Design and Analysis IDMA and CDMA In Rayleigh Channel With Equalization Technique Using Tree Based Interleaver

Asharani Patil and G. S. Biradar

Abstract The recent era evolved with many new technologies with new multiple access technique. New technique known IDMA is emerging in fourth and fifth generation mobile communication systems. In this article we have analysis different multiple access techniques in Rayleigh channel using equalization technique using adaptive filters. IDMA-interleave division multiple access technique gives a efficient performance over CDMA, MC-CDMA using chip by chip iterative detection in multipath channel with lesser receiver design complexity. Equalization process with IDMA multiple accesses in multipath single channel gives desirable bit error rate performance with faster convergence rate and track stability compared with conventional CDMA and MC-CDMA in multiuser channel. Detailed expression with variable values is defined in article. In article different equalization adaptive filters used are LMS, RLS and variable forgetting factor RLS algorithm. This article gives performance for single user as well as multiuser channel in Rayleigh channel.

Keywords IDMA · LMS · NLMS · RLS · VF-RLS · Equalization

1 Introduction

Today's era is completely replaced by wireless virtual mobile communication technology wherein second and third generation mobile communication systems is replaced by fourth and fifth generation mobile communication systems. This generation has significant revolution with new multiple access scheme such as OFDM, OFDMA, IDMA [1], NOMA, SMDA etc. the reason behind this is consequential and revolution requirements of present generation applications. With increased data rates in all multimedia application and new revolutionized communication systems.

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In third generation, CDMA and MC-CDMA [2] had tremendous application and need was seen with higher data rates and achievable reliable communication. But the design was increased as number of users increased in channel. Receiver design for detection and estimation was very complex as number of users was increased in channel hence CDMA, MC-CDMA failed to perform in MAI environment [2, 3]. Multiuser detection failed to better BER performance in multipath channels as well as ISI and MAI environment. Hence evolution of new multiple access started to give new multiple access techniques. New multiple access OFDM, MIMO OFDM, OFDMA, IDMA, NOMA [4] etc.,. These multiple access techniques perform efficiently in ISI and MAI environment.

Potential high data rates is seen in these new multiple access techniques in fourth and fifth generation mobile communication systems. OFDM and OFDMA give well orthogonal property among the users with addition of cyclic prefix gave efficient orthogonal property among users in single channel.

IDMA [1] is new technology which is revised version of CDMA, has replaced CDMA in fourth and fifth generation mobile communication systems. In IDMA each user is assigned with a unique interleaver which distinguishes it from each other users. IDMA is considered as special case of CDMA which allows use of low complexity iterative multiuser detection techniques in multiuser with single channel. IDMA with equalization techniques gives improvised of previous IDMA performance. Equalization is done through adaptive filters such as LMS [5], NLMS [6] RLS [5], V-RLS [5] algorithm [7].

2 IDMA

Interleave Division Multiple Access is multiple access mainly inherit the principles of CDMA [8], MC-CDMA with significant performance. Figure 1 represents the brief diagram of IDMA with processing blocks. Chip-level interleaving ensures that the transmitted sequences in multiuser multipath channel from different users remain un-correlated.

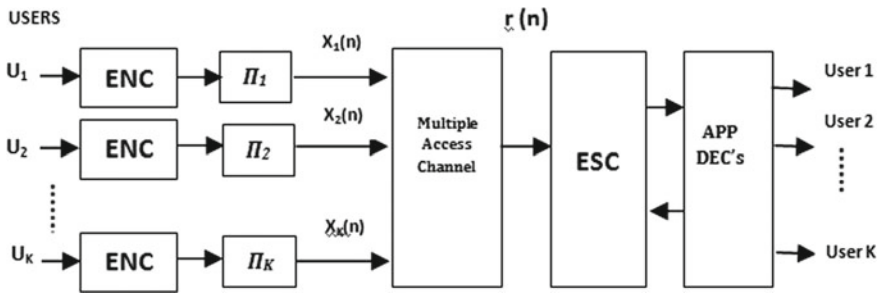

Fig. 1 Processing block of IDMA

In above we have considered k users which undergo encoding with interleaving process. Each user is differentiated among itself by these chip based interleavers in single multiple path channel. Channel used Rayleigh channel, each coefficients of Rayleigh channel is multiplied with users. Encoded is done by FEC encoder as shown in figure with ENC block. 'π_k' indicate interleaving using tree based interleaver.

At receiver section:

$$\mathrm{r(n)} = \sum_{k=1}^{K} h_k(n)x_k(n) + z(n) \tag{1}$$

$$= h_k(n)x_k(n) + \in_k (n) \tag{2}$$

At receiver, ESE indicates elementary signal estimation in this along with estimation we have introduced equalization using LMS and RLS adaptive filters [5]. These filters give a stable BER performance with very number of iterations in simulation process. Aposterior Probability (APP) decoders are used for efficient operating in an iterative process. Each output gives a log likelihood ratio output in order to differentiate each user in the channel.

