TSG-RAN Working Group 1 meeting #7bis **TSGR1#7bis(99) f10**

Kyongju (Korea), Oct 4th – Oct 5th 99

Agenda Item : ad-hoc 9

Source : **Nortel Networks**

Title : **Downlink power control in soft handover, summary of issues and way forward**

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1. Introduction

In the last WG1 meeting, the down link rate reduction during soft handover [1] was accepted as a working assumption. The rate reduction algorithm allows to reduce the frequency at which the UTRAN access point or Node Bs adjust their powers by reducing the error rate on the TPC commands sent by the UE. Another proposal presented as an alternative to downlink PC rate reduction (the adjustment loop) was introduced later on the reflector [2].

This contribution summarises the problem that the downlink power control rate reduction addresses when combined together with a power resynchronisation scheme. In a second step the contribution analyses the adjustment loop proposal comparing it to the rate reduction and the resynchronisation.

2. Downlink power control rate reduction

The general problem addressed by the power control rate reduction is that the UE sends one TPC command asking the Node B or UTRAN access points to either decrease or increase its(their) powers by a fixed step. The smallest step size would be 1 dB (mandatory) and 0.5 optional. When the UE is in soft handover, each BTS will demodulate the TPC and adjust its power independently from the other BTSs in the active set. This results in the BTSs transmitted powers deviating from the desired power levels and in a loss of diversity gain that we get from the soft handover.

The rate reduction algorithm looks into the actual cause of the problem: the errors on the TPC commands. If the TPC commands (sent by the UE) are error free, all BTSs in the active set will adjust their powers in the same direction and hence the problem is eliminated. TPC commands are sent un-coded which results in their error rate being much higher than the data error rate. During soft handoff, the problem becomes worse: all of the BTSs in the active set are sending TPC commands to the UE. If one BTS is receiving enough power and asks the UE to decrease its power, the UE will decrease its power even though the other BTSs are not receiving enough power and asked for an increase in power. This results in higher TPC (sent by the UE) error rate on some of the links. A similar problem exist during soft handover for the TPC commands sent by the BTS where the BTSs in the active set send the same data bits (the UE combines them using RAKE receiver) but sends independent TPC bits which the UE has to decode independently. Thus, during soft handover, the error rate on the TPC (on both links) is high.

To reduce the error rate on the TPC bits sent on the downlink, we can send these bits with extra power compared to the data bits. Unfortunately, we can't do this to the TPC bits sent by the UE due to the power amplifier non-linearities. The other parameter that we can control is the rate of the TPC commands. This is the function of the DPC_MODE: when it is 0, each slot has a unique TPC command and during soft handover, we can make DPC_MODE=1 which indicates that the UE repeats the same TPC command over three slots. Repeating the same command three times, results in a considerable reduction in the TPC commands error rate (the cause of the problem).

Even with such an algorithm, there will be some errors on the TPC command. Hence, another scheme has to be employed to balance the base stations transmitted powers every while. The currently agreed on scheme in WG3 is the resynchronisation scheme. The rate reduction scheme reduces the deviation in the BTSs transmitted powers and hence reduces the required resynchronisation period which reduces the required signalling. We see the TPC rate reduction during soft handover as a complement to the power balancing scheme. Hence, irrespective of which power balancing scheme is used, TPC rate reduction will reduce the deviation in the BTSs transmitted powers.

3. Adjustment loop

Another method was proposed by NEC to balance the BTSs transmitted powers and was called adjustment loop [TSGR1#7bis(99)E69]. Under the used simulation assumption, the method is claimed to help in reducing the deviation in the BTSs transmitted powers without the need to reduce the rate of the power control algorithm and without the need for resynchronisation. We can see that the loop adjustment method is easier to implement than the synchronisation but we believe that there are a number of issues that has to be addressed before we can evaluate the performance of the adjustment loop algorithm. We have to see if the loop adjustment loop is capable of replacing both the rate reduction algorithm and the resynchronisation algorithm or just one of them or non of them.

- Adjustment loop versus rate reduction

The simulations in R1-99e69 fail to show that there is no need for the rate reduction algorithm. The assumed multipath channel is a four equal gain channel which results in a very low TPC error rate (2%). We believe that simulations have to be shown for a more realistic channel conditions where the TPC error rate is much higher and the TPC commands rate reduction will improve the performance of the loop adjustment scheme. This is to say again that the rate reduction algorithm is beneficial irrespective of the used balancing scheme.

- Adjustment loop versus resynchronisation

The simulations shown in R1-99e69 again do not allow us to judge if the loop adjustment loop is capable of replacing the resynchronisation algorithm or not. This is due to the following reasons.

The adjustment loop algorithm reduces the deviation in the BTSs transmitted powers by introducing a small change in the transmitted powers every power change. The transmitted powers can only be changed by fixed step and the smallest mandatory step is 1 dB. This contradicts with the main idea behind the adjustment loop algorithm. Hence, simulations have to be performed under the limitation that the minimum change in the BTS transmitted power is 1dB.

Figure 1 in R199-e69 shows that the difference in the BTS transmitted powers can approach zero. This is achieved at a high reference power. However, at this high reference power, the reduction in the difference transmitted powers is not due to the adjustment loop. It is due to the fact the we can not reduce the transmitted powers. Hence, we see in Figure 2 that the FER is low and in Figure 3 that the transmitted powers is high. Hence, the objective is not only to reduce the difference in the transmitted powers but also to reduce the transmitted power of each BTS. We should notice that at a high reference power, the difference in the transmitted powers also approaches zero when the adjustment loop is off. Hence, simulations should show the average and the variance of **each** BTS in the active set.

4. Conclusion

The rate reduction algorithm reduces the number of times the BTSs in the active set adjust their powers and reduces the TPC commands error rate. These two factors result in reducing the deviation in the BTSs transmitted powers. The loop adjustment algorithm is a proposal to change the BTSs balancing algorithm. Irrespective of how BTSs transmitted powers balancing is achieved, down link power control rate reduction is needed because of the two above mentioned advantages. Hence, we believe that the rate reduction algorithm should be upgraded from a working assumption to a general agreement.

In order to make a decision of whether the loop adjustment algorithm is capable of replacing the resynchronisation algorithm or not, a new set of simulations is required. The simulations should limit the change in the BTS transmitted powers to 1dB steps and the average and variance of each BTS transmitted power has to be shown.

References

[1] TSGR1#7 99-b15 Downlink Power Control Rate Reduction during Soft Handover, Nortel Networks.

[2] TSGR1#7bis(99)E69 Adjustment Loop in downlink power control during soft handover, NEC.