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Title: Timing measurements in UTRA/FDD

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1 Introduction

In TS 25.302 two measurements to measure downlink frame timing in the UE are defined, e.g. “CFN-SFN Observed time difference” and “SFN-SFN Observed time difference”. The UE measurement “Relative Timing Difference Between Cells” is defined in TS 25.215 and is similar to the “CFN-SFN Observed time difference” measurement, but the difference is that the “Relative Timing Difference Between Cells” measurement does not consider the frame offset. This document aims to introduce these two timing measurements defined by WG2.

2 Timing measurements defined by WG2

2.1 CFN-SFN Observed time difference

When adding a new radio link to the active set the target Node B has to adjust the transmission time of the DPCH to align the downlink DPCH with the other radio links in the UE. Therefore prior to adding a new radio link the UE has to measure the time difference between the uplink DPDCH/DPCCH and the target cell P-CCPCH frame timing, called CFN-SFN Observed time difference, and report it to the network.

The measurement of CFN-SFN Observed time difference can be divided into two parts (see TS 25.401):

1. CFN-SFN chip offset T_m
2. CFN-SFN frame offset OFF

according to figure 1, where:

$\mathbf{T_m}$= T_{RxSFN} **-** $(T_{UETx}\text{-}T_o)$, given in chip units with the range [0…38400-1] chips

$\mathbf{T_{UETx}}$ is the time when the UE transmits an uplink DPCCH/DPDCH frame.

$\mathbf{T_0}$ is a constant timing offset of 1024 chips used to set up the timing difference between the first received DPCH frame in the UE and the following uplink DPCCH/DPDCH frame.

$\mathbf{T_{RxSFN}}$ is time at the beginning of the next received neighbouring P-CCPCH frame after the time instant $T_{UETx}\text{-}T_o$ in the UE. If the next neighbouring P-CCPCH frame is received exactly at $T_{UETx}\text{-}T_o$ then $T_{RxSFN}=T_{UETx}\text{-}T_o$ which leads to that $T_m=0$.

OFF=(CFN_{Tx}-SFN) mod 256, given in number of frames with the range [0..255] frames.

$\mathbf{CFN_{Tx}}$ is the connection frame number for the UE transmission of an uplink DPCCH/DPDCH frame at the time T_{UETx}.

SFN = the system frame number for next entirely received downlink P-CCPCH frame from the target cell in the UE at the time T_{RxSFN}.

