Performance Analysis of R-KrushD based on the Hetrogenious Sensor Node Deployed in Random Finite Field of Sea Levels

Rani Astya[1*], C K Jha[2] and Nitin Rakesh[3]

Department of Computer Science & Engineering, Sharda University, India [1]
Department of Computer Science, Banasthali Vidyapeeth, Jaipur, India [2]
Department of Computer Science & Engineering, Sharda University, India [3]

Abstract

Underwater Sensor Network (UWSN) is one of the challenging areas of wireless sensor network. Various routing mechanisms have been proposed for effective communication possibilities in this extreme environment of Underwater. This paper shows the performance of R-KrushD routing mechanism in heterogeneous network environment by utilizing the node deployment within the finite field of underwater. The results shows that the performance of R-KrushD is effective in different cases as considered for the dry-run. Simulation results proves that performance of the approach is better than existing traditional underwater sensor network routing mechanisms.

Keywords

Underwater Sensor Network, Mobility, Node Deployment, Throughput, Doppler Effect, Node Failure

1.Introduction, Motivation and Objectives

Under water sensor network [1-9] is adopted for traditional application function monitoring of ocean's bottom, data recording for weather, mining, aquatic life & other applications using vehicles/sensors. The communication is established to send and receive message using sound propagation within under water environment. USWN is used for distinct applications like pollution monitoring, ocean bottom, data recording for weather, mining, aquatic life and other applications using vehicles/sensors. The communication is established to send & receive messages using sound proportion within under water environment. USWN is used for distinct applications like pollution monitoring, oceanographic data compilation, monitoring/discovering environmental condition. Due to enhanced implications of aquatic applications, this field is highly potential towards the research and data generation requirements. In view of increased involvement of commercial applicability of USWN, several research dimensions are being exploited for its influences. The infrastructural requirements also plays an important role in the development of UWSN.

*Rani Astya, #Nitin Rakesh
Department of Computer Science & Engineering, Sharda University, India, 201310.
* astyarani@gmail.com (first author)
# nitin.rakesh@gmail.com (corresponding author)

Underwater sensor network faces constraints from the environment which not only acts as a disadvantage while implementing it, but also is a challenge and opens several research problems. Some of the key challenges are high propagation delay, node mobility, limited bandwidth, failure recovery/residency, constraint sound speed, underutilised acoustic spectrum, and variation in characteristics of acoustic channels [10-12], Doppler Effect, limited performance of acoustic channels. All these disadvantages are because of the dynamic nature of underwater sensor network environment as they have movement within the water at an average rate of 2-3m/sec as per the current. Due to this energy consumption becomes quite high and various protocols are underperforming specifically. However, multiple protocols are existing in literature which claims to have low-energy consumption like resilient-routing, HH-VBF, DUCS, DDD, MCCP, FBR and H2-DAB [9-11]. These protocols are having other disadvantages to cope up.

Various research approaches exists for Indian applications were the UWSN is vital requirement. Verdah cyclone in Tamilnadu, India are due to improper presence disaster management and lack of adequate data generation. During such natural disasters can be estimated only when huge and real-time data generation and aggregation must be performed. There are few research those have developed Zigbee module for monitoring of Indian water quality of rivers. This proposed system is designed for processing the data sensed and comparing with the existing data for maintaining and monitoring the temperature, pH, and other factors. Indian navy inducts underwater sensor system developed by Defence Research and Development Organisation (DRDO) in Kochi, India. The undersee sensors at Bay of Bengal and others generates enormous quality of raw data but the concern is lack of resource which is required for data-collection. Now-a-days Underwater Radiated Noise (URN).[Z] is research for both military and non-military applications. These are several challenges for Indian Ocean Region(IOR) for data generation, security of data, utilisation of resources IOR states the deployment of sensor nodes for surveillance and monitoring in Indian oceans. The signal received and recorded post processing into the systems consists of noise of undersea minerals. The European Undersea Observation Network (ESONET). Program started from 2007 to 2010 in the Indian ocean and Pacific Ocean. The researcher has faced huge challenges due to the adoption of electromagnetic waves which actually propagates at a rate of 3×10^8 m/sec with minor propagation delay in air. While in using this in underwater environment the propagation of signals is up to very smaller distances which makes it impractical for long-distance communication[A]. Further, it has to be experimented that light is quite better in propagation in comparison to electromagnetic signals but it is having issue of color dispersion. When the sound is being used it seems to propagate better even but the attenuation speed is very low, however, transmits to a longer-distance.

