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Agenda Item:

Source: **Samsung Electronics & SK Telecom**

Title: **OVSF code allocation rule for Uplink Synchronous Transmission Scheme (USTS)**

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 receive 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 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 $C_{ch,4,0}$ and $C_{ch,256,64}$ are allocated to a UE for DPDCH and DPCCH, respectively, and $C_{ch,4,2}$ and $C_{ch,256,192}$ are allocated to another UE for DPDCH and DPCCH, respectively. Then no more OVSF code with SF 4 can be allocated. Just two UEs that want channelisation code with SF4 can share the scrambling code. 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 can share the scrambling code with SF 4.

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 ‘node number’ of channelisation code tree are delivered from network to each UE, and
- the signal transmission time of each UE is adjusted by UTRAN.

The channelisation codes for DPDCH and DPCCH in a UE are chosen to follow OVSF code allocation rule. The channelisation code allocation scheme for USTS is described below.

2. Code allocation for DPCCH/DPDCH

A special OVSF code allocation scheme is required for USTS due to the following facts:

- A whole set of OVSF code is shared by the UEs which use the same UL scrambling code in USTS.
- At least two OVSF codes should be assigned to each UE, one for DPCCH and the others for DPDCH. The SF of OVSF code for DPCCH is always 256 while the SF of OVSF code for DPDCH can be between 4 and 256.
- USTS can reduce uplink intra-cell interference further by making more UEs share a scrambling. Thus, the gain of USTS increases as more UEs share one scrambling code.

Therefore the following OVSF code allocation rule is introduced. For the allocation of the channelisation code for DPDCH and DPCCH pair of one UE, a novel code-mapping rule can be applied.

First of all, the sub-tree below the node $C_{ch,4,3}$ is reserved for DPCCH.

For the DPDCH of a UE, the UTRAN assigns a node number v_d ($0 \le v_d \le SF*3/4-1$) where SF corresponds to allowed maximum data rate for the UE. The sub-tree below the assigned node is used for spreading of DPDCH.

- The DPDCH is spread by code $C_{ch,SF,k}$, where SF is the spreading factor of DPDCH, and $k=v_d$.

For the DPCCH in USTS, the UTRAN assigns a node number v_c ($192 \le v_c \le 255$) in the code-tree that corresponds to a channelisation code of length 256.

- The DPCCH is always spread by the code $C_{ch,256,k}$, where $k=v_c$.

3. Mapping Rule of Channelisation Code between DPDCH and DPCCH

UTRAN shall assign a specific node of OVSF code tree to a UE in USTS. The DPDCH uses any of the channelisation codes of spreading factor from the SF corresponding to the assigned node to 256 in the upper-most branch of the sub-tree. If $C_{ch,SF,k}$ is the channelisation code assigned to DPDCH, where the range of k depends on the SF as follows,

$$k = \begin{cases} 0,1,\cdots,(3\times SF/4-1) & \text{if } SF \le 64 \\ 0,2,\cdots,94 & \text{if } SF = 128 \\ 0,4,\cdots,188 & \text{if } SF = 256 \end{cases}$$

then, the OVSF code $C_{ch,256,255-n}$ is assigned for DPCCH associated with the DPDCH, where

$$n = 64\times k / SF .$$

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

4. 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 $C_{ch,256,255}$ will be allocated to the UE for DPCCH as shown with the yellow-coloured codes.

Example 2: If one of $C_{ch,16,7}$, $C_{ch,32,14}$, $C_{ch,64,28}$, $C_{ch,128,56}$, and $C_{ch,256,112}$ is allocated to a UE for DPDCH, then OVSF code $C_{ch,256,227}$ will be allocated to the UE for DPCCH as shown with the green-coloured codes.

Example 3: If one of $C_{ch,64,31}$, $C_{ch,128,62}$, and $C_{ch,256,124}$ is allocated to a UE for DPDCH, then OVSF code $C_{ch,256,224}$ will be allocated to the UE for DPCCH as shown with the blue-coloured codes.

