

ENERGY EFFICIENT ADAPTIVE ROUTING PROTOCOL FOR UNDERWATER COMMUNICATION

¹G.Subramanian, ²R.Nisha, ²R.Priya, ²M.Sabitha, ²V.Vishnu Priya

¹Assistant Professor I, ²UG student

Department of Electronics and Communication Engineering,
Velammal Engineering College, Chennai-66(India)

ABSTRACT

Underwater sensor networks are made up of number of fixed or mobile sensor nodes that are deployed at various depths and are networked via wireless acoustic communication links to carry out collaborative monitoring mission. For this, underwater sensor node requires Multihop communication and efficient routing schemes to communicate with sink. The existing path setup-based routing protocols take much time when establishing a path between source and destination nodes due to the long propagation delay. In addition, the path establishment requires much overhead of control messages and high packet loss degrades reliability, which invokes more retransmissions. Even though existing routing protocols such as SUN protocol were proposed to achieve lower error rates, they did not take into account the end to end delivery delay due to path discovery. We therefore proposed a directional flooding-based routing protocol, called ARP. ARP relies on a packet flooding technique to increase the reliability. Therefore the ARP achieves lower error rates and energy consumption with maximum throughput. Our simulation study using ns-2 proves that ARP is a feasible solution for underwater sensor network.

KEYWORD- ARP, End to End delivery, Leach algorithm, Routing protocol, UWSN.

I.INTRODUCTION

Underwater Acoustic Networks (UANs) are perceived as an increasingly feasible approach for several applications, such as oceanographic data collection, water monitoring, offshore exploration, disaster prevention and assisted navigation. Depending on the specific scenario, UANs may consist of a variable number of entities, both mobile and static. These include sensor nodes, Autonomous Underwater Vehicles (AUV), buoys, and ships that can collaborate in order to carry out a task in a given area. Moreover, some nodes can be anchored, while others can be mobile (e.g., drifters and floaters). Fig 1 represents the basic diagram.

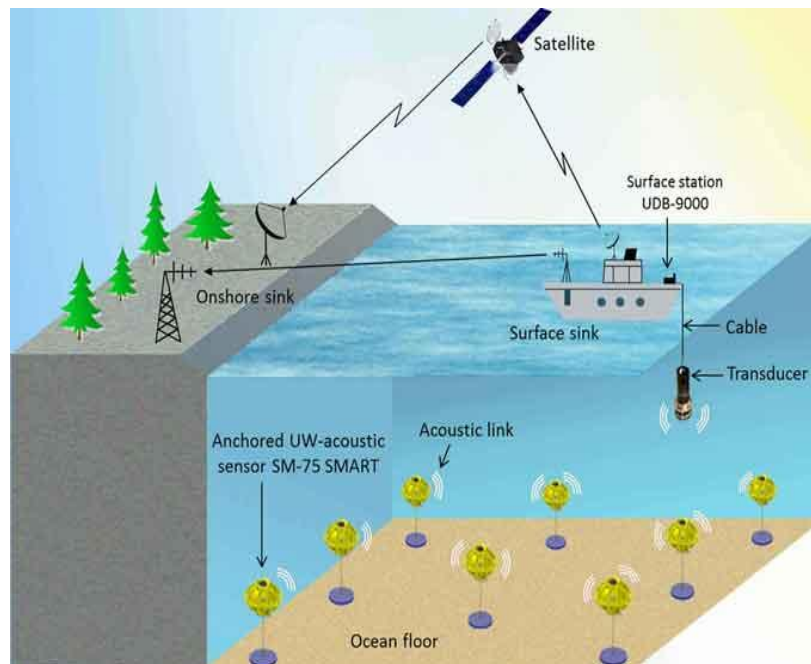


Fig 1

Whenever operations over a large area are required, such networks become inherently Multihop. This is partly due to the limited range of underwater acoustic transmission equipment, and partly to the fact that shorter acoustic links are characterized by a larger bandwidth, and less energy is required to communicate over them. In such Multihop scenarios, the nodes must autonomously organize into a network and find Multihop routes to deliver data to their intended destinations. This mechanism is usually delegated to a routing protocol. There are several types of solutions to the routing problem in underwater networks. These include dynamic vs. static routing, source routing vs. hop-by-hop relay selection, proactive vs. reactive and distributed vs. centralized protocols. Each approach has its own pros and cons. In this paper, we argue that source routing is a feasible approach for generic underwater networks, despite the comparatively smaller amount of attention it has received in the body of research carried out so far. Our objective is therefore to recast source routing in underwater networks by designing a protocol that is specifically tailored to the underwater environment.

