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Agenda Item:
Source: Rapporteur (SK Telecom)
Title: Answer to questions and comments on USTS
Document for: Discussion

Introduction

There were many questions and comments on USTS at TSG RAN WG1 #14 meeting and also on e-mail reflector afterward. This is the summary of them and answer to them.

Answer to questions and comments

1) Is USTS mandatory or optional for UE and UTRAN?

USTS is optional for both UE and UTRAN. Our intention is to support USTS with minimum modification of current specification in low mobility environment such as indoor and pedestrian cases.

2) Comments on the USTS gain when additional scrambling code(s) are used.

In order to prevent code limitation, a number of scrambling codes can be used. In this case, to fully use the USTS advantage, the scrambling codes need to be assigned carefully. i.e., if there are three scrambling codes, and each scrambling code can accommodate 5 UEs, and 9 UEs are in USTS mode in a cell, then 5 UEs are assigned to scrambling code 1 and the remaining 4 UEs are assigned to scrambling code 2 and no UE is assigned to scrambling code 3. This kind of assignment is better than the case when 3 UEs are assigned to each of three scrambling codes. Moreover, I think we can expect large USTS gain if code limitation occurs because this means many UEs are in USTS mode.

3) Comment on Closed Loop Power Control (CLPC) delay

If the timing of the uplink can be adjusted at the initial synchronisation phase and during the call (downlink timing stays the same), then UL/DL relative timing, T_0, does not stay fixed. It is closely related to T_{ref} and the UE capability (CLPC processing power). If T_{ref} is sufficiently large, UL/DL relative timing can be maintained not to be less than T_0 in most case. If T_0 of 1024 chips is strictly required to respond to TPC command at UE, then CLPC delay becomes 2 slots when UL/DL relative timing becomes below T_0. In the paper presented at the last meeting T_{ref} was said to be set to the average value of RTPD for an example. But if CLPC delay is taken into consideration,

T_{ref} needs to be large enough as long as it does not cause CLPC delay to be 2 slots. In my opinion, in indoor and micro cell (urban area) cases, the cell radius is not so large. Hence, appropriate values for T_{ref} can be found in such cases so that CLPC delay is kept at 1 slot, even when using USTS. For example, when cell radius is 10 km and chip rate is 3.84 Mcps, the one way propagation delay comes to 128 chips. T_{ref} can be set to 128 chips. Then, UL/DL relative timing can be maintained to be longer than T0. At UTRAN, maximum RTPD becomes 2*128 chips when using USTS. Then, UTRAN still have enough time to respond to DL CLPC.

4) Comment on T_{ref}

It is given to RNC as initial loading data. Its value depends on the cell size. It is used to calculate T_{INIT_SYNC} together with the measured RTPD. If the cell radius is 10km and the chip rate is 3.84 Mcps, the maximum propagation delay comes to 128 chips. In this case, T_{ref} can be set to 128 chips. Therefore, T_{INIT_SYNC} is in the range of [0 chips, +128 chips].

5) Comment on T_{INIT_SYNC}

It is the amount of initial adjustment to make the receiving signal from the UE arrive at $t_{DPCH,n} + T_0 + T_{ref}$ after the frame boundaries on the DPCH at Node B (see Figure 3.2 in Tdoc903). The DPCH timing may different for different DPCHs, but the offset from the P-CCPCH frame timing is a multiple of 256 chips, i.e. $t_{DPCH,n} = T_n \times 256$ chip, $T_n \in \{0, 1, \ldots, 149\}$. T_0 is a constant defined to be 1024 chips. T_{ref} is a given value and same for all UEs in a cell. T_{INIT_SYNC} is calculated at RNC and is informed to UE via RRC message.

6) Comment on *Round Trip Propagation Delay*

According to TS25.215, Propagation delay is included in UTRAN measurement abilities and can be used for measuring RTPD by doubling its value. However, the resolution of 3 chips is supported in the current specification. In my opinion, in order to increase the resolution the size of the field to report propagation delay needs to be increased. If this method is not easy, performance degradation due to coarse initial synchronisation results. But some kind of adaptive tracking method can be applied to make the initial synchronisation faster. Moreover, since the time required for tracking to overcome the coarse initial synchronisation (<= 3 chips) is less than 240 msec assuming 20 msec TAB command period and a timing control step size of 1/4 chip, the performance is expected to slightly degrades.

