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ÜSTEL OLARAK AĞIRLIKLANDIRILMIŞ TOPARLAMA DİZİLERİ KULLANAN BİR DD-KBÇE SİSTEMİ İÇİN DOĞRU VE BASİT BİR KOD SEÇME KRİTERİ

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ÖZET

Kod seçimi, bir doğrudan dizili-kod bölmeli çoklu erişim (DD-KBÇE) sisteminin başarımı üzerinde oldukça etkilidir. Çoklu erişim sistem tasarımcılarının amaçlarından birisi, mümkün olduğunca düşük çoklu erişim girişimi ile bir frekans bandının olabildiğince fazla sayıda kullanıcı tarafından kullanılabilmesini sağlayacak yayma kodlarının bir grubunu ortaya koymaktır. Eğer, üstel olarak ağırlıklandırılmış toparlama dizilerinin kullanıldığı bir DD-KBÇE sistemindeki aktif kullanıcıların sayısı, verilen bir kod setindeki kod sayısından daha az ise, alınan bilginin kalitesi açısından en iyi bit hata oranı başarımını sağlayacak kodların belirlenmesi oldukça önemlidir. Bu çalışmada, üstel olarak ağırlıklandırılmış toparlama dizileri kullanan bir DD-KBÇE sistemi için verilen bir kod seti içerisinde diğerlerine göre daha iyi bit hata oranı başarımları oluşturacak referans yayma kodlarını belirleyen basit ve doğru bir kriter önerilmektedir.

Anahtar Kelimeler: Yayılı Spektrum Haberleşmesi, DD-KBÇE, Çoklu Erişim Girişimi

AN ACCURATE AND SIMPLE CODE SELECTION CRITERION FOR A DS-CDMA SYSTEM WHICH EMPLOYS EXPONENTIALLY WEIGHTED DESPREADING SEQUENCES

ABSTRACT

Code selection has a large impact on the performance of a direct sequence-code division multiple access (DS-CDMA) system. A goal of spread spectrum system designers for a multiple access system is to find a set of such spreading codes that as many users as possible can use a band of frequencies with as little multiple access interference (MAI) as possible. If the number of active users in a DS-CDMA system using exponentially weighted despreading sequences is less than the number of codes in a given code set, it is very important in terms of the quality of the recovered information to determine the codes which will yield the best bit error rate (BER) performances. In this study, it is proposed that, a simple and efficient criterion which enables the determination of the spreading sequences in a given code set achieves better BER performances than others when used as references for a DS-CDMA system which employs exponentially weighted despreading sequences.

Key Words: Spread spectrum communication, DS-CDMA, multiple access interference

1. INTRODUCTION

Research and developments of digital communications systems is undergoing a revolution fuelled by rapid advances in technology. With the ever-growing sophistication of signal processing and computation, advances in communication theory have an increasing potential to bridge the gap between practically feasible channel utilization and the fundamental information theoretic limits on channel capacity. If conquering channel capacity is the manifest density of communications technology, the need for efficient use of channel bandwidth and transmission power is felt most acutely in wireless communication (1).

Direct sequence-code division multiple access (DS-CDMA), its roots in spread spectrum communication, can effectively multiplex multiple users simultaneously and asynchronously across the same spectrum band by imprinting data bits with a unique code (2). A DS-CDMA signal is created by modulating the binary data signal with a spreading sequence (a code consisting of a series of binary pulses) known as a *pseudo-noise* (PN) digital signal because that make the signal appear wide band and ‘‘ noise like ’’. The *multiple access interference* (MAI) is an important factor that affects the capacity and performance of DS-CDMA systems. With the objective of MAI rejection, an optimum multiuser receiver was proposed in (3). However, it is extremely complex. Subsequently, a number of suboptimal receivers using simplified structures have been proposed (4-9). These suboptimal multiuser receivers require locking and despreading some or all of the co-user signals, hence they are still too complex to be implemented in practice. Based on the noise whitening approach, an integral equation receiver has been studied in (10) for MAI rejection. In this receiver, it is not easy to tune to the optimum despreading function in practice when the processing gain *N* is large. The idea of weighting the despreading sequences by adjustable chip waveforms has been proposed in (11,12). In this model, the resulting despreading function under consideration is determined only by one parameter, γ, when the system parameters are given.

