Agenda Item:	
Source:	**Samsung Electronics & SK Telecom**
Title:	**OVSF code allocation rule for Uplink Synchronous Transmission Scheme (USTS) (rev. 1)**
Document for:	**Information and Discussion**

Introduction

USTS is an alternative technology applicable to low mobility terminals. USTS can reduce uplink intra-cell interference by making UEs share a scrambling code and the cell receives orthogonalized signals from the UEs. This feature is intended to support uplink synchronous transmission with low overhead, good capacity characteristics, and minimal impact on hardware and software resources at the UE and in the UTRAN [1-12].

In the USTS, the same scrambling code can be allocated to more than one UEs. Whenever more than one UEs share one scrambling code, the different and orthogonal channelisation codes should be allocated to each UE. UL DPCH of a UE in USTS needs at least two channelisation codes: one for DPCCH and the others for DPDCH. The DPCCH part of a UL DPCH has SF 256 and the DPDCH part of a UL DPCH can have variable SF from 4, 8, 16, 32, 64, 128 and 256. The channelisation codes for DPDCH and DPCCH in a UE shall be chosen from either upper half part or the lower half part of the OVSF code tree in a UE to reduce PAPR (peak to average power ratio) [13].

The performance gain of USTS is greater as more UEs share one scrambling code. If OVSF codes are allocated inefficiently, less UEs can share one scrambling code. For example, assume that the channelisation codes for DPDCH and DPCCH in UEs are chosen from either upper half code tree and $C_{ch,8,0}$ and $C_{ch,256,32}$ are allocated to a UE for DPDCH and DPCCH, respectively, and $C_{ch,8,2}$ and $C_{ch,256,120}$ are allocated to another UE for DPDCH and DPCCH, respectively. Then no more OVSF code with SF 8 can be allocated in the upper half code tree. Since the SF of OVSF code for DPCCH is always 256 while the SF of OVSF code for DPDCH can be between 4 and 256, a special OVSF code allocation rule can be introduced to allocate OVSF codes to more UEs. If an efficient OVSF code allocation scheme is used, maximum three UEs in each half code tree can share the scrambling code with SF 8.

This contribution introduces and proposes an efficient OVSF code allocation rule for USTS.

Discussion

1. Procedure for USTS

When USTS is applied, to orthogonalize receiving signals from UEs,

- the network allocates the same scrambling code to multiple UEs that using USTS,

- different channelisation codes are allocated to all dedicated physical channels across all UEs which share a scrambling code in a cell, and the spreading factor and the channelisation code for uplink DPDCH are delivered from network to each UE,

- the UE shall choose the channelisation code for uplink DPCCH from the same upper or lower half part of the OVSF code tree with the assigned DPDCH channelisation code to reduce PAPR, and

- the signal transmission time of each UE is adjusted by UTRAN.

The mapping rule of channelisation code between DPDCH and DPCCH is specified in the next section.

2. Mapping Rule of Channelisation Code between DPDCH and DPCCH

- The sub-trees below the nodes $C_{ch,8,3}$ and $C_{ch,8,7}$ are reserved for DPCCH.

- ***In the upper half code tree***, the channelisation code for the DPDCH, $C_{ch,SF,k}$ shall be chosen among the following ranges of k.

$$k = \begin{cases} 0,1,\cdots,(\lfloor 3\times SF/8 \rfloor \text{-}1) & \text{if } SF \leq 64 \\ 0,2,\cdots,46 & \text{if } SF = 128 \\ 0,4,\cdots,92 & \text{if } SF = 256 \end{cases}$$

And, the channelisation code for the associated DPCCH shall be $C_{ch,256,127\text{-}n}$, where
$$n = 64\times k / SF$$

As a result, maximum of 24 channelisation code can be assigned to UE in upper half code tree.

