TSG-RAN Working Group 1 meeting #7bis **TSGR1#7bis(99)f86**

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Agenda Item : Ad Hoc 9

Source : Nortel Networks[1]

Title : Open loop power control for dedicated channels

Document for : Discussion

1. Introduction

Power control tracks changes in the communication channel such that the received SIR is equal to the target SIR. This requires tracking changes due to distance, shadowing and multi-path fading. R1-99e20 (25.214) states that the open loop power control (OLPC) is used to determine the initial transmitted powers of the dedicated channels. In this contribution, we argue that the OLPC process has to be a continuous process. That is to say, we should use OLPC and the TPC bits received from the base station when determining the UE transmitted power even after the start of the call.

2. References

[1] TSGR1#7 R1-99e20 (25.214) Physical layer Procedures (FDD)

[2] S. Soliman, et al., "CDMA Reverse Link Open Loop Power Control", Global Telecommunications Conference, 1992, Pages: 69-73, Vol. 1

3. The communication channel

Power control should track changes in the communication channel due to distance, shadowing and multipath fading. There are three main differences between these three factors. First, distance and shadow variations are slow compared to variations due to multipath fading. Second, the variations due to distance and shadowing are reciprocal on the down link and the uplink while the variations due multipath fading are independent on both links. This is due to the fact that the frequency separation between the two links is much greater than the coherence bandwidth of the channel. Third, the dynamic range required to track variations due to distance and shadowing is much larger than the dynamic range required to track multipath fading. These three factors have to be considered in the implementation of the power control algorithm.

4. Tracking the variations of the communication channel

4.1 Shadowing and distance variations

As we have said before, the variations due to distance and shadowing are reciprocal on the down and up links. Let us call the variations due to both distance and shadowing the path loss. Thus, the UE should be able to estimate the path loss by looking at the pilot channel received on the down link dedicated channel or on the common pilot channel. If the measured path loss is high (low), the UE should increase (decrease) its transmitted power. In IS-95, the dynamic range for the OLPC process is 80 dB and it is designed to allow rapid

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response to a sudden improvement in the channel while disallowing a rapid response to a sudden degradation in the channel.

4.2 Multipath fading

Since the variations due to multipath fading are independent on the down and up links, the power control loop has to be closed and hence we use the pilot bits from the uplink channel to estimate the received SIR and the TPC commands in the downlink so that the UE is to either decrease or increase its transmitted powers. The dynamic range for the closed loop power control process should be about 20 dB.

The UE should use the OLPC estimate and the TPC commands received from the BTS to determine its transmitted power hence power control can efficiently track both shadowing/distance and multipath fading.

5. Limitations of the current implementation

In the current power control implementation, OLPC is used only at the start of the transmission and after that only closed loop power control is implemented. This means that the initial transmission will take into account the variations due to distance and shadowing and after that the closed loop power control will be compensating for the effect of the three factors: distance, shadowing and multipath fading. Such an approach does not take into consideration the differences between the path loss variation and the multipath variations as we have mentioned above.

5.1 Example

Let us assume that the UE is close to the base station and there is no shadowing between the UE and the BTS. This means that the initial transmit power will be compensating for a small path loss. If the UE starts moving away from the BTS or shadowing increases (UE is coming behind a building for example), the closed loop will be now trying to compensate for such a change in the channel. Assuming that we limit the range of the uplink inner loop power control to 20 dB as we do in the downlink, then if the closed loop uses 15 dB to compensate for such a change, it will be left with only 5 dB to compensate for the multipath fading. This will definitely means a degradation to the multipath fading process. Even worse, if the path loss change after the start of the transmission is greater than 20 dB, the UE will not be able to compensate for the path loss variations alone.

5.2 Range increase vs intercell interference

One solution will be to increase the dynamic range of the closed loop to a higher value, 80 dB for example. This is what is in the current specification, since no range is indicated, and this indication could not be found either in the RRC protocol (25.213).

In this case, however, the whole dynamic range can be used to track changes due to multipath fading. We don’t believe that it is a good idea to allow 80 dB to be used to track the multipath fading. The power control rate is 1500 commands/sec which is capable of tracking multipath fading accurately at low speeds. It is known that tracking multipath fading results in increasing the inter-cell interference. The larger the closed loop dynamic range, the higher this increase in the inter-cell interference.

To show the increase in the inter-cell interference, a very simple simulation is performed. A UE is communicating with base station x, the fading channel is a single path Rayleigh fading channel, power control commands are sent at a rate of 1500 commands/sec and we are looking at the received signal at another base station (d). The multipath fading processes between the UE and the two base stations are assumed to be independent. This is shown in Figure 1. Figure 2 shows the standard deviation in the received signal at base station d for different velocities. The slower the UE the higher the standard deviation since power control commands sent by base station x are tracking the multipath fading between the UE and base station x and thus when the UE is in a deep fade, extra power is transmitted which causes higher interference at base station d. The larger the dynamic range, the more power the UE can send to compensate for multipath fading and hence the higher the inter-cell interference.