2.Problem Statement

Our previous work has proposed with the algorithms which is effective and efficient for performing routing in underwater environment. We have shown in our algorithm that for three different levels of under-sea levels where, different parameters are undertaken while performing routing of data between different sensing nodes, the algorithm results in effective communication outcomes. The proposed approach also exploits the resonance behavior and noise/ attenuations issues in acoustic channel. The performance of the algorithm is though dependent on the physical layer and is yielding better results over existing approach during path loss, pressure, temperature, mobility factor of the nodes (due to Doppler effect). The proposed work shows that communication in underwater environment is contention– free communication.

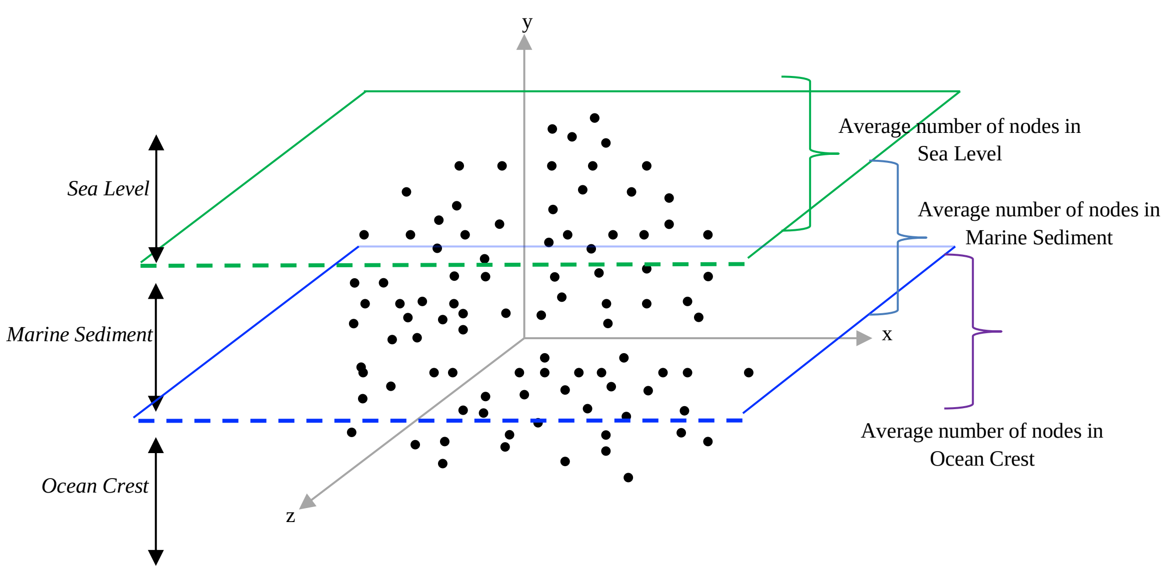

Figure 1 Deployment of nodes at different level of underwater environment

In this section, we have shown the performance of the algorithm for parameters like node mobility, path loss (due to turbulence, high attitude waves, ocean-object motion, or noise for the comparative analysis we have considered different size of networks with same parameters and distinct case studies are considered to evaluate the result. We have considered the algorithm is performing with all the possible parameters which are required to be considered in underwater sensor environment. This section is further divided in two

parts, one which covers the setting up of the test-bed/ case study and, second parts shows the application of the parameters once the existing environment. We have shown all the parameters considered for complete experimentation of the simulating environment. Refer table 1, which shows all the parameters, considered for the simulating environment. Considering network size 30 (last level with last nodes deployed)
Case -1: $[A: 10, B: 10, C: 10]$
Case -2: $[A: 20, B: 5, C: 5]$
Case -3: $[A: 10, B: 20, C: NIL]$

For the comparison and performance evaluation of R-Krushd, We have considered underwater sensor network to be deployed at three different sea levels (Marine, ocean crust and litrospese) and have considered five different network size $(30, 60, 120, 240, and\ 480)$ so that our result can be composed holistically. Further we have considered node mobility, Doppler's effect, path loss, temperature, connection reestablishment count, maximum time nodes fails, to compute the performance of R-KrushD. Based on all the factors we will also show the case rating in which the algorithm is performing the best and conclude our experimentation accordingly in the forthcoming sections.

3.R-KrushD performance analysis

The RKrushd approach consists of following functions, i) Ran doming the node distribution in all four quadrants with ecludian distance.