Recently, much research on underwater wireless sensor networks (UWSNs) has been performed to support practical applications such as underwater tactical surveillance, undersea exploration, underwater disaster prevention, seismic monitoring, etc. UWSNs have inherent characteristics which are significantly different from terrestrial sensor networks. First, an acoustic is used as their communication medium instead of radio frequency (RF). The use of an acoustic causes a long propagation delay because the speed of an acoustic in water is about 1500 m/s which is much slower than RF in terrestrial sensor networks. Second, similar to terrestrial sensor networks, a node is powered by battery. Moreover, the price of a node for water is much higher than that for ground. Therefore, energy efficiency in UWSNs is emphasized more than terrestrial sensor networks. Third, the packet loss probability is high and dynamic, which leads to much retransmissions and lower reliability. Finally, the available bandwidth is severely limited. An efficient resource-aware reliable

routing protocol plays a significant role to ensure successful data transfer from sensors to the sink to fulfil the different application requirements in dynamic environmental conditions. For this, a robust energy-efficient adaptive routing technique based on physical distance of nodes to sink, residual energy of nodes, link quality and packet characteristics is being proposed. It aims to reduce unnecessary transmissions, to implement energy balancing and to adapt to the packet and network conditions.

1.1 EXISTING SYSTEM

The existing method is the SUN protocol [1] which is a reactive, source-routing based protocol. For improved efficiency, SUN is designed as a cross-layer protocol. In particular, SUN internally buffers both the packets to be transmitted and those received from the lower layers of the protocol stack. A buffering system within the network layer yields several advantages: it makes it possible to store specific Data packets, and optionally to decide which packets should be saved or dropped if buffer overflows occur. When a node does not know a valid path to the sink, a buffer gives the possibility to store the packets, send a Path Request, wait for an answer, and finally fills the header of the packet with a valid route. The results show that SUN achieves lower error rates and energy consumption, while naturally requiring a longer end-to-end delivery delay due to the path discovery and maintenance procedure.

1.2 PROPOSED SYSTEM

In order to overcome the longer end to end delivery delay in the existing system and for effective energy consumption an efficient resource-aware reliable routing protocol is proposed i.e. adaptive routing protocol (ARP). It plays a significant role to ensure successful data transfer from sensors to the sink to fulfil the different application requirements in dynamic environmental conditions. It aims to reduce unnecessary transmissions, to implement energy balancing and to adapt to the packet and network conditions. It is explained in detail in the section (2.1)

The paper is organized as follows: Section 2 covers the proposed system methodology. Section 3 discuss the results of the experiment where we tested ARP. Section 4 presents simulation results used to validate the design of ARP. Finally Section 5 concludes the paper.

II.METHODOLOGY

To ensure successful data transfer from sensor to sink a robust energy efficient adaptive routing technique based on physical distance of nodes to sink, the residual energy of nodes ,link quality and packet characteristics is being proposed to reduce unnecessary transmission.

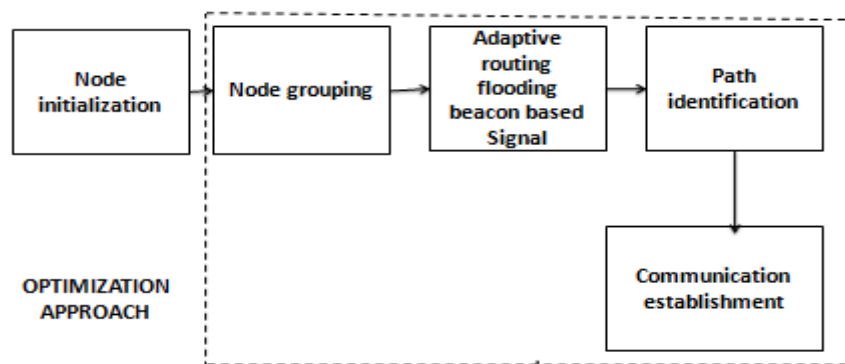


Fig 2.Overall Block Diagram

In this work first the node initialization is done where the nodes are fixed in particular positions. Next the node grouping is the clustering of each node to form a group by leach algorithm .Then Adaptive routing flooding routing protocol is used which is a packet flooding technique to flood a packet in controlled manner. So that it prevents a packet from flooding over the whole network and the nodes to forward the packet are decided according to the link quality node. From this, the shortest path to reach the destination is identified and communication is established between the source and destination successfully.

