Comparison of the 3GPP and CPM Schemes

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Abstract

In this report, we compare the current 3GPP cell search scheme for W-CDMA with a new proposal called the Code Position Modulation method (CPM) described in [1]. In [2], it was shown that the proposed CPM based cell search scheme outperforms the 3GPP method. The performance improvement is because the parameters chosen for the 3GPP cell search scheme were not optimized. This fact was also pointed out in [3]. It was also shown in [3] that the complexity of the CPM method is higher than that of the 3GPP scheme. In this report, we show that by making very simple modifications to the parameters chosen for 3GPP in [2] and [3] we obtain much better performance than the CPM method for comparable complexity. We also show in this report that the CPM method also has the additional disadvantage of a much complex control and buffer management.

Simulation Parameters

We performed link level simulations with the following parameters.

	Handoff	No Handoff
Channel model	2 Path Vehicular, with paths 0 and -2.5 dB.	2 Path Vehicular, with paths 0 and -2.5 dB
Doppler	5Hz and 100Hz[1]	5Hz and 100Hz
SCH Power	10% of BS power	10% of BS Power
PSCH & SSCH power for 3GPP	Total SCH power equally divided between the 2 SCHs, 5% of BS power[2].	Total SCH power equally divided between the 2 SCHs, 5% of BS power.
Side Information	10 BS's in the candidate list, whose groups are different and known. Path information of primary BS is known.	None
Primary Cell - Target Cell Power	3dB and 6dB[3]	None
Primary Cell Power/IOC	Variable, -8 to –2 dB	Variable, -8 to –2dB
Stage1	Length=10ms for both 3GPP & CPM[4]	Length=5ms for both 3GPP & CPM
Stage 2	Length=20ms for both 3GPP & CPM. Coherent for 3GPP, L=4, K=4 for CPM.	Length=10ms for both 3GPP & CPM. Coherent for 3GPP, L=4, K=1 for CPM

[1] 100Hz simulation results will be presented at the meeting.
[2] The power allocation between the primary and secondary SCHs can be optimized to obtain a better acquistion time for the 3GPP scheme. This is an issue for further study.
[3] The simulation results for Primary Cell-Target Cell power = 6dB will be presented at the meeting.
[4] Tried other combinations such as 5ms for Stage 1, 10ms for Stage 2 etc. Picked the best results for both CPM and 3GPP methods.

Length of Stage 3	Assumed to be ideal, with a length of 10 ms for both 3GPP and CPM	Assumed to be ideal, with a length of 5 ms for both 3GPP and CPM

Note that the above parameters were chosen, taking into consideration both the performance and the constraint that the complexity of both methods be about the same. Note also that the results would still be valid with a non-ideal stage 3. This is because of the following: Consider the acquisition state diagram is shown in Figure (1).

Figure 1. Figure showing the state diagram of acquisition

Thus, the average acquisition time with an ideal Sage 3 would be T_1/P_d. With a non-ideal Stage 3, the average acquisition time would be proportional to $(T_1/P_d)/P_{d3}$, where P_{d3} is the probability of successful detection in a non-ideal Stage 3. Thus, a method having a lower acquisition time with the ideal 3rd stage (lower T_1/P_d) would still have a lower acquisition time with a non-ideal Stage 3.

Results and Discussions

The results of this simulation are shown in Figures (2) & (3). The figures show that for the handoff case, the performance of CPM is comparable for the regions of operation, when the Stage 1 decision variables are reset after Stage 1 completes (T_{acc} = Time taken in Stage 1).