Figure 2 shows the representation of nodes in 3D environment over eight sub quadrants. This division of underwater plan is based on our approach Krush-D in which nodes are represented in planes like, upper left 1 & 2, upper right 1 & 2, lower left 1 & 2 and lower right 1 & 2. This representation of underwater environment provides numerical visibility to the algorithm and the readers. It enables the algorithm to perform the effectively with different network size. Furthermore this representation also provides euclidean distance among the nodes in proper manner. i.e. Krush-D, approach is used to communicate and transmit data among the nodes in inter / intra connectivity R-KrushD exploits the algorithm to communicate among the nodes.

The algorithm considers that for threshold of source node (Ts) and threshold of destination node (Td) must be determined as per each quadrants (Q (1,2,3,4)) for its nearest available communication network(CN). Further, it is also considered that communication may failure when the path loss factor (PLF) is greater than the signal to noise ratio (SNR) or when neither the source nor the destination are equal. The cases are considered with viscosity level below 10KH . The communication in CN is based on DDD approach. The authors have already copyright (12360/2021-CO/SW) The R-KrushD approach. The proposed approach exploits the Krush-D routing to provide the communication and for each establishment and DDD provides underwater node deployment and mobility factor.

3.1Case Based Analysis

This section shows all the cases which are analysed by the given parameters. Like mobility, Doppler effect, path loss, temperature, throughput, connection reestablishment count, maximum node failure. The performance is calculated based on these parameters. Below are the cases give with network of 120 nodes which are deployed in underwater sensor network (see figure 2).

For, CN as a heterogeneous network,
$N = 120$
$P(L) = Null$ (as established during deployment)

Case 1: Considering the three oceans levels (Marine, Ocean crust and Litrospere). Representing A: Marine Level, B: Ocean crust and C: Litrospere. As per case 1, the distribution made by KrushD, DDD approach as$A: 80, B: 20\ and\ C: 20$. The nodes distributed in A are the highest compared to B and C ocean levels. Figure 3 shows the deployment of 120 nodes are in A, B, and C levels. As per the three ocean levels the parameters like $P(t), P(L), M,$ ^ and $P(f)$ are higher at level A of the ocean. However, $P(L), P(f)$ are quite comparable in A, B and C levels. But Ss is higher as the depth of the ocean increases. This means that the effect of Sc are lower in A, more in B and higher in C. Another issue to be considered is the $P(t)$ reduces as the depth of the ocean increases. While M is higher in A as it is very close to the surface and factors like turbulence, object distracting on surface, high wave attitude are more prominent.

Let us dry sum the algorithm for each level, one-by-one. Let us start with Level A where the highest number of nodes are deployed ($N4 = Nodes\ in\ level\ 4$). As per the given distribution $N4 = 80$ which is approximately 66% of total deployed nodes in CN. Table 4 shows the parameters which will be computed as per the proposed algorithm.

