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Power control procedures for TDD

Source: Panasonic

Introduction

Given the impact it has on DCA and code division aspect of the access scheme, power control is an important issue for TDD. This paper addresses the correction of the initial open loop based Tx power setting, the addition or removal of users in a slot, and the reference source for open loop power control.

Initial Tx power setting

Absolute power measurement at the mobile cannot be very accurate unless the cost of the unit is significantly increased. The combined error of initial path loss measurement and Tx power setting has been estimated at around 9dB. For the initial RACH attempt, given that the load on the RACH cell cannot be known beforehand, a predefined value will have to be used by all mobiles. This will most likely correspond to high loading – close to 8 users – in the slot. The base station will measure the received power and when allocating a dedicated resource to a user with a FACH message, the base station will also provide a correcting factor for the mobile's Tx power, relative to the power the mobile used to transmit the RACH message.

The calculation of the correcting factor will be based on the received power of the RACH message and the load of the slot that the user has been assigned to.

For its first transmission in the dedicated slot, the mobile will calculate its Tx power based on the difference in the path loss estimate made prior to the RACH attempt, the correcting factor received on the FACH and the path loss estimate made just prior to transmission.

Traffic load changes

Every time the number of users in a slot is increased or decreased, the target received value for all the users in that slot changes. The new user can be informed of the target value with the FACH message, the other users however will have to be dealt with in a different manner.

The use of higher layer signaling is wasteful on resources. Especially in the case that dedicated resource is allocated for a small number of frames in order for user to transmit a packet, the overhead would be very large. Alternatively the power control procedure could be allowed to adjust the power for each user. This procedure will at best take a few frames

and the existing users in a slot will be under-powered for that period and suffering unacceptably high frame losses. When a user terminates his connection it will result in the rest of the users transmitting at higher level than necessary hence slowing down DCA and reducing its effectiveness.

The solution is to use fast – layer 1 – signaling to inform each user in the slot of the addition or the removal of a user. The obvious means of doing this is the use of the TFCI field. At least two values have to be reserved, one for signaling a predefined increase in Tx power and one for signaling a predefined decrease in Tx power. More values may be necessary depending on the range of spreading factors and BER attributes associated with each code.

Open loop power control reference

All the studies into the power control scheme for TDD acknowledge that there is gain in utilizing the reciprocity between uplink and downlink. There are basically two ways of providing the necessary power reference for the path loss estimation. Either the control channels will be used or the traffic channels.

Using the traffic channels poses a number of problems. Firstly, this is no longer possible if beam-forming techniques are to be used. Whilst it is acceptable to transmit at least the midamble omni-directionally in the same slot as a common control channel that may use beam-forming – such as the FACH – this cannot be done for every active downlink traffic slot due to increased interference to own and other cells.

Procedural issues are also difficult to resolve. If the uplink only is active for a given user then there is no transmission directed to that user that could be used as a reference. If other user's midambles are used then when these users terminate their calls if they are the last in the slot, all mobiles that were using them as reference must immediately find another reference source. This necessitates scanning of other slots for references which would otherwise not be performed. Additionally, using the traffic channels for reference imposes restrictions on the DTX function forcing the transmission of the midamble even when there is no data to transmit. This affects DCA performance significantly by virtually removing the benefit of reduced interference.

It is therefore recommended that common control channel are used as power measurement references for open loop power control. The delay between path loss estimation and Tx power setting is critical to the performance of OL PC. Significant gains can be had for the whole range of speeds over which power control should be employed when this delay is kept under 4 slots (at high speeds power control should be switched off).

So, for cellular outdoor deployment where the higher end of

the speed range may be witnessed we propose the use of 4 CCCH slots, equally spaced in the frame. There are enough downlink throughput requirements for the common channels to justify a single code allocation in 4 slots in a frame. These slots should be TS#0, TS#4, TS#8, TS#12.

For indoor environments the downlink control slots should be 2 only to facilitate uncoordinated operation. These slots should be TS#0 and TS#8. In the transition from an outdoors environment to an indoor one, the mobile can very easily detect that there are only 2 control slots present in the cell that it will be handed off to, and this can also be verified in the handover signaling.

Uncertainties in open loop power control

The combined uncertainty of the power measurement process and the Tx power setting are a significant parameter in the performance of open loop power control. In dedicated traffic channel operation, not for initial access, both of these process are relative, i.e. the power measurement records the path loss difference for the last two measurements, and the Tx power is increased or decreased with respect to the value used in the previous transmission.

The Tx power setting can be expected to have an accuracy of 0.5 dB according to WG4 and an estimate for the relative power measurement is in the order of 1.5dB (strong reliance on the efficiency of downlink power control). We expect the overall uncertainty stemming from these two components to be small enough to allow considerable gains from the use of open loop power control.