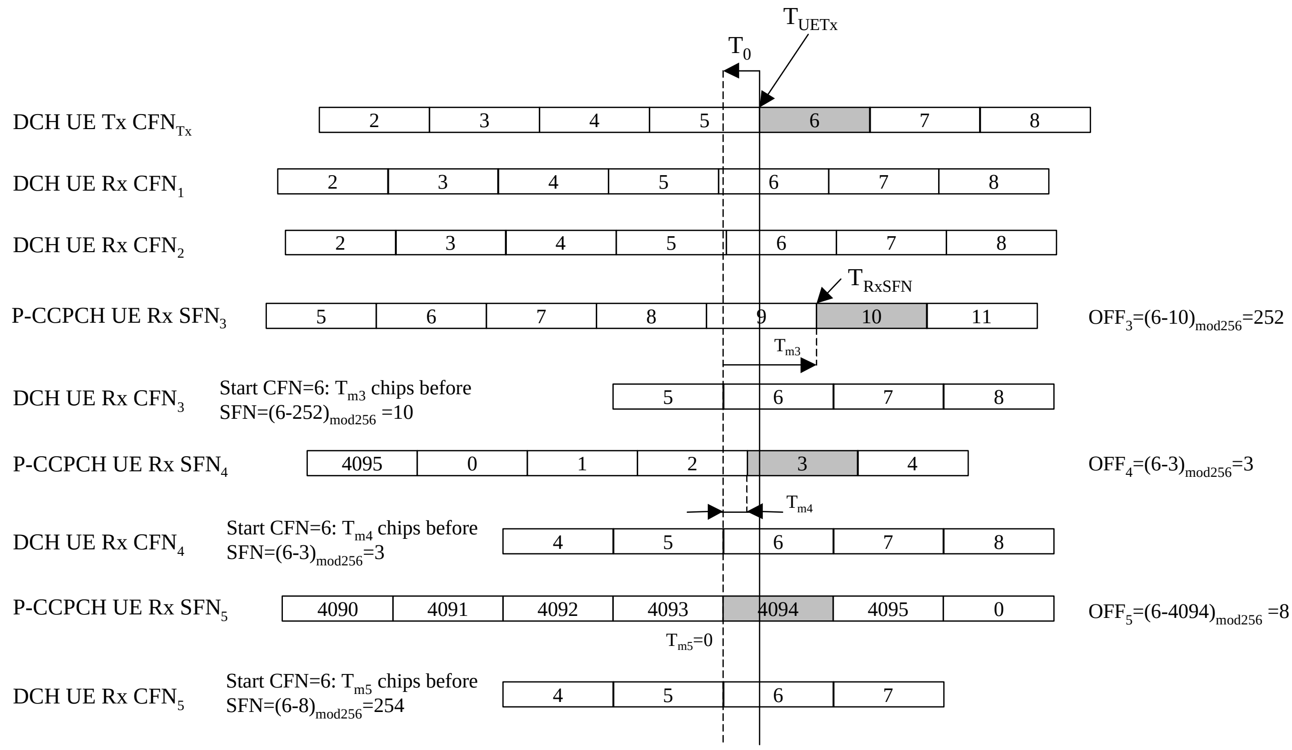

Figure 1 Measuring the CFN-SFN chip and frame offset

The CFN-SFN observed time difference to cell is defined as: OFF*38400+ T_m, given in number of chips and has a range of [0..255*38400+38400-1] chips. As the range for T_m is [0..38400-1] the frame offset (OFF as used by WG3) and chip offset (T_m as used by WG3) can easily be extracted from the CFN-SFN observed time difference.

A simple rule for when Node Bj shall start the transmission of CFN=X to align the reception of DPDCH frames in the UE can be written as:

- Start transmission of frame X, T_{mj} chips before SFN_j mod 256=(X-OFF_j) mod 256.

Note that T_m has to be rounded by Node B to the closest 256 chips to preserve downlink orthogonality in the cell.

2.2 SFN-SFN Observed time difference

When a UE changes from idle to dedicated mode there is a possibility immediately enter soft handover, e.g. setting up more than one radio link at call set-up. The involved Node Bs has to adjust the transmission time of the DPCH to align the downlink DPCHs in the UE. Therefore the UE has to measure the time difference between the downlink P-CCPCHs of the cells involved, called SFN-SFN Observed time difference, and report it to the network.

The measurement of SFN-SFN Observed time difference can be divided into two parts (see TS 25.401):

1. SFN-SFN chip offset T_m
2. SFN-SFN frame offset OFF

according to figure 2, where:

$\mathbf{T_m}$= T_{RxSFN2} - T_{RxSFN1}, given in chip units with the range [0…38400-1] chips

$\mathbf{T_{RxSFN1}}$ is the time at the beginning of a received neighbouring P-CCPCH frame from cell 1.

$\mathbf{T_{RxSFN2}}$ is time at the beginning of the next received neighbouring P-CCPCH frame from cell 2 after the time instant T_{RxSFN1} in the UE. If the next neighbouring P-CCPCH frame is received exactly at T_{RxSFN1} then T_{RxSFN2}= T_{RxSFN1} which leads to that T_m=0.

OFF=(SFN_1- SFN_2) mod 256, given in number of frames with the range [0..255] frames

SFN_1 = the system frame number for downlink P-CCPCH frame from cell j in the UE at the time T_{RxSFN1}.

SFN_2 = the system frame number for next entirely received downlink P-CCPCH frame from cell i in the UE at the time T_{RxSFN2}.