2.1 LEACH ALGORITHM

In our work we use LEACH algorithm for clustering of nodes. The low-energy adaptive clustering hierarchy (LEACH) deploys randomized rotation of cluster-heads to evenly distribute the energy load among all sensors. The cluster head is selected randomly based on node having highest energy. The cluster head aggregates and compress data. And then it forward it to sink(as illustrated in fig 3)

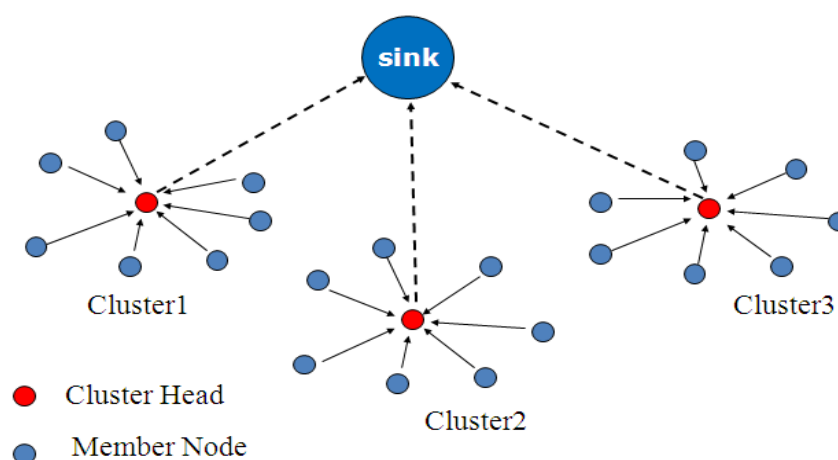


Fig 3

$$T(n) = \begin{cases} \frac{p}{1 - p * (\text{rmod} \frac{1}{p})} & \text{if } n \in G \\ 0 & \text{if } n \notin G \end{cases}$$

2.2 ADAPTIVE ROUTING PROTOCOL

236 | Page

Thus ARP relies on a packet flooding technique to increase the reliability i.e. the number of nodes which flood a packet is controlled and prevents a packet from flooding over the whole network and the nodes to forward the packet are decided according to the link quality. In addition, DFR also addresses a well-known void problem by allowing at least one node to participate in forwarding a packet. The cluster head checks whether the destination node is present in its group or not. According to that, it will send the positive or negative acknowledgement to neighboring group until then it holds the data in its buffer. This ensures that the chance of packet loss is minimized here leading to lower error rates on transmission. Thus flooding occurs which will finally find the shortest path to reach the destination node. Now the packet is effectively send from source to sink via the path identified and communication is established. In this way the Adaptive routing protocol works effectively. The path discovery is made faster and packets are forwarded as soon as possible.

2.3 EVALUATION METRICS

In this section, the performance of ARP is to be evaluated via simulations with respect to the following metrics:

2.3.1 THROUGHPUT

Throughput is the maximum rate of production or the maximum rate at which something can be processed. When used in the context of communication networks, such as Ethernet or packet radio, throughput or network throughput is the rate of successful message delivery over a communication channel. Network throughput is measured in bits per second (bps).

2.3.2 RESIDUAL ENERGY

Residual energy is the how much of energy remains. This measure also gives an indication of the bandwidth usage. The energy consumption is the time spanning from the moment the cluster head sends the first advertisement message to the moment at which the cluster members receives the TDMA schedule. Thus the residual energy is calculated by,

Residual energy=Initial energy-Consumed energy

2.3.3 END TO END DELAY

End-to-end delay or one-way delay (OWD) refers to the time taken for a packet to be transmitted across a network from source to destination. It is a common term in IP network monitoring, and differs from round-trip time (RTT) in that only path in the one direction from source to destination is measured. It is measured as the time normalized against the average time for a single-hop along the shortest path from a node to the sink. Recent studies in WSNs focus on timeliness as a QoS metric. The average delay taken by the first copy of a packet from the source node, S_i , to the sink is denoted as $T(S_i)$. $T(S_i)$ includes all possible delays that are caused by queuing in the interface queue, retransmission at the MAC layer and the propagation through the environment. The average delay of all n nodes, denoted as T_N , is given by

$$T_{N=1/n} \sum_{i=1}^n (t_a, t_s)$$

Where t_a is the time a packet arrives at the sink and t_s is the time a packet sent at the source. The delay depends also on the scale of the network.

2.3.4 PACKET DELIVERY RATIO

Packet Delivery Ratio is a service level parameter that indicates the network effectiveness in transmitting offered data in one direction of virtual connection. It is considered as one of the prime measures of robustness. Packet delivery ratio is a ratio of successful distinct payload octets received to attempted payload octets transmitted. When calculating packet delivery ratio, the packets which arrived late at the destination are considered ineffective. The formula for packet delivery ratio is

$$\text{Packet delivery ratio} = \frac{\sum \text{data delivered to the sink}}{\sum \text{data offered by } S_i}$$

III. FIELD EXPERIMENTS

In this section we present field experiments that have been done to test the adaptive mechanisms of the ARP in the real-world environment. For this we deployed Aquasim tool that is integrated in ns2 for handling underwater sensor networks. This simulator supports new Mac layer, new protocols that are helpful in routing inside water. Thus to measure and evaluate the performance of the routing protocol below process is explained as follows.

