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Reliable efficient cluster routing protocol based HTDE scheme for UWSN

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ABSTRACT

Underwater sensor networks (UWSNs) are recently recognized as a promising method for monitoring and exploring the underwater environment. Due to real-time remote data monitoring requirements, UWSN has become a preferred network to a large extent. But reliable and efficient secure data transmission to the receiver is one of the most important challenges for UWSNs, often suffer from irreplaceable batteries and high latency for long-distance communications. The most challenging task is extending network life, shortening transmission distances for each node. Thus, this paper presents the reliable efficient cluster routing (RECR) protocol, optimal shortest path finding (OSPF) algorithm and hill transformation data encryption (HTDE) algorithm for UWSNs. The proposed encryption algorithm encrypts the data from the source node, and the RECR protocol is used for reliable data delivery from source to destination. To extend the network's life, RECR employs autonomous underwater vehicle (AUV) from the sink node (SN) for data collection. The OSPF algorithm is used to find the shortest path for data transmission to avoid latency. The proposed RECR protocol, HTDE and OSPF algorithm enhance the secure data transmission efficiency, minimizing the energy consumption and improves the network life time. The proposed protocol decreases end-to-end latency, packet loss.

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1. INTRODUCTION

Underwater wireless sensor networks (UWSNs) consist of many wireless sensor nodes distributed in a marine environment that support various applications such as surveillance, navigation, data acquisition, and resource exploration. The responsibility of the sensor node is to monitor the underwater environment, like temperature, and send the collected data to the sink node (SN) via a single hop or multiple hops. Each node and select a group of candidate nodes transmit data to sink node in the data transfer process. According to various priorities and criteria, a candidate node is selected as the next forwarding node.

Each node selects a group of candidate nodes to send data to the candidate node or sink node during the data transfer process. Candidate nodes are selected as the next forwarding node according to various priorities and criteria. The standard is based on the effective energy or link quality of the node's transfer selection to determine the use of the indicator. The data can then be transferred to the destination through the highest priority node.

The location of underwater nodes is much more difficult than wireless terrestrial networks. Underwater networks are dynamic and flow freely with ocean current nodes. This allows the position to change frequently. Finding and locating nodes leads to high energy consumption in the network. It is a difficult task in an unpleasant environment with water due to the operation of the underwater node, which has to charge or replace the battery of the limited energy node.

The operation of an underwater communication node with limited energy and charging or replacing the node's battery is a demanding task because of the unpleasant environment with water. From cluster data transmission to the sink node, one must note the attention to the intermediate node. Each cluster head acts as a bridge between the receiver and the cluster to transmit large amounts of data. However, repetitive data transmissions gradually run out of energy in the intermediate nodes, and this method makes their lives shorter than other nodes, resulting in loss of connectivity.

Cluster analysis is powerful, and it means the most effective way for energy-saving in UWSNs. In reality, a cluster refers to the position of a sensor node in another category called a cluster. The cluster head (CH) assigned to each cluster is the leader of the member nodes of that cluster. The CH assembles the data from the sensing data of the member node, combines the collected data, and then sends the processed data to the adjacent CH or SN.

Figure 1 defines the cluster based architecture of UWSNs in CH manages each cluster. Other nodes operate as a member of the cluster. CH can transfer collected data to the sink node and report their sensing results to reach the neighboring cluster head in a single-hop scheme. The proposed hill transformation data encryption (HTDE) algorithm encrypts the data from the source node reliable efficient cluster routing (RECR) protocol for efficient data transmission process and optimal shortest path finding (OSPF) algorithm to reduce long communication in UWSN. The rest of the paper chapter 2 defines the related work, chapter 3 describe proposed methodology for UWSN, chapter 4 defines the proposed result analysis compared with previous methods, and finally chapter 5 describes the conclusion.

