3GPP TSG RAN WG1 No 6 ***TSGR1#6(99)820***
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Agenda item: **Ad-hoc 14**

Source: **Philips**

Title: **Improved performance and downlink code use for CPCH**

Document for: **Approval**

Summary

This document proposes a method for improving the contention resolution in the Common Packet Channel, by providing a second resolution phase. 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. This minimizes both BS station hardware requirements and use of downlink channelization codes.

Discussion

The current proposal for CPCH is illustrated in Figure 1. It includes an initial access phase with power ramping of RACH-like preamble signatures and acknowledgment via an AICH (Acquisition Indicator Channel). A maximum of one access attempt per access slot is given a positive acknowledgement. The initial access is followed by a contention resolution phase where the UE randomly selects from another set of preamble signatures with a different scrambling code. The network would normally respond (on an AICH-like channel) to the transmission received with greatest power, thus granting permission to send the packet. The acknowledgements for the contention and resolution phases can be distinguished by different channelization codes. Thus if more that one UE selected the same initial preamble, the probability of selecting the same signatures in the contention resolution phase is reduced in proportion to the number of available signatures.

However, if the contention resolution fails, then two (or more) UEs will attempt to transmit packets at the same time, leading to a high probability of data loss. This could be resolved by higher protocol layers, but would result in significant delay as well increased interference, and loss of capacity.

In the CPCH proposal the access phase preambles are each mapped to one of a limited number of specific downlink spreading codes and uplink scrambling codes (with associated data rates). Therefore it is likely that more than one UE will be waiting for a given resource to become available, particularly with high traffic loading. Thus, when the resource is free, there could be a significant probability of collision. If the set of valid signatures for initial access is restricted, for example because most of the CPCH resources are already occupied or some of the preamble codes are shared with PRACH then the initial collision probability could be rather high. With 16 signatures for contention resolution, the probability of an unresolved collision would be reduced to less than 1/16. Considering the negative impact of such events, the reduction of system capacity could be significant, particularly if fewer than 16 signatures were available. With the current proposal for CPCH this prevents the sharing of preamble signatures between RACH and CPCH contention resolution, because not enough signatures are available for good performance.

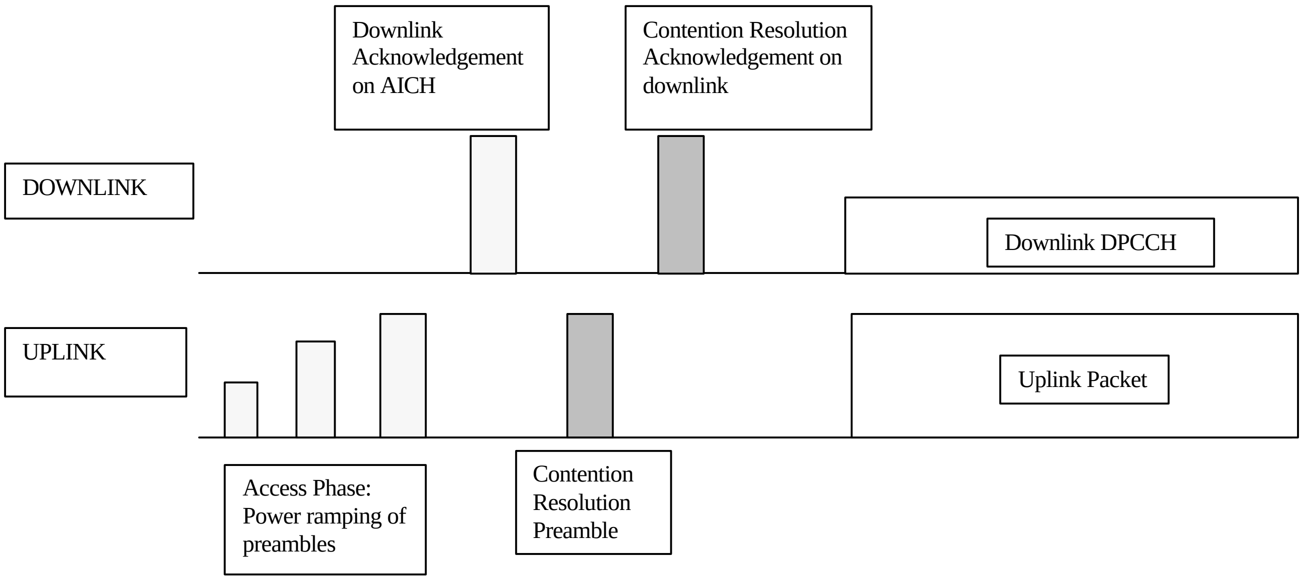

Figure 1: Basic CPCH scheme

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However, sharing of preamble signatures would minimize the downlink code resource required for AICH channels. Therefore it is desirable to consider ways of improving the collision resolution phase to allow full preamble sharing. This paper presents one solution.