7) Some more explanation for Figures 3.2 and 3.3 in Tdoc903

The tracking process looks very like closed loop power control. The tracking process uses TAB command instead of TPC command and TAB commands are sent by puncturing TPC commands every 20 msec. Puncturing interval of 20 msec is expected to cause slight degradation of TPC performance and to be fast enough for low mobility environment such as pedestrian case. The tracking process decides whether advance or delay the transmission time based on the comparison between the measured DPCH frame arrival time and the desired arrival time. On the other hand, the closed loop power control decides power up or down based on the comparison between the measured SIR and the target SIR.

In Figure 3.2, different DPCH may have different timing according to $t_{DPCH,n}$ to distribute the processing load in the UTRAN. Since T_0 and T_{ref} are the same for all UEs in the same cell, the timing differences between different UEs (DPCHs) are exactly a multiple of 256 chips as stated in (5) in this document. In non-USTS mode, the (UE specific) scrambling codes start to be generated at each DPCH frame starting point. However, in USTS mode to guarantee the orthogonality between different UEs, the (cell specific) scrambling code alignment is necessary as shown in Figure 3.3 in Tdoc903. To get rid of scrambling code after de-scrambling process, the scrambling code generation starts at the P-CCPCH frame starting point for every UE.

8) Comment on soft handover

Until the last WG1 meeting at Oulu, Finland, handover had not been considered for USTS because its target was low mobility environment. However, at the last meeting it was commented that even in a low mobility environment, handover is necessary and moreover, if soft handover is not supported, performance can degrade due to increased inter-cell interference. Also commented was that forced termination for handover-requesting UEs is not desirable.

Soft handover while in USTS mode requires more than two transmitters for UEs. Hence this option is excluded from our consideration. We elaborated the specifications to support handover for USTS with as small modifications as possible. The followings can be candidates for supporting soft handover for USTS (There can be any other candidates besides the following four ones). In this case, only two-way soft handover is considered for easy explanation.

1) When a UE enters SHO region, the UE leaves USTS mode and changes its mode to non-USTS mode, and then adds one more link to target cell and performs soft handover with two non-USTS mode links, and does not return to USTS mode. (see Appendix B) This candidate is the simplest way but has some drawback because of not using USTS in SHO and after SHO.

2) When a UE enters SHO region, the UE changes its mode to non-USTS mode and performs soft handover with two non-USTS mode links, and returns to USTS mode after deleting a weak link.

Mode change from USTS to non-USTS is very simple as you can see in Appendix B in this paper. And the required modification is also very small. However, mode change from non-USTS to USTS after SHO has some problem. A very similar reconfiguration to that for non-USTS -> USTS is required for USTS -> non-USTS. The problem is timing control while UEs are in DPCH transmission. Some kind of initial synchronisation is necessary like the initial synchronisation at call setup phase. However, two initial synchronisations are different becuase (a) different RTPD measurement is required and (b) a large amount of timing control (<256chips) may be required for DPCH in transmission. Regarding (a), the measurement “RTT” can be used to measure RTPD through DPCH and its resolution is sufficiently small (1/4 chip). Now we are working on the impact of the problem (b). By using this candidate, we can mitigate the drawback of candidate (1) because the UE resumes USTS after SHO.

3) When a UE enters SHO region, the UE adds a new link to the target cell in addition to the existing USTS mode link. In this case, since a UE has only one transmitter, the UE is in USTS mode only for the existing link and in non-USTS mode for the newly-added link. The target cell should be known the scrambling code and the channelisation code(s) of the SHO-requesting UE in USTS mode and the target cell use these codes to demodulate the signal without timing control for this link. When the UE moves out of SHO region, it can be in USTS mode with target cell as in candidate (2). This candidate can provide seamless USTS but some more clarifications are to be done in each WG.

4) When a UE enters SHO region, it is in USTS mode with the original cell and in non-USTS mode with the target cell. What is different from candidate (3) is that in this candidate, the modes of the links can be changed while in SHO region, i.e., the UE is now in USTS mode with the target cell and in non-USTS mode with the original cell. Hence, this candidate may provide seamless USTS-mode link to the Node B in better condition. But more clarifications are to be done in each WG.

