TSG-RAN Meeting #14 **_TSGRP#14(01) 0846_**
Kyoto, Japan, 11 - 14, December, 2001

Title: **Agreed CRs to TS 25.402**

Source: **TSG-RAN WG3**

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

RP Tdoc	R3 Tdoc	Spec	CR_Num	Rev	Release	CR_Subject	Cat	Cur_Ver	New_Ver	Workitem
RP-010846	R3-013699	25.402	029	2	R99	CFN Calculation for UE	F	3.7.0	3.8.0	TEI
RP-010846	R3-013700	25.402	030	2	Rel-4	CFN Calculation for UE	A	4.2.0	4.3.0	TEI

3GPP TSG-RAN WG3 Meeting #25
Makuhari, Japan, November 26th-30th, 2001

Tdoc R3-013699

CR-Form-v4

CHANGE REQUEST

⌘ **25.402 CR 029** ⌘ ev **2** ⌘ Current version: **3.7.0** ⌘

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

Proposed change affects: ⌘ (U)SIM [ ] ME/UE [ ] Radio Access Network [X] Core Network [ ]

Title: ⌘	Correction to CFN Calculation for UE
Source: ⌘	R-WG3
Work item code: ⌘	TEI
Date: ⌘	November 30, 2001
Category: ⌘	**F**
Release: ⌘	R99

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

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

Use one of the following releases:
- *2 (GSM Phase 2)*
- *R96 (Release 1996)*
- *R97 (Release 1997)*
- *R98 (Release 1998)*
- *R99 (Release 1999)*
- *REL-4 (Release 4)*
- *REL-5 (Release 5)*

Reason for change: ⌘ The formula for determining the CFN within the UE is incorrect and not in alignment with Figure 15 in TS 25.402. Also, the specification is not clear about the frames to which the formula is referring.

Summary of change: ⌘ The formula is corrected to:

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

and the following definition is added:

'This formula gives the CFN of the downlink DPCH frame which starts at the same time as or which starts during the PCCPCH frame with the given SFN.'

Impact Analysis:

Impact assessment towards the previous version of the specification (same release):

This CR has non isolated impact with the previous version of the specification (same release) because specification was not sufficiently explicit and contained some contradiction with another specification. This CR would not affect implementations based on Figure 15, would affect implementations based on the old formula.

---- ONLY if there is impact following shall also be included: ----

This CR has an impact under functional point of view.
The impact cannot be considered isolated because the change affects every function requiring tight synchronisation between the CFN in the UE and the CFN in the UTRAN (e.g. ciphering, synchronous RL reconfiguration).

Consequences if not approved: ⌘ If not approved the calculation of CFN the will be ambiguous. This could lead to UEs and all UTRAN nodes with incorrect implementations of the CFN calculation

		and cause layer 1, 2, and 3 interoperability problems.

Clauses affected:	⌘	8.2.1, 9.1, 9.3.1, 9.3.1A, 9.5			
Other specs affected:	⌘	X	Other core specifications	⌘	TS 25.402 v4.2.0 CR 030 TS 25.331 CR 1167
			Test specifications		
			O&M Specifications		
Other comments:	⌘	See R2-012549 for further explanation.			

How to create CRs using this form:

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

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

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

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

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.

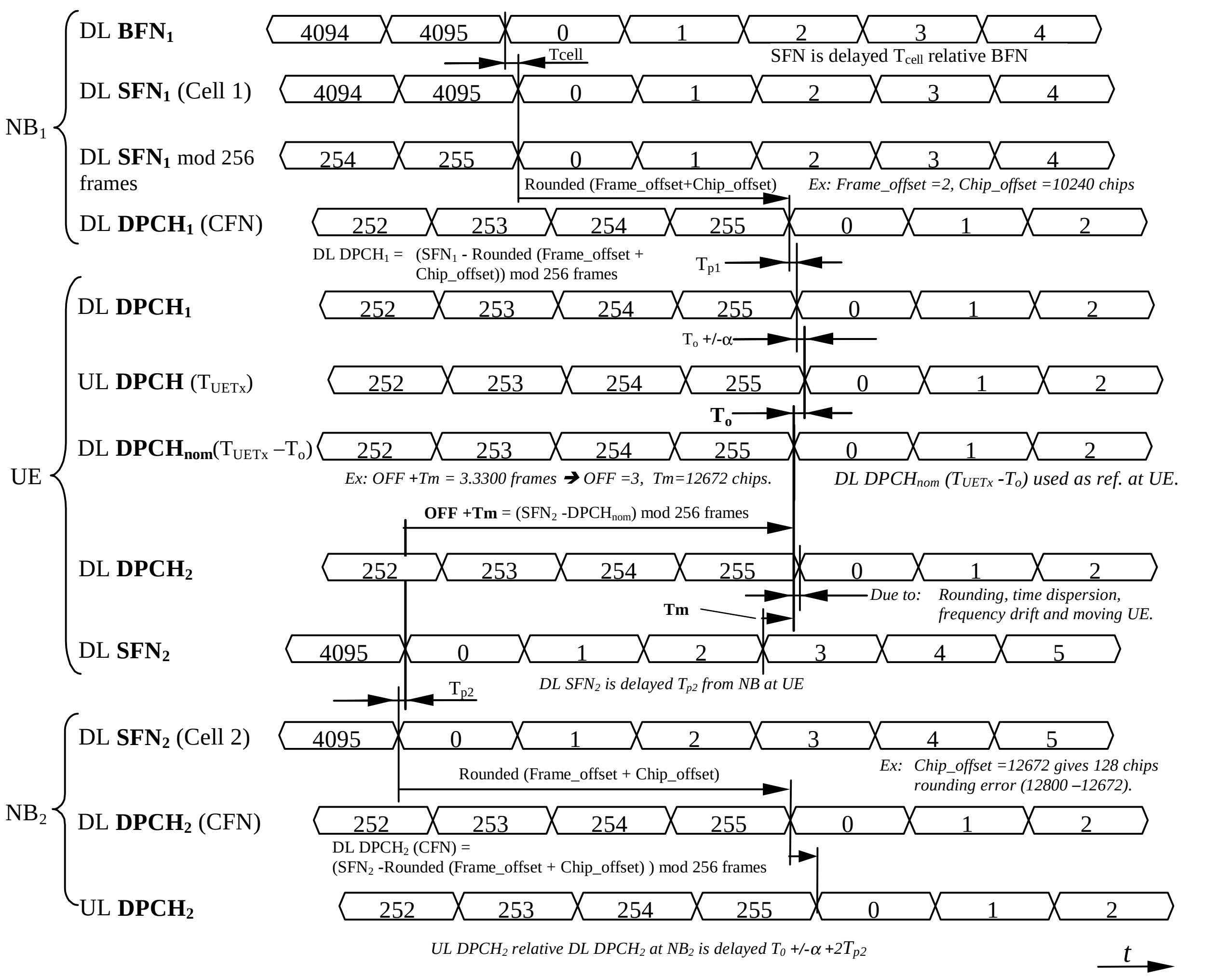
Services are scheduled by using $DOFF_{FDD}$ in order to average out the Iub traffic load and the Node B processing load. $DOFF_{FDD}$ (FDD Default DPCH Offset value) is only used when setting up the first RL in order to initialise Frame Offset and Chip Offset and to tell UE when frames are expected.

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 15 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 15: 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$_2$~~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. Time dispersion and UE movements are examples of other factors affecting this phase deviation.

The nominal DL DPCH timing at UE is T_o before the T_{UETX} time instant, which could be expressed:

$$DL\ DPCH_{nom} = T_{UETX} - T_o \qquad (8.1)$$

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

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

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

EXAMPLE 1: Assume that OFF + T_m equals "3.3300" frames (as given as an example in Figure 158). 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 158):

- 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 2: (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

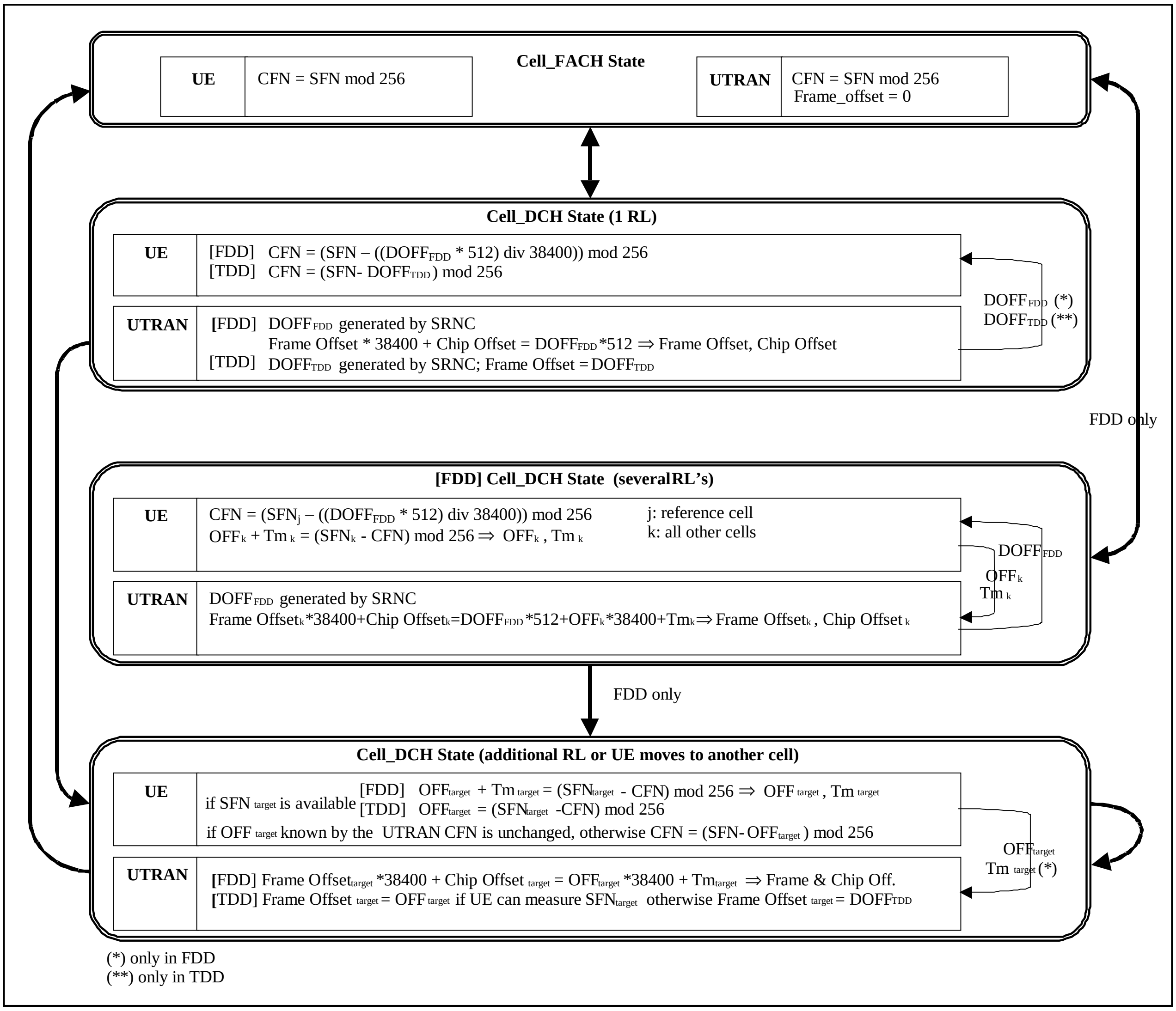
9.1 General

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


Cell_FACH State
UE
CFN = SFN mod 256
UTRAN
CFN = SFN mod 256
Frame_offset = 0
Cell_DCH State (1 RL)
UE
[FDD] CFN = (SFN – ((DOFFFDD * 512) div 38400)) mod 256
[TDD] CFN = (SFN- DOFFTDD) mod 256
UTRAN
[FDD] DOFFFDD generated by SRNC
Frame Offset * 38400 + Chip Offset = DOFFFDD*512 ⇒ Frame Offset, Chip Offset
[TDD] DOFFTDD generated by SRNC; Frame Offset = DOFFTDD
DOFFFDD (*)
DOFFTDD (**)
FDD only
[FDD] Cell_DCH State (several RL's)
UE
CFN = (SFNj – ((DOFFFDD * 512) div 38400)) mod 256
OFFk + Tm k = (SFNk - CFN) mod 256 ⇒ OFFk , Tm k
j: reference cell
k: all other cells
UTRAN
DOFFFDD generated by SRNC
Frame Offsetk*38400+Chip Offsetk=DOFFFDD*512+OFFk*38400+Tmk⇒ Frame Offsetk , Chip Offset k
DOFFFDD
OFFk
Tm k
FDD only
Cell_DCH State (additional RL or UE moves to another cell)
UE
if SFN target is available
[FDD] OFFtarget + Tm target = (SFNtarget - CFN) mod 256 ⇒ OFF target , Tm target
[TDD] OFFtarget = (SFNtarget -CFN) mod 256
if OFF target known by the UTRAN CFN is unchanged, otherwise CFN = (SFN- OFFtarget) mod 256
UTRAN
[FDD] Frame Offsettarget *38400 + Chip Offset target = OFFtarget *38400 + Tmtarget ⇒ Frame & Chip Off.
[TDD] Frame Offset target = OFF target if UE can measure SFNtarget otherwise Frame Offset target = DOFFTDD
OFFtarget
Tm target (*)
(*) only in FDD
(**) only in TDD

