TSG-RAN Working Group 1 meeting #16 ***TSGR1#16(00)1263***
Pusan, KOREA, Oct. 10 – Oct. 13, 2000

Agenda Item:
Source: Rapporteur (SK Telecom)
Title: Feasibility study on USTS
Document for: Discussion

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1. Introduction

Until now, three documents have been presented at WG1 #14 in Oulu and at WG1 #15 in Berlin. Before proceed to the feasibility study on USTS, let me first briefly summarise them.

- Tdoc 903 explained the overview of USTS including transmission timing control and code usage. Timing control is required for synchronized reception at Node B and is performed by two steps; initial synchronization and tracking process. In order to exploit the orthogonality in the uplink, different scrambling/channelisation code usage has been proposed.
- Tdoc 904 discussed the performance of USTS analytically and by simulations as well.

After presenting the above two documents at WG1 #14, the following two issues were raised:

- Soft handover in USTS mode
- Further performance result for USTS+non-USTS mixed situation

Tdoc 1114 resolved many ambiguities about USTS by preparing answer to questions and comments on USTS. It covered some details about

- additional scrambling code(s)
- applicable environment for USTS
- the reference time
- impact on power control loop delay

and so on. It also proposed four candidates to provide soft handover in USTS mode.

The issues to be discussed at this meeting include:

- Performance gain for USTS+non-USTS mixed situation
- USTS in soft handover and application scenario
- Node B hardware requirement

2. Performance of USTS

=> Previous results

✍✍ **Simulation parameters**

- The first detected paths (in time) of UEs are aligned
- All UEs are in USTS mode
- Channel model : outdoor urban high-rise channel model (JTC)
- Number of Rake fingers = 3
- Mobile speed : 5.6 km/h
- Single cell
- Closed power control : OFF
- Number of oversamples per chip : 8
- Center frequency : 1.9 GHz

✍✍ **Simulation results**

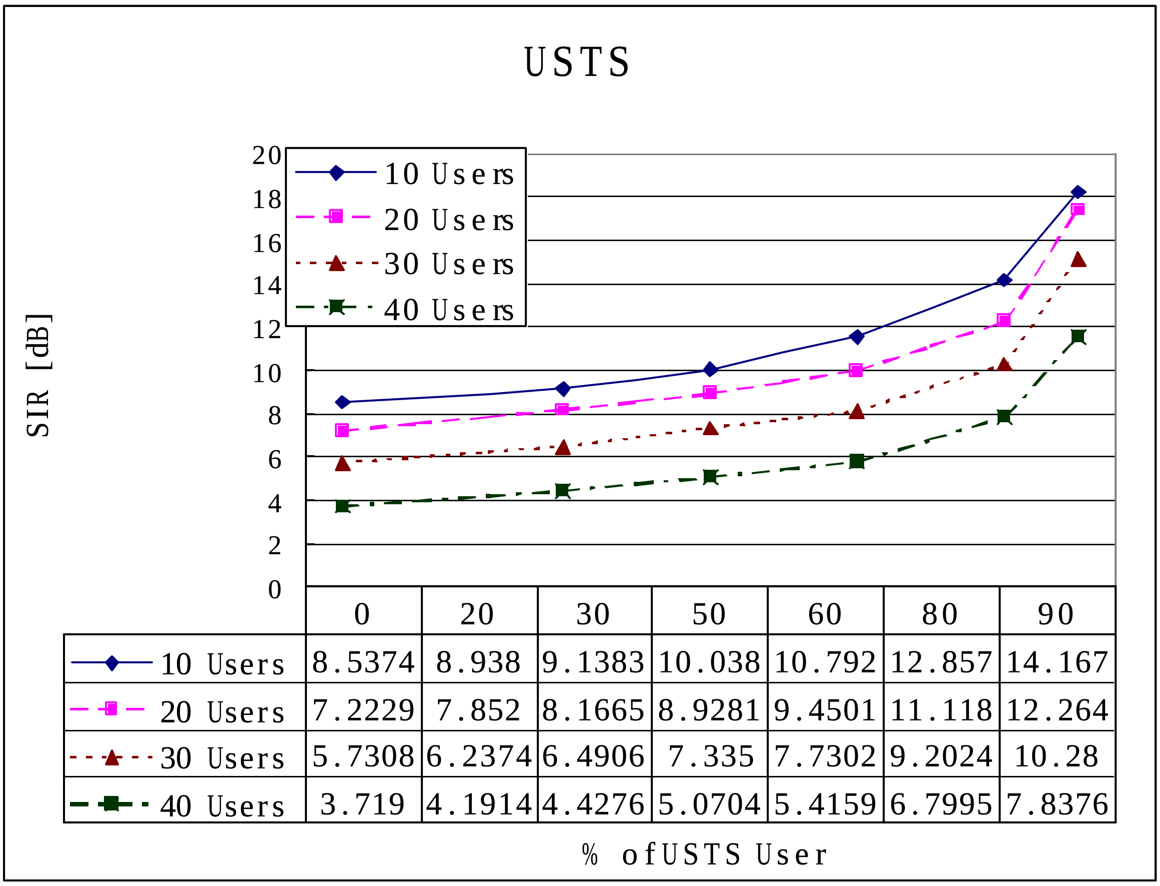
- About 3 dB gain in SIR compared to non-USTS mode
- Timing control resolution of less than 1/2 chip duration is desirable
- TAB error of less than 10 % provides good performance gain
- TAB rate needs to be at least three times faster than the channel variation rate (no problem in indoor & pedestrian environment)

