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A Linear Path Combined MAC Based Routing for Improving the Energy Efficiency in Underwater Acoustic Network

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Abstract: ***Energy is one of the important major constraints in all kinds of networks. Sensor nodes meets very less energy, it causes node death, where it creates various problems in data transmission. In this paper it is aimed to improve the energy efficiency by reducing the energy consumption. To do this, a linear path is constructed between end-points, nodes mode is changed into Sleep and Awake, Awake and Sleep and scheduling is applied. These three functionalities provide a very good data transmission with less energy consumption. Simulation of this proposed approach is carried out in NS2 software and the performance is verified in terms of Energy, throughput and delay.***

Keywords: ***Acoustic Network, Underwater Sensor, Energy Notification Meter.***

I. INTRODUCTION

Among the most difficult communications in the media, underwater acoustic channels are the mostly recognized communication in today's world. At low frequencies the acoustic propagation is supported and the limitation is provided at the bandwidth available for the communication. If the acoustic system operates at the frequency range of 10-15 Hz, the bandwidth at the total communication is very low (5 KHz). Here the system is said to be at ultra-wideband, where the bandwidth is not negligible respective of the center frequency. The propagation of sound is in the underwater at the speed of 1500 m/s. This occurs at multiple paths with a low speed. The delay spreads over the hundreds of milliseconds resulting in the frequency selective signal distortion. But its motion will create extreme Doppler Effect. The worst properties of radio channels which are classified as poor physical link quality of mobile terrestrial channel of radio and satellite channel latency.

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These are combined in underwater acoustic communications [1]. This testifies the advances of signal processing when the physical nature of propagation was dignified through channel modeling. This was illustrated in the combined model of the multipath and phase distortion in a single carrier wideband system. It is also applied in the real time acoustic modem .In the past decades this method of communication is drastically growing at a peak interest due to its applications such as oceanography, marine research and its commercial operations, offshore oil industry and defense[2]. There are still some lacks of standards for underwater communication. They are due to some technical challenges which persist among the reliable underwater acoustic communication [3]. Since the electromagnetic wave travels only short distances in the underwater than in the terrestrial spaces due to attenuation and absorption effects [4]. Optical signal faces the problem of absorption and scattering in underwater .Hence the acoustic energy is the widely used signal in the underwater data transmission [5]. The other problem is that the fluctuating nature causes bit error rate in a high level in the transmission in the ocean. It is also affected by the loss of path due to spreading and absorption [6]. This comes from many sources such as rain, wind, water current, seismic and some volcanic activities [7]. There are two main issues in the underwater environment. They are energy efficiency and reliability. These two issues are intertwined. The reliability requires error correction where the error correction requires energy. If the reliability is high then the energy consumption is high. This causes some difficulty in the application of the method which requires nodes. This operates in the underwater for longer periods of time without recharge of battery and in the aquatic environments. It renders task of recharging or replacement of batteries. Appropriate strategically levels must be ensured in order to place reliable transmission of data while conserving the energy too.

The other issue related to the reliability is the scalability. A reliable network should be a scalable one too. Each network should be capable to provide equal importance to all the present sensors which will be added to the network. This is known as the scalability. This equal performance will provide reliable data in the communication. Both the scalability and reliability depends on the routing protocol. This is used in the purpose of routing process in the networks.

Data security is also the major issue. The most important phenomena are data integrity in all the types of communications. Some cryptographic schemes were employed in an effective manner in order to improve the data security.

In recent times the issues of energy efficient transmission are analysed by introducing and defining many theories and conditions. This paves an approximate solution to attend the better performance metrics in the data communication such as better reliability.

This is also done in the less communication delay. The energy consumption depends on the reliability and the communication delay.

II. RELATED WORKS

The problems of the underwater acoustic channel estimation for communication were addressed in time varying environments. In this rapidly time varying environment the estimation of the channel was done and continuous tracking was performed. Prior statistical information on the time variation channel is used in order to obtain the maximum posterior estimator for the tap coefficients. Performance gain of 5-10 dB was demonstrated [8]. The acoustic propagation measurements and analysis of the effects were demonstrated in the in the narrowband channels. Their frequency dependence differs in the paths and violation of the assumption was done. According to the method the correlative channel preserves wideband properties based on the direct replay principle [9]. The issues and challenges in the underwater communication regarding the underwater acoustic sensor networks. Some of the challenges are multipath fading, limited bandwidth, battery and data capacity and some delay occurring in the propagation [10]. The methods to estimate the matched signal transformation due to time varying underwater acoustic channel in the OFDM communication systems were discussed.

