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Agenda Item: **26**

Source: **TSG RAN WG3**

Title: **Liaison statement on L1 Timing issues**

To: **TSG RAN WG1**

Copy: **TSG RAN WG4, TSG RAN WG2**

During WG3 #5 in Helsinki, WG3 received input paper R3-99685 proposing several issues related to detailed L1 timing issues. WG3 feels that several of the proposed issues are more within the competence of WG1 rather than WG3.

As a result, WG3 would kindly like to ask WG1 to answer the following two questions:

1. Does WG1 agree to the need for a procedure to adjust the DL transmit timing offset (T_d) during a radio connection ?

2. Does WG1 intend to specify the tolerable difference between time of arrivals of signals from different cells at the UE in SHO situation (definition of a margin ΔT_o according to Tdoc R3-99685) ?

For clarification purposes, the concerning WG3 contribution is attached to this liaison statement. Question 1 is related to chapter 2 of R3-99685, question 2 is related to chapter 4 of R3-99685.

Agenda Item: **6.3**

Source: **Alcatel**

Title: **Radio Interface Synchronisation, Modifications on TS 25.401, TS 25.423, TS 25.433**

Document for: **Decision**

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1 Introduction

This contribution identifies some errors and open points mainly related to radio interface synchronisation. As a result of these discussions, changes to TS25.401 (chapter 9) are proposed. Since the contents of TS25.401 and TS25.211 (chapter 7) partly overlap, it is proposed to make a liaison statement to WG1 in order to maintain consistency. For information purpose, also the proposed changes to TS25.211 are attached to this contribution.

The following issues are addressed:

- Adjustment of T_d during connection
- Time reference for T_m measurement
- Definition of the margin ΔT_o
- Definition of range for T_m and T_d
- Algorithm to calculate T_d from T_m
- Transfer of T_m and T_d
- Removal of inconsistency for range of FN_{cell} in TS25.401

General remark: This contribution assumes a chip rate of 4.096 MHz. With a chip rate of 3.84 MHz, figures have to be modified accordingly.

2 Adjustments of T_d During Connection

2.1 In order to guarantee a power control delay of one slot in both uplink and downlink, it is required that the time offset between reception of a DPCH and transmission of a DPCH at the UE is limited to "$T_o \pm \Delta T_o$", where ΔT_o is some margin TBD. A procedures is identified that guarantees that this requirement is always met, even if a drift between NodeB clock and UE clock occurs.

First, macrodiversity and non-macrodiversity are considered seperately:

<u>2.2 Non-Macrodiversity</u>

According to [1], "*the UE modulated carrier frequency shall be accurate to within ±0.1 PPM compared to carrier frequency received from the BS. These signals will have an apparent error due to BS frequency error and Doppler shift. In the later case, signals from the BS must be averaged over sufficient time that errors due to noise or interference are allowed for within the above ±0.1PPM figure.*"

In other words, the UE locks its clock to the NodeB's downlink signal only in frequency, but not in time, i.e. only AFC is applied, but time of arrival (TOA) measures of the received DPCH are not used by the UE for adjusting its local oscillator frequency.
As a result, the UE clock drifts relative to the NodeB clock. The time difference between reception of a downlink DPCH frame and transmission of a DPCH frame in uplink (which is T_o in the optimum case) will increase or decrease due to this drift. To restrict the difference to T_o ± some margin "ΔT_o", basically three solutions are possible:

- 1. The NodeB changes the downlink DPCH transmission time, i.e. change of T_d.
- 2. The UE changes its uplink DPCH transmission time.
- 3. A third possibility would be to completely avoid a long term drift between UE and NodeB by means of a control loop inside the UE that adjusts the local oscillators frequency as a function of the TOA of the received DPCH. However, such a loop might introduce quite high frequency offsets to the UE oscillators for fast moving UEs, which might conflict with the "±0.1PPM" requirement given in [1]. To avoid this, the frequency source for clocking the UE's time base would have to be different from the frequency source for RF frequency generation, which is not considered favourable.

