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Multiuser Detection and Channel Estimation for CDMA System under Flat Fading Channels

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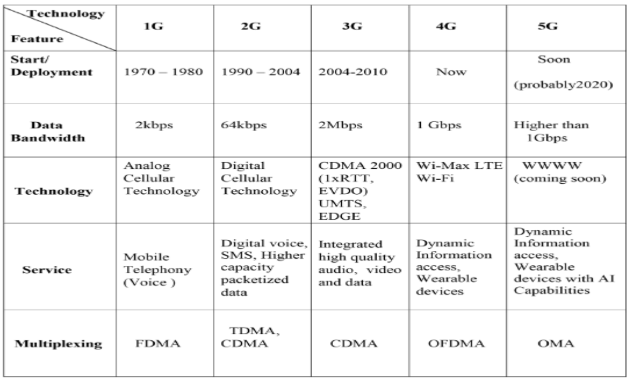
Abstract**:** ***For a level blurring code-division multiple access (CDMA), the numerous entrance framework is done by speech signal, and it shows the real framework by different conditions like comprising of state condition, multiplicative commotion condition , the nonlinear estimation condition, and an ideal separating calculation and these are used for joint recursive channel estimation and multi users separation. It ought to be focused on that the new calculation is pertinent to issues with a similar sort of nonlinear framework which shows that related commotions. Recreations process demonstrates that the new calculation performs are superior to the expanded Kalman channel estimation in faster merging rate and lower in bit mistake rate.***

Keywords: **Channel Estimation, Fading Channels, CDMA**

I. INTRODUCTION

Over the recent decade we have found substantial increase in the usage of wireless spread technology where we could find that the transition from second to fourth generation. This have also captivated an enormous amount of customers Right now the hike in customers requires proper pre setup requisition in network establishment which should be followed by planned connection .



Technology / Feature	1G	2G	3G	4G	5G
Start/ Deployment	1970 – 1980	1990 – 2004	2004-2010	Now	Soon (probably2020)
Data Bandwidth	2kbps	64kbps	2Mbps	1 Gbps	Higher than 1Gbps
Technology	Analog Cellular Technology	Digital Cellular Technology	CDMA 2000 (1xRTT, EVDO) UMTS, EDGE	Wi-Max LTE Wi-Fi	WWWW (coming soon)
Service	Mobile Telephony (Voice)	Digital voice, SMS, Higher capacity packetized data	Integrated high quality audio, video and data	Dynamic Information access, Wearable devices	Dynamic Information access, Wearable devices with AI Capabilities
Multiplexing	FDMA	TDMA, CDMA	CDMA	OFDMA	OMA

Fig.1 Comparative account of all generations

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II. MULTIPLE- ACCESS TECHNIQUES & CHANNELS

When the focus falls on transmission of data in air mode pipelining of data to the base station (BS) is a mandatory feature. Everyone knows that independent area to be partitioned into sub cells to have connection with a BS. To increase the capacity of the channel there are few multiple access methods.

a) Frequency division multiple-access (FDMA)
b) Time division multiple-access (TDMA)
c) Code division multiple-access (CDMA)

AWGN and Racian channel will face the same trouble when traces of original signal found at the receiver. In Rx the signal appears in multipath ate different directions. This fading occurs when LOS is higher that others. But in case of Rayleigh fading there should not be any LOS whatever the environment may be.

III. MULTI USER DETECTION (MUD)

To reduce the near far effect in ireless all single users are combined to form MUD. Here we have mentioned the reverse method of tx between BS and MS.

