3GPP TSG RAN WG 1 #19 *TSG R1-01-0270*
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Title: Text proposal for TR 25.854: Study report for USTS

Document for: Approval

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1. Introduction

In last Boston meeting, we presented and discussed "comparison of soft handover schemes for USTS" [1]. According to decision of WG1 in the previous meeting, we propose text proposal for the TR 25.854 in this document.

2. Text proposal for TR 25.854

=========================== text proposal ===========================

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4.3. Soft handover in USTS mode

<This section is describing only sample candidates which is restricted to USTS Study report and not universal description of soft handover procedure>

For seamless communication, soft handover needs to be considered for USTS, where the different code usage of scrambling and channelisation codes, and the transmission timing control should be taken into account.

The radio link can be in one of the following three modes:

- Normal mode : No timing control, UE discrimination by Scr code
- USTS mode : Timing control, UE discrimination by both Scr and Ch codes
- Non-USTS mode : No timing control, UE discrimination by both Scr and Ch codes

The difference between Normal mode and Non-USTS mode is as follows. If one of the radio links to the cell sites in Active set is in USTS mode, it is discriminated by both scrambling code and channelisation codes assigned for USTS mode in all cells in Active set. Therefore, the other links should be in non-USTS mode. This is because the UE has only a single transmitter and there can be more than one UEs who enter the SHO region from the same original cell and accordingly, they use the common scrambling code and the discrimination can be done only by channelisation codes. In normal mode, the UEs in SHO region use their own unique scrambling codes.

Four candidates for supporting soft handover have been proposed in USTS mode. Table 4.1 summarises these candidates. In this section, only two-way soft handover is considered for easy understanding. In Candidate 1, when the UE enters SHO region, it abandons the USTS mode and operates in normal mode with both cell sites. For this, a reconfiguration process is first required to assign new scrambling codes and channelisation codes for the radio link with the original cell and then, the normal soft handover procedure is followed. When the UE moves further into the target cell and leaves out of SHO region, it continues to be in normal mode with stronger radio link. If it leaves out of SHO region back into the original cell, it resumes the USTS mode and accordingly, for normal to USTS mode transition, reconfiguration process is required to assign new scrambling code and channelisation codes, and timing adjustment is necessary. Candidate 2 is different from Candidate 1 only in that the soft handover happens in the reverse direction.

In Candidates 3 and 4, the UE continues to be in USTS mode with either of two cell sites in SHO region, which may provide better performance. In Candidate 3, the UE keeps the radio link with the original cell site being in USTS mode until it moves out of the coverage of the original cell. When the UE drops the radio link with the original cell, it changes the mode of the radio link with the target cell to USTS mode. At this point, reconfiguration of scrambling and channelisation codes and also the timing control are required for non-USTS to USTS mode transition. If the UE returns to the original cell, just dropping the weaker radio link is the only thing the UE has to do.

In Candidate 4, the radio link modes of both links are changed in the middle of soft handover, which may improve the performance by providing USTS mode to a better radio link compared to Candidate 3. When the change point is at the cell boundary, Candidate 4 is the same as Candidate 3. And therefore, Candidate 3 can be seen as a special case of Candidate 4. If the change point is anywhere inside the SHO region, the optimum point and how to detect it need to be elaborated further.

Table 4.1 Four soft handover candidates for USTS (A simple example in case of two-way soft handover).

	The mode of UE		
Movement of UE	In original cell	In SHO region	In target cell
Candidate 1	USTS	Normal(O)+Normal(T)	Normal
Candidate 2	Normal	Normal(O)+Normal(T)	USTS
Candidate 3	USTS	USTS(O)+Non-USTS(T)	USTS
Candidate 4	USTS	USTS(O)+Non-USTS(T) ✍ Non-USTS(O)+USTS(T)	USTS

<Note> (O) : the mode with the **original** cell (T) : the mode with the **target** cell

If the new cell does not support USTS, only candidate 1 is applicable. And Candidate 2 is appicable when the original cell does not support USTS. R5 Node B means that it has the following two capabilities:

(1) timing control.

