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Analysis of ACE and EACE Protocols in Underwater Wireless Sensor Networks

Rajini S*, Dr. M Ramakrishna**

*Assistant Professor , Dept. of IS&E , Vidyvardhaka College of Engineering, Mysuru, Karnataka, India
**Professor & Head, Dept. of CS&E,Vemana Institute of Technology, Bengaluru,Karnataka, India
(*Corresponding author's e-mail: rajinis2021@gmail.com)

Abstract— Underwater Wireless Sensor Networks (UWSNs) are extremely significant in running every type of duties underwater. Dependable and effective communication among sensor nodes is extremely stimulating. Initially, since radio waves can't function fine in such atmosphere, so we utilize acoustic communication. Secondly, acoustic communication is extremely slower compared to radio communication. Furthermore, atmosphere is extremely dynamic, that transforms topology of network. Because of these motives information can't spread to destination timely or dependably. This generates necessity of method that can advance functioning of network in terms of dependability and quantity. Cooperation among nodules is one of main methods that can significantly improve dependability of network at price of extra energy ingesting. In this paper, we are focusing on ACE (Adaptive Cooperative Retransmission in EEDBR) Protocol and EACE (Enhanced Adaptive Cooperative Retransmission in EEDBR) protocols for improving the functioning regarding network lifetime, energy efficiency, throughput, relay, packets delay compared to other cooperative routing protocols.

Index Terms— UnderWater Wireless Sensor Networks, Cooperative routing protocols, ACE, EACE protocols.

I. INTRODUCTION

Underwater Wireless Sensors Networks (UWSNs) possess functions such as temperature supervising, submarine supervising, salinity, pollution supervising and so on. Consequently these functions have requested scientists to watch problems which are extremely challenging for tremendously functioning of UWSNs. These disputes comprise delay, packet drop, bit error rate, interference etc. Without concentrating these subjects in UWSNs we can't utilize these networks as per our necessities. Furthermore resources such as time and energy can't be utilized capably since resources such as battery of sensor nodules are extremely restricted in such atmospheres.

UWSN are modern wireless technology where minor size sensors are deployed at different depths where these nodes have limited power, memory and bandwidth. Sink nodules are positioned on surface of water as revealed in Fig 1.

Progressions of technology outcomes in fast development of underwater network functions like ocean sampling, coastal areas scrutiny, pollution scrutinising and aided course-plotting. For apply specified uses in under water atmosphere, Underwater Wireless Sensors Networks are extensively utilized [1]–[2]. In these networks, extensive variety of sensor nodules is positioned underwater. In marine atmosphere, radio and optical signals don't spread correctly because of which it faces absorption difficulties. Because of severe adjacent circumstances, UWSNs confront specific restraints like additional stoppage, frequency limits, small information degree and incapability to refill nodules' batteries [3]– [5].

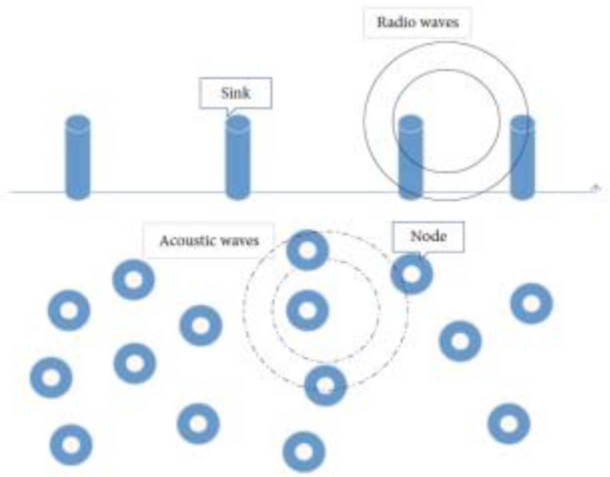

Fig 1: Underwater sensor network architecture

Therefore, restricted battery volume of nodules and complication of restoring nodule energy in marine atmosphere are main boundaries of Underwater Wireless Sensors Networks [6]–[8]. To overwhelm the subject, nodules' energy wants to be capably used for improving network lifespan. Routing procedures is significant in reserving nodules' energy, nevertheless, growth of energy-aware routing procedures for Underwater Wireless Sensors Networks is stimulating job [9]–[11].