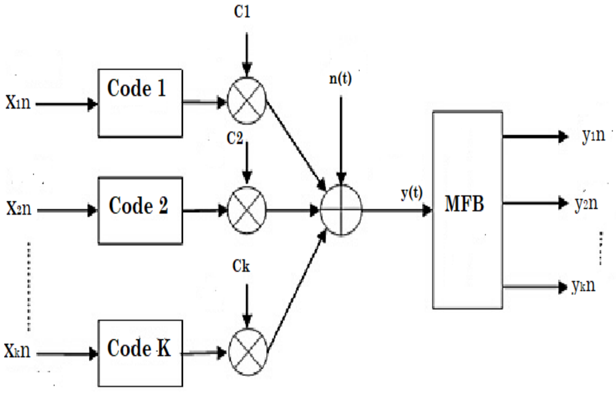

Fig.2 MUD Model

Baseband signal for the kth user is:

$$u_k(t)=\sum_{i=0}^{\infty} x_k(i)*c_k(i)*s_k(t-i*T-\tau_k)$$

$u_k(t)$=Base band signal of the kth user.
$c_i(t)$=real positive gain.
$s_k(t)$=signature waveform containing PN sequence.
k = transmission delay

Received signal at baseband is given by

$$= c_k * x_k + \sum_{j\neq k}^{K} x_j * c_j * \int_0^T s_k(t) * s_j(t)dt + \int_0^T s_k(t) * z(t)dt$$

$$y_k = \int_0^T y(t) * s_k(t)\, dt.$$

IV. PROPOSED SYSTEM FOR CHANNEL ESTIMATION AND MUD

Consider a K-user synchronous direct-sequence CDMA (DS-CDMA) system signaling through a flat fading channel. The scalar form output of the receiver can be modeled as

$$Y(n) = \sum_{k=1}^{K} h_k(n) * b_k(n) * s_k(n) + i(n)$$

where hk(n) is the channel response, which is assumed tobe zero mean independent Gaussian random variable with variance unity; y(n) is the output of the receiver; i(n)is the additive channel noise; K is the number of users, bk(n) is the nth symbol transmitted by the kth user, chosen independently and equally from {−1, +1}; sk(n) is the kth signature waveform in the nth chip interval, which is assumed to have energy 1/N, where N is the processing gain. As to the system model (1), using separate KALMAN filters for each user yields

$$Y_k(n) = h_k(n) * b_k(n) * s_k(n) + v_k(n)$$

Where vk(n) includes the interference from other user which is approximated as a zero mean Gaussian noise. In order to estimate the channel response and symbols jointly, by setting xk(n) = bk(n), we assume xk(n) and hk(n) be random walk models, i.e. we obtain the following system model consisting of state equation

$$x_k(n+1) = a_k(n) * x_k(n) + w_k(n)$$

The multiplicative equation

$$h_k(n+1) = h_k(n) + q_k(n)$$

and the measurement equation

$$Y_k(n) = s_k(n) * h_k(n) * x_k(n) + v_k(n),\ k = 1,2,3,\ldots\ldots,K$$

where $a_k(n)$ is equal to unity except when there is a symbol change between time instants n−1 and n at which point it is set to zero; $w_k(n)$ is zero except when there is a symbol change, at which point it can be taken as a zero mean Gaussian process; $q_k(n)$ is a zero mean Gaussian noise with variance $D_k(n)$.

The variance of wk(n) during a symbol is $Q_k(n)$ = 0, while $Q_k(n)$ = 1 when a symbol change comes. In most cases, {$w_k(n)$} and {$q_k(n)$, v(n)} are uncorrelated, while $q_k(n)$ and v(n) are usually correlated at the same time instant. The optimal state estimation algorithm for the above non-linear system is proposed under the following assumptions.

1) $E\{w_k(n)\} = E\{q_k(n)\} = E\{v(n)\} = 0,$
$E\{w_k(n) * w_k(l)\} = Q_k(n) * \delta_{nl};\ E\{q_k(n) * q_k(l)\} = D_k(n) * \delta_{nl};$
$E\{v(n) * v(l)\} = N_o * \delta_{nl}$
2) $E\{x_k(0)\} = 0,\ E\{x_k^2(0)\} = S_k(0);$
3) $\{w_k(n)\}$ and $\{q_k(n), v(n)\}$
4) $\{x_k(n)\}$ and $\{h_k(n)\}$