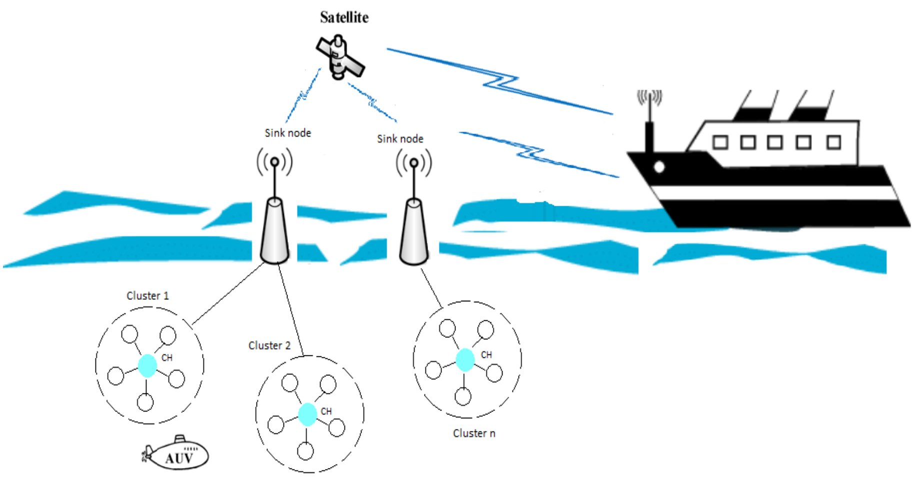

Figure 1. Architecture of UWSNs

2. RELATED WORK

This section describes the previous work of UWSN for various authors discusses different types of methods for data transformation. Hou *et al*. [1], investigates underwater acoustic sensor networks (UASNs) are widely used in underwater data collection and water pollution detection activities. The author proposes energy-balanced unequal layering clustering (EULC) algorithm is used to enhance the energy efficiency (EE) performance. The suggested EULC algorithm is based on the uneven stacking of the depth of the design UASNs node, through the structure of the different sizes of clusters of the same layer offers a solution to the problem of "hot spots". But in that method occur high packet loss and low energy consumption.

Xing *et al*. [2], presents the UASN based on named data networking (NDN) to enhance energy consumption. The battery energy of the sensor node is limited, and the battery is difficult to replace or charge in the underwater environment. Sundarasekar *et al*. [3] uses the adaptive energy-aware quality of service (AEA-QoS) algorithm to reliable data transmission by configuring discrete-time random control process and deep learning technology for UWSAN. However, in that method challenging tasks for energy consumption in the UWASN.

Chen *et al*. [4] expresses the rapid random exploring tree with linear reduction (RRLR) method for better sensing node locations without losing the information. The spatial correlation of the sensor nodes arranged in a large geographic area of interest is minimized. However, mobile sensor node resources are typically limited to large-scale on-site monitoring because they cannot be deployed arbitrarily. Voronoi-based optimized depth adjustment (VODA) has been proposed by Su *et al*. [5]. First, the gateway node collects the coordinates of the sensor node to establish the voronoi diagram. According to this graph, particular sensor nodes are selected to remain on the water's surface, called the primary node. The rest of the nodes will need to sink to different depths to reduce the coverage overlap between the nodes. But in this method didn't provide proper adjust for UASNs.

Harb *et al.* [6] proposes a K-means algorithm based on the analysis of variance (ANOVA) model to identify the node generating the same data set and aggregate these sets before sending it to the receiver. However, that method consumed a lot of energy on the acoustic technology used for underwater communication due to the UWSNs sensor and didn't improve the network lifetime. Detweiler *et al.* [7] discussed a depth adjustment system for waters up to 50 meters deep connection to the aqua-node sensor network node. Depth adjustment systems on underwater sensor networks (USNs) also improve global sensing and communication.

Li *et al*. [8] investigates the underwater optical wireless sensor networks (UOWSNs) to improve the high transmission rate and low latency using distributed multi-agent reinforcement learning routing (DMARL). However, the highly dynamic topology movement of water caused by the limited energy resources has been challenged to provide reliable routing of low consumption in UOWSNs. Karim *et al*. [9] introduces geographic and cooperative opportunistic routing protocol (GCORP) to minimize energy consumption with low time while data transmission. However, the most tedious task in that method is to transfer data with a minimal energy rate in UWSN. Time synchronization for mobile underwater sensor networks (TS-MUWSNs) has been proposed by Pallares *et al*. [10]. The synchronization system is based on bidirectional information exchange between the reference node and the slaves that must be synchronized. But in that method very challenging task, and it takes a lot of time.