Proposed Solution

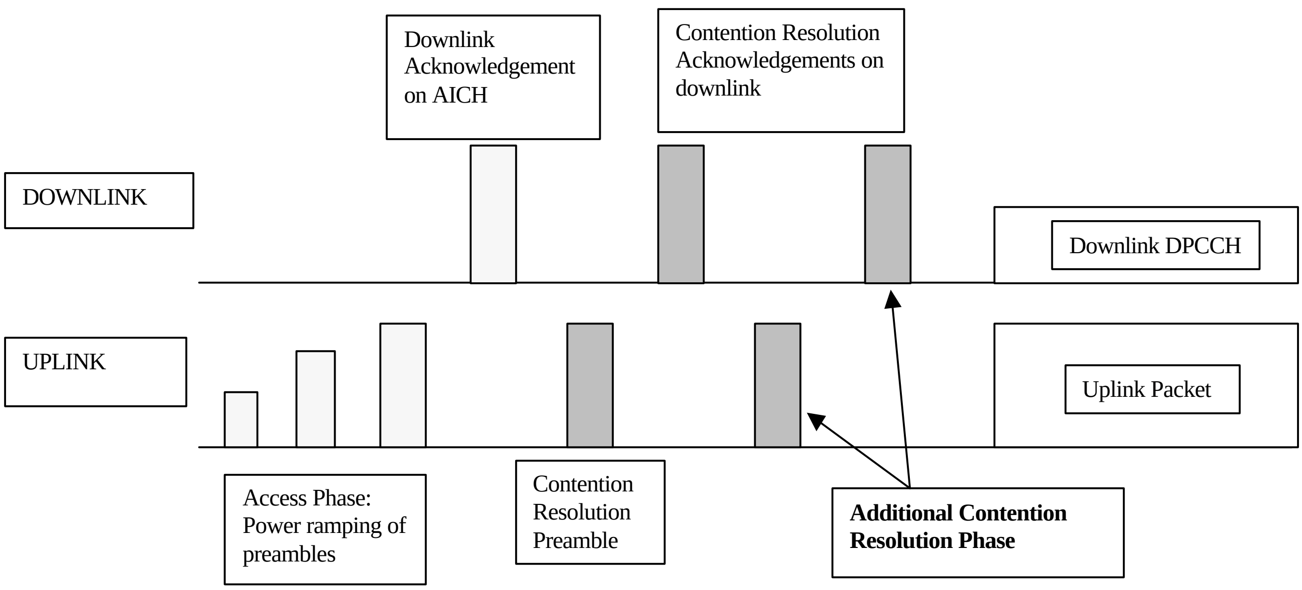

Figure 2: Extented collision resolution phase for CPCH

A second collision resolution phase is added. Thus the collision resolution procedure is extended in time by transmission from the UE of a second randomly selected signature, followed by another acknowledgement (on an AICH or AICH-like channel) of the strongest signal, as shown in Figure 2.

With 4 preamble signatures used in both the first and second contention resolution phases, the probability of unresolved collision in the access phase is reduced by a factor of 16 (the same as if 16 signatures are used in one CR-phase). If 16 signatures were used with two CR-phases, then a factor of 256 improvement could be achieved, if this were needed.

If a set of preamble signatures are shared by both collision resolution phases, then it is possible that a UE could receive an acknowledgement which appeared to be in response to its first collision resolution attempt, but was in fact intended as an acknowledgement for the second collision resolution attempt of a different UE.

To avoid this confusion it is therefore desirable to be able to distinguish the first and second contention preambles and acknowledgements. Some solutions are:

(a) Different spreading codes could be used for first and second CR-preambles. An additional AICH channel would also be needed, but this somewhat defeats the main purpose of this proposal.

(b) By using the same spreading codes, but different sub-sets of signatures for first and second contention phases. This may not always be feasible, particularly if it is desired to minimize the number of signatures used.

(c) To require that a downlink acknowledgement for the access phase cannot be transmitted at the same time as the first acknowledgement in the contention resolution phase. This requires no additional resources, but may increase average delay slightly (but only by about one access slot).

