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Title: Performance of Weighted Open Loop Scheme for Uplink Power Control in TDD Mode.

1 Introduction

In this paper, we introduce an enhanced version of open loop power control scheme, called here "weighted open loop power control" for uplink power control in UTRA TDD mode. The weighted open loop power control scheme is based on applying a weighting factor to open loop power control, in order to reduce the effect of pathloss estimation error. Then we compare the performance of the weighted open loop power control scheme with that of the current (unweighted) open loop power control scheme.

2 Weighted Open Loop Power Control Scheme

[1] evaluated the performance of open loop power control, showing that even in the absence of gain and interference uncertainties, the performance of the open loop scheme is degraded for large delays, due to the imperfect pathloss estimates of time-varying radio channels.

To overcome this drawback of the open loop scheme, we propose a weighted open loop scheme, which can be described by the following equation:

$$\begin{aligned} T_{MS} &= P_{BTS} + a\left(\hat{L} - L_0\right) + L_0 + \Delta G \\ &= P_{BTS} + a\hat{L} + (1-a)L_0 + \Delta G \\ &= SIR_t + \hat{I} + a\,(T_{BTS} - R_{MS} - L_0) + L_0 + \Delta G \end{aligned}$$

Denote by T_{MS} the required transmitted power of UE in dBm and by P_{BTS} the desired received power at the base station in dBm, which can be expressed by the target signal-to-interference ratio, SIR_t, in dB, and the estimated interference level at BS, $\hat{I}$, in dBm. Let R_{MS} be the received power of the down link common channel and T_{BTS} be the transmitted power of the down link common channel (broadcasted on the down link common channel). Note that T_{BTS}-R_{MS} provides an estimate of the pathloss, $\hat{L}$, in dB. $0 \le a \le 1$ is a weighting factor, which may be determined according to channel conditions, and uplink/downlink delay. L_0 is the long term average of the pathloss in dB. ΔG is a gain adjustment term representing the difference in dB between the downlink and uplink gains.

In the simulations the open-loop scheme is implemented in the following way,

$$T_{MS}(n) = SIR_t + \hat{I}(n) + a\left(\hat{L}(n) - L_0\right) + L_0 + \Delta G$$

It is assumed that one uplink slot per frame is assigned to the user. In this case n is the frame index, so that L(n) is the most recent available estimate of the path loss and I(n) is the estimated interference level for the n-th frame.

3 Simulation results

We consider the same simulation model and assumptions as in [1]. The following simulation parameters are assumed:

- Target raw BER: 1%
- Channel: ITU Pedestrain B type
- 2 antenna diversity at BS: each having 3 fingers RAKE receiver
- Realistic channel estimation and SIR estimation: based on the midamble sequence of burst type 1 field in the presence of AWGN
- Mobile speed: 30 km/h and 60 km/h
- $\Delta G = 0$ dB, $L_0 = 0$ dB
- No uncertainty in interference level
- $\alpha = 1-(D-1)/6$: D is the delay, expressed in number of slots, between the uplink slot and the most recent downlink slot. Note that $\alpha=1$ for a delay of one slot (minimal delay), and $\alpha=0$ for a delay of 7 slots (maximal delay).

The open loop only power control and weighted open loop power control schemes were simulated under steady-state conditions, that is, only fast fading channels due to multipath fading were considered ($L_0 = 0$ dB). The uplink data was QPSK modulated. Channel coding schemes were not considered.

The performance is expressed in terms of average Es/No required to achieve the target raw BER, as a function of the delay in slots between the uplink slot and the most recent downlink slot.
Es is the energy of the complex symbol. Figure 1 shows that at 30 km/h the weighted open loop scheme requires lower Es/No levels than the unweighted open loop power control scheme for delays greater than 1 time slot. The difference between the required Es/No levels for the weighted and unweighted open loop schemes increases with delay. For reference, the performance of closed loop power control scheme was included, as described in [2]. Figure 2 shows results for 60 km/h. It can be observed that at 60 km/h, the performance gain of the weighted scheme with respect to the unweighted scheme is more pronounced. This is due to the fact that for higher speeds, causing channel conditions to rapidly change, the weighted open loop scheme reduces the effect of pathloss estimation error, which generally increases with delay.
Figures 1-2, also demonstrate that, in the absence of gain and interference uncertainties, the weighted open loop scheme outperforms the closed loop power control scheme at both 30 km/h and 60 km/h.

Note that in the simulation, we considered the case of no gain and interference uncertainties. Also we didn't account for error in the long term average of the pathloss (L_0). As discussed in [1], gain and interference uncertainties cause significant degradation in the performance of both open loop schemes (weighted and unweighted), since the desired Es/No cannot be achieved. However if some method to eliminate the uncertainties will be incorporated, the (modified) weighted open loop scheme proposed in this paper should be selected for open loop uplink power control in TDD mode.

