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Design and Development of a Hybrid Cooperative- Based Routing Protocol avoiding the void nodes in WSNs using the Concepts of Minimum Energy Consumption with good Data Security features

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Abstract:- This paper presents a novel cooperative-based routing protocol designed for underwater Wireless Sensor Network Cloud Applications (uWSNCA). The protocol aims to minimize energy consumption by avoiding void nodes, which are areas without sensor coverage. The proposed approach consists of two main steps: first, avoiding void nodes using an adaptive hop-by-hop vector method, and second, applying a cooperative rule-based adaptive hop-by-hop vector method to create a hybrid algorithm that is more efficient than existing approaches, such as the watch-dog protocol. The research focuses on developing an energy-efficient distributed cooperative routing protocol for wireless sensor networks, specifically tailored for cooperation-based uWSNCA. This is achieved by preventing data packets from being forwarded through void nodes. The proposed routing protocol utilizes cooperation-based adaptive hop-by-hop vector-based forwarding concepts, where sensor nodes forward data packets in a multi-hop fashion within a virtual pipeline. In the developed algorithm for the underwater WSN cloud application, data packets are forwarded in a multi-hop manner using a virtual pipelining mechanism.Nodes outside the virtual pipeline do not forward data packets, thereby reducing flooding in the cooperative WSN. To prevent data packets from being forwarded towards void areas in the WSN, 2-hop information is used at each hop. This approach improves the performance of the wireless sensor network in terms of various performance criteria compared to existing routing protocols. The simulation tool NS2 is used to observe the simulation results of the energy packets being transferred from the source to the sink. The simulation results demonstrate the effectiveness of the proposed methodology. Overall, this paper contributes to the field of underwater WSNs by introducing a novel routing protocol that improves energy efficiency and performance for cloud applications.

***Keywords**:*WSN, Static, Dynamic, Packets, Authentication, Sensor, Node, Management.

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I.Introduction

A wireless sensor network (WSN) is a specialized monitoring system that collects data from various parameters, known as nodes (including source, sink, base station, and potential attackers), and stores this data centrally. WSNs can be categorized into two types: static WSNs and mobile WSNs, each offering distinct advantages. Our research focuses on mobile WSNs, which have been chosen for their specific benefits. The transmission of data packets in WSNs is crucial in the modern digital age, contributing significantly to a nation's progress. It is essential to ensure that energy consumption in these networks is minimized [1]-[5].

II.Proposed Methodology

In our research, we have introduced a novel energy-efficient cooperative routing protocol for wireless sensor networks, specifically designed to avoid void nodes in marine applications. The proposed methodology was implemented and evaluated using the NS-2 platform through simulations. The results demonstrate the efficiency of our approach, which was further validated through comparisons with existing methods. Data transmission from source to sink was achieved effectively through cluster heads in aquatic environments. Our work is titled "Design & Development of a cooperative-based routing protocol by avoiding void nodes for an underwater WSN Cloud application (uWSNCA) with minimal energy," and a prototype for a typical marine application is illustrated in Figure 1 [50].

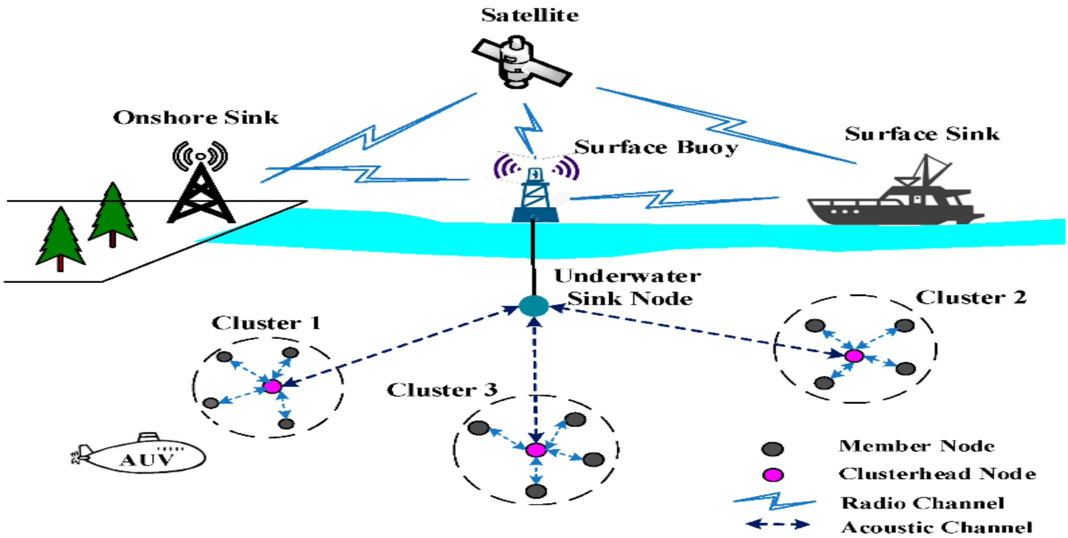

Fig. 1 : A typical underwater WSN prototype using cloud concepts

III. Drawbacks of the existing systems

The shortcomings in the current systems are as follows:

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- High communication overhead and the need for substantial memory space.
- Lack of scalability and resilience against compromises, as well as inability to support node mobility.
- Some schemes are more computationally expensive.
- Presence of data packet switching losses.
- Significant time required for data packet transfer.
- Vulnerability to attacks from malicious nodes [21]-[25].