Interleaver used is tree based interleaver, its one of efficient and stable interleaver which difference each user in channel by its unique procedure wherein each eight bits of user data is divided into odd and even bits then each 4 bits are divided into its odd and even bits among given four bits (Fig. 2).

So based on the length of user data, interleaving process takes in the transmitter along with encoding and spreading.

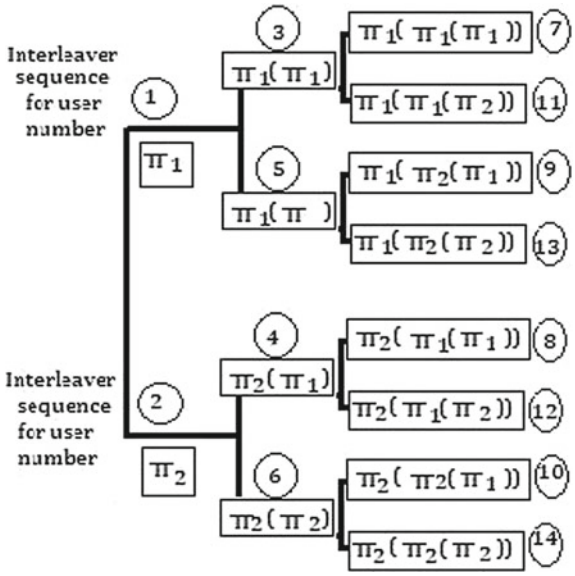

Fig. 2 Tree based interleaver

3 Adaptive Filter Equalization

For the estimation process to initiate we go for initial channel estimation [9] using LS estimator in iterative conditions by employing the mean of $x_k(n)$ that is $\hat{x}_k(n)$ obtained from prior information $L^a_{ESE}(x_u[n])$ from APP decoders further LMS and RLS computes the channel impulse response [7].

$$\hat{h}_k(n+1) = \hat{h}_k(n) + \mu\, e[n]\hat{x}^*_k(n) \tag{3}$$

μ is step size which positive real number where $0 < \mu < 1$ for system to be stable in nature. And estimated error gives $e[n] = z[n] - \hat{h}_k(n)\hat{x}_k(n)$.

Normalized LMS gives real time applications which computes the estimate of the channel impulse response

$$\hat{h}_k(n+1) = \hat{h}_k(n) + \mu e[n]\frac{\hat{x}^*_u(n)}{\left\|\hat{x}_u[n]\right\|^2} \tag{4}$$

In normalized least mean square NLMS, the step ranges from 0 to 2 for system stability. Furthermore LMS and NLMS [6] gives inefficient BER performance with slower convergence rate therefore

We have considered Recursive Least Square algorithm which gives faster convergence rate, trails stability for steady state. Below expressions gives channel estimation expression.

$$\hat{h}_k(n) = \hat{h}_k(n-1) + k[n]e[n] \tag{5}$$

In above expression $\hat{h}_k(n-1)$ is equivalent previous estimate channel response, e(n) gives estimation error.

$$e[n] = z[n] - \hat{h}^H_k[n]\hat{x}_u[n] \tag{6}$$

$$k[n] = G[n-1]\hat{x}_u[n]/\lambda[n] + \hat{x}^H_k[n]G[n-1]\hat{x}_u[n] \tag{7}$$

k[n] is exponential weighted least square with matrix inversion, $\lambda[n]$ indicates the constant between zero to unity, $G[n-1]$ indicates inverse correlation matrix [10].

$$G[n] = \lambda^{-1}G[n-1] - \lambda^{-1}k[n]\hat{x}^H_l[n]G[n-1] \tag{8}$$

Further more conventional Recursive LS algorithm [11] gives further convergence with stable performance but at higher steady state, unacceptable performance, therefore we have considered increase in variable forgetting factor which is constant in above equation [3] is made variable with larger value which results in lesser mean square error but slower convergence rate and tracking speed. Therefore variable for-

getting factor λ[n] is given by

$$\lambda[n] = \lambda_{min} + 1^{2p(n)} - 2^{p(n)},\ where\ p(n) = negative\ round\left[e^2(n)\right],\quad \lambda_{min} \geq 0 \tag{9}$$

Therefore a comparative analysis is made between CDMA and IDMA [9] for above mentioned adaptive algorithms, BER performance is derived among each algorithm, analyzed the rate of convergence too.

