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Research paper



Acoustic simulation of underwater communication network with fixed and transponder nodes in a sea platform and performance study using MCDMA

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Abstract

The field of underwater acoustic communication has been developing innovatively to help the growth of mankind in various fields and in many underwater applications. Modulation techniques like FDMA and TDMA in underwater acoustic is very difficult because it uses elec-tromagnetic waves, which will be attenuated due to conductivity. So here, we use the acoustic waves to transmit the data between the nodes by using CDMA algorithm because of its high spectral efficiency and limited bandwidth usage. VBF (vector based forward) routing proto-col is used for data transmission between the fixed nodes and anchoring node. The comparative study reveals that the performance of delay constrained CDMA shows better throughput and PDR when compare with existing CDMA.

Keywords: *AQUASIM; BER; CDMA; MCDMA; PDR; VBF*

1. Introduction

This Underwater acoustic communication is the process of transmitting data between the nodes below the sea level. Since the water surrounds 70.78% of the surface of earth and it has plenty of natural resources compared to terrestrial. To explore those resources and to achieve underwater applications like ocean monitoring, offshore exploration, data collection and tactical surveillance. To transfer the data effectively we go for CDMA.

Some of the underwater applications are:

1) Environmental Monitoring: collects the data regarding oceanography, geo-science and marine biology. It also involves climatic recording, pollution control, prediction of natural disaster, oil and gas fuse etc.
2) Underwater navigation and tracking: it is a common requirement that is used for exploring, AUV, manned submersibles and submarines.
3) Seismic exploration: it uses low frequency of about 100KHZ to explore deep into sea platform. The high frequency signals are highly attenuated.
4) Autonomous underwater vehicle: an AUV is a robotic vehicle that can travel underwater without obtaining the input from an operator. An AUV include the non-autonomous remote operator that is classified under unmanned underwater vehicles.

2. Modulation techniques in underwater communication

Many modulations techniques like TDMA, FDMA, CDMA and OFDM is used in any communication system to send and receive data in any network. Like in Frequency Shift Keying (FSK), the discrete frequency changes with respect to the carrier signal, transmits the digital information, and measures the speed of sound in water whereas PSK changes the reference of the signal along with the modulation scheme that is used to convey the data. Section 3 gives broad perspective of other work carried out towards channel modeling and acoustic simulation using CDMA. Section 4 & 5 gives a brief analysis of the proposed work based on software simulation. Finally, conclusion and summaries of result are in section 6 & 7 respectively. However, the detailed study based on previous works shows that CDMA techniques would be highly suitable in underwater communication networks because of its high bandwidth efficiency. Thus, the current research is highly focused on performance study of CDMA for acoustic communication using Aquasim.

1) CDMA (Code Division Multiple Access)

It is a modulation technique that uses low frequency carrier (2–11 khz). It allows 61 simultaneous users in one 1.2288MHz channel. The CDMA reduces packet transmission and has increased channel reuse with an increase in network throughput.

2) Direct sequence spread spectrum

It is a spread spectrum technique used to reduce interference in the signal. DSSS divides the broad bandwidth spectrum into many possible broadcast frequencies. It has better performance and more

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reliable when compared to other spread spectrum techniques like FHSS. The chipping code used in DSSS divides the data in accordance with the spreading ratio.