2. SYSTEM DESCRIPTION

The *k*th user transmits a signal of the form

$$S_k(t)=\sqrt{2P}b_k(t)a_k(t)\cos(\omega_c t+\theta_k) \quad (1)$$

where P and ω_c represent the transmitted power and carrier frequency which are common to all users, respectively; θ_k is a random phase; $b_k(t)$ is a random binary data sequence; $a_k(t)$ is the spreading sequence modeled as a random sequence. It is assumed that data bit and chip durations are represented by T_b and T_c seconds, respectively, and the spreading sequence has period $N=T_b/T_c$. The received signal $r(t)$ consisting of K asynchronous DS-CDMA active users can be represented as

$$r(t)=\sum_{k=1}^{K}S_k(t-\tau_k)+n(t)$$

$$=\sqrt{2P}\sum_{k=1}^{K}b_k(t-\tau_k)a_k(t-\tau_k)\cos(\omega_c t+\phi_k)+n(t) \quad (2)$$

where $n(t)$ is additive white Gaussian noise (AWGN) with two-side spectral density $N_0/2$. τ_k and $\phi_k\,(=\theta_k-\omega_c\tau_k)$ for $1\le k\le K$ are random time delays and phases along the communications links between the *K* transmitters and the particular receiver, respectively. The weighted despreading sequence for the *k*th receiver is given by

$$\hat{a}_k(t)=\sum_{j=-\infty}^{\infty}a_j^{(k)}w_j^{(k)}\left(t-jT_c\middle|\left\{c_j^{(k)},c_{j+1}^{(k)}\right\}\right)P_{T_c}(t-jT_c)$$

(3)

where $c_j^{(k)}=a_{j-1}^{(k)}a_j^{(k)}$, $w_j^{(k)}\left(t\middle|\left\{c_j^{(k)},c_{j+1}^{(k)}\right\}\right)$ for $0\le t\le T_c$ is the *j*th chip conditional weighting waveform based on the status of three consecutive chips $\left\{a_{j-1}^{(k)},a_j^{(k)},a_{j+1}^{(k)}\right\}$ and $P_x(y)=1$ for 0< *y*< *x* and 0 otherwise. Each $c_j^{(k)}$ is a random variable which indicates whether or not the next element of the *k*th spreading signal is the same as the preceding element. $c_j^{(k)}=-1$ implies $a_{j-1}^{(k)}\neq a_j^{(k)}$, and a transition occurs between the two consecutive chips, while $c_j^{(k)}=1$ implies $a_{j-1}^{(k)}=a_j^{(k)}$, and no transition occurs between the two consecutive chips. The *j*th chip conditional weighting waveform for the *k*th receiver is defined as

$$w_j^{(k)}\left(t\middle|\left\{c_j^{(k)},c_{j+1}^{(k)}\right\}\right)=\begin{cases}m_1(t) & if\ c_j^{(k)}=+1\ and\ c_{j+1}^{(k)}=+1\\ m_2(t) & if\ c_j^{(k)}=-1\ and\ c_{j+1}^{(k)}=-1\\ m_3(t) & if\ c_j^{(k)}=-1\ and\ c_{j+1}^{(k)}=+1\\ m_4(t) & if\ c_j^{(k)}=+1\ and\ c_{j+1}^{(k)}=-1\end{cases} \quad (4)$$

where $m_p(t)$ for $p\in[1, 2, 3, 4]$ are the chip weighting waveforms. Noting that the optimum despreading function given in (10) emphasizes the transitions of the received signal of interest user, the elements of the chip weighting waveforms vector $\{m_1(t), m_2(t), m_3(t), m_4(t)\}$ given by the following:

$$\begin{aligned}m_1(t)&=e^{-\gamma/2}P_{T_c}(t)\\ m_2(t)&=e^{-\gamma t/T_c}P_{T_c/2}(t)+e^{-\gamma(1-t/T_c)}P_{T_c/2}(t-T_c/2)\\ m_3(t)&=e^{-\gamma t/T_c}P_{T_c/2}(t)+e^{-\gamma/2}P_{T_c/2}(t-T_c/2)\\ m_4(t)&=e^{-\gamma/2}P_{T_c/2}(t)+e^{-\gamma(1-t/T_c)}P_{T_c/2}(t-T_c/2)\end{aligned} \quad (5)$$

where $\gamma\in[0,\infty)$ is a parameter of the exponential chip weighting waveforms. Assuming that user *i* is the reference user $(\tau_i=0$ and $\phi_i=\theta_i-\omega_c\tau_i=0)$, the decision variable $\xi(\lambda)$ for the λth data bit of the reference user, consists of three terms which are the conditional desired signal, the noise and the MAI components. The signal to interference plus noise ratio $SINR_i$,conditioned on $\left\{c_j^{(i)}\right\}$, is given by