IV. Review of literature / survey

The literature review for our research topic involved a comprehensive examination of numerous studies conducted by researchers in the field [1]-[50]. Our thesis report presents a concise overview of these works, highlighting their respective strengths and weaknesses. Initially, a vast array of research papers was gathered from diverse sources and meticulously analyzed. Our focus was specifically on methodologies related to aquatic marine environments [50]. Our research aimed to address some of the drawbacks identified in prior studies. We developed new algorithms to mitigate deficiencies found in existing algorithms, particularly focusing on enhancing energy efficiency during data transmission from source to sink. These efforts were aimed at improving the overall performance of wireless sensor networks in aquatic environments. The effectiveness of our research was validated through extensive simulations conducted in the Network Simulator (NS-2) environment. These simulations provided valuable insights into the performance of our proposed algorithms, helping to substantiate the research problem we aimed to tackle. [1]-[50].

V. Tools used in the research work

The hardware and software tools utilized in our research work are as follows. For hardware simulations, the specifications include a Dual-Core main processor, a minimum of 1 TB hard disk capacity, 4 GB cache memory, 8 GB RAM, a flat-screen LCD monitor, and a Logitech 3-button mouse. On the software side, the operating system used was Linux (Ubuntu 13.01v), with the NS-2 platform serving as the primary simulation environment. The backend support was provided by VMWare, and the software tools employed included Network Simulator 2.35. The programming languages utilized were Tool Command Language (TCL), AWK, and C++ [16]-[20].

VI. Design of the routing protocol

This section discusses the design and development of a cooperation-based protocol that avoids void nodes, focusing on energy efficiency in underwater wireless sensor network routing for a cloud application. The protocol utilizes cooperation-based adaptive hop-by-hop vector-based forwarding, allowing sensor nodes to forward data packets in a multi-hop manner

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within a virtual pipeline. The paper presents results from various test cases, along with discussions, observations, and explanations. Additionally, a proposed block diagram for the routing protocol design is included, depicted in Figure 2.

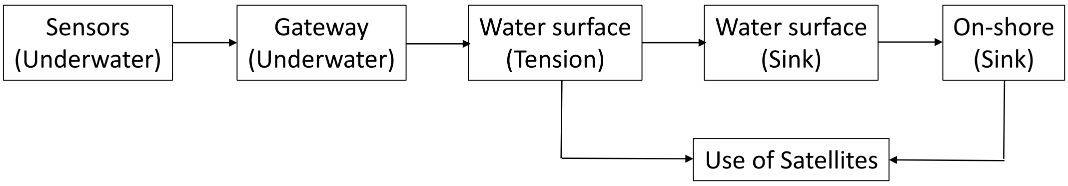

Fig. 2 : The block-diagram of underwater cloud example this is used in our work [50]

Developing an energy-efficient and resourceful managerial scheme for cooperative underwater Wireless Sensor Networks (WSNs), with a focus on avoiding void nodes, is crucial for optimizing energy usage in underwater environments, as seen in UWSNs [26]-[30]. This research considers a revised routing protocol for underwater applications, addressing void nodes that can be likened to dead-end parts of a cloud. The approach starts by avoiding void nodes using an adaptive hop-by-hop vector method, followed by applying a cooperative rule-based adaptive hop-by-hop vector method. This hybrid algorithm offers significant advantages, as highlighted in [50]. In the algorithm developed for an underwater application problem of the WSN cloud, the data packets are forwarded in a multi hop manner in a virtual pipelining mechanism created. As there are a number of sensor nodes which are lying outside the virtual pipeline, such nodes are not used to forward the data packets as flooding in the cooperative WSN can be avoided to a greater extent [31]-[35].

By utilizing 2-hop information at each hop, the forwarding of data packets towards void areas in the WSN can be effectively prevented. This approach improves the overall performance of the wireless sensor network, enhancing various performance criteria compared to existing routing protocols. This method helps in optimizing the routing path, ensuring efficient data transmission and reducing energy consumption in the networks [50].

VII. Main targeted area of the research work

The primary goal of the research presented in this paper is to introduce a routing algorithm designed for computing routing paths based on both energy consumption and channel qualities in a marine environment. In this algorithm developed for underwater applications in the WSN cloud, data packets are forwarded in a multi-hop fashion using a virtual pipelining mechanism. This approach optimizes data transmission in underwater wireless sensor networks, improving overall network efficiency and performance [36]-[40].

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To improve the performance of wireless sensor networks (WSNs), particularly in underwater environments, it's crucial to optimize data packet forwarding. In our research, we've implemented a virtual pipelining mechanism for multi-hop data transmission. This mechanism ensures that only nodes within the virtual pipeline forward data packets, reducing the risk of flooding in cooperative WSNs.Additionally, we've incorporated a 2-hop information strategy at each hop to prevent data packets from being forwarded toward void areas in the WSN. This strategy enhances routing efficiency and reduces energy consumption by avoiding unnecessary data transmission. Overall, these approaches significantly improve the performance of WSNs compared to existing routing protocols, making them more suitable for underwater applications. [50].

VIII. Flow chart of proposed algorithm

The proposed flow chart for the algorithm development in the under-water scenarios had been created but is not included here for the sake of brevity. When the main file, main.tcl, is executed, several files are generated to store data from node deployment to data transfer to the endpoint. These files are created during script writing and program execution and are numerous in number. Running the developed program (main.tcl) results in the generation of subsidiary files that help analyze various characteristics of the Wireless Sensor Network (WSN). The coding for efficient data transfer using minimal energy in an underwater scenario for a WSN is implemented in the NS2 tool by writing .tcl scripts. Once the script is completed, it is tested for effectiveness according to the algorithm steps provided.

Here is the algorithm developed for efficient data transfer using minimum energy concepts for underwater wireless sensor networks, as per the steps provided below.

