Implementation of interleave Division Multiple Access in Underwater Communication

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***Abstract* - A typical underwater communications has been established through transmission of acoustic waves. A challenge in underwater acoustic communication is the long propagation delay, limited bandwidth, and signal fading issue. In recent years, several different techniques are used to resolve these challenges in underwater communication. In the paper, IDMA communication is implemented with QPSK modulation technique in underwater channel. In IDMA systems, the transmitter is required to transmit the interleaver matrix consisting of interleaving pattern along with spread data related to users, to the receiver. It is observed that IDMA has several advantages over CDMA and IDMA communication is far much better in terms of errors. Moreover, in this paper, different modulation techniques and different interleaving techniques is implemented for comparative analysis.**

***Keywords* - IDMA, CDMA, Underwater communication, BER**

I. INTRODUCTION

Since from the last few years, technologies have taken rapid growth to provide new methods and products for wireless communications. The ability to communicate with people on the move has evolved because of Guglielmo Marconi first demonstrated radios ability to provide continuous contact with ships sailing the English channel and since then new wireless communications methods and services have been adopted by people all over the world.
Cellular radio was mainly developed for offering phone services to mobile users. Now-a-days, it is engaged in even providing a variety of services, including video conferencing, music or movie appreciation, games, internet access, image processing. The demands and applications from subscribers stimulate the market and drive the technology for further growth. On the other hand, research and development department of communication engineering are undergoing a revolution due to rapid advances in technology. In India, cellular industry came into existence nearly in mid 1990s and since then the average growth rate per annum has been about 85 percent. By the end of 2002, the total number of cellular subscribers, in India, had increased to about 10 million subscribers. In addition to it, telecom customers have also been doubled during last two years from 300 million to 600 million. According to Reuters India, total mobile users in India, now, stand at 584.32 million, data from the sector regulator showed, behind only China that had 777 million at the end of March 2010.There is tremendous scope for researches in the area of wireless communication for improving the back-bone of communication systems as per the recommendations of International Telecommunication Union (ITU). One of the hot-cake areas for research is improvement in technology related to multiple access techniques with communication channels.
Underwater communication is a technique which is used for sending and receiving message below water. There are many ways of perform such communication but the most common is using hydrophones. Underwater communication is effected due to several factors like, time variations of the channel, multi-path propagation, small available bandwidth and strong signal attenuation, especially over long distances. In underwater communication there are low data rates compared to other communication, since underwater communication uses acoustic waves instead of electromagnetic waves. Hence it also called as underwater acoustic communication. Underwater acoustic communications have a wide variety of applications in undersea warfare. These applications include wireless networked sensor telemetry in littoral areas, controlling of minefields and networking of surface vessels, submarines, Unmanned Underwater Vehicles (UUVs) and divers. The underwater communications channel is impaired by its band-limited nature and multipath propagation. During the last few years the growth of interest in the resources and condition of the ocean has provide many researchers to investigate the reliability of the underwater acoustic (UWA) channel as a communication medium. This channel is one of the most complex and challenging to be encountered for the transmission of data. Underwater sensor network are envisioned to enable application for oceanographic data collection, pollution monitoring, offshore exploration, disaster prevention, seismic monitoring, equipment monitoring, assisted navigation, tactical surveillance applications. Multiple unmanned or Autonomous Underwater Vehicles (UUVs, AUVs).Equipped with underwater sensors, will also find application in exploration of natural undersea resources and gathering of scientific data in collaborative monitoring missions. To make these applications viable, there is a need to enable underwater communications among underwater devices. Underwater sensor nodes and vehicles must possess self configuration capabilities, i.e. be able to coordinate their operation by exchanging configuration, location and movement information and to relay monitored data to an onshore station [8, 9].Underwater Acoustic Sensor Networks (UW-ASNs) consist of a variable number of sensors and vehicles that are deployed to perform collaborative monitoring task over a given system. To achieve this objective, sensors and vehicles self-organize in an autonomous network, which can be adapt to characteristics of the ocean environment.

