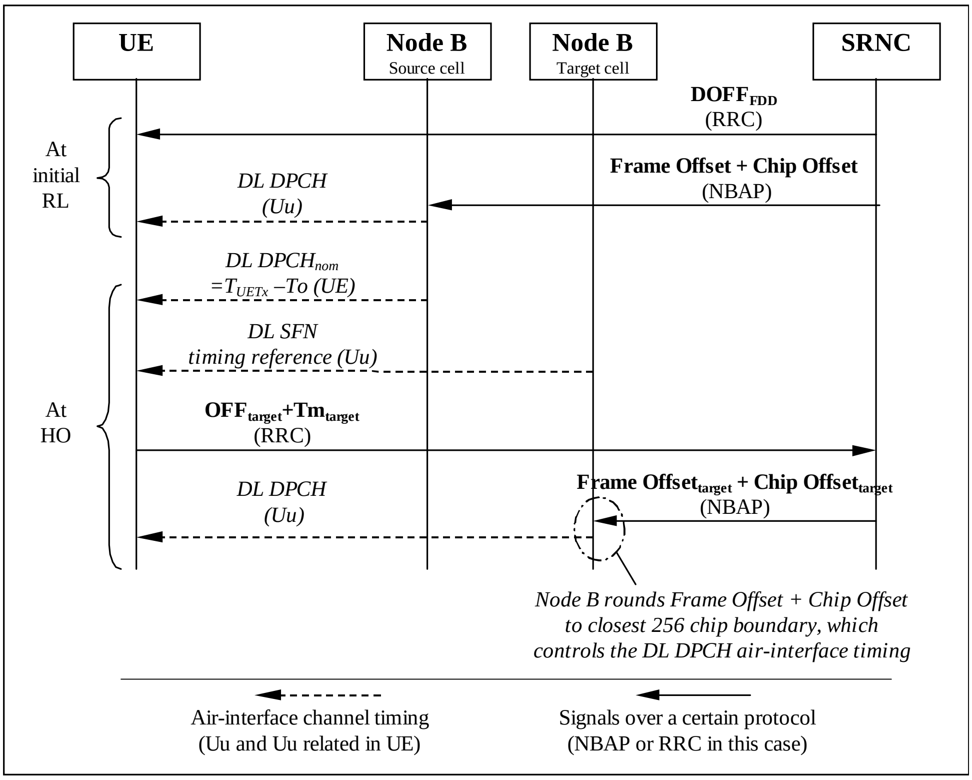
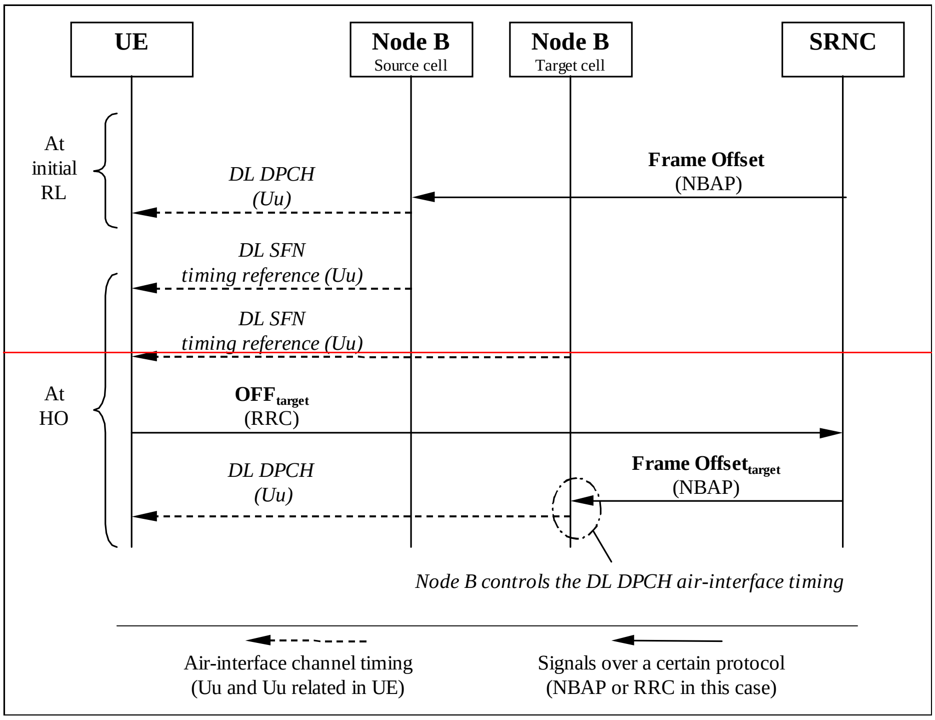


Figure 20: [FDD - Usage of Offset values at initial RL and at HO]

Figure 21 describes what offset parameters are signalled and used in the different nodes at Initial RL setup and at Handover (HO) in TDD.

Note that in some cases the parameter OFF_{target} cannot be measured by the UE before handover (e.g. in case of inter frequency handover or inter-mode handover). In these cases a value as defined in [FDD - 13] [TDD - 14] shall be reported by the UE.



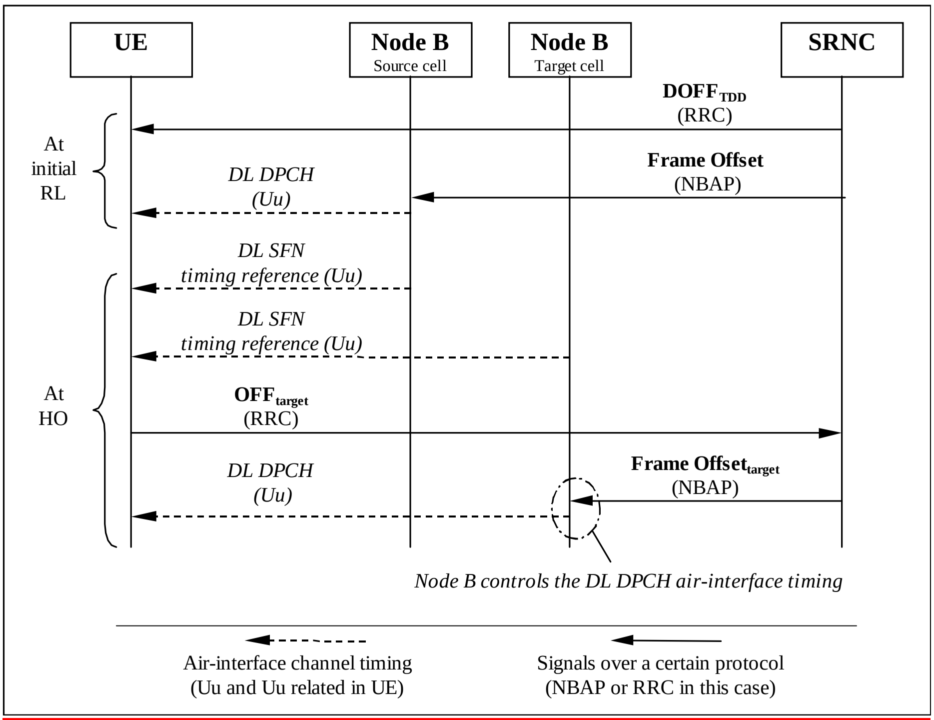


Figure 21: [TDD- Usage of Offset values at initial RL and at HO]

9.2 Calculations performed in the UTRAN

9.2.1 UE in CELL_FACH/PCH state or CELL_DCH state with only stand-alone shared channels~~.~~

In CELL_FACH/PCH state or CELL_DCH state with only stand-alone shared channels the Frame Offset is set to 0.

9.2.2 UE changes from CELL_FACH/PCH state to CELL_DCH state: 1 RL

[FDD - Based on the received parameters from the UE and the $DOFF_{FDD}$ value generated in the SRNC, the SRNC calculates the Frame Offset and the Chip Offset from formula (9.1).

$$\text{Frame Offset}*38400 + \text{Chip Offset} = DOFF_{FDD}*512 \qquad (9.1)$$

Frame Offset and Chip Offset are then signalled to the Node B controlling the serving cell.]

[TDD - Based on the $DOFF_{TDD}$ value generated in the SRNC, the SRNC calculates the ~~In this case~~ Frame Offset = $DOFF_{TDD}$~~0~~.