The methods estimated the channel by spreading and extracting process using the Mellin transform and decomposition algorithm. The data were obtained from the Kauai Acomms MURI 2008 experiment [11]. The reconfigurable modem was presented along with the new simulation model. It could model the acoustic communication and the networking systems which generate the C code based model. This could be run on a DSP model board for the real time study of experiments [12]. To explore the higher communication in the UAC channel mapping, novel cognitive intelligent algorithm was developed to select the UAC channel modes accurately. This cognitive intelligent model presented a valuable work to channel models in the UAC environment [13]. For the wideband OFDM a time varying Doppler shift compensation was proposed for shallow water communications. This proposed scheme accommodates the channel model to accelerate and de-accelerate of frames. The fractional deviation of the sub carrier was also estimated. This technique proved to be robust and pragmatic than the existing algorithms [14]. The proposed algorithm determines the DFE coefficient placements from the response of the channel. It relied on the heuristics in simplifying the search of placements.

Thus complete automation of the tap placement process was provided while maintain its performance. [15] S.BeenoAncy et al. discussed about the energy efficient based reliable communication in underwater acoustic sensor networks [16], by providing multi-path power control communication. Since multi-path power control communication functions basically by MAC based REQ-RES method, in this paper also MAC functionality is utilized. Salvador Climent et al. [17] proposed a robust architecture named as EDETA [Energy-Efficient a Daptivehi Erarchical and RobusT Architecture] - for improving the energy efficiency in underwater acoustic networks. There are various routing protocols has been proposed for improving the energy efficiency in Underwater acoustic sensor networks and some of them are: FAMA (Floor Acquisition Multiple Access) protocol [18], Slotted FAMA MAC protocol [19], a hybrid between RTS/CTS and CSMA protocol [20], DBR (Depth Based routing) [21] mechanism, Minimum Cost Clustering Protocol (MCCP)- [22]. From the introduction and literature survey section, it is clear that there is need of a best solution to save the energy in sensor nodes and increase the life time of the network. In this paper, reducing the energy consumption is taken as the problem and finds a better solution in underwater acoustic sensor networks.

III. PROPOSED ARCHITECTURE

The main objectives of the proposed approach in this paper are:

- Increasing the UWA network lifetime
- Improving the efficacy of the acoustic nodes
- Transmitting the data packets in a linear path [designed newly]
- Finally MAC based Sleep-Awake rules integrated with scheduling algorithm

Proposed Architecture:

In this paper, a linear path combined MAC configuration procedure is applied to reduce the energy consumption and improve the network life time with improved throughput and delay. The architecture of the underwater acoustic sensor network utilized for experiment, the proposed approach is given in Figure-1. There are many nodes is deployed and connected linearly under the water environment. Each sensor node is having a sensing tower and an ENM. The end-points are available in the land [above water]. The two end points are located in land environment and the distance among the end points are too far, so that the end-points are communicating through underwater acoustic networks. To obtain the above objectives, some concepts are assumed as the initialization in the underwater acoustic network.

Initialization:

- Nodes are deployed in a linear path among end-points [see Figure-1].
- Data packets are transmitted in linear path.
- Distance among the nodes are constant, if necessary it can be adjusted at the need of juncture.
- Data packets can be transmitted in alternate paths in case of the linear route gets failure unfortunately.
- It is assumed that each acoustic sensor nodes are inbuilt with an ENM-[Energy Notification Meter] for intimating the Base station about the energy status.

From Figure-1, it is noticed that the passing a message [information] through a ship may take more time. Since, technology grows speedily, underwater acoustic network based communication is utilized here for transmitting the data [message/information].