USTS Node B needs to have the following two capabilities: (1) timing control (2) discrimination of different UEs with both scrambling code and channelisation code(s). If Node B does not have either of two capabilities, then it is herein called Non-USTS Node B. The following table summarises possible three cases for SHO and applicable candidates for each case.

Possible case	USTS Node B -> Non-USTS Node B	Non-USTS Node B -> USTS Node B	USTS Node B -> USTS Node B
Applicable candidates	Candidates 1 & 2	Similar way to Candidates 1 & 2	Candidates 1 & 2 & 3 & 4

At the last meeting, the fact that USTS does not support SHO was commented. And the impact when USTS supports SHO was also questioned. I think the above candidates can cover these two comments properly even though some more works are to be done further.

9) Intra-cell interference and inter-cell interference

It is very clear that USTS can provide performance gain in a single cell case by reducing intra-cell interference. So far, USTS had a drawback in terms of inter-cell interference. However, if soft handover is supported as proposed in (8) in this document, performance gain can be still expected even in a multiple cell case.

10) How to discriminate USTS and non-USTS mode UEs?

UE informs the UTRAN whether it supports USTS or not at call setup. Hence UTRAN is known which UE supports USTS.

11) Performance gain when USTS and non-USTS mode UEs are mixed..

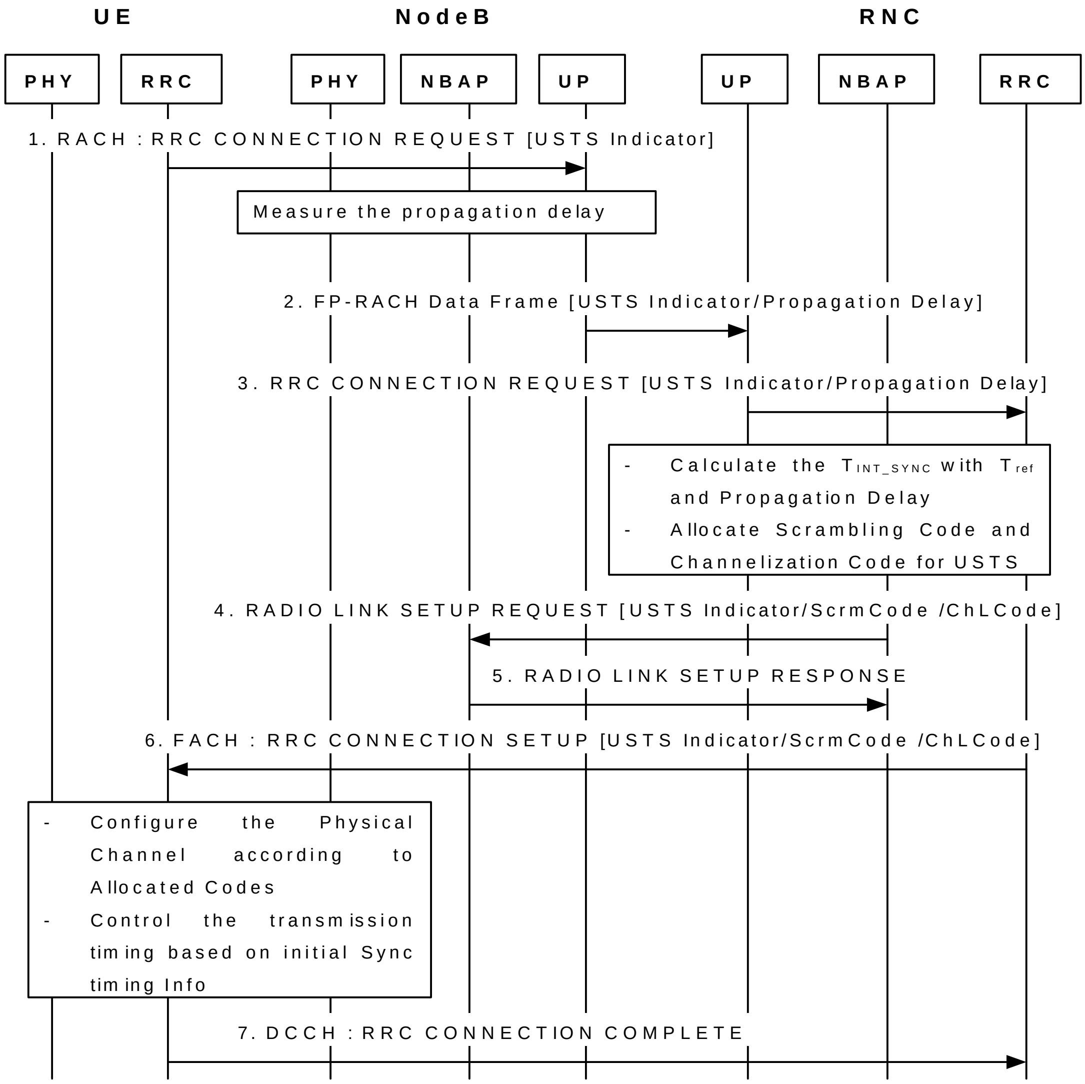
By using the analysis in section 2.2 in Tdoc904, when aN UEs are in USTS mode and $(1-a)N$ UEs are not in USTS mode, eqn. (2.8) can be modified to