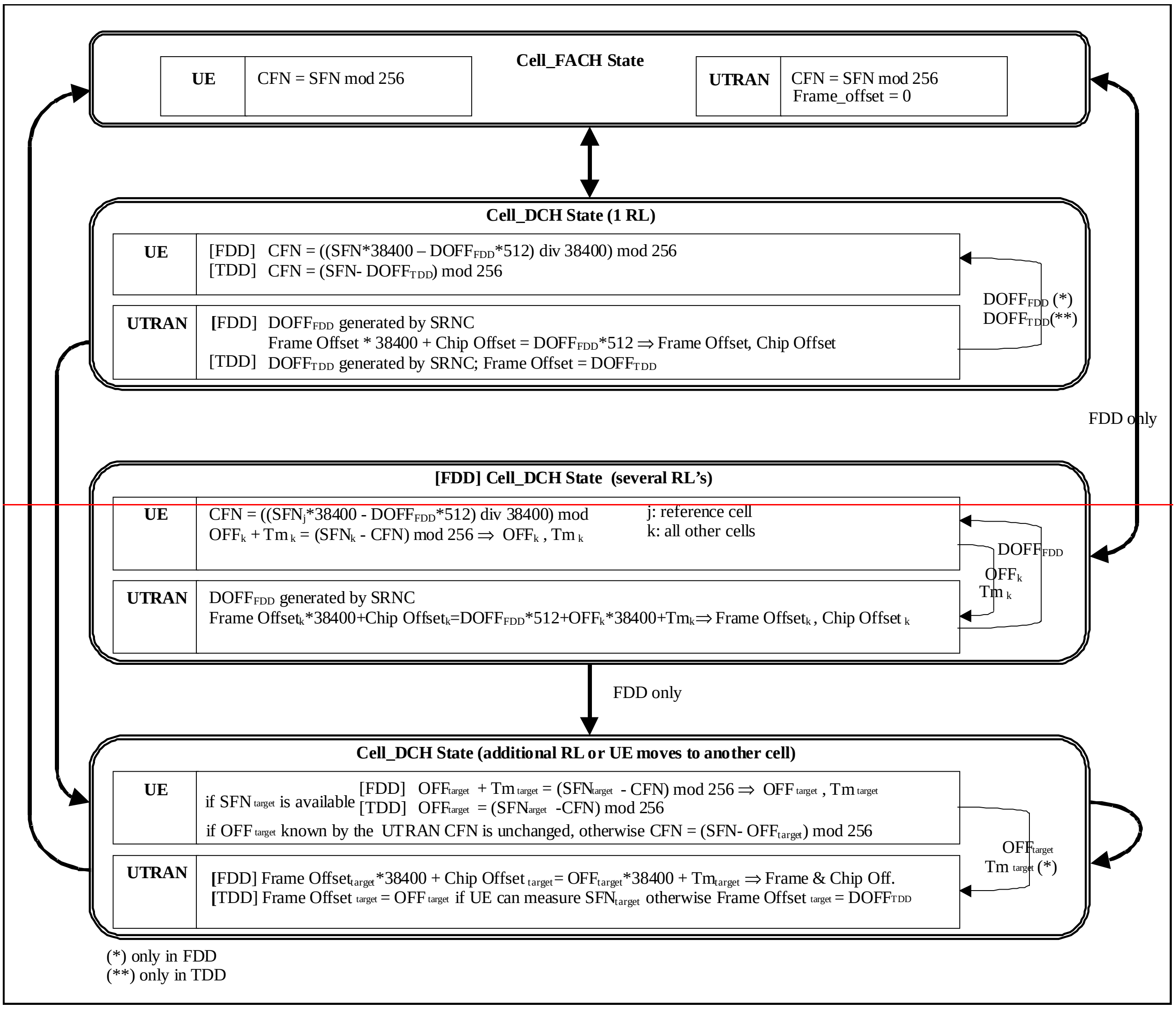


Figure 17: Calculations performed by UE and UTRAN

Figure 18 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).

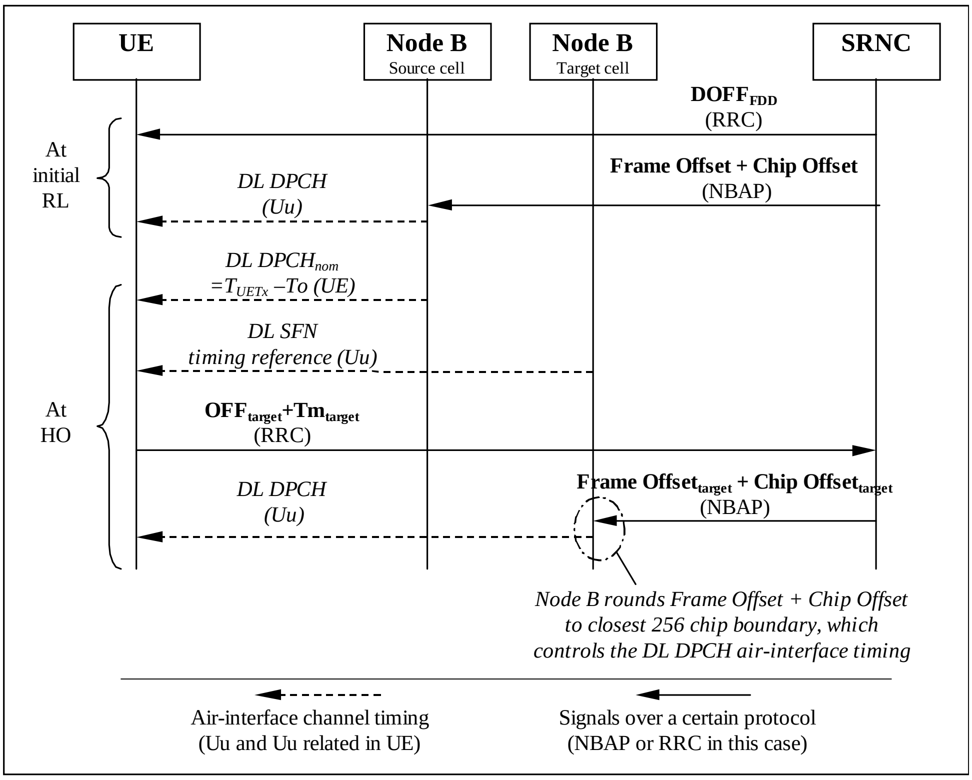


Figure18: [FDD - Usage of Offset values at initial RL and at HO]

Figure 19 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.

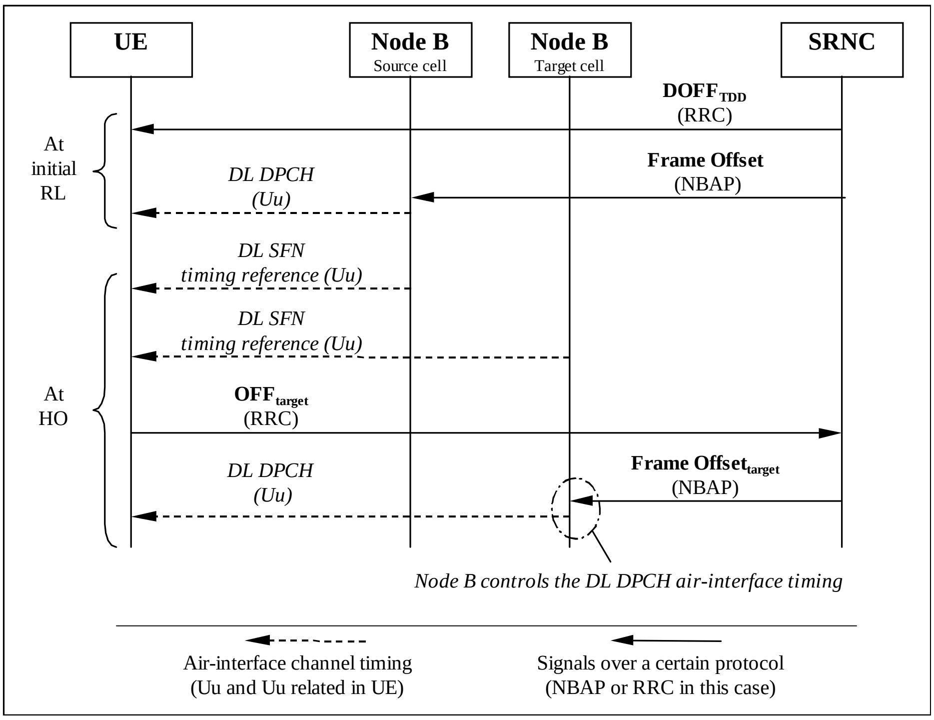


Figure 19: [TDD- Usage of Offset values at initial RL and at HO]

9.2 Calculations performed in the UTRAN

9.2.1 UE in CELL_FACH/PCH state

In CELL_FACH/PCH state 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 $DOFF_{FDD}$ 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 Frame Offset = $DOFF_{TDD}$.

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 $DOFF_{FDD}$ 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 (9.2) is covering formula (9.1) since in the case described in subclause 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: addition of a new RL or handover to 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 Frame $Offset_{target}$ and the 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 Frame $Offset_{target}$ and the Chip $Offset_{target}$ with formula (9.1).

Frame $Offset_{target}$ and 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 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 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

9.3.A UE in CELL_FACH/PCH state

In CELL_FACH/PCH state 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):

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

This formula gives the CFN of the downlink DPCH frame which starts at the same time as or which starts during the PCCPCH frame with the given SFN.]

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

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

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

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

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

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 (9.6):

$$OFF_k + Tm_k = (SFN_k - CFN) \text{ mod } 256 \quad (9.6)$$

After having performed OFF_k and Tm_k measurements for all target cells, the UE initialises the CFN with the value given by formula (9.7), based on the received $DOFF_{FDD}$ and the SFN_j of the reference cell:

$$CFN = (SFN_j - ((DOFF_{FDD} * 512) \text{ div } 38400)) \ ((SFN_j*38400 - DOFF_{FDD}*512) \text{ div } 38400) \text{ mod } 256 \quad (9.7)$$

This formula gives the CFN of the downlink DPCH frame which starts at the same time as or which starts during the PCCPCH frame with the given SFN.

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

9.3.2 UE in CELL_DCH state: addition of a new RL or handover to 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 - In case the SFN_{target} can be measured, 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.]

[TDD - In case the SFN_{target} can be measured, 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 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.