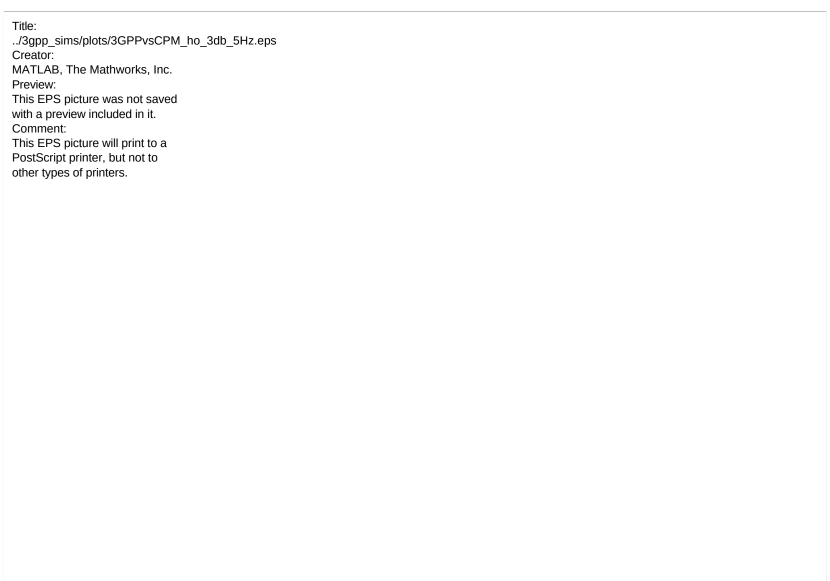

Figure 2. Performance of 3GPP and CPM methods for the handoff case

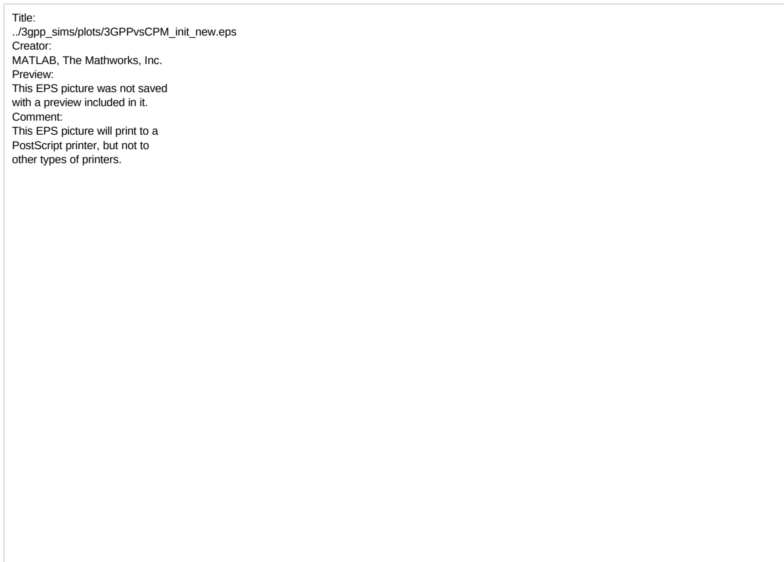

Figure 2. Performance of 3GPP vs. CPM, Initial Acquisition

From Figure 3 we can see that for the non-handoff case, the performance of both the 3GPP and the CPM method is about the same when Stage 1 decision variables are reset at the end of Stage 1, except at very low SNRs, where the CPM method performs better.

This performance degradation for 3GPP is because, at lower SNRs, more averaging is required in Stage 1. However, increasing the averaging in Stage 1 increases the acquisition time. In this report, we used a simple variation of the averaging. Instead of resetting the Stage 1 decision variables each time Stage 2 is entered, we reset the Stage 1 decision variables every T_{acc}ms. For e.g., if T_{acc} = 2 times the time taken for Stage 1 (T_1 in the figure), then Stage 1 decision variables are averaged T_1ms for half the times we enter Stage 2, and the decision variables are averaged $2T_1$ms for the other half times. This improves the decisions made in Stage 1 without adversely

Figure 4. Figure showing current and proposed averaging schemes. This is just one simple setting of a parameter among various others to obtain better performance.

lengthening time taken in Stage1, thereby improving the overall acquisition time. Clearly, T_{acc} should be a multiple of the time taken in Stage 1 (T_1). The duration T_{acc} is only limited by clock drift; for initial acquisition, therefore, we would limit T_{acc} to few ten milliseconds. But during handoff situations, where clock drift is small, T_{acc} can be chosen to be as large as a few hundred milliseconds. The results of the simulation with the changed reset times are also shown in Figures (2) and (3). The results show that with this simple modification it is possible to outperform the CPM method significantly. In particular, for the non-handoff case, performance of the two schemes is comparable when T_{acc} = 15ms for 3GPP; the 3GPP scheme is clearly superior when T_{acc} = 20ms. Note that the time taken for the three stages is 5ms, 10ms, and 5ms respectively for both schemes in this comparison. Similar results are seen for the handoff case. Since T_{acc} can be much larger for this case, the gains over CPM also are more significant (Figure 2).

Control Complexity

Design complexity and power consumption for the mobile handset depends heavily on the control complexity of the algorithms, not just the raw add and multiply operation counts. For the 3GPP method, Stage 1 and 2 control is quite simple. Correlations with the SSC have to be performed every slot position from the position indicated by the output of Stage 1 and these results have to be combined appropriately to obtain the decision metrics for Stage 2.

For the CPM method, however, the output of the matched filter is sampled every 128 chips (for the mini-slot information), starting at the peak positions indicated by Stage 1. If L > 1, this implies that the samples have to be appropriately chosen out of the matched filter for each peak position. This requires complex multiplexing of the matched filter outputs as the L peaks need not be at multiples of 128 chips from each other.

A second problem occurs because of the way the mini-slot samples are collected for each peak position. The mini-slot samples are collected as soon as a peak is found. The problem now occurs when all the buffers are full and a new peak occurs which is greater than one of the older peaks. For e.g. for L=4 we observe the first four peaks and start collecting the information. Now if a 5’th peak greater than one of the first 4 peak is found the buffer corresponding to one of the previously detected peaks has to be killed and a new one started. This is pictorially shown in Figure (5). Thus, a complex buffer management control is required for CPM, which in turn requires more power for control circuitry. On the other hand the current ETSI scheme has simple

Figure 5. Figure showing the complex buffer control for the CPM method

buffer management at the expense of slightly more memory for storing Stage 1 decision variables. Power consumption of the handset, however, is more likely to be impacted by the complex control of the CPM scheme than the extra memory for the 3GPP scheme.

Conclusions

The major conclusions of this report are

1) 3GPP and CPM schemes have very close performance for both the handoff and non handoff case for a wide range of SNRs.
2) The performance of 3GPP scheme can be improved over the CPM scheme, especially for the handoff scenario, by appropriate choice of parameters. We have shown only one parameter that can be optimized, namely, the reset time of the decision variables of Stage 1. Various other schemes such as sequential detection using a set of thresholds for Stage 1 to improve its detection probability are possible.
3) It is possible to optimize the power ratio between the primary and the secondary SCH's. This results in better acquisition time for 3GPP.
4) CPM method has complex control circuitry and a complex buffer management. On the other hand, 3GPP has a very simple control.
5) The advantages of the time multiplexed SCH (such as low PAR) are lost if CPM is used on a parallel channel. It would be very complicated to time multiplex the CPM SCH with the rest of the CCPCH.

We therefore feel that the changing the SCH structure and the acquisition scheme from the current 3GPP scheme to CPM is **not** necessary.

References

[1] "CPM based fast cell search algorithm," December 1998. Tdoc SMG2 UMTS-L1 634/98.
[2] "CPM based fast cell search algorithm (link level simulation results)," January 1999. Tdoc SMG2 UMTS-L1 s209x006/99.
[3] "Comparisons of cell search schemes: 3GPP versus CPM," Ericsson, March 1999.