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Spectral Efficient IDMA System Using Multi User Detection

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***Abstract*—**With the prevailing CDMA, high information rates are often achieved by reducing spreading factor or adopting multi-code CDMA, however the previous leads to reduced spreading gain against fading and interference, and latter has to overcome the interference among spreading sequences. In contrast, high rate transmission can be achieved in IDMA systems by assigning the FEC codes with high coding rates. Neglecting intra-cell interference at low computational price the multiple access interference (MAI) could be a major concern for both CDMA and IDMA cellular networks. The present CDMA mitigates the MAI by multi-user detection (MUD). However, the high computational price concerned in MUD that limits the high range of user- application in practical systems. In distinction to CDMA, IDMA uses the iterative chip-by-chip (CBC) detection formula to combat intra-cell interference. The per-user computational quality of the CBC is independent of the quantity of users concerned. It achieves multi-user gain in the case of each user with a rate constraint. The features of IDMA distinguished from the other MA techniques should be thought-about in MAC design for IDMA based networks. IDMA involves dynamic power management to boost link capacity and guarantee QoS for users. So, IDMA will perform better for large range of users. It supports asynchronous transmission. The orthogonal MA technologies, like time-division multiple-access (TDMA), frequency-division multiple-access (FDMA) and orthogonal-FDMA (OFDMA), need frame synchronization to keep up orthogonality. In IDMA networks, there's no subtle synchronization demand on data transmission.

***Keywords*—** Orthogonal-FDMA; inter symbol interference; orthogonality; interleaver; IDMA.

I. INTRODUCTION

The capacity of a wireless communication system has become vital due to rapid climb in mobile users. The capacity of a system is often increased by any one of following methods: Increasing the Effective isotropic Radiated power (EIRP), using additional spectrums, economical utilization of channel resources. Of these, increasing EIRP and bandwidth costs high to the service provider however by using effective multiple access techniques we are able to enhance the capacity. Therefore several researches mainly concentrate on numerous multiple access techniques since the origin of multi user communication [1–3]. Channel access methods are transmission strategies in which many stations will access a channel and send data over a time span. Flexibility, reuse and efficiency of spectrum square measure necessary for any multiple access ways [4], [5]. The new multiple access technologies would be backward compatible and should be with the existing IMT-2000 systems. Contention based multiple access methods can support those demand. Examples for contention based multiple access methods are OFDMA (Orthogonal Frequency Division Multiple Access), SC-FDMA (Single Carrier- Frequency Division Multiple Access), OFDM-TDMA (Orthogonal Frequency Division Multiplexing - Time Division Multiple Access) [6].

II. CODE DIVISION MULTIPLE ACCESS TECHNOLOGY

In modern communication system, CDMA has created its impact in wireless communication. It offers standard options like dynamic channel sharing ,soft capability, recycle factor of 1, low dropout rate and huge coverage (due to soft handoff suggests that create before break),ease of cellular planning, strength to channel impairments and immunity against interference. These benefits square measure available because of spreading the information over a large bandwidth. The performance of standard CDMA system is restricted by multiple access interference (MAI) also as inter symbol Interference (ISI). Also, the complexness of CDMA multiuser detection has perpetually been a significant concern for large range of users. Code Division Multiple Access (CDMA) is a spread spectrum technology which together with the rake receiver idea helps to attenuate communication errors ensuing from multipath effects. The spread spectrum technology aims to spread the information signal over a wide bandwidth to render electronic jamming and interception harder [7]. CDMA 2000 could be a wireless system that's a part of IMT- 2000 specification associated is an extension of the CDMA one wireless platforms using IS-95. CDMA 2000 has been deployed in the existing IS-95 system and can exhibit various enhancements. It permits multiple users to share identical spectrum, differing types of hand-offs provided. Due to its wide Bandwidth and rake receiver, CDMA uses the multipath signals and combines them to form a stronger signal at the receiver which provides higher Bandwidth efficiency and immunity to multipath weakening [9]. Wideband Code Division Multiple Access (WCDMA) has attracted the foremost attention in the development of third generation wireless systems (International Mobile Telecommunications IMT-2000) in the year 2000 [8]. WCDMA applications embrace electronic messaging, voice, net browsing, video conferencing, video police investigation, prime quality audio, and information access. However, the performance of wideband CDMA is restricted by Multiple Access interference (MAI) also as Inter symbol Interference (ISI) in the presence of multipath fading scenario which ends up in possible

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frequency- selective fading. A next Generation system is anticipated to produce a comprehensive and secure all potential solution where facilities such as IP telephony, ultra-broadband internet access, gaming services and streamed multimedia system may be give to users. There are numerous numbers of multiple access techniques that are proposed for 4G system [10–12] named as DS-CDMA (Direct Spread-Code Division Multiple Access), MCCDMA (Multicarrier-CDMA), OFDMA (Orthogonal FDMA), IDMA (Interleave Division Multiple Access) etc. IDMA (Interleave Division Multiple Access) could be a new technology that can remove the disadvantages of existing CDMA technique i.e. multiple access interference (MAI) and intersymbol interference (ISI).