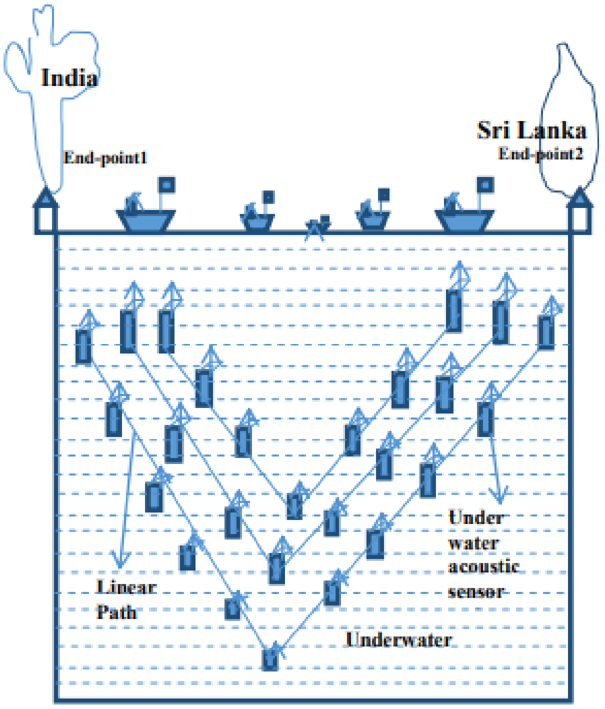

Figure-1: Proposed Underwater Acoustic Sensor Network

In the network, N number of nodes are deployed in X number of linear path where each path consists of m number of nodes. K number of end points are connected communicate through the underwater acoustic sensor networks.BS is always monitoring the routing, route information and node conditions to take necessary activity. Whenever an end-point tries sends a data our proposed approach selects an available path among the various paths which is free and transmits the data packet by splitting the whole data. For example, 2 MB of data is divided into 45 KB as a packet, where each packet follows the following format.

Table-1: Packet Format

1. SA	2. DA	3. TTL	4. NH	5. DATA	6. MEDATA	7. HEAD

SA denotes the source address, DA denotes the destination address, TTL denotes the Time to leave, NH denotes the next hop, DATA denotes the real data content, MEDATA denotes the Meta data of the real data and finally HEAD denotes the header information of the data transmission.

In this network, for transmitting the data our proposed approach selects a path which is not in data transmission presently. Whenever a path is going to be utilized for data transmission it is intimated [broadcast] to the end-points in source side and the destination can also intimated that through which path the data is coming from the source. All the nodes are initialized with Q Joules as initial energy. During the network process, the energy of the nodes are consumed for various purpose of the nodes such as Idle, Sleep, Wakeup, Listen , Receiving and Transmitting. For each of these purposes different amount energy will be reduced from the initial energy. The energy efficiency can be computed by remaining energy of each node as:

RE = IE- [IDE + SE +RxE + TxE + WE + LE] -(1)

Where,

RE - Remaining Energy, **IE**–Initial Energy,

IDE - Idle Energy, **SE**-Sleep Energy,

RxE - Receiving Energy, **TxE**-Transmission Energy,

WE - Wakeup Energy & **LE**-Listen Energy.

When a source end-point selected a free linear path it transmits the data in that path and broadcast to other end points as well as the destination end point about path. Since, the path is linear and the distance among the nodes are constant each destination and source can compute the receiving time and wait for the ACK. Data is transmitted through multi-hop communication in a fixed distance. Each multihop ID is noticed in the packet format also from their ACK after successful receipt of the data receiving from their successor nodes. In case, if the source is not receive the ACK, then it verifies the path and resends via the same path if there is no interruption, else it resend through the other linear path.

The EDM in each sensor nodes started monitoring the energy level and intimate to BS or to the Administrator of the network. The various stages of the nodes energy can be intimated to the BS such as 100% of battery it intimate as "Super Life", 80% of the battery it intimate as "Good Life, 60% of the battery it intimate as "Take care about Life-time", 40% of the battery it intimate as "U will be going to danger Zone" and below 20% of the battery it intimate as "Node is in critical Life time".

According to the EDM message the BS will take care about the sensor node by replacing the battery of the node or by replacing the sensor node by a new node.

During the data transmission, if any intermediate node is not in condition then BS can guide the routing algorithm to proceed with the alternate path in the network. The advantages of this proposed is the EDM intimation, free path selection, linear path and alternate path based data transmission. According to these criteria it is very easy to notify the sending-time, receiving-time, intrusion occurrence, data loss, congestion and jamming in the route. IT helps to eliminate these problems immediately anomaly.

