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1. Introduction

A procedure for cancelling the multiple access interference (MAI) associated with the pilot channels of the active and neighbouring base stations, is proposed for the UE. As a result, the DL capacity is increased by approximately 10%. A by-product of this pilot MAI cancellation procedure could be an improved hand-over mechanism, since the UE constantly monitors the channel taps of the neighbouring base stations. Applying the same procedure to the demodulation of the active pilot channel(s) results in an improvement in the channel estimator. As is briefly shown in the Appendix, the overall computational complexity added to the UE is very small.

2. Simulation Examples

In this section we provide some simulation examples to assess the usefulness of the proposed procedure. A channel tap estimator was utilized in all examples and, unless otherwise stated, the DL physical channels were set according to [1, Annex 3, C.3.2]. The channel multipath taps were set according to Case 3 in [1].

In Figure 1 we present the results obtained for voice users (spreading factor of 128), where only one base station was simulated and Ior/Ioc was set to infinity. Hence, the only source for signal degradation is the MAI of the active base. On top of the common channels, 21-31 dedicated voice users were simulated with the desired user being 6dB lower than the other, equal power, users. As can be seen from the Figure, the proposed receiver allows increasing the number of voice users by about 10% compared to the conventional receiver. Looking specifically at the point where BLER=1%, we see that the conventional receiver can support slightly less than 25 additional voice users whereas when the pilot MAI cancellation algorithm is incorporated, this number can be increased to 27.

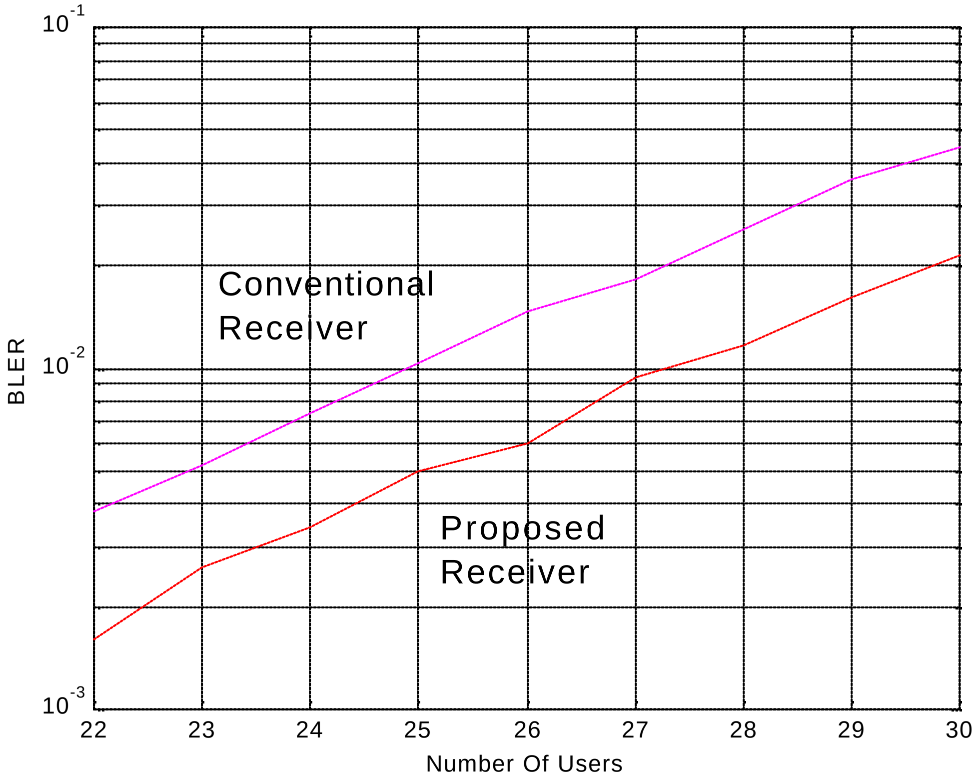

Figure 1: Performance with & without pilot MAI cancellation – Single Base Scenario, Voice Users.

In Figure 2, we repeated the same scenario, only that now we addressed data users operating with a spreading factor of 32. Once again an increase of about 10% in DL capacity is evident.