II. RELATED WORK

Szczepanski et al. Today research interests in underwater (UW) communication and navigation technologies are steadily growing. However, the design of robust UW communication and navigation systems demands a deep knowledge of the transmission medium. Acoustic UW (AUW) communication is widely used due to the good propagation characteristics of sound waves in water compared to electromagnetic waves that are highly attenuated. Besides its advantage - the low attenuation compared to electromagnetic waves - AUW communication suffers from multipath propagation, severe Doppler spread due to the low propagation speed of sound, and shadow zones, to name some of the most challenging effects. Evaluation of new communication devices under realistic conditions in sea trials is expensive and time-consuming. Therefore, a simulator modelling the AUW communication channel accurately is a valuable tool for development and evaluation of AUW communication devices. In this paper an Acoustic Underwater Channel and Network Simulator is proposed that uses ray tracing to model the AUW channel. It uses channel impulse responses (CIRs) generated by the BELLHOP ray tracing model to simulate multipath propagation. These CIRs for static constellations of receiver and transmitter are post-processed to be in agreement with the mobility of transmitters and receivers. Thereby, Doppler spread is introduced into the channel model. An empirical noise model is used to superimpose received signals with noise. Different modulation schemes can be evaluated using this AUW channel model in laboratory before expensive sea trials are conducted. In this paper a frequency hopping and an OFDM implementation are realized besides the channel model. Multiple mobile transmitters and receivers can be considered to simulate UW networks.

Andre Goalic et al, A highdata rate acoustic link has been developed by the GESMA. The Main objective of this project was to create an acoustic communication link between anAWV(Autonomous Underwater Vehicle) and a surface vessel. This acoustic link must be sufficiently robust and improve underwater vehicles autonomy. The first years of this project were devoted to upstream studies **.**The goal was *to* choose the best solution able to deal with different perturbations generated by underwater acoustic channelAn equalizer developed and patented by the ENST Bretagne stood for a very good solution for thisapplication .An acoustic link was then developed to validate the whole communication between source dataemitter and receiver. Transmission part aswell asreception stage (hydrophones, amplifier) were designed by ORCA Instrumentation (SERCEL), a French company specialized in underwater acoustics modems. The receiver platform was developed by ENST Bretagne**.** The spatio-temporal equalizer called SOC-MI-DFE (Self Optimized Configuration Multiple Input Decision Feedback Equalizer) constitutes the receiver core. Some experiments were carried out in 2002 and 2003 to show some images, dataandtext transmissions. From now, GESMA plans to extend TRIDENT possibilities to low bit rate speech digital transmission. Existing andcommercial products are mostly based on analog communications; Digital transmission is expected to provide improved reliability. Duringour fistsea-trail, digitized speech by code excited linear predictive coding (CELP) clearly shown a better listening quality.

Clemens novarket al,Interleave-division multiple access (IDMA), recently proposed in, achieves user separation by means of user-specific interleavers combined with low-rate channel coding. The iterative IDMA multiuser detector derived in assumes perfect channel state information (CSI) at the receiver. In practice, however, pilot-assisted channel estimation is usually employed to obtain (imperfect) CSI. Here, we propose an iterative joint data detection and channel estimation algorithm for pilot-assisted IDMA for related work in the context of single-user systems). This algorithm is derived by applying the sum-product algorithm to the factor graph corresponding to the overall system. A low-complexity implementation of the receiver is obtained by means of Gaussian approximations to the messages propagated through the factor graph.

