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October 4 - 5, Kyongju, Korea

Agenda Item : Ad hoc 14

Source : LG Information & Communications, Ltd.

Title : The Secondary Collision Detection for CPCH (revised version)

Document for : Proposal

Abstract

This document proposes the Secondary Collision Detection reinforcing the capability of collision detection of CPCH with low complexity, no additional delay and no effects on the current collision detection configuration.

1. Introduction

Philips previously proposed the second resolution phase to improve the collision resolution in CPCH [1]. This would allow sharing with RACH of all the preamble signatures and AICH channels used by CPCH. This is a significant benefit in that it allows RACH and CPCH to be implemented with a single set of preambles and a single AICH. But this proposal requires additional delay and downlink channelization code.

On the other hands, GBT suggested the power control (PC) preamble. It stabilizes packet transmission tracking down varying fading environments.

LGIC developed Philips' proposal and suggested the secondary collision detection (SCD). It harmonizes the second resolution phase by Philips with the PC preamble by GBT. In our scheme, SCD preamble operates with PC preamble [2],[3], which solves two problems on the Philips' proposal, mentioned before. Furthermore, it has low complexity because it utilizes the existing L1 configuration.

2. Proposal

Our proposal, SCD scheme, developed Philips' the second resolution phase [1]. In the document, two kinds of orthogonal codes called SCD (Secondary Collision Detection) preamble signature and SCDI (Secondary Collision Detection Indicator) signature are defined. SCD preamble signature corresponds to SCDI signature. SCD preamble signature is randomly picked up among the pre-determined SCD preamble signatures and is transmitted on SCD preamble by UE. It helps BS detect collision. On the other hand, SCDI signature is used for BS to acknowledge each UE. SCDI signature is deliberately determined and is transmitted in SCDI fields on DL-DPCCH by BS. The SCD procedure is similar to the CD procedure in current CPCH.

Figure 1 shows the structure of SCD scheme in CPCH. In this proposal, we name the DPDCH carrying SCD code the SCD preamble. SCD preamble simultaneously operates with PC preamble. SCD preamble has flexible length 2*p slot, where p = 1,2,3,4 with variable length of PC preamble.

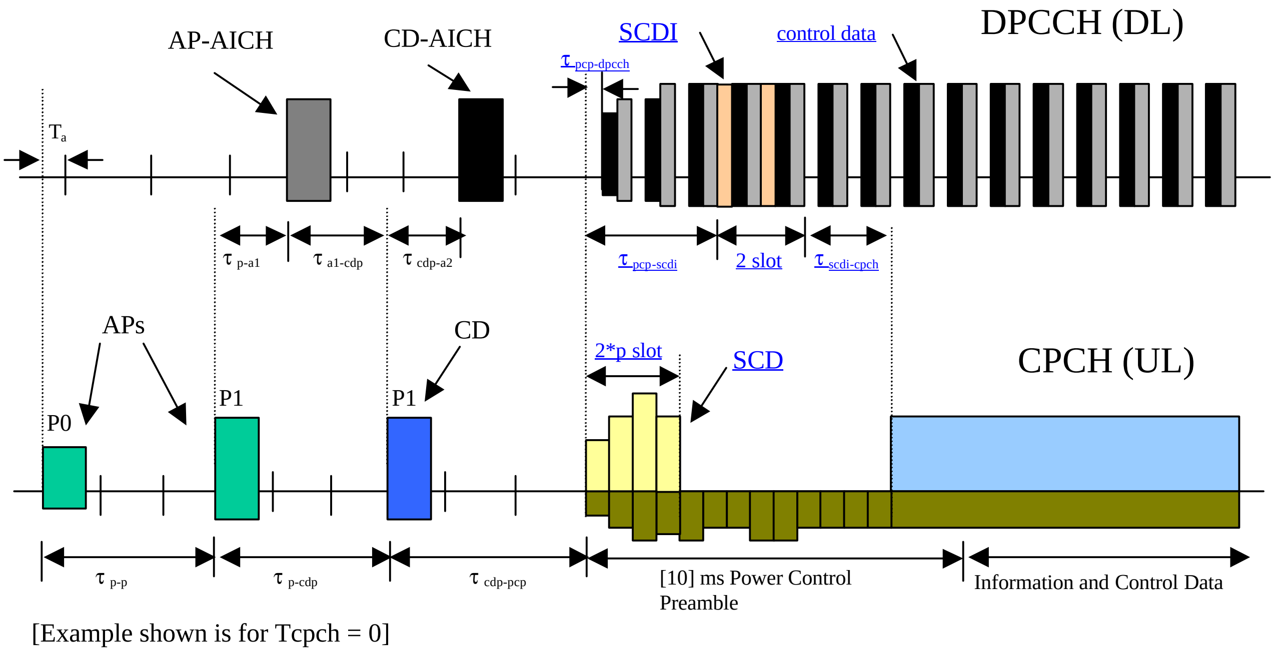

Figure 1: Structure of the CPCH with SCD preamble.