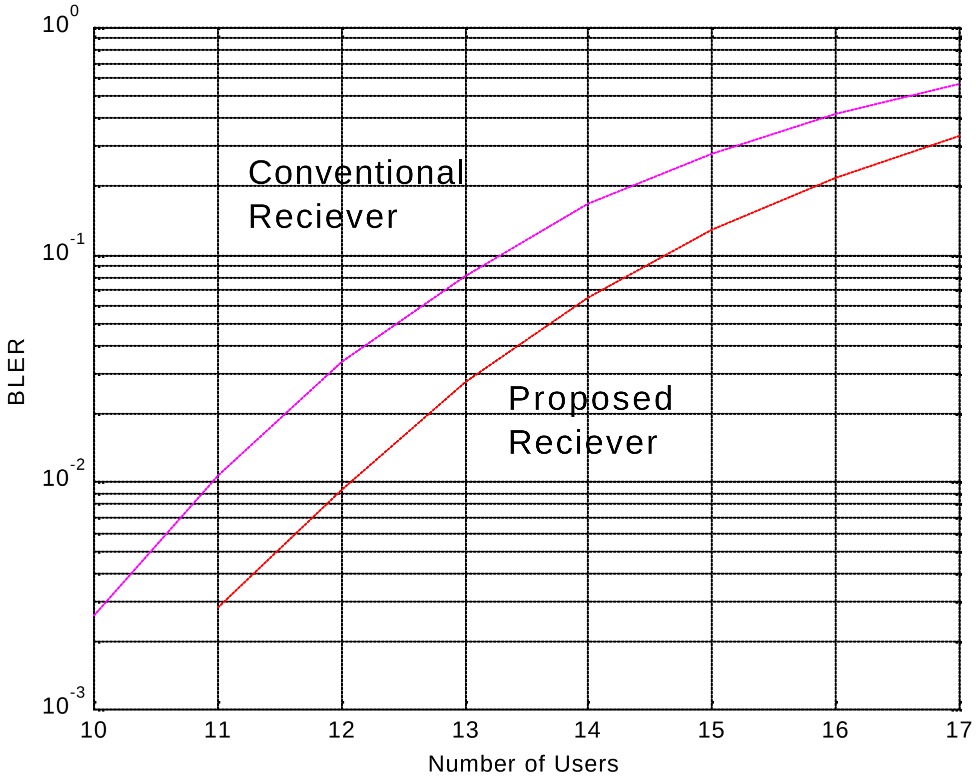

Figure 2: Performance with & without pilot MAI cancellation – Single Base Scenario, Data Users.

Next we examined a multiple base station scenario. The specific set-up is described in Section 3, but it is important to note that the interfering BS is assumed to be operating at 50% of its maximal load and hence its P-CPICH relative power is 20%. In Figures 3 and 4, we present the performance obtained for voice and data users, respectively. As can be seen, an increase of about 20% in DL capacity is achieved in these scenarios.

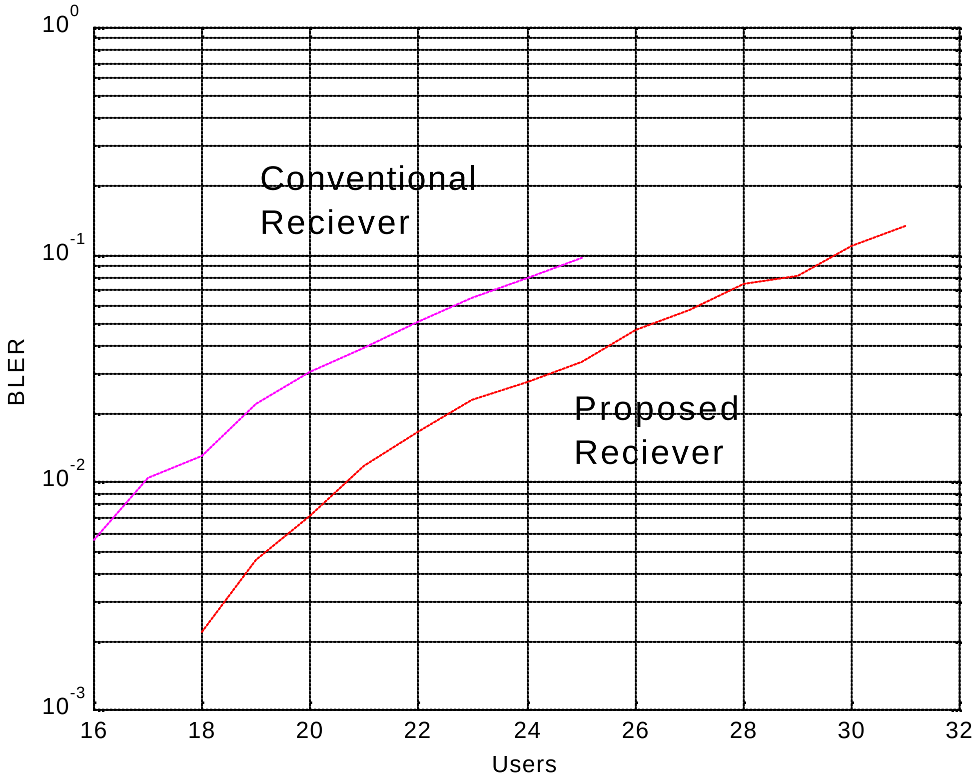

Figure 3: Performance with & without pilot MAI cancellation – Two BS Scenario, Voice Users.