$$SINR_i=\left\{\frac{\gamma\left[\chi(1-e^{-\gamma})+\gamma(1-\chi)e^{-\gamma}\right]}{2\kappa_b\left[2\chi(1-e^{-\gamma/2})+\gamma(1-\chi)e^{-\gamma/2}\right]^2}+\frac{(K-1)\,\Xi(\Gamma^{\{c_j^{(i)}\}},\gamma)}{2N\left[2\chi(e^{\gamma/2}-1)+\gamma(1-\chi)\right]^2}\right\}^{-1} \quad (6)$$

where $E_b=PT_b$, $\kappa_b=E_b/N_0$, $\chi=\hat{N}_i/N$. $\hat{N}_i$, is a random variable which represents the number of times of occurrence that $c_j^{(i)}=-1$ for all

$j \in [0, N-1]$. $\Xi\left(\Gamma^{\{c_j^{(i)}\}}, \gamma\right)$ in the eqn. (6) is given by

$$\Xi\left(\Gamma^{\{c_j^{(i)}\}}, \gamma\right) = \frac{1}{N}\left\{\Gamma^{(i)}_{\{-1,-1,-1\}}\left[4 + \frac{12}{\gamma} - \frac{16e^{\gamma/2}}{\gamma} + \frac{4e^{\gamma}}{\gamma}\right]\right.$$
$$+\left(\Gamma^{(i)}_{\{-1,-1,1\}} + \Gamma^{(i)}_{\{1,-1,-1\}}\right)\left[\frac{5}{2} - \frac{\gamma}{4} + \frac{\gamma^2}{24} + \frac{19}{2\gamma} + e^{\frac{\gamma}{2}} - \frac{12e^{\gamma/2}}{\gamma} + \frac{5e^{\gamma}}{2\gamma}\right]$$
$$+\left(\Gamma^{(i)}_{\{-1,1,1\}} + \Gamma^{(i)}_{\{1,1,-1\}}\right)\left[-\frac{3}{2} - \frac{3\gamma}{4} + \frac{19\gamma^2}{24} - \frac{1}{2\gamma} + e^{\gamma/2} + \frac{e^{\gamma}}{2\gamma}\right] \quad (7)$$
$$+\Gamma^{(i)}_{\{-1,1,-1\}}\left[-3 - \frac{3\gamma}{2} + \frac{7\gamma^2}{12} - \frac{1}{\gamma} + 2e^{\gamma/2} + \frac{e^{\gamma}}{\gamma}\right]$$
$$\left.+\Gamma^{(i)}_{\{1,-1,1\}}\left[1 - \frac{\gamma}{2} + \frac{\gamma^2}{12} + \frac{7}{\gamma} + 2e^{\gamma/2} - \frac{8e^{\gamma/2}}{\gamma} + \frac{e^{\gamma}}{\gamma}\right] + \Gamma^{(i)}_{\{1,1,1\}}\left[\gamma^2\right]\right\}$$

where $\Gamma^{(i)}_{\{\nu_1,\nu_2,\nu_3\}}$ is the number of times of occurrence that $\left\{c^{(i)}_{j-1}, c^{(i)}_{j}, c^{(i)}_{j+1}\right\} = \left\{\nu_1, \nu_2, \nu_3\right\}$ for all j in the ith user's spreading sequence and each ν_n, $n \in [1,2,3]$, takes values +1 or –1 with equal probabilities.

3. EFFECT OF A SELECTED REFERENCE CODE ON THE RECEIVER PERFORMANCE

Code-selection has a large impact on the performance of the DS-CDMA system. The codes used for spreading (reference codes) should have low cross-correlation values and be unique to every user. The family of PN sequences called Gold codes have only three cross-correlation peaks which tend to get less important as the length of the code increases. They also have a single auto-correlation peak at zero and are useful because of the large number of codes they supply (13).