Cooperative routing is capable method to improve network lifespan in such a severe atmosphere [12], [13]. This routing system is appropriate for refining energy efficacy and lessening interruption as related to other routing methods like multi-hop method [14]. Choice standards of relay and destination nodules hinged on limits such as remaining energy, link superiority and depth of sensor nodules. Furthermore, logical categories of network, sink nodules' placement and messenger nodules' flexibility designs disturb network functioning in Underwater Wireless Sensors Networks. Consequently, suggesting and scheming supportive routing method which contemplates every above conversed feature in ideal method, is challenging job.

Bulk of cooperative interaction devices in Underwater Wireless Sensors Networks are planned to attend physical and Medium Access Control (MAC) levels matters; nevertheless, network level has mainly been ignored. Elementary reason of cooperative communication systems is to advance dependability and link superiority in underwater punitive atmosphere. While, projected analysis acquires benefit to utilize this method at network level to improve network lifespan. Furthermore, dependable information distribution is one of main matters in marine atmosphere. For this reason, depth-founded routing is recommended for sustaining dependability and quantity. A few supportive routing structures utilize mobile sinks to progress packet delivery ratio [15]; nevertheless, this upsurges network charge. While, using courier nodules is improved choice to decrease this price.

Collaboration is characterized as the demonstration of cooperating for a typical reason. Cooperative routing is carried out in UWSNs as this brands routing system extra effective compared to different methodologies, for example, multi-trusting. In agreeable steering, the information signal is sent by source hub to objective hub and is additionally over-headed from transfer hubs. Relay hubs convey information messages to the objective by transferring measure.

The relaying system plots which are utilized at relay hubs are Amplify and Forward (AF) and Decode and Forward (DF). In Amplify and Forward, transfer hub intensifies specified sign and communicates this to objective. In DF, transfer hub adjusts the sign and communicates this to objective. Equivalent Gain Combining (EGC) procedure is variety joining strategy that is utilized at objective hub to work on nature of information signal. [16]

1.1 Applications

UWSN technology can substitute conventional methods by presenting instantaneous supervising, an aground scheme for controlling underwater applications slightly, and progressive appliances for information logging. Usually, UWSN uses are comprised of 3 groups: scientific, industrial, and military and safety. In military, sensor nodules are utilized for detecting the traffic of rivals and their position. This can be used for monitoring docks and harbours, manage borderline observation, recognize underwater mine positions, and sense rival submarines. In the situation of natural calamities, sensor nodules can sense aquatic atmospheres from executing seismic supervising beforehand of calamities.

An extensive variety of uses needs fast growths in norms and technologies for supporting and improve the development of novel functions. Although, there are numerous diverse functions, this unit gives a review of fresh growths in the area of UWSN functions, that are helping in technical, industrial, and security and calamity inhibition actions.

II. LITERATURE REVIEW

In [17], authors have focused on perfect bunching for UWSN compatible with every wave-based wave communication procedures of FSO (free space optics), audio and electromagnetics. Also, they recommended d generacy prototype for energy of sensor nodules in Free Space Optical and communication supported on Electromagnetic wave sand contrasted it with current degeneracy prototype of energy for communication founded on audio. In precise, suitability of 3 above-stated underwater interaction approaches is discovered and writers contrasted their efficacy founded on use of energy and perfect bunching.

In [18], Underwater wireless sensor networks learning is achieved on underwater communication network, ecological variables, position, media access control, routing procedures, and communication consequences of packet dimensions. They contrasted existing practices and attended their advantages and disadvantages for additional development in UWSNs for highlighting new learning instructions.

In [19], authors projected a plan that utilizes the energy aware cooperative system (EAC) with flexible depth threshold (Dth). The proposed plot utilizes "transmission class " of hubs. Determination of source hub depended on streamlined Dth. Besides, in view of dynamic neighbors, source hub was adjusted. While choosing the objective hub, it should fall outside the Dth. Moreover, the determination of relay and objective hubs depended on hub's depth, energy remaining and nature of connection amid hubs.

In [20], EEDBR creators create receiving hub model. That is while choosing collector hub sender considers depth just as outstanding energy of getting hub. Energy and profundity data is divided among hubs in this plan. Hub keeps a rundown of hubs which are at inferior profundity than itself. Rundown is arranged in such manner that hub at initial situation in register contains advanced remaining energy. Primary hub in register advances the parcel quickly, if residual hubs catch similar packet inside a holding period, packet is released.

In [21] creators introduced that 2 relay nodules and an expert nodule is chosen for broadcast of info from source to sink. Expert hub is chosen amid adjoining hubs that has short depth, great remaining energy and should rest outside edge characterized. Based on profundity edge of source hub and expert hub, 2 hand-off hubs are chosen for retransmission component. Simulation outcomes depict that IACR accomplishes improved outcomes regarding bundle acknowledgment proportion, throughput, network lifespan and parcel fall when contrasted with ACE.