It is practical and reasonable to make the above assumptions. Since the transmitted symbol sequence is chosen independently and equally from {−1, +1}, the additive noise wk(n) in (3) is set to be zero except when a symbol change comes, at which point it can be taken as a random Gaussian noise with variance $Q_k(n)$= 1, namely, $Q_k(n)$ = 0 during a symbol, while $Q_k(n)$= 1 when a symbol change comes. $q_k(n)$is the modeling error, which can be taken as a zero mean Gaussian noise. The initial transmitted symbol can be +1 or −1, so its mean can be set to be E{$x_k(0)$} = 0. Actually, since $x_k(n) = b_k(n)$, it is reasonable to make Assumption 2) that the initial value Sx(0) is set to be exactly unity. Assumption 3) is practical, because in some complex circumstance, the noises $q_k(n)$ and v(n) are usually correlated at the same time instant. From the above illustrations of $w_k(n)$) in (3), we know that{$w_k(n)$} and {$q_k(n)$, v(n)} are uncorrelated. Since $x_k(n)$ is chosen independently, it is uncorrelated with hk(n), which acts in accord with Assumption 4). Let $x_k(n/n)$ denote the minimum mean square error(MMSE) estimate of $x_k(n)$ given the observation sequence $Y_k(n)$ = [$y_k(0)$, $y_k(1)$, ..., $y_k(n)$], and let $x_k(n/n)$ be the one-step prediction of $x_k(n)$ given $y_{n-1}(k)$ .Our new algorithm for joint channel estimation and multiuser detection is directly based on the well-known projection theorem whose geometrical properties are shown. We see that the projection of $x_k(n)$ on $y_k(n)$ is equal to the projection of $x_k(n)$ on $y_{n-1}(k)$ plus the projection of $y_k({}^{n}/_{n-1})$) on ˜yk(n/n −1), namely,

$$X_k(n/n) = \mathrm{proj}\{x_k(n)/Y_k^{n}\}$$

$$= \mathrm{proj}\{x_k(n)/Y_k^{n-1}, y_k(n)\}$$

$$= \mathrm{proj}\{x_k(n)/Y_k^{n-1}\} + \mathrm{proj}\{\hat{y}(n/n-1)\}$$

where ˜xk(n/n−1) = xk(n)−xk(n/n−1) is the one-step prediction error, and ˜yk(n/n − 1) = yk(n) − yk(n/n − 1)is the innovation. In addition, the well-known projection equation is

$$\mathrm{Proj}\{X/Y\} = E\{X\} + \mathrm{Cov}\{X,Y\} * \mathrm{Var}^{-1}\{Y\} * (Y - E\{Y\})$$

For the system model, under correlated noises, an optimal filtering algorithm is proposed. Then an algorithm for joint channel estimation and MUD can be obtained.

An Optimal Filtering Algorithm for Joint Channel Estimation and MUD is given below.

$$x_k(n|n) = a_k(n-1)*x_k(n-1/n-1) + R_{xy}(n)*R_L^{-1}(n)*\hat{y}_k(n/n-1)$$

$$h_k(n/n) = h_k(n-1/n-1)+R_{hy}(n)*R_L^{-1}(n)*\hat{y}_k(n/n-1)+R(n-1)*R_L^{-1}(n-1)*\hat{y}_k(n-1/n-2)$$

$$\hat{y}k(n/n-1) = y_k(n) - c_k*[\hat{y}_k(n-1)-N_o*R_L^{-1}(n-1)*\hat{y}_k(n-1/n-2)]$$

$$R_{xy}(n) = a_k(n-1)*c_k(n)*N_o*R_L^{-1}(n-1)*R_{xy}(n-1)$$

$$R_{hy}(n) = c_k(n)*N_o*R_L^{-1}(n-1)*[R_{hy}(n-1)+R(n-1)]$$

$$R_L(n) = s_k^2(n)*S_X(n)*S_h(n)+N_o[1-c_k(n)] - c_k(n)*s_k^2(n-1)*S_h(n-1)+c_k^2(n)*N_o[1-N_o*R_L^{-1}(n-1)]$$