(2) discrimination of different UEs with both scrambling code and channelisation code(s).

R99/R4 Node B does not have either of two capabilities.

Figure 4.4 shows handover procedure for candidate 3 in more details. Both cells are in USTS mode, and UE2 and UE3 are in USTS mode with Node B1 and Node B2, respectively. When UE1 is in USTS mode, Node B1 assigns Scr1 and Ch3 to UE1. During soft handover, UE1 continues to use these codes and continues to be in USTS mode with Node B1. However, while UE1 is in SHO but it is in non-USTS mode with Node B2 because Tx timing of UE is controlled only to Node B1. When the UE1 moves out of SHO region, reconfiguration is required to assign new Scr and Ch codes and to inform the amount of timing adjustment for non-USTS to USTS transition. The amount of timing adjustment can be calculated with Round trip time measured in TS 25.215 (accordingly, RTPD) and T_{ref} . At this point, abrupt timing control may be required, which results in transmission gap at UE1. The same procedure is also required for normal to USTS mode transition.

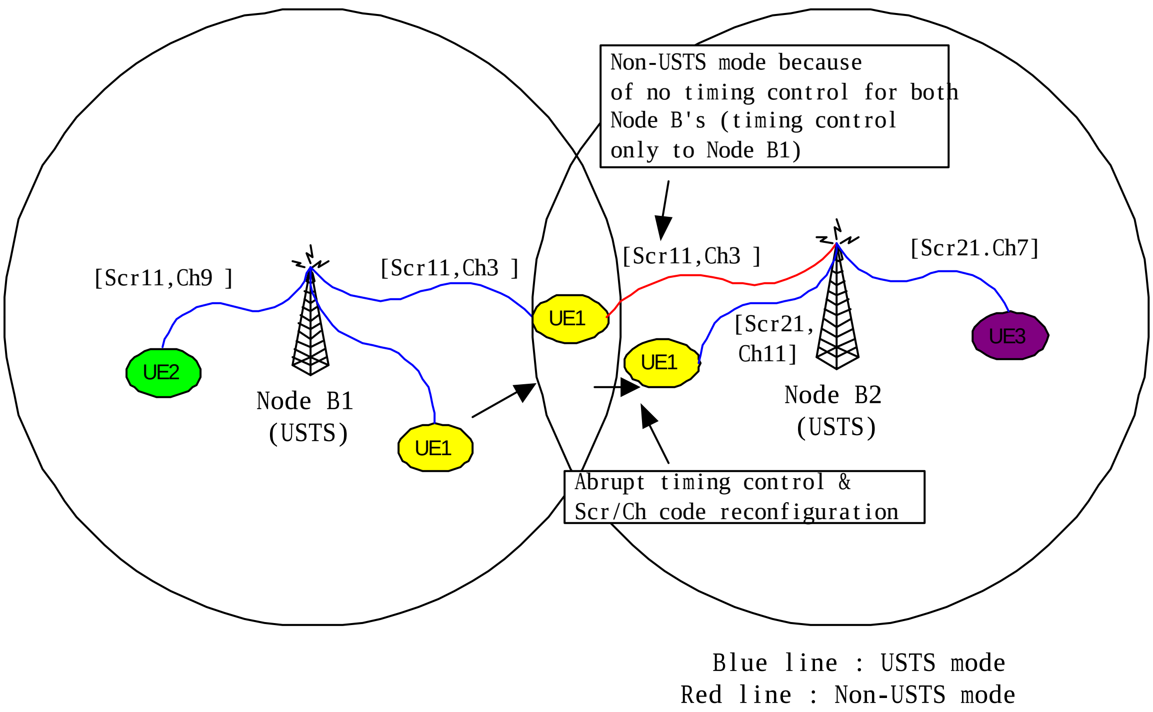

Figure 4.4 Two-way soft handover procedure for Candidate 3.

