International Journal of Engineering Science Invention Research & Development; Vol. 1 Issue 1 July 2014
www.ijesird.com e-ISSN: 2349-6185

Evolution OF IDMA

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***Abstract*— The demand for wireless broadband communication services has been growing steadily for last several years. Over the last two decades, wireless communications have gained enormous popularity in all over the world. It offers an attractive option for many personal as well as organizational communication requirements due to various parameters including cost, effectiveness, and mobility. The next generation mobile communication systems i.e. fourth generation (4G) are needed to support multiple services in different types of environments. 4G is being developed to accommodate the QOS (quality of service) and required data rate such as wireless broadband access, Multimedia Messaging Service (MMS), video chat, mobile TV. This paper focuses the light on various multiple access techniques proposed in 4G communication systems. Among all the multiple access (MA) techniques, it is attempted to demonstrate that IDMA (Interleave Division Multiple Access) technology can efficiently mitigate the interference among users and support high data rates without compromising the required quality of service**

***KEYWORDS*: CDMA, IDMA, Multiple access Interleavers, Multi user detection, random interleaver, master random interleaver, tree based interleaver.**

I. INTRODUCTION

IDMA stand for the interleave division multiple access scheme. IDMA is the 4G technology of CDMA. IDMA uses the different type of interleavers for different user[2][3][4].By using different type of interleaver, we optimize the interference among all the users. Interleaver, rearrange the sequence of code. Interleaver work in the form of matrix, it take the data row wise and transmit the data column wise.Some time voice coder do not code the all speech, then this gap is also filled by the interleaver, so data voice data do not loss. In IDMA scheme do not need of orthogonal coding and signature for every user that's an advantage of IDMA.IDMA is also better in respect of cost, diversity, fading and etc

The well established Direct-Sequence code-division multiple-access (DS-CDMA) which is also known as simply CDMA has been adopted in second and third generation cellular mobile standards. The CDMA scheme possesses many attractive features such as dynamic channel sharing, mitigation of cross-cell interference, asynchronous transmission, ease of cell planning, and robustness against fading.In CDMA system, many users share the same transmission media so that signals from different users are superimposed, causing the multiple access interference (MAI) problems. At the receiver side, it is necessary to separate the mixed signals. Multi-user detection (MUD) is a technique to improve performance by jointly processing the signals forms all of the users.Recently, it has been shown that multiuser detection together with unequal power control can enhance the performance of code division multiple access (CDMA) systems. The complexity and computational cost isthe major problem of CDMA systems Interleave Division Multiple Access (IDMA) scheme in which interleavers are employed as the only means of user separation. Interleave division multiple access (IDMA) is a special case of random waveform CDMA, and the accompanying chip-by-chip (CBC) estimation algorithm is essentially a low cost iterative soft cancellation technique [Ping L. & Lihai L. (2004)].The chip-by-chip (CBC) MUD algorithm for IDMA is an iterative soft cancellation technique for treating multiple access interference (MAI). Its computational cost is very low, being independent of the total number of users when normalized to eachuser [Wang P., Ping L. & Liu L. (2006)].. IDMA is much similar toconvolution CDMA[7][8][9][10][11][12], except IDMA uses interleaver andconvolution CDMA uses the direct sequences.

II. TERMS RELATED TO IDMA

A. *Multiple access interference*

At the physical and medium access layers, there are two main issues in cellular communication: *multiple access* and *interference management*. The first issue addresses how the overall resource (time, frequency, and space) of the system is shared by the users in the same cell (intra-cell) and the second issue addresses the interference caused by simultaneous signal transmissions in different cells(inter-cell). At the network layer, an important issue is that of seamless connectivity to the mobile as it moves from one cell to theother(and thus switching communication from one base-station to the other, an operation known as *handoff*). In this we will focus primarily on the physical layer issue of multiple access and interference management, although we will see that in some instances these issues are also coupled with how handoff is done.

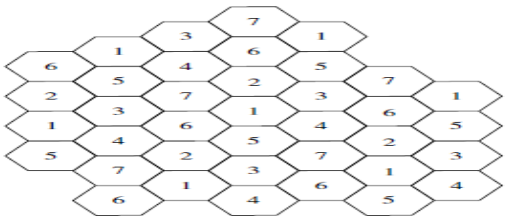

Figure1.1: Diagram showing cochannel and Adjacent channel interference.

INTERSYMBOL INTERFERENCE (ISI)

In a digital transmission system, distortion of the received signal, which distortion is manifested in the temporal spreading and consequent overlap of individual pulses to the degree that the receiver cannot reliably distinguish between changes of state, *i.e.* , between individual signal elements.

1: At a certain threshold, intersymbol interference will compromise the integrity of the received data.