$$S_x(n) = a_k^2(n-1)*S_x(n-1)+Q_k(n)$$

$$S_h(n) = S_h(n-1)+D_k(n)$$

V. RESULTS AND DISCUSSION

Simulation results shows that in Flat faded AWGN channels the BER and NMSE value changes with change in the Eb/No values. BER and NMSE decreases with increase in Eb/No which shows that on increasing the energy of the bit the noise power reduces which results to decrease in corrupted bit. Here nine values of Eb /No are observed that BER and NMSE value decreases drastically at a certain point of time it results to zero on increasing the number of users the BER value reduces to zero at very less Eb/No value which shows that on increasing the number of users the Bit-Error Rate increases

Table I. Multiuser detection for sixteen users

Eb/No	*Bite Error Rate (BER)*	*Normal Mean Square (NMS)*
0	0.0832	1
1	0.0568	0.4661
2	0.0416	0.25
3	0.02	0.0578
4	0.0142	0.0291
5	0.0066	0.0063
6	0.003	0.0013
7	0.004	0
8	0.002	0

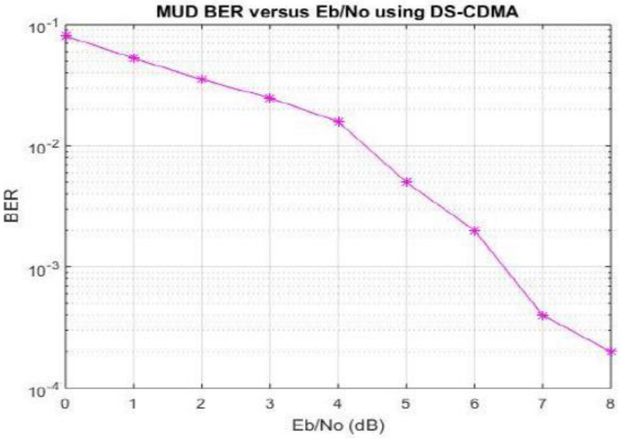

Fig.3 BER versus Eb/N0 in MUD for sixteen users

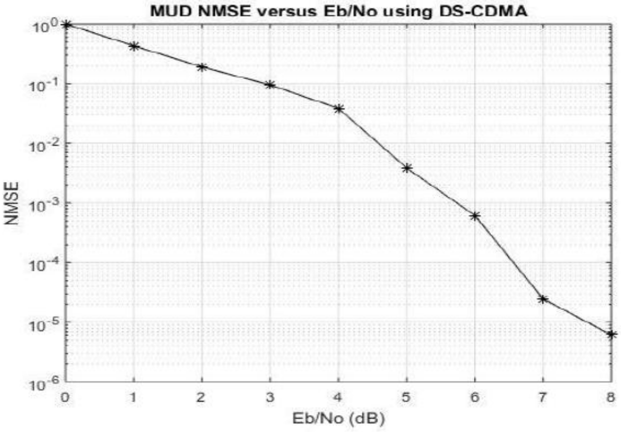

Fig.4 NMSE versus Eb/N0 in MUD for sixteen user

Table II. Multiuser detection for two users

Eb/No	*Bite Error Rate (BER)*	*Normal Mean Square (NMS)*
0	0.0756	1.000
1	0.0552	0.5331
2	0.0396	0.2744
3	0.0244	0.1042
4	0.0126	0.0278
5	0.0060	0.0063
6	0.0032	0.0018
7	0.002	0.000
8	0.000	0.000