In [22], creators introduced that energy skilled cooperative routing plan called as Region Based Courier hubs Mobility with Incremental Cooperative (RBCMIC) steering. Projected plot utilizes transmission quality of remote hubs and plays out a gradual agreeable steering. A thorough assessment and confirmation of proposed plot having present status of-the-workmanship production further developed energy proficiency, bringing about broadened network lifespan. Outcomes display that a general enhancement of 20% is seen in energy use, while an eminent 89% enhancement is accomplished in start to finish delay in contrast with DEADS procedure.

III. PROPOSED WORK

The proposed research work is given below:

1. ACE (Adaptive Cooperative Retransmission in EEDBR) Protocol.

Here, we proposed a protocol called ACE (Adaptive Cooperative Retransmission in EEDBR). In ACE procedure, retransmission method is integrated in supportive way for improving dependability of a current routing procedure called Energy efficient depth based Routing (EEDBR).

Here, we suggest section founded cooperative routing for Underwater Wireless Sensors Networks. Three kinds of nodules are present. Source, destination and relay as revealed in fig 2. Primary transmission is by equal section. If whichever destination nodule not obtains information, or obtains mistaken information nonetheless assistance is attained by instant section and relay nodule by cooperate section retransmits that info.

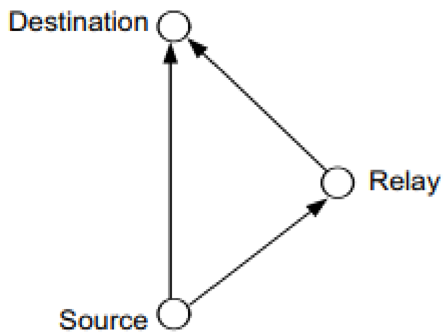

Fig. 2. Basic mechanism

Following are stages of projected structure

A) Information exchange stage

B) Route Establishment stage

C) Data transmission

A. Information exchange stage

Here, every nodule transmits their info through hello packet. This comprises profundity info, remaining energy and identification of sender nodule. Every nodule sustain chart of neighbours. In chart short profundity and greater remaining energy nodules are registered. Region is separated in 4 sections known R1, R2, R3, plus R4. Section one nodules only sustain info of neighbours which are by R1 plus R2. Correspondingly R2 nodules retain info of neighbours by R2 plus R1. R3 nodules retain info of neighbours by R3 plus R4 plus the other way around. These are communicated occasionally so that info around neighbours in register is restructured. Set-up of these packet is revealed in Figure 3.

ID of node	Depth	Residual energy

Fig. 3. Hello packet format

B. Route establishment phase

When neighbours are placed upon bottom of profundity and remaining energy subsequently each nodule chooses destination nodule which is from equal section. Another neighbour is chosen as relay nodule plus which nodule eavesdrop information which is directed from source nodule to destination nodule. Like this, multi-hop trail is created from source to sink. Reason of specific stage is choosing neighbour which is designated for information advancing and nodule which will perform as relay. Nodule sustains a record of neighbours. Register is displayed in fig.6. This register is founded upon ratio of energy to profundity of precise nodule. Register is organized on bottom of this proportion in plunging arrange. Hereafter nodule at 1st state in this record is highly effective plus appropriate neighbour. Like this, primary nodule of this record is destination nodule and second nodule of record is relay nodule. Each nodule achieves this activity till sink is in reach of nodule. Like this, multi-hop route is recognized by deepest nodule to sink.

As area is separated in sections thus each route will contain hops of only 2 units e.g section 1 and section 2 or section 3 and section 4. Fig 4 displays how nodule sustains a record of neighbours.