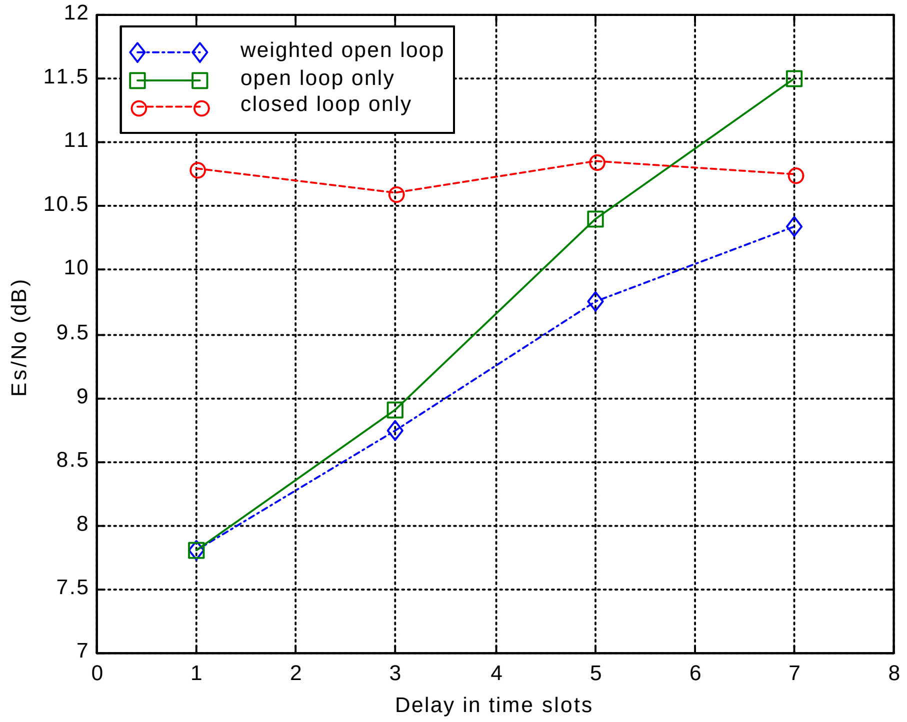

Figure 1: Required Es/No for BER=0.01 vs. delay at 30 km/h

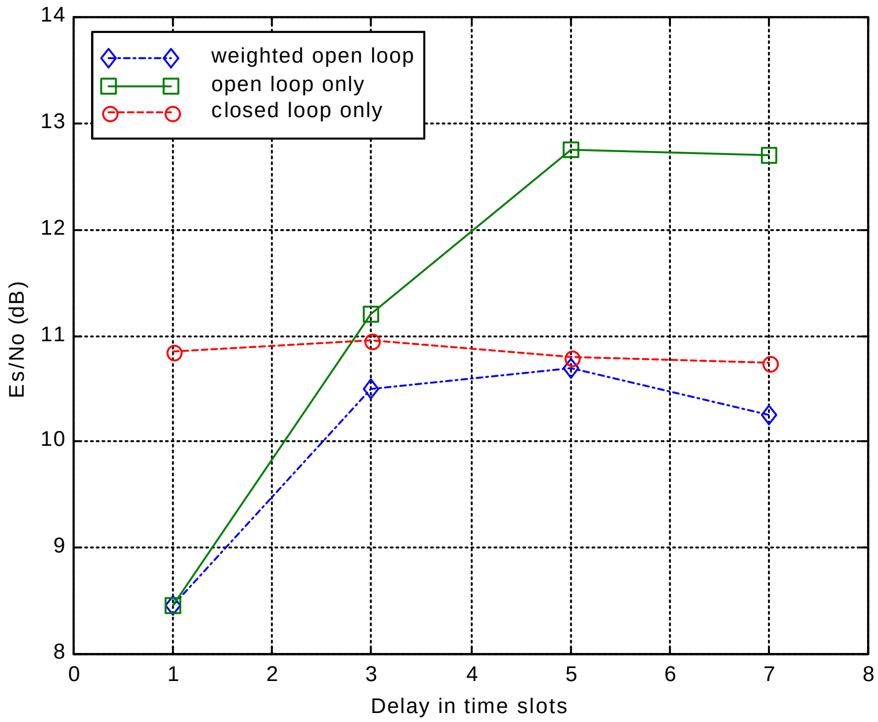

Figure 2: Required Es/No for BER=0.01 vs. delay at 60 km/h

4 Conclusions

- The performance gain of the proposed weighted open loop scheme, compared to the current (unweighted) scheme, increases with the delay between the uplink time slot and the most recent downlink slot. At higher mobile speeds, the gain becomes more significant as the delay increases.

- When gain and interference uncertainties are ignored, the weighted open loop scheme outperforms the closed loop scheme for all delays.

- In order to take advantage of the weighted open loop scheme, it is essential to incorporate a method eliminating the gain and interference uncertainties into the power control scheme.

5 References

[1] InterDigital, "Issues Regarding Open Loop Schemes for Uplink Power Control in TDD", Tdoc R1-99576, Cheju, Korea, June 1999.

[2] InterDigital, "Performance of Open Loop and Closed Loop Schemes for Uplink Power Control in TDD Mode", Tdoc R1-99359, Yokohama, Japan, April 1999.