Implementation of IDMA system for estimation of multiple access interference

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***Abstract*— Many multiple access techniques are used in 3G and 4G communication systems like wise code division multiple access, time division multiple access, frequency division multiple access and interleave division multiple access. In many multiple access techniques as number of users go on increases then multiple access interference problem arises. For a large number of users, interleave division multiple access system is known to be user detection performance in communication. Interleave division multiple access provide better performance as interleavers are used by the means of user separation but multiple access interference is still found in interleave division multiple access system. Multiuser detection is a solution to multiple access interference problems. For reducing this problem, this paper reports encoding multiple sequence together to form output sequence and producing channel. A multiuser interference cancellation algorithm can be used to reduce the multiple access interference, which will improve interleave division multiple access system performance. This method will be an innovative and useful approach in near future.**

Keywords- ***Interleaver, Spreader, Encoder, CDMA, Intersymbol interference, Forward error correction etc…***

I. INTRODUCTION

In recent years, an innovative approach in mobile system has drawn an increasing research interest in communication systems. There are two main features that is high power efficiency and low decoding complexity makes the system among various multiple access schemes for future communication. Wireless cellular communication play important role for 4G communication devices because it need more and more users for high rate and high reliability to increase performance in communication system [1].

There is various multiple access technique in the wireless communication system. It is one of the techniques that also used in mobile communication system. Various techniques have been studied that have to improve the bandwidth, efficiency complexity and multi-user detection (MUD) is always and there are the number of users which increases that can be accommodated within each cell. For very high mobility, the data rates are up to 100 Mbps and for low mobility, it is up to 1 Gbps are required. These requirements for the system are considered as fourth generation (4G) systems. Data rate of 3.6 to 7.2 Mbps are useful in third generation system. While in modern communication system, Code Division Multiple Access (CDMA) has greater impact in wireless communication. CDMA system is provided with high complexity and main problem in CDMA is multi user detection. It offers well known features such as dynamic channel sharing ,soft capacity, reuse factor of one, low dropout rate and large coverage, ease of cellular planning, robustness to channel impairments and immunity against interference [2].

Interleaver Division Multiple Access (IDMA) is a one of the technique that relies on different interleavers to separate signals from different users in a multiuser spread-spectrum communication system. In CDMA, many users are distinguished by different signature sequences, while IDMA distinguishes users by chip level interleaving methods. The main limitation with conventional CDMA systems is multiple access interference (MAI) and intersymbol interference (ISI). As per Kuldeep choudhary, P S Sharma, CDMA systems are having high degree of big problem [6]. For conventional CDMA system, the characteristic feature is the use of signature sequences for user separation. As per Shuang Wu, Xiang Chen, interleaving is generally occurred in between forward error correction (FEC) coding and spreading and is imply to the fading effect [2].

The key principle of Interleave division multiple access scheme is different interleavers for different users. If the interleavers are assigned for the user, then it obtains the interleavers that are used in IDMA system should be efficient and least complex. In the transmitter of IDMA scheme, there is a chip level interleaver is followed by spreading process which is different from conventional CDMA scheme. Hence IDMA inherits many advantages from CDMA especially, chip by chip interleaving can be against fading and mitigation of other cell user interference. Since interleavers are used for the means of separating users in IDMA systems, it is necessary to design them properly [4]. For random interleavers, the interleaver matrix has to be transmitted to the receiver, which can be very costly. For reducing the memory consumption and some amount of information must be exchanged between mobile stations and base stations [6].

II. IDMA SYSTEM MODEL

IDMA stands for interleave division multiple access. As demand for high data rate services that grows in wireless networks, number of challenges amongst the existing multiple access technologies is being used. For orthogonal multiple access technologies such as frequency division multiple access, time division multiple access, the major problem will be the

sensitivity amongst inter cell interference and to maintain orthogonality that synchronization requires. For non-orthogonal multiple access technologies such as code division multiple access, it initiates inter cell interference problem and supports asynchronous transmission. This challenge will contrast to the inter cell interference problem. So there is a new technique called IDMA which seems to be a solution to these problems [8].

This arrangement receives many benefits from CDMA such as dynamic channel sharing, asynchronous transmission, easiness of cell planning, and robustness in contrast to fading. It also permits a low complexity multiple user detection methods appropriate to organizations with great amounts of users in multipath channels.