3.1 NODE INITIALIZATION

Here the sensor nodes are fixed in particular position at various depths. These node forms the underwater sensor networks. It is illustrated in fig 5.

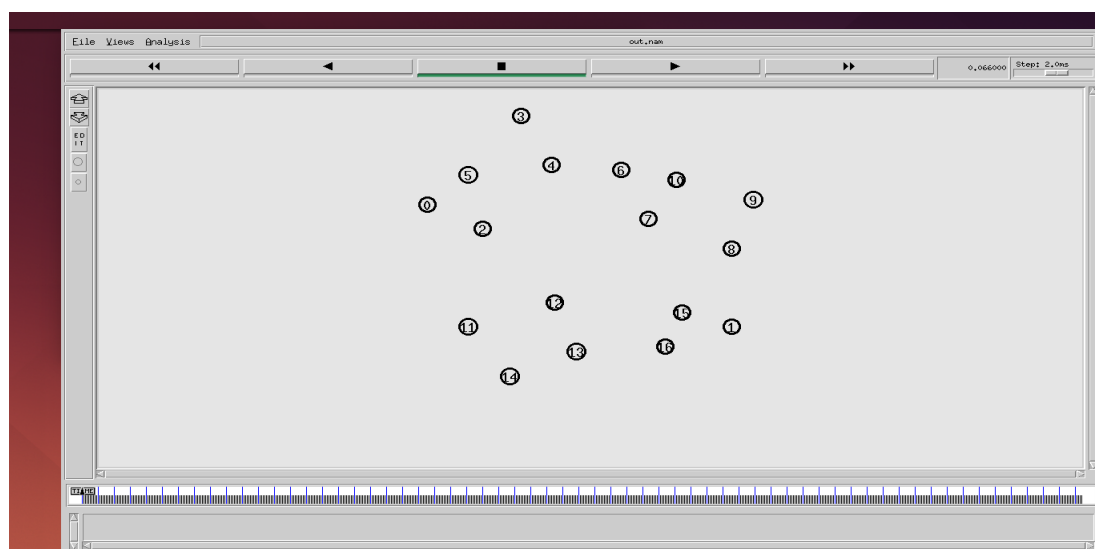


Fig 5

3.2 GROUPING

In this, first the source and destination is assigned and then clustering of nearby nodes takes place. Cluster head is also chosen in every group. Each group is given different color to identify which group the node belongs to. Here the grouping is done by leach algorithm and it is illustrated in fig 6.

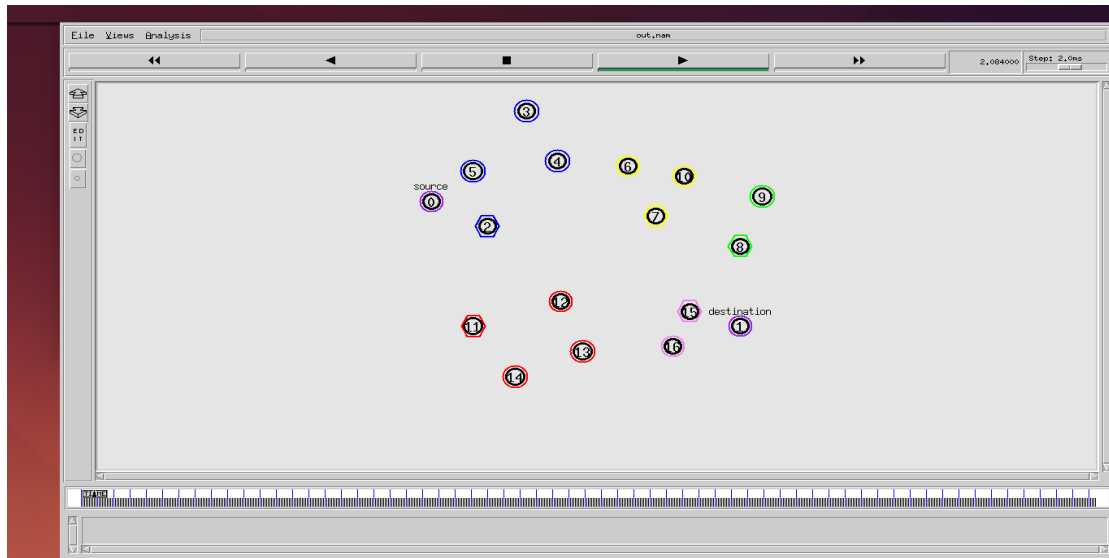


Fig 6

3.3 AREA COVERAGE

The area coverage is the range of each node. Here each node covers the range of 120 mts. It is illustrated in fig 7