Frame Offset is then signalled to the Node B controlling the serving cell.]

9.2.3 [FDD - UE changes from CELL_FACH/PCH state to CELL_DCH state: several RL's]

Based on the received parameters from the UE for each $cell_k$ (OFF_k and Tm_k) and the $DOFF_{FDD}$ value generated in the SRNC, the SRNC calculates the Frame Offset_k and the Chip Offset_k. The Frame Offset_k and the Chip Offset_k are calculated from formula (9.2).

$$\text{Frame Offset}_k*38400 + \text{Chip Offset}_k = DOFF_{FDD}*512 + OFF_k*38400 + Tm_k \qquad (9.2)$$

NOTE: formula (9.~~3~~2) is covering formula (9.1) since in the case described in section 9.2.2, OFF_k and Tm_k are both equal to zero.

Each Frame Offset_k and Chip Offset_k are then signalled to the Node B controlling the $cell_k$.

9.2.4 UE in CELL_DCH state: ~~request to~~ addition of a new RL or ~~moves~~ handover to ~~another~~ a new cell

[FDD - Based on the received parameters from the UE or already known by the UTRAN (OFF_{target}, Tm_{target}), the SRNC calculates the $\text{Frame Offset}_{target}$ and the $\text{Chip Offset}_{target}$ with formula (9.3).

$$\text{Frame Offset}_{target}*38400 + \text{Chip Offset}_{target} = OFF_{target}*38400 + Tm_{target} \qquad (9.3)$$

During hard handover in case the parameter OFF_{target} cannot be measured by the UE and it is not already known by the UTRAN, than the SRNC calculates the $\text{Frame Offset}_{target}$ and the $\text{Chip Offset}_{target}$ with formula (9.1).

$\text{Frame Offset}_{target}$ and $\text{Chip Offset}_{target}$ are then signalled to the Node B controlling the target cell.]

[TDD - Based on the parameter OFF_{target} received from the UE or already known by the UTRAN, the SRNC calculates the ~~In this case~~ $\text{Frame Offset}_{target} = OFF_{target}$.

In case the parameter OFF_{target} cannot be measured by the UE and it is not already known by the UTRAN, than the SRNC calculates the $\text{Frame Offset}_{target} = DOFF_{TDD}$.

It is signalled to the Node B controlling the target cell.]

9.2.5 Handover from other RAN to UMTS

[FDD- Based on the definitions for OFF and Tm formula (9.1) can also be used when the UE enters the UTRAN from another CN and establishes one dedicated RL. The same is true for formula (9.2) when establishing one or more dedicated RL's.]

[TDD - When the UE enters the UTRAN from another CN and establishes one dedicated RL, OFF is 0.]

9.3 Calculations performed in the UE

This chapter describes which synchronisation parameters are computed and how the CFN is initialised in the UE in case of CELL_FACH/PCH state and CELL_DCH state.

9.3.1A UE in CELL_FACH/PCH state or CELL_DCH state with only stand-alone shared channels.

In CELL_FACH/PCH state or CELL_DCH state with only stand-alone shared channels the Frame Offset is set to 0, i.e. the CFN is initialised with the values CFN = SFN for PCH and CFN = SFN mod 256 for all other common and shared channels. The CFN for all common and shared channels in the CRNC is increased (mod 256) by 1 every frame, except PCH, which CFN has the same range of the SFN.

9.3.1 UE changes from CELL_FACH/PCH state to CELL_DCH state: 1 RL

[FDD- Based on the received $DOFF_{FDD}$ and the SFN of the cell in which the UE is source, the UE can initialise the CFN with the value given by formula (9.4)

$$CFN = ((SFN*38400 - DOFF_{FDD}*512) \text{ div } 38400) \text{ mod } 256 \qquad (9.4)]$$

[TDD - Based on the received $DOFF_{TDD}$,the UE can ~~The CFN is initialised~~ initialised the CFN with the value given by formula (9.5).

$$CFN = (SFN - DOFF_{TDD}) \text{ mod } 256 \qquad (9.5)]$$

After the initialisation, the CFN in the UE is increased (mod 256) by 1 every frame.

9.3.1B [FDD - UE changes from CELL_FACH/PCH to CELL_DCH state: several RL's]

Based on the received $DOFF_{FDD}$ and the SFN_j of the reference cell, the UE initialises the CFN with the value given by formula (9.6)

$$CFN = ((SFN_j*38400 - DOFF_{FDD}*512) \text{ div } 38400) \text{ mod } 256 \qquad (9.6)$$

After the initialisation, the CFN in the UE is increased (mod 256) by 1 every frame.

The UE reports to the SRNC the parameters OFF_k and Tm_k for each $cell_k$ measured respect to the reference $cell_j$ determined by means of formula (9.7)

$$OFF_k + Tm_k = (SFN_k - CFN) \text{ mod } 256 \qquad (9.7)$$

9.3.2 UE in CELL_DCH state: addition ~~request to add~~of a new RL or ~~moves~~ handover to ~~another~~ a new cell

The UE in CELL_DCH state may be requested by the UTRAN to report OFF_{target} by means of System Info broadcast in the source cell.

[FDD - ~~No special corrections to CFN are needed when moving from one cell to another.~~

~~However every time the UE enters a new cell (target cell), OFF~~~~$_{target}$~~ ~~might have to be reported.~~

~~[FDD - Tm_{target} is always reported.~~

In case the SFN_{target} can be measured, ~~T~~the target cell OFF_{target} is calculated using formula (9.8):

$$OFF_{target} + Tm_{target} = (SFN_{target} - CFN) \bmod 256 \quad (9.8)$$

otherwise a value as defined in [13] is reported. Tm_{target} is always reported, except for the case of FDD-TDD handover.]

~~NOTE: OFF_{target} is calculated as the integer number of frames, Tm_{target} is the frame fractional part with the unit chips.]~~

[TDD - In case the SFN_{target} can be measured, ~~T~~the target cell OFF_{target} is calculated using formula (9.9):

$$OFF_{target} = (SFN_{target} - CFN) \bmod 256 \quad (9.9)$$

otherwise a value as defined in [14] is reported.]

Note that, regarding the CFN, two cases may occur:

a) the value of OFF_{target} is known by the UTRAN before handover execution:

a1) either because the SFN_{target} has been measured by the UE and reported to the UTRAN by means of the OFF_{target} before handover;

a2) or because the UTRAN already knows the difference between serving cell SFN_{source} and target cell SFN_{target} and derives OFF_{target} from OFF_{source} by applying the difference between SFN_{target} and SFN_{source} (this difference between SFNs may be known in the UTRAN from previous UE's measurement reports);

a3) [TDD - or because cells involved in the handover are synchronised – and hence OFF_{target} equals OFF_{source}].

b) the value of OFF_{target} is not known by the UTRAN before handover execution because the SFN_{target} cannot be measured by the UE before handover and the UTRAN does not know the difference between serving cell SFN and target cell SFN.

In case a) the UTRAN shall not signal to the UE any value of [FDD- $DOFF_{FDD}$] [TDD- $DOFF_{TDD}$] before handover in the the RRC message PHYSICAL CHANNEL RECONFIGURATION, and the UE shall maintain the old CFN, i.e. no correction to CFN is needed during handover.

In case b) the UTRAN shall signal to the UE the new value of [FDD- $DOFF_{FDD}$] [TDD- $DOFF_{TDD}$] before handover by means of the RRC message PHYSICAL CHANNEL RECONFIGURATION. The CFN shall be re-initialised after handover (as soon as the UE reads the SFN_{target}) according to formula [FDD- (9.4)] [TDD- (9.5)].

Note that in cases a2) and a3) the UTRAN may not request the UE to report OFF_{target}, while in case b) the value of OFF_{target} reported by the UE is the one defined in [FDD - 13], [TDD - 14] for this case.