- Initialize: Set initial parameters and variables.
- Deploy Nodes: Deploy sensor nodes in the underwater environment.
- Set Sink Node: Set the sink node for data collection.
- Compute Optimal Path: Compute the optimal path from source to sink considering energy consumption and channel qualities.
- Avoid Void Nodes: Implement a mechanism to avoid void nodes along the routing path.
- Adaptive Hop-by-Hop Vector Method: Use an adaptive hop-by-hop vector method to avoid void nodes.
- Cooperative Rule-Based Method: Apply a cooperative rule-based method to further optimize the routing path.
- Implement Virtual Pipelining: Use virtual pipelining for multi-hop data packet forwarding.
- Avoid Flooding: Exclude sensor nodes outside the virtual pipeline from forwarding data packets to avoid flooding.
- Use 2-Hop Information: Utilize 2-hop information at each hop to prevent data packet

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forwarding toward void areas.

- Evaluate Performance: Evaluate the performance of the algorithm in terms of energy efficiency and channel quality.
- Compare with Existing Protocols: Compare the performance of the developed algorithm with existing routing protocols.
- Simulate Results: Simulate the algorithm using NS2 to observe the data transfer efficiency and energy consumption.
- Optimize Parameters: Fine-tune parameters to further enhance the algorithm's performance if necessary.

This algorithm aims to improve the efficiency of data transfer in underwater wireless sensor networks by minimizing energy consumption and optimizing routing paths [50].

- Node configuration parameters [41]-[45] must be defined before deployment:
- Channel Type, radio propagation, network interface, MAC type
- Interface queue type, link layer type, antenna model, max packet size
- Number of mobile nodes, X-axis distance, Y-axis distance, Initial Energy
- Configuration is a mandatory first step.
- Next, we are going into the deployment process
- All the nodes will be deployed
- We will be deploying the attacking nodes (red)
- Next we are going to see how the nodes are going to communicate
- Basically, we are using the UDP protocol here
- Then for packet generation we are using the CBR (constant bit rate) file
- Euclidean distance between the nodes is found out using the Euclidean formula
- Neighbour file is loaded with the distances between the different nodes set
- Sending the packets is the next move, use the packet.awk file
- Control then goes to packet.awk file
- It will start sending the data from one to neighbour node
- For that reason it is calling the neighbour file & starts sending the data to the neighbours
- While sending the data, it uses the CBR file
- One more file is generated for the tracing purposes tracing.tcl
- Next routing operation is started
- Here, route request operation is carried out route request.awk file
- Starts sending the request to the neighbours (route request process is initiated)
- In route request, we will be finding how the route request will be transferred
- route-request.awk file will be in operation
- data will be sent in the encrypted format as it should not be damaged

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- in the process the ascending order (s to d)
- chain of the process is formed next
- how to send the encryption data, the file send-msg.awk is revoked
- attacker process comes in the middle – 2 attacks taken in the coding
- verification logic process starts, sub-routine developed is going to verify how packets are sent
- find whether any malicious nodes are then in the network
- if present, then control goes to the alternate or cooperated nodes
- packets are sent bypassing the malicious & using the cooperative nodes
- next one more path is identified, data packets are sent
- like this data transfer of packets process goes on till all data is sent from source to sink
- attackers may attack the data, verification is done, dead/malicious nodes identified, process repeats by choosing the alternative path
- last part of the coding, the graphic display is embedded
- various performance measure graphs are plotted by using exec graph commands
- Plot Fraction of Packet Dropped
- Plot Link Losses Detection Ratio
- Plot Verification Failure Rate
- Plot Average Energy
- Plot Throughput [46]-[50]

IX. Simulation results

The network simulator-based simulation results, along with discussions, demonstrate the successful implementation of the proposed methodology. Running the main.tcl script file initiates the simulation in the NAM window, allowing observation of results after a specific duration. The results validate the efficacy of the proposed methodology, as shown here. The NS2 simulation results, presented alongside discussions, confirm the successful implementation of the proposed methodology. Running the main.tcl script file initiates the simulation in the NAM window, where results are observed after a specific duration. These results effectively demonstrate the efficacy of the proposed methodology, especially when compared with existing approaches. The simulation outcomes are displayed in Figures 3-17, complemented by quantitative results in Tables 1-3 [50].

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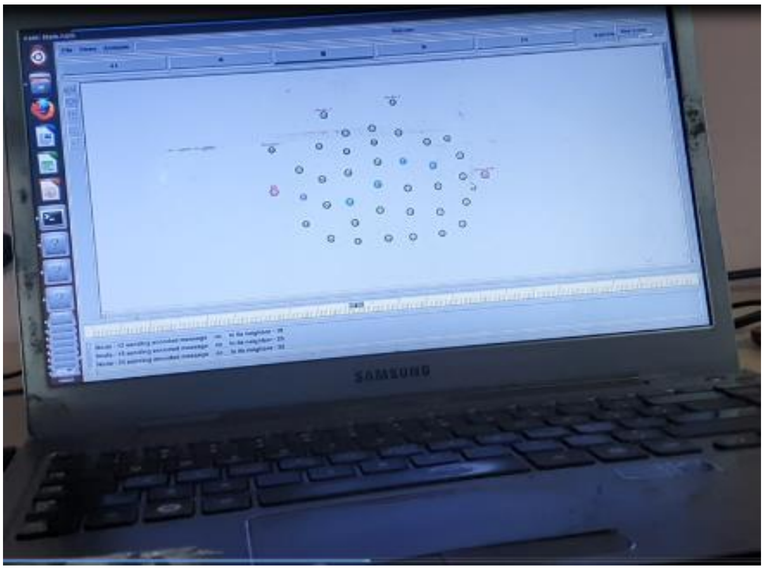