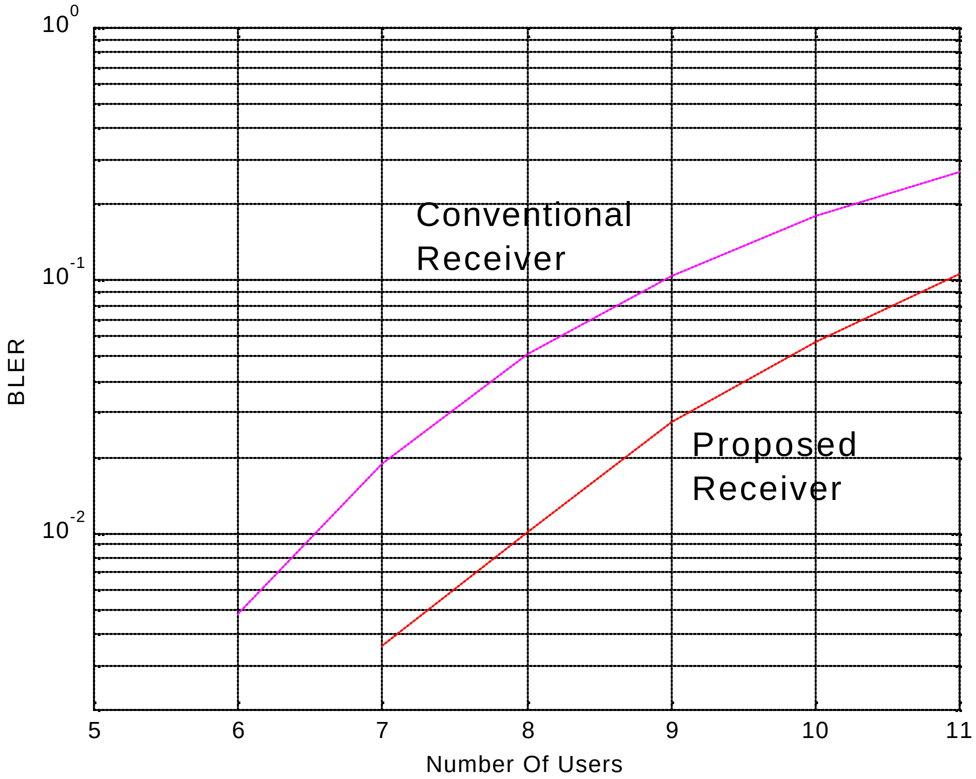

Figure 4: Performance with & without pilot MAI cancellation – Two BS Scenario, Data Users.

3. Simulation Environment

Two BS emulators are required for this performance test. The delay profiles of signals received from different base stations are assumed to be the same but time shifted by 10 chip periods (2604 ns, see also [1, Section 8.6.3]). All voice or data users are transmitted with equal power at each BS. Table 1 below defines the P-CPICH and DCH parameters, and Tables 2 & 3 define the DCH requirements.

Table 1: P-CPICH and DCH parameters for inter-cell pilot channels MAI cancellation (Case 3).

Parameter	Unit	Test 1	Test 2
Phase reference		P-CPICH	
$\hat{I}_{or1}$	dBm/3.84 MHz	-83	
$\hat{I}_{or2}$	dBm/3.84 MHz	-80	
P-CPICH_Ec/Ior1	dB	-10	
P-CPICH_Ec/Ior2	dB	-7	
Information Data Rate	kbps	12.2	64

Table 2: DCH requirements for inter-cell pilot channels MAI cancellation Test 1 (Case 3).

$\frac{DPCH\_E_c}{I_{or1}}$	Number of Voice Users (BS 1)	$\frac{DPCH\_E_c}{I_{or2}}$	Number of Voice Users (BS 2)	BLER
-15.6dB	29	-16.1dB	29	10^{-1}
-14.0dB	20	-14.5dB	20	10^{-2}

Table 3: DCH requirements for inter-cell pilot channels MAI cancellation Test 2 (Case 3).