Proposed Algorithm:

Initialization

Number of end-points = K;

Number of nodes = N;

Number of linear paths = X;

Number of nodes in each path is = m; // approximately

Distance among Nodes = D and it is initialized as distance=0;

RE =0, IE=100 J, IDE= 0.0003, SE= 0.0002, RxE= 0.25;TxE =1.002,

WE=0.002; LE=0.03

Procedure

For I = 1 to N

For J = 1 to X

for K = 1 to m

$Node_k$ placed in $Path_j$

distance = distance + D;

$Node_i$ = sleep;

```
end k
    end J
  end I
  For I = 1 to X
    broadcast=0;
    if (path_i == free) then choose path_i for transmission
      broadcast = path_i-free
    else
   End-point-I sends data through path_i
broadcast = path_i-not-available
end if
end for
For I = 1 to m
Apply Scheduling
  if  (Node-I == sleep) then
 Node-I = wakeup
  else
    check the Node-I mode and call MAC to change the
Node-I mode
  end if
  S(i) pass data to D(i)
  node-I (ACK ) -> S(i)
  If (D(i) .ACK  -> S(i) ) then transmission over
    terminate
  else
    continue
  end if
end i
For I = 1 to N
  RE = IE- [IDE + SE +RxE + TxE + WE + LE]
end i    End
```

The entire functionality of the proposed approach is given in the form of pseudo code and it can be programmed in various computer languages to verify the efficiency of the proposed approach. In this paper NS2 simulator is used to verify the efficiency of the proposed approach and the parameter settings is given in the following Table-2.

IV. SIMULATION SETTINGS

The above algorithm can be developed in any programming language and the proposed approach based network performance can be obtained using linear path and MAC configuration. The front end coding is developed using TCL language and the routing of UWASN can be configure using .cc coding.

The number of simulation can be obtained repeatedly by changing the number of sensor nodes deployed in the network region as 500, 1000, 1500 and 2000 nodes. In all the iteration, the route is elected due to the availability within a short period. To improve the performance all the route, distance among the nodes, time taken for transmission is considered as constants.

Table-2: Simulation Settings

Parameter	Level
Area	1200m x 1000m
Speed	1 to 15 m/s
Radio Propagation Model	Two-ray ground reflection
Radio Range	Constant [250 to 500 m]
Number of Nodes	500, 1000, 1500 and 2000
MAC	802.1x
Application	CBR, 100 to 500
Packet size	42
Simulation Time	50 s
Placement	Linear

The number of simulation can be obtained repeatedly by changing the number of sensor nodes deployed in the network region as 500, 1000, 1500 and 2000 nodes. In all the iteration, the route is elected due to the availability within a short period. To improve the performance all the route, distance among the nodes, time taken for transmission is considered as constants.

V. RESULTS AND DISCUSSION

During and after simulation the performance of the proposed approach can be investigated by verifying the parameters such as energy, throughput and time. It is assumed that a random node End-point1 is elected as source node and the End-point-m is elected as the destination node and using CBR traffic pattern the data packet is transmitted with the help of the scheduled-MAC integrated in the NS2 software. The following figures show the results obtained in the simulation.

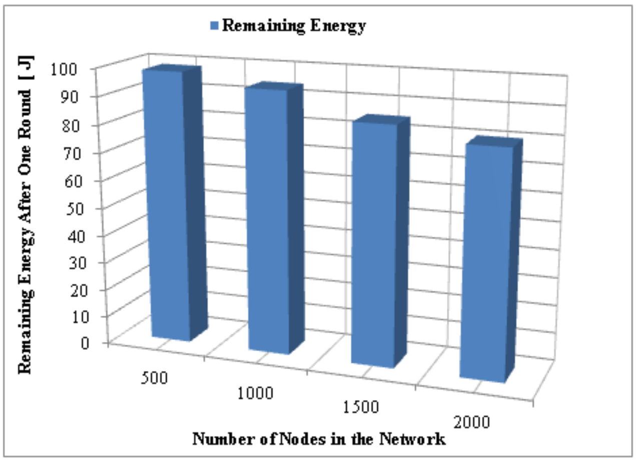

Figure-2: Performance Calculation In terms of Energy

The end-point-1 is elected as source node and end-point-3 is elected as destination node, and the data transmitted through path-2 and it is monitored.

Among the several paths path-2 is elected as the free path [available path] and it is selected as the right path for data transmission. After successful transmission the energy taken to traverse and time taken for traversing in the path and the total throughput is calculated and the results are shown if Figure-2 to Figure-4 respectively.