III. IDMA Organization

A. *IDMA transmitter and IDMA receiver*

The block diagram of IDMA scheme is shown in "Fig. 1," for K users. The principle of iterative multi user detection (MUD) is used which is a promising technique used for multiple access problems (MAI) that are illustrated in the lower part of "Fig.1". The turbo processor which includes elementary signal estimator blocks (ESEB) and number of K decoders. The ESEB partially resolves MAI without considering encoding. The outputs of the ESEB are then passed to the decoder for further refinement using the encoding that is used for de interleaving block. The decoder outputs are fed back to the ESEB for improvement in estimation in the next iteration with proper user specific interleaving. This iterative procedure will repeated for number of times and also terminated if a given certain criteria is fulfilled. After the final iteration, the decoder produces hard decisions on the information bits [5].

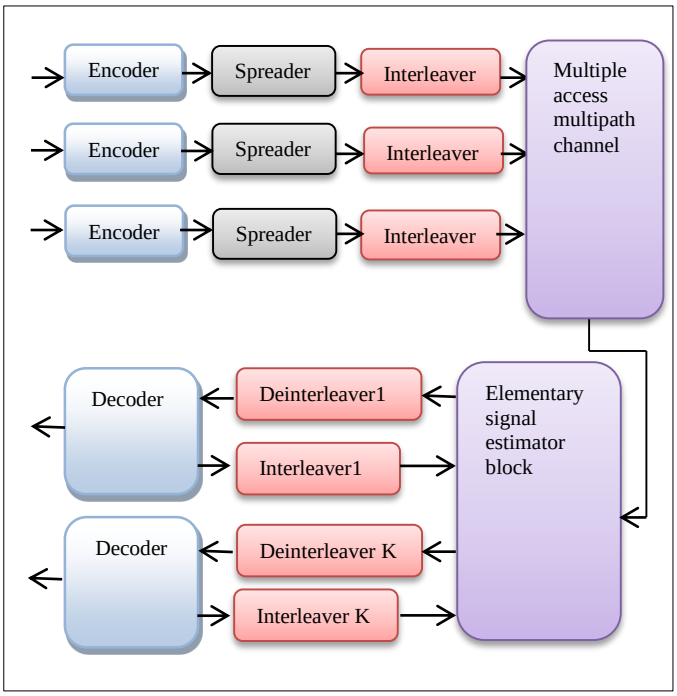

Figure1. IDMA Transmitter and Receiver structure

B. *Interference cancellation algorithm*

In the receiver, the received signal y can be expressed by the desired and interference signal components as

$$y(n) = h_k(n)x_k(n) + I_k(n) \quad (1)$$

Where $I_k(n)$ denotes the sum of the noise and interference components in the n-th symbol [9].

$$I_k(n) = \sum_{l=0,}^{K-1} h_l(n)\, x_l(n) + z(n) \quad (2)$$

The interference cancellation algorithm form by the repetition of the decoder and interference canceller is obtained by following equations.

1. Obtain the extrinsic value as the inputs of the interference canceller by interleaving the extrinsic value of the decoder outputs.

$$\partial_{dec}(\bar{c}_k) = \pi_k(\partial_{dec}(c_k)) \quad (3)$$

Where $\lambda_{dec}(c_k)$ =0 for the first time in the iterative process.

2. Compute the expectation and variance value E(n), $V(n)$ to the interference components and their summations $\bar{E}(n).\bar{V}(n)$ for all the users.

$$E_k(\mathrm{n}) = E(|x[n] - \hat{x}[n]|^2) \quad (4)$$

$$V_k(n) = N_0 \sum_1^k {c_k}^2 \quad (5)$$

$$\bar{E}(n) = \sum_{k=0}^{k-1} E_{k(n)} \quad (6)$$

$$\bar{\mathrm{V}}(\mathrm{n}) = \sum_{\mathrm{k}=0}^{\mathrm{k}-1} V_{k(n)} \quad (7)$$

3. Obtain the extrinsic value of the decoder input $\lambda_{mud}(c_k)$ by de-interleaving.

$$\partial(c_k) = {\pi_k}^{-1}(\partial(\bar{c}_k(\mathrm{n})) \quad (8)$$

4. Compute the decoder output of the BPSK demodulation and extrinsic value of the decoder output $\partial(c_k)$.

$$j = E(|x[n] - \hat{x}[(n-\partial)]|^2 \quad (9)$$

j denotes a function which gives output in form of binary code with BPSK demodulation.