2: Intersymbol interference attributable to the statistical nature of quantum mechanisms sets the fundamental limit to receiver sensitivity.

3: Intersymbol interference may be measured by eye patterns.

III. HISTORY OF IDMA

A.FDMA

Frequency Division Multiple Access (FDMA) scheme is the most common technique used in analog communication system employing division of whole spectrum into multiple frequencies slots which are further assigned to various users, as shown in figure 1.2. With FDMA scheme, each subscriber at any given time is assigned with particular frequency channels for transmission and reception independently. The channel, therefore, is closed to other conversations until the initial call is completed, or handed-off to a different channel. FDMA scheme has been used for first generation analog communication systems.

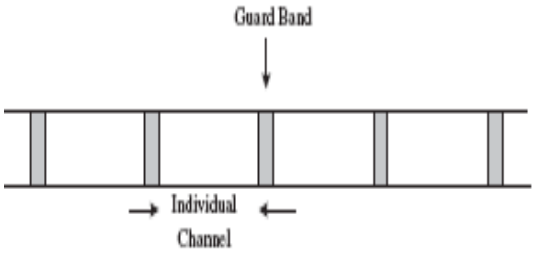

Figure 1.2: Frequency Division Multiple Access (FDMA)

The scheme is referred to be inefficient due to underutilization of bandwidth. In addition to it, FDMA systems are bound to employ a guard-band between adjacent channels, for avoiding random Doppler shift, occurring due to the user's random mobility. The guard-bands also reduce the probability of adjacent channels interference, while decrease the spectral efficiency

B.TDMA

Time Division Multiple Access (TDMA) scheme improves spectrum capacity by splitting each time period into multiple time slots. It allows each user to access the entire radio frequency channel for the allotted time slot of during a call as shown in figure 1.3. Other users are also allowed to share the same frequency channel at different time slots. TDMA scheme is the dominant technology for the second generation (2G) mobile cellular networks.

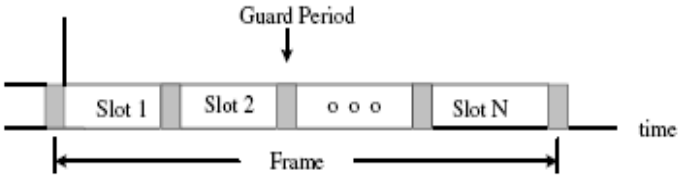

Figure 1.3: Time Division Multiple Access (TDMA)

C.CDMA

Code Division Multiple Access (CDMA) scheme is, basically, based on "spread spectrum" technology. Since it is suitable for encrypted transmissions, it has long been used for military purposes all over the world. CDMA scheme increases spectrum capacity by allowing all users to occupy all channels at the same time . Transmissions are speeded over the whole radio band, and each voice or data call is assigned a unique code to differentiate from the other calls carried over the same spectrum. CDMA scheme allows for a "soft hand-off," leading to facility of communication between mobile terminals with several base stations at the same time. Asynchronous CDMA system offers a key advantage in the flexible allocation of resources. It is ideally suited to a mobile network where large numbers of transmitters generating a relatively small amount of traffic at irregular intervals individually.

The performance of CDMA scheme is mainly limited by multiple access interference (MAI) and intersymbol interference (ISI). Its processing gain is reduced considerably with increment in users per sector. The processing gain is referred as a figure of merit in spread spectrum communication. Also, in CDMA scheme, the complexity of decoder increases with increment in user count.

In addition to it, as quoted in regarding future requirements in wireless communication, it is recommended that a communication system must possess the essential parameters for consumers including low receiver cost, de-centralized control, diversity against fading, power efficiency, multi-media services, high user number, and high throughput along with high spectral efficiency. Recently, a new variant of CDMA scheme known as interleave-division multiple-access (IDMA) scheme has evolved on the horizon of wireless communication. The IDMA scheme employs the interleavers as the only means of user separation in order to ensure privacy related to data of users.

IV. TYPES OF INTERLEAVERS USED IN IDMA

A. Random Interleaver

Random interleavers scramble the data of different users with different pattern. Patterns of scrambling the data of users are generated arbitrarily.

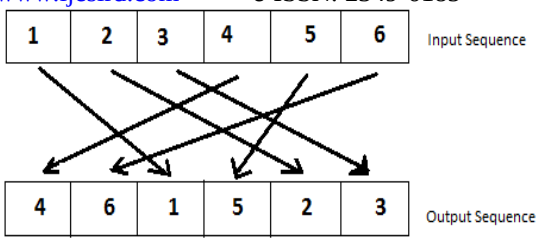

Figure1.4:diagram showing scrambling of data in IDMA.