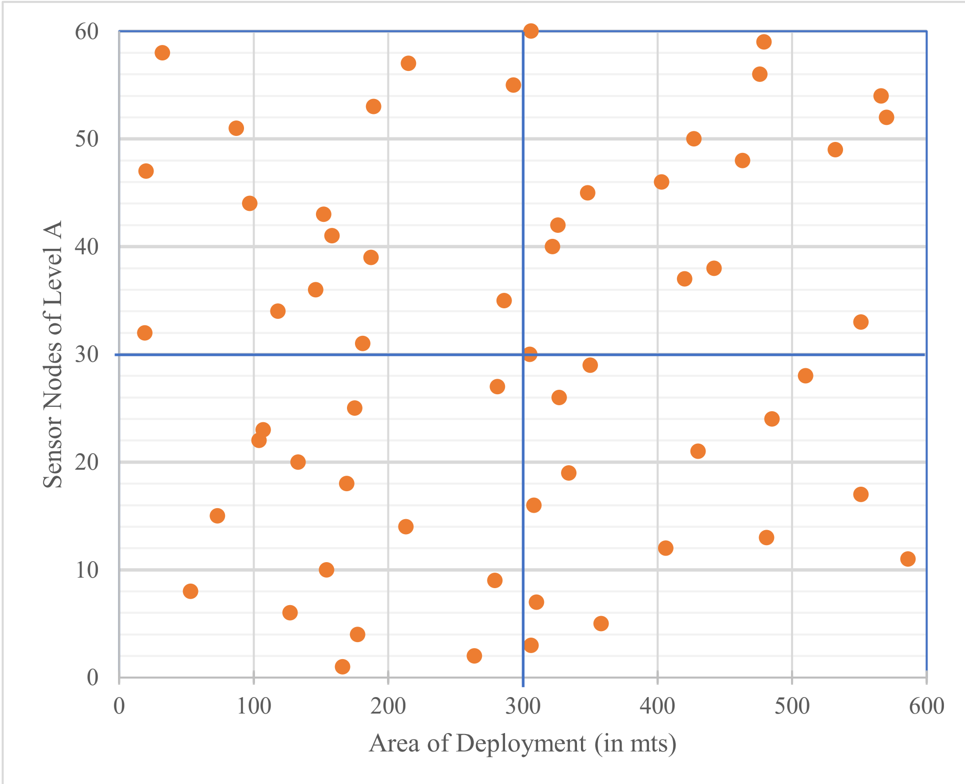

Figure 2 Case 1: Deployment of nodes with Q [1, 2, 3, 4]

3.2Results

Based on the liner distribution of the nodes over Euclidian distance. Each case is considered based on the channel propagation $P(t)$ varies as the depth increases. Figure 3 shows that mobility (M) is highest at level A in case 1 and case 2, however in case 3 due to negligible number of nodes at level C it may not be effectively compared. Furthermore, in case 2, the mobility factor is the highest and is the most critical node distribution. Figure 3 clearly shows the performance in underwater environment and the role of effective node deployment. For the Case 1 where the node deployment is linear in distribution of nodes in all three levels, the effect of mobility is variable.

Figure 4 shows the behaviour of nodes while exposed to Level A, B and C in Case 1, 2 and 3. The deployment of nodes in layer A are experienced to highest mobility while level 3 is resulting the least changes. This signifies that any application in underwater sensor network where the marine sediment of ocean is used for major data communication will experience highest mobility, highest propagation delay, node failure, least effectiveness of communication. While applications where the maximum density of nodes are in lithosphere mantle, the communication will be slower, lest node failure, comparably less propagation delay, higher transmission strength is required and will have reliable communication. However, other factors like viscosity of water is highest so, more energy for transmission of signal is required. Further, the communication with the surface buoy is difficult and re-establishment of communication is involving distinct factors for basic communication.

From these results it is established that R-KrushD is one of the most effective underwater sensor network approach as it exploits the node deployment for the purpose of underwater internode communication (see figure 5). The results also shows that the finite field of application area in underwater network is dependent upon the type of node density in all the three levels. The fact of pre-identification of application based identification can effectively done by the R-KrushD routing mechanism. However, temperature, salinity and SNR are not included as the part of the study in this paper. These parameters will also add extreme outcome as required for underwater sensor network.

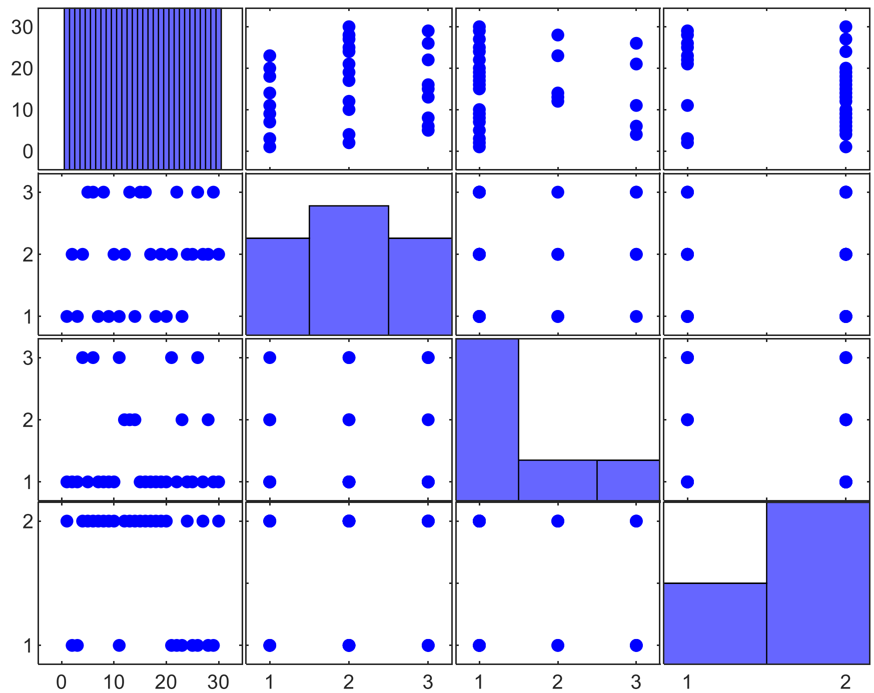

Figure 3 Propagation in Level A, B, C of Q [1, 2, 3, 4]