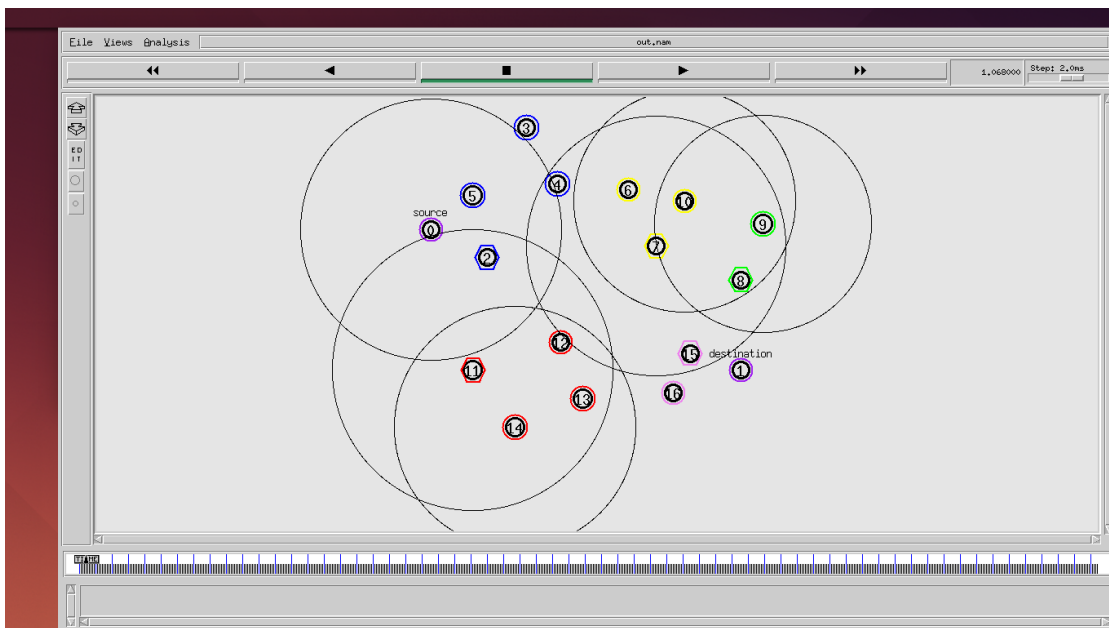


Fig 7

3.4 PACKET DELIVERY

Packet delivery is the final stage of this process where the shortest path is identified and packet is transferred to the destination node by directional flooding. Here the shortest path route is 0-11, 11-15 and 15-1. It is illustrated in fig 8.

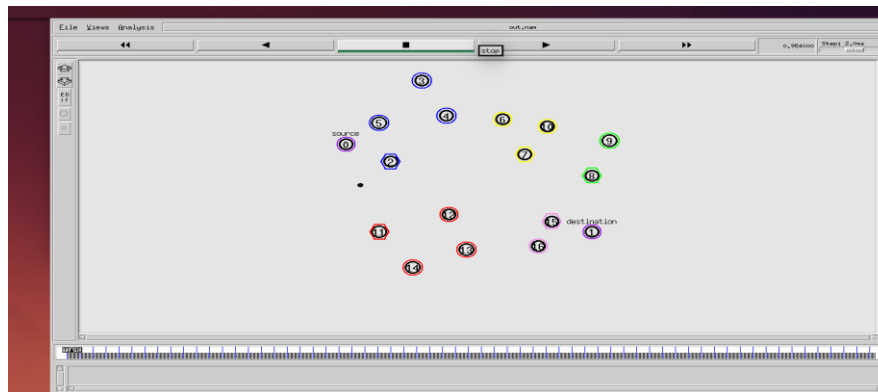


Fig 8

In this way the packet is transmitted to the destination node from the source node by adaptive routing protocol. The performance of ARP is analyzed from the evaluation metrics which is discussed in next section.

IV.SIMULATION RESULTS

This section presents some preliminary results that prove the validity of our design in the networks. The parameters used to configure the simulation are residual energy, packet delivery ratio, end to end delay and throughput. For better understanding we made a comparison between existing and proposed system performances. (In the below figures, red line indicates proposed system and green line indicates existing system)