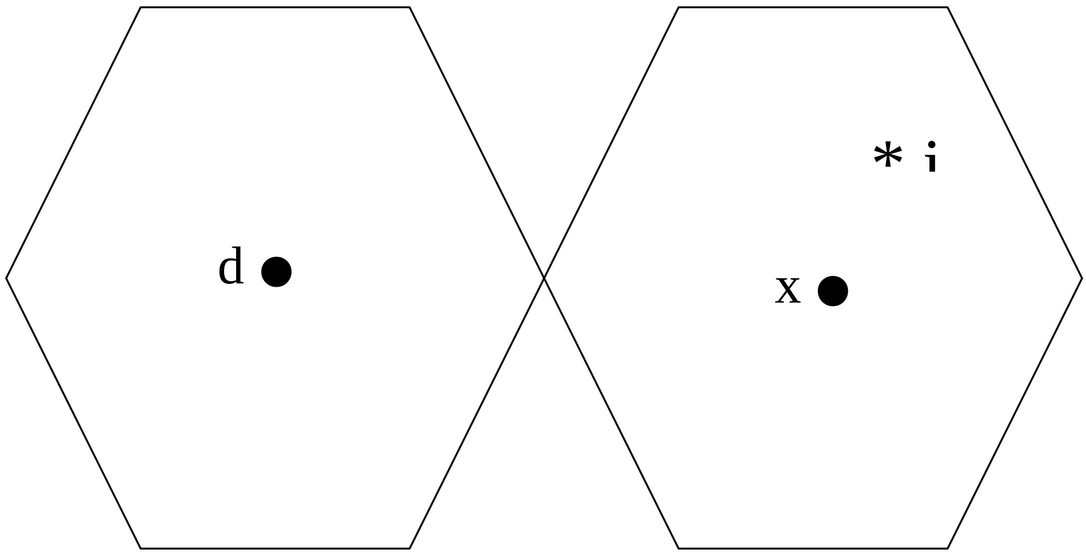

Figure 1 : The UE is denoted by i. Base station x controls the power of the UE by sending 1500 commands/sec, the signal is measured at base station d and modelled by a log-normal variable with a certain standard deviation.

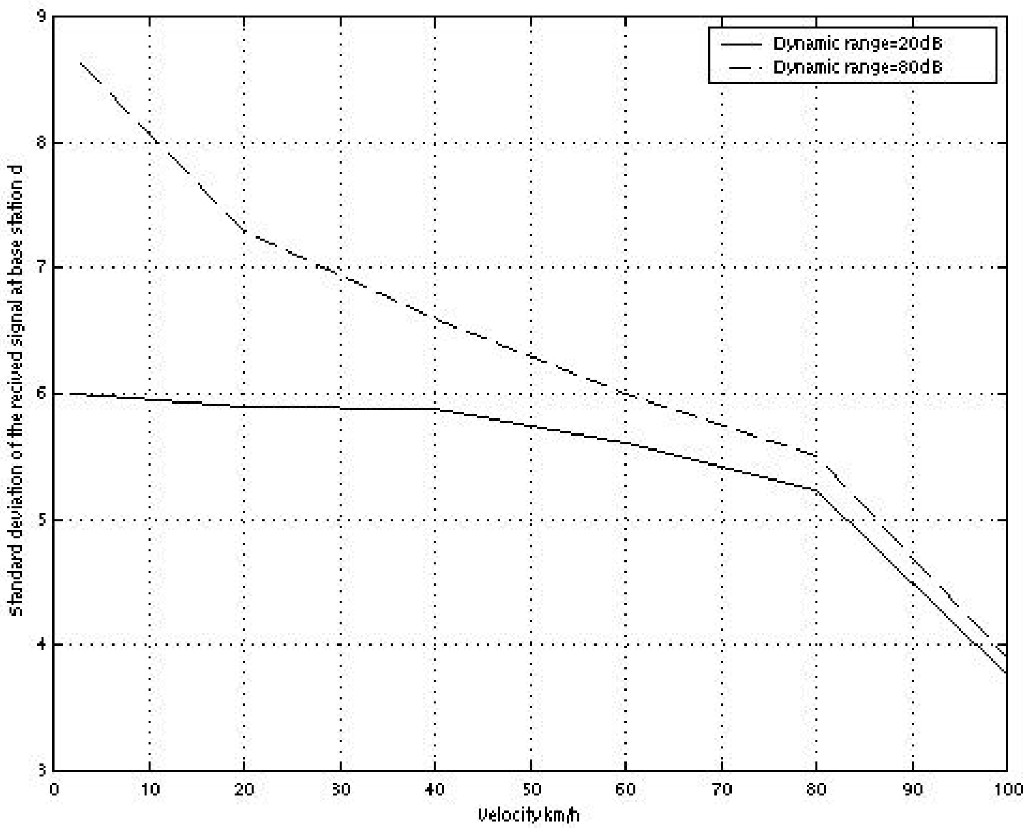

Figure 2: Standard deviation of the received signal at base station d as a function of the UE velocity.

6. Conclusion

As explained above, OLPC is to track changes in the channel due to distance and shadowing path loss. Closed loop power control is to track changes due to multipath fading. The path loss changes are reciprocal on both down and up links while changes due to multipath fading are not. Both the open and the closed loop are necessary to determine the UE transmitted powers. It is not enough to apply the OLPC at the beginning of the transmission. By doing so, the closed loop should track changes due to the path loss in addition to changes to the multipath fading. Allowing the inner loop power control to use the full range of transmit power can lead to high inter-cell interference. Limiting the dynamic range of the closed loop does not allow it to track both changes, unless inner loop and open loop are combined.

Hence, we think that the OLPC process should be implemented continuously after the start of the transmission. If we agree on this requirement, we will be providing the text proposal to describe how OLPC should be implemented. The text proposal would lead to the following modifications :

- Introduction of an inner loop power control range, with a centre value P, which is given by the open loop
- The centre value P is provided by the open loop power control, either located in the physical layer or higher layers, and hence either in the WG2 or WG1 specifications.
- When a new value for the open loop is calculated, the transmit power of the UE is changed to that value.