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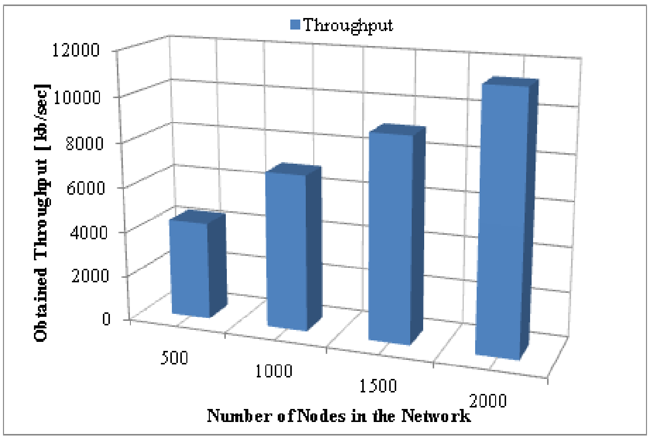

Figure-3: Performance Calculation In terms of Throughput

The energy efficiency is computed by obtaining the remaining energy of each node after one successful round data transmission and given here. The remaining energy is calculated using the equation-(1). All the three parameters deciding the performance of our proposed approach is verified for 500, 1000, 1500 and 2000 number of nodes deployed in the network. The simulation time assigned for the entire simulation is 40 to 50 seconds. Within the time period a 512 MB of data is given as transmission data and verified. The remaining energy after one successful data transmission is 98.45%, 94.23%, 85.11% and 80.32% Joules for 500, 1000, 1500 and 2000 respectively.

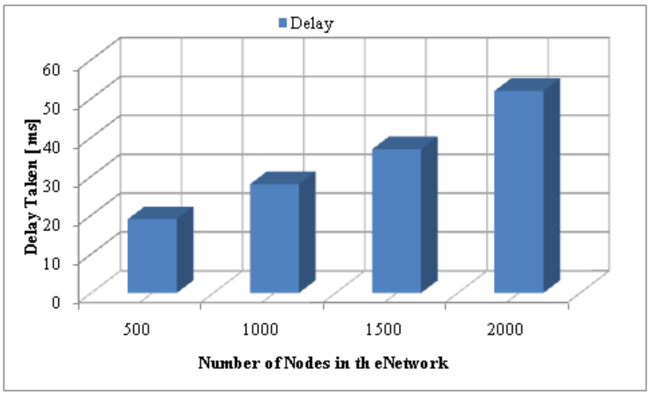

Figure-4: Performance Calculation In terms of Delay

Similar to Figure-3, proposed approach is verified and evaluated in NS2 simulation in terms of throughput. The throughput obtained by proposed approach is verified by changing the number of nodes in the network and depicted in Figure-3. From the Figure, it is clear that the proposed approach is best approach in terms of throughput for underwater communication. The proposed approach obtained the throughput for 500, 1000, 1500 and 2000 nodes are 4356, 6937, 9012 and 11293 KB/sec respectively. The total time taken to travel in a path is the delay and the delay of the network is computed by the sum of the total delay for entire path in the network. The delay time 19, 28, 37 and 53 ms is taken for 500, 1000, 1500 and 2000 nodes respectively in the network and it is shown in Figure-4.

VI. CONCLUSION

From the simulation results it is clear that the proposed approach be a better approach for underwater sensor network to obtain a best part of the routing from the surface level to the seabed level. From the results and discussion it is very clear and understand that the energy, throughput and the delay utilized for data transmission in a selected path provides better efficiency and shown in Figure-2 to Figure4 respectively. The overall energy saved, time spent for the total data transmission in a best path is more effective and it can compared with existing approaches discussed in the literature survey can suggest this approach can be a permanent approach for underwater acoustic sensor network.