Conclusion

In this contribution, an efficient OVSF code allocation rule for USTS is introduced and proposed. Using the introduced OVSF code allocation rule, UTRAN can allocate more UEs to one scrambling code which enhances the operation of USTS.

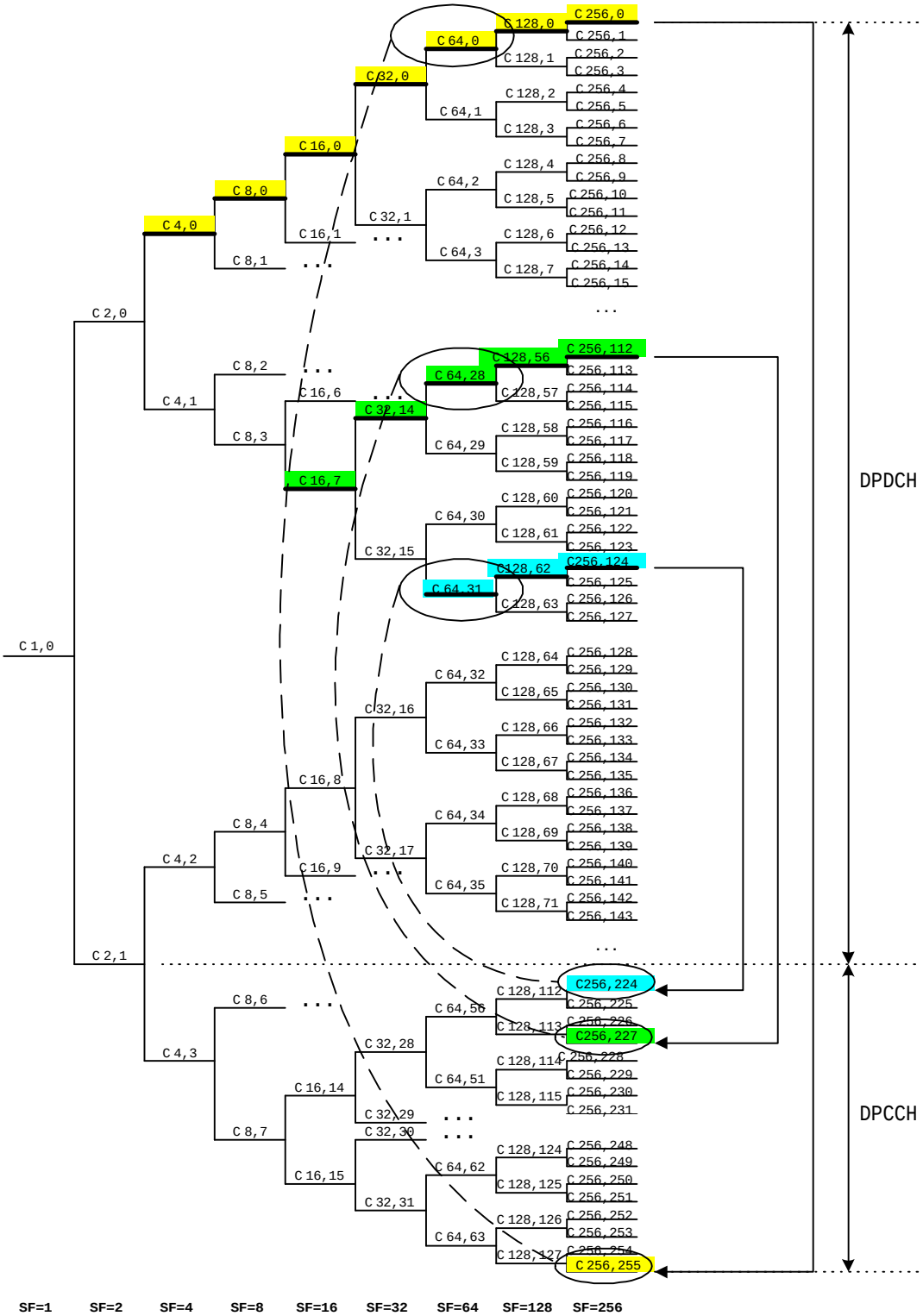

Figure 1 OVSF code tree and mapping rule

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