Review of Distributed Sample Acquisition for DS/CDMA

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1 Introduction

In this project we review the work of Kim and Lee[2] [3] [4] [5] on Distributed Sample Acquisition. We begin by considering the Distributed Sample Acquisition Technique. We analyze the variation in performance with the increase in the number of users, something that the authors had not explicitly analyzed. We find that the Mean Acquisition Time remains of the same order in the presence of MAI but the probability of detection suffers significantly.

2 Shift Register Generator Model

The shift register is modeled as follows. Let $\mathbf{T}$ be State Transition Matrix, $\mathbf{d}_k$ be State vector of Shift Register, and $\mathbf{h}$ be the Generating Vector The next state vector is given by,

$$\mathbf{d}_{k+1} = .\mathbf{T}\mathbf{d}_k \tag{1}$$

The sequence value, s_k is given by

$$s_k = \mathbf{h}^t.\mathbf{d}_k \tag{2}$$

3 Acquisition

The block diagram of DSA technique is shown in Figure 1. Noting that the sample z_i or $\hat{z}_i$ is the sequence value emitted from the SRGs at time $(r+i)N_I$ and the corresponding correction is made at time $(r+i)N_I + D_c$ for a correction delay D_c in $0 < D_c < N_I$, the following relations are obtained

$$z_i = s_{(r+i)N_I} = \mathbf{h}^t \cdot \mathbf{d}_{(r+i)N_I} \tag{3}$$

$$\hat{z}_i = s_{(r+\hat{i})N_I} = \mathbf{h}^t \cdot \hat{\mathbf{d}}_{(r+i)N_I} \tag{4}$$

$$i = 0, 1, \cdots, L-1$$

and

$$\mathbf{d}_{(r+i)N_I+D_c} = \mathbf{T} \cdot \mathbf{d}_{(r+i)N_I+D_c-1} \tag{5}$$

$$\hat{\mathbf{d}}_{(r+i)N_I+D_c} = \mathbf{T} \cdot \hat{\mathbf{d}}_{(r+i)N_I+D_c-1} + (z_i + \hat{z}_i)c_0 \tag{6}$$

$$i = 0, 1, \cdots, L-1$$

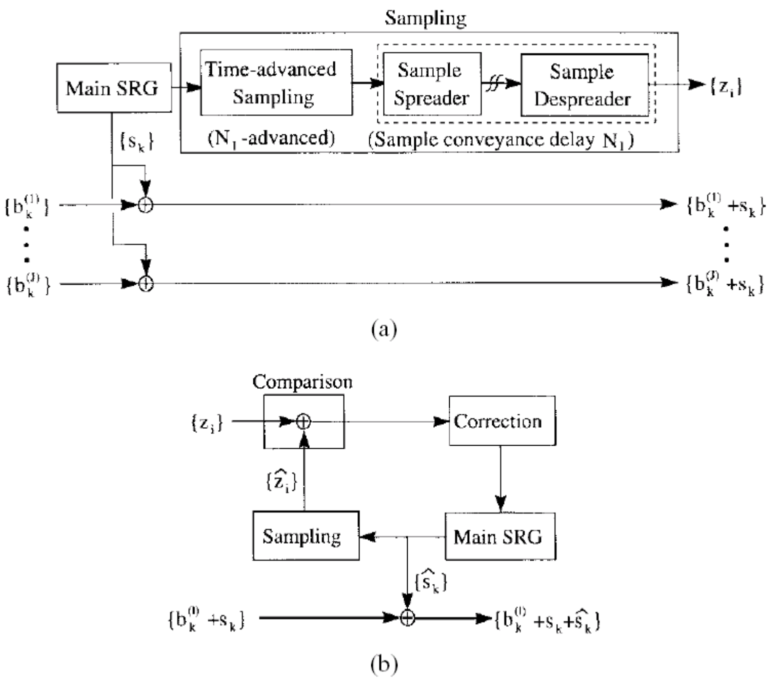

Figure 1: Block diagram of DSA

where c_0 is the *correction vector*. let the *state distance vector* be $\delta_k = \mathbf{d}_k + \hat{\mathbf{d}}_k$. After L times of correction, the finally corrected state distance vector are obtained

$$\delta_{(r+L-1)N_I+D_c} = \Lambda \cdot \delta_{rN_I} \tag{7}$$

For the $L \times L$ correction matrix

$$\Lambda = \left(\mathbf{T}^{N_I} + c_0 \cdot \mathbf{h}^t \cdot \mathbf{T}^{N_I+D_c}\right)^{L-1} \cdot \left(\mathbf{T}^{D_c} + c_0 \cdot \mathbf{h}^t\right) \tag{8}$$