3. Related works

The paper [1] focuses on CDMA based MAC protocol to achieve high network throughput, limited channel access delay and energy consumption. Based on several studies paper [2] states that aquasim is a widely used simulation tool because of its fidelity and flexibility and it is also most suited for underwater networking research when compared to other simulation tools. The work is based on analyzing the performance of the slow and fast moving vehicles and to compare bit error rate (BER) with signal to noise ratio (SNR) in underwater communication [3] & [4]. In [5] an efficient two-rate data transmission scheme for AUV communication with CI/DS CDMA is proposed here and a novel approach of minimizing the transmission power of the sensor nodes is discussed in [6] by using delay constrained CDMA.
In [7] a complete survey of different ocean application of underwater network like Early Warning System based on UWSN, UWSN model for pipeline monitoring, an integrated Wired/UWSN network, fish farm monitoring, Autonomous Underwater Surveillance Sensor Network etc are broadly discussed by the authors. This paper also explains the importance of the Ocean monitoring and the different challenges faced in constructing the UW network. In [8] a brief discussion of various layers involves in the performance analysis of the underwater network model. The author also proposes a efficient algorithm with good modulation technique to improvise the system performance by reducing the power consumption and good security. [9] proposes a novel method for the acoustic and wireless transmitting data under water with high transmission rate. In [10] we can analyze the advantages of CDMA and the spread spectrum signal when compared with the TDMA and FDMA modulation techniques.
The main advantage of CDMA over FDMA, TDMA is multiple users. From [11] underwater acoustic Communication imposes dependence between achievable data-rate and transmission distance, depth, frequency and transmission power. It is clear that using a multi-hop approach and preferring deeper routes in underwater communication will have a greater reliability and transmission capacity. Increase in transmission distance and shallow water communication provides a high bit-error-rate (BER) and signal-to-noise ratio (SNR). We can analyze the bit error rate in [12] with DS-CDMA that has low-density parity check codes.

4. Work methodology

The algorithmic steps to create nodes and execute the data transmission using DSSS with Delay Constrained Multirate CDMA is explained in this following session.

4.1. Network performance

Aquasim effectively simulates the attenuation of the underwater acoustic communication channel. The flexibility and high fidelity can be reproduced in the real world with the help of aquasim tool
The different classes are,

i) Network entity classes: this type of network class denotes the concrete network entities. Pure interface classes: this type of class is not instantiated and it is purely virtual. It is used to specify some common interfaces and serves as base class for other classes.
ii) Common function classes: These types of classes can be included into any classes in aquasim. The common function class is used to provide some common functions to other classes.

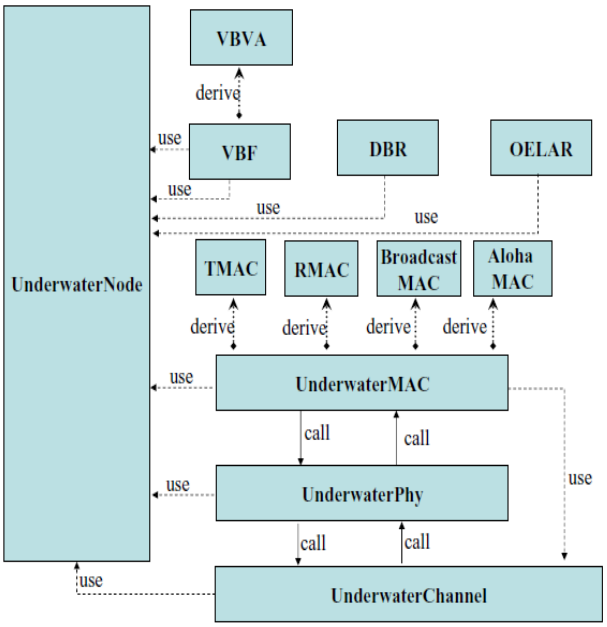


Fig. 1: Architecture of Aquasim

4.2. Existing protocol

i) VBF: Vector based routing is used to address the node mobility issue in an energy efficient way. Here each packet is used to carry the position of the sender, the target and the forwarder.
ii) Broadcast MAC: It first senses the channel before sending the packets. Broadcast MAC is efficient in low traffic networks. It broadcast the packets only if the channel is free otherwise it will back off.
iii) Slotted aloha: This protocol sends the packets directly without sensing the channels. The timer and ACK are used in the transmitting and the receiving sides to send and receive messages.