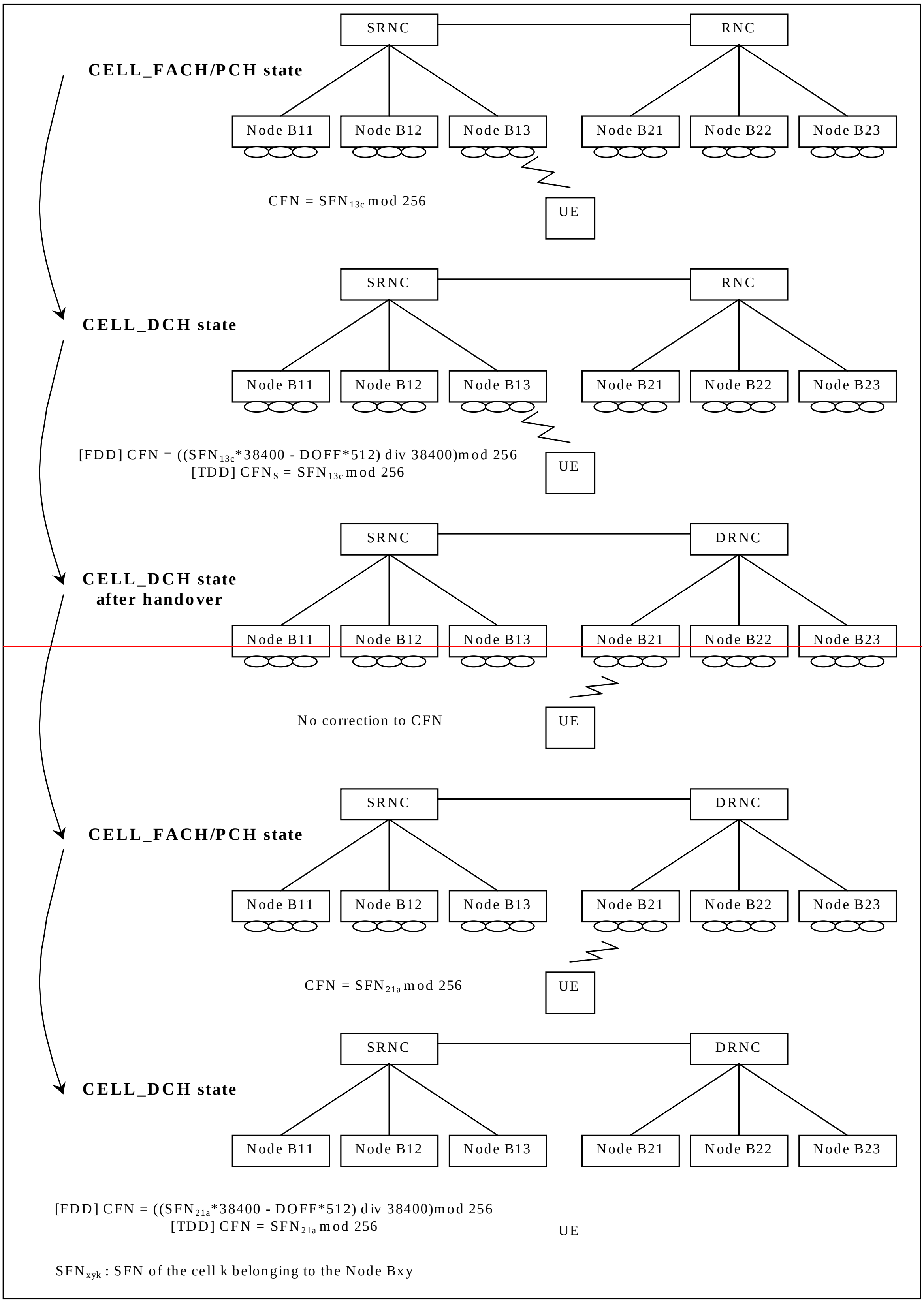
9.4 Synchronisation of L1 configuration changes

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 RNSAP and NBAP Synchronised Radio Link Reconfiguration procedures.

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

9.5 Examples of synchronisation counters during state transitions

The example of Figure 22 shows the corrections applied to UTRAN synchronisation counters during multiple transitions from CELL_FACH/PCH state to CELL_DCH state before and after handover, without SRNS relocation. In this example the two handover cases described in 9.3.2 are considered.


CELL_FACH/PCH state
SRNC
RNC
Node B11
Node B12
Node B13
Node B21
Node B22
Node B23
CFN = SFN13c mod 256
UE
CELL_DCH state
[FDD] CFN = ((SFN13c*38400 - DOFF*512) div 38400)mod 256
[TDD] CFNS = SFN13c mod 256
CELL_DCH state after handover
DRNC
No correction to CFN
CELL_FACH/PCH state
CFN = SFN21a mod 256
CELL_DCH state
[FDD] CFN = ((SFN21a*38400 - DOFF*512) div 38400)mod 256
[TDD] CFN = SFN21a mod 256
SFNxyk : SFN of the cell k belonging to the Node Bxy

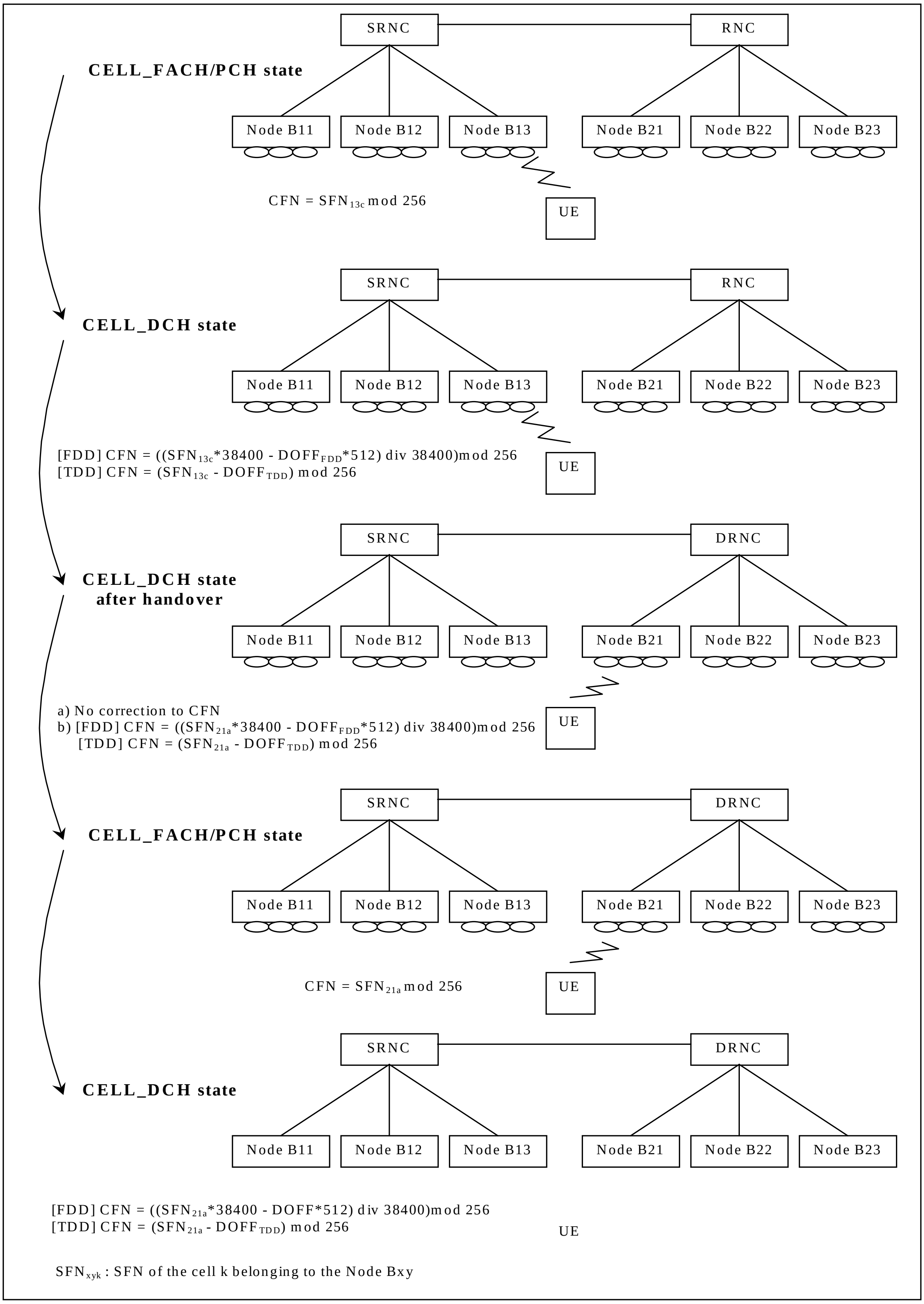


Figure 22: Example 1

The example of Figure 23 shows the corrections applied to UTRAN synchronisation during multiple transitions from CELL_FACH/PCH state to CELL_DCH state after cell reselection, without SRNC relocation.