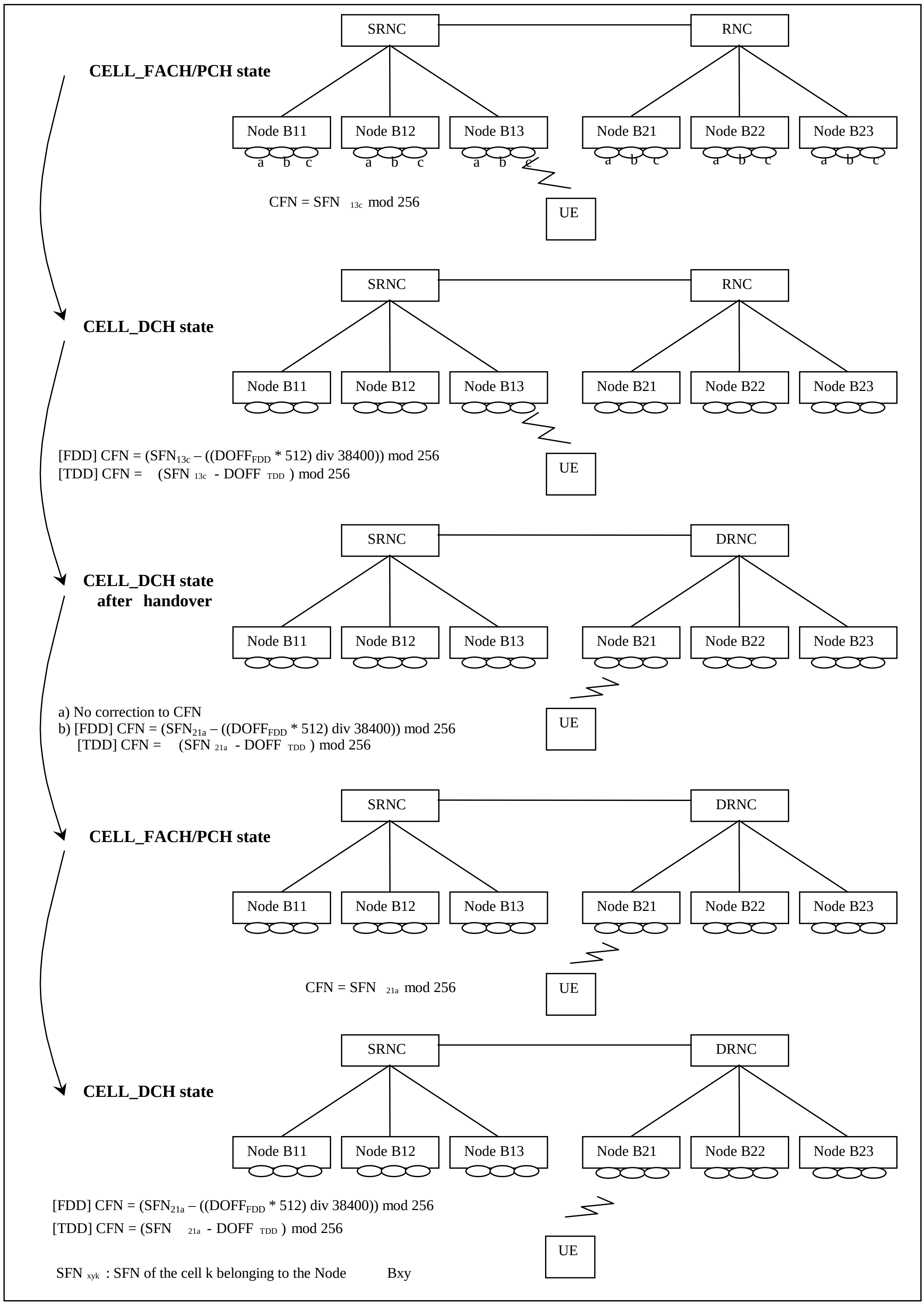
9.4 Synchronisation of L1 configuration changes

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 20 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 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
a b c
CFN = SFN 13c mod 256
UE
CELL_DCH state
[FDD] CFN = (SFN13c – ((DOFFFDD * 512) div 38400)) mod 256
[TDD] CFN = (SFN 13c - DOFF TDD) mod 256
CELL_DCH state
after handover
DRNC
a) No correction to CFN
b) [FDD] CFN = (SFN21a – ((DOFFFDD * 512) div 38400)) mod 256
[TDD] CFN = (SFN 21a - DOFF TDD) mod 256
CELL_FACH/PCH state
CFN = SFN 21a mod 256
CELL_DCH state
[FDD] CFN = (SFN21a – ((DOFFFDD * 512) div 38400)) mod 256
[TDD] CFN = (SFN 21a - DOFF TDD) mod 256
SFN xyk : SFN of the cell k belonging to the Node Bxy

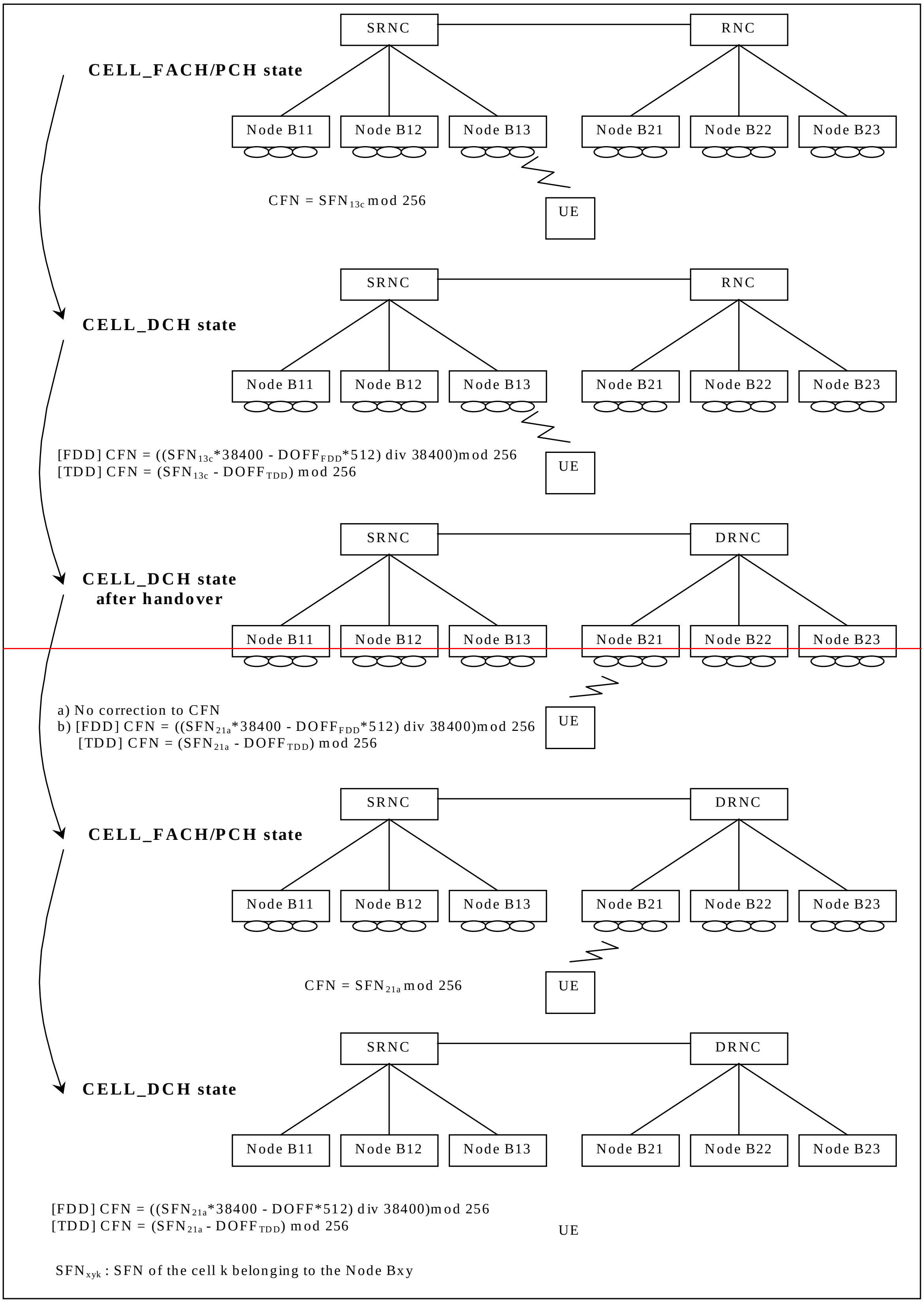
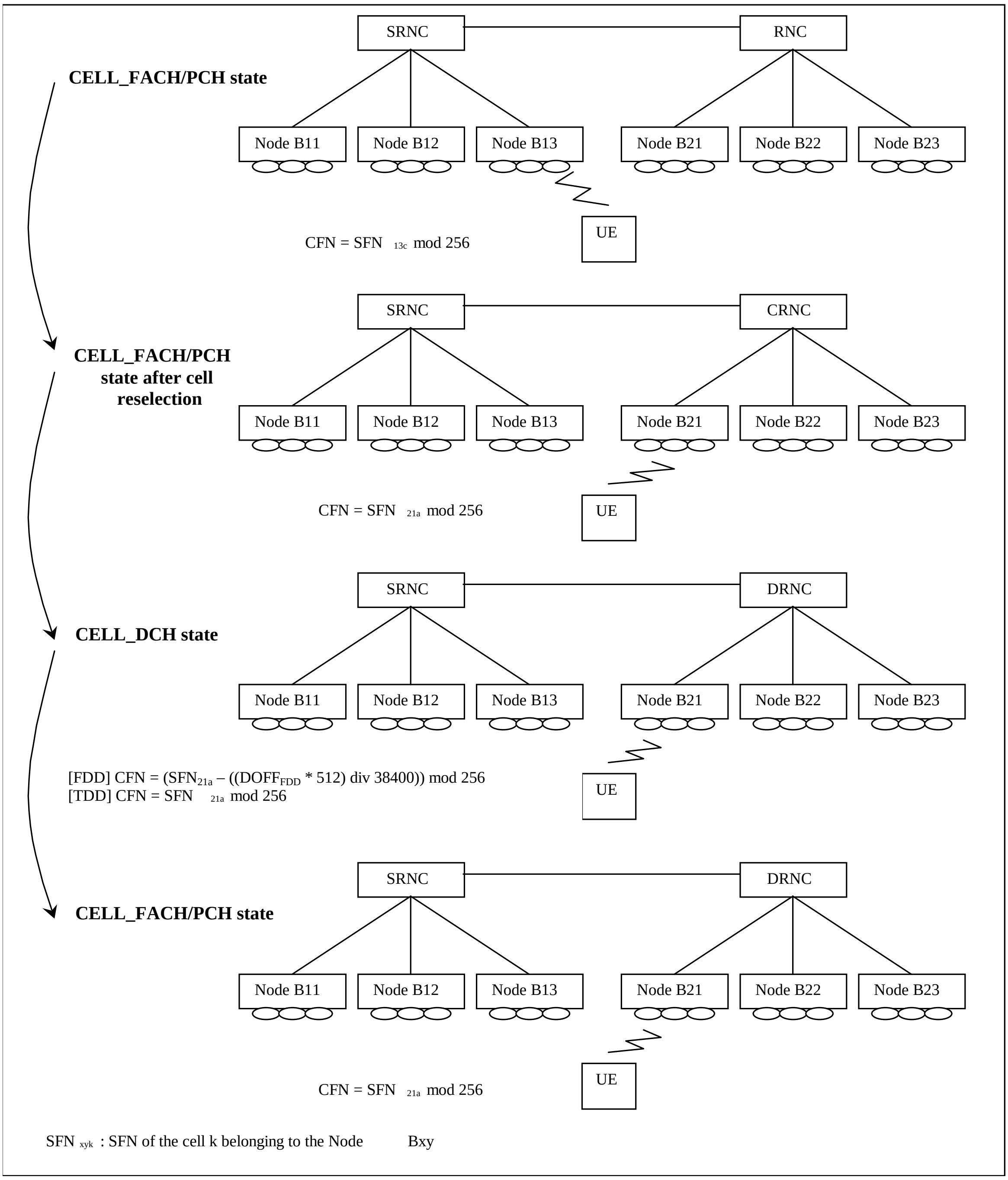


Figure 20: Example 1

The example of Figure 21 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.