4.3. Routing protocols

The routing strategy results in less traffic and energy consumption. The network layer present in the protocol has the responsibility to find the path between source and the destination nodes.
Distance based routing
This type of routing protocol is used to route the information from its neighbors of the topology that changes periodically. It is based on calculating the distance and direction to any link that is present within the network. It also uses Bellman-Ford algorithm, Ford-Fulkerson algorithm or dual FSM to calculate the path that has been travelled.Sector based routing protocol
This routing protocol works based on knowledge of node information and location of sender and it collects the knowledge of the destination location to delivers the data packets.
Vector based routing protocol
This routing is based on the forwarding path that is used to specify a vector that connects the source and destination nodes. Each packet transmitted by VBF carries the position of the sender, receiver and the destination node. It has a virtual pipe that completes the transmission between the source and the target. [13]

5. Theoretical analysis

The study of different performance metrics based the information transmitted from the fixed nodes to the anchor nodes via mobile nodes by using delay-constrained multirate CDMA along with DSSS. The network model consist of nine nodes are chosen in this proposed underwater working model where each nodes are separated from each other with a calculated distance. Five nodes as

sensor nodes, [2] anchor nodes, [1] fast moving vehicle and [1] slow moving vehicle.

The total packet size is 812. The information or the messages that is transmitted from the sensor node to the anchor nodes via slow moving and fast moving mobile stations with a speed of 20 and 40 seconds. It transmits the information with the help of delay-constrained multirate CDMA along with Direct Sequence Spread Spectrum. The simulated result of data transmission between sensor nodes, transponder and fixed nodes is shown in fig. 2, fig. 3, and fig. 4 respectively. Fig. 5 concludes that delay decreases with an increase in time.

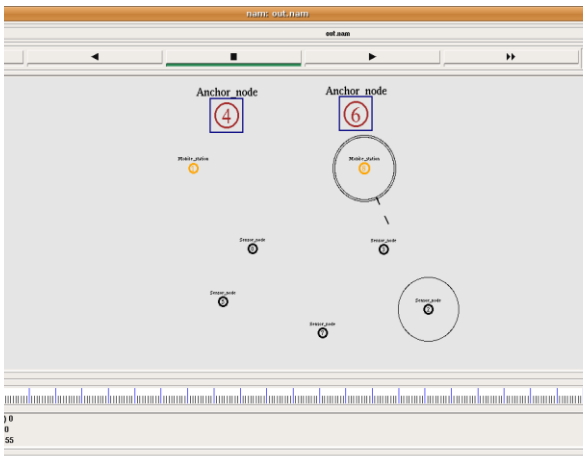


Fig. 2: Data Transmitted from Sensor Node through Mobile Node to Fixed Node



Fig. 3: Data Transmission between Transponders Node and Fixed Node.

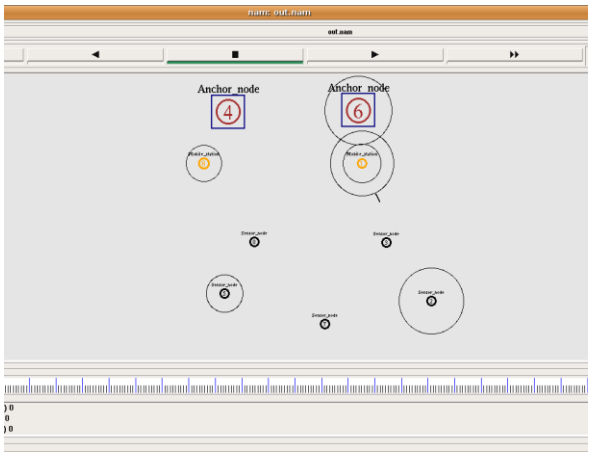


Fig. 4: Data Transmission between Sensor Nodes.

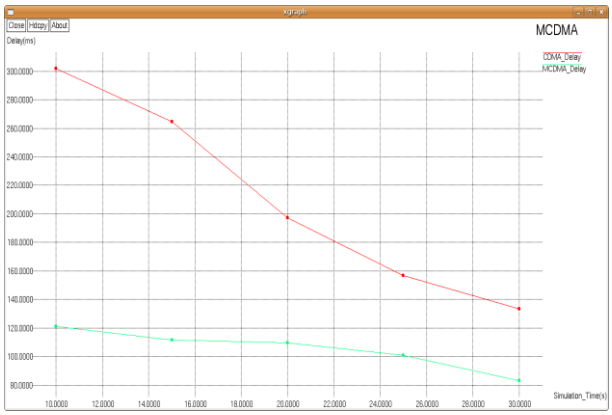


Fig. 5: Delay vs Simulation Time.