2.3 Macrodiversity with different NodeBs

In Macrodiversity, the UE cannot lock its clock to all NodeBs at the same time, since the NodeB's oscillators drift against each other. As a result, the UE clock drifts against at least one NodeB's clock. The time difference between reception of this
and transmission of a DPCH frame in uplink (which is T_o in the optimum case) will increase or decrease due to this drift. To keep the difference at T_o (±some margin "ΔT_o"), only one solution is possible:

- The NodeB changes the downlink DPCH transmission time, i.e. change of T_d

2.4 Conclusion

The method to change the T_d values for the downlink DPCH signals can cope with both macrodiversity and non-macrodiversity situations. Assuming a frequency drift of the UE of 0.1ppm relative to the NodeB, such an adjustment would occur once every 2-3 minutes, hence the signalling overhead is negligible.

2.5 Proposal

A procedure is proposed that adjusts these T_d offsets upon request by the UE. To avoid possible loss of data and additional layer 1 processing inside the UE, the reconfiguration of Td shall be "synchronised", i.e. the UE shall know at what CFN the change of T_d takes effect (compare "synchronised radio link reconfiguration", TS25.433/TS25.423). If T_d crosses a frame boundary due to such an adjustment, the corresponding OFF value (see TS25.401) has to be in- or decreased accordingly.

Proposed changes to TS25.401 are given in the Appendix. Also, the chapters on synchronised radio link reconfiguration in TS25.423 and TS25.433 need to be extended correspondingly.

3 Time Reference for T_m Measurement

In TS25.401 the T_m value that is measured by the UE when performing SHO measurements, is defined as the time difference between the earliest received PCCPCH path of the target cell and the earliest received existing DPCH path. This definition has some drawbacks:

- The TOA of the earliest received existing DPCH path is not identical to the "optimum" TOA of a DPCH path. The optimum TOA for a first received DPCH path of a new cell is T_o before the UE sends an uplink DPCH frame (see above, need to guarantee a power control delay of one slot in both uplink and downlink)! Since UTRAN does not know if the current earliest received DPCH path is before or after this optimum time, UTRAN might decide for the "wrong" T_d (mind that T_d is a multiple of 256 chips).
- After the RNC has signalled T_m to the NodeB of the target cell, the NodeB has to search for paths of the signal received from the new UE. The size of the initial search window is always determined by the unknown propagation delay T_p. With the current solution, there is another uncertainty due to the fact that T_m is not related to the transmission time of an uplink DPCH frame, but to the earliest received existing DPCH path, i.e. the initial search window would have to be larger.

The following proposal circumvents both drawbacks.

3.1 Proposal
The T_m measured by the UE should be defined as the time difference between "$T_{TX,UL} – T_o$" and the earliest received PCCPCH path of the target cell, whereas $T_{TX,UL}$ is the time when the UE transmits an uplink DPCH frame. Hence, "$T_{TX,UL} – T_o$" is the "optimum" arrival time for the first path of a received DPCH.

Proposed changes to TS25.401 are given in the Appendix.

4 Definition of the margin ΔT_o

From the discussions above it is clear that the TOAs of the earliest received paths of DPCHs from different cells differ due to the granularity of T_d. Some maximum tolerated difference ΔT_o between any earliest received DPCH path and the optimum arrival time "$T_{TX,UL} – T_o$" for an earliest received DPCH path needs to be specified. ΔT_o should be closely related to the granularity of T_d and should allow some margin for T_d adjustments.

4.1 Proposal
A value of ΔT_o = 128 chips + 5µs = 36.25 µs is proposed, and the requirement would be:
"By means of appropriate T_d adjustments it shall be ensured that the earliest received DPCH path of any cell in the active set always arrives within the time intervall [$T_{TX,UL} – T_o – \Delta T_o$; $T_{TX,UL} – T_o + \Delta T_o$] at the UE, whereas ΔT_o = 128 chips + 5µs = 36.25 µs and $T_{TX,UL}$ is the time at which the UE transmits an uplink DPCH frame".

Note: In the worst case, the time difference between the first and the last received path can be as much as 256 chips+2*5µs + $T_{DS,max}$, where $T_{DS,max}$ is the maximum delay spread of the radio channel between UE and a cell. Assuming $T_{DS,max}$ =20µs, this means that the UEs buffer needs to cover a period of 92.5µs.

