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UNDERWATER COMMUNICATION WITH THE HELP OF FREQUENCY MULTIPLE ACCESSES TECHNIQUE

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ABSTRACT

The usage of TDMA and CSMA techniques for underwater communications is strictly limited in efficiency and scalability, the mostly due to the very large propagation delays. Frequency Hopping Multiple Accesses (FHMA) seems a feasible alternative in that the propagation delay does not impact significantly its efficiency. However, in underwater communications, the capacity achievable on a particular channel depends strongly both on its frequency and on the communication distance. Unlike in traditional radio transmissions system where FHMA channels usually has comparable performance. Therefore, fixed channel allocation schemes traditionally used for radio FHMA do not perform well in underwater communications. In this paper, we explore the application of the principles of frequency multiple access to underwater communications. In particular, we proposed a data transmission scheme which exploits user location knowledge in order to maximize the throughput capacity among those achieved by the users. This provides maximum fairness and makes a more efficient use of the available frequency accesses resources. Performance evaluation of proposed work is carried out by means of simulation shows that our approach can achieve a great improvement in fairness among users, with respect to other schemes, while at the same time throughput of system is much better and thus allowing effective communications over larger distances within the water with less energy consumption rate.

Keywords: Underwater Communication, Frequency Hopping Multiple Access (FHMA), Media Access Control (MAC), Networking, Performance.

I. INRTODUCTION

Underwater communication networks (UW-CNWs) enable applications for oceanographic data collection, ocean sampling, ecological monitoring, offshore-exploration, disaster prevention, tsunami warning, assisted navigation, distributed tactical surveillance, and mine reconnaissance. Underwater communications are the typical physical layer technology in networks, although they create unique challenges due to the harsh underwater environment such as distortion in path, limited bandwidth, high and unpredictable propagation delays, high bit error rates and temporary losses of connectivity caused by multipath and fading phenomena, and asymmetric links between transmitter and receiver. Other physical layer technologies are often unreasonable in this environment due to several reasons. In reality, radio waves propagate from transmitting end to receiving end by conductive salty water only at extra low frequencies (30 − 300 Hz), which have need of large antennae and high transmission power for the communication stabilization. Optical waves do not endure from such high attenuation but they are affected by scattering problem. Moreover, the transmission of optical signals requires high precision in pointing the narrow laser beams. UW-CNWs consist of sensors and autonomous underwater-vehicles deployed to carry out collaborative monitoring tasks. A major challenge for the deployment of UW-CNWs is the development of a Medium Access Control (MAC) protocol tailored for the underwater surroundings. In particular, an underwater MAC protocol should grant high network throughput, low transmission delay, and low energy consumption, in face of the harsh characteristics of the underwater propagation medium, while guaranteeing fairness among competing techniques.

Frequency Hopping Multiple Access (FHMA) is the foremost promising physical layer and multiple access procedure for UW-CNWs because:

- It is strong to frequency-selective fading,
- Compensates for the effect of multipath at the receiver by designing a rake filters, which can gather the transmitted energy spread over multiple rays, and

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- Allows receivers to differentiate among signals simultaneously transmitted by multiple transmitting devices.

For these reasons, FHMA increases channel reuse and reduces packet retransmissions, which results in decreased energy consumption and increased network throughput within the water. In this paper, we introduce FHMA based UW-CNW with MAC protocol that incorporates a novel closed-loop distributed algorithm to jointly set the optimal transmit power and code length to minimize the near-far effect. One of the novelties of UW-CNW, which is motivated by the huge propagation delay affecting the underwater environment, is that it is not a pure distributed FDMA protocol; rather, it is a distributed hybrid MAC that combines both MAC and FDMA.

UW-CNW with MAC aims at achieving three objectives,

1. High network throughput with less bit error rate,
2. Low transmission access delay, and
3. Low energy consumption rate.

We demonstrate that UW-CNW with MAC to manages the simultaneously achieve these three objectives in deep water communications, which are usually not strictly affected by multipath. In shallow water communications, which may be heavily affected by multipath, it dynamically finds the most favorable trade-off among these objectives according to the application requirements of proposed work. We also formulate the 4FSK modulation and demodulation technique to account for the problem of near-far effect, and propose a low-complexity yet optimal solution.