Fig. 3 : The developed code being run on the research scholar's laptop in the NS-2 simulator, Network simulator / animator front screen panel from where the simulation can be started by pressing forward button (4th from top)

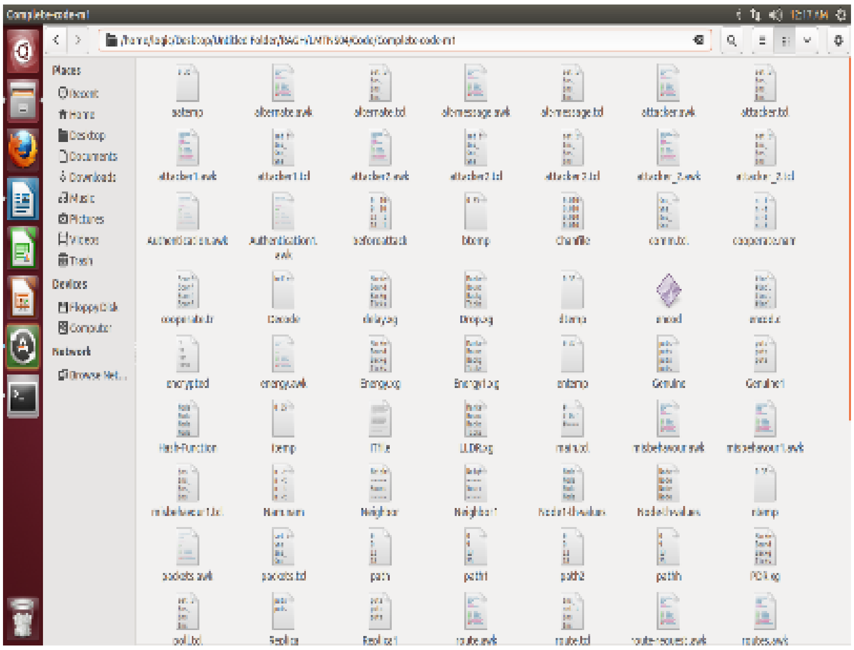

Fig. 4 : The path showing where the code has been developed with all the subsidiary files of .tcl, .awk, .tr files

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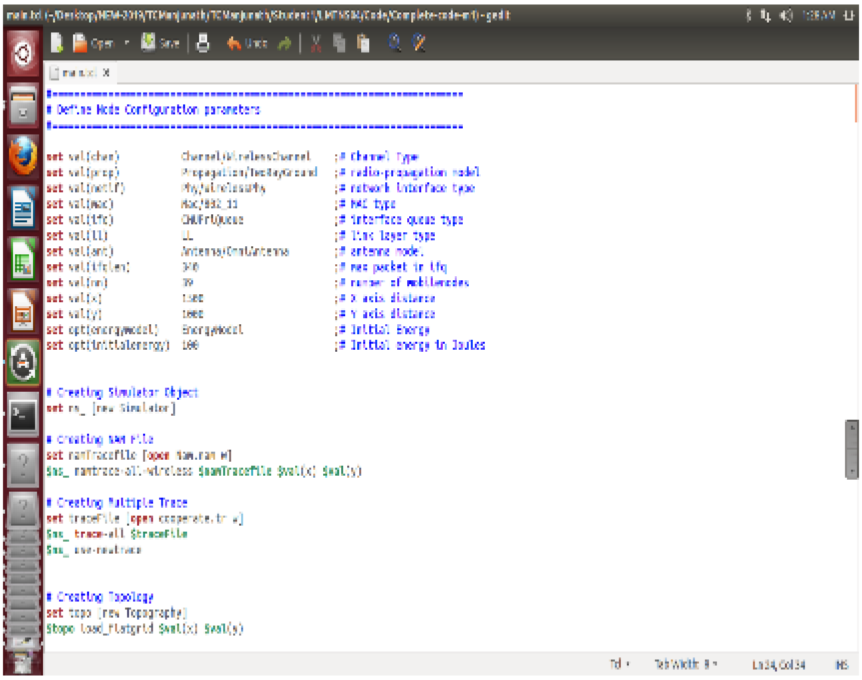

Fig. 5 : Coding in NS2–terminal-1

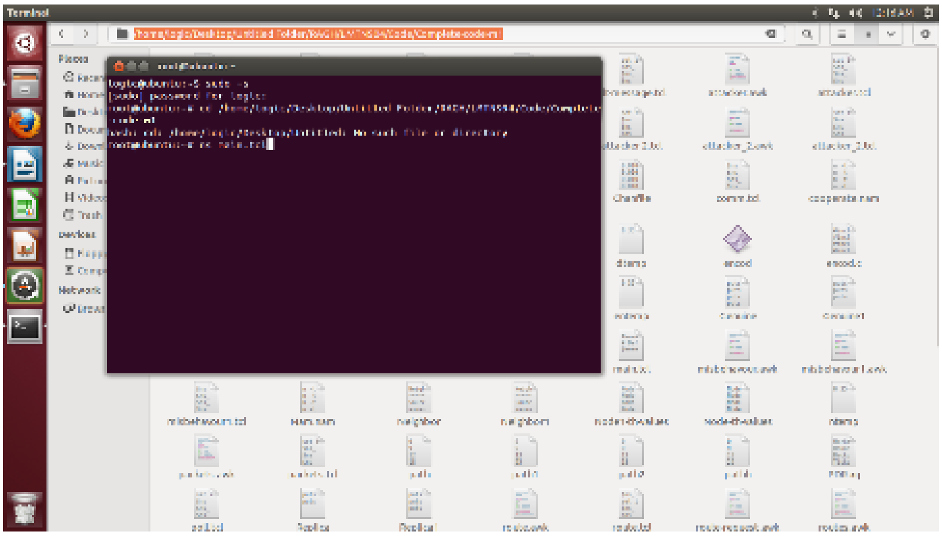

Fig. 6 : The root terminal showing how to run the main program developed by changing the directory to the location where the main file is located