Proposed changes to TS25.401 are given in the Appendix.

5 Definition of Range for T_m and T_d

The standard is still unclear about the definitons of some timing variables. It is proposed that both T_m and T_d are defined as positive values that cover the range of 1 frame.

5.1 Proposal
- T_m: range=[0..1 frame)
- T_d takes on values n*256 chips, n $\in$ {0, 1, 2, ..., 159}, i.e. range=[0..1 frame)

Proposed changes to TS25.401 are given in the Appendix. Note that T_m and T_d are both positive, hence Figure 9 of 25.401 has been changed.

6 Algorithm to Calculate T_d from T_m

6.1 Before an add branch (SHO), the UE sends a T_m value to the UTRAN. The SRNS then calculates the T_d value of the new cell, based on T_m. When the rule how to calculate T_d from T_m, is standardised, then there is no need for the SRNC to tell the UE what T_d value has been chosen.

6.2 Proposal
It is proposed that T_d of a target cell 'j', which is added to an active set, is calculated from the T_m value measured by the UE as follows:

$T_{d,j}$ = (n*256 chips) mod 1 frame, where n is chosen such that 256*(n–0.5) chips $\leq T_m <$ 256*(n+0.5) chips.

Proposed changes to TS25.401 are given in the Appendix.

7 Transfer of T_m and T_d

The signalling of T_d and T_m values between RNC, NodeB and UE, as indicated in the figure in TS25.401, is contradictory to the text in TS25.401 and is proposed to be modified. In particular, the RNC does not need to signal $T_{d,j}$ to a new cell for an add branch. When the algorithm how to calculate T_d from T_m is standardised, only T_m needs to be signalled to the NodeB.

The reason why T_m rather than T_d shall be signalled from RNC to NodeB is the following: After a NodeB has been added to the active set, the NodeB has to search for paths of the signal received from the new UE. The size of the initial search window is always determined by the unknown propagation delay T_p. If T_d rather than T_m was signalled to the NodeB, there would be another uncertainty due to the granularity of T_d, i.e. the initial search window would have to be larger.

Another issue that needs to be specified is the definition of the reference for OFF_j, in case the UE reads the target BCH frame number and signals OFF_j to the SRNC. Since large T_m values close to 1 frame translate into $T_{d,j}$=0, it needs to be specified whether the OFF_j value signaled by the UE already takes into account this frame slip.

7.1 Proposal

It is proposed that, for SHO (add branch of cell j),

- UE signals T_m to the SRNS
- SRNC signals T_m to the target NodeB
- $T_{d,j}$ are independently calculated from T_m inside UE, SRNC, NodeB, hence signalling of $T_{d,j}$ is not needed.
- If UE also signals OFF_j (related to the target cell) to SRNC, this shall be related to $T_{d,j}$ rather than T_m. This means that, for large T_m values close to 1 frame which translate into $T_{d,j}$=0, the OFF_j value signalled by the UE is already decreased by 1 (modulo 72).

Proposed changes to TS25.401 are given in the Appendix.

8 Removal of Inconsistency for Range of FN_{cell} in TS25.401

In TS25.401 contradictory statements are made as to the range of the cell frame number FN_{cell}. In 9.4.2 its range is given as 0..71, whereas in 9.3 its range is sometimes indicated to be 0..M-1. TS25.211 suggests a value of 512*72=36864 for M. It is proposed that the frame number sent on the BCH is modulo 72 and not modulo M (the latter would require 9 more bits).

8.1 Proposal

The range for the cell frame number FN_{cell} shall be 0..71.

Proposed changes to TS25.401 are given in the Appendix. Note that all figures suggesting a periodicity of M for the cell frame number, have been changed accordingly.

9 Appendix: Text proposals

See attached documents.

10 References

[1] TS25.101 v1.2.0
[2] TS25.211 v2.1.0
[3] TS25.401 v1.1.1
[4] TS25.423 v1.1.1
[5] TS25.433 v1.1.1