=> Performance for a USTS+non-USTS mixed situation

Simulation parameters

- The first detected paths (in time) of UEs are aligned with a resolution of 1/4 chip duration
- Channel model : Pedestrian A (Speed : 3 km/h)
- No channel coding
- Uplink & single cell
- Closed loop power control : OFF
- SF : 128
- Number of oversamples per chip : 4
- Center frequency : 2 GHz
- Number of fingers : 1
- Modulation/Spreading : QPSK/complex
- Chip rate : 3.84 Mcps

Simulation results



	0	20	30	50	60	80	90
10 Users	8.5374	8.938	9.1383	10.038	10.792	12.857	14.167
20 Users	7.2229	7.852	8.1665	8.9281	9.4501	11.118	12.264
30 Users	5.7308	6.2374	6.4906	7.335	7.7302	9.2024	10.28
40 Users	3.719	4.1914	4.4276	5.0704	5.4159	6.7995	7.8376

Under the above channel model, the first three paths are very close to each other so that they are within one chip duration and therefore, they are not discriminated. And the signal powers of the other paths are very small. Accordingly, choosing one Rake finger in the simulation is reasonable under this channel model.

The percentage of USTS users largely affects the performance gain as well. If all UEs support USTS, then 30 % of them are usually in SHO and half of the UEs in SHO are not in USTS mode. Accordingly, if the multiple cell system is taken into account, no more than 85 % of UEs can be in USTS mode.

We also have simulation results in Indoor A and Pedestrian B channel models. As more strong multipaths exist, the performance gain of USTS decreases. However, since in most cases of indoor or pedestrian environment, the first detected path is relatively stronger than any other paths, good performance gain can be expected by using USTS.

Compared to the single cell system, if multiple cell (other cell) and soft handover are taken into account, the performance gain of USTS is reduced. For example, the other cell inteference factor f is 0.77 and half of the UEs in SHO are assumed to be in non-USTS mode, the gain is reduced by half approximately. However, the performance gain of USTS is still high, especially in indoor and dense pedestrian environments.

3. Handover scenarios

Four candidates were proposed for USTS at the last meeting:

1. USTS ✍ non-USTS (SHO) ✍ non-USTS
2. USTS ✍ non-USTS (SHO) ✍ USTS
3. USTS ✍ USTS + non-USTS (SHO) ✍ USTS
4. USTS ✍ USTS + non-USTS (SHO) ✍ non-USTS + USTS (SHO) ✍ USTS

From performance point of view, it's better in the increasing order. However, the complexity increases in the same order as well. Considering this trade-off relation, when the both old and new cells support USTS, candidates 3 or 4 are adequate. If the new cell does not support USTS, only candidate 1 is applicable, where USTS 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). If Node B does not have either of two capabilities, then it is herein called Non-USTS Node B. During the transition from non-USTS mode to USTS mode in candidates 2,3, and 4, transmission (Tx) gap is required to support USTS. Fig. 1 shows handover procedure for candidate 3.