SRNC
RNC
CELL_FACH/PCH state
Node B11
Node B12
Node B13
Node B21
Node B22
Node B23
UE
CFN = SFN 13c mod 256
SRNC
CRNC
CELL_FACH/PCH state after cell reselection
Node B11
Node B12
Node B13
Node B21
Node B22
Node B23
CFN = SFN 21a mod 256
UE
SRNC
DRNC
CELL_DCH state
Node B11
Node B12
Node B13
Node B21
Node B22
Node B23
[FDD] CFN = (SFN21a – ((DOFFFDD * 512) div 38400)) mod 256
[TDD] CFN = SFN 21a mod 256
UE
SRNC
DRNC
CELL_FACH/PCH state
Node B11
Node B12
Node B13
Node B21
Node B22
Node B23
CFN = SFN 21a mod 256
UE
SFN xyk : SFN of the cell k belonging to the Node Bxy

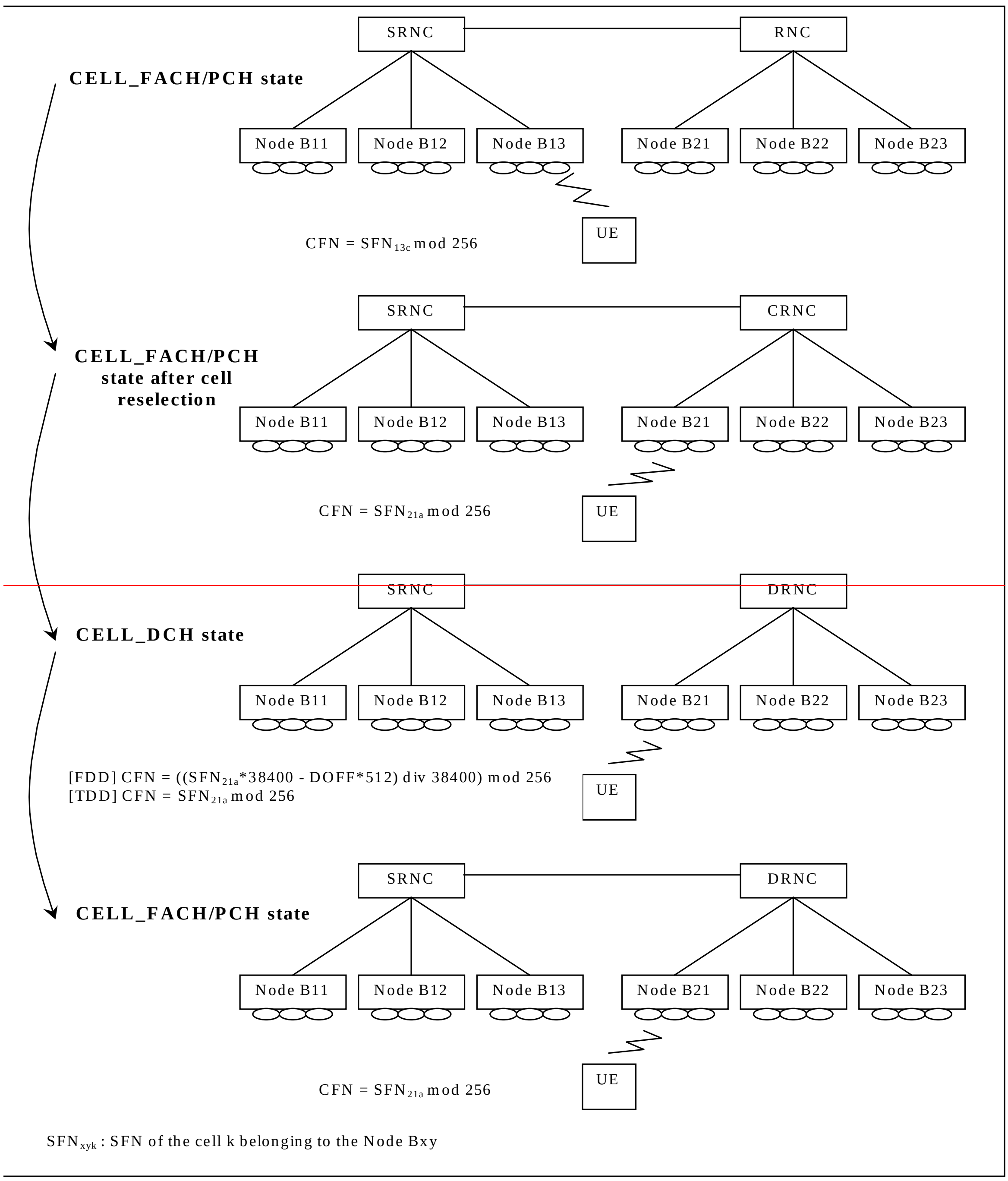
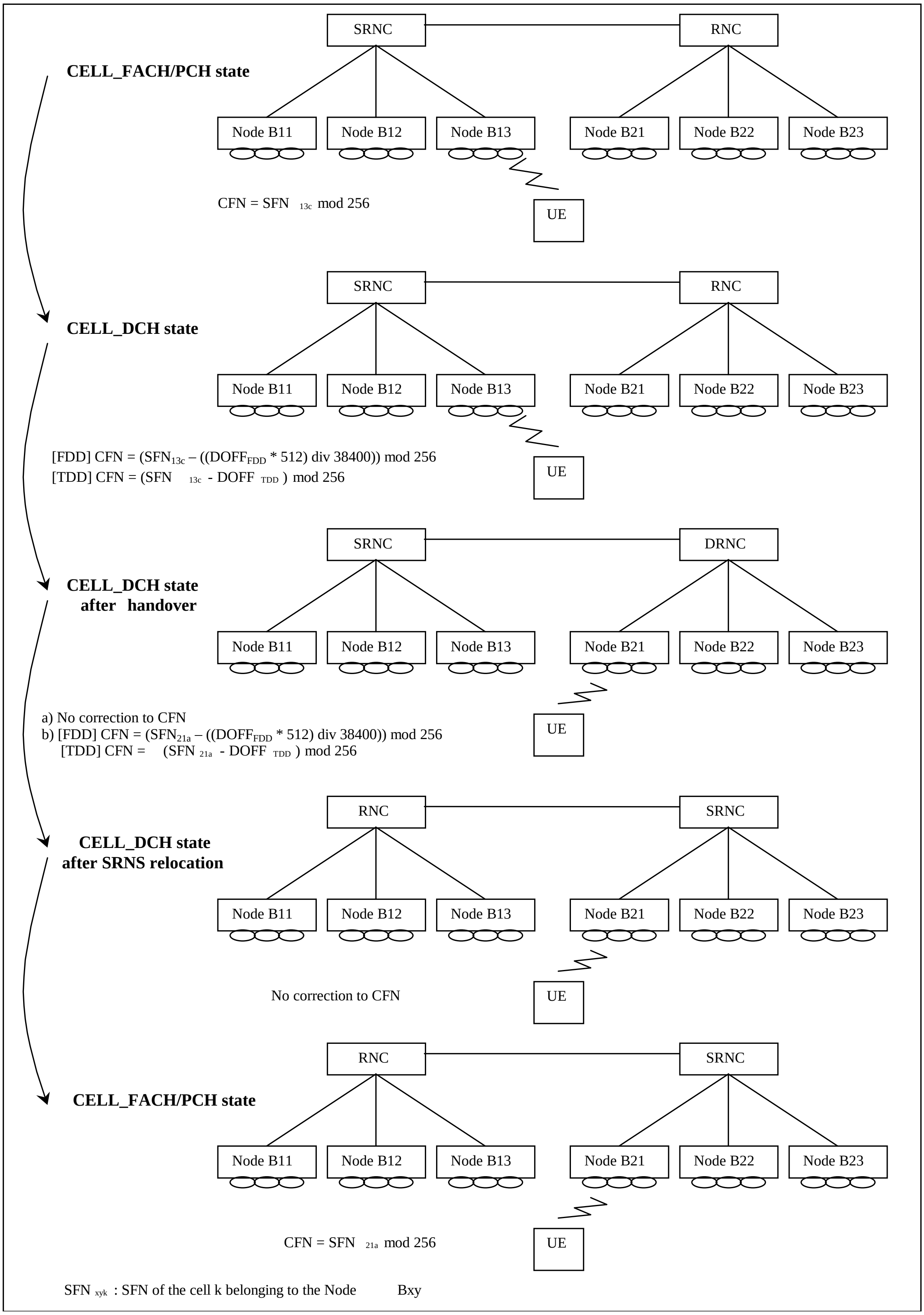


Figure 21: Example 2

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 and SRNS relocation (without UE involvement). In this example 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
UE
CFN = SFN 13c mod 256
CELL_DCH state
[FDD] CFN = (SFN13c – ((DOFFFDD * 512) div 38400)) mod 256
[TDD] CFN = (SFN 13c - DOFF TDD) mod 256
CELL_DCH state after handover
DRNC
a) No correction to CFN
b) [FDD] CFN = (SFN21a – ((DOFFFDD * 512) div 38400)) mod 256
[TDD] CFN = (SFN 21a - DOFF TDD) mod 256
CELL_DCH state after SRNS relocation
No correction to CFN
CELL_FACH/PCH state
CFN = SFN 21a mod 256
SFN xyk : SFN of the cell k belonging to the Node Bxy

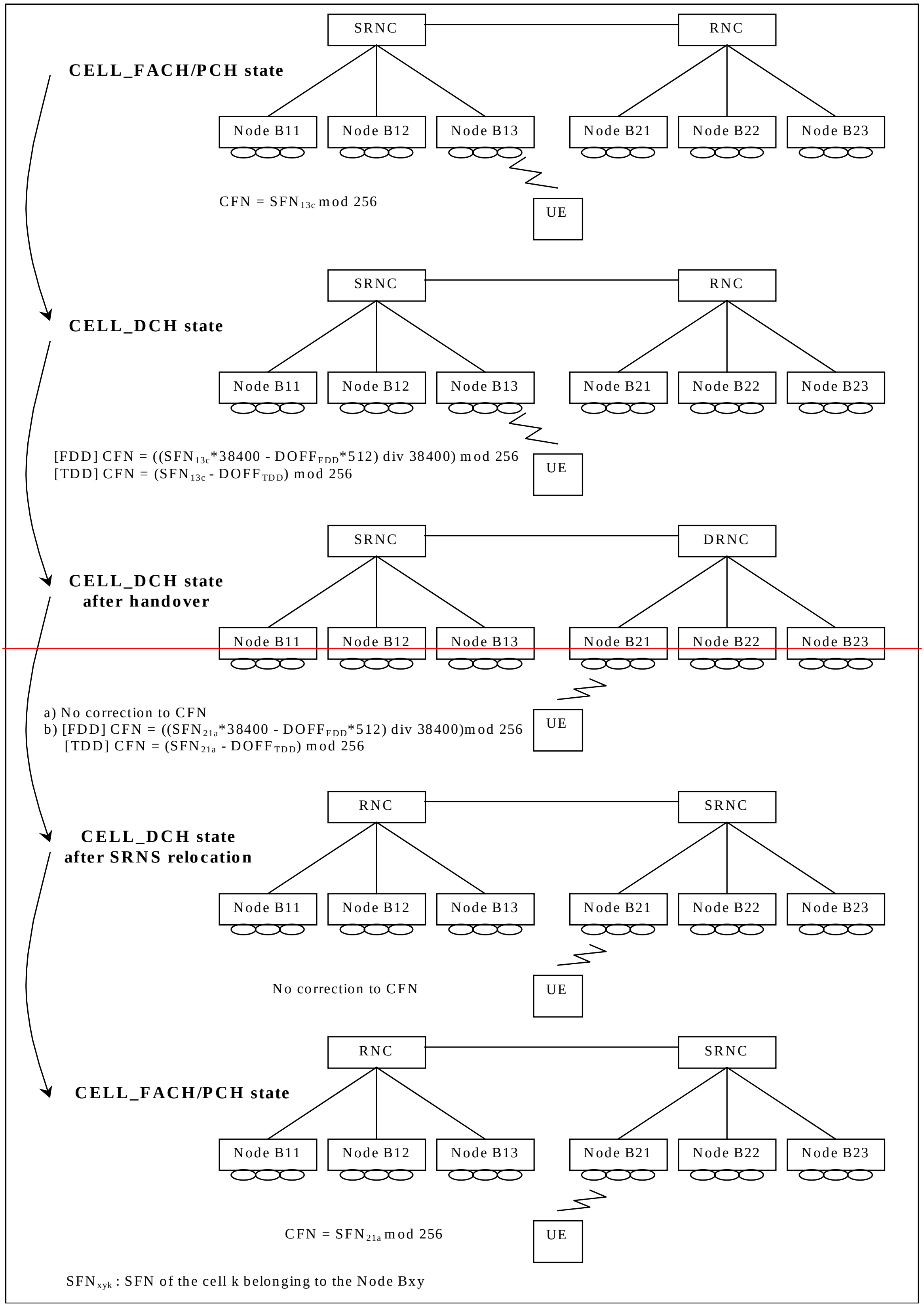


Figure 22: Example 3

3GPP TSG-RAN WG3 Meeting #25
Makuhari, Japan, November 26th -30th, 2001

Tdoc R3-013700

CR-Form-v4

CHANGE REQUEST

⌘ **25.402 CR 030**	⌘ ev **2**	⌘ Current version: **4.2.0**	⌘	

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

Proposed change affects: ⌘ (U)SIM [ ] ME/UE [ ] Radio Access Network [X] Core Network [ ]