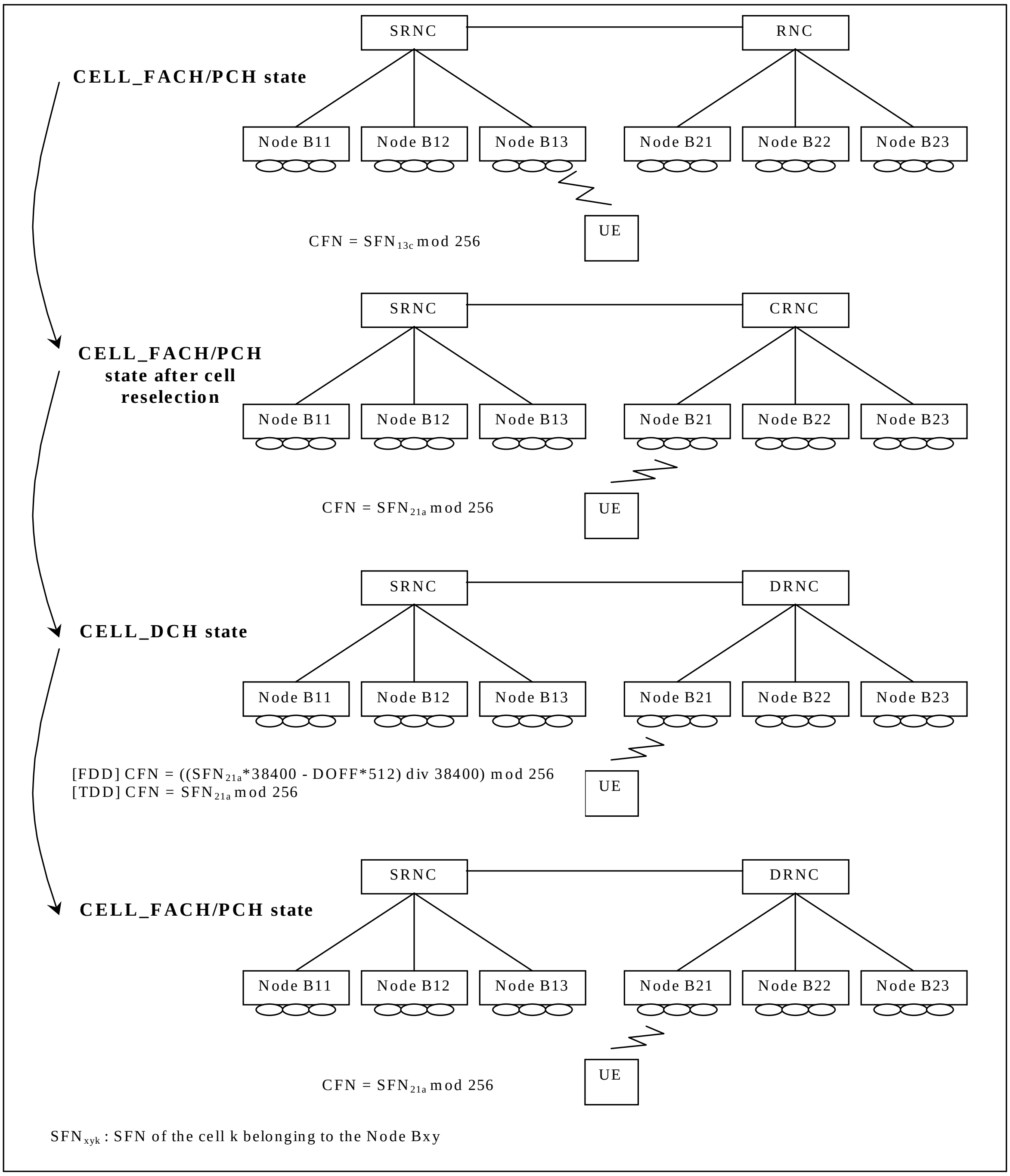
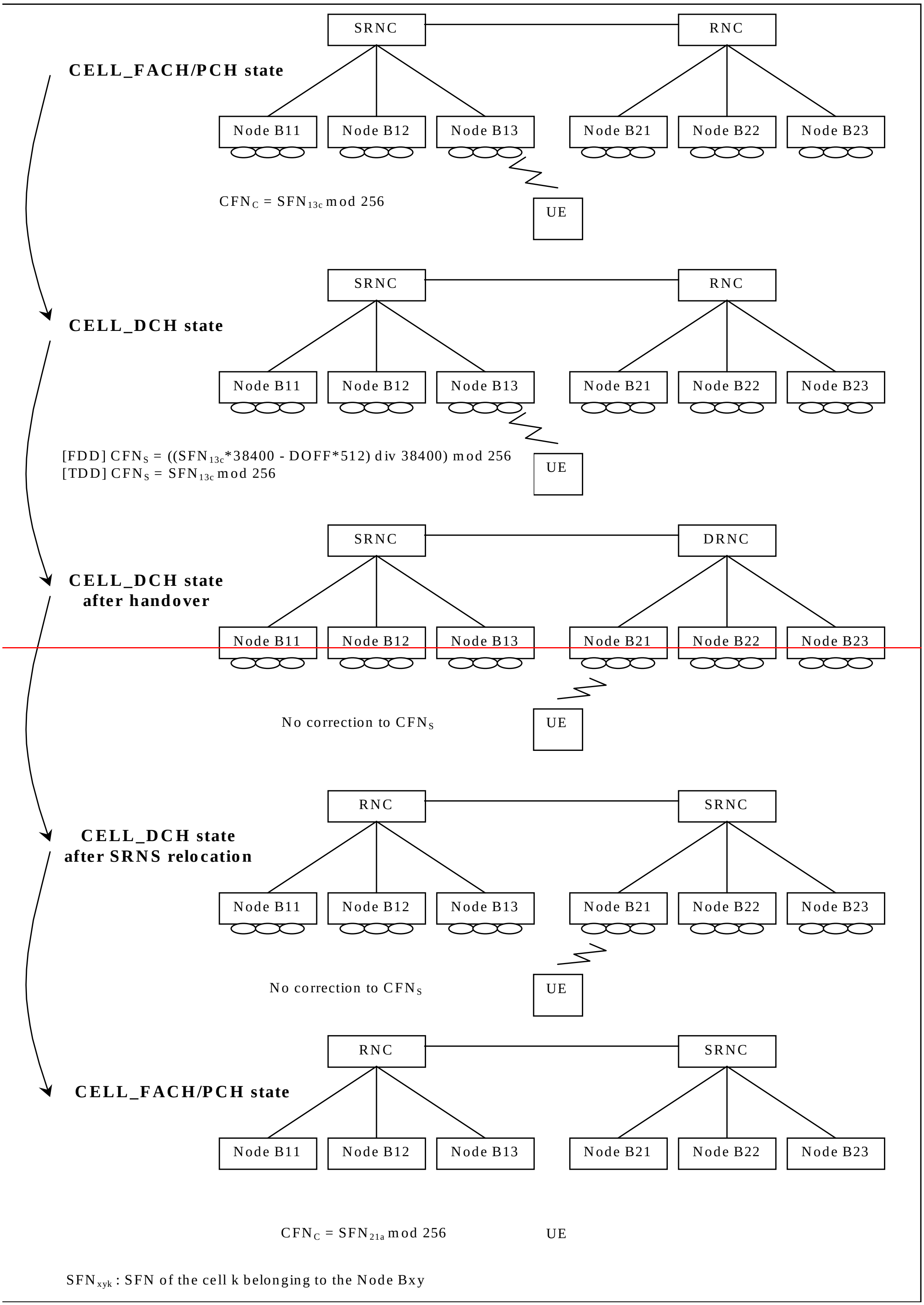


Figure 23: Example 2

The example of Figure 24 shows the corrections applied to UTRAN synchronisation counters during multiple transitions from CELL_FACH/PCH state to CELL_DCH state before and after handover and SRNS relocation (without UE involvement). In this example the two handover cases described in 9.3.2 are considered.