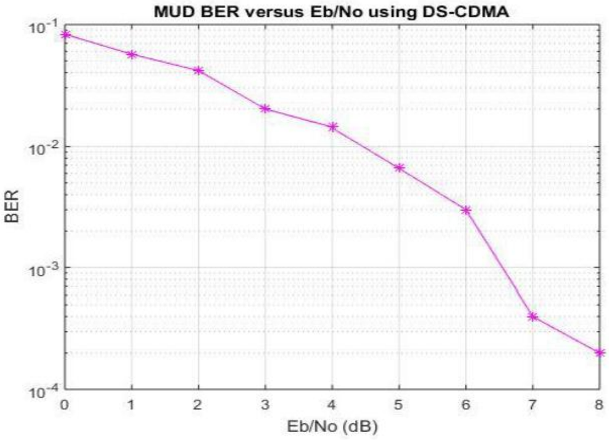

Fig.5 BER versus Eb/N0 of MUD for two users

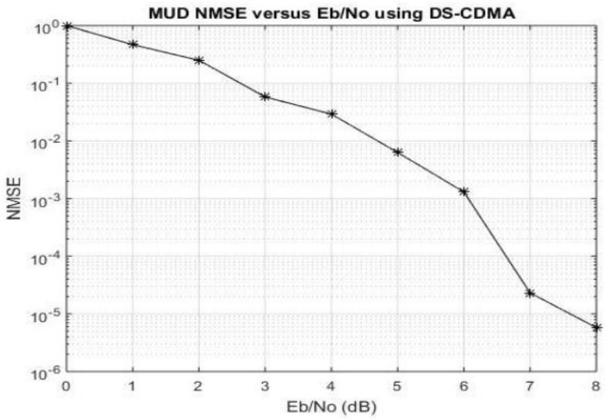

Fig.6 NMSE versus Eb/N0 in MUD for two users

Channel Estimation Simulation results shows that noise channels of Rayleigh and AWGN the BER and NMSE values changes with respect to Eb /No .BER and NMSE decreases with increase in Eb/No which shows that on increasing the energy of the bit the noise power reduces which results to decrease in corrupted bit. Here nine values of Eb /No are observed that BER and NMSE value decreases drastically.

Table III. Channel estimation for sixteen users

Eb/No	*Bite Error Rate (BER)*	*Normal Mean Square (NMS)*
0	0.1469	1.000
1	0.1295	0.771
2	0.1098	0.5587
3	0.0942	0.4112
4	0.0730	0.2469
5	0.0635	0.1869
6	0.0506	0.1186
7	0.0422	0.0825
8	0.0381	0.0673
9	0.0275	0.0350
10	0.0229	0.0243