Title:	⌘ Correction to CFN Calculation for UE		
Source:	⌘ R-WG3		
Work item code:	⌘ TEI	***Date:*** ⌘	November 3~~2~~0, 2001
Category:	⌘ **A** *Use one of the following categories:* ***F*** *(correction)* ***A*** *(corresponds to a correction in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)* Detailed explanations of the above categories can be found in 3GPP TR 21.900.	***Release:*** ⌘	REL-4 *Use one of the following releases:* *2 (GSM Phase 2)* *R96 (Release 1996)* *R97 (Release 1997)* *R98 (Release 1998)* *R99 (Release 1999)* *REL-4 (Release 4)* *REL-5 (Release 5)*

Reason for change: ⌘	The formula for determining the CFN within the UE is incorrect and not in alignment with Figure 15 in TS 25.402. Also, the specification is not clear about the frames to which the formula is referring.
Summary of change: ⌘	The formula is corrected to: CFN = (SFN - ((DOFF * 512) div 38400)) mod 256 and the following definition is added: 'This formula gives the CFN of the downlink DPCH frame which starts at the same time as or which starts during the PCCPCH frame with the given SFN.' Impact Analysis: Impact assessment towards the previous version of the specification (same release): This CR has non isolated impact with the previous version of the specification (same release) because specification was not sufficiently explicit and contained some contradiction with another specification. This CR would not affect implementations based on Figure 15, would affect implementations based on the old formula. ---- ONLY if there is impact following shall also be included: ---- This CR has an impact under functional point of view. The impact cannot be considered isolated because the change affects every function requiring tight synchronisation between the CFN in the UE and the CFN in the UTRAN (e.g. ciphering, synchronous RL reconfiguration).
Consequences if not approved: ⌘	If not approved the calculation of CFN the will be ambiguous. This could lead to UEs and all UTRAN nodes with incorrect implementations of the CFN calculation and cause layer

		1, 2, and 3 interoperability problems.		

Clauses affected:	⌘	8.2.1, 9.1, 9.3.1, 9.3.1A, 9.5		
Other specs affected:	⌘	X Other core specifications	⌘	TS 25.402 v3.7.0 CR 029 TS 25.331 CR 1168
		Test specifications		
		O&M Specifications		
Other comments:	⌘	See R2-012549 for further explanation.		

How to create CRs using this form:

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

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

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

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

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 80 ms) when entering in dedicated state from common channel state.

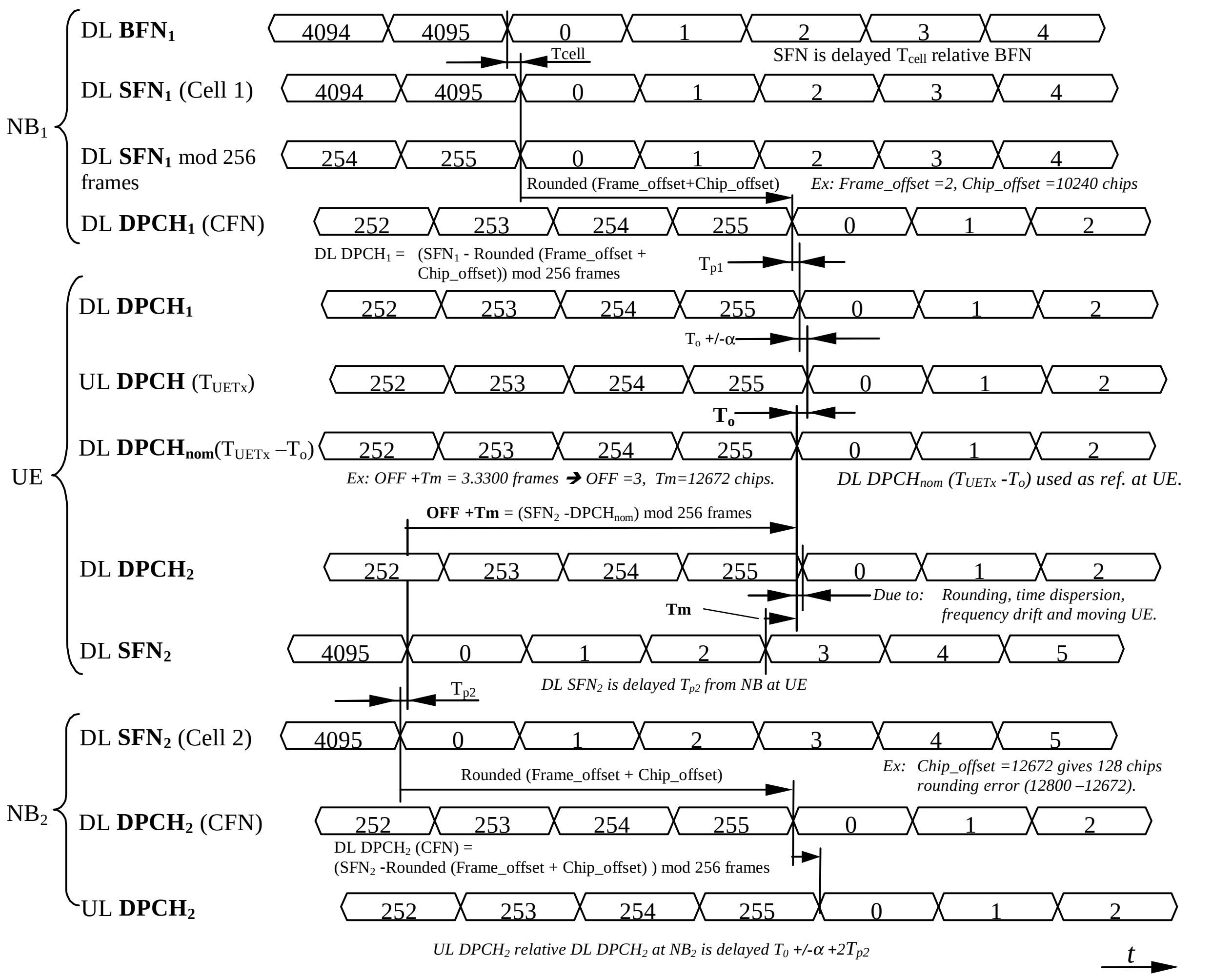
Services are scheduled by using $DOFF_{FDD}$ in order to average out the Iub traffic load and the Node B processing load. $DOFF_{FDD}$ (FDD Default DPCH Offset value) is only used when setting up the first RL in order to initialise Frame Offset and Chip Offset and to tell UE when frames are expected.

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 15 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 15: 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 $DPCH_2$ 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. Time dispersion and UE movements are examples of other factors affecting 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:

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

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

EXAMPLE 1: Assume that OFF + T_m equals "3.3300" frames (as given as an example in Figure 158). 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 158):

- 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 2: (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

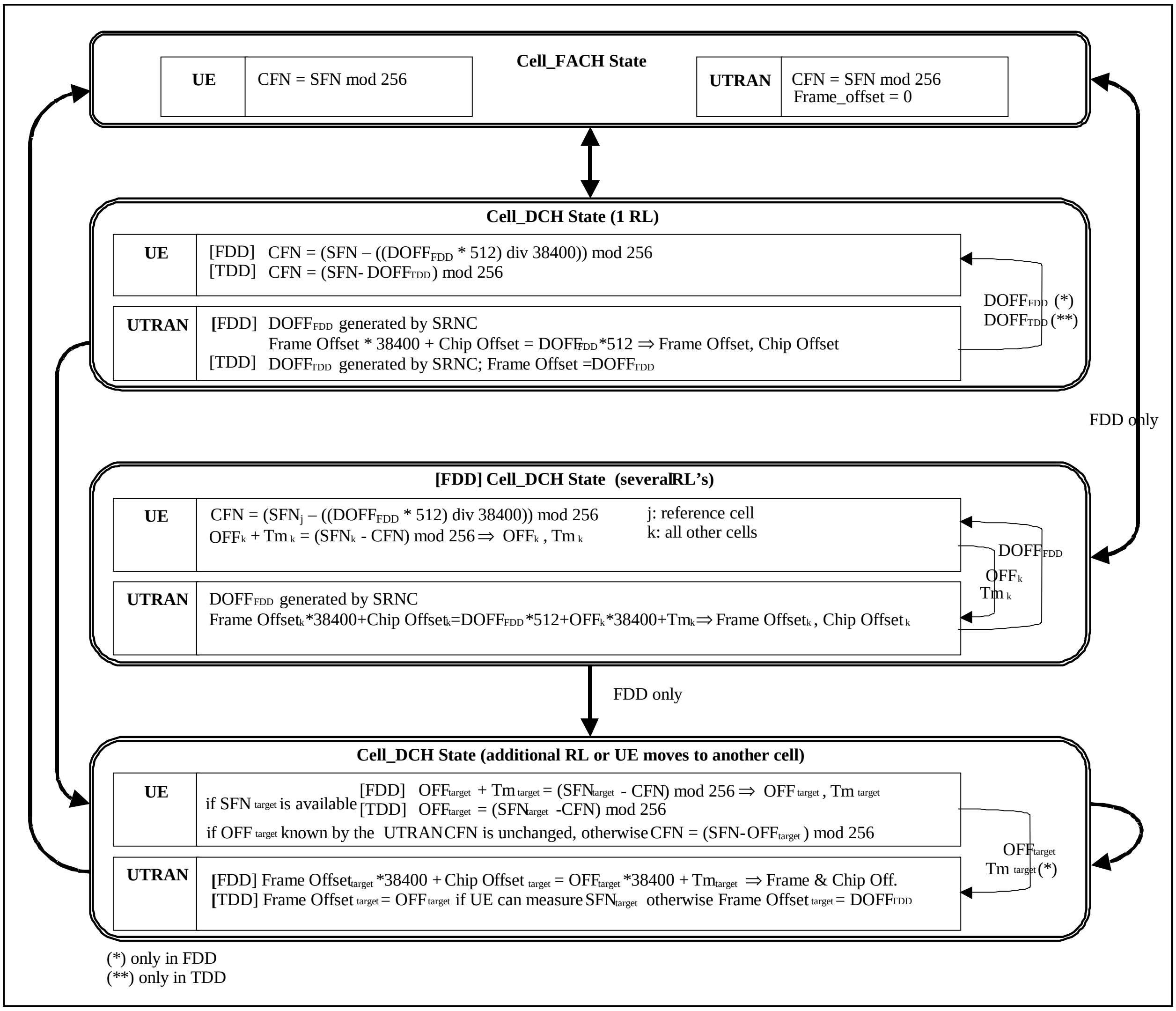
9.1 General

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 17 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.