SCD preamble signatures use the Hadamard codes of length 16 that is identical to the RACH preamble signatures. The SCD preamble signatures of length 16, SC_{16} are listed in Table 1.

	16 SCD preamble signatures															
	h_0	h_1	h_2	h_3	h_4	h_5	h_6	h_7	h_8	h_9	h_{10}	h_{11}	h_{12}	h_{13}	h_{14}	h_{15}
$SC_{16,1}$	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
$SC_{16,2}$	1	-1	1	-1	1	-1	1	-1	1	-1	1	-1	1	-1	1	-1
$SC_{16,3}$	1	1	-1	-1	1	1	-1	-1	1	1	-1	-1	1	1	-1	-1
$SC_{16,4}$	1	-1	-1	1	1	-1	-1	1	1	-1	-1	1	1	-1	-1	1
$SC_{16,5}$	1	1	1	1	-1	-1	-1	-1	1	1	1	1	-1	-1	-1	-1
$SC_{16,6}$	1	-1	1	-1	-1	1	-1	1	1	-1	1	-1	-1	1	-1	1
$SC_{16,7}$	1	1	-1	-1	-1	-1	1	1	1	1	-1	-1	-1	-1	1	1
$SC_{16,8}$	1	-1	-1	1	-1	1	1	-1	1	-1	-1	1	-1	1	1	-1
$SC_{16,9}$	1	1	1	1	1	1	1	1	-1	-1	-1	-1	-1	-1	-1	-1
$SC_{16,10}$	1	-1	1	-1	1	-1	1	-1	-1	1	-1	1	-1	1	-1	1
$SC_{16,11}$	1	1	-1	-1	1	1	-1	-1	-1	-1	1	1	-1	-1	1	1
$SC_{16,12}$	1	-1	-1	1	1	-1	-1	1	-1	1	1	-1	-1	1	1	-1
$SC_{16,13}$	1	1	1	1	-1	-1	-1	-1	-1	-1	-1	-1	1	1	1	1
$SC_{16,14}$	1	-1	1	-1	-1	1	-1	1	-1	1	-1	1	1	-1	1	-1
$SC_{16,15}$	1	1	-1	-1	-1	-1	1	1	-1	-1	1	1	1	1	-1	-1
$SC_{16,16}$	1	-1	-1	1	-1	1	1	-1	-1	1	1	-1	1	-1	-1	1

[Table 1.] The SCD preamble signature of length 16

Figure 2 shows the structure of DPDCH SCD preamble. The SCD-preamble once or more than once carries one of sixteen different orthogonal signatures identical to the ones used by the preamble part of the random-access burst. The spreading factor of DPDCH SCD-P is identical to the spreading factor of the data part of CPCH message part. For $N_{scd}=8*2^k$ bits, where k=1…6, SCD preamble signature of 16 bits is repeatedly 2^{k-1} times mapped onto each slot, where k=1…6. In case of $N_{scd}=8$ bits, the first half of SCD preamble signature is mapped onto every odd slot and the latter half of SCD preamble signature is mapped onto every even slot.

UE performs closed loop power control on SCD preamble. The initial power level of SCD preamble is reduced in proportion the length of the SCD preamble.

In this proposal, we suggested even-slot SCD preamble, but odd-slot SCD preamble (i.e. 1,3,5,7 slot) can be possible when the last slot of odd-slot SCD preamble is cut from even-slot SCD preamble (i.e. 2,4,6,8 slots). In case of odd-slot SCD preamble for SF= 256, the number of SCD preamble signatures and SCDI signatures would be 8.