Lee *et al*. [11] describes the energy harvesting (EH) technology for extending the communication range between wireless sensor nodes (WSNs). Energy generated from the photovoltaic, thermoelectric generator is coupled to the power wireless sensor nodes. These are mainly driven WSNs, usually battery limited capacity, so it extends the communication range and does not increase network life. Cooperative energy efficient optimal relay selection (CoEEORS) protocol is introduced by Khan *et al*. [12] suggested that the cooperative routing protocol reduces the adverse channel effect in harsh water environments to ensure reliable data packets from the lower distribution on the water's surface. However, that protocol didn't provide proper communication between WSNs.

Qadir *et al*. [13] proposes a cooperative-energy path and channel aware (CoEPACA) and energy path and channel aware (EPACA) protocol for UWSNs. Efficient data transmission using EPACA protocol and CoEPACA is used to analyze the reliability of routing during packet transmissions. However, in that method, the acoustic wave production delays and the small available bandwidth affect the network's reliability, high transmission, and high speed.

Zhang and Cai [14] uses the energy-efficient probabilistic depth-based routing (EEPDBR) algorithm for UWSNs to enhance the depth routing protocol. The key idea of the EEPDBR algorithm is to design an improved probabilistic surface sonobuoy with reliable depth reporting, underwater data requiring remaining energy, and the number of transfers of two-hop adjacent nodes. Liang *et al*. [15] investigates low-latency and high-coverage WDNs limit the number of constraints of a receiver node and the mobile device, and it is a monitoring solution. The suggested solutions, building during high coverage cooperative multi-objective optimization model between the mobile node and the receiving node low latency and probability model tradeoff, are dependent. The mobile node and the receiving node can find the best deployment strategy.

Du *et al*. [16] uses energy balancing for improves the network lifetime. If the sensor node initial energy analyses these two optimization problems, the maximum life difference is small, as shown in the energy balance. This gives a different solution, which is much more than the energy consumed by a single transmission. However, that method occurs high packet loss and time delay during data transmission.

Han *et al*. [17] presents the multi-hop transmission scheme and clustering-based autonomous underwater vehicle (AUVs) to reduce network consumption and maximizing network lifetime for UASNs. However, the data collection plan is high power consumption to cause so in UASNs, serious propagation delay, from those of the WSN to and have significantly different. Chen and Lin [18] hor proposes a 3D zone of reference (3-D ZOR) and AUV to minimize energy consumption and improve the network lifetime. The underwater robot travels to a user-defined path and continuously collects data from a set of 3D ZORs sensors at different times. However, that method leads to data leakage during the transmission.

Ponnan *et al*. [19] proposes a AI based systems to solve the energy crisis in real time WSN. This method increases the latency and life span of the networks. The author proposes an AI quorum which reduces the network latency due to increase in time slots and reduces the energy consumption of the nodes by weighted load balancing improves the life span of the node.

Saravanan and Suresh [20]. presents the energy saving mechanism is been utilized by proper planning to transmit the packets from the nodes using critical and non real information by reading overheads which reduces the throughput and bandwidth in large scale clip networks. Saravanan and Suresh [21] presents the selection of cluster heads by an adaptive and dynamic cluster head selection to resolve the overlapping and non dissipation of energy provides an unneeded choice of cluster head. Proposed mechanism reduces the energy dissipation compared to other systems.

Xing *et al*. [22] proposes a GTC scheme for under acoustic sensor networks to improve the network balance and energy consumption. The cluster head is evenly distributed in the non uniform sectors of network area .Using this scheme the network life time increases by balanced energy. Sathyasri *et al*. [23] presents a novel technique for channel assignment which is used to exploit the multiple non overlapping of channels that improves the capacity and decreases the intervention in the wireless network. This system discussed the channel assignment in large scale mesh networks. Bharathi *et al.* [24] proposes a secure protocol for data transmission in IoT the proposed system uses Open HAB to connect to coordinate the simulated devices. The proposed system can be used to secure the data packets in the IoT transmission. Halle and Shiyamala [25] proposes a reliable routing protocol using reactive and proactive DV to calculate the security by the parameters such as efficient transfer of packet delivery ratio (PDR), delay, energy consumption and throughput.

3. PROPOSED METHOD

In this section describes the proposed methodology process. UWSN is a network for performing the task of monitoring in a particular area. It is equipped with a vehicle and sensors suitable for cooperative communication via a wireless connection. RECR protocol and optimal OSPF algorithm are proposed for UWSN. UWSN efficient communication proposed diagram shown in Figure 2. The proposed method process based on three stages there are analysis the node energy estimation to find best node, then OSPF algorithm find shortest path and efficient secure data transmission using HTDE algorithm and RECR protocol.