III. Interleaved Division Multiple Access System

Numerous multiple access techniques have been proposed for broadband wireless networks to support multiservice transmissions over the shared wireless link. Extensive studies have been made on multiple access techniques like time-division multiple-access (TDMA), frequency division multiple-access (FDMA), orthogonal-frequency division multiple-access (OFDMA) and code-division multiple-access (CDMA).

Cell specific interleaving brings a lot of sturdy performance than cell specific scrambling. The advantages of interleaving over scrambling looks important for cell edge subscriber stations to receive broadcast services like common signaling broadcasting as a result of some advanced transmission techniques for unicasting can't be used for broadcasting. The block diagram of IDMA structure is shown in figure 1 for K users. The principle of repetitive multi user detection (MUD) that could be a promising technique for multiple access issues (MAI) is also illustrated in t. The turbo processor involves elementary signal estimator block (ESEB) and a bank of K decoders (SDECs). The ESEB partly resolves MAI while not considering FEC coding. The outputs of the ESEB are then passed to the SDECs for more refinement using the FEC coding constraint through de-interleaving block. The SDECs outputs are fed back to the ESEB to enhance its estimates within the next iteration with correct user specific interleaving. This iterative procedure is continual 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 [1]. The complexity involved (mainly for resolution a size KxK correlation matrix) is O (K2) per user by the well-known iterative minimum mean sq. error (MMSE) technique in CDMA, whereas in IDMA, it's independent of user. This can be a major profit when K is large.

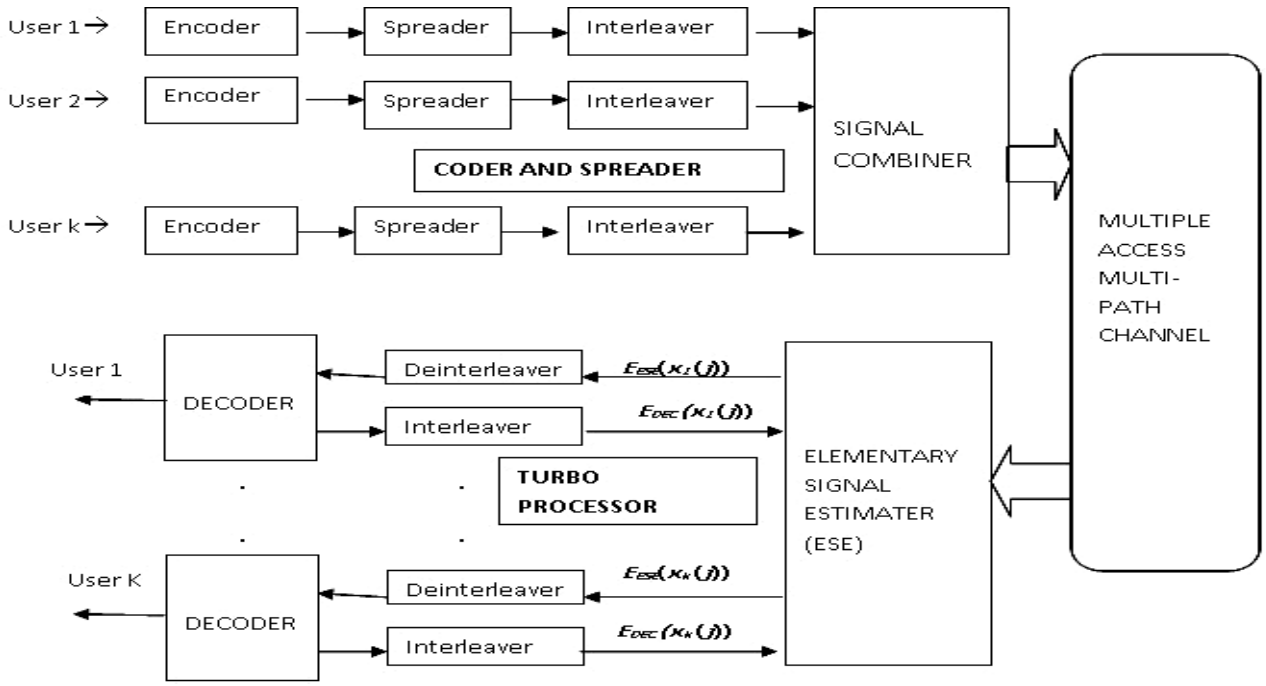

Fig. 1. Structure of IDMA system.