IV. Encoder Implementation

The conventional arrangement for the turbo encoder is shown in "Fig. 2," consist of two transfer functions representing the non- symmetric components of recursive systematic convolutional encoders called constituent encoders and interleaver, which permutes the input prior symbol to input second constituent encoder and interleaver which permutes the input symbol prior to input to the second constituent encoder. A block of input symbols $\mathrm{x} = [\mathrm{x0}, \mathrm{x1}, \ldots, x_{N-1}]$ is presented to the encoder, where each xi is an alphabet A with $|A|$ elements in it. In the encoder, input sequence x is used three ways. First, it is copied directly to the output sequence${v_t}^{(0)} = x_t, t = 0, 1, \ldots, N-1$. Second, the input sequence runs through the first RSC encoder with transfer function G(x), resulting in a parity sequence $\{{v_0}^{(1)}, {v_2}^{(1)}, \ldots \ldots, {v_{N-1}}^{(1)}\}$. The combination of the sequence $\{{v_t}^{(0)}\}$ and the sequence $\{{v_t}^{(1)}\}$ results in a rate R =1/2 systematically encoded convolution

ally encoded sequence, Third, the sequence x is also passed through an interleaver of length N, which produces two output $v^{(2)} = \{ v_0{}^{(2)}, v_2{}^{(2)}, \dots\dots, v_{N-1}{}^{(2)}\}$. The third output sequence are multiplexed together to form the output sequence $v = \{(v_0{}^{(0)}, v_0{}^{(1)}, v_0{}^{(2)}),((v_1{}^{(0)}, v_1{}^{(1)}, v_1{}^{(2)}), \dots, ((v_{N-1}{}^{(0)}, v_{N-1}{}^{(1)}, v_{N-1}{}^{(2)})\}$.

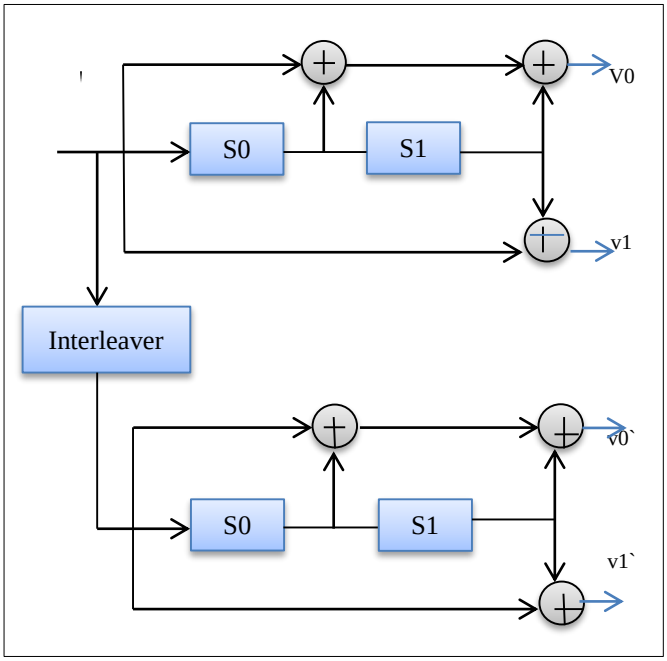

Figure 2.Encoder circuit structure

V. SPREADER IMPLEMENTATION

The input sequence of data is given to encoder spreaded data forming spreading modulated signal output. A block of input symbols $x = [x0, x1, \dots, x_{N-1}]$ is presented to the encoder in "Fig. 3," where each xi is an alphabet A with $|A|$ elements in it. The patterns of scrambling the data of users are to be generated.

Hence a random sequence generator generating N number of modulated bits from bit sequence and coded data. Hence considerable amount of bandwidth will be consumed for transmission of all the spreader. The spreaded data can be calculated for N bit number of users as shown in "Fig.5".