DeveePrasan.Uet al. At the end of 20th century, wireless sensor networks became hot research area. At starts, it covers only terrestrial applications, but we know the Earth is a water plant as more than 70 % of the surface is covered by the water and the largely unexplored vastness of the oceans has attracted human's attention. From many decades, there have been significant interests in monitoring aquatic environments for scientific, commercial exploration and as well as for military operations. The largely unexplored vastness of the ocean, covering about two-thirds of the surface of Earth, has fascinated humans for as long as we have records. Recently, there has been a growing interest in monitoring aqueous environments (including oceans, rivers, lakes, ponds and reservoirs, etc.) for scientific exploration, commercial exploitation and attack protection. The ideal vehicle for this type of extensive monitoring is a networked underwater wireless sensor distributed system, referred to as Underwater Wireless Sensor Network (UWSN).

Evriclea Voudouri-Maniati et al. Bandwidth limitation in applications involving underwater acoustic communication networks has motivated researchers to focus on multiple access techniques, and code division multiple access (CDMA) in particular. Multiuser detection is a critical component of the overall receiver design; however, it faces many challenges especially in the underwater environment. The channels are characterized fading due multipath propagation caused by signal reflections from the surface and bottom of the sea, especially in shallow water. Other considerations are phase fluctuations and Doppler spread because of movement, and multiple access interference (MAl). Direct sequence spread spectrum (DSSS) primarily has been used to increase the signal-to-interference plus-noise ratio (SINR). Direct sequence CDMA is used in conjunction with phase shift keying (PSK) and demonstrates multipath resolving properties which minimize the effects of frequency selective fading. However, limitations in temporal coherence of the channel reduce the length of the sequences and, therefore, limit the maximum attainable spreading factor. On the other hand, DSSS spreads the data using codes with good cross-correlation properties, yet, DS-CDMA cannot eliminate MA1 completely because the spreading sequences are slightly correlated and, therefore, some interference remains. The level of residual MA1 is also determined by the input powers of the interferes and the desired user. The situation where the interference is much closer to the receiver than the desired transmitter and the processing gain **is** not sufficient to offset the signal-to-ratio is called the near-far effect. Two techniques are used to alleviate the near-far effect: Power control and/or arrays of adaptive spatial-beamforming receivers that can also suppress inter-symbol interference. Power control **is** employed in radio communication to ensure that all user signals arrive at the base station with almost equal power. However, this approach is difficult to realize in underwater acoustics mainly due to the time-varying propagation properties and extensive latency of the channel, especially in shallow waters.

Fang Xuet al, The underwater acoustic (UWA) channel is one of the most challenging environments to be encountered for the communication. Multipath propagation and Doppler spread introduce time and frequency selective fades to the signals. Intersymbol interference (ISI) is seriously in UWA channel and it always extends over tens of milliseconds and it can affect several symbols. This dramatically limits the data rate achievable. In order to operate at higher data rate, there has been particular interest in the application of orthogonal frequency division multiplexing (OFDM) in UWA communication systems in the last ten years. In coded OFDM modulation and a block-data frequency domain equalizer based upon the minimum mean square error (MMSE) solution were studied. An outline of the COFDM UWA communication system and an adaptive receiver structure were investigated in. The author in presented design criteria for a practical OFDM UWA system. A 2D MMSE scheme was employed for channel estimation. In results of sea trials showed that OFDM was more robust in UWA channel than a direct sequence spread spectrum (DSSS) technique with the same environment parameters.

Lars Michael Wolffet al, in this paper a new AUW channel and network (AUWCN) simulator is proposed. The goal is to avoid improper simplifications and to reproduce most effects existing in the physical AUW channel. Effects implemented in this simulator include, among others, attenuation, multipath propagation, Doppler spread, and shadow zones. Furthermore, long travel times of acoustic waves from transmitter to receiver call for special strategies in the development of network protocols for use in the AUW environment. Therefore, these travel times are considered by the AUWCN simulator in order to evaluate network protocols under this influence. This simulator also uses the BELLHOP ray tracing model, but instead of the transmission loss output, it uses the CIR option as in to model multipath propagation. These CIRs for fixed nodes are post-processed to simulate mobile nodes, differently. The remainder of this paper is organized as follows: gives a system overview. The AUW channel model with all realized effects is introduced.