Cell_FACH State
UE
CFN = SFN mod 256
UTRAN
CFN = SFN mod 256
Frame_offset = 0
Cell_DCH State (1 RL)
UE
[FDD] CFN = (SFN – ((DOFFFDD * 512) div 38400)) mod 256
[TDD] CFN = (SFN- DOFFTDD) mod 256
UTRAN
[FDD] DOFFFDD generated by SRNC
Frame Offset * 38400 + Chip Offset = DOFFFDD*512 ⇒ Frame Offset, Chip Offset
[TDD] DOFFTDD generated by SRNC; Frame Offset =DOFFTDD
DOFFFDD (*)
DOFFTDD (**)
FDD only
[FDD] Cell_DCH State (several RL's)
UE
CFN = (SFNj – ((DOFFFDD * 512) div 38400)) mod 256
OFFk + Tm k = (SFNk - CFN) mod 256 ⇒ OFFk , Tm k
j: reference cell
k: all other cells
UTRAN
DOFFFDD generated by SRNC
Frame Offsetk*38400+Chip Offsetk=DOFFFDD*512+OFFk*38400+Tmk ⇒ Frame Offsetk , Chip Offsetk
DOFFFDD
OFFk
Tm k
FDD only
Cell_DCH State (additional RL or UE moves to another cell)
UE
if SFN target is available
[FDD] OFFtarget + Tm target = (SFNtarget - CFN) mod 256 ⇒ OFF target , Tm target
[TDD] OFFtarget = (SFNtarget -CFN) mod 256
if OFF target known by the UTRAN CFN is unchanged, otherwise CFN = (SFN-OFFtarget) mod 256
UTRAN
[FDD] Frame Offsettarget *38400 + Chip Offset target = OFFtarget *38400 + Tmtarget ⇒ Frame & Chip Off.
[TDD] Frame Offset target = OFF target if UE can measure SFNtarget otherwise Frame Offset target = DOFFTDD
OFFtarget
Tm target (*)
(*) only in FDD
(**) only in TDD

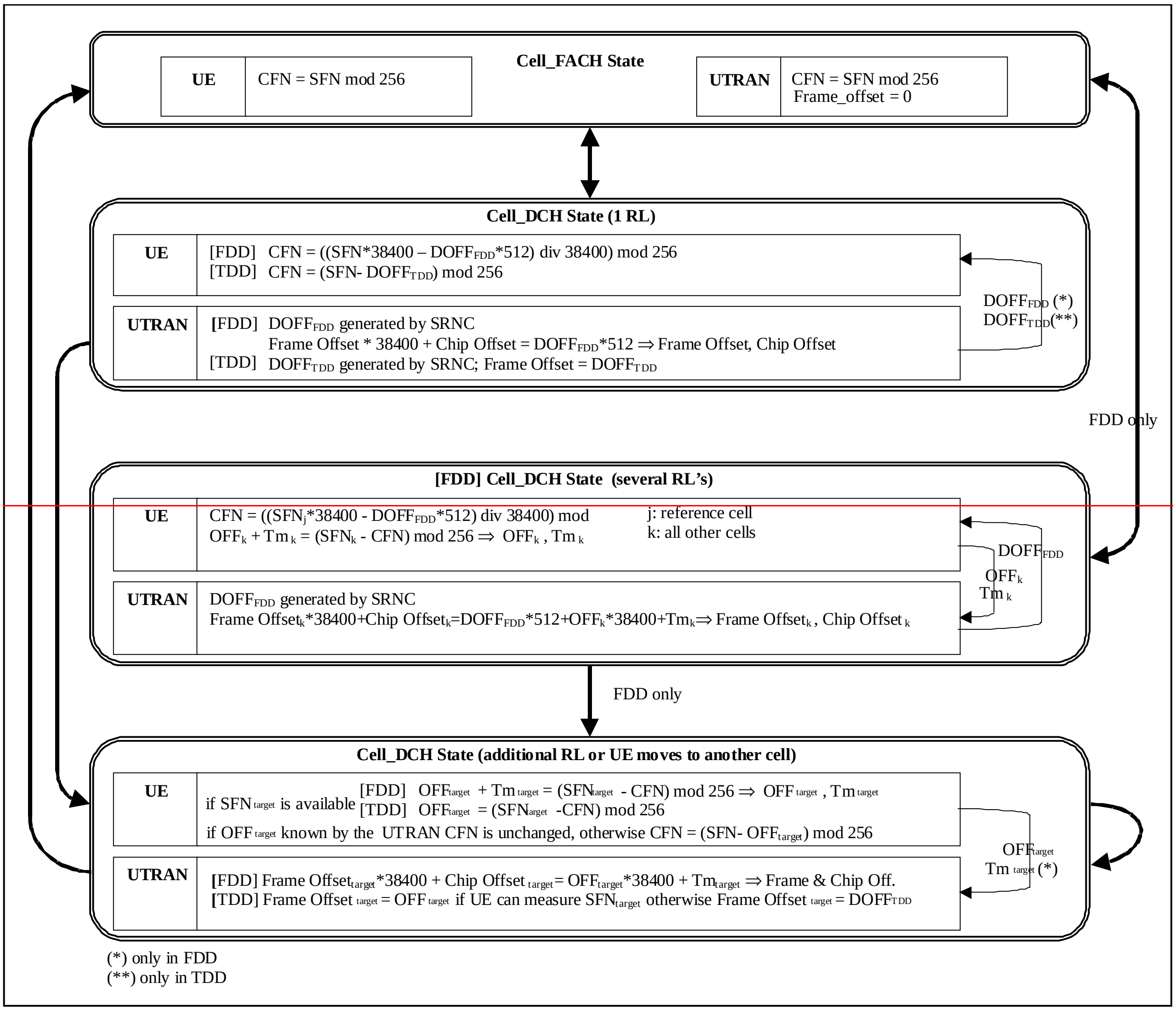


Figure 17: Calculations performed by UE and UTRAN

Figure 18 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).

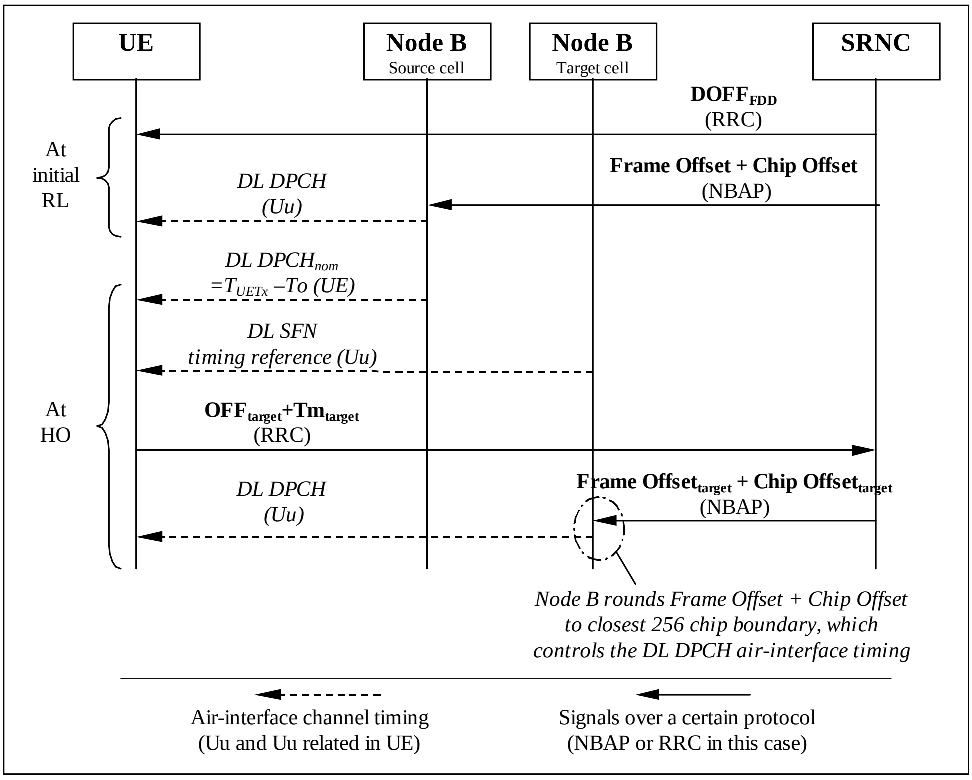


Figure18: [FDD - Usage of Offset values at initial RL and at HO]

Figure 19 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.

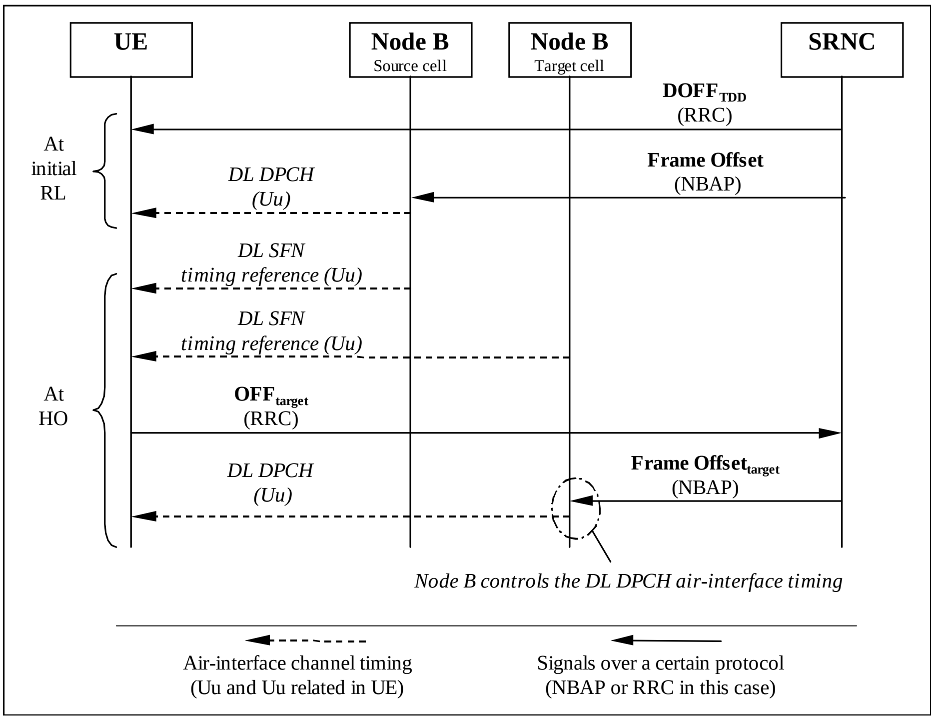


Figure 19: [TDD- Usage of Offset values at initial RL and at HO]

9.2 Calculations performed in the UTRAN

9.2.1 UE in CELL_FACH/PCH state

In CELL_FACH/PCH state 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 $DOFF_{FDD}$ value generated in the SRNC, the SRNC calculates the Frame Offset and the Chip Offset from formula (9.1):

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

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 Frame Offset = $DOFF_{TDD}$.

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 $DOFF_{FDD}$ 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):

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

NOTE: Formula (9.2) 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: addition of a new RL or handover to 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 Frame $Offset_{target}$ and the Chip $Offset_{target}$ with formula (9.3):

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

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 Frame $Offset_{target}$ and the Chip $Offset_{target}$ with formula (9.1).

Frame $Offset_{target}$ and 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 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 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

9.3.A UE in CELL_FACH/PCH state

In CELL_FACH/PCH state 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 - (($DOFF_{FDD}$ * 512) div 38400)) ((SFN*38400 - $DOFF_{FDD}$*512) div 38400) mod 256 (9.4)

This formula gives the CFN of the downlink DPCH frame which starts at the same time as or which starts during the PCCPCH frame with the given SFN.]

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

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

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

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

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

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 (9.6):

$$OFF_k + Tm_k = (SFN_k - CFN) \bmod 256 \qquad (9.6)$$

After having performed OFF_k and Tm_k measurements for all target cells, the UE initialises the CFN with the value given by formula (9.7), based on the received $DOFF_{FDD}$ and the SFN_j of the reference cell:

CFN = (SFN_j - (($DOFF_{FDD}$ * 512) div 38400)) ((SFN_j*38400 - $DOFF_{FDD}$*512) div 38400) mod 256 (9.7)

This formula gives the CFN of the downlink DPCH frame which starts at the same time as or which starts during the PCCPCH frame with the given SFN.

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

9.3.2 UE in CELL_DCH state: addition of a new RL or handover to 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 - In case the SFN_{target} can be measured, the target cell OFF_{target} is calculated using formula (9.8):

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

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

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

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

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 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.