FHMA is a spread-spectrum transmission technology, which authorize simultaneous data communications to share the exact same communication medium. This is done by allowing the receiving and transmitting stations to regulate the frequency rapidly in a pseudorandom sequence between several discrete radio channels. The transceivers are harmonized with a hopping sequence computed from a predefined algorithm. This hopping progression can be modified effectively to avoid various other interference and transmissions in the same frequency band. The architecture of FHMA transmitter and receiver is given in the figure 1 and figure 2 respectively.

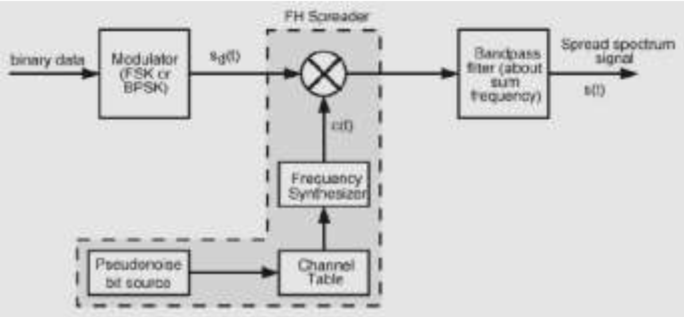

Figure 1: Architecture of FHMA Transmitter

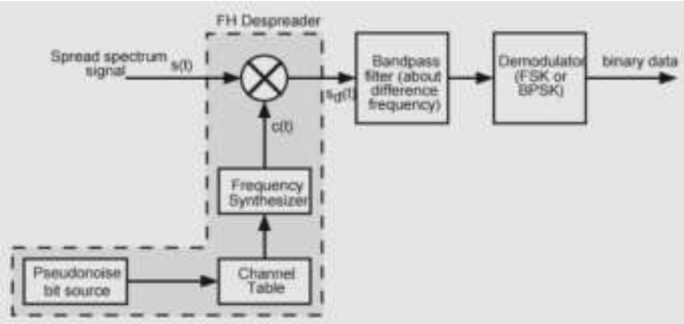

Figure 2: Architecture of FHMA Receiver

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Above figures represent the architecture of FHMA transmitter and receiver. The proposed FHMA technique is allow a lot of users to distribute simultaneously a finite amount of radio spectrum resources with less distortion. Experimental calculations were achieved on random data representing the accurateness of the system. The efficiency of proposed system is evaluated on the basis of the performance parameters in the simulation and results section by following the proposed methodology.

II. PROPOSED METHODOLOGY

In proposed work we used UW-CNW with FHMA technique to minimize the data losses during the transmission. The methodology of proposed work is given below:

Step 1: Design and develop a simulator to simulate the proposed underwater communication.
Step 2: Design a model for the FHMA transmitter and receiver with the MAC scheme.
Step 3: Develop a code for the generation of data for the simulation of proposed network using the signal generator.
Step 4: Design a modulator and demodulator using the FSK technique.
Step 5: Initialize a channel for the data transmission using the simulation block.
Step 6: Simulate the model and analyze the performance parameters like Throughput of network, BER, Transmission delay.

There are some algorithms which are used in the proposed simulation work and the used algorithms are given as:

Algorithm 1st: Data Generation

Define the range of data
Initialized canny magnitude technique
For I = 1 to maximum range of data
    Random Data = Random (I)
    Round off Random Data = Round (Random Data)
    Data = Ones (Round off Random Data)
    Carrier = Cos (2XSampting Time)
End

Algorithm 2nd: FHMA Algorithm

Upload Generated Data
Apply Modulation on Data
For I = 1 to all Data
    Random Hop Freq = Cosine (Data (I))
    Generated Carrier Freq = Random Hop Freq (I, 6)
    Output Signal = Data (Generated Carrier Freq (I))
End

Algorithm 3rd: Channel Creation Algorithm

Apply Filter on Output Signal
For I = 1 to all Filtered Signal
    Fad Signal = $20\log_{10}$ (Filter Signal (I))
    Channel Selection form AWGN, Rayleigh and Rician.
If Noise is present
    Channel =AWGN (Data)
End
    Channel = Rayleigh (Data)
End