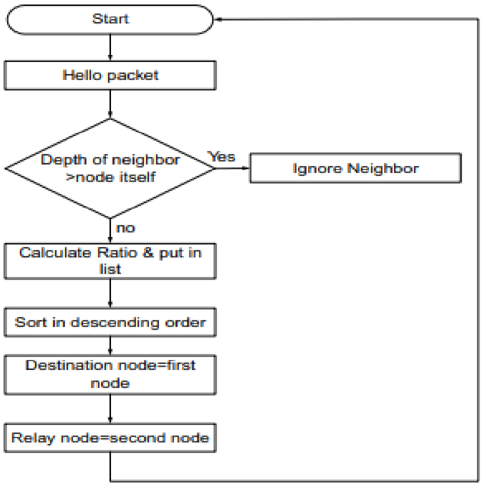

Fig. 4. Neighbour list

C. Data transmission

Here, nodule advances information to primary destination nodule that is from equal area and chosen in above stage. Relay nodule will eavesdrop information. At once destination nodule will treat information and this will compute BER of information. If that is greater than 50% thenceforth NACK is directed to relay nodule. We suppose that source nodule and relay nodule are conscious of each other. If neither NACK, nor ACK is obtained by destination nodule till clock perishes subsequently that relay nodule will retransmit duplicate of that packet to destination nodule. If BER is fewer than 50% after which this will receive the information and +ve signal is directed to relay nodule. If again BER is superior than 50% after which information is released from destination nodule. When relay nodule obtains this signal, this rejects information as this is positively obtained from destination nodule. After that, destination nodule will more advance to their skilled forwarders. Method is revealed in Fig 5.

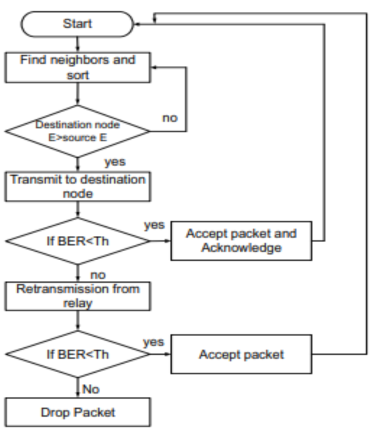

Fig. 5. Data transmission

Adaptive Cooperative retransmission Algorithm

Initialization: Initialize $E_2^{\varepsilon}(s)$which is the energy threshold value of the nodes belonged to E_2 and $E_3^{\varepsilon}(s)$ which is the energy threshold value of the nodes belonged to E_3.
repeat
  determine the set of candidate relay nodes between two adjacent routers along the route
  for every node **in** the candidate relay set
  repeat
  if $E \in E_1$ **then**
    The node cannot run RL.
  else if $E \in E_2$
    if $E_{rem} > E_2^{\varepsilon}(s)$ **then**
      The node is used to maintain routing tables.
      The node runs RL to obtain the current knowledge of $C_{rd}(t)$ 1dnd $C_{dd}(t)$.
      Update $E_2^{\varepsilon}(s)$ according to the selected β by the agent
    else
      The node cannot be used to run RL.
    end if
  else if $E \in E_3$
    if $E_{rem} > E_3^{\varepsilon}(s)$ **then**
      The node is used to maintain routing tables.
      The node runs RL to obtain the current knowledge of $C_{rd}(t)$ and .$C_{dd}(t)$
      Update $E_3^{\varepsilon}(s)$ according to the selected β by the agent
    else
      The node cannot run RL.
    end if
  end if
  weigh the $C_{rd}(t)$ and $C_{dd}(t)$ of the node to determine whether it can be a relay node, and return its transmission mode to RL system, i.e., direct transmission mode or relay transmission mode
  until all the candidate relay nodes are traversed once
  The remaining energy of nodes E_{rem} is known as is mentioned in Section III.
until equal the sink
create an optimal alternative path
end

3.2 EACE (Enhanced Adaptive Cooperative Retransmission in EEDBR) Protocol.

Here, we projected a procedure called as Enhanced Adaptive Cooperative Retransmission in EEDBR (EACE). EACE is presented as replacement of an already present procedure known Adaptive Cooperation in EEDBR (ACE). EACE advances dependability and network lifespan that's was formerly attained in ACE.

This unit gives system model and functioning of projected system.

In this system, source nodule directs information shape three courses,

i) Source node to destination node,

ii) Source node to relay1 to destination node and

iii) Source node to relay2 to destination node.

Destination nodules collect information packet by source nodule and in certain circumstances obtain by relay nodules. These circumstances are discoursed in particular in procedure operation segment.

A. System Model

This comprises of nodules which are arbitrarily organized and operate as whichever source, destination or relay nodules. Fig. 6 displays projected system model. Links which join these nodules agonize Ray Leigh Fading (RLF) and Additive white Gaussian Noise (AWGN). Modulation structure we utilized in our structure is Binary Phase Shift Key (BPSK). At destination nodule, signals which are accepted are prejudiced with reverence to its signal-to-noise proportion and nonetheless totaled. This method is founded on supposition that every nodule is coordinated with each other. Because of restricted broadcast reach, information packet is directed by source to sink in multi-hop method.