3.1. Node deployment

Each node uses a specific ID, name, and other details assigned to the server register. In UWSN, the node scattered into the surrounding environment is maybe the same or different. Node similar or homogeneous, the battery life will be the same for all characteristics such as communication ranges and processing power. The sensor node observes the surrounding network area, then collects and transmits the data previously detected.

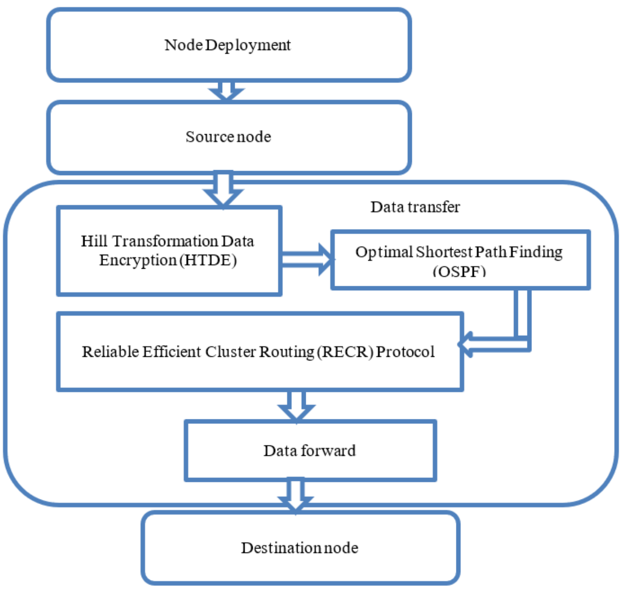

Figure 2. Proposed diagram for UWSN efficient communication

3.2. Hill transformation data encryption

In this stage is done to encrypt the data from the source node for secure data transformation. In this algorithm break the plaintext (P) into two consecutive letters then convert characters into corresponding ASCII values next encrypt the message using 2X2 matrix modulo26 for cipher text (Ct) assign the every characters numerical value like A-0,B-1…Z-25 the space 0.

Algorithm steps

```
Begin
–  Step 1: Deployment the n number of sensor nodes
–  Step 2: Get the location of every sensor nodes by considering node id=1
–  Step 3: Get the source node and the destination node id
–  Step 4: Break the plaintext into two consecutive letters
–  Step 5: Convert the characters into corresponding ASCII Values
–  Step 6: Cipher text (Ct) =P*M mod 26
```

$$\begin{bmatrix} Ct \\ Ct \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} M1 \\ M2 \end{bmatrix} \text{ Mod 26}$$

```
–  Step 7: Order the obtain alphabets
–  Step 8: Return Cipher text (Ct)
Stop
```

The above algorithm provide the encrypted data from the source node. Let assume P is the plain message and M refers to Matrixa_{11}. To encrypt the message using 2×2 matrix mod 26 using Hill Transformation Data Encryption (HTDE).

3.3. Analysis of node energy

Each of the sensor nodes communicates with each other in the region of the communication range. It deployed along the center line of uniformly water surface many sink nodes, and the network has gradually formed an approximation hierarchy state. Each node can perceive its own depth information so that it can determine the number of layers. Each node has a unique ID. Nodes use unified underwater acoustic signals that can communicate information. SN sends the information to the base station via a radio frequency signal:

$$L=\frac{N_{E(init)}}{Maxe(c)} \tag{1}$$

the above equation can be calculated for network lifetime. Let assume L refers to life time, e(C) energy consumed and $\boldsymbol{N_{E(init)}}$initial node energy:

$$e_c(t,f) = S_0 D_t t^e 10^{\propto(f)} \tag{2}$$

the above equation can be calculated node energy consumption process. Let assume $e_c$energy consumption, S_0 represents threshold for node, D_t denotes delay transmission, t refers to transmitting distance, e presents the spreading energy factor, and f refers to frequency signal.