$$\left(\frac{E_b}{I_o}\right)_i \approx \frac{GL}{N(L-a)}. \qquad (1)$$

Hence, the gain is changed from $L/(L\text{-}1)$ to $L/(L\text{-}a)$. As more UEs are in USTS mode, more performance gain is expected. At an initial stage, a small number of UEs are in USTS mode. However, as time goes by and more UEs become to support USTS, then the performance gain increases.

Appendix A: Basic call flow to support USTS.

USTS indicator: UE informs RNC whether UE supports USTS or not via RRC message



Appendix B: Procedure for soft handover (Candidate 1)

To support soft handover, the UE in USTS mode first changes its mode from USTS mode to non-USTS mode and then performs soft handover and if the UE no longer requires more than one links, it remains in non-USTS mode after deleting unnecessary link(s). By providing this kind of soft handover, both the intra-cell interference and inter-cell interference can be reduced owing to USTS and soft handover, respectively.

Figure 1 shows an example case for UE state. Let's assume that R99 UEs cannot support USTS and R00 UEs can support USTS and that R99 UEs coexist with R00 UEs. R00 UEs are in non-USTS mode when they are either in SHO or after SHO. Otherwise, they are in USTS mode.

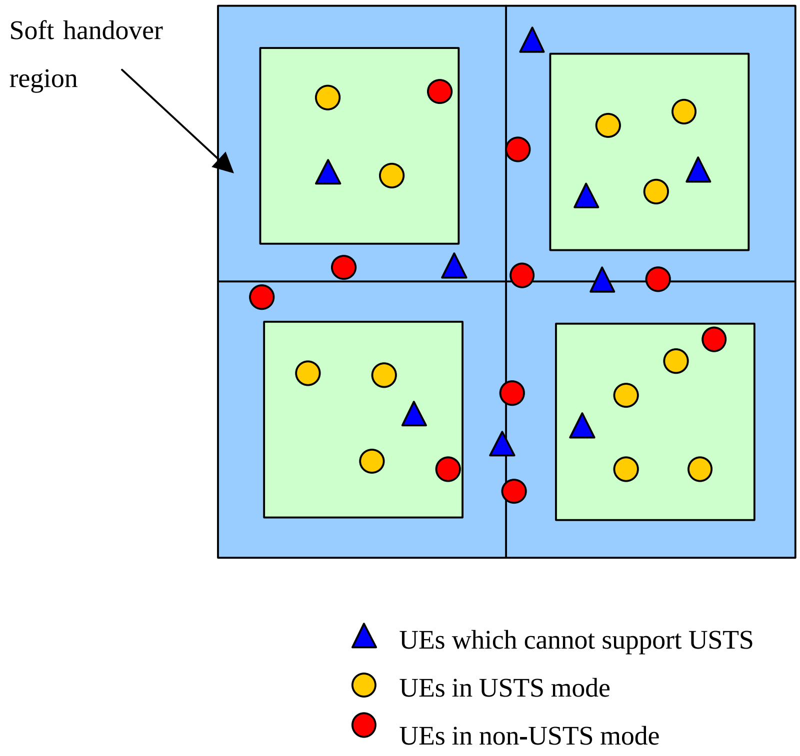


Figure 1. An example for UE state.

In the following figure, a yellow-colored part is newly added for supporting mode change. The other parts are the same as those for ordinary soft handover.