Above mentioned algorithm is used to design the proposed simulator to simulate the underwater communication system. According to the methodology and algorithms, the simulation model represents FHMA AND MAC techniques that show the results on different parameters on different channels. As we can see in the methodology section, firstly, we initialize the random data and FHMA transmitter will transmit the data. There are three different channels that are used in simulation model, such as AWGN channel, Rayleigh channel, and Rician channel. Each channel used three different encoding techniques to encode the data such as reed Solomon, convolution and cyclic encoding technique and same these techniques are used for decoding. From the above mentioned channel network select the appropriate channel according to the data and their filtration.

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III. SIMULATION & RESULTS

In this section we describe the simulation of proposed work with results.

Simulation result for AWGN Channel with Reed Solomon Encoding Technique:

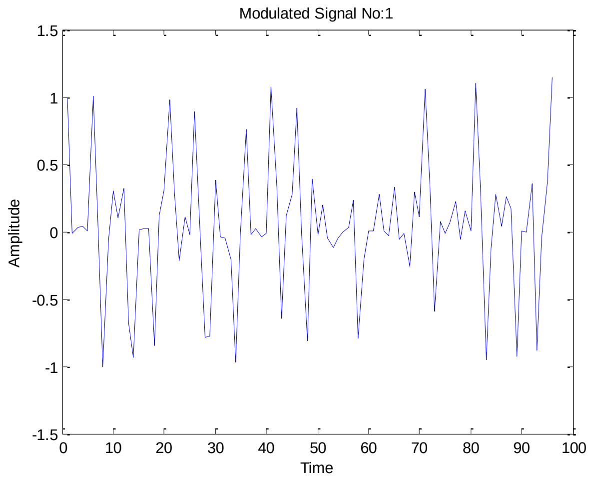

Figure 3: Modulated Signal

Above signal represents the modulated signal for simulation of the proposed underwater communication system. The amplitude range of modulated signal is between the -1.5 to 1.5 in time frame. AWGN is a type of noise that affects the modulated transmitted signal when it passes through the AWGN channel. It contains a uniform continuous frequency-spectrum over a particular frequency band.

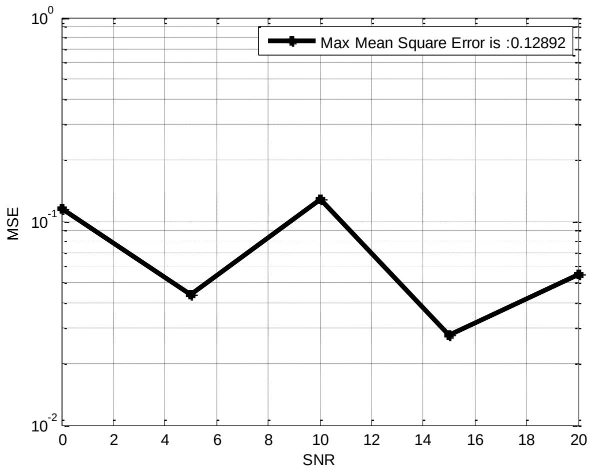

Figure 4: MSE with respect to the SNR

Above graph represents Mean Square Error with respect to the Signal to Noise Ratio performance over channel with FHMA and MAC Technique and we observed the maximum mean square error is 0.129.

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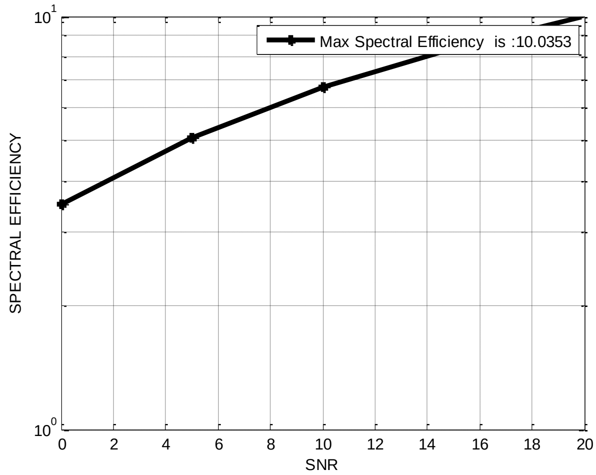

Figure 5: Spectral Efficiency with respect to the SNR

Above graph represents Spectral Efficiency with respect to the Signal to Noise Ratio performance over AWGN channel with Reed Solomon Encoding Technique and we observed the maximum mean square error is 10.035.