3.4. Optimal shortest path finding

The proposed OSPF algorithm ensures an effective and reliable path to reduce the consumption of resources. OSPF attempts to select minimal depth neighbor as the first node to forward the packet. It also tries to reduce energy consumption by preventing other neighboring nodes from forwarding the same data packet. The proposed method ensures an effective and reliable path to reduce the consumption of resources based on response rate, delay time, tolerance and delivery rate. Depending on any given probability, this method selects the path for each burst and selects high-ranking path load to serve depending on the power split and the available path or route. The main purpose of establishing multiple paths is to reduce traffic during packet transmission. In addition, it will avoid congestion by determining the distribution of traffic.

Algorithm steps

```
Begin
–  Step 1: Obtain Ct data
–  Step 2: Calculate distance between nodes
```

$$\text{Distance}=\sqrt{((x2-x1)^2+(y2-y1)^2)}$$

```
–  Step 3: Calculate Trust node Tn
```

$$T_n = T_{ns} + T_{nm} + T_{nr}$$

```
–  Step 4: Calculate the trust path
```

$$T_p = \min\left(\{T_{ic} | N_i, N_j \in P, N_i \to N_j\}\right)$$

```
Stop
```

Let us assume that x1, x1, y2, y2 are the current positions of the node distance calculated. T_nDenotes Trust node, T_{ns} denotes trust node of security model, T_{nm} is the trust node of mobility, T_{nr} refers to trust node of reliability, T_p refers to trust path, N_i, Nj is an adjacent node, P refers to a path, $N_i \rightarrow N_j$ means $N_i$next hop node N_j.In the algorithm, steps obtain each node position with id calculating distance between each neighboring nodes using the distance formula. Then, trust node and trust path for packet transmission are computed.

3.5. Reliable efficient cluster routing protocol

The proposed RECR protocol is used for communication without packet loss. The proposed aim is to reduce the congestion of bottleneck links by providing these links and reduce the load on burst traffic. However, the proposed continuous data transmission increases the number of broadcast links that can be used to transmit some extent at the same time. The delivery rate indicates the possibility of selecting a relay node during transmission.

Algorithm steps

Begin
- Step 1: Source node (s) sends data to the destination node (d) with id
- Step 2: Calculate total node energy consumption of sending data packet neighbor node
  $E_c(N_i, N_j) = gXp_d(N_i, N_j)Xp'_d$
- Step 3: Node (N_i) stores the carries the effective packet
- Step 4: Data receiving central node
  $p_d^{in} = g(N_{cen}) \oplus g(N_i)$
- Step 5: d can receive information from s
- Step 6: End packet transmission

End

4. RESULT AND DISCUSSION

This section defines the proposed implementation process compared with previous algorithms. In the simulation sensor nodes are randomly generate the 50-100 nodes in simulation dimensional area of 1500 m*1500 m. The proposed reliable efficient cluster routing protocol and hill transformation data encryption (RECR-HTDE) algorithm compared with previous methods are VODA and balanced energy efficient joining distance matrix (BE^2JDM) algorithm.

Table 1 defines the simulation parameters and their ratings of the proposed implementation in network simulator 2 (NS2) with TCL and C++ language. The proposed and existing algorithm parameters are throughput performance, PDR performance, End to End latency performance, and network lifetime. Analysis of throughput performance shown in Table 2. The proposed method compared with the previous algorithms.

Table 1. Simulation parameters

Parameters	Ratings
Tool used	NS2
Number of nodes	50-100
Simulation area	1500*1500m
Packet size	512 bytes
Channel Type	Wireless communication

Table 2. Analysis of throughput performance

Time in sec	VODA in kbps	BE^2JDM in kbps	RECR-HTDE in kbps
20	131	294	298
40	175	329	335
60	184	339	347
80	192	353	361

Figure 3 shows the analysis of throughput performance in the UWSN. The proposed reliable efficient cluster routing protocol and hill transformation data encryption (RECR-HTDE-HTDE) algorithm throughput performance result is 361 kbps; similarly, the existing algorithm results are VODA throughput performance result is 192 kbps and BE^2JDM throughput performance result is 353 kbps algorithm respectively.

$$Packet\ Delivery\ Ratio\ (PDR)\ = \frac{\sum Total\ Number\ of\ Successfully\ recevied\ packets}{\sum Total\ number\ of\ sent\ packets} * 100 \quad (3)$$

The equation can be calculated for PDR performance.