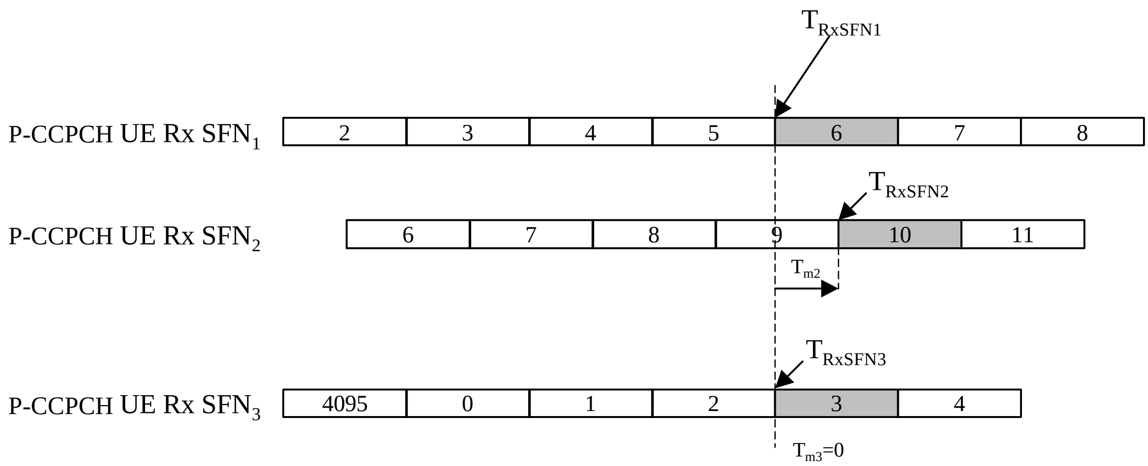

Figure 2 Measuring the SFN-SFN chip and frame offset

The SFN-SFN observed time difference to cell is defined as: OFF*38400+ T_m, given in number of chips and has a range of [0..255*38400+38400-1] chips.

Consider a UE in idle mode and is camping in cell i and measuring neighbouring cell j. If the UE shall set-up up a call directly in soft handover a simple rule for when Node Bi and Node Bj shall start their downlink transmission to align the the reception of DPDCH's in the UE can be:

- Node Bi shall align the DPDCH with the P-CCPCH frame timing and shall start the transmission at SFN_i=X.
- Node Bj shall start transmission of DPDCH'frames T_{mj} chips before SFN_j mod 256=(X-OFFj) mod 256.

Note that T_m has to be rounded by Node Bj to the closest 256 chips to preserve downlink orthogonality in the cell.

3 Proposal

It is proposed that UE layer 1 shall be able to measure and report the following quantities:

1. CFN-SFN Observed time difference,
2. SFN-SFN Observed time difference

The "CFN-SFN Observed time difference" measurement is proposed to replace the measurement "Relative Timing Difference Between Cells" defined in TS 25.215.

The text proposals for the proposed changes can be found in section 4.

4 Text Proposal for TS 25.215

6 Radio link measurements

6.1 UE measurement abilities

Measurement ability	**Measurement target on which the measurement shall be possible (Idle mode= I / Connected mode = C)**	
	Intra-frequency	Inter-frequency
RSCP	CPICH (I/C), DPCH measured on DPCCH for each RL and after RL combination (C)	CPICH (I/C)
SIR	DPCH measured on DPCCH for each RL and after RL combination (C)	n.a.
RSSI	UTRAN DL carrier (I/C)	UTRAN DL carrier (I/C), GSM BCCH carrier (I/C).
Ec/No	CPICH (I/C), DPCH measured on DPCCH for each RL and after RL combination (C)	CPICH (I/C)
Transport CH BLER	Transport channel DCH carried by physical channel DPCH after RL combination (C)	n.a.
Physical CH BER	Transport channel DCH carried by physical channel DPCH after RL combination (C)	n.a.
UE TX Power	DPCCH/DPDCH (C)	n.a.
~~Relative Timing Difference Between Cells~~**CFN-SFN observed time difference**	~~CPICH~~ P-CCPCH (C)	n.a.
UE RxTx timing	DPCH (C)	n.a.
Relative Timing Difference Between Cells for LCS	CPICH (TBD.)	CPICH (TBD.)
SFN-SFN observed time difference	P-CCPCH (I/C)	n.a.