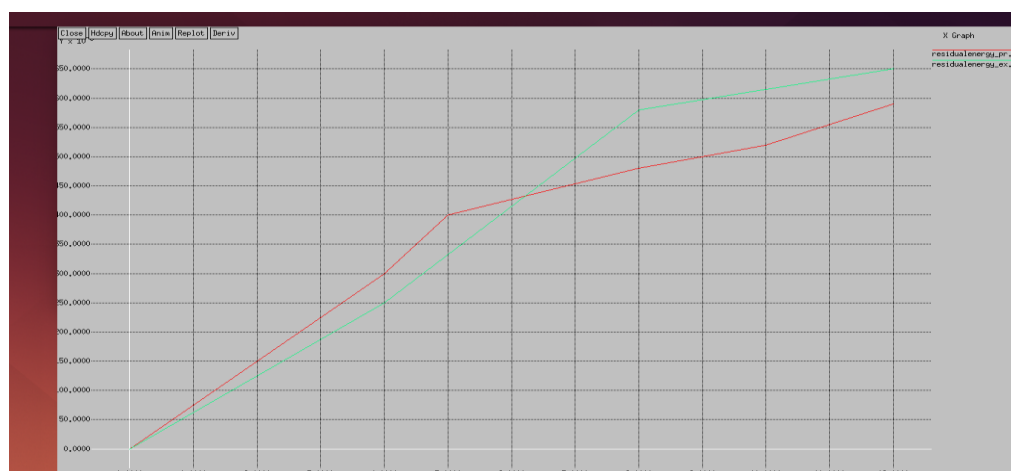


Fig 9-RESIDUAL ENERGY

In fig 9 compared to existing system the residual energy starts increasing and after a certain point it gets decreased. This shows the energy consumption is low in the proposed system.

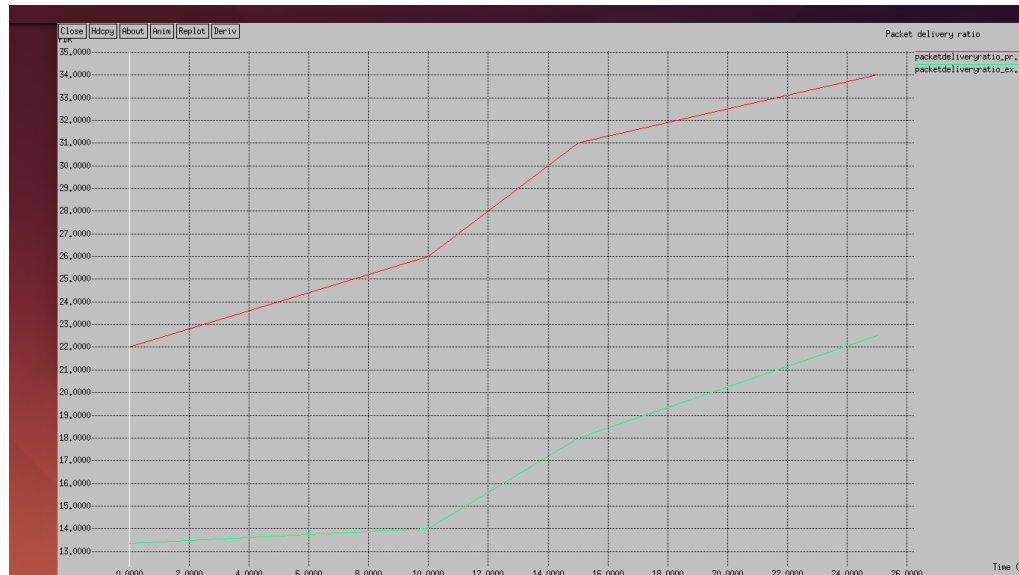


Fig 10-PACKET DELIVERY RATIO

In fig 10, the proposed system's packet delivery ratio is very high when compared to the existing system. This implies that packet loss is greatly reduced and achieving lower error rates.

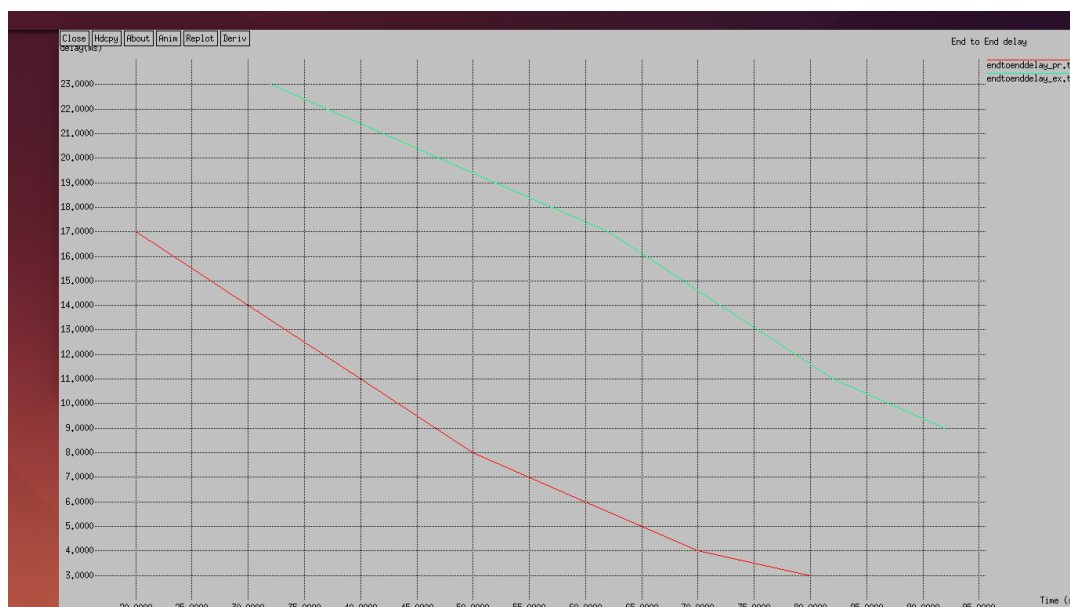


Fig 11-END TO END DELAY

In fig 11, the end to end delay is very less compared to existing system. This indicates that the path discovery is faster in the proposed system i.e. the time taken for a packet to be transmitted across a network from source to destination is faster.