- ***In the lower half code tree***, the channelisation code for the DPDCH, $C_{ch,SF,k}$ shall be chosen among the following ranges of k.

$$k = \begin{cases} \lfloor 4\times SF/8 \rfloor,(\lfloor 4\times SF/8 \rfloor+1),\cdots,(\lfloor 7\times SF/8 \rfloor \text{-}1) & \text{if } SF \leq 64 \\ 64,66,\cdots,110 & \text{if } SF = 128 \\ 128,132,\cdots,220 & \text{if } SF = 256 \end{cases}$$

And, the channelisation code for the associated DPCCH shall be $C_{ch,256,255\text{-}n}$, where
$$n = 64\times k / SF.$$

As a result, maximum of 24 channelisation code can be assigned to UE in lower half code tree.

- The DPDCH uses any of the channelisation codes of spreading factor from the SF corresponding to the assigned channelisation code to 256 in the upper-most branch of the sub-tree

- If more than one channelisation codes for DPDCHs are allocated to a UE, then the channelisation code for DPCCH corresponding to the first allocated channelisation code for DPDCH will be used as the channelisation code for the DPCCH.

3. Examples for explanation

Figure 1 shows the OVSF code allocation rule described above. Coloured codes explain how to map the OVSF code for a DPDCH to the OVSF code for a DPCCH.

Example 1: If one of $C_{ch,4,0}$, $C_{ch,8,0}$, $C_{ch,16,0}$, $C_{ch,32,0}$, $C_{ch,64,0}$, $C_{ch,128,0}$, and $C_{ch,256,0}$ is allocated to a UE for DPDCH, then OVSF code $C_{ch,256,127}$ will be allocated to the UE for DPCCH as shown with the red-coloured codes.

Example 2: If one of $C_{ch,64,3}$, $C_{ch,128,6}$, and $C_{ch,256,12}$ is allocated to a UE for DPDCH, then OVSF code $C_{ch,256,124}$ will be allocated to the UE for DPCCH as shown with the blue-coloured codes.

Example 3: If one of $C_{ch,8,2}$, $C_{ch,16,4}$, $C_{ch,32,8}$, $C_{ch,64,16}$, $C_{ch,128,32}$, and $C_{ch,256,64}$ is allocated to a UE for DPDCH, then OVSF code $C_{ch,256,111}$ will be allocated to the UE for DPCCH as shown with the green-coloured codes.

The examples consider the case that the OVSF codes for DPDCHs are in the upper half code tree. When the OVSF codes for DPDCHs are allocated in the lower half code tree, the same rule is to be applied.