SRNC
RNC
CELL_FACH/PCH state
Node B11
Node B12
Node B13
Node B21
Node B22
Node B23
CFN_C = SFN_{13c} mod 256
UE
SRNC
RNC
CELL_DCH state
Node B11
Node B12
Node B13
Node B21
Node B22
Node B23
[FDD] CFN_S = ((SFN_{13c}*38400 - DOFF*512) div 38400) mod 256
[TDD] CFN_S = SFN_{13c} mod 256
UE
SRNC
DRNC
CELL_DCH state
after handover
Node B11
Node B12
Node B13
Node B21
Node B22
Node B23
No correction to CFN_S
UE
RNC
SRNC
CELL_DCH state
after SRNS relocation
Node B11
Node B12
Node B13
Node B21
Node B22
Node B23
No correction to CFN_S
UE
RNC
SRNC
CELL_FACH/PCH state
Node B11
Node B12
Node B13
Node B21
Node B22
Node B23
CFN_C = SFN_{21a} mod 256
UE
SFN_{xyk} : SFN of the cell k belonging to the Node Bxy

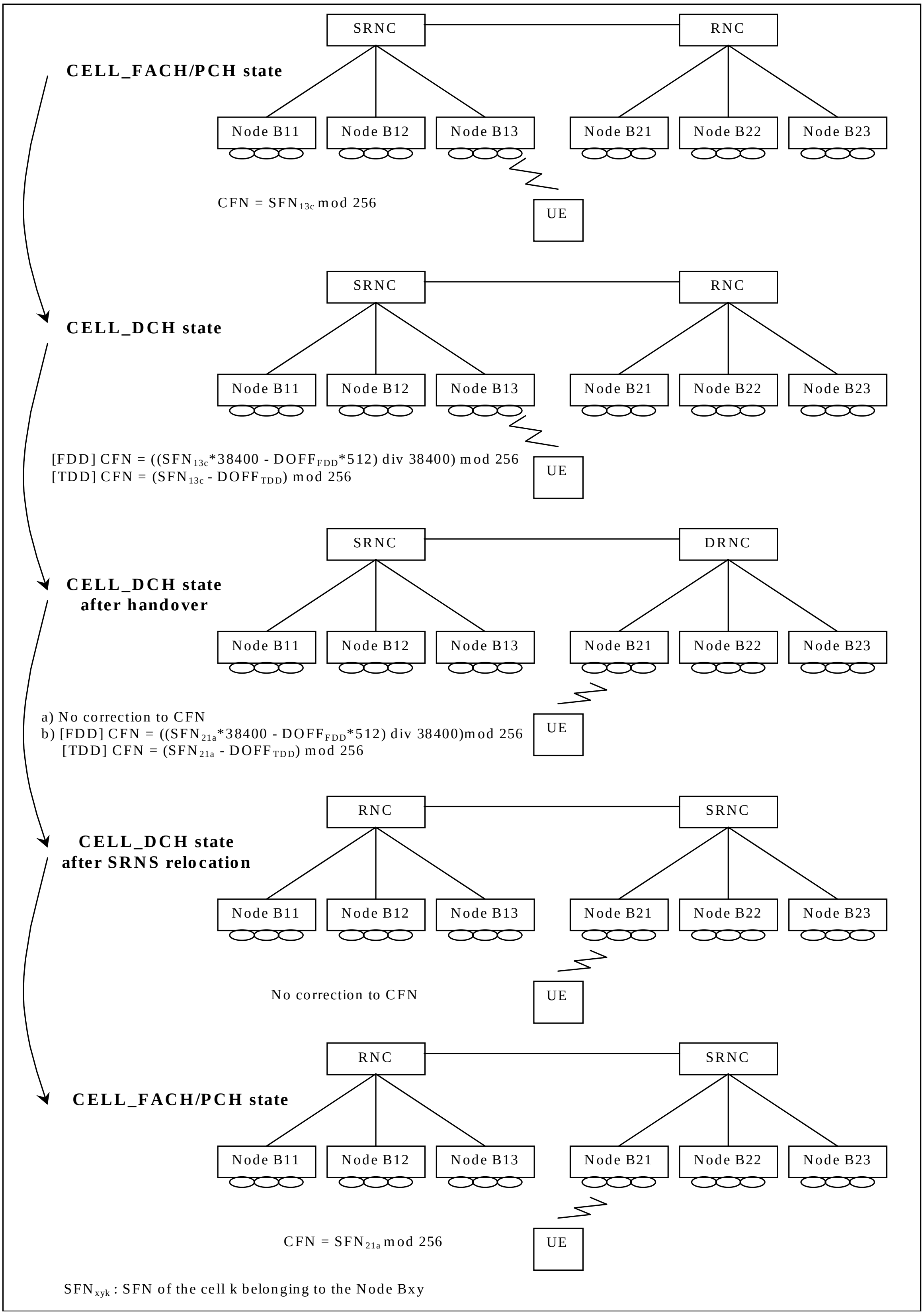


Figure 24: Example 3

3GPP TAG RAN WG3 Meeting #14
Helsinki, Finland, 3 - 7 July, 2000

Document R3-001986

e.g. for 3GPP use the format TP-99xxx
or for SMG, use the format P-99-xxx

CHANGE REQUEST

Please see embedded help file at the bottom of this page for instructions on how to fill in this form correctly.

25.402	**CR**	**9r2**	Current Version:	3.2.0

GSM (AA.BB) or 3G (AA.BBB) specification number ↑ *↑ CR number as allocated by MCC support team*

For submission to:	RAN#9	for approval	X	strategic		*(for SMG use only)*
list expected approval meeting # here ↑		for information		non-strategic		

Form: CR cover sheet, version 2 for 3GPP and SMG *The latest version of this form is available from:* ftp://ftp.3gpp.org/Information/CR-Form-v2.doc

Proposed change affects: *(at least one should be marked with an X)*	(U)SIM		ME		UTRAN / Radio	X	Core Network

Source: R-WG3 **Date:** July 3, 2000

Subject: TDD intercell synchronisation

Work item:

Category:				**Release:**		
	F	Correction	X		Phase 2	
	A	Corresponds to a correction in an earlier release			Release 96	
(only one category shall be marked with an X)	B	Addition of feature			Release 97	
	C	Functional modification of feature			Release 98	
	D	Editorial modification			Release 99	X
					Release 00	

Reason for change:

Currently the following synchronisation issues have been defined for TDD:

- Inter node B synchronisation;
- Radio frame synchronisation;
- Multi Frame synchronisation.

The relations between these items are not completely clear and, furthermore, the last two aspects are related to the same issue (inter-cell synchronisation).
Therefore this CR modifies the terminology and clarifies the relations between the different TDD synchronisation issues.

Clauses affected: 2, 4.1, 4.5, 5, 6.1, 6.1.2, 6.1.2.2, 8.3.1, 8.3.2, 8.3.3

Other specs affected:			
	Other 3G core specifications		→ List of CRs:
	Other GSM core specifications		→ List of CRs:
	MS test specifications		→ List of CRs:
	BSS test specifications		→ List of CRs:
	O&M specifications		→ List of CRs:

Other comments:

help.doc

<--------- double-click here for help and instructions on how to create a CR.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.
- For this Release 1999 document, references to 3G documents are for Release 1999 versions (version 3.x.y).

[1] 3G TS 25.401: "UTRAN Overall Description".

[2] 3G TS 25.423: "UTRAN I_{ur} Interface RNSAP Signalling".

[3] 3G TS 25.433: "UTRAN I_{ub} Interface NBAP Signalling".

[4] 3G TS 25.435: "UTRAN I_{ub} Interface User Plane Protocols for COMMON TRANSPORT CHANNEL Data Streams".

[5] 3G TS 25.427: "I_{ub}/I_{ur} Interface User Plane Protocol for DCH Data Streams".

[6] EIA 422-A-78: "Electrical characteristics of balanced voltage digital interface circuits".

[7] 3G TS 25.411: "UTRAN Iu Interface Layer 1".