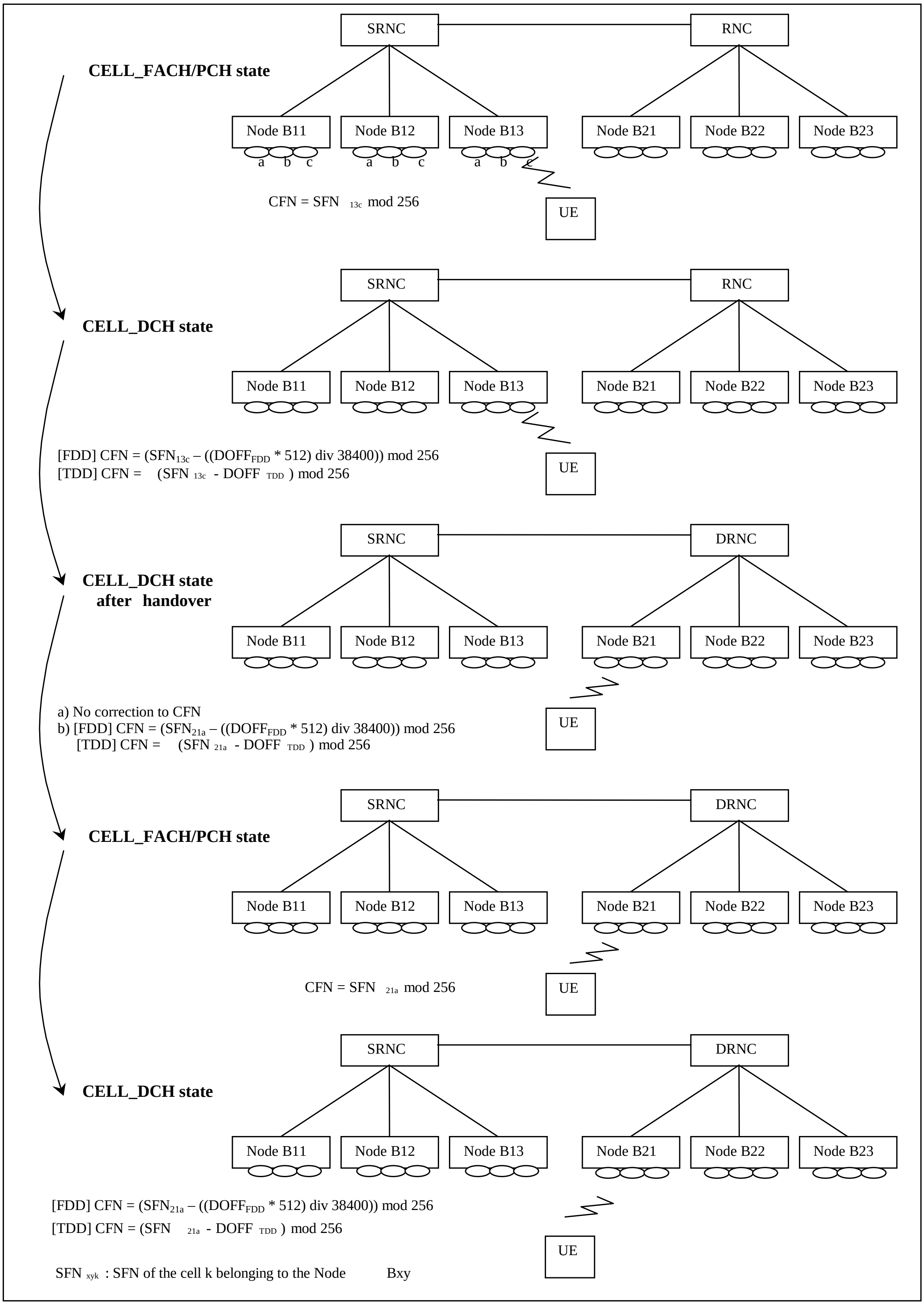
9.4 Synchronisation of L1 configuration changes

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 20 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 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
a b c
a b c
a b c
CFN = SFN 13c mod 256
UE
SRNC
RNC
CELL_DCH state
Node B11
Node B12
Node B13
Node B21
Node B22
Node B23
[FDD] CFN = (SFN13c – ((DOFFFDD * 512) div 38400)) mod 256
[TDD] CFN = (SFN 13c - DOFF TDD) mod 256
UE
SRNC
DRNC
CELL_DCH state
after handover
Node B11
Node B12
Node B13
Node B21
Node B22
Node B23
a) No correction to CFN
b) [FDD] CFN = (SFN21a – ((DOFFFDD * 512) div 38400)) mod 256
[TDD] CFN = (SFN 21a - DOFF TDD) mod 256
UE
SRNC
DRNC
CELL_FACH/PCH state
Node B11
Node B12
Node B13
Node B21
Node B22
Node B23
CFN = SFN 21a mod 256
UE
SRNC
DRNC
CELL_DCH state
Node B11
Node B12
Node B13
Node B21
Node B22
Node B23
[FDD] CFN = (SFN21a – ((DOFFFDD * 512) div 38400)) mod 256
[TDD] CFN = (SFN 21a - DOFF TDD) mod 256
UE
SFN xyk : SFN of the cell k belonging to the Node Bxy

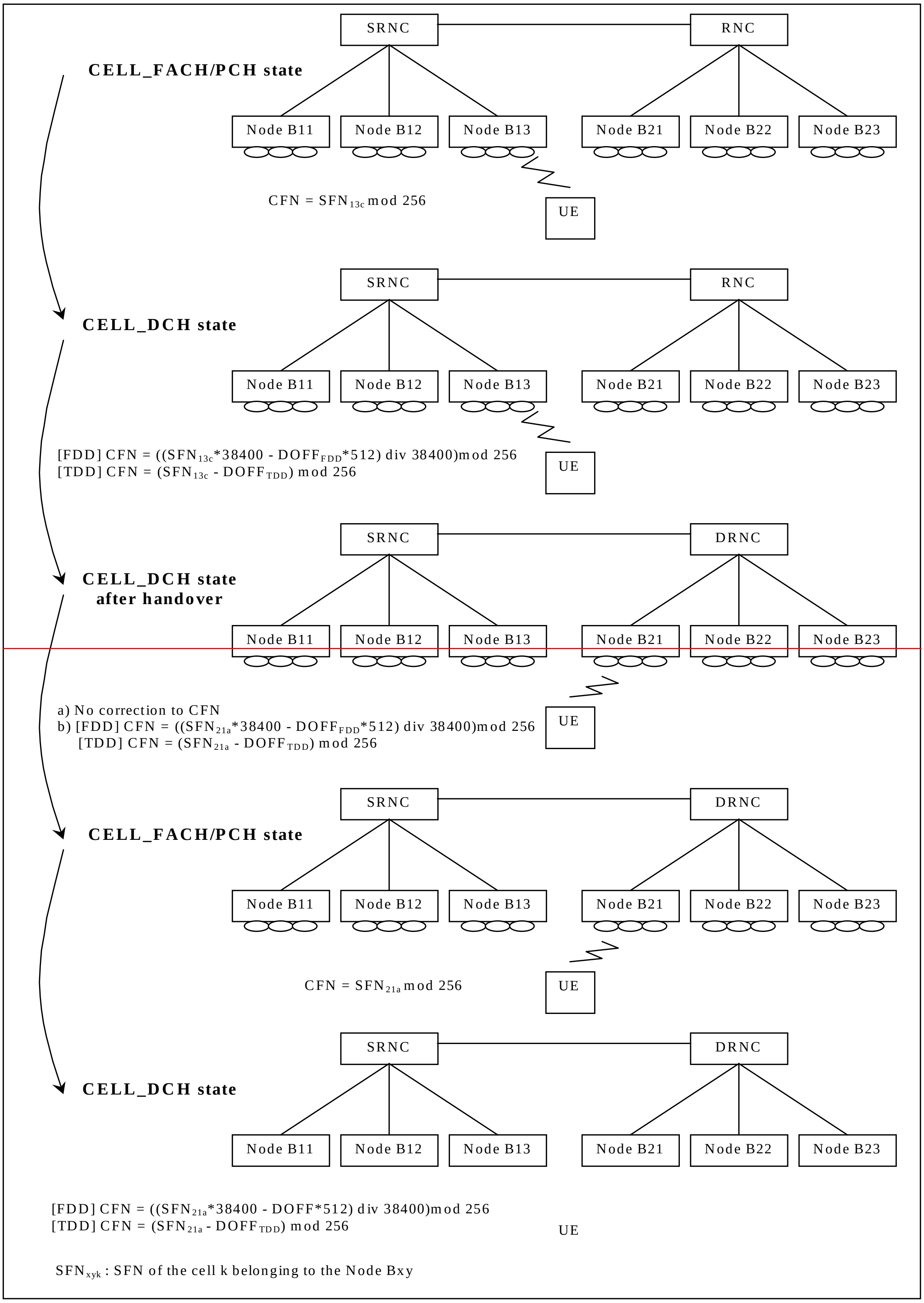
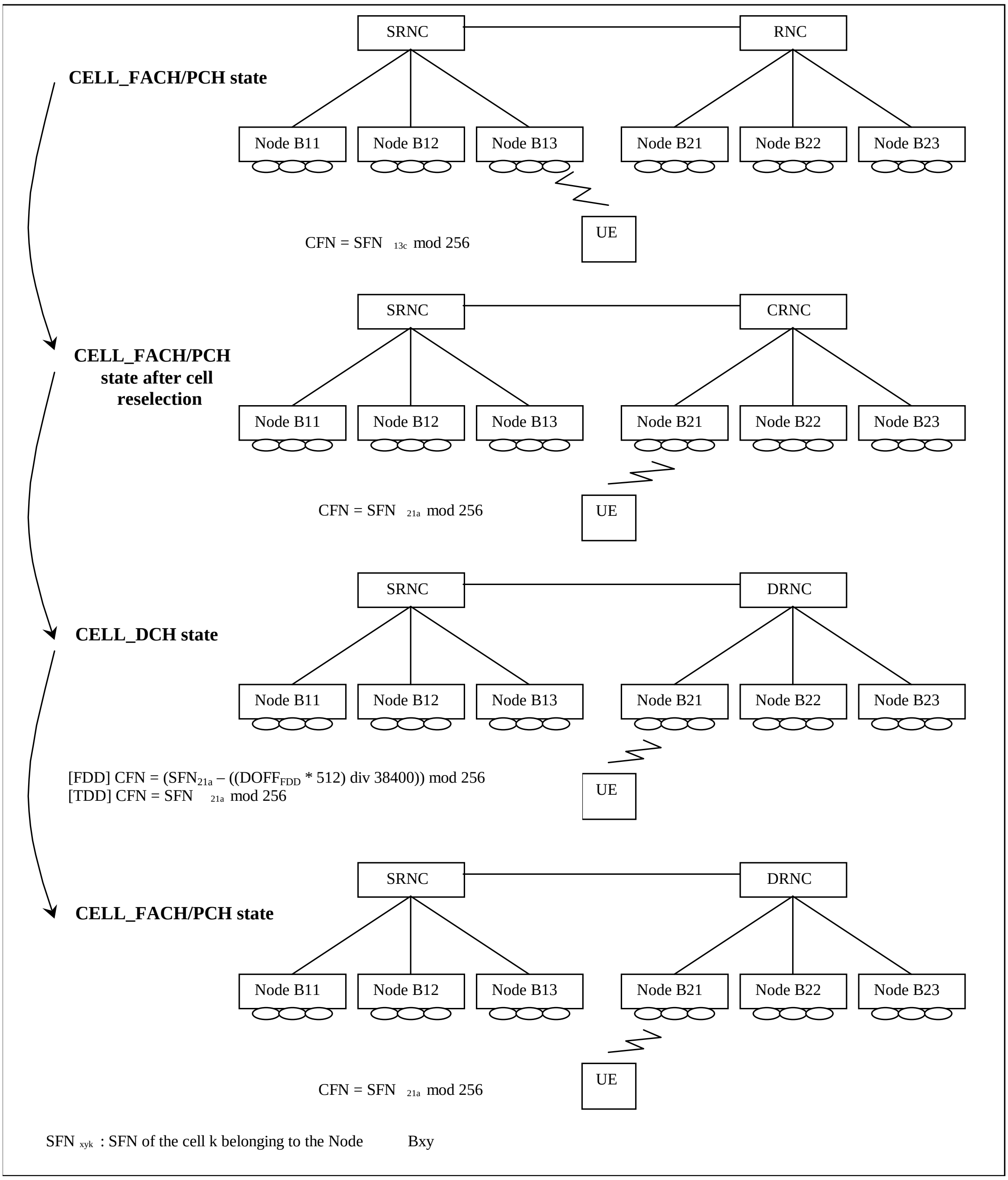


Figure 20: Example 1

The example of Figure 21 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.