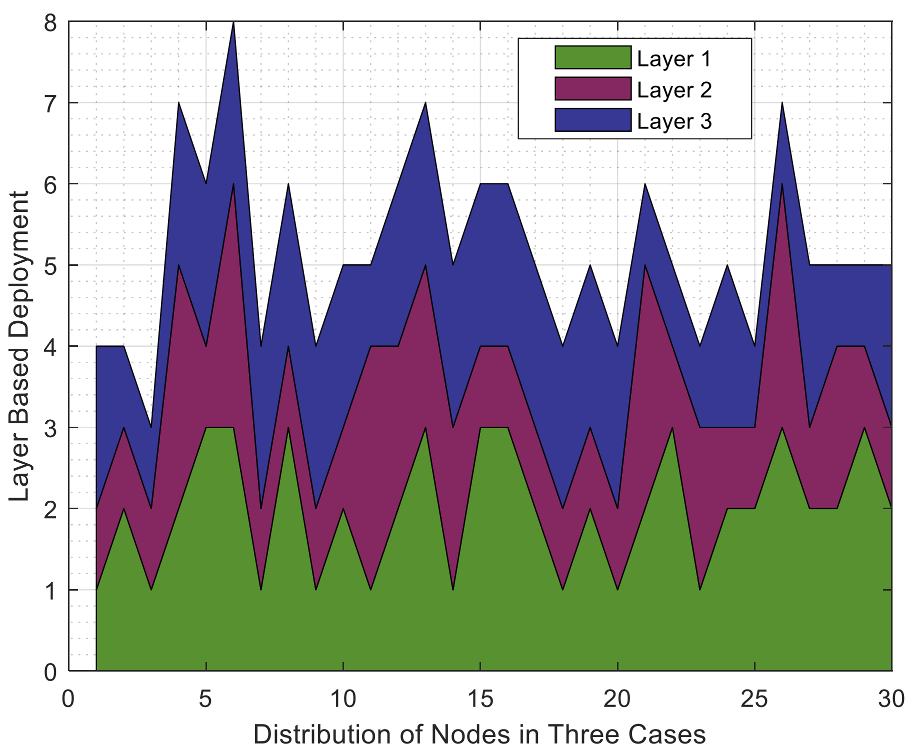

Figure 4 Layer wise effect of mobility as per Case 1, 2 and 3

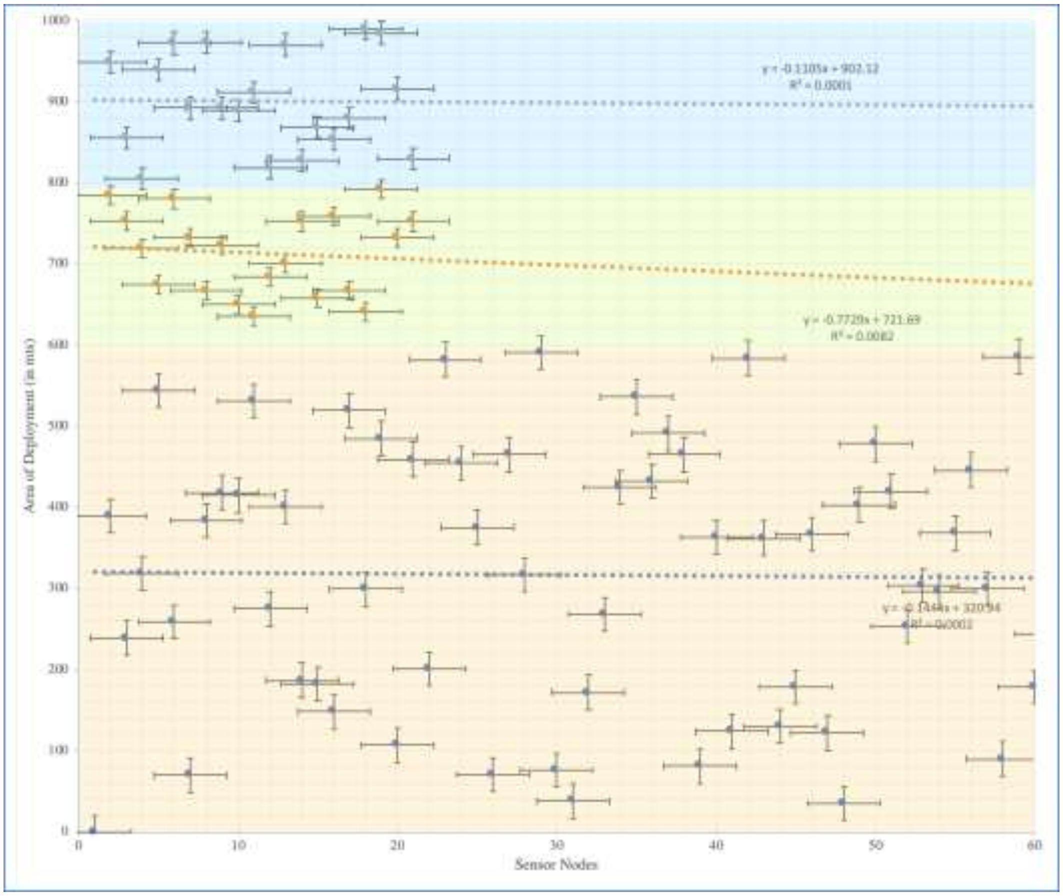

Figure 5 The overall network span for 30 nodes deployment in three sea level

Conclusion and Future Work

This paper shows the performance of R-KrushD routing approach. As per the cases formulated to study the performance of approach, it is established that effectiveness of the approach is higher than existing approaches as in previous work, node deployment analysis is not the part of the routing mechanism. Furthermore, this paper shows that in extreme environment of underwater, network formulation must be based on the type of application. It is shown that the performance of R-KrushD for mobility factor can be controlled and monitored in efficient manner.

For the extreme analysis of the approach the parameters like temperature, salinity, SNR may also be analyzed to identify the performance of R-KrushD to extreme environments.

Appendix

The copyright version 12360/2021-CO/SW of R-KrushD algorithm is given for the reference of the readers.

Symbol	Descriptions
S	Source Node
D	Destination Node
⊡	Surface Buoy
–	Flow of information
N_c	Communication Node
N	Nodes
d	Euclidian Distance
$Q: 1, 2, 3, 4$	Quadrants
x, y, z	Axis in 3D environment
P	Path Factor
$P(t)$	Channel Propagation
$P(l)$	Propagation loss within CN
M	Mobility Issue