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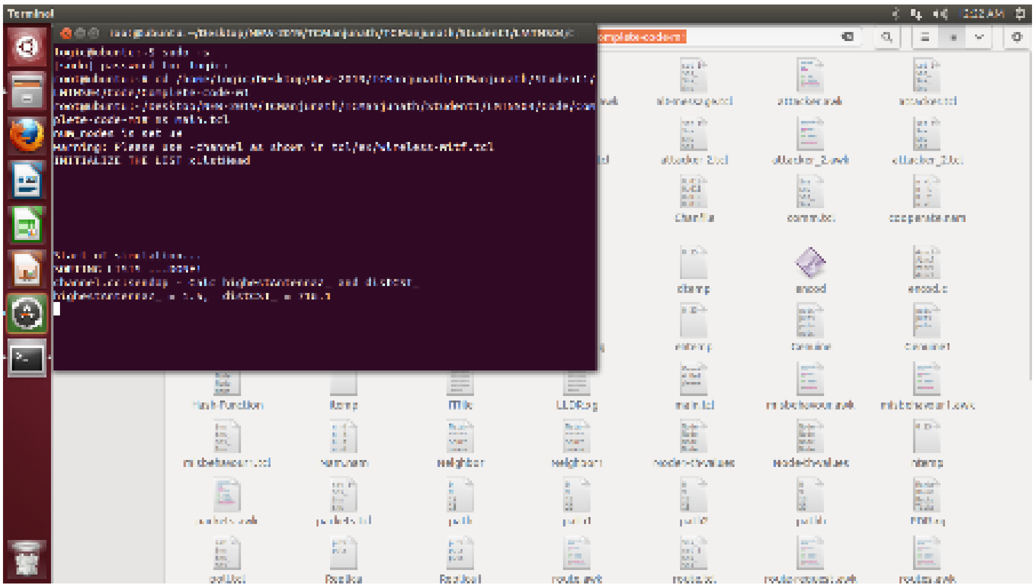

Fig. 7 : The root terminal showing that the main program is being run

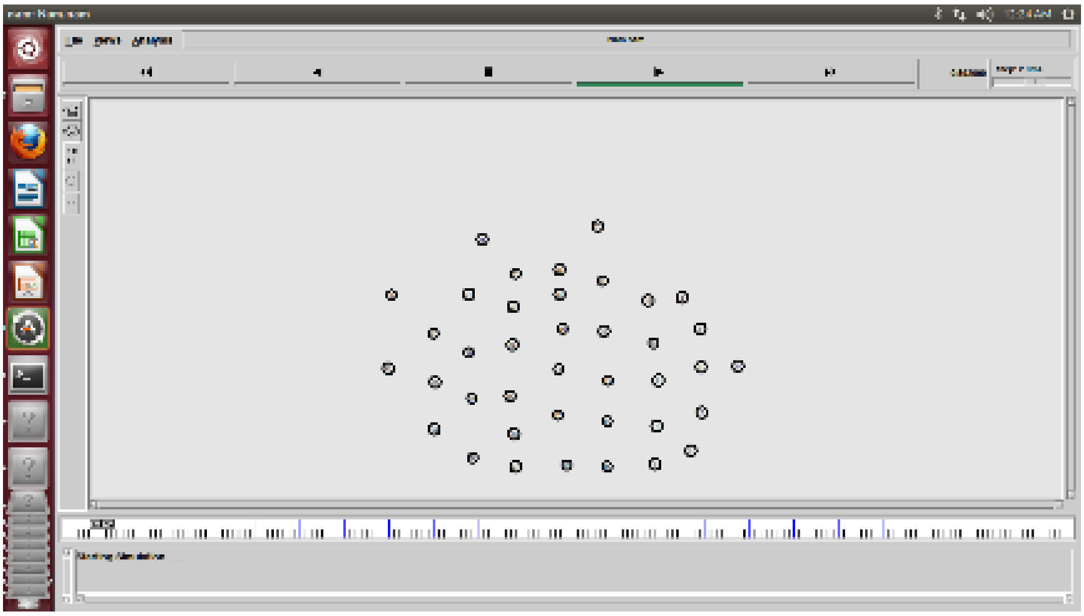

Fig. 8 : The NAM terminal showing the random deployment of the sensor nodes

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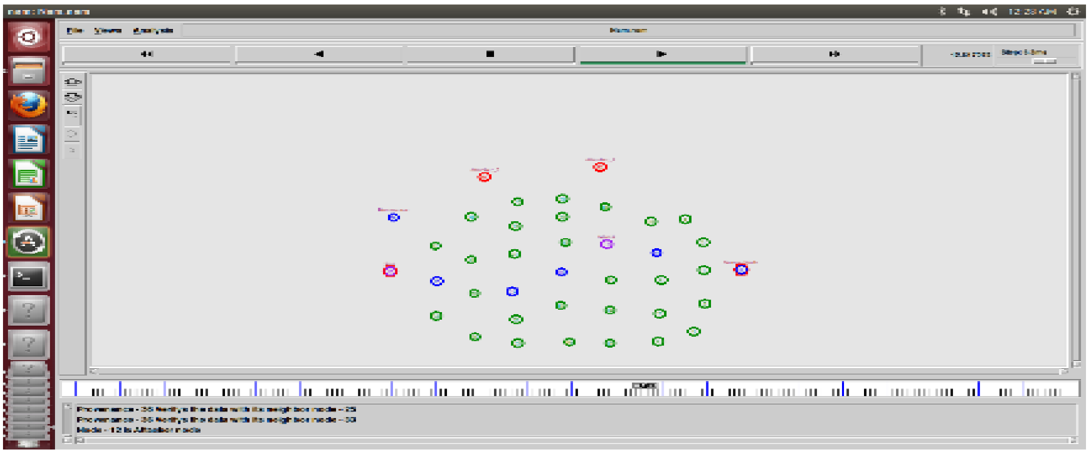