CELL_FACH/PCH state
SRNC
RNC
Node B11
Node B12
Node B13
Node B21
Node B22
Node B23
UE
CFN = SFN 13c mod 256
CELL_FACH/PCH state after cell reselection
SRNC
CRNC
Node B11
Node B12
Node B13
Node B21
Node B22
Node B23
UE
CFN = SFN 21a mod 256
CELL_DCH state
SRNC
DRNC
Node B11
Node B12
Node B13
Node B21
Node B22
Node B23
UE
[FDD] CFN = (SFN21a – ((DOFFFDD * 512) div 38400)) mod 256
[TDD] CFN = SFN 21a mod 256
CELL_FACH/PCH state
SRNC
DRNC
Node B11
Node B12
Node B13
Node B21
Node B22
Node B23
UE
CFN = SFN 21a mod 256
SFN xyk : SFN of the cell k belonging to the Node Bxy

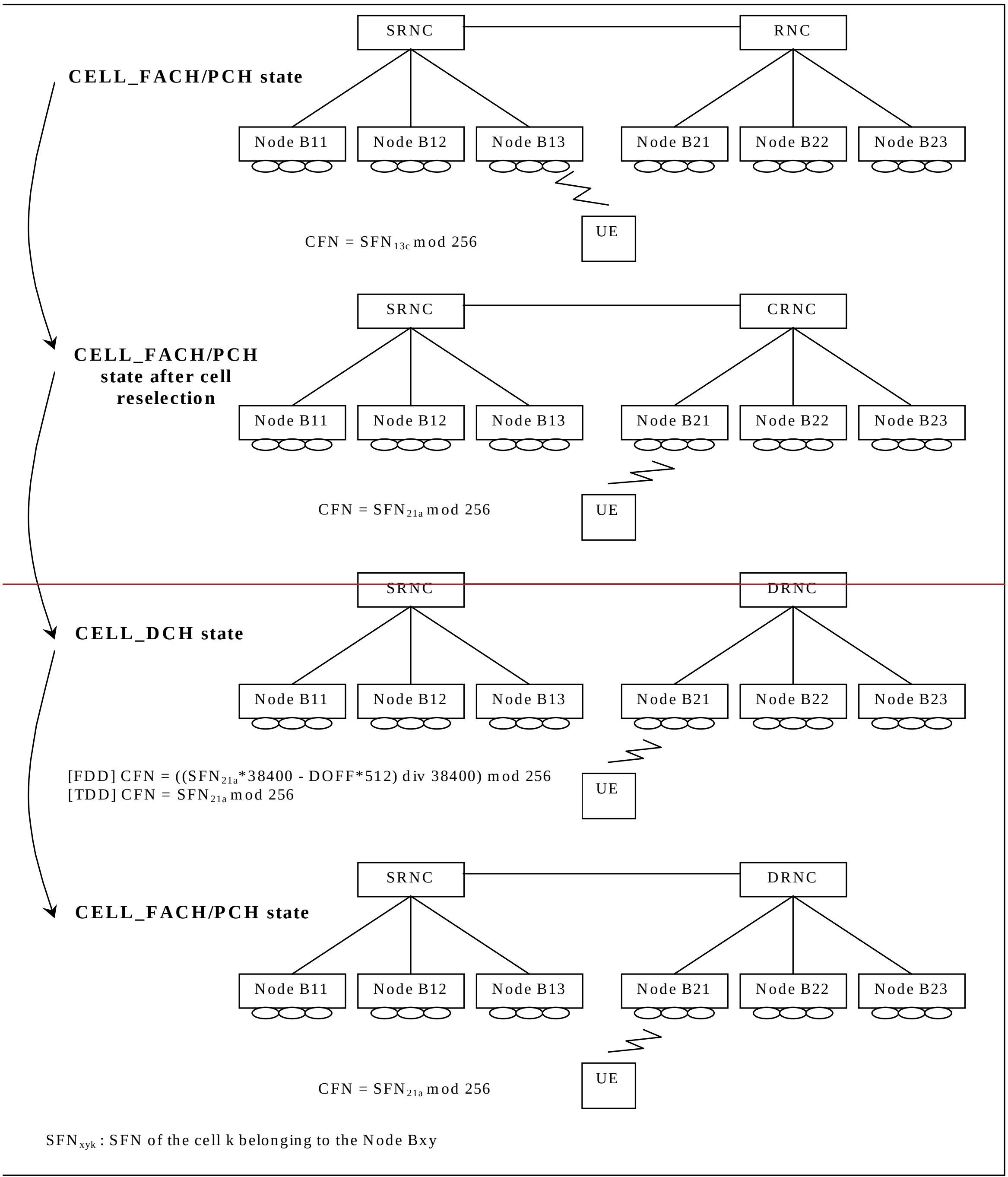
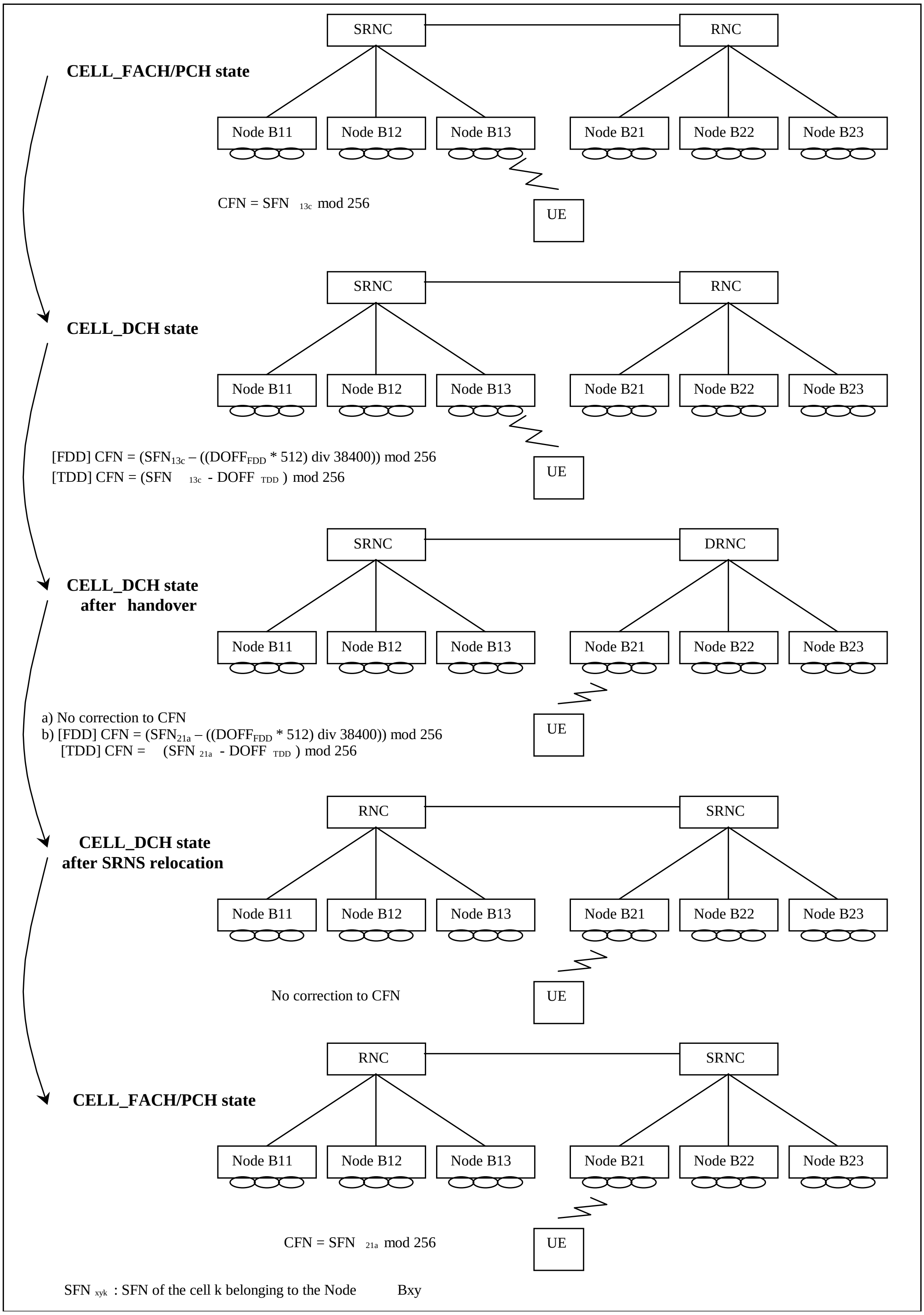


Figure 21: Example 2

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 and SRNS relocation (without UE involvement). In this example 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 = SFN 13c mod 256
UE
SRNC
RNC
CELL_DCH state
Node B11
Node B12
Node B13
Node B21
Node B22
Node B23
[FDD] CFN = (SFN13c – ((DOFFFDD * 512) div 38400)) mod 256
[TDD] CFN = (SFN 13c - DOFF TDD) mod 256
UE
SRNC
DRNC
CELL_DCH state
after handover
Node B11
Node B12
Node B13
Node B21
Node B22
Node B23
a) No correction to CFN
b) [FDD] CFN = (SFN21a – ((DOFFFDD * 512) div 38400)) mod 256
[TDD] CFN = (SFN 21a - DOFF TDD) mod 256
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
UE
RNC
SRNC
CELL_FACH/PCH state
Node B11
Node B12
Node B13
Node B21
Node B22
Node B23
CFN = SFN 21a mod 256
UE
SFN xyk : SFN of the cell k belonging to the Node Bxy

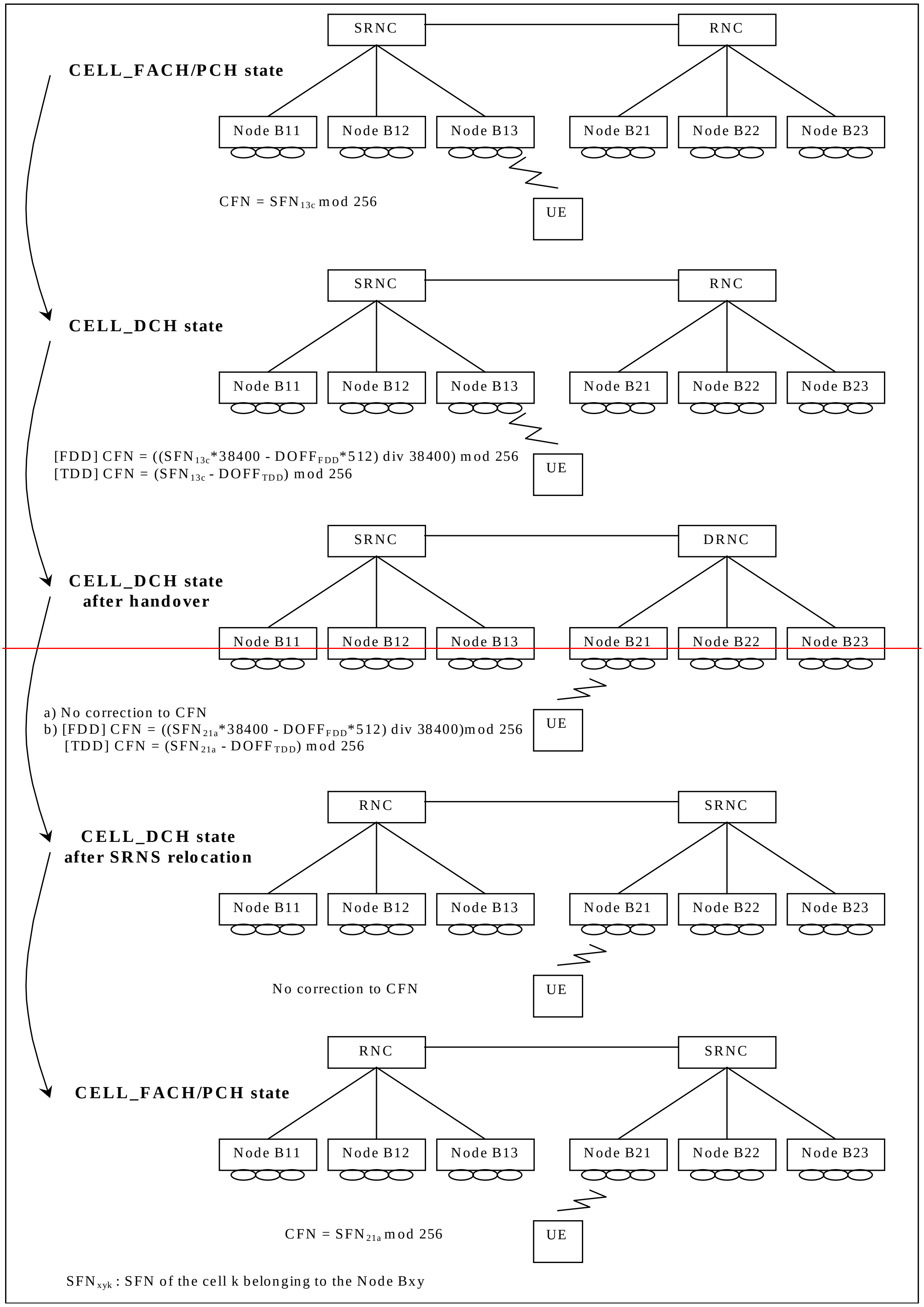


Figure 22: Example 3