Now, in order to achieve synchronization by L correction it is necessary to make the final state distance vector $\delta_{(r+L-1)N_I+D_c}$, a zero vector regardless of the initial state distance vector δ_{rN_I}, which can be done only by making the correction matrix Λ a zero matrix. This will happen *if and only if* the following two conditions are met.

1. The state transition matrix $\mathbf{T}$ should be non-singular and N_I should be chosen such that the *discrimination matrix* $\Delta_{\mathbf{T},\mathbf{h}}$ is non-singular, where

$$\Delta_{\mathbf{Th}} = \left[h \quad (\mathbf{T}^{N_I})^t \cdot h \quad (\mathbf{T}^{2N_I})^t \cdot h \cdots (\mathbf{T}^{(L-1)N_I})^t \cdot h\right]^t \tag{9}$$

2. The choice of c_0 and D_c is made such that it satisfies

$$c_0 = \mathbf{T}^{(L-1)N_I+D_c} \cdot \Delta_{\mathbf{T},\mathbf{h}}^{-1} \cdot e_{L-1} \tag{10}$$

where $e_{L-1} = [0 \quad 0 \quad 0 \quad 0 \quad \cdots \quad 1]$

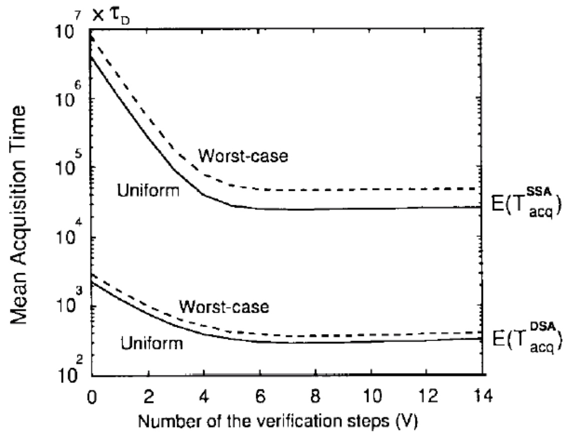

Figure 2: Acquisition Time for SSA and DSA for $\gamma_c = -10\text{dB}, k_u = 5$

4 Performance: Analysis and Discussion

Mean acquisition time of proposed scheme is substantially less (factor of 100) than the hierarchal method of serial search. Figure-1 depicts the comparative performance of DSA and SSA against the number of verification steps. The acquisition time graph polarizes after a fix number of verifications. The length of acquired long pn code is 2^15-1. It is observed that for even longer pn codes (say 2^42-1), the average time of acquisition will be of the same order since it depends upon the length of igniter sequence code and the length of main SRG.

4.1 Length of igniter sequence

The proposed scheme chooses length of igniter sequence on the basis such that the discrimination matrix ? is non singular. This can be achieved by various values of N_I. The scheme arbitrarily picks N_I to be 128 which eventually turn out to be the optimal choice. Performance curve in Figure 3 show acquisition curve for different values of N_I. N_I takes on different values of 63, 127, 255, 511.

4.2 Variation with SNR

Plots of probability of detection against probability of false alarm for different values of SNR are present in Figure 4. It can be observed that with the increase of SNR, P_d polarizes for very small value of P_f and effect or dependence goes by. At a lower SNR like 5 dB performance of the system degrades significantly. This plot of P_d vs P_s is quite identical with popular scheme of SSA.

4.3 Multiple Access Interference

The proposed scheme out perform popular scheme of SSA in single user situation. This makes us look for it's performance in multiple access systems.