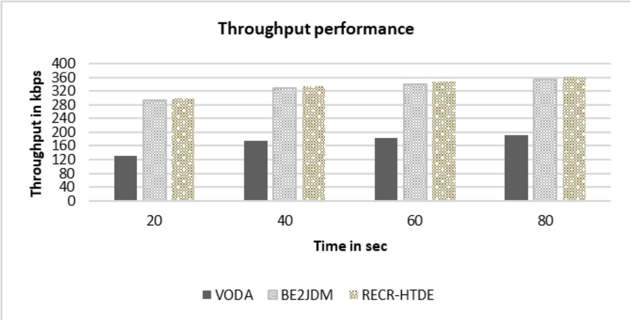

Figure 3. Analysis of throughput performance

Table 3 analyzes the PDR performance. PDR is the ratio of the total number of successful packets received by the destination and the total number of transmitted data packets by the sender. Figure 4 defines the analysis of PDR performance. The proposed RECR-HTDE algorithm PDR performance result is 93%; similarly, the existing algorithm results are BE^{2}JDM PDR performance result 87%, and VODA PDR performance result 81% respectively.

Table 3. Analysis of packet delivery ratio (PDR) performance

No of nodes	VODA (%)	BE^{2}JDM (%)	RECR-HTDE (%)
10	65	71	77
20	67	78	81
30	74	83	86
40	81	87	93

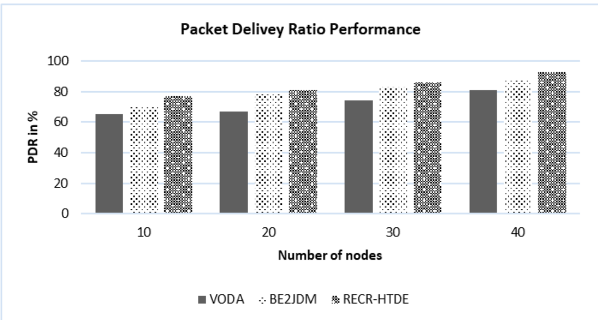

Figure 4. Analysis of packet delivery ratio (PDR)

Table 4 defines the end-to-end latency performance. end-to-end latency is defined as the average time required for data packets traversing any sink from the source node (it includes the transmission latency and propagation latency). The proposed method provides low time during packet transmission.

Table 4. Analysis of end to end latency performance

No of Packets	VODA (sec)	BE^{2}JDM (sec)	RECR-HTDE (sec)
10	12.3	9.5	7.2
20	17.8	13.4	10.1
30	22.3	17.2	13.5
40	31.9	21.6	16.2

Figure 5 defines the end-to-end latency performance in UWSNs. The proposed RECR-HTDE algorithm result is 16.2 sec; similarly, the existing algorithm results are BE^2JDM result 21.6 sec, and VODA result 31.9 sec respectively. Table 5 describes the network lifetime in UWSN. The proposed method extent the network lifetime compared with existing methods. Figure 6 defines the analysis of network lifetime in UWSN. The proposed RECR-HTDE algorithm network lifetime is 92%; similarly, the existing algorithm results are BE^2JDM has network lifetime is 87%, and VODA has network lifetime 80% respectively.

The Figure 7 depicts the analysis of energy consumption performance in Joules for UWSN. The proposed RECR-HTDE algorithm has result is 107J for 80 sec. Similarly, the existing algorithm BE^2JDM has result is 112J and VODA has result is 147J for 80 sec respectively. The proposed cluster to achieve the lower energy consumption than existing methods.

Analysis of security performance the proposed compared with existing algorithms shown in Figure 8. The proposed RECR-HTDE algorithm is provide security performance result is 94%. Similarly, the existing algorithm results are BE^2JDM security result is 88%, and VODA algorithm security result is 81%. The proposed algorithm provide security performance is high than existing algorithms.