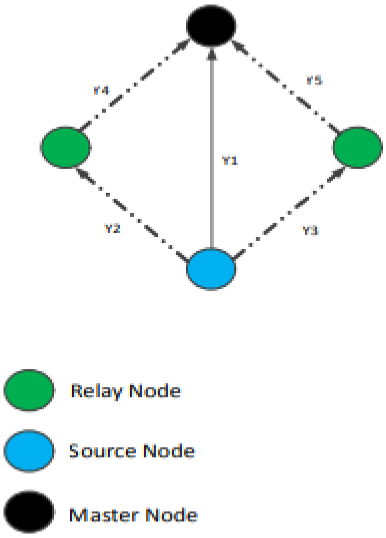

Fig. 6. System model

Universal mathematical model for projected system is granted from equation 1:

$$Yn = Xgn + Nn \text{ ……………………………(1)}$$

I n which n=1,2,3,4,5. X is original signal directed by source nodule, Y is received signal at nodules, N is channel noise and g is gain of channel.

B. Protocol Operation

This unit exhibits functioning of our projected system. This protocol functions in rounds and in each round every nodule communicates information.

Each round contains of 3 stages:

1) Initialization Stage

2) Route Establishment Stage

3) Data Forwarding Stage

1) Initialization Stage:

Here, every nodule transmits hello packet inside its broadcast limit. Hello packet contains source identification, profundity and remaining energy. Every nodule transmits its profundity and remaining energy data to extra nodules inside their broadcast limit. On foundation of this data, neighbours are recognized. This procedure is replicated for every nodule and record is sustained at every nodule comprising data of local neighbours.

2) Route Establishment Phase:

Here, track is created from source nodule to sink. This stage contains 2 significant purposes: primary is recognition of succeeding stop and subsequent one is choice of relay nodules. Source nodule recognizes neighbours on foundation of profound info. Nodules which contains lower profundity compared to source nodule are trained forwarders for information forwarding. These nodules are comprised in forwarding record of source nodule. Nodules which have bigger profundity compared to source nodule are ignored. For choice of succeeding stop, master nodule is chosen by forwarding record. In this procedure, nodule succeeds to develop master nodule that contains lower profundity nonetheless outside the limit demarcated and contains great residual energy. Afterward choice of master nodule, following stage is choice of supportive nodules. Supportive nodes are recognized from nodules which rest in supportive area. From cooperative nodules, 2 finest nodules (which contain lower profundity, great residual energy and should rest outside limit of both source nodule and master nodule) are designated as relay nodules as disclosed in Figure 7. So as to regulate amount of relay nodules included in packet forwarding, profundity limit is outlined.

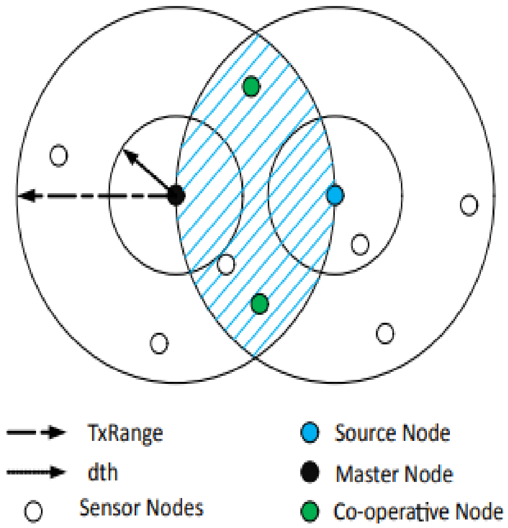

Fig. 7. Cooperative region and relay nodule choice

3) Data Forwarding Phase:

Here, information is advanced by source to sink at way which is formed in route formation stage. Source nodule advances information packet to master nodule and to relay nodules. Relay nodules stores information packet for specific quantity of period, which is called as holding time. At relay nodules, this time for packet is computed, founded on contrast among intensity of source nodule and intensity of relay nodule itself. Subsequently finishing of holding time, relay nodule throw-outs information packet. Every link throughout packet advancing grieves declining because of which BER is presented. Information obtained at master nodule is contrasted with fundamental information directed by source nodule and BER is computed. Threshold T is demarcated for BER. If BER is less or at level to T, information packet is received and control packet is directed to both relay nodules and these release information packet even if holding time is not perished. Instead, if BER is bigger compared to T, master nodule directs -ve acceptance to relay nodules plus if holding period of any of relay nodule isn't finished after that information packet is advanced to master nodule or else process will be sustained with one more source nodule. Information which is directed by relay nodules to master nodule is advanced on foundation of AF method. At master nodule, signals obtained by source nodule and by relayed nodule are united utilizing EGC method so as to decrease disappearing and BER is equated each stint signal is obtained. Choice of relay nodules each stint progresses functioning and lifespan of network although as source nodule directs a solitary information packet via 3 routes consequently mean end to end delay rises.