In practice all these methods can be used, given flexible allocation of preamble signatures and scrambling codes to the CPCH access and contention phases. The restriction mentioned in (c) should be applied to cover the case when the same signatures are used.

Since the better contention performance offered by the second contention resolution stage may not always be required, its use could be indicated on the BCH. However, terminals would need to support both modes. Furthermore, at least in principle, single and two stage contention resolution can be mixed in the same cell, and the two stage option only applied for some of the initial access preambles (i.e. for only some of the CPCH packet resources).

We can now consider some representative system configurations with the following details:

System 1: New Scheme, full signature sharing, low CPCH throughput

RACH	8 signatures, spreading code 1
CPCH access	4 signatures, spreading code 1
CPCH collision resolution	4 signatures, spreading code 1
Preamble receivers at BS	1
AICH channels	1

System 2: Current CPCH scheme, partial signature sharing, low CPCH throughput

RACH	10 signatures, spreading code 1
CPCH access	6 signatures, spreading code 1
CPCH collision resolution	16 signatures, spreading code 2
Preamble receivers at BS	2
AICH channels	2

System 3: New scheme, partial signature sharing, high CPCH throughput

RACH	16 signatures, spreading code 1
CPCH access	12 signatures, spreading code 2
CPCH collision resolution	4 signatures, spreading code 2
Preamble receivers at BS	2
AICH channels	2

System 4: Current CPCH scheme, no signature sharing, high CPCH throughput

RACH	16 signatures, spreading code 1
CPCH access	16 signatures, spreading code 2
CPCH collision resolution	16 signatures, spreading code 3
Preamble receivers at BS	3
AICH channels	3

System 1 requires minimal hardware resource at the BS, and can support a small number of CPCH users. The RACH capacity is reduced by a factor of 2 in this case, but this is probably sufficient for most deployment scenarios.

System 2 provides increased capacity on both RACH and CPCH, but at the cost of an additional preamble receiver at the BS, and an additional AICH channel on the downlink. Note that each AICH uses a channelization code with SF=256 (Compared with the DPCCCH control channel needed for each CPCH packet channel which has SF=512).

System 3 provides higher capacity on both RACH and CPCH than System 2, with the same collision resolution capability, but requires no more hardware or downlink channelization codes for AICH.

System 4 provide more CPCH than System 3, but requires a total of 3 preamble receivers and 3 AICH channels on the downlink.

To summarize, the pros and cons of the proposed improvement to CPCH contention resolution are:

Advantages
Available as an option on a per cell basis
Fewer preamble signatures are needed for a given collision resolution performance
Full preamble signature sharing is possible between RACH and CPCH
Offers scaleable CPCH performance vs. use of downlink resources (AICH) and BS complexity
Minimizes use of AICH

Disadvantages
Presence of two-phase contention resolution may need to be indicated on the BCH
Minor increase in complexity of UE to handle two-phase CR.
Minor increase in packet delay in some scenarios
Minor increase in uplink and downlink interference (small compared with packet transmission)

Conclusion

The proposed improvement to the CPCH offers significant benefits at minimal additional cost and complexity. The text proposal given in Annex 1 should be adopted.

Annex 1-Text Proposal for 25.211

Here text is proposed as an addition to the description of CPCH (as currently proposed by GBT). The details may need to be further modified depending on decisions taken by WG1.

Addition to 5.2.2.2.1 CPCH transmission

The preamble signatures and scrambling codes for both the access and collision resolution phases of CPCH can be shared with the RACH or assigned independently. In each case a corresponding acknowledgement is provided using one or more AICH's.

An additional phase of contention resolution can be applied as an option for one or more of the access preamble signature codes.

The same preamble signature and scrambling codes may be used for both the first and second phases of collision resolution. In this case only, the transmission of an acknowledgement to an access preamble is not allowed at the same time as a transmission of an acknowledgement to the first stage of collision resolution. This is necessary to avoid confusion between the first and second collision resolution phases.

<Note: The access preamble signature codes for which a second collision resolution phase is to be used can be broadcast via BCH>

Addition to 5.3.3.6 AICH

A positive acknowledgment to a CPCH access preamble must not be transmitted in the same AICH access slot as an acknowledgement to any first CPCH collision resolution preamble for which two phases of collision resolution are required, where both collision phases use the same scrambling code and set of signatures in the uplink and same channelization code in the downlink. In this case the acknowledgement for collision resolution should take precedence.