B.Master Random Interleaver

In random interleavers, the base station (BS) has to use a considerable amount of memory to store the random patterns of interleavers—which may cause serious concern of storage when the number of users is large. Also, during the initial link of setting-up phase, there should be messages passing between the BS and mobile stations (MSs) to inform each other about their respective interleavers. In master random interleavers or power interleaver method, a master interleaver pattern Φ is assigned. Then K (K is an integer) interleavers can be generated using $\pi k = \Phi k$. Here, Φk (c) is, $\Phi 1$ (c) = Φ (c), $\Phi 2(c) = \Phi(\Phi(c))$, $\Phi 3(c) = \Phi(\Phi(\Phi(c)))$, etc. By this rule, every interleaver is a 'power' of Φ. The principle for this method is that if Φ is an 'ideal' random permutation, so are all $\{\Phi k\}$, and these permutations are also approximately independent from each other. Now BS assigns the power index k to each user k, and then Φk will be generated at the MS for user k accordingly. This method of generating patterns increases the performance in the term information that has to be sending by the base station to the mobile station

B. *Tree Based Interleaver*

Tree Based Interleaver (TBI) is evaluated to alleviate concerns including bandwidth requirement, memory requirement and computational complexity optimally. Its performance is also compared with that of random interleaver (RI) and master random interleaver (MRI).The Tree Based Interleaver (M.Shukla et al., 2008, 2009) is basically aimed to minimize the computational complexity and memory requirement that occur in power interleaver and random interleaver, respectively [6]. The mechanism of Tree Based user-specific interleaver generation is based on two master interleavers, which are randomly selected. The algorithm for TBI is based on the selection of combination of two master interleavers. The odd number of users is taken upside while even number of users is taken downside. In this manner, a large number of users may be allocated with user specific interleavers with extremely less complexity. User specific interleaver is designed using a combination of these randomly selected master interleavers. Here Π1 and Π2 two master interleavers which are randomly selected. The interleaver Π1 is opted for upper branch while Π2 is reserved for initiation for lower branch. Upper branch is selected in case of odd user count while lower branch is selected if user count is even. For the sake of understanding, from figure 3, for first user interleaver will be Π1 while for second user, the interleaver will be Π2.In case of third user it will be Π1 (Π1) and for fourth user, the interleaving sequence will be Π2 (Π1).

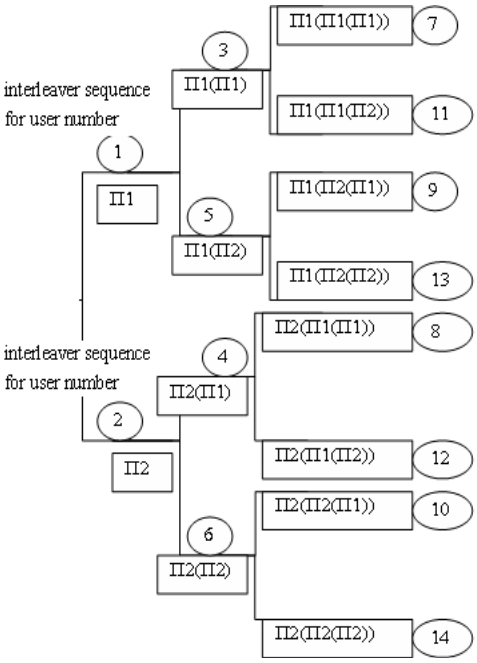

Figure1.5: Interleaving masks allocation for the Tree Based Interleaving scheme.

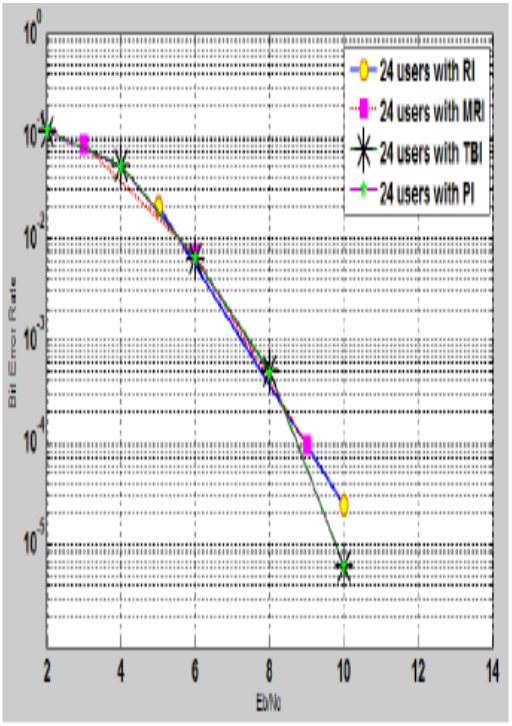

Figure1.6: Comparison between RI, MRI, TBI and PI .