Figure 4.5 shows the handover candidate 4 in two-cell layout. Both Node Bs are operated in USTS. UE1 and UE2 are operated in USTS with Node B #1 and Node B #2, respectively. Let us focus on UE0 with interest. When UE0 is operated in USTS with Node B #1, UE0 gets scrambling code (Scr11) and channelisation code (Ch3) from Node B #1. When UE0 enters into the handover process, the radio link in non-USTS mode with Node B #2 is set up. Note that only Node B #1 controls the transmit timing of UE0, which uses the same codes and is operated in USTS with Node B #1. While UE0 exists in the soft handover region, the reconfiguration process is required to assign new scrambling code (Scr21), channelisation code (Ch11) and timing adjustment for non-USTS to USTS transition in Node B #2. Also USTS to non-USTS transition in Node B #1 is required to preserve the reliability from soft handover. The required timing adjustment for new USTS link can be obtained by RTPD and Tref in the same manner with candidate 3. Timing of non-USTS link in Node B #1 is acquired by the new USTS time adjustment and the time difference between Node B #1 and Node B #2. Finally, UE0 releases the radio link with Node B #1 when the UE0 does not need soft handover and soft handover process is completed.

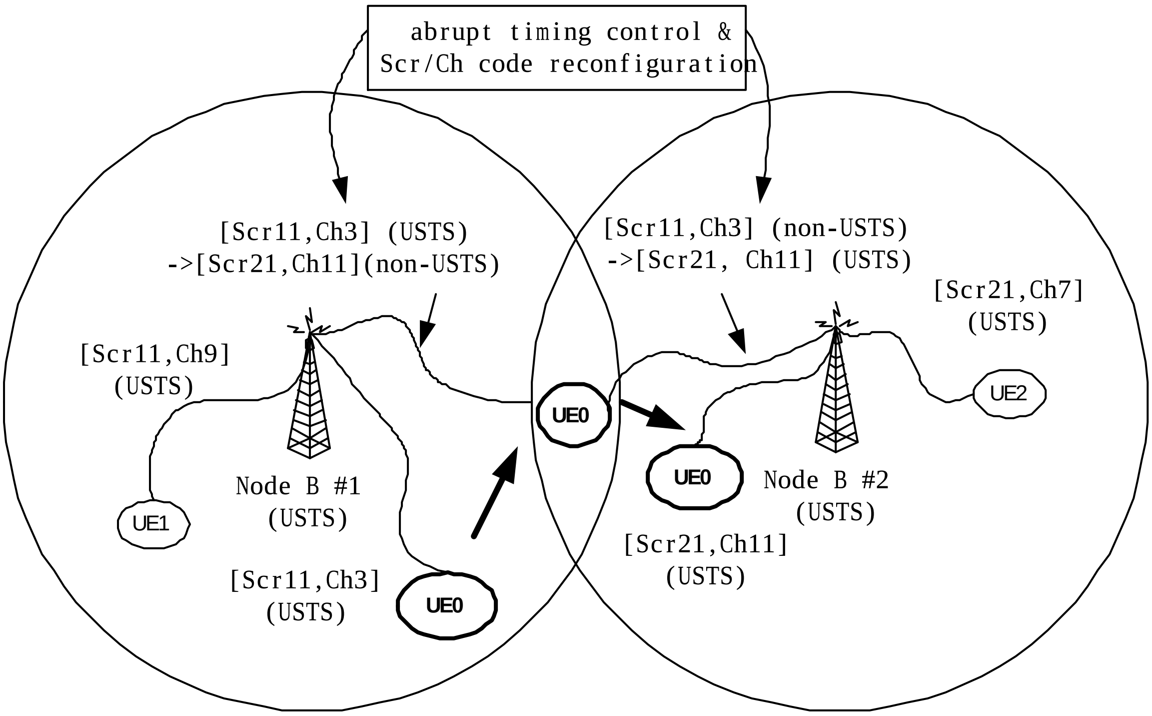

Figure 4.5. **Two-way soft handover procedure for candidate 4.**

Figure 4.6~~5~~ describes the arrival timing at Node B1 and Node B2. The arrival times from UEs in the Node B1 are controlled to be $?_{DPCH,1i}$? T_0 ? T_{ref} from the beginning of P-CCPCH1. Since $?_{DPCH,1i}$ is a multiple of 256 chips, the possible arrival point at Node B1 repeats every 256 chips. During soft handover, UE3 is in USTS mode with Node B1 and therefore, its arrival time at Node B1 is kept at $?_{DPCH,13}$? T_0 ? T_{ref}. However, even though the UE3 is in SHO with Node B2, it is in non-USTS mode because the arrival time at Node B2 is not controlled to guarantee synchronized reception with UE4 & UE5. When UE3 moves further into Node B2 area and drops the old link, then in order to be in USTS mode with Node B2, the arrival time at Node B2 needs to be controlled. Point a or point b can be chosen for USTS and their difference is 256 chips. To prevent abrupt timing advance at UE side, point b is always selected and therefore, transmission gap may result, which is less than 256 chips, i.e., the transmission at UE needs to be stopped for less than 256 chips and resumes after the gap. For this, $?_{DPCH,23}$ needs to be reassigned when selecting point b.