IV. RESULTS

Experimental results of ACE and EACE procedures in Underwater Wireless sensor Networks based applications are shown beneath:

4.1. ACE Protocol

In this work, we have allowed up to 4 retransmission from relay nodes.

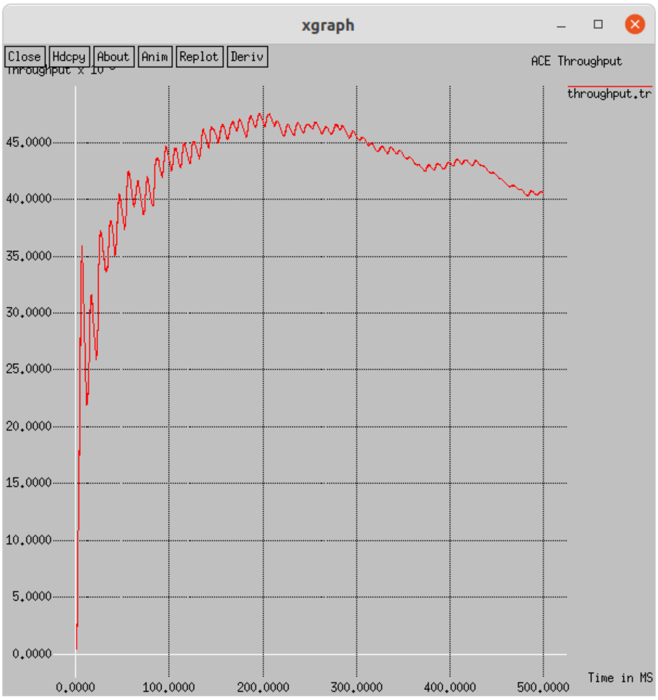

Fig 8: ACE Throughput

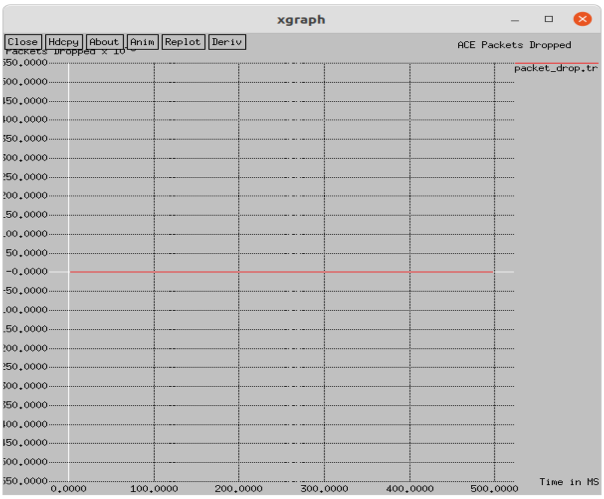

Fig 9: ACE Packets Dropped

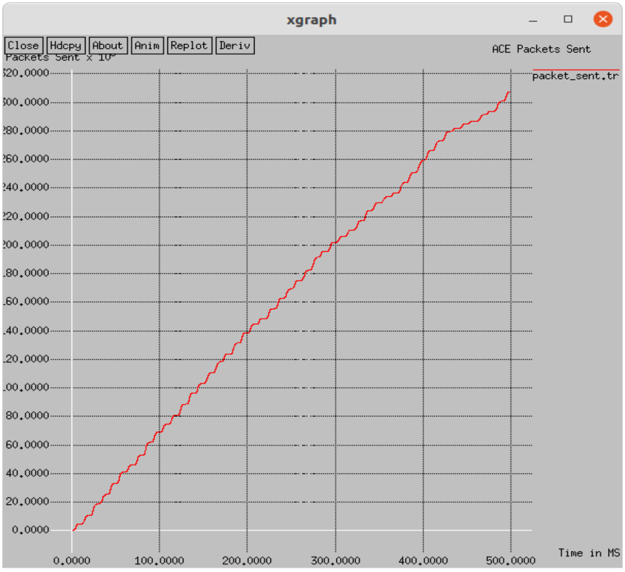

Fig 10: ACE Packets Sent

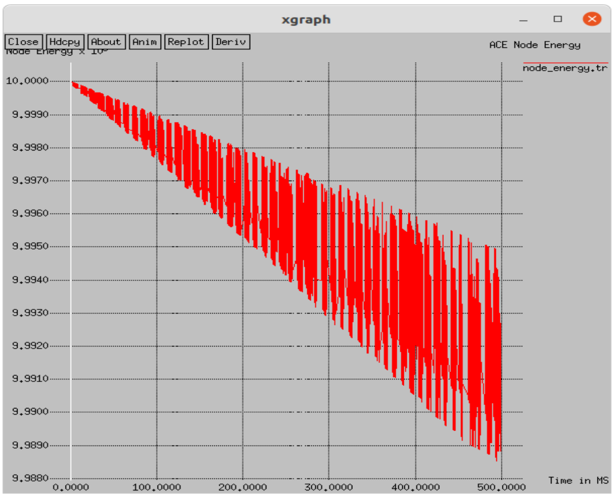

Fig 11: ACE Node Energy

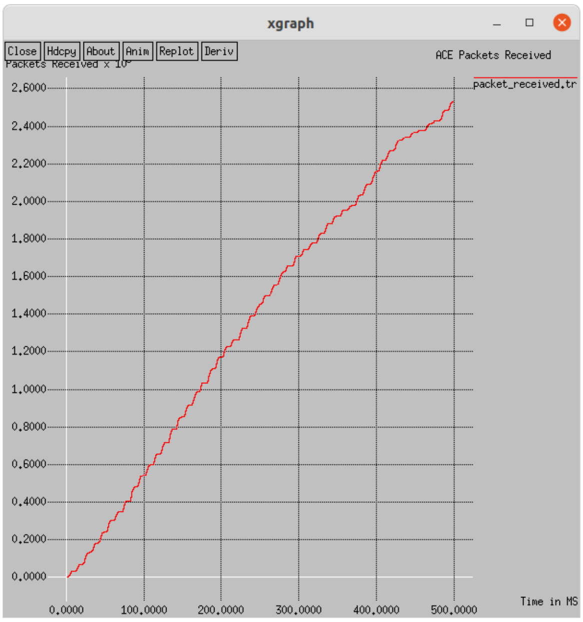

Fig 12: ACE Packets Received

4.2. EACE Protocol

In this work, we have allowed 'n' number of retransmission by relay nodules. Amplified quantity of retransmission aids in achieving extra reliability and throughput of network to increase throughput efficiency.

Added check for TTL for each relay node to avoid excessive power consumption.