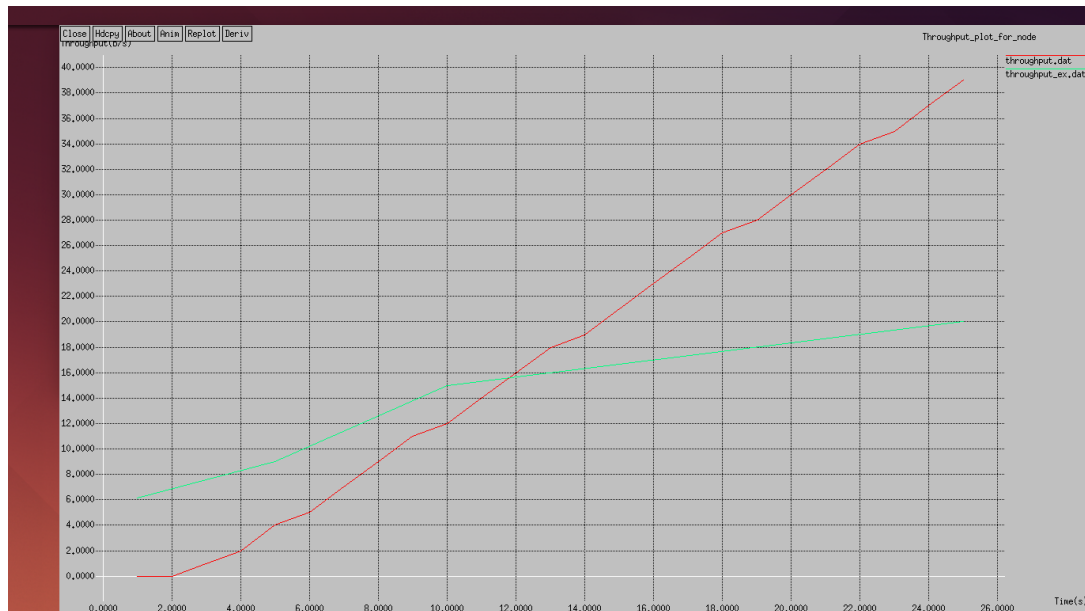


Fig 12 -THROUGHPUT

In fig 12, Maximum throughput is obtained when compared to existing system which indicates successful packet delivery i.e. message is transmitted successfully over a communication channel.

From the simulation results the performance of proposed system is analyzed. Thus it achieves lower end to end delivery delay, lower packet loss delivery, minimal energy consumption and maximum throughput. Thus from all the above considerations it allow us to conclude that ARP is able to correctly handle dynamic network scenarios.

V. CONCLUSION

In this paper we presented ARP as an efficient resource-aware reliable routing protocol plays a significant role to ensure successful data transfer from sensors to the sink to fulfil the different application requirements in dynamic environmental conditions such as oceanographic data collection, water monitoring, offshore exploration, disaster prevention and assisted navigation. Thus this robust energy-efficient adaptive routing technique is based on physical distance of nodes to sink, residual energy of nodes, link quality and packet characteristics. From the experiments, it is clearly explained that it aims to reduce unnecessary transmissions, implement energy balancing and adapt themselves to the packet and network conditions. The simulation results show that ARP achieves lower error rates, less energy consumption, less end-to-end delivery with maximum throughput when compared to existing system. Even though the proposed system's overall energy consumption is less, it consumes more energy initially for clustering of nodes. The simulations were used as a starting point to design and perform real world field experiments using routing metrics provided by ARP. The experiments also confirmed that the ARP's ability to handle dynamic network topologies involving link quality variations, the insertion and removal of network nodes. Based on the simulation and experimental results, we conclude that ARP is a feasible solution for underwater acoustic networks.