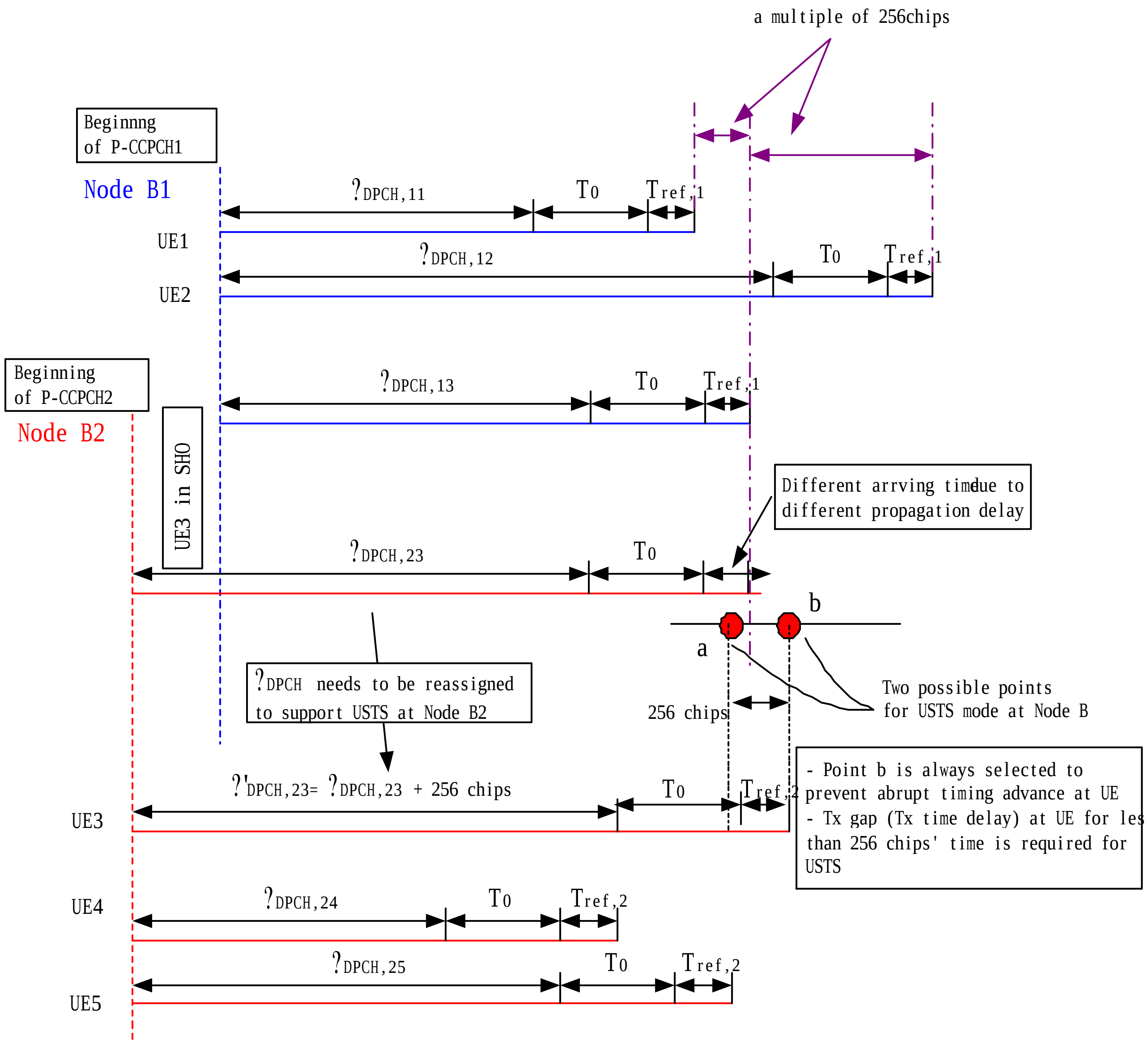

Figure 4.5 Arrival timing at Node B1 and Node B2

Reference

[1] R1-01-0061, "Comparison of soft handover for USTS", LGE

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5.1. Soft handover complexity

Timing control compexity and different assignment of scrambling/channelisation codes are discussed in the previous two subsections. Most of the complexity for soft handover is related to higher layers and will be dealt with in WG2 and WG3. UL/DL timing related issues in soft handover will be discussed in the following subsection because it is closely related to the CLPC.

Table 6.1 Complexity comparison of four soft handover candidates (two-way case, O: Original cell, T: Target cell)

Case	Candidate 1	Candidate 2	Candidate 3	Candidate 4 *
Adding a new link	Scr/Ch code reconf. (O,T,UE)	Radio link setup (T)	Radio link setup (T)	Radio link setup (T)
Dropping the link with original cell	Nothing	Scr/Ch code reconf. (T,UE) & Timing adjust. (T,UE)	Scr/Ch code reconf. (T,UE) & Timing adjust. (T,UE)	Nothing
Dropping the link with target cell	Scr/Ch code reconf. (O,UE) & Timing adjust. (O,UE)	Nothing	Nothing	Scr/Ch code reconf. (O,UE) & Timing adjust. (O,UE)
At mode transition within SHO region	Not occur	Not occur	Not occur	Scr/Ch code reconf. (O,T,UE) & Timing adjust. (T,UE)

* In candidate 4, the mode transition is assumed to occur within SHO region. If it occurs at the boundary, Candidate 4 is the same as Candidate 3.

The proposed soft handover candidates 3) and 4) need the timing adjustment and code assignment process, in order to operate in USTS mo de at target Node B. The reason why both timing adjustment and code assignment are operated is to get performance gains from orthogonality by USTS. The criterion that makes the reconfiguration process be operated is different in 3) and 4). In candidate 3), it is whether UE exists inside handover region or out of the region. However, the reconfiguration process occurs