4 Result

Communication Model is defined considering transmitter section with receiver in Rayleigh channel. Rayleigh Channel is considered with three coefficients. Model is defined for single user and multiuser for n = 20 users. We have taken 1000–10,000 numbers as input for a user with BPSK modulation with encoding process. Interleaving process is considered using tree based interleaver. Comparative analysis is made considering bit error rate performance and convergence rate using equalization technique in Rayleigh channel [12] with Interleave Division Multiple Access and Code Division Multiple Access. Error estimation is made considering bit rate versus signal to noise ratio.

From the above graph Fig. 3, represents the BER performance of IDMA with CDMA in Rayleigh channel using equalization process. Error rate found to be 0.45

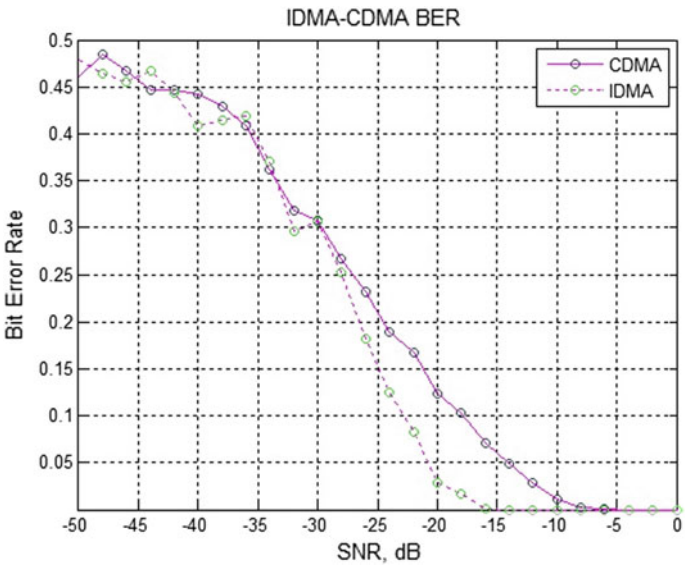

Fig. 3 Bit error rate performance

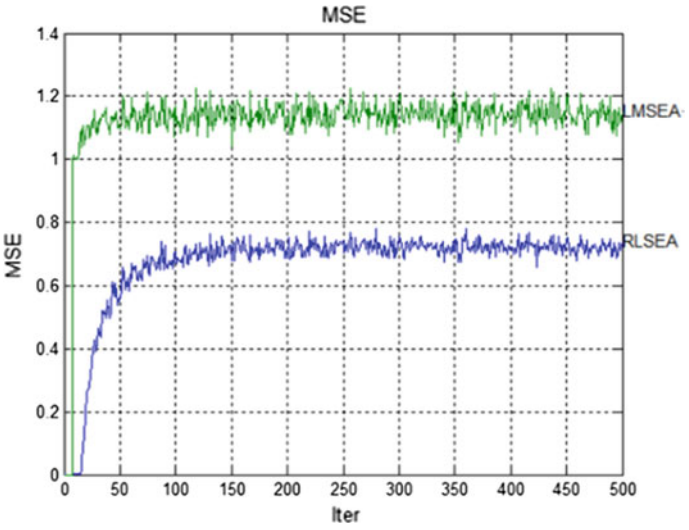

Fig. 4 Rate of convergence of RLS versus LMS algorithm for IDMA

for the SNR value of −45 dB, as SNR value increases it is seen that bit error rate decreases. At SNR of −30 dB bit error rate graph for IDMA declines very lesser than compared to bit error rate graph for CDMA. For SNR value of −20 to −5 dB, error rate found to be −13 dB difference between IDMA and CDMA. So it can be interpreted with conclusion that bit error rate performance is found to be efficient in IDMA than CDMA considering equalization technique with Rayleigh channel along with computational complexity reduces in the equalization process with iterative estimator (Fig. 4).

The above represents graphical representation Rate of Convergence. Adaptive filter exhibits the property known as Rae of convergence which indicates the process where in the system or signal achieves its significant or constant stable level of processing after which signal get stable with high efficient within less number of iterations. In above graph signal with LMS and NLMS filtering IDMA user signal takes much higher number of iterations for gaining its stability where as RLS filtering IDMA gain faster stability with very less number of iteration in the process.

5 Conclusion

In this paper we have proposed an equalization technique with channel estimator for IDMA systems using LMS, RLS with variable forgetting factor RLS algorithm in Rayleigh channel using tree based interleaver. We can say from the results that bit error rate performance is efficiently improved with reduced complexity using recursive filters when compared with static least mean square filter. Computation

speed that is rate of convergence is also observed that recursive least mean filter achieves stability faster to its ideal within few iterations when compare to least mean square filters. Hence we conclude that recursive filters are much efficient for bit error performance compare to the least square for IDMA system. Along with it BER performance is compared with CDMA system using adaptive filter, it is perceived that IDMA shows desirable performance compared to CDMA systems in Rayleigh channels.

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