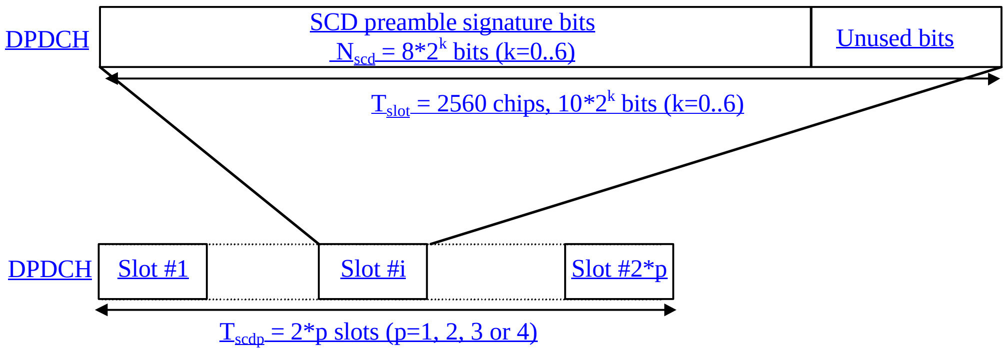

Figure 2: Structure of the Secondary Collision Detection Preamble.

Figure 3 shows the slot structure of the downlink dedicated physical channel carrying Secondary Collision Detection Indicator (SCDI) signature. SCD preamble signature corresponds to SCDI signature. 8-bit SCDI signature is split into SCDI fields in pre-designated consecutive 2 slots (see figure 1) on the downlink dedicated physical channel.

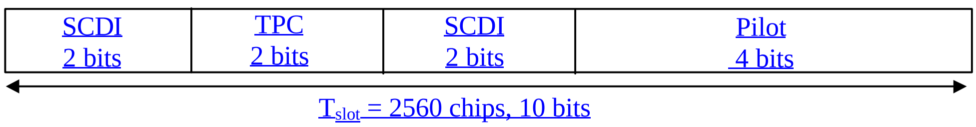

Figure 3: Slot structure of the downlink dedicated physical channel carrying Secondary Collision Detection Indicator

The SCDI fields on DL-DPCCH carries one of sixteen different code words of the bi-orthogonal (8, 4) code. Table 2 shows the mapping between SCD preamble signatures and SCDI signatures.

SCD preamble signature	Code words for SCDI signature
1	$C_{8,0}$
2	$\overline{C}_{8,0}$
3	$C_{8,1}$
…	…
14	$\overline{C}_{8,6}$
15	$C_{8,7}$
16	$\overline{C}_{8,7}$

Table 2. mapping between SCD preamble signatures and SCDI signatures

3. Analysis & Discussion

We analyze the packet transmission failure rate in the current CPCH and the proposal. The packet transmission failure rate means the probability of failure owing to simultaneous CPCH packet transmission by colliding UEs. The number of signatures for AP, CD and SCD is assumed to be 16. The details on analysis are found in appendix.

Figure 4 shows the analysis results of the packet transmission failure rate in case of the current CPCH and the CPCH with SCD scheme. In this figure, solid lines denote the result for the current CPCH and dashed lines denote the result for the CPCH with SCD scheme according to the number of AP signatures.

As mentioned in [1], the result shows that when the resource is free, there could be a significant probability of collision. Considering that AP preambles correspond to CPCH data rates, if the set of valid signatures for initial access is restricted, for example because most of the CPCH resources are already occupied, then the initial collision probability could be rather high. But in case of the CPCH with SCD scheme, it is very stable though as shown in figure 4.