[8] 3G TS 25.421: "UTRAN Iur Interface Layer 1".

[9] 3G TS 25.431: "UTRAN Iub Interface Layer 1".

[10] 3G TS 25.104: "UTRA (BS) FDD; Radio transmission and Reception".

[11] 3G TS 25.211: "Physical channels and mapping of transport channels onto physical channels (FDD)".

[12] 3G TS25.223 : "Spreading and modulation (TDD) ".

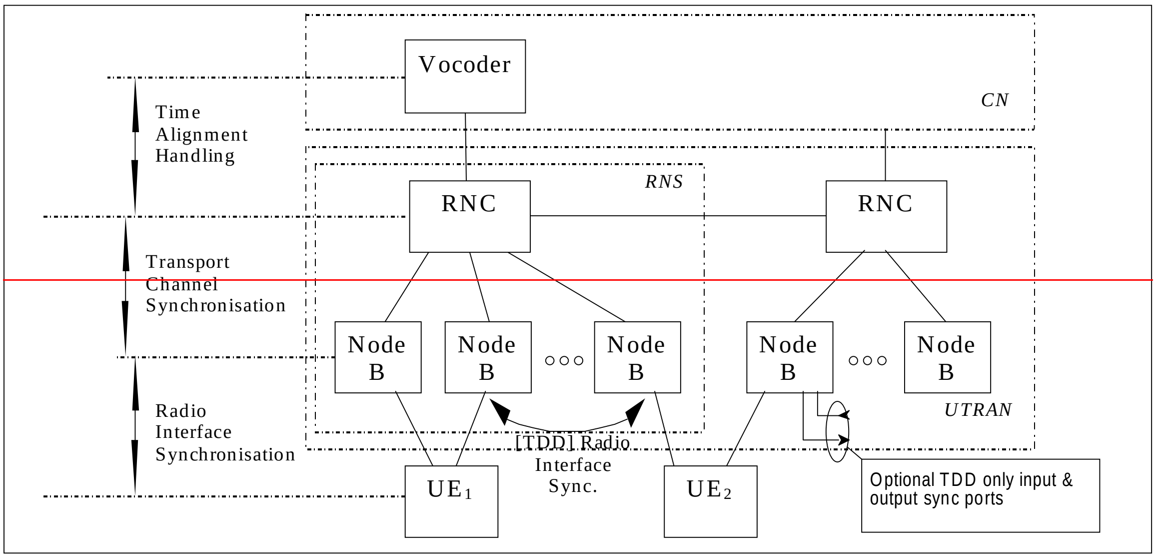
4 Synchronisation Issues

4.1 General

This clause identifies the different UTRAN synchronisation issues, i.e.:

- Network Synchronisation;
- Node Synchronisation;
- Transport Channel Synchronisation;
- Radio Interface Synchronisation;
- Time Alignment Handling.

The Nodes involved by the above mentioned synchronisation issues (with the exception of Network and Node Synchronisation) are shown by the Synchronisation Issues Model of Figure 1.



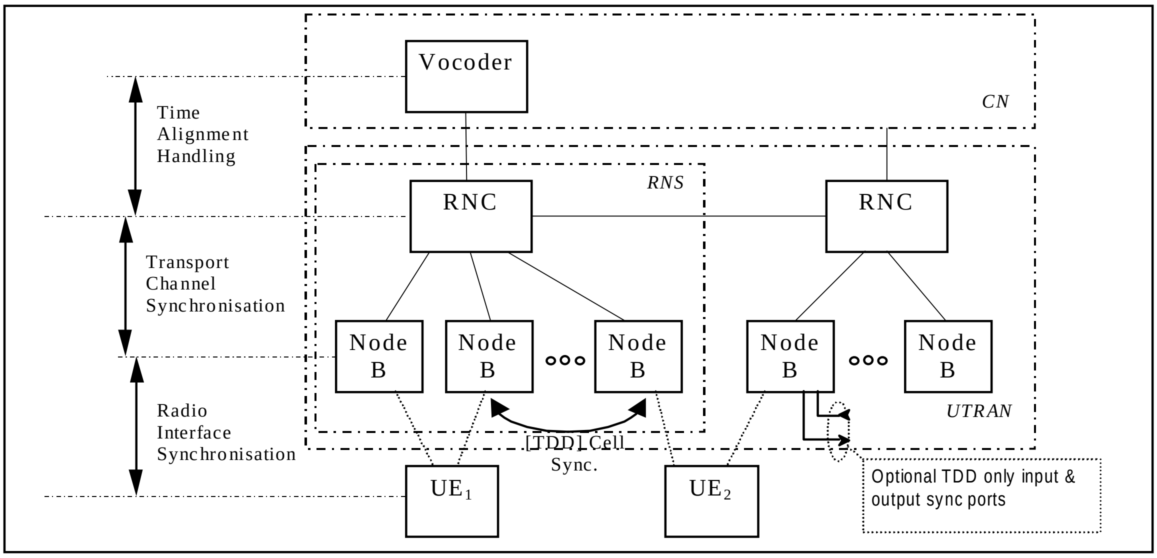


Figure 1: Synchronisation Issues Model

The UTRAN solutions for most of the identified items are described in clauses 6-10. Additional information on UTRAN synchronisation issues and the detailed specification of UTRAN solutions can be found in the following Technical Specifications:

- Summary of UTRAN Synchronisation Issues:

  TS 25.401 "UTRAN Overall Description", clause 9.

- Network Synchronisation:

  TS 25.411 "UTRAN Iu Interface Layer 1", subclause 4.2.

- RNC-Node B Node Synchronisation:

  TS 25.427 "Iub/Iur Interface User Plane Protocol for DCH Data Streams", subclause 8.5;

  TS 25.435 "UTRAN Iub Interface User Plane Protocols for COMMON TRANSPORT CHANNEL Data Streams", subclause 5.2.

- Transport Channel Synchronisation:

  TS 25.427 "Iub/Iur Interface User Plane Protocol for DCH Data Streams", subclauses 8.2 – 8.3;

  TS 25.435 "UTRAN Iub Interface User Plane Protocols for COMMON TRANSPORT CHANNEL Data Streams", subclauses 5.3 – 5.4.

- Time Alignment Handling:

  TS 25.415 "UTRAN Iu Interface User Plane Protocols", subclauses 6.5.4.

4.2 Network Synchronisation

The Network Synchronisation relates to the stability of the clocks in the UTRAN. The standard specifies the performance requirements on UTRAN internal interfaces. Depending on the L1 adopted for each interface, the clock stability required shall be according to references [8] and [9].

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 ~~is necessary~~ 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 ~~Radio Frame~~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:~~is necessary for various reasons~~:

- ~~Radio Frame~~Intercell Synchronisation that is used to synchronise radio frames within neighbouring cells in order to minimise cells cross-interference~~;~~ ,

  ~~- Multi frame Synchronization is used~~ to allow frame wise hopping mechanisms among cells (e.g. Cell Parameter Cycling according to Ref. [12]~~TS25.223~~) and to make procedures involving more ~~Nodes B~~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.

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.

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] The DOFF (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 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.

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

[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.

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.

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.
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.
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 14). 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 14). 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 8). 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).

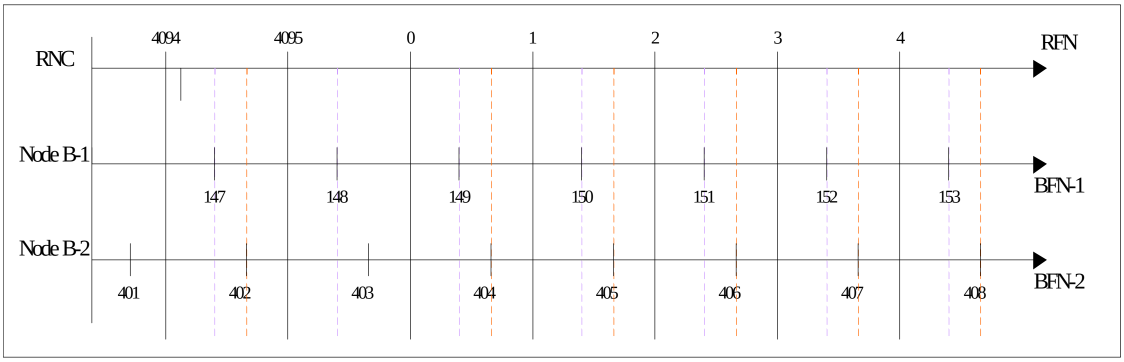


Figure 2: Timing of UTRAN counters

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 ~~is needed~~ in TDD to ~~allow~~ support ~~Radio Frame~~Cell Synchronisation~~, i.e. the phase differences among Node B's clocks shall be compensated~~.