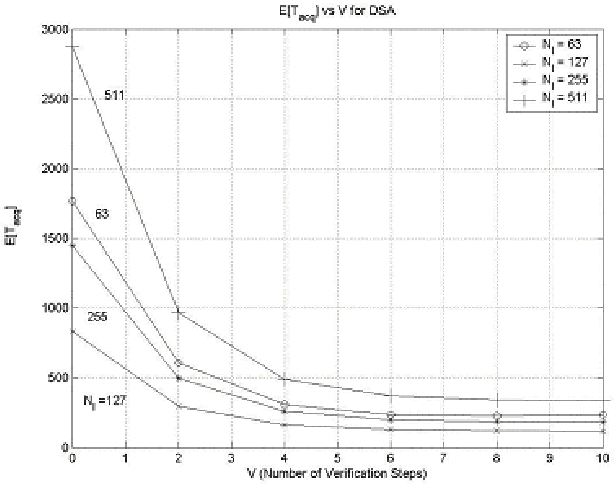

Figure 3: Variation of T_{acq} with Length of Igniter Sequence

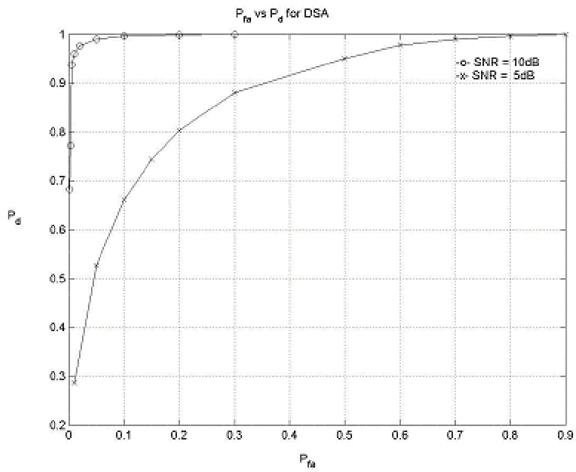

Figure 4: Variation of P_D for different values of SNR

Following Figure 5 is drawn to show the effect of multiple users upon mean acquisition time. There is a noticeable feature that the mean time is not significantly different from the case of single user. Performance graph is consistent (better than SSA) at both P_{fa} =0.1 and 0.01.

4.4 Performance: Probability of detection

Mean acquisition time of proposed scheme is much better than SSA. Power requirement is equivalent then where is the point of trade off. This gets noticed in the following curve of P_D. It is observed that in the situation of 5 users,

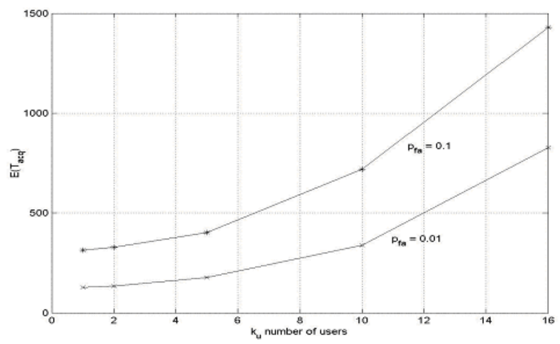

Figure 5: Variation of Mean Acquisition Time with Number of Users

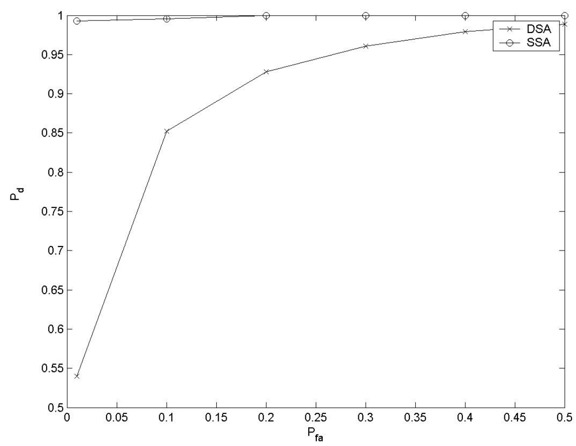

Figure 6: P_d vs P_{fa} for $k_u = 5$ for DSA and SSA

though mean acquisition time remains of the same order but probability of detection falls down acceptable values. Comparative graph against SSA shows the tradeoff of proposed scheme. These graphs are plotted using the close form expression mentioned in proposed scheme.

References

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