inside the soft handover region in 4). Even though the detailed procedures are beyond WG1's interests, UTRAN can select the proper timing for the reconfiguration process, because it selects the better frame between the two possible candidates within RNC, or knows the number of UEs in USTS mode at each Node B and pilot signal power of each UE from the reception of the measurement. The candidate 3) can provide more reliable USTS link at target Node B, because the UE obtains better channel conditions during handover process. As well, there would be more interference of a UE penetrating into target Node B without being timing alignment by USTS in 3) comparing with 4). That is because the timing change of target Node B always occurs outside the handover region. Such effects are more important in three-way soft handover. Figure 6.1 shows three-cell layout for candidate 3). When a UE gets out of USTS area with Node B #1, it should be decided whether USTS would be operated with Node B #2 or Node B #3 in soft handover region. In addition, non-USTS link should be set-up with the other Node B to keep the soft handover. Therefore, the reconfiguration process needs for candidate 3) in three-way soft handover operation like candidate 4). As well, there exist more chances to operate the soft handover in 4) for three-cell situation than in 3), which can reduce the interference to target Node Bs and improve the link performances. Ping-pong effects can be reduced by hysteresis as a similar manner with the handover method in Release 99. As explained above, the candidate 4) may give more reliable performance. However, complexity is expected to increase because the reconfiguration process needs to happen at original Node B. If USTS to non-USTS transition in original Node B does not happen, then the candidate 4) is the same with 3) except the point that handover takes place inside the handover region. Thus, the candidate 4) is a more general approach of soft handover for USTS.