The delay time is mathematically represented in Eq. 1

D end-end= N [dtra +d prop+ d proc + d queue] (1)

dtra – Transmission delay
D prop-Propagation delay
D proc-queue delay
D queue- queuing delay

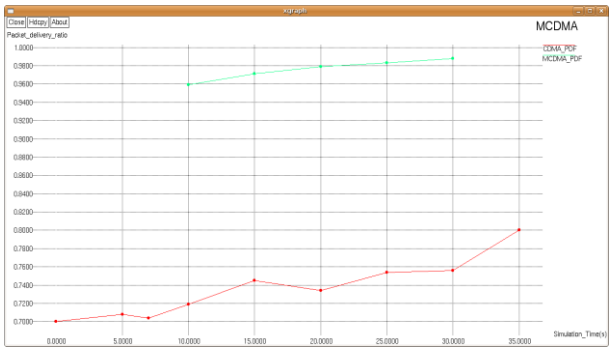


Fig. 6: PDR vs Simulation Time.

The comparison of PDR and simulation time as shown in fig. 6 concludes that PDR increases slightly with increase in time and mathematical representation of PDR is given in Eq.2.

PDR = no of delivered packets / Total no of transmitted packets (2)

The Fig 7 shows clearly that throughput increases as the time increases.

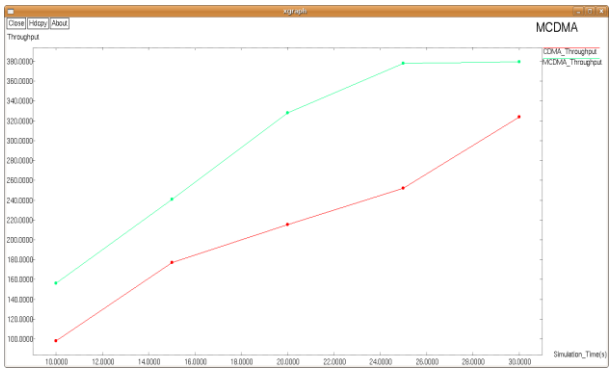


Fig. 7: Throughput vs Simulation Time.

Throughput = (no of delivered packets *size of packets*8) / Total duration of simulation (bits/sec) (3)

Where Eq. 3 is the mathematical relation of throughput. The performance of CDMA & MCDMA with respect to delay, PDR, Throughput is shown fig 8.

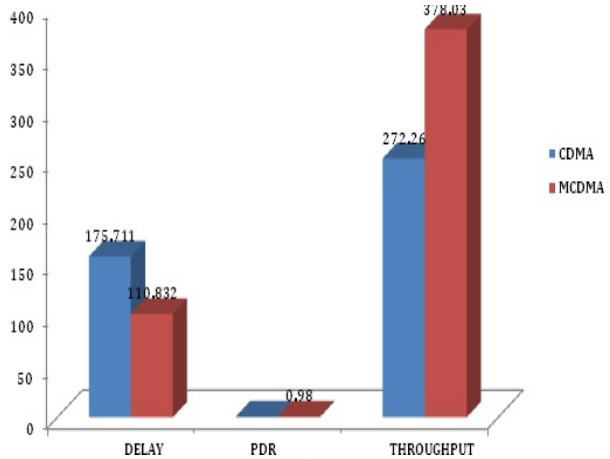


Fig. 8: Comparison of MCDMA vs CDMA.

From the graphical analysis, the performance of modified CDMA with Delay constrained shows better performance when compare to existing CDMA.

6. Conclusion

From the analysis of DSSS with delay-constrained MCDMA, the transmission of the information is found to be efficient. The waiting time is reduced and transmission range increases. Here every node allocates two slots. It reduces the number of hops and transmits the information in the shortest path for transmitting.

7. Future work

From the detailed study it is clear that the proposed work based on transmission of the information with the help of delay constrained multirate CDMA along with DSSS where the efficiency is measured in terms of delay, PDR and throughout. The delay is reduced when compare to previous work and same time the PDR and throughput is increased. Hence the future work is to enhance the present work and also trying to improve the security mechanism and energy consumption.

Acknowledgement

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