REFERENCES

- [1]]Giovanni Toso, Riccardo Masiero, Paolo Casari, Maksym Komar, Oleksiy Kebkal ,Michel Zorzi, "Revisiting source routing for underwater networking: The SUN protocol" IEEE Access(Volume PP) Issue 99 , December 2017
- [2] G. Toso, R. Masiero, P. Casari, O. Kebkal, M. Komar, and M. Zorzi, "Field experiments for dynamic source routing: S2C EvoLogics modems run the SUN protocol using the DESERT Underwater libraries," in Proc. MTS/IEEE OCEANS, Hampton Roads, VA, Sep. 2012.
- [3] M. Zorzi, P. Casari, N. Baldo, and A. F. Harris III, "Energy-efficient routing schemes for underwater acoustic networks," IEEE J. Sel. Areas Commun., vol. 26, no. 9, pp. 1754–1766, Dec. 2008.
- [4] R. Otnes, A. Asterjadhi, P. Casari, M. Goetz, T. Husøy, I. Nissen, K. Rimstad, P. Van Walree, and M. Zorzi, Underwater Acoustic Networking Techniques, ser. SpringerBriefs in Electrical and Computer Engineering. Springer, 2012.
- [5] Y. Bayrakdar, N. Meratnia, and A. Kantarci, "A comparative view of routing protocols for underwater wireless sensor networks," in Proc. IEEE OCEANS, Santander, Spain, Jun. 2011.
- [6] N. Li, J. Martinez, J. M. Meneses Chaus, and M. Eckert, "A survey on underwater acoustic sensor network routing protocols," MDPI Sensors, vol. 16, no. 3, Mar. 2016.
- [7] R. W. L. Coutinho, A. Boukerche, L. F. M. Vieira, and A. A. F. Loureiro, "Geographic and opportunistic routing for underwater sensor networks," IEEE Trans. Comput., vol. 65, no. 2, pp. 548–561, Feb. 2016.
- [8] M. Goetz, S. Azad, P. Casari, I. Nissen, and M. Zorzi, "Jammingresistant Multi-path Routing for Reliable Intruder Detection in Underwater Networks," in Proc. ACM WUWNet, Seattle, WA, Nov. 2011.
- [9] C. Tapparello, P. Casari, G. Toso, I. Calabrese, R. Otnes, P. van Walree, M. Goetz, I. Nissen, and M. Zorzi, "Performance evaluation of forwarding protocols for the RACUN network," in Proc. ACM WUWNet, Kaohsiung, Taiwan, Nov. 2013.
- [10] Ian F. Akyildiz, Dario Pompili and Tommaso Melodia, "Underwater acoustic sensor networks: reserch challenges," Journal of Ad Hoc Networks (Elsevier), Vol. 3, No. 3, pp. 257-281, March 2005
- [11] Ethem M. Sozer, Milica Stojanovic, John G. Proakis, "Underwater Acoustic Networks," IEEE Journal of Oceanic Engineering, Vol. 25, NO. 1, January 2000
- [12] Y. Noh, U. Lee, P. Wang, B. S. C. Choi, and M. Gerla, "VAPR: Voidaware pressure routing for underwater sensor networks," IEEE Trans. Mobile Comput., vol. 12, no. 5, pp. 895–908, May 2013.
- [13] M. Tariq, M. S. Abd Latiff, M. Ayaz, and M. Z. Abbas, "Beacon-based routing protocols for underwater acoustic sensor networks," Wiley Int. Journal of Commun. Syst., Aug. 2017.
- [14] R. Diamant, P. Casari, F. Campagnaro, and M. Zorzi, "Routing in multi-modal underwater networks: a throughput-optimal approach," in Proc. WCNEE (IEEE INFOCOM Workshop), Atlanta, GA, May 2017.
- [15] R. W. Coutinho, A. Boukerche, L. F. Vieira, and A. A. Loureiro, "Modeling and analysis of opportunistic routing in low duty-cycle underwater sensor networks," in Proc. ACM MSWiM, Cancun, Mexico, Nov. 2015

- [16] N. Kanthimathi and Deje, "Balanced and multi-objective optimized opportunistic routing for underwater sensor networks," Springer Wireless Personal Communications, vol. 94, no. 4, pp. 2417–2440, Jun. 2017.
- [17] M. A. Rahman, Y. Lee, and I. Koo, "EECOR: An energy-efficient cooperative opportunistic routing protocol for underwater acoustic sensor networks," IEEE Access, vol. 5, pp. 14119–14132, Jul. 2017.
- [18] R. W. L. Coutinho, A. Boukerche, L. F. M. Vieira, and A. A. F. Loureiro, "Design guidelines for opportunistic routing in underwater networks," IEEE Commun. Mag., vol. 54, no. 2, pp. 40–48, Feb. 2016.
- [19] W.-G. Seah and H.-X. Tan, "Multipath Virtual Sink Architecture for Underwater Sensor Networks," in Proc. IEEE OCEANS, Singapore, 2006.
- [20] S. Azad, P. Casari, and M. Zorzi, "Multipath routing with limited cross path interference in underwater networks," vol. 3, no. 5, pp. 465–468, Oct. 2014.