Fig. 9 : The NAM terminal showing the verification of the data with the neighbouring nodes, red coloured ones-attacker nodes, rose coloured ones-source & sink nodes

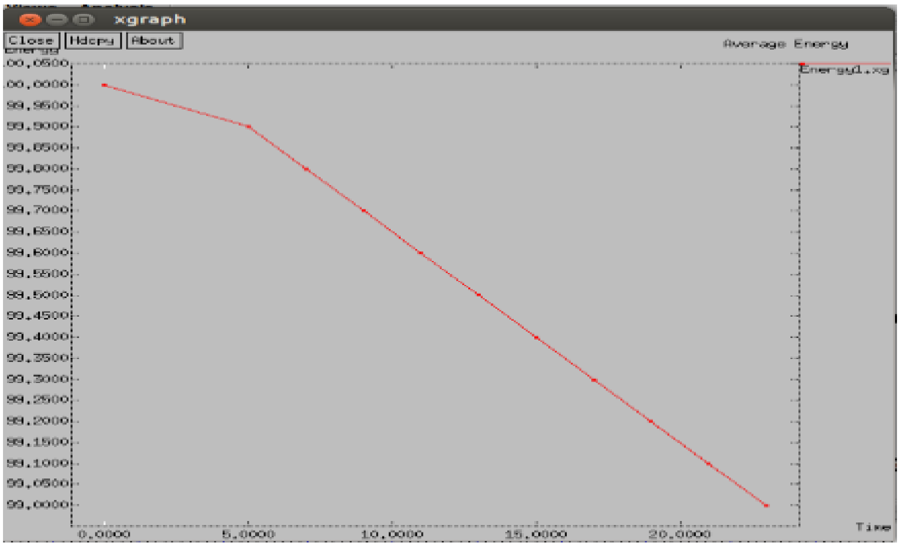

Fig. 10 : Graph showing the average energy (efficient not drooping suddenly, but gradually)

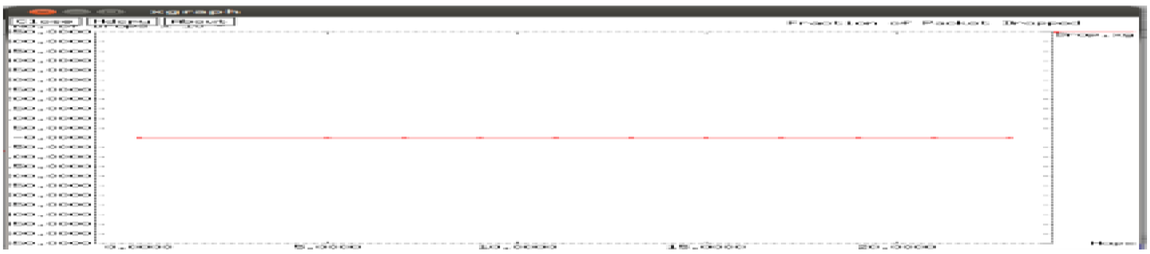

Fig. 11 : Graph showing the fraction of packet dropped – Nil (all packets have reached the destination

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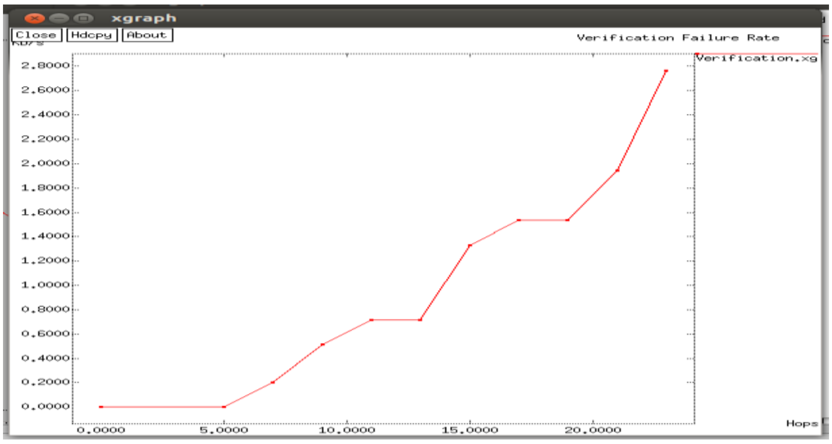