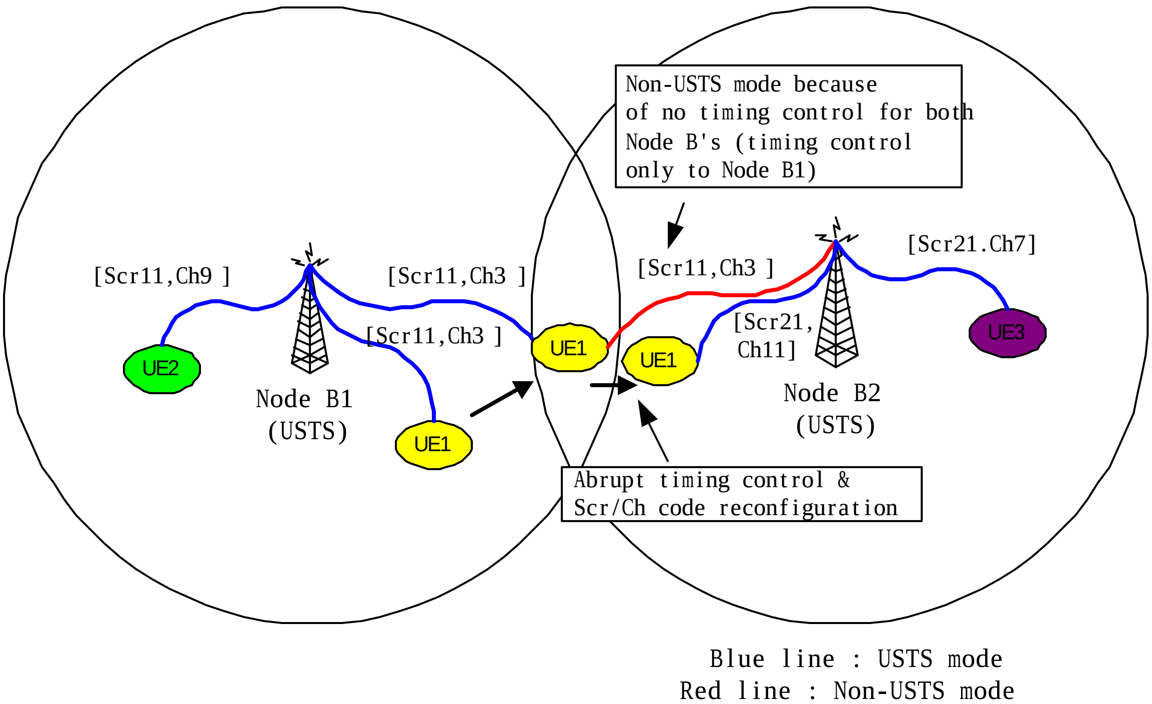


Fig. 1. Soft handover procedure for Candidate 3.

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, new Scr and Ch codes are assigned and now UE1 is in USTS mode with Node B2. At this point, abrupt timing control is required and this requires transmission gap at UE1. To explain this in more detail, Fig. 2 describes the arrival timing at Node B1 and Node B2.