Peter Kinget al introduced Developing a seabed underwater acoustic sensor network is a task filled with many challenges. One challenge is providing reliable horizontal acoustic communication between nodes positioned in close proximity to the sea floor. To understand the potential communication rates between nodes, the theoretical limits that such communication links can support, as well as the factors that most affect these limits must be known. The channel capacity is a metric that is used to determine the theoretical maximum bit rate one can expect .The capacity of a communication link is directly calculated from its frequency dependant attenuation and noise characteristics. An underwater acoustic channel's attenuation and noise are directly related to frequency, distance, transducer placement, and environmental characteristics. The goal of this work is to explore the theoretical capacity limits for a known environment and to determine how this capacity will react to changes in transducer placement and bottom bathymetry. The environment of interest in this study is in the North-Atlantic Ocean, off the coast of Newfoundland. This work also explores the use of the BELLHOP Gaussian beam tracing program to provide a more accurate model of a particular environment, through the use of available to ensure that a complete understanding of the target environment is attained, including the determination of possible performance expectations for the communication channel. The channel capacity can provide a theoretical maximum on what the channel performance will be although it is not currently attainable; it does serve as a means for comparison to other.

III. PROPOSED METHODOLOGY

A. IDMA scheme

In IDMA inter leavers as the only means in order to distinguish the users. Historical point of view, interleaving was employed in ordering block storage on disk-based storage devices including floppy disk and the hard disk systems. The primary preference of interleaving was to adjust the timing differences between the adjacent bits during data transmission between computer and storage media. Interleaving was very common prior to the 1990s, but, later, faded due to availability of high speed processors. Now-a-days, all the modern disk storage systems are not at all being interleaved. Multiple Access technique is one of the key techniques in the wireless communication system, especially in the cellular mobile communication systems .In communication systems, interleaving is commonly used to overcome correlated channel noise such as burst error or fading [2]. In interleaving mechanism, the input data streams rearranges itself such that consecutive data bits are split among different blocks and is swapped in a known pattern amongst them. At the receiver end, the interleaved data is arranged back into the original sequence with the help of de-inter leaver. As a result of interleaving, correlated noise introduced in the transmission channel appears to be statistically independent at the receiver and thus allows better error correction.

The user-specific inter leavers play important role in the performance of IDMA system. It not only provides de correlation between adjacent bit sequences as provided in the case of orthodox turbo coding and decoding, but also provide a means for de correlating various users .The correlation between inter leavers should measure how strongly signals from other users affect the decoding process of a specific user . The better the inter leaver de correlation, the lesser the iterations, required for detection in multiuser detection (MUD) mechanism. The de correlation among the user- specific inter leavers provides a mean to reduce the multiple access interference (MAI) from other users thus helping in the convergence of detection process. A set of inter leavers is considered to be practical if it is easy to generate, and no two inter leavers in the set "collide". The transmitter and receiver need not store or communicate many bits in order to agree upon an interleaving sequence. It may be demonstrated that a properly defined correlation between inter leavers can be used to formulate a collision criterion, where zero cross-correlation (i.e., orthogonality) implies no collision .In case of IDMA systems, the transmitter is required to transmit the interleaver matrix consisting of interleaving pattern along with spread data related to users, to the receiver. So, greater the size of the interleaver, the more bandwidth and resources are consumed during transmission. Also, it is worth to be mentioned that greater the size of interleaver, more the orthogonality is achieved amongst interleaver.