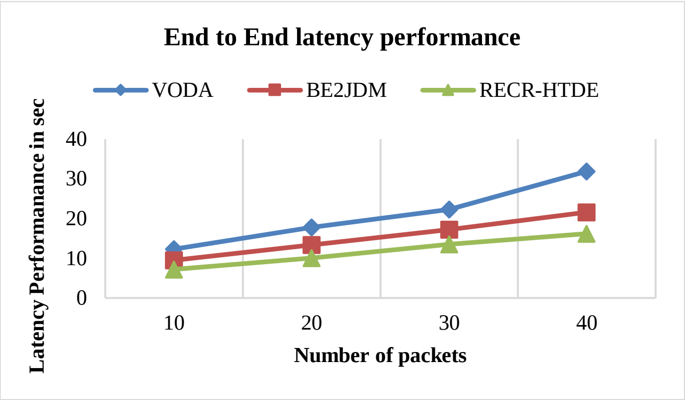

Figure 5. Analysis end to end latency performance

Table 5. Analysis of network lifetime

No of nodes	VODA (%)	BE^2JDM (%)	RECR-HTDE (%)
10	66	73	76
20	71	79	82
30	76	84	88
40	80	87	92

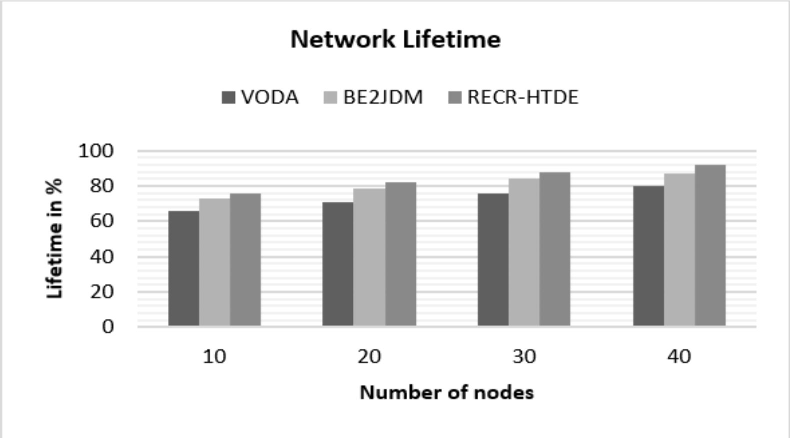

Figure 6. Analysis of network lifetime

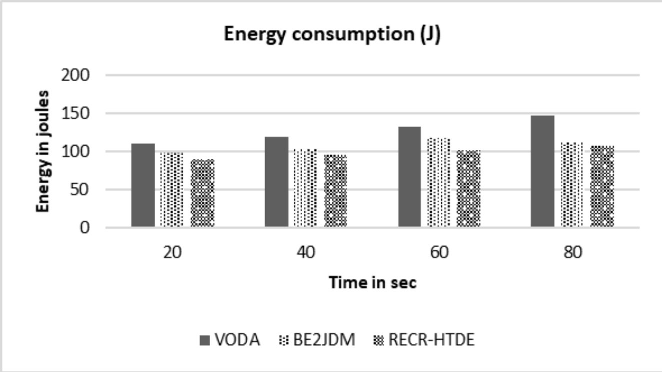

Figure 7. Analysis of energy consumption

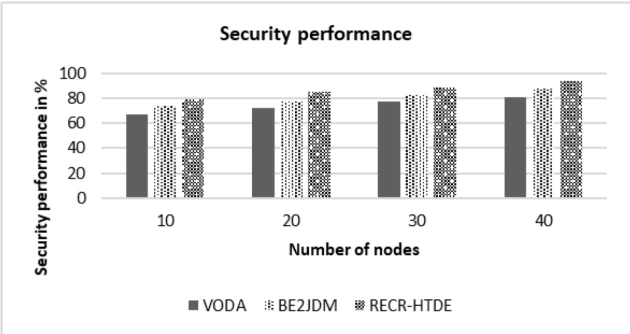

Figure 8. Analysis of security performance

5. CONCLUSION

In this paper presents the RECR, HTDE algorithm and OSPF algorithm for UWSNs. The proposed HTDE algorithm done to encrypts the data then RECR protocol is used for reliable data delivery from source to destination in UWSN. To extend the network's life, RECR employs Autonomous Underwater Vehicle AUV from the SN for data collection, uses the OSPF algorithm. The OSPF algorithm is used the find the shortest path for data transmission to avoid latency. The proposed RECR protocol and OSPF algorithm enhance the data transmission efficiency, minimizing the energy consumption and improve the network life time. The proposed protocol decreases end-to-end latency and packet loss. The proposed RECR protocol and OSPF algorithm simulation results gives better performance than previous algorithms.

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