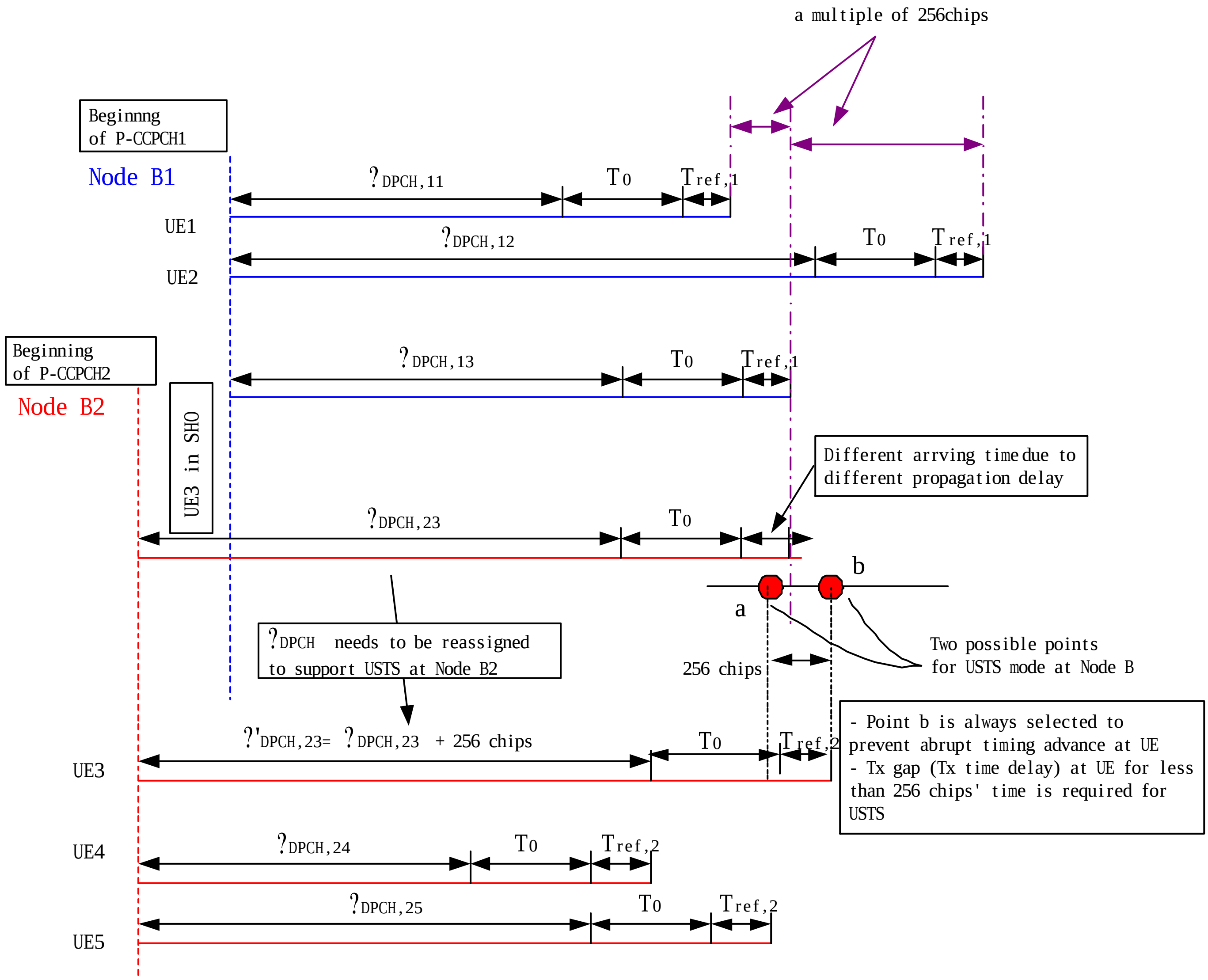


Fig. 2. Arrival timing at Node B1 and Node B2

The arrival times of UEs in 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 arrival point at Node B1 repeats every 256 chips. During soft handover, UE3 is in USTS mode 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 not in USTS mode because the arrival time at Node B2 is not controlled to guarantee synchronized reception with UE4 & UE5. When UE3 further moves into Node B2 area and drops the old link, then in order to be in USTS mode with Node B2, the arriving 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 is needed, 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. This kind of timing control is necessary for fast transition to USTS mode. $?_{DPCH,23}$ needs to be reassigned when selecting point b.

4. Expected Node B/UE hardware requirements

No additional Node B hardware requirement to support USTS

- The same scrambling /channelisation codes are used
- TAB is transmitted by puncturing TPC
- Measuring round trip propagation delay already exists

Small increase in computational complexity

- to calculate initial synchronisation time
- to set TAB command

Tx timing needs to be adjusted at UE side

- at initial synchronisation phase
- during tracking process
- Tx gap during non-USTS-to-USTS transition for soft handover

Impacts on WG2&3 specifications have been investigated but not so much discussed in both groups.

References

[1]R1-00-0903,"Uplink synchronous transmission scheme (USTS)", SK Telecom

[2]R1-00-0904,"Performance study of uplink synchronous transmission scheme (USTS)," SK Telecom

[3]R1-00-1114,"Answer to questions and comments on USTS", SK Telecom