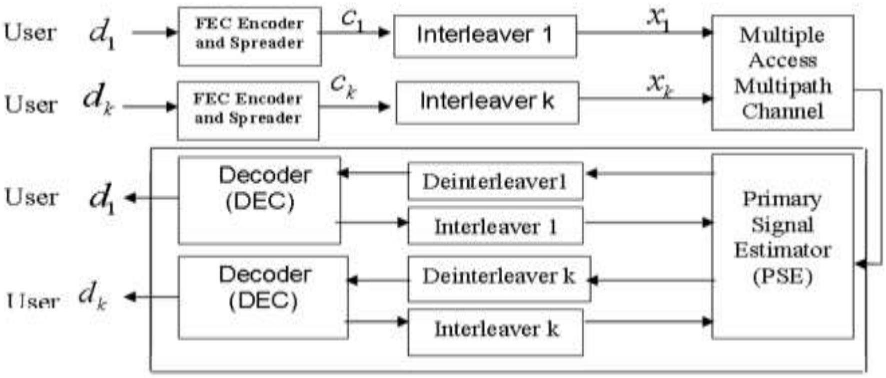

Fig.1: Block diagram of IDMA

IV. RESULT

The implementation is done in the mathematical programming language MATLAB. In this paper, a system for underwater communications is presented. The system is based on the IDMA.MATLAB(.m) file scripting is learned and the implementation of IDMA on MATLAB scripting has been started and the IDMA transmitter has been successfully implemented. The acoustic signal propagation is characteristised as shown in fig.2. Also, BER rate for the Direct Path and QPSK States for Direct Path is shown in Fig2 respectively. The response behaviour of BER for Multi Path and QPSK state for underwater communication with IDMA are shown in Fig.3 and Fig. 4 respectively. CDMA BER and IDMA BER behaviour are shown in Fig. 5and Fig. 6 respectively.

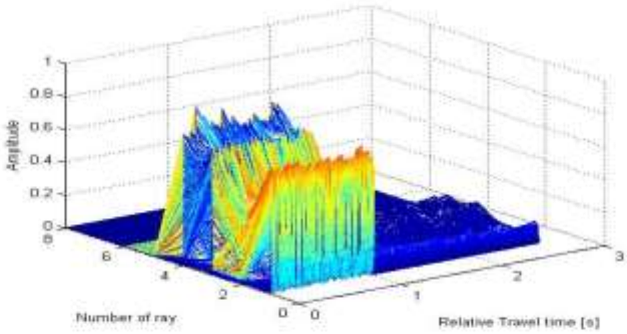

Fig. 2: Acoustic Signal Propagation

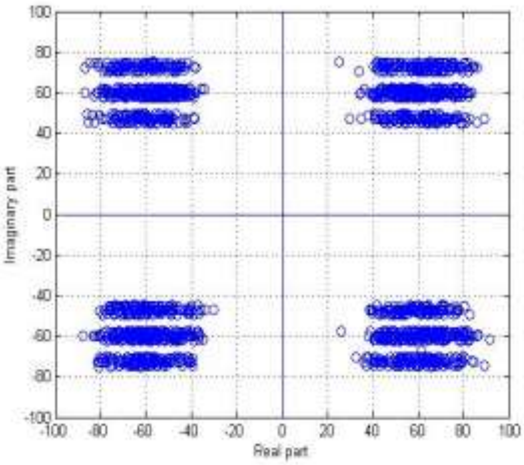

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Fig. 3: QPSK States for Direct Path

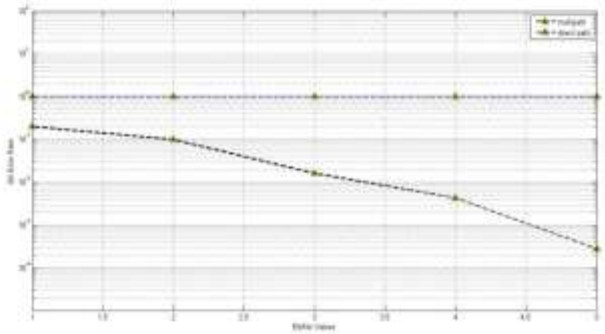

Fig. 4:BER for Multi Path and direct path

In the multipath communication there is noise in the signal and the BER is also there but that is getting decreased to a good amount. When we transmit the data on direct path there will not be any noise present in the transmission, only there will attenuation of signal. So we have the BER equals to zero.