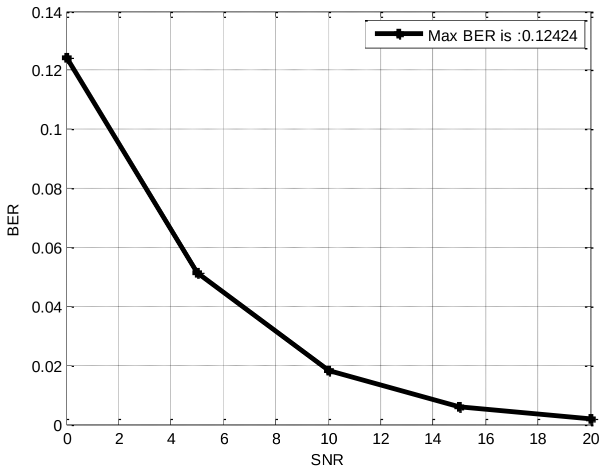

Figure 6: BER with respect to the SNR

Above graph represents Bit Error Rate with respect to the Signal to Noise Ratio performance over channel with FHMA Technique and we observed the maximum mean square error is 0.125.

The comparison of proposed work is given in table on the basis of different channels in the underwater communication system.

Table 1: Comparison of proposed work on the basis of BER

TECHNIQUE	PROPOSED WORK
AWGN CHANNEL	0.21186
RAYLEIGH CHANNEL	0.24688
RICIAN CHANNEL	0.19879

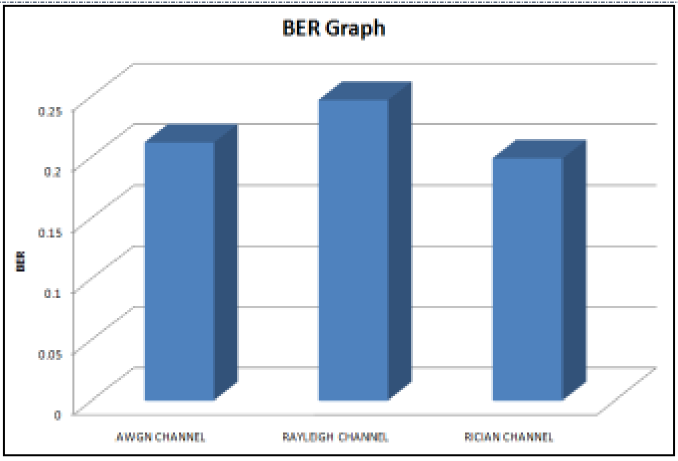

Figure 7: BER comparison between different channels

Above table 1 and figure 7 shows the comparison of Bit Error Rate among AWGN Channel, Raleigh Fading Channel and Rician Fading Channel which is used in the underwater communication system. Bar graph represent the proposed work Bit Error Rate for all three channels and aim of our proposed work is to decrease the Bit Error Rate and at last we observed that the Bit Error Rate of our propose work using Rician fading channel is better than others.

So, we can say that the Racian fading channel can communicate with the underwater with respect to the other channel and the combination of FHMA and MAC along with the Racian fading channel is better for the underwater communications.

IV. CONCLUSION

In this section, we introduced underwater communication networks (UW-CNW) with FHMA technique to minimize the data losses during the transmission. The proposed work has described the underwater channel model that can be used as the bases for testing the performance of several underwater communication systems and also proposed an energy saving model using the concept of MAC protocols. The limitation of proposed work is frequency bandwidth and high noise in underwater channel, there is two important techniques of tamed spread spectrum and FHMA were adopted with MAC in order to reduce the influences caused by the multi path effect. The simulation results of proposed work are indicated that this system could enable multiples routes to transmit the data within the underwater with very less BER.

In the future work, UW-CNW will have proposed using the hybridization of optimization algorithm with FHMA technique to create an optimized route.

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