IV. Difference Between IDMA and CDMA

In CDMA, interleaver are used for coding gain whereas in IDMA, they're utilized for user separation. IDMA may be a recently proposed theme that employs chip- level interleavers for user separation and the receiver employ an easy chip- level iterative multiuser detector (MUD). Such a system may be a logical development of the earlier analysis on introducing chip- level interleaving as a method of mitigating burst impulsive noise disturbances, multiple access interference, as well as intersymbol interference. the basic principle of IDMA (figure 1) is that 2 users are separated by an interleaver (and the interleavers ought to be different for various users) while, OCDMA/IDMA, that uses the orthogonal spreading code and

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interleaver completely differentiate|to tell apart} different users, increase the receiver complexity of the user ends (UEs).The received signal (r(j)) over AWGN channel for 'K' user is written as, $r(j) = \sum h_k x_k(j) + n(j)$, j=1,2.....J
Where h_k is the channel coefficient for user k and {n(j)} are samples of an AWGN with variance $N_0/2$. We assume that channel coefficients (h_k) are known a priori at the receiver.

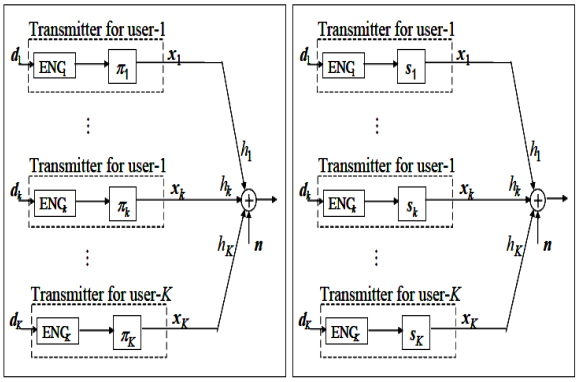

Fig. 2. Multi user detection algorithm for IDMA system.

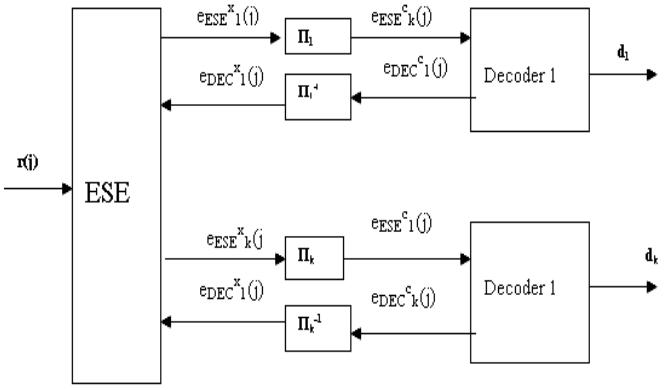

Fig. 3. IDMA receiver.

The receiver consists of an Elementary Signal Estimator (ESE) and a posteriori probability (APP) decoders (DECs). The received signal r(j) which is to be de-interleaved and decoded with appropriate interleaver. For any receiver it is complex to retrieve the transmitted information by using various Multi User Detection (MUD) algorithms. In this IDMA receiver Elementary Signal Estimation (ESE) is used as detection algorithm. The ESE function is done as follows,

1. Initialize $e_{DEC}(x_k(j)) = 0$
2. Set $E(x_k(j)) = \tanh(e_{DEC}(x_k(j))/2)$
3. Var $(x_k(j)) = 1 - (E(x(j)))^2$.
4. Find $E(r(j)) = \sum h_{k'} E(x_{k'}(j))$
5. Next find variance as,

$$\mathrm{Var}(r(j)) \Leftarrow \sum_{k'=1}^{K} |h_{k'}|^2 \mathrm{Var}(x_{k'}(j)) + \sigma^2$$

6. Finally find ESE function as,

$$e_{ESE}(x_k(j)) \Leftarrow 2h_k \cdot \frac{r(j) - \mathrm{E}(r(j)) + h_k \mathrm{E}(x_k(j))}{\mathrm{Var}(r(j)) - |h_k|^2 \mathrm{Var}(x_k(j))}$$

V. Discussion

Significant features of all named multiple access are compared IDMA are compared with the prevailing MA technologies [Table 1]. With the existing CDMA, high information rates will be achieved by reducing spreading factor or adopting multi-code CDMA, however the former ends up in reduced spreading gain against fading and interference, and the latter must overcome the interference among spreading sequences. In distinction, high rate transmission can be achieved in IDMA systems by assigning the FEC codes with high coding rates. Neglecting intra-cell interference at low computational price the multiple access interference (MAI) is a major concern for each CDMA and IDMA cellular networks. the prevailing CDMA mitigates the MAI by multi-user detection (MUD). However, the high computational price concerned in MUD that limits the high number of user- application in practical systems. In distinction to CDMA, IDMA uses the iterative chip-by-chip (CBC) detection algorithmic program to combat intra-cell interference. The per-user computational quality of the CBC is independent of the quantity of users concerned. It achieves multi-user gain within the case of every user with a rate constraint. This implies that given constant sum-rate, the a lot of users in a system, the less average transmitted sum-power is needed. The features of IDMA distinguished from the other MA techniques should be considered in MAC design for IDMA based networks. IDMA involves dynamic power management to enhance link capability and guarantee QoS for users. So, IDMA will perform higher for large number of users. It supports asynchronous transmission.

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