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 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 could occur. If a Network synchronisation reference isn't available or is poor, 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 e.g. the Node B's).

In the RNC-Node B Node Synchronisation procedure, the RNC sends a DL Node Synchronisation control frame to Node B containing the parameter t1. Upon reception of a DL Synchronisation control frame, the Node B shall respond with UL Synchronisation Control Frame, indicating t2 and t3, as well as t1 which was indicated in the initiating DL Node Synchronisation control frame (see Figure 3).

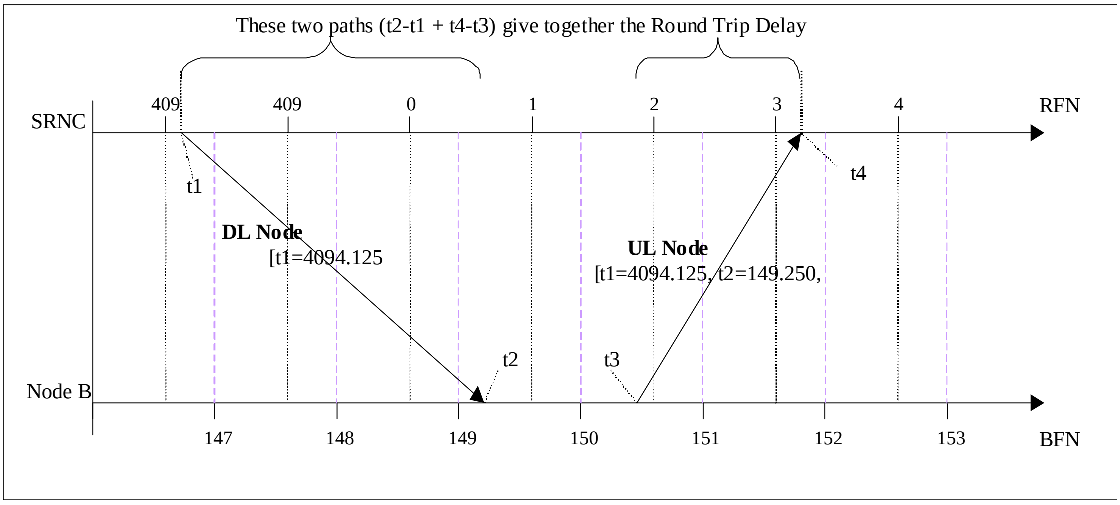


Figure 3: RNC-Node B Node Synchronisation

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).

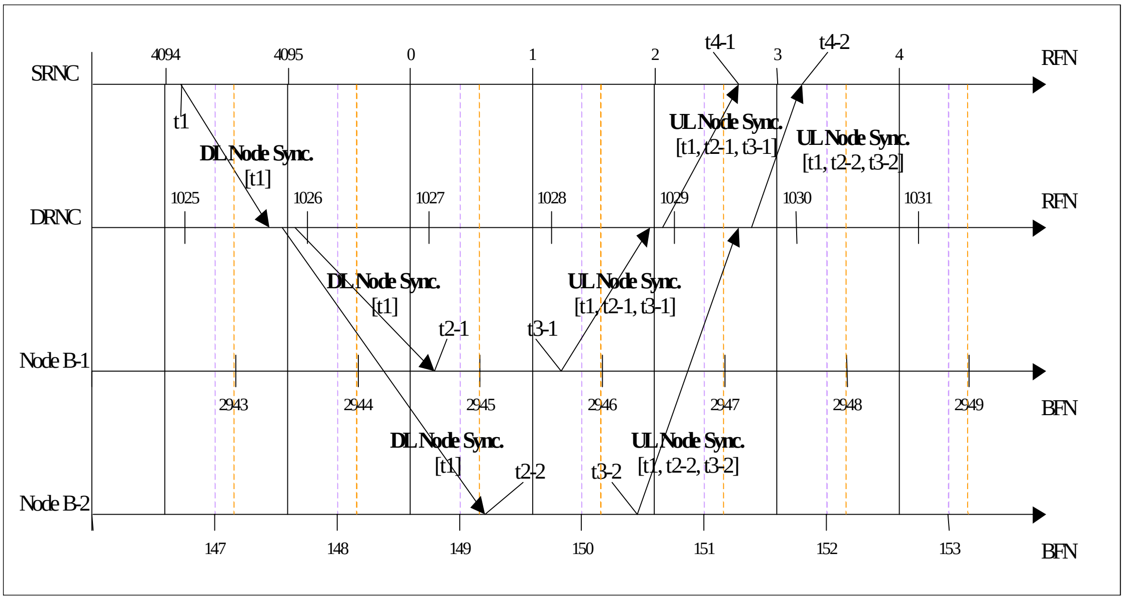


Figure 4: [FDD - RNC-Node B Node Synchronisation during soft handover with selection/recombining in the DRNC]

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.

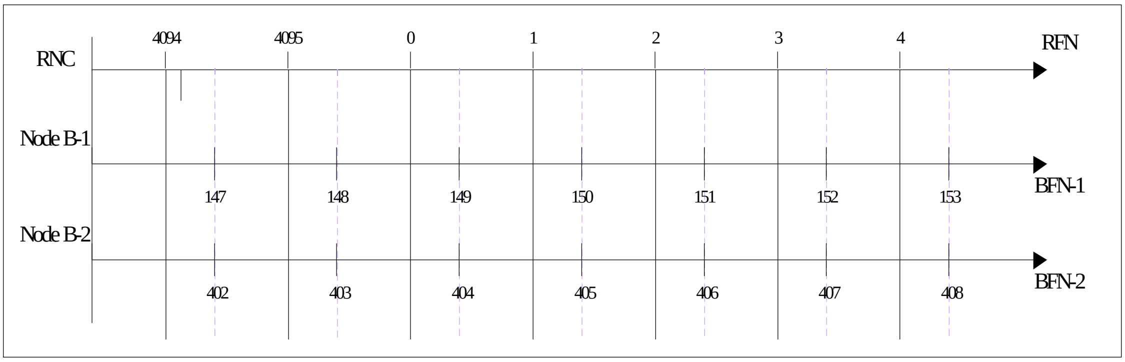


Figure 5: Synchronisation of BFNs through TDD Inter Node B Synchronisation

In TDD ~~may have several solutions for~~ Inter Node B Node Synchronisation may be achieved~~:~~

- ~~Synchronisation of Node B's to an external reference~~ via a standardised synchronisation port (see subclause 6.1.2.1) that allows to synchronise the Node B to an external reference.~~;~~

- ~~Synchronisation of Node B's on the air-interface, e.g. through Node B's cross measurements.~~

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).

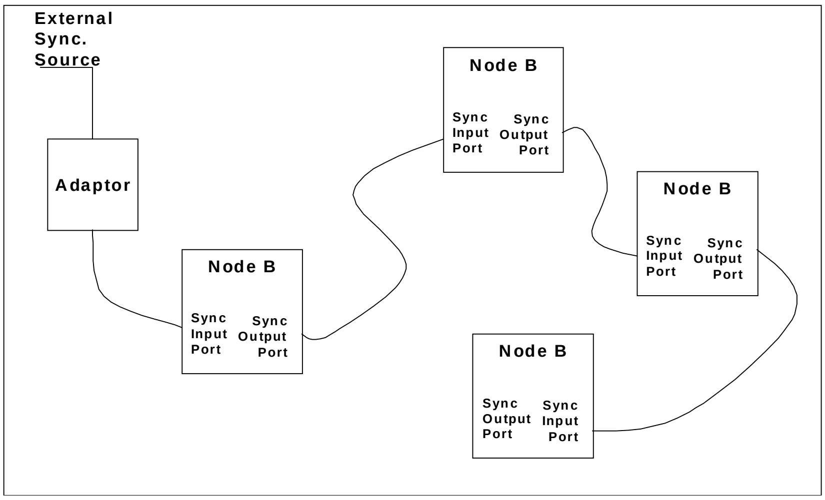


Figure 6: Usage of Synchronisation Ports

This allows to connect 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 propagation delay between the input and output synchronisation ports shall not exceed 500 ns.