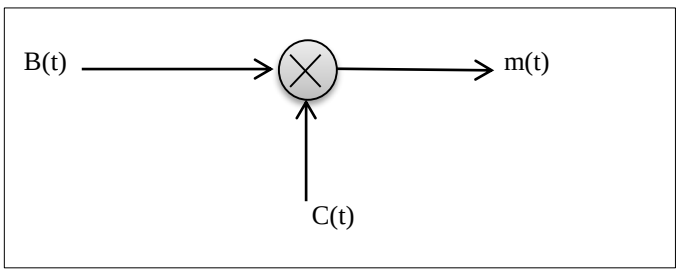

Figure 3.Spreader circuit structure

VI. INTERLEAVER IMPLEMENTATION

The interleaver design is play very important role in the efficiency of IDMA system. It provides decorrelation between adjacent bit sequences that are provided in the orthodox turbo coding and decoding. It also provides uncorrelate to the various users. The correlation amongst interleavers is used to measure signals that are used from other users that affecting decoding process of a specific user. If decorrelation is better, then less iteration are required for detection in IDMA multiuser detection (MUD) mechanism. The interleaver providing decorrelation is used for reducing the MAI from other user. Hence it helps in the convergence of detection process [6]. A set of interleavers is lie under these two criteria. First, it is easy to generate from transmitter and receiver so that do not store or communicate many bits in order to steady upon an interleaver and second is that no two interleavers are in the form of set collide. It also shown that correlation between interleavers can be used to formulate a collision criterion, where zero correlation called as orthogonality which implies that no collision. In case of IDMA, the transmitter needs to transmit the interleaver matrix which consists of interleaving pattern of the users to the receiver. If greater the size of the interleaver then more bandwidth and resources are to be used. Also in IDMA, greater the size of interleaver then more the orthogonality is achieved between them. Interleaving is generally a process of rearranging the ordering of a data sequence from one to one deterministic format. Interleaving is a technique that will enhance the error correcting capability of code. Interleaving is used before the information data is encoded by the second component encoder in turbo encoder. The main role of an interleaver is constructing a long block code from small memory convolution codes. The final role of the interleaver is that break the low weight input sequences then increase the code free Hamming distance or reduce the number of code words with very small distance in the code distance spectrum. The size and structure of interleavers also play a major role in case of turbo encoder. There are a various number of interleavers, which either can be implemented [6].

A. *Random interleaver*

Random interleavers can interleave the data of different users with different pattern. These patterns of scrambling the data of users are to be generated. These scrambling of data causes burst error of the channel are randomized to the receiver end. With the help of random generator, the user specific random interleaver is used to rearrange the elements of its input vector [7]. These incoming data can rearrange using a series of generated permuter indices as shown in "Fig. 4". A permuter is generally a device that helps to generate the pseudo-random permutation of given memory addresses. These data is arranged in order of pseudo-random order of memory addresses [8]. When random interleavers are work for the purpose of user separation, then it requires a lot of memory space will be at the transmitter and receiver ends for storage purpose. Hence considerable amount of bandwidth will be consumed for transmission of all these interleaver. Thus at receiver end, computational complexity will be increases. After randomization of the burst error that has to rearrange the whole block of the data afterwards it can now be easily detected and corrected. Spreading is the essential for random interleavers. Random interleaver is used for user separation, so interleaver must satisfy certain design criteria [6]. Interleavers

of different users do not collide for user separation. The property of minimum collision amongst user specific interleavers depends on property of orthogonality. It is one of the important factor in generating the interleavers [5].

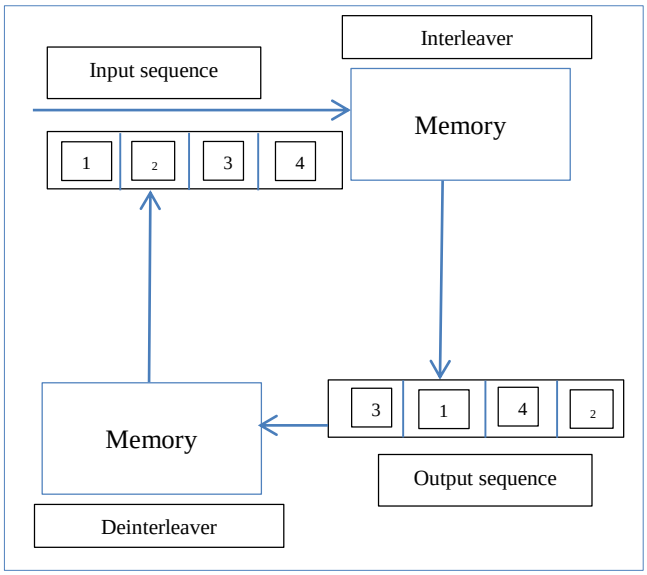

Figure 4.Interleaver and de-interleaver operation

B. *Deterministic interleaver*

The interleavers are generated randomly for users in random interleavers. Therefore, transmitting the entire chip level interleavers is required. Multiple users are modified from single user symbol level interleavers for turbo codes. The deterministic interleaver modified as prime interleavers [4].