In order to proceed, it is first necessary to illustrate the BER performance of the ith user's receiver when different spreading codes are employed as a reference, sequentially. Because of the characteristics given above, the Gold codes are used as reference code set. It is assumed that the number of the spreading codes in a given code set are 25 and these codes are selected from a set of length N=63 (14). In Table 1, we present the selected spreading codes. Since the MAI is modeled as a zero-mean Gaussian process, the probability of error P_e for the data symbol $b_{\lambda}^{(i)}$ in all the BER curves is defined as

$$P_e = Q(\sqrt{\max[SINR_i]}) \qquad Q(x) = \frac{1}{\sqrt{2\pi}}\int_x^{\infty} \exp(-t^2/2)dt \quad (8)$$

where *max*[$SINR_i$] is the maximum value of $SINR_i$. Note that the parameter γ, should be tuned with respect to each signal to noise ratio (*SNR*) so as to maximize the $SINR_i$ (15). The number of the set $\{\Gamma^{(i)}_{\{\nu_1,\nu_2,\nu_3\}}\}$ and $\hat{N}_i$, $i \in [1,25]$, for the codes given in Table 1 are calculated and transferred to Table 2. Figure 1 shows the BER performances of the ith user's receiver when different codes (first, fifth and twentieth code in Table 1) which have different $\hat{N}_i$ occurrences are used as a reference, respectively. As can be seen from this Figure, especially in relative high κ_b (> 15 dB), the BER's are mostly caused by the MAI, also in low κ_b (< 5 dB), where the BER's mostly caused by the AWGN, the minimum BER would be achieved by using the codes which have the highest $\hat{N}_i$ occurrences.

It is worth mentioning that there are a great number of codes whose $\hat{N}_i$ occurrences are equal and the elements of their sets $\{\Gamma^{(i)}_{\{\nu_1,\nu_2,\nu_3\}}\}$ are not completely the same as each other in the sample code set. Figure 2 shows the BER performance attained at the ith user's receiver for the situation where the codes (fifth, sixth and seventh code in Table 1) having the characteristics mentioned above used as a reference. It should be noted that although the $\hat{N}_i$ occurrences of some codes are equal to each other, the BER performance of the ith user's receiver is not almost the same. Also, it is possible to achieve the same performance with the codes (sixth and twentieth code in Table 1) which have equal number of $\hat{N}_i$ but different number of $\{\Gamma^{(i)}_{\{\nu_1,\nu_2,\nu_3\}}\}$ as seen from Figure 2. As a consequence, the contribution of the $\Xi\left(\Gamma^{\{c_j^{(i)}\}}, \gamma\right)$ to the $SINR_i$ expression for each code must be determined to evaluate the performances of codes with equal number of $\hat{N}_i$ while the performance evaluation of the codes having different number of $\hat{N}_i$ can roughly be done by just looking at the $\hat{N}_i$.

4. NUMERICAL ANALYSIS

If the number of active users in a DS-CDMA system using exponentially weighted despreading sequences is less than the number of codes, in other words if there are a number of alternative codes for each active user, it is very important in terms of the quality of the recovered data to determine the codes which yield better BER performances, easily. Eqn. (7) can be rearranged as

$$\Xi\left(\Gamma^{\{c_j^{(i)}\}},\gamma\right)=\frac{1}{N}\Big[\boldsymbol{A}(\gamma)\,\Gamma^{(i)}_{\{-1,-1,-1\}}+\boldsymbol{B}(\gamma)\left(\Gamma^{(i)}_{\{-1,-1,1\}}+\Gamma^{(i)}_{\{1,-1,-1\}}\right)+\boldsymbol{C}(\gamma)\left(\Gamma^{(i)}_{\{-1,1,1\}}+\Gamma^{(i)}_{\{1,1,-1\}}\right)+\boldsymbol{D}(\gamma)\,\Gamma^{(i)}_{\{-1,1,-1\}}+\boldsymbol{E}(\gamma)\,\Gamma^{(i)}_{\{1,-1,1\}}+\boldsymbol{F}(\gamma)\,\Gamma^{(i)}_{\{1,1,1\}}\Big] \qquad (9)$$

where;

$$A(\gamma)=\left(4+\frac{12}{\gamma}-\frac{16e^{\gamma/2}}{\gamma}+\frac{4e^{\gamma}}{\gamma}\right)$$

$$B(\gamma)=\left(\frac{5}{2}-\frac{\gamma}{4}+\frac{\gamma^2}{24}+\frac{19}{2\gamma}+e^{\frac{\gamma}{2}}-\frac{12e^{\gamma/2}}{\gamma}+\frac{5e^{\gamma}}{2\gamma}\right)$$