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 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 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 Node B's shall not exceed 5 µs.

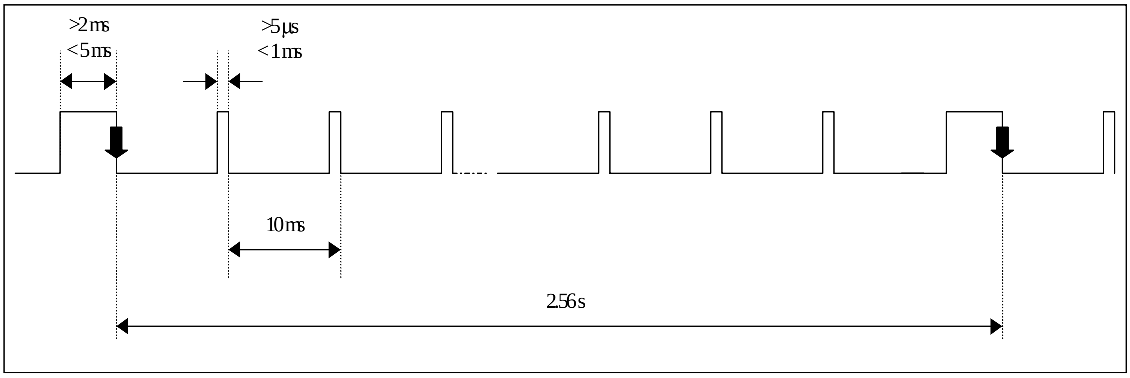


Figure 7: Synchronisation signal

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~~

~~In TDD it is assumed that all the cells belonging to the same Node B are synchronised among each other. This means that as Inter Node B Node Synchronisation is achieved, also cells belonging to those Node B's are synchronised.~~

~~In order to achieve Inter Node B Node Synchronisation several solutions can be applied.~~

~~In the procedure described in this subclause it is assumed that Node Bs may be synchronised through an external reference (e.g. GPS) connected to the input synchronisation port defined in subclause 6.1.2.1. The other Node Bs may be synchronised through Node B's cross measurements on the air interface.~~

~~All the Node B's that are synchronised through the external source become Reference; all the other Node B's are synchronised via the air through a master-slave mechanism.~~

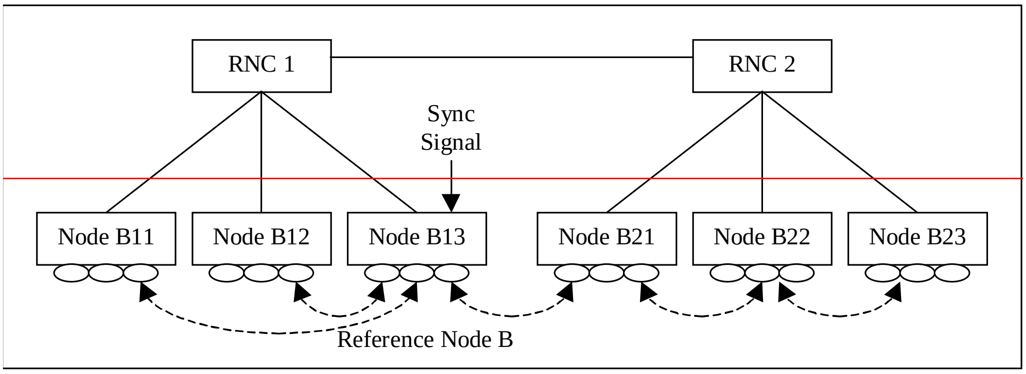
~~Note that in case of isolated area one of the Node B's could act as a free-running reference, i.e. as a reference not connected to an external source.~~

~~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 Node B's that cannot listen to cells belonging to other Node B's shall be synchronised through their synchronisation port (i.e. they are References as well).~~

~~Note that the propagation delay between a slave cell and its master cell can be determined through cells cross measurements. This allows the slave cell to take into account this propagation delay when synchronising to its master.~~

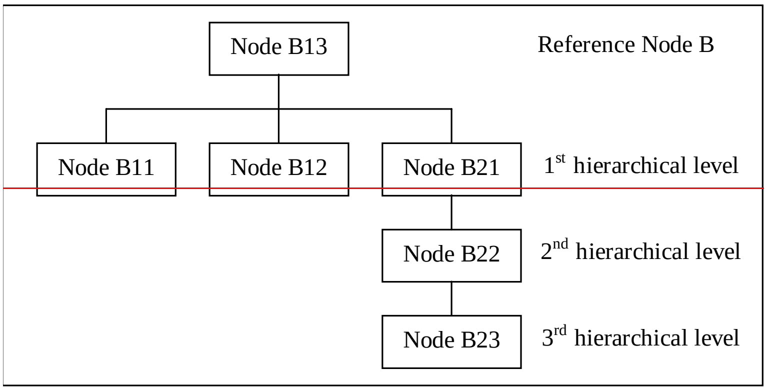
~~The Inter Node B Node Synchronisation procedure is shown in Figure 8.~~



~~**Figure 8: TDD Inter Node B Node Synchronisation**~~

~~In the example of Figure 8 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).~~

~~The synchronisation hierarchy for the example of Figure 8 is shown in Figure 9.~~



~~**Figure 9: TDD Synchronisation Hierarchy**~~

8 Radio Interface Synchronisation

8.1 General

8.2 FDD Radio Interface Synchronisation

8.3 TDD Radio Interface Synchronisation

8.3.1 General

The TDD Radio Interface Synchronisation relates to the following ~~three~~ two aspects:

- ~~Radio Frame~~Intercell Synchronisation;
- ~~Multiframe Synchronisation,~~
- Timing Advance.

In TDD mode ~~Radio Frame~~Intercell Synchronisation ~~among Node B's is~~may be achieved by means of :

- ~~the~~ Inter Node B Node Synchronisation that allows to achieve a common timing reference among Node B's.

The Radio Interface Synchronisation between UE and UTRAN is achieved by means of the Timing Advance mechanism.

8.3.2 ~~Radio Frame~~Intercell Synchronisation

~~Radio Frame~~Intercell Synchronisation ~~is necessary to~~ ensures that the ~~uplink/downlink switching points~~frame boundaries are positioned at the same time instant ~~at least~~ in adjacent cells (see Figure 18).

This requirement is necessary to minimise the interference between UEs ~~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.

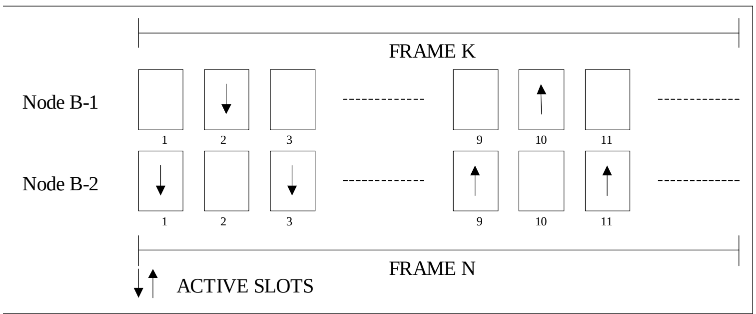


Figure 18: ~~Radio Frame~~Intercell Synchronisation

~~8.3.3 Multi Frame Synchronisation~~

Furthermore, Intercell Synchronisation assures the

~~In this subclause, the term multiframe is used to refer to a sequence of 256 radio frames starting with an SFN with SFN mod 256 = 0. Hence multiframe synchronisation means the synchronization of the last 8 bits of the SFN (i.e. in Figure , N mod 256 = K mod 256).~~

~~The~~ synchronisation ~~on~~ of the last 8 bits of the SFN, that is required if frame wise hopping mechanisms among cells are used. It also can be used to keep more efficient and faster all procedures involving a switch from one ~~Node-B~~cell to another, such as searching for new ~~Base Stations~~cells, locking to new ~~Base Stations~~cells or handover.

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