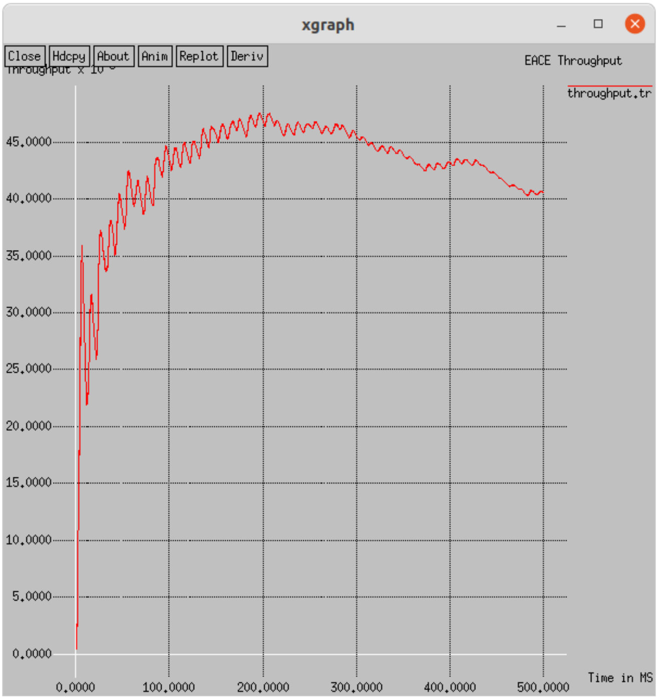

Fig 13: EACE Throughput

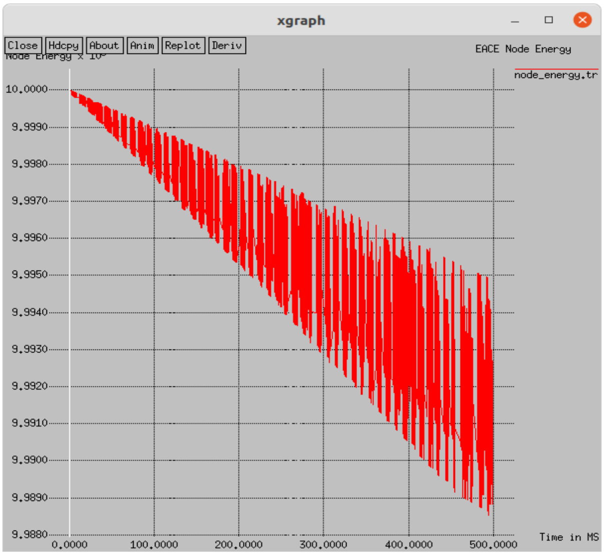

Fig 14: EACE Node Energy

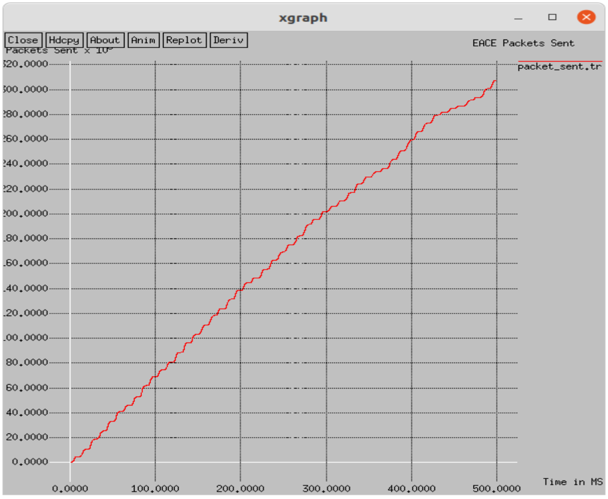

Fig 15: EACE Packets Sent

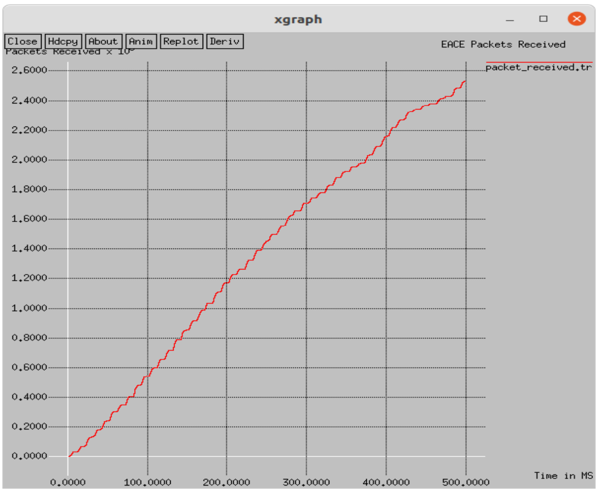

Fig 16: EACE Packets Received

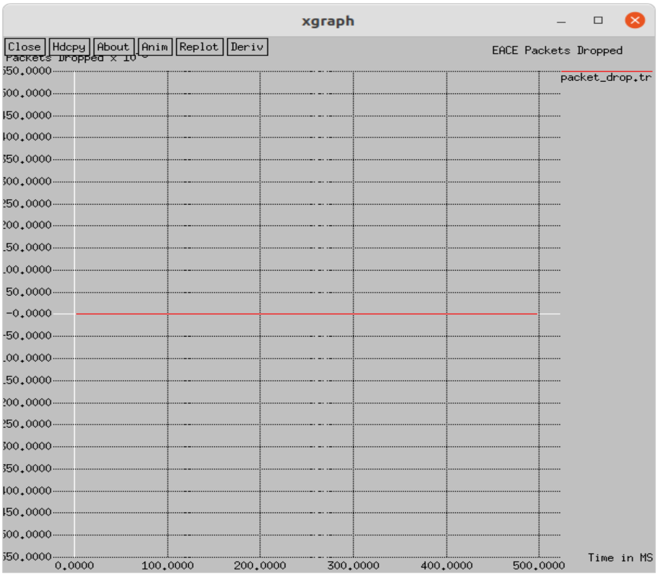

Fig 17: EACE Packets Dropped

V. CONCLUSION AND DISCUSSION

In Underwater Wireless Sensor Networks (UWSNs), dependability is a significant influence that influences complete functioning of network. As underwater atmosphere is deafening and because of multipath fading and poor link quality, dependability of network and information uprightness is influenced. By supportive routing, dependability and uprightness of information is enhanced. Thus, here, we discussed ACE (Enhanced Adaptive Cooperative Retransmission in EEDBR) Protocol and EACE (Enhanced Adaptive Cooperative Retransmission in EEDBR) protocols and concluded that the operation in terms of functioning, dependability, efficacy, period of network in weak link quality and in noisy underwater atmosphere is improved as linked to other cooperative routing procedures.

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