$$C(\gamma)=\left(-\frac{3}{2}-\frac{3\gamma}{4}+\frac{19\gamma^2}{24}-\frac{1}{2\gamma}+e^{\gamma/2}+\frac{e^{\gamma}}{2\gamma}\right)$$

$$D(\gamma)=\left(-3-\frac{3\gamma}{2}+\frac{7\gamma^2}{12}-\frac{1}{\gamma}+2e^{\gamma/2}+\frac{e^{\gamma}}{\gamma}\right)$$

$$E(\gamma)=\left(1-\frac{\gamma}{2}+\frac{\gamma^2}{12}+\frac{7}{\gamma}+2e^{\gamma/2}-\frac{8e^{\gamma/2}}{\gamma}+\frac{e^{\gamma}}{\gamma}\right)$$

$$F(\gamma)=\left(\gamma^2\right)$$

To derive a simple criterion enables to determine the reference spreading codes in a given code set; the fifth, sixth and seventh codes given in Table 1 are selected as references and the achieved performances which are shown in Figure 2 and which are obtained by using these codes are taken into consideration. These codes have been arbitrarily chosen from a group of codes whose $\hat{N}_i$ occurrences are equal and the elements of $\{\Gamma^{(i)}_{\{v_1,v_2,v_3\}}\}$ for each code are different (a few elements may be the same). For simplicity, let

$$\Xi^{(5)}=\Xi\left(\Gamma^{\{c_j^{(5)}\}},\gamma\right)\quad,\qquad \Xi^{(6)}=\Xi\left(\Gamma^{\{c_j^{(6)}\}},\gamma\right)\quad,$$
$$\Xi^{(7)}=\Xi\left(\Gamma^{\{c_j^{(7)}\}},\gamma\right) \qquad (10)$$

Figure 3 shows the $\Xi^{(6)}/\ \Xi^{(7)}$, $\Xi^{(5)}/\ \Xi^{(6)}$ and $\Xi^{(5)}/\ \Xi^{(7)}$ variations for the situation where the three codes mentioned are used as a reference. If the receiver is accepted to have been tuned to a same γ value for these three codes, it is clear that the best receiver performance would be achieved by using the reference code which would make the smallest $\Xi\left(\Gamma^{\{c_j^{(i)}\}},\gamma\right)$ contribution, and the lowest performance would be achieved by using the code which would make the highest contribution to the $SINR_i$ expression given by eqn. (6). On the basis of this fact, we could conclude that the performance situation shown in Figure 2 for these three codes can be achieved only with the γ value (or values) which would perform the following condition

$$\Xi^{(5)}\langle\,\Xi^{(6)}\langle\,\Xi^{(7)} \qquad (11)$$

5. PROPOSED CRITERION AND NUMERICAL RESULTS

According to Figure 4, it is clear that $\Xi^{(5)}>\Xi^{(7)}$ for γ values which are selected from an interval before the crossing point (γ ≅ 2.2). For this reason, the condition given by eqn. (11) can not be met. To express more precisely, when the value of the γ is chosen from an area extending from the crossing point to a point where the derivations of these changes begin to approach to constant values (2.2 < γ < 20), the condition would be easily satisfied. If the value of γ is chosen from the interval where the derivations of the variations are zero,

$$\frac{d}{d\gamma}\left(\Xi^{(6)}/\Xi^{(7)}\right)=0\ ,\ \frac{d}{d\gamma}\left(\Xi^{(5)}/\Xi^{(6)}\right)=0 \ \text{ and }$$
$$\frac{d}{d\gamma}\left(\Xi^{(5)}/\Xi^{(7)}\right)=0$$

the differences between the $\Xi^{(5)}$ / $\Xi^{(6)}$, $\Xi^{(6)}$ / $\Xi^{(7)}$ and $\Xi^{(5)}$ / $\Xi^{(7)}$ would be maximum. After these observations, it seems suitable to use these γ values which are selected from this interval in the selection criterion.