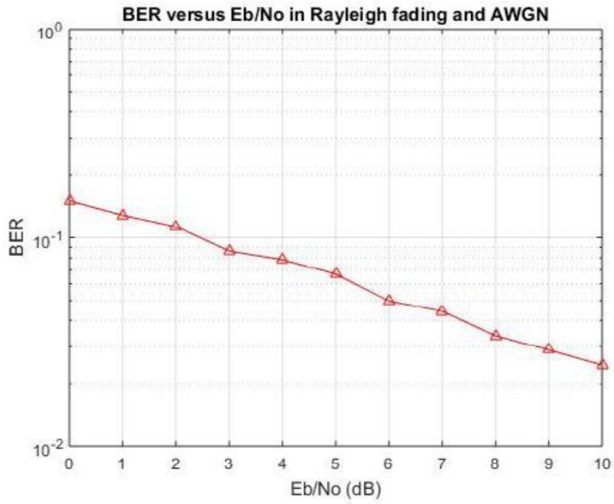

Fig.7 Channel Estimation (BER vs Eb/N0) for sixteen users

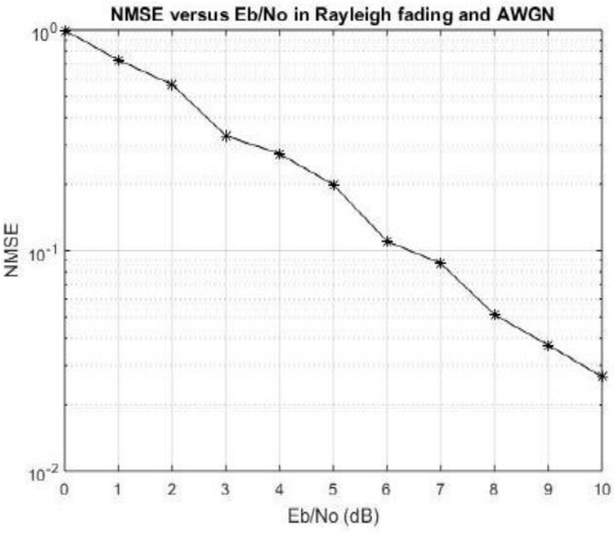

Fig.8 Channel Estimation (NMSE vs Eb/N0) for sixteen users

Table IV. Channel estimation for 2 users

Eb/No	*Bite Error Rate (BER)*	*Normal Mean Square (NMS)*
0	0.1448	1.000
1	0.1289	0.7924
2	0.1081	0.5573
3	0.0935	0.4170
4	0.0800	0.3052
5	0.0653	0.2034
6	0.0565	0.1523
7	0.0402	0.0711
8	0.0365	0.0635
9	0.0305	0.0444
10	0.0216	0.0223

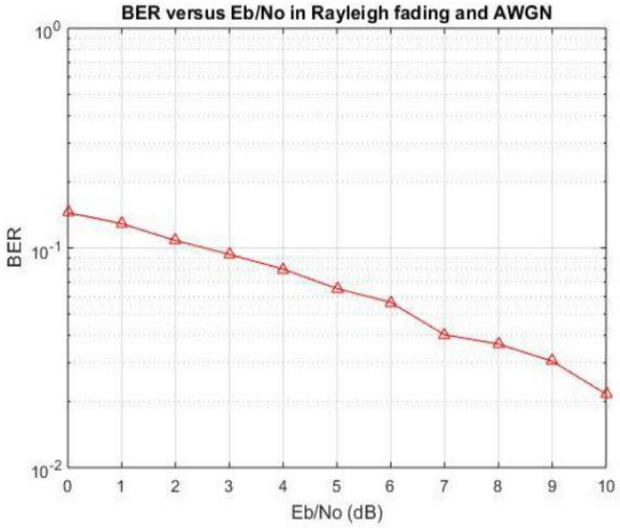

Fig.9 Channel Estimation (BER vs Eb/N0) for 2 users

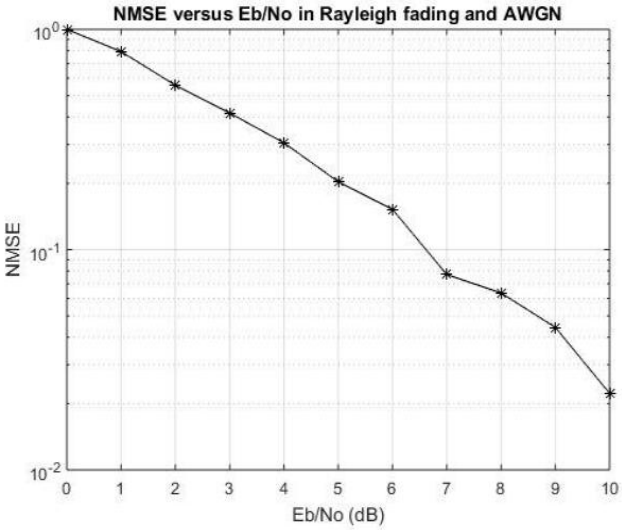

Fig.10 NMSE versus Eb/N0 of channel estimation in Rayleigh fading and AWGN Noise Channel for two users.

VI. CONCLUSION

Here a joint recursive channel estimation and multiuser detection method for CDMA systems in slow fading channels is discussed.

The new algorithm is derived for the system with correlated noises, and the derivation is based on the projection theorem, which is simple and is easy to be extended for solving more complex problems. The algorithm not only applicable for joint channel estimation and multiuser detection, but also can be extended to recursive solving a major class of engineering problems satisfying the system model. Simulation results show that the new algorithm is superior to the extended KALMAN filtering algorithm when applied in MUD of CDMA systems in slow fading channels.

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