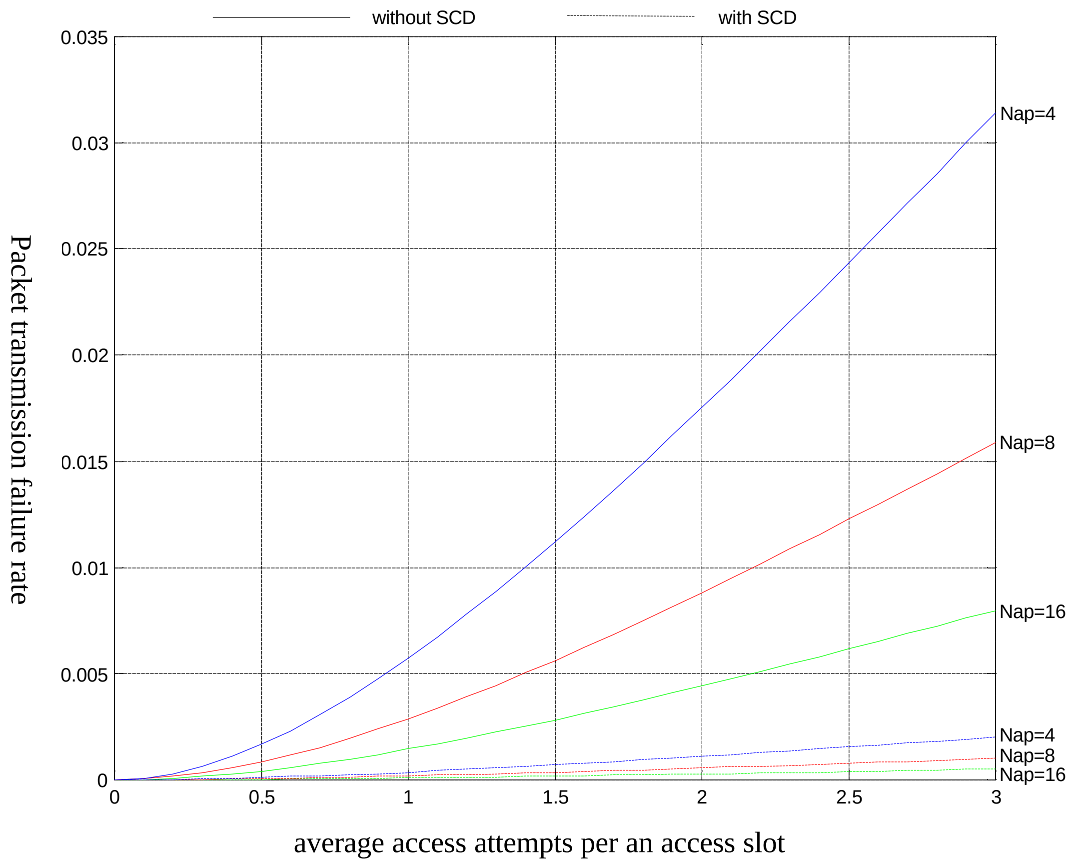

Figure 4: Packet transmission failure rate vs. average access attempts per an access slot

(N_{ap}: the number of available AP signatures)

4. Conclusion

We proposed the Secondary Collision Detection. CPCH with the proposed scheme would diminish collision more and more. This has no additional delay and no effects on the current collision detection configuration. We recommend the scheme described above be adopted as working assumptions for CPCH.

5. References

[1] Philips, "Improved performance and downlink code use for CPCH", TSGR1#6(99)820

[2] LGIC, "The Secondary Collision Detection for CPCH", TSGR1#7(99)b54

[3] LGIC, “The Timing of the Secondary Collision Detection for CPCH”, TSGR1#7(99)c60
[4] LGIC, “Text proposal for Secondary Collision Detection”, TSGT1#7bis(99)f84

Appendix: packet transmission failure rate in CPCH

In this analysis, we consider access attempts with Poisson statistics. Parameters in our analysis are defined as follows:

T: arrival time interval [sec]

G: average access attempts per a access slot

N_{ap} : the number of AP signatures

N_{cd} : the number of CD signatures

N_{scd} : the number of SCD signatures

The probability of k+1 access attempts in time interval T, $P_{arr}(G,k+1) = e^{-GT}\frac{(GT)^{k+1}}{(k+1)!}$

The probability of packet transmission failure in current CPCH,

$$Pc_{m|k,l}^{AP-CD}\left(N_{ap}\right) = \sum_{l=1}^{k}\left[\binom{k}{l}\left(\frac{1}{N_{ap}}\right)^{l}\left(\frac{N_{ap}-1}{N_{ap}}\right)^{k-l}\sum_{m=1}^{l}\binom{l}{m}\left(\frac{1}{N_{cd}}\right)^{m}\left(\frac{N_{cd}-1}{N_{cd}}\right)^{l-m}\right]$$

The probability of packet transmission failure in CPCH with SCD scheme,

$$Pc_{n|k,l,m}^{AP-CD-SCD}\left(N_{ap}\right) = \sum_{l=1}^{k}\left[\binom{k}{l}\left(\frac{1}{N_{ap}}\right)^{l}\left(\frac{N_{ap}-1}{N_{ap}}\right)^{k-l}\sum_{m=1}^{l}\left\{\binom{l}{m}\left(\frac{1}{N_{cd}}\right)^{m}\left(\frac{N_{cd}-1}{N_{cd}}\right)^{l-m}\sum_{n=1}^{m}\binom{m}{n}\left(\frac{1}{N_{scd}}\right)^{n}\left(\frac{N_{scd}-1}{N_{scd}}\right)^{m-n}\right.\right.$$

The packet transmission failure rate in case of k+1 access attempts can be defined as

$\sum_{k=1}^{\infty}\left[Pc_{n|k,l,m}^{AP-CD}(N_{ap})P_{arr}(G,k+1)\right]$ for current CPCH

$\sum_{k=1}^{\infty}\left[Pc_{n|k,l,m}^{AP-CD-SCD}(N_{ap})P_{arr}(G,k+1)\right]$ for CPCH with SCD scheme