Fig. 12 : Graph showing the verification failure rate

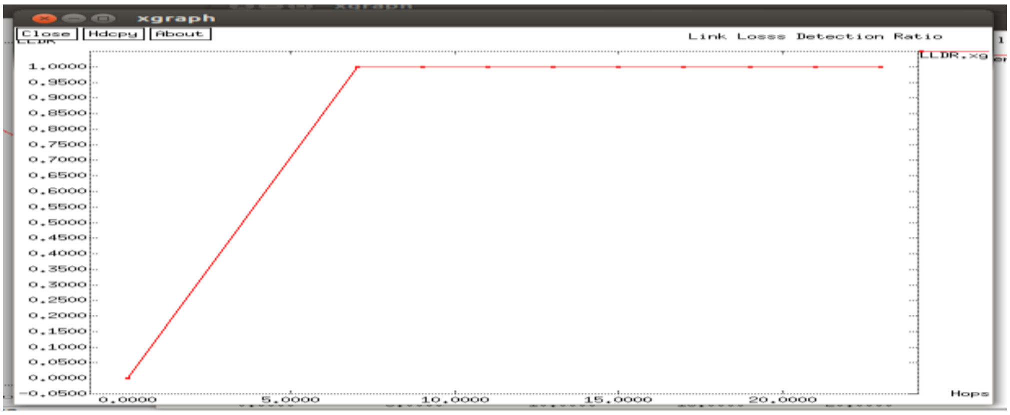

Fig. 13 : Graph showing the link loss detection ratio

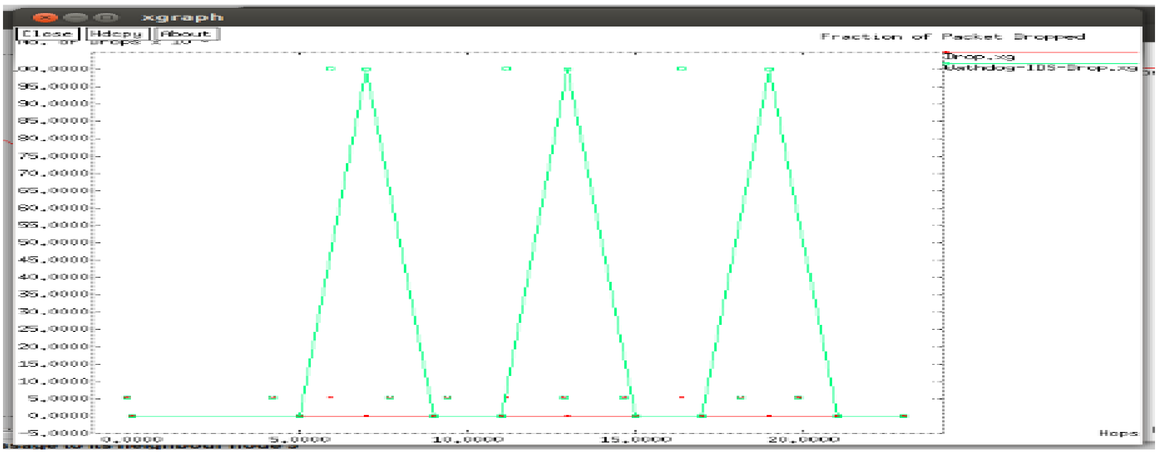

Fig. 14 : Graph showing the comparison result of the work considered with the watch-dog (showing that in our algorithm, there is no dropping of the packets

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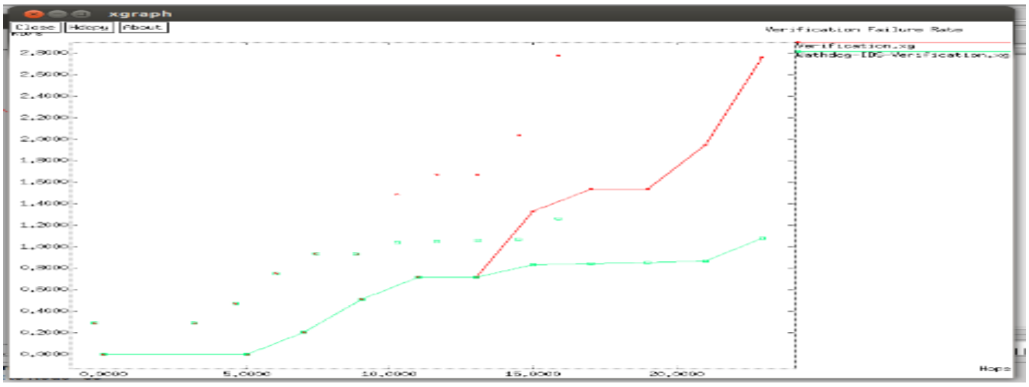

Fig. 15 : Graph showing the comparison result of the work considered with the watch-dog (showing that in our algorithm w.r.t. the verification of the failure rate)

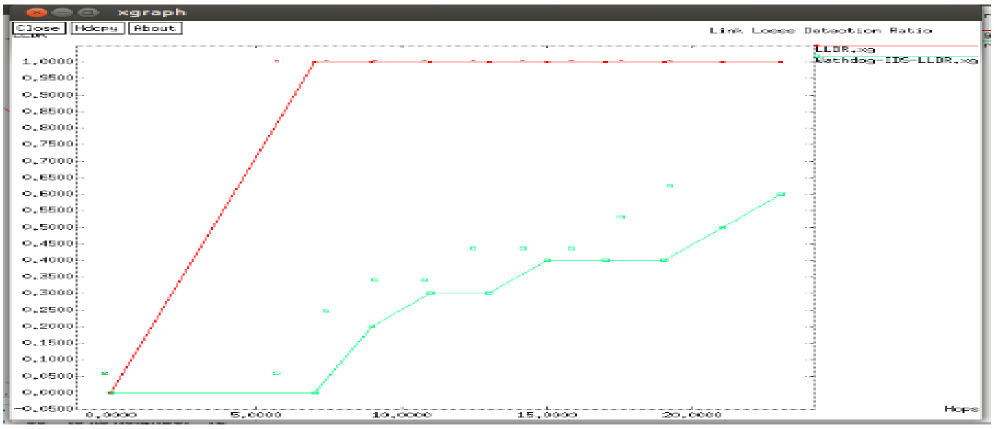

Fig. 16 : Graph showing the comparison of the work done with the watchdog showing that in our case, there is no link loss (link loss detection ratio)