It is assumed a criterion might help to determine the reference spreading codes achieving lower BER's for a DS-CDMA system is given by

$$\Psi^{(i)}\left(\Gamma^{(i)}_{\{v_1,v_2,v_3\}}\right)=\ \mathbf{a}\,\Gamma^{(i)}_{\{-1,-1,-1\}}+\mathbf{b}\left(\Gamma^{(i)}_{\{-1,-1,1\}}+\Gamma^{(i)}_{\{1,-1,-1\}}\right)+\mathbf{c}\left(\Gamma^{(i)}_{\{-1,1,1\}}+\Gamma^{(i)}_{\{1,1,-1\}}\right)$$

$$+ \mathbf{d}\,\Gamma^{(i)}_{\{-1,1,-1\}} + \mathbf{e}\,\Gamma^{(i)}_{\{1,-1,1\}} + \mathbf{f}\,\Gamma^{(i)}_{\{1,1,1\}} \qquad (12)$$

where; **a** = A(γ = γ_c), **b** = B(γ = γ_c), **c** = C(γ = γ_c), **d** = D(γ = γ_c), **e** = E(γ = γ_c), **f** =F(γ = γ_c) and γ_c is a specific value of γ. The process of estimating the coefficient values of the elements of $\{\Gamma^{(i)}_{\{\nu_1,\nu_2,\nu_3\}}\}$ is important to obtain accurate evaluations by using the proposed criterion. For the reasons described above, the criterion using coefficient values which are determined by taking $\gamma_c \in [0, 2.2]$, would produce results which would cause wrong decisions as shown in Table 3 (for γ_c = 2). The criterion using any value of γ_c which are selected from the interval $\gamma_c \in (2.2, 20]$ would make a correct evaluations as also shown in Table 3 (for γ_c = 10) . The criterion using coefficient values calculated according to the values of γ_c which are greater than approximately 20 would enable the evaluation to be done with the maximum accuracy.

The results given in Table 3 show the accuracy of the evaluations when the value of γ_c is chosen as 25. Based on the results given above, the coefficient values of the elements of the set $\{\Gamma^{(i)}_{\{\nu_1,\nu_2,\nu_3\}}\}$ in the proposed criterion can be calculated as

a = A(γ_c = 25) = 11.50×10^9 , **b** = B(γ_c = 25) = 7.20×10^9 **c** = C(γ_c = 25) = 1.44×10^9

d = D(γ_c = 25) = 2.88×10^9 **e** = E(γ_c = 25) = 2.88×10^9 **f** = F(γ_c = 25) = 6.25×10^2

As seen above, the value of the last coefficient **f** is quite small compared with the others. For this reason, the element $\Gamma^{(i)}_{\{1,1,1\}}$ of the set $\{\Gamma^{(i)}_{\{\nu_1,\nu_2,\nu_3\}}\}$ can be neglected because the **f** comes as a multiplier to this element. Also, the values of **d** and **e** are the same. So, the resulting simplified code selection criterion can be written as

$$\Psi^{(i)}\left(\Gamma^{(i)}_{\{\nu_1,\nu_2,\nu_3\}}\right) = \mathbf{a}\,\Gamma^{(i)}_{\{-1,-1,-1\}} + \mathbf{b}\left(\Gamma^{(i)}_{\{-1,-1,1\}} + \Gamma^{(i)}_{\{1,-1,-1\}}\right) + \mathbf{c}\left(\Gamma^{(i)}_{\{-1,1,1\}} + \Gamma^{(i)}_{\{1,1,-1\}}\right) + \mathbf{d}\left(\Gamma^{(i)}_{\{-1,1,-1\}} + \Gamma^{(i)}_{\{1,-1,1\}}\right) \qquad (13)$$

5.1. Selection Procedure Based on the Results of the Criterion

If the number of active users is less than the total number of the codes in a given code set, the selection process should be realized by the steps given below based on the results of the proposed criterion;

i-) First, begin with the code group which have the largest value of $\hat{N}_i$. If the number of the active users is less than the number of codes in this group, select the spreading codes which have lowest $\Psi^{(i)}$ values.

ii-) If the number of the active users are more than the number of the codes in this group, follow the same procedure given above for the next group which has a $\hat{N}_i$ value closest to previous until there are no user waiting for assignment.

CONCLUSION

The effects of the spreading codes on the receiver performance are determined before the code assignment process provides the flexibility of the selection of the codes with a high performance when the number of the users is less than the total number of the codes in a given code set.

In this study, it is thought that the more suitable codes are selected as references, the better BER performances might be achieved for a DS-CDMA system using exponentially weighted despreading sequences. For this purpose, we have presented a simple and efficient criterion to determine the most suitable spreading codes which should be used as references in a given code set. The accuracy of the proposed criterion was tested with different parameter values. Numerical results show that the criterion which use a proper value of the parameter could simply expose the performance achievements of different codes in a given set of codes. It should be noticed finally that the criterion presented in this study can be safely used for other DS-CDMA systems which have different processing gains.

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