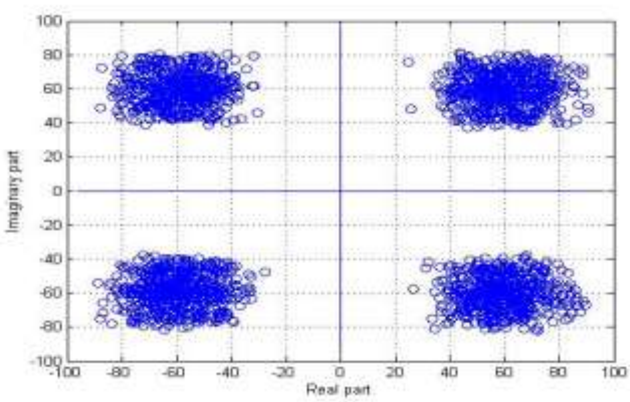

Fig. 4: QPSK state

Minimal error QPSK states of the multi path communication

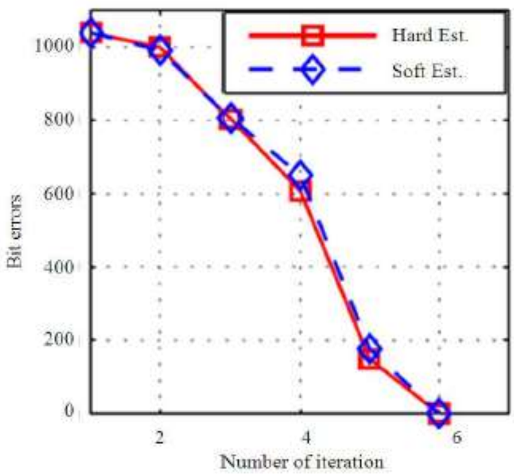

Fig 5.CDMA BER

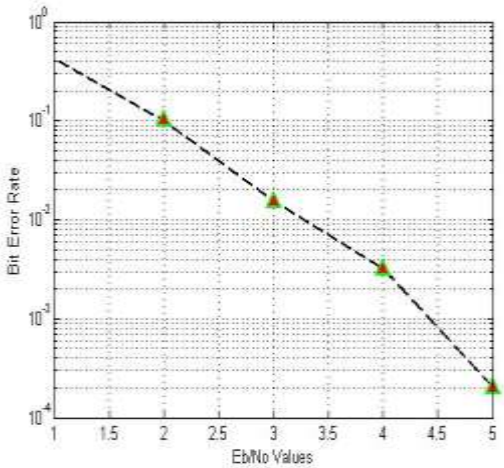

Fig.6 IDMA BER

V. CONCLUSION

IDMA and CDMA turbo multiuser receivers, both employing chip detectors and Rake reception, have been integrated with developed channel estimation and phase tracking and examined for reliable multi-user communication in UACs. The channel estimation was significantly refined by multiplexing the training symbols and multiuser signal. The receivers have been successfully tested and applied to experimental data transmitted over different ranges using QPSK. Extensive results at each scenario were compared and the adaptive IDMA demonstrated slightly improved performances compared to CDMA-based systems. Additionally, the iterative channel estimation is shown to be robust against severe channel fluctuation and it is limited with small processing gain. Therefore, the feasibility of using iterative receivers is worthy of further research as a strong candidate for Underwater communication.The BER (Bit Error rate) of CDMA underwater communication with reference to paper has been compared with the IDMA underwater channel result of our simulation in the current work. IDMA communication is far much better in terms of errors. IDMA demonstrated slightly improved performances compared to CDMA-based systems.In the present work we have implemented IDMA communication with QPSK modulation technique in underwater channel. The results are quite good as compared to the CDMA scheme. The further results can be improved using different modulation techniques and using different interleaving techniques. The comparative analysis can be proposed for different modulation and interleaving techniques.

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