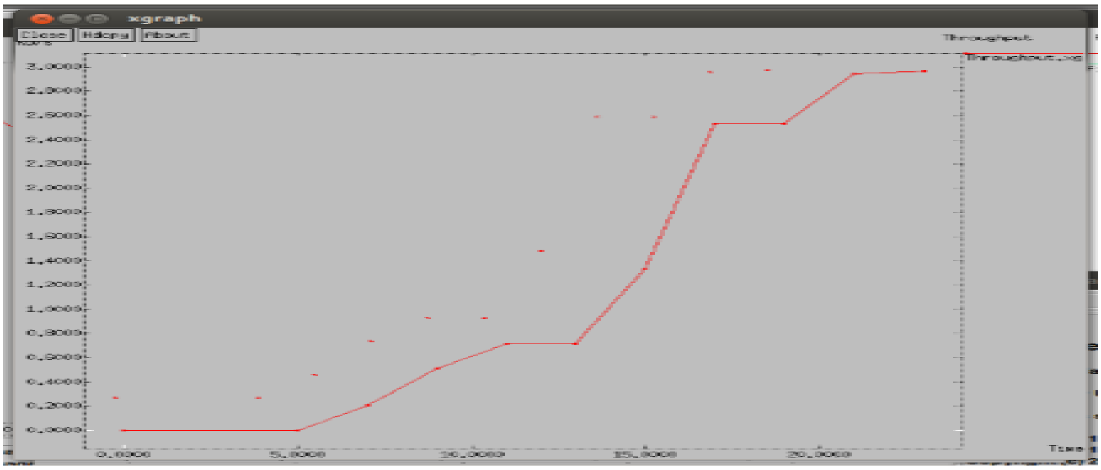

Fig. 17 : Graph showing the smoothness of the throughput

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Table 1 : Quantitative results showing the comparison result of the work considered with the watch-dog (showing that in our algorithm w.r.t. verification of the failure rate is better)

No. of HOPS → Vfn fail rate kb/s ↓	Watch Dog	Our Algo
0	0	0
5	0	0
7	0.2	0.2
9	0.5	0.5
11	0.75	0.75
13	0.75	0.75
15	1.3	0.8
17	1.5	0.82
19	1.6	0.84
21	1.9	0.85
25	2.75	1.05

Table 2 : Quantitative results showing the comparison of the work done with the watchdog showing that in our case, there is no link loss (link loss detection ratio)

No. of HOPS → Link loss Detection ratio ↓	Watch Dog	Our Algo
0	0	0
7	0	1.0
9	0.2	1.0
11	0.3	1.0
13	0.3	1.0
15	0.4	1.0
16	0.4	1.0
17	0.4	1.0
19	0.4	1.0
21	0.5	1.0
22	0.6	1.0

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Table 3 : Quantitative results of watchdog v/s our proposed algo showing no packet drop, i.e., the fraction of packets dropped in our case is ZERO

No. of HOPS → Faction of packets dropped ↓	Watch Dog	Our Algo
5	100	0
10	100	0
15	100	0
20	100	0

X. Discussion on simulated results

This paper presents a research work focusing on the development of an energy-efficient routing protocol for underwater, aquatic, or marine applications in Wireless Sensor Networks (WSNs). The proposed protocol aims to reduce energy consumption effectively in these challenging environments. The design and development of an energy-efficient distributed cooperative routing protocol for WSNs are highlighted, emphasizing cooperation-based strategies to avoid void nodes and improve routing efficiency. Specifically, the protocol addresses the energy efficiency of underwater WSNs for cloud applications, utilizing adaptive hop-by-hop vector-based forwarding within a virtual pipeline for multi-hop data packet transmission.

In conclusion, this paper introduces two energy routing algorithms tailored for underwater wireless sensor networks. These algorithms are designed to enhance energy efficiency, a critical factor in prolonging the network's lifetime and ensuring reliable operation. The research contributes to the advancement of energy-efficient routing protocols for underwater WSNs, which are essential for various marine applications where energy resources are limited and challenging environmental conditions must be considered. The proposed algorithms demonstrate the potential to significantly improve the performance and sustainability of underwater WSNs. [50].

XI. Overall Conclusions

In conclusion, the algorithm developed for the underwater application problem of the WSN cloud employs a virtual pipelining mechanism for multi-hop data packet forwarding. This approach ensures that only nodes within the virtual pipeline forward data packets, reducing the risk of flooding in the cooperative WSN. Additionally, by utilizing 2-hop information at each hop, the algorithm prevents data packets from being forwarded toward void areas, further enhancing routing efficiency and energy conservation. Overall, these strategies contribute to

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improved performance metrics compared to existing routing protocols, making them more suitable for current WSN scenarios.

The method proposed in this paper offers several significant advantages. Firstly, it enhances energy efficiency by intelligently navigating through the network in forward selection mode, effectively avoiding numerous voids. This optimization reduces unnecessary energy consumption, making the network more sustainable and cost-effective in the long run. Additionally, the method reduces time consumption for data transfer schemes, improving the overall efficiency of the network.

Furthermore, the proposed method minimizes errors in data transmission, ensuring reliable and accurate communication within the network. By optimizing routing paths and minimizing the holding time for each packet transfer, the method enhances the network's performance and reliability. These improvements contribute to a more efficient and effective wireless sensor network, particularly in scenarios where energy consumption, packet delivery, and delays are critical factors.

The algorithms developed for this method were implemented using NS2 tools in the Ubuntu environment. Through simulations, the method's effectiveness was evaluated across various test cases. The results of these simulations, along with detailed observations and explanations, were presented in the paper. Overall, the method's performance was found to be highly efficient, demonstrating its potential for improving the energy efficiency and overall performance of wireless sensor networks..

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