Table1:Hardware requirement

Parameter	RI	MRI	TBI
Flip Flop	850	3528	108
Adder/sub	272	1152	32
Register	850	3528	108
MUX	576	2592	72

IDMA STRUCTURE

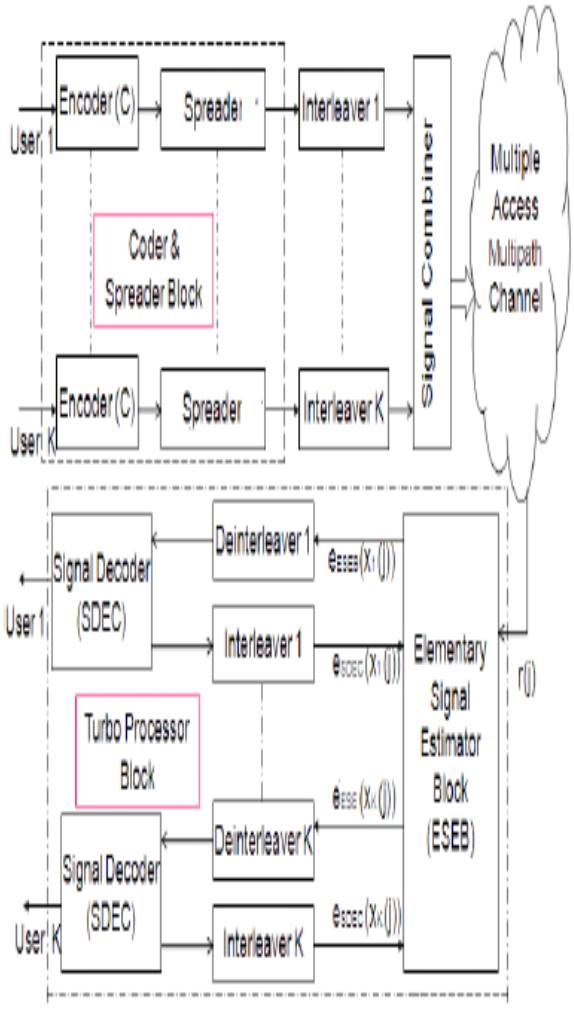

Figure 1.7: Transmitter and Receiver structures of IDMA scheme with *K* simultaneous users.

In IDMA, data streams are separated by different interleavers rather than by different spreading codes as employed in DS-CDMA. Each data stream is encoded by the same low-rate channel encoder. The data rate can be adapted by superimposing many encoded and interleaved data streams. In contrast to other system designs, channel coding is an integral part of the system design. Separation of the data streams at the receiver can be done in an iterative, low complexity way. These properties are advantageous for multi-user detection at the uplink and therefore make IDMA an attractive candidate for the 4G uplink, but also for an evolution of existing DS-CDMA systems The block diagram of IDMA scheme is shown in figure 1.6 for K users. The principle of iterative multi user detection (MUD) which is a promising technique for multiple access problems (MAI) is also illustrated in the lower part of Fig.1. The turbo processor involves elementary signal estimator block (ESEB) and a bank of *K* decoders (SDECs). The ESEB partially resolves MAI without considering FEC coding. The outputs of the ESEB are then passed to the SDECs for further refinement using the FEC coding constraint through de-interleaving block. The SDECs outputs are fed back to the ESEB to improve its estimates in the next iteration with proper user specific interleaving. This iterative procedure is repeated a preset number of times (or terminated if a certain stopping criterion is fulfilled). After the final iteration, the SDECs produce hard decisions on the information bits .

V. CONCLUSION

In this paper, comparisons between different Interleavers have been made on the basis of parameters like complexity, bit error rate (BER), memory requirement etc. Among all the comparisons discussed so far, the features of Tree Based Interleavers and Prime interleavers shows their suitability for the IDMA technology for fourth generation communication .On the basis of above comparison in table 1, we can see that tree based interleavers and prime interleavers perform better than other interleavers. But if we consider 24 users and calculate the bit error rate then we find that these all interleavers have almost same performance shown in figure Tree based interleaver has low complexity than other interleavers in consideration. In this we also see that the no. Of users is limited in case of FDMA,TDMA because in this we provide different frequency band and time slot to different users while in case of CDMA we require orthogonal codes .As we know it is easy to generate orthogonal codes for small no. Of users but as no. Of users increases it is difficult to generate orthogonal codes and complexity of system also increases. The main disadvantage of CDMA is Multiple Access Interference(MAI) and Inter Symbol Interference(IDMA).IDMA overcome these disadvantages of CDMA along with some additional features e.g. low receiver cost, decentralised output,diversity against fading ,power efficiency and easy for adaptive rate control.

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