6.1.9 CFN-SFN observed time difference~~Relative Timing Difference Between Cells~~

~~**Definition**~~	~~The relative timing difference between cells T_m is defined as $T_m = \|T_{UETx} - T_o - T_{CPICH}\|$, where:~~ ~~- T_{UETx} is the time when the UE transmits an uplink DPCCH/DPDCH frame.~~ ~~- T_o is a constant timing offset between the first received DPCH frame in the UE and the following uplink DPCCH/DPDCH frame. T_o is used to set up the transmission frame timing in the UE and given in number of chips.~~ - ~~T_{CPICH} = the time for the earliest received downlink CPICH path of the target cell in the UE.~~
~~**Purpose**~~	~~Cell timing measurement for soft handover (CPICH of neighbour cells).~~
~~**Range/mapping**~~	~~T_m is an absolute value and is therefore always positive. T_m is given in chip units and has a range of [0…38400-1] chips.~~

Definition	The CFN-SFN observed time difference to cell is defined as: OFF×38400+ T_m, where: T_m= T_{RxSFN} - (T_{UETx}-T_0), given in chip units with the range [0, 1, …, 38399] chips T_{UETx} is the time when the UE transmits an uplink DPCCH/DPDCH frame. T_0 is defined in TS 25.211 section 7.1.3. T_{RxSFN} is time at the beginning of the next received neighbouring P-CCPCH frame after the time instant T_{UETx}-T_0in the UE. If the next neighbouring P-CCPCH frame is received exactly at T_{UETx}-T_0 then T_{RxSFN}=T_{UETx}-T_0 (which leads to T_m=0). and OFF=(CFN_{Tx}-SFN) mod 256, given in number of frames with the range [0, 1, …, 255] frames CFN_{Tx} is the connection frame number for the UE transmission of an uplink DPCCH/DPDCH frame at the time T_{UETx}. SFN = the system frame number for the neighbouring P-CCPCH frame received in the UE at the time T_{RxSFN}.
Purpose	Cell timing measurement for soft handover (P-CCPCH of neighbour cells).
Range/mapping	Given in number of chips and has a range of [0, 1, …, 9830399] chips.

6.1.11 SFN-SFN observed time difference

Definition	The SFN-SFN observed time difference to cell is defined as: OFF×38400+ T_m, where: T_m= T_{RxSFNj} - T_{RxSFNi}, given in chip units with the range [0, 1, …, 38399] chips T_{RxSFNj} is the time at the beginning of a received neighbouring P-CCPCH frame from cell j. T_{RxSFNi} is time at the beginning of the next received neighbouring P-CCPCH frame from cell i after the time instant T_{RxSFNj} in the UE. If the next neighbouring P-CCPCH frame is received exactly at T_{RxSFNj} then T_{RxSFNj}= T_{RxSFNi} (which leads to T_m=0). and OFF=(SFN_j- SFN_i) mod 256, given in number of frames with the range [0, 1, …, 255] frames SFN_j = the system frame number for downlink P-CCPCH frame from cell j in the UE at the time T_{RxSFNj}. SFN_i = the system frame number for the P-CCPCH frame from cell i received in the UE at the time T_{RxSFNi}.
Purpose	Entering soft handover directly at call set-up (P-CCPCH of own and neighbour cells).
Range/mapping	Given in number of chips and has a range of [0, 1, …, 9830399] chips.

5 References

[1] TS 25.302 v2.4.0 Services provided by the Physical Layer

[2] TS 25.215 v0.1.0 Physical Layer - Measurements (FDD)