Conclusion

In USTS, more than one UEs share the same scrambling code and hence the UEs are distinguished by channelisation codes. Since the number of channelisation codes is limited, an efficient channelisation code allocation rule is required.
In this contribution we introduced a simple and efficient channelisation code allocation rule. Using the introduced channelisation code allocation rule, UTRAN can allocate UEs to share one scrambling code, which enhances the operation of USTS.
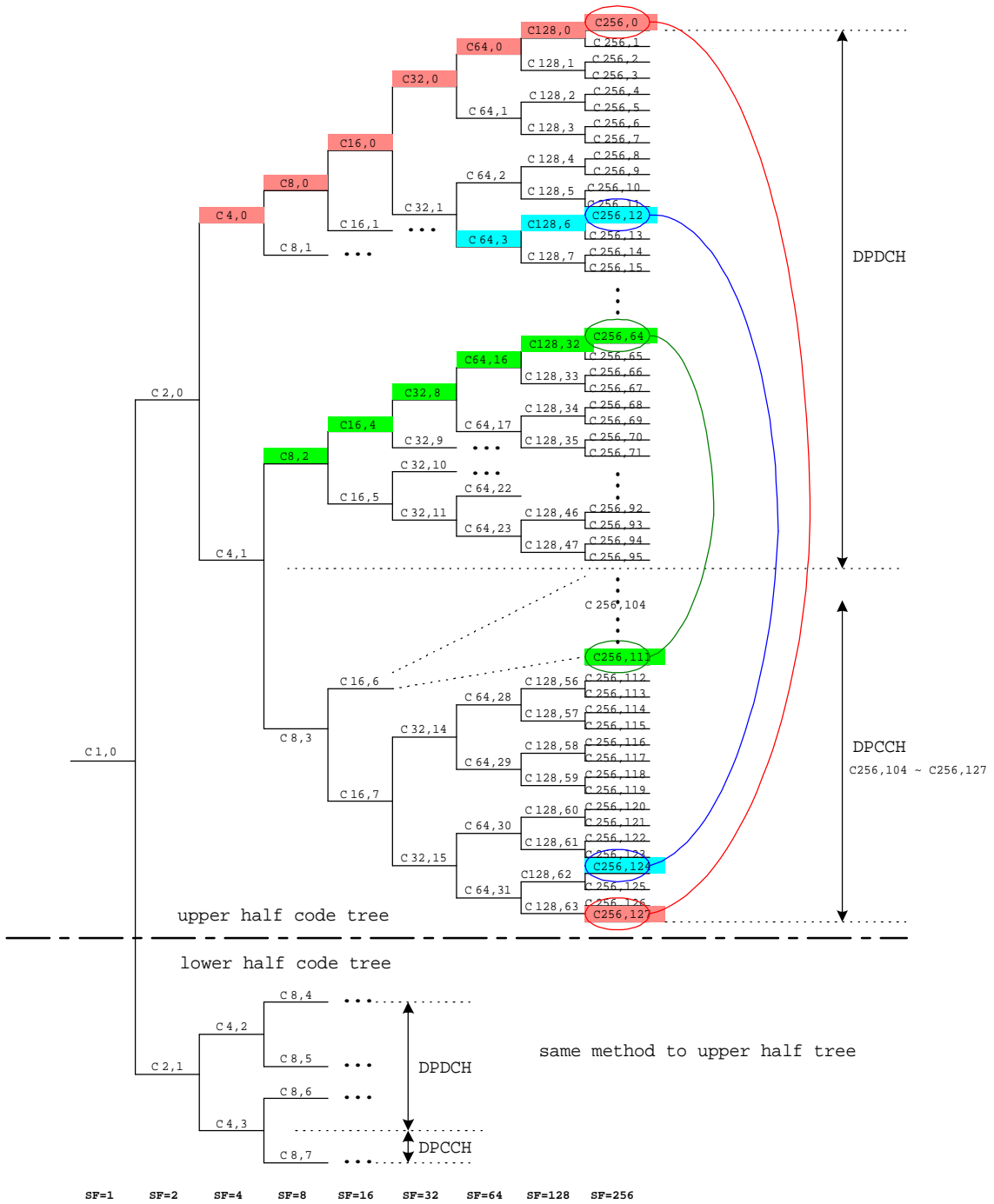
Figure 1 OVSF code tree and mapping rule

References

[1] R1-99e68, "Uplink synchronous transmission scheme (USTS)", SK Telecom

[2] R1-99j82, "Code allocation and timing control for USTS", SK Telecom

[3] R1-99j84, "CR for TAB structure and timing relation for USTS in TS 25.211", SK Telecom

[4] R1-99j85, "CR for channelisation code allocation for USTS in TS25.211", SK Telecom

[5] R1-99j86, "CR for the procedure for USTS in TS25.214", SK Telecom

[6] R1-99j87, "Initial synchronisation and CR for initial synchronisation for USTS in 25.215", SK Telecom

[7] R1-99l29, "CR for TAB structure and timing relation for USTS in TS25.211", SK Telecom

[8] R1-99l30, "CR for channelization code allocation for USTS in TS25.213", SK Telecom

[9] R1-99l31, "CR for the procedure for USTS in TS25.214", SK Telecom

[10] R1-00422, "CRs to 25.211, 25.213, and 25.214 for clean up of USTS related specifications", SK Telecom

[11] R1-00451,"Proposed Work Item on USTS", SK Telecom

[12] R2-99j93, "Proposed CR 107r1 to 25.331 on Modification of RRC message for USTS", SK Telecom

[13] R1-99-0581 "Channelization code assignment for RSTS", ETRI

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