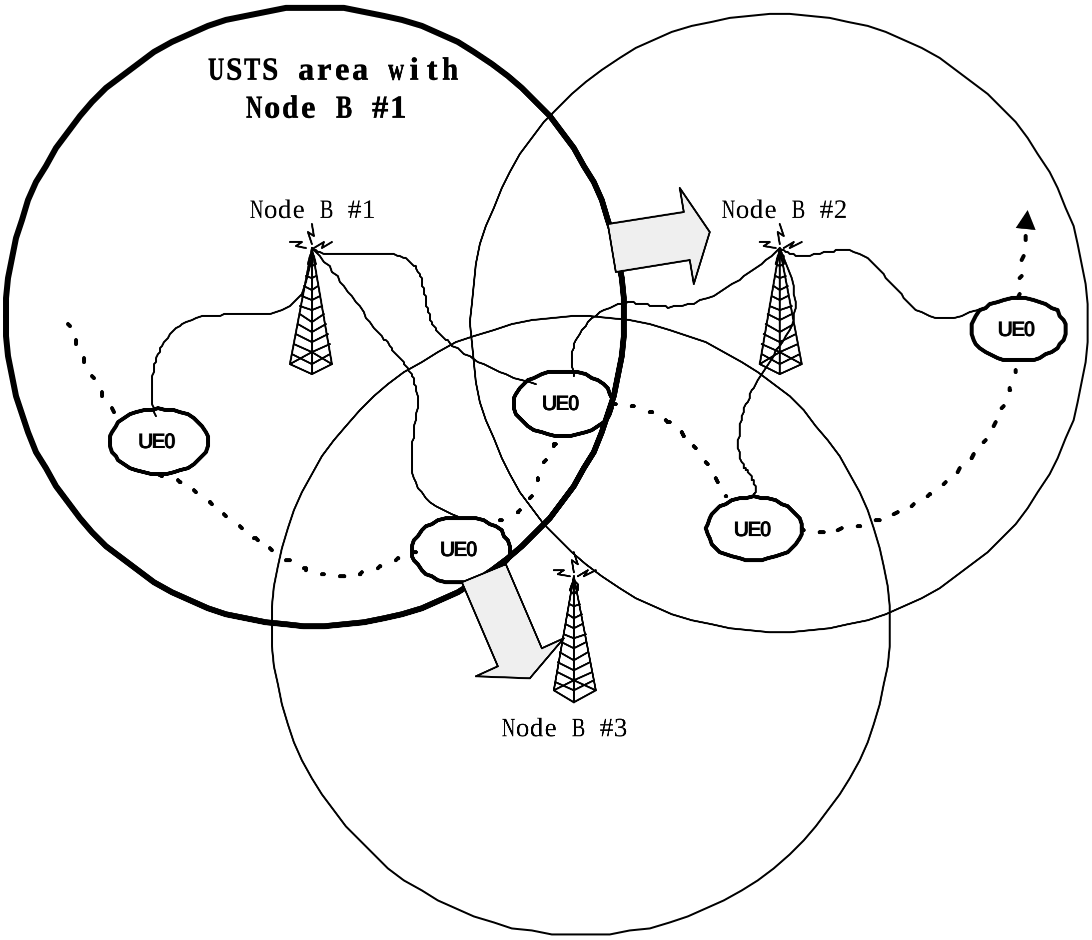

Figure 6.1. Three-way soft handover situation for candidate 3.

Reference: R1-01-0061, "Comparison of soft handover scheme for USTS", LGE.

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3. Reference

[1] TSG R1-01-0061, Comparison of soft handover schemes for USTS in soft handover, LG Electronics.