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Agenda item:
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Title: Proposal for downlink interference measurement method
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Summary

In UTRA/FDD, the downlink interference measurement algorithm is very critical, since it indirectly affects the power management at Node B. It is highly important that it is accurate, and that it considers the level of intra-cell orthogonality in the downlink. We propose that the downlink interference is measured at the UE using a channelisation code that is guaranteed to be unused by Node B. This method has several advantages such as simplicity and robustness. The only potential drawback is that it consumes at most one downlink channelisation code. However, at a maximum SF of 256, only a 256th, i.e. less than 0.5%, of the code-resource is consumed. If there is an odd number of CCPCHs at the highest SF, then this method does not consume any channelisation codes at all.

1 Introduction

Closed-loop Transmit Power Control (TPC) is employed in the downlink of UTRA/FDD in order to handle propagation-loss as well as multi-path and shadow fading.

Downlink closed-loop TPC typically works in the following way: The UE estimates the Signal-to-Interference ratio (SIR) level from the signals received from the cells in the active set. The estimated SIR level is compared to a target value, and if the target value is exceeded, a “power down” command is generated, otherwise a “power up” command is generated. The “power down” or “power up” command is sent back to the NBs handling the cells in the active set, which react to the commands by raising or lowering their transmit power. Since downlink power is a limiting resource in a CDMA system, it is obviously extremely important that the downlink SIR is measured accurately.

The SIR estimate is formed by measuring the signal power “S”, and the interference power, “I”. Although it is quite straightforward to measure “S”, it is far from obvious how to measure “I” in the downlink. The underlying reason is that there may be more or less intra-cell orthogonality in the downlink, which depends on the environment, the UE-NodeB distance etc.

In estimating the downlink interference, it is important that the measurement reflects the actual experienced interference in a proper way. For example, if the radio channel consists of a single path, the measurement should not reflect intra-cell interference at all. If a first downlink signal is transmitted with a low power and a second downlink signal in the same cell is transmitted with a very high power (e.g. very high information bit-rate), this high-power signal should not affect the interference measurement of the first signal, since the actual mutual interference experienced in the de-spreading process is virtually zero due to the orthogonality.

This paper discusses pros and cons of various methods of estimating the downlink interference, and includes a proposal on what method to use and how to handle downlink interference measurement in the 3GPP specification.

2 Possible ways to measure “I” in the downlink

Method 1: Searcher output

One way to measure downlink “I” is to use the “noise-floor” seen by a searcher as in Figure 1.

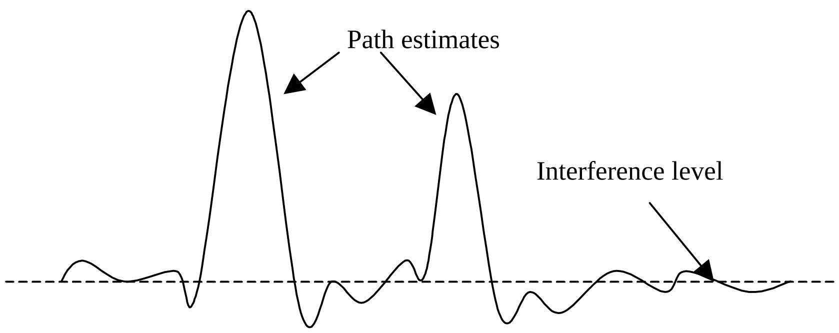

Figure 1: Searcher output

Method 2: Pilot regeneration

Another way of estimating downlink interference is to re-generate the pilot symbols (after de-spreading) and calculate their average deviation from the ideal signal points.

Method 3: Unused own channelisation code

A third way would be to de-spread the received signal with the channelisation code(s) allocated to the connection during time-periods when nothing is transmitted to the user in question. Since there is no "own" signal, a de-spreading would then yield an estimate of the interference.

Method 4: Unused reserved channelisation code

A fourth way is to reserve one downlink channelisation code as an "interference-measurement code" which is never used for information transfer. All UEs could relatively easily at all times generate a downlink interference estimate by simply de-spreading the received signal with the "interference-measurement code".

3 Discussion on the methods

Method 1: Searcher output

The first of the methods described above is insensitive to orthogonality or lack of orthogonality, and is therefore only suitable for non-orthogonal systems. Since the uplink in UTRA/FDD is non-orthogonal, such a method could be applied in the uplink SIR estimation.

Method 2: Pilot regeneration

The second method includes the orthogonality aspect if the measurement is done for all paths considered in the de-spreading process. However, since it relies on the existence of at least two adjacent pilot symbols, the measurement can only be done during reception of pilot symbols. Furthermore, it is sensitive to channel variations between the adjacent pilot symbols. Such variations will become part of the I-estimate.

Method 3: Unused own channelisation code

The third method includes the orthogonality aspect if the measurement is done for all paths considered in the de-spreading process. However, it has the drawback that the UE has to know when no information is transmitted to it. This could be solved by having pre-determined time-instants of no transmission, but such a solution obviously has a certain capacity loss, since the interference measurement would need to be updated quite regularly, considering its use in the closed-loop TPC algorithm.

Method 4: Unused reserved channelisation code

The fourth method includes the orthogonality aspect if the measurement is done for all paths considered in the de-spreading process. A potential drawback would be a risk of orthogonal channelisation code shortage. Clearly, given the limitations in the simultaneous usage of OVSF codes in the downlink, it is not obviously desirable to reserve one of the codes as "unused".

However, it is clear that the "bottom" of the code-tree will be at SF=256 or higher, since the primary CCPCH uses SF=256. Thus an SF=256 code or higher can be reserved as the "interference-measurement code", which would not necessarily impose any significant loss of code-resources. For example, the sub-branch parallel to the sub-branch used for the primary CCPCH could be reserved for the "interference-measurement code". This would not incur any channelisation-code loss at all, since the code on the node immediately above could not be used anyway due to the primary CCPCH. This can be generalised into saying that whenever an odd number of common control channels exist @ SF=256, it is possible to allocate an "interference measurement code" @ SF=256 without code-loss.

4 Proposal

The downlink interference measurement method is highly critical for capacity management in Node B, and must therefore be standardised. Either a plurality of methods are specified, and UTRAN informs UE over e.g. BCH which method to use, or a single method is standardised.

We propose that at least the "unused reserved channelisation code" method should be standardised. The description of the algorithm should be added to the measurement document S1.31. There may also be a need to include information on the BCH regarding which channelisation code should be used for interference measurements, but that is up to WG2.

Text proposal for S1.31

Add the following text in clause 8, Radio Link Measurements:

8.x Downlink interference measurement

The network can provide information about an unused channelisation code. When this is done, the downlink interference in a certain cell and carrier frequency shall be measured by de-spreading the received signal with the channelisation code known to be unused.

The details of the interference measurement, like averaging etc., are for further study.