Steps involved in deterministic interleavers are:

1. A consecutive bit positions transmitted.
2. Choose prime number depending on the maximum bits.
3. Let q be position of symbol transmitted.
4. Find interleaved bit position by
$$D_p = (p * q) mod\ N$$
5. D be interleaved position and deinterleaved position is obtained by using $D_p = D_q$ [3].

The correlation for different user specific interleavers are as follows, user 1= data 1 and user 2= data2. The XOR of user 1 and user 2 can be obtained. Then calculating count of 1's after XORing both users as X value. Then calculating count of 0's after XORing both users as Y value. The correlation value obtained as (X-Y)/(X+Y) as shown in "Fig.6"[3].

TABLE I. IDMA SIMULATION CONDITION

Sr. no	IDMA system model	
1	Communication system	IDMA
2	Modulation	BPSK
6	Number of users	1

VII. IMPLEMENTATION EVALUATION

The performance analysis can be carried out with the help of BPSK modulator. The number of bits per symbol can be considering as 52. The analysis can be considered as maximum of 35 users. Number of symbols can be 10,000 considered as shown in "Fig.7".

The memory requirement can be calculated by using the random interleaver = c1* log2 (c1), deterministic interleaver= log2 (c1), where c1=chip length.

TABLE II. COMPARISON CHART

Sr. no	IDMA system model	
	Random interleaver	Deterministic interleaver
Bandwidth requirement	High	Less
Memory requirement	High	Less

A. *Interference canceller and IDMA receiver*

The interference canceller utilizes two memory units for interleaving and de-interleaving. The decode block outputs decoding results. Based on interference cancellation algorithm of IDMA receiver, we are implementing measure performance parameter reducing bit error rate. With the help of SOVA decoder, number of users at transmitter area reduces complexity at received signal and channel coefficient at the users.

VIII. SIMULATION RESULT

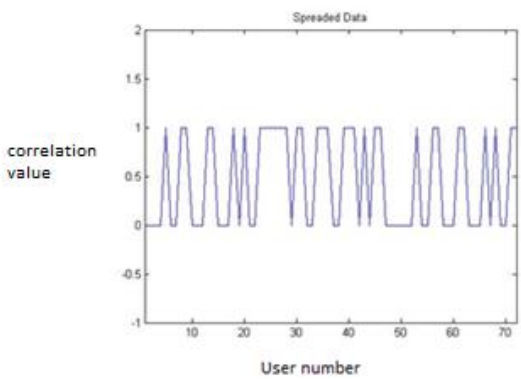

Figure 5.Simulation results of spreader

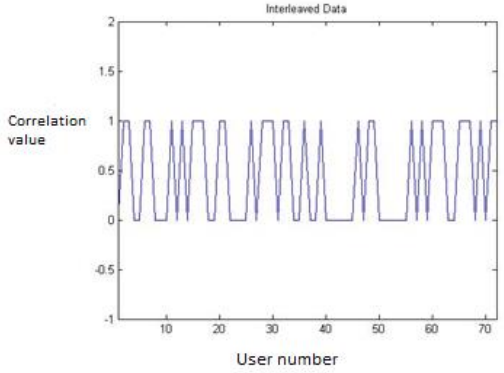

Figure 6.Simulation results of interleaver

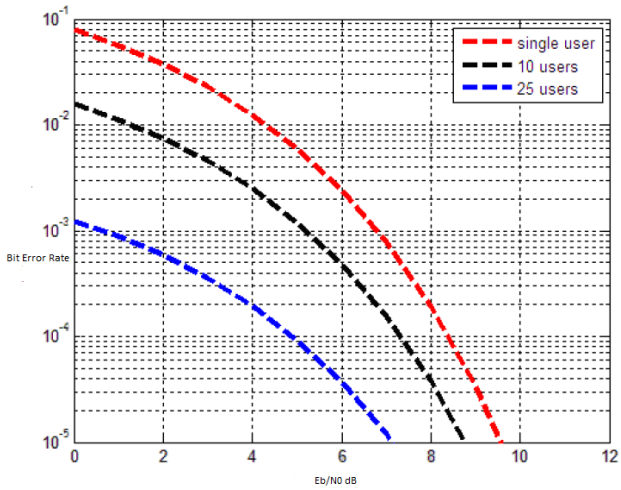

Figure 7. Comparison of random based and deterministic interleaver

IX. CONCLUSION

This paper has presented implementation of IDMA system for estimation of multiple access interference in wireless communication systems. IDMA system providing encoded sequence data multiplexing together to form two output sequence and generates interleaved data which helps for user separation. IDMA system will provide very high rate and high reliability to increase performance in communication system.

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