REFERENCES

1. S.A. Kalaiselvan, V. Parthasarathy (2014), "An Energy-Efficient Routing Protocol for UASN by AFISHS Optimization Algorithm", International Journal of Applied Engineering Research, Vol. No. 9(24), pp. 30589-30602.
2. S.A. Kalaiselvan, V. Parthasarathy (2015), "Performance Evaluation of FMMS using Underwater Sensor Network, Elsevier, ICBEC 2014: October 29-30, San Diego, USA, PID - Z0005.
3. S. A. Kalaiselvan (2015), "Location Verification Based Neighbor Discovery For Shortest Routing in Underwater Acoustic Sensor Network", Advances in Environmental Biology, Volume 9, Number 14, PP-117-121.
4. S. A. Kalaiselvan, Teena Joseph (2018), "Interesting Unknown Facts About the Fish and its Behavior", International Journal of Emerging Science and Engineering, Volume-5 Issue-11.
5. S. A. Kalaiselvan, (2018), "Performance Evaluation of AFISH Algorithm for Energy Efficient Data communication in UWSN", WSEAS TRANSACTIONS ON COMPUTERS, Volume 17.
6. S. A. Kalaiselvan, (2018), "A novel design and simulation on reliability and energy efficiency in underwater sensor networks", https://shodhganga.inflibnet.ac.in/bitstream/10603/204018/1/01_title.pdf
7. D.Pompili (2007), "Efficient communication protocols for underwater acoustic sensor networks," PhD, School of Electrical and Computer Engineering, Georgia Institute of Technology.
8. M.Wasserblat, J.Tabrikian (2000), "Underwater acoustics communications in a time-varying environment", IEEE Proceeding on 21st IEEE Convention of the Electrical and Electronic Engineers, ISBN: 0-7803-5842-2.
9. Paul A. van Walree, Roald Otnes (2013), "Ultra wideband Underwater Acoustic Communication Channels", IEEE Journal of Oceanic Engineering, PP-678-688.
10. Himanshu Jindal, Sharad Saxena, Singara Singh (2014), "Challenges and issues in underwater acoustics sensor networks: A review", International Conference on Parallel, Distributed and Grid Computing, ISBN: 978-1-4799-7683-6.
11. N. F. Josso, J. J. Zhang, D. Fertonani, A. Papandreou-Suppappola, and T. M. Duman (2011), "Time-varying wideband underwater acoustic channel estimation for OFDM communications," Proceedings of the IEEE International Conference on Acoustics, Speech, and Signal Processing, pp. 5626-5629.
12. E.M. Sozer (2005), "Simulation and rapid prototyping environment for underwater acoustic communications: reconfigurable modem", IEEE Europe Oceans, ISBN: 0-7803-9103-9
13. Sadia Ahmed ; Huseyin Arslan (2009), "Cognitive intelligence in the mapping of underwater acoustic communication environments to channel models", IEEE Oceans.
14. A.E. Abdelkareem ; B.S. Sharif ; C.C. Tsimenidis ; J.A. Neasham (2011), "Time Varying Doppler-Shift Compensation for OFDM-Based Shallow Underwater Acoustic Communication Systems, IEEE Eighth International Conference on Mobile Ad-Hoc and Sensor Systems, ISBN: 978-1-4577-1345-3.
15. M.J. Lopez, A.C. Singer, S.L. Whitney, G.S. Edelson (1999), "A DFE coefficient placement algorithm for underwater digital acoustic communications", Conference Proceeding on Oceans '99. MTS/IEEE. Riding the Crest into the 21st Century, ISBN: 0-7803-5628-4.
16. S.Beeno Ancy, S.Shahul Hammed (2013), "Energy Efficient and Reliable Communication in Underwater Acoustic Sensor Networks", International Journal of Advanced Research in Computer Engineering and Technology, Vol- 2, No-1.

17. Salvador Climent, Juan Vicente Capella, Nirvana Meratnia and Juan José Serrano (2012), "Underwater Sensor Networks: A New Energy Efficient and Robust Architecture", Sensors, doi: 10.3390/s120100704.
18. L.Chane, Fullmer and J.J.Garcia-Luna-Aceves (1995), "Floor Acquisition Multiple Access (FAMA) for Packet-Radio Networks", Proceeding of the conference on Applications, technologies, architectures, and protocols for computer communication, PP-262–273.
19. M.Molins, Stojanovic (2007), "M. Slotted FAMA: A MAC Protocol for Underwater Acoustic Networks", Proceeding of the OCEANS 2006-Asia Pacific, pp. 1-7.
20. Syed, A.; Ye, W.; Heidemann, J. T-Lohi(2008), "A New Class of MAC Protocols for Underwater Acoustic Sensor Networks", Proceedings of the 27th Conference on Computer Communications (INFOCOM '08), PP- 231-235.
21. H.Yan, Z.J.Shi, J.H.Cui, DBR (2008), "Depth-Based Routing for Underwater Sensor Networks", Proceedings of the Networking 2008 Ad-Hoc and Sensor Networks, Wireless Networks, Next Generation Internet.
22. P.Wang, C.Li, J.Zheng (2007), "Distributed Minimum-Cost Clustering Protocol for UnderWater Sensor Networks (UWSNs)", Proceedings of the IEEE International Conference on Communications (ICC '07), PP-3510–3515.