$\frac{DPCH\_E_c}{I_{or1}}$	Number of Data Users (BS 1)	$\frac{DPCH\_E_c}{I_{or2}}$	Number of Data Users (BS 2)	BLER
-7.9dB	5	-8.5dB	5	10^{-1}
-9.4dB	7	-10.0dB	7	10^{-2}

4. Summary

A procedure for cancelling the multiple access interference (MAI) associated with the pilot channels of the active and neighbouring base stations, was proposed. It was shown that the DL capacity is increased by approximately 10%. This 10% improvement follows immediately from [1, Annex 3, C.3.2] that sets P-CPICH_Ec/Ior to −10dB, hence, the pilot channel contributes 10% to the total MAI (for both intra-cell and inter-cell cases). A larger increase in DL capacity should be expected when the neighbouring base stations are not fully loaded (and hence their relative pilot power is larger) and/or when secondary pilot channel(s) are utilized (where according to [1, Annex 3, C.3.2] the relative pilot power is increased to 20%). A by-product of this pilot MAI cancellation procedure could be an improved hand-over mechanism, since the UE constantly monitors the channel taps of the neighbouring base stations. Applying the same procedure to the demodulation of the active pilot channel(s) results in an improved channel estimator. The overall computational complexity added to the UE is very small.

Appendix: Pilot Channel(s) MAI Cancellation

Let $y_i(n)$ denote the output of the i-th rake finger, i.e.

$$y_i(n) ? \hat{h}^{?}_i ?\overset{SF}{\underset{k?1}{?}} r(n ?SF ? k) ?s_d(n ?SF ? k)^{?}$$

Equation 1

where $r(k)$ is the signal at the i-th despreader input, $s_d(k)$ is the spreading sequence of the dedicated channel (and for future reference we note that $s_0(k)$ denotes the spreading sequence of the pilot channel), $\hat{h}_i$ is the i-th channel tap estimator, and SF is the spreading factor of the dedicated channel.

The pilot channel MAI at the i-th rake finger output that is associated with the j-th multipath component is given by

$$\hat{h}^*_i ?h_j ? \overset{?}{\underset{k???}{?}} R(?_{i,j} ? k,n) ??(k ?OS ? ?_{i,j})$$

Equation 2

where $R(?,n)$ is the cross-correlation between the spreading sequences and is thus given by

$$R(?,n) ? \overset{SF}{\underset{□?1}{?}} s_d(□ ? n ?SF)^* ?s_0(□ ? n ?SF ? ?),$$

Equation 3

$?(?)$ is the cross-correlation between the transmit (BS) and receive (UE) filters and is thus given by

$$?(?) ? \overset{?}{\underset{??}{?}} h_{Tx}(? ?\frac{T_c}{OS} ?t) ?h_{Rx}(t) ?dt$$

Equation 4

with OS being the over sampling factor (number of samples per chip interval - T_c), and the delay between the i-th and j-th multipath components was decoupled into its integer component $?_{i,j}$ and fractional component $?_{i,j}$, that is

$$?_i ? ?_j ? ?_{i,j} ?T_c ? ?_{i,j} ?\frac{T_c}{OS} \quad ; \quad |?_{i,j}|? OS$$

Equation 5

It should be noted that Equation 2 also covers the case where the MAI is due to a neighbouring base station. In Equation 3, $s_0(k)$ should then be taken as the spreading sequence of the pilot channel of that base.

Now, in order to cancel pilot channel MAI at the i-th finger output, the receiver needs to compute the cross-correlations in Equation 3, convolve it with $?(?)$ ($?(?)$ may be computed before hand and stored in memory), and subtract from the i-th finger output the term,

$$\hat{h}^{*}_{i}\ ?\hat{h}_{j}\ ?\ \overset{?}{\underset{k???}{?}} R(?_{i,j}\ ?\ k,n)\,??(k\ ?OS\ ?\ ?_{i,j})$$

Equation 6

This term is identical to the one in Equation 2, up to the fact that h_j is replaced by its estimate -- implying that the UE should estimate the fingers of the neighbouring base stations as well.

In practice, a finite number of elements should be taken in the summation of Equation 6. Setting the Tx filter according to [2, Section 6.8.1] and assuming a matched filter as the Rx filter, one can verify from Equation 4 that taking 3 elements of each side of the main lobe of $?(?)$ is sufficient to capture more than 99.5% of the pilot MAI over all channel scenarios.

In terms of the UE complexity, the amount of resources required for pilot MAI cancellation is directly proportional to the number of pilot channels of other base stations “seen” by the UE, and the number of fingers needed per base. According to [3, Section 11], it seems that there is no point in covering more than 4 neighbouring base stations. Assuming an average of 3 pilot fingers per base, the overall complexity added to the UE is small. Moreover, a simple selection mechanism that selects out of the potential 12 additional pilot fingers only the instantaneously strongest, would further simplify the implementation while, if carefully addressed, will have no meaningful affect on the performance.

References

[1]3GPP TS 25.101 v3.4.0 (2000-09).

[2]3GPP TS 25.104 v3.4.0 (2000-09).

[3] 3GPP TR 25.942 v2.3.0 (2000-09).