Δ	Doppler's Effect
CN	Communication Network

$\boldsymbol{T}$	Threshold of distance
$\boldsymbol{T_s}$	Threshold of source node
$\boldsymbol{T_d}$	Threshold of destination node
$\boldsymbol{info}$	Source (S) and Destination (D) information to different quadrants
$\boldsymbol{P(f)}$	Path loss factor
$\boldsymbol{S_s}$	Salinity (temperature, pressure, volume heat and viscosity)
$\boldsymbol{T_n}$	Total Nodes
R-KrushD	Name of the proposed algorithm in the name the author

1. Deployment of ⊡ as per the sea bed in proportion to the number of communication node
2. Establish communication among ⊡ and Arial devices
3. Include the $\boldsymbol{Q}$ (1, 2, 3, 4) for communication with ⊡
4. **Rand ()** distribution of N in 3D $(\boldsymbol{x}, y, z)$
// N *are distributed at d eceludian distance*
5. Send information of $\boldsymbol{S}$ and $\boldsymbol{D}$ to ⊡
6. **If** $(\boldsymbol{M} > \boldsymbol{T_s} \parallel \boldsymbol{T_d})$ // $\Delta < M$
7. **{**
8. $\boldsymbol{S}$ && $\boldsymbol{D}$ contact nearest ⊡
9. Get new info
10. Update new info to ⊡
11. **}**
12. **Else**
13. **{**
14. Using *Krush-D routing*
15. **}**
16. Send info to $\boldsymbol{Q}$ (1, 2, 3, 4)
17. **If** $(\boldsymbol{N} = \boldsymbol{N_c})$
// *as per* d *for, such as* $d \in \Delta$
18. **{**
19. $\boldsymbol{N}$ Nearest $\boldsymbol{CN}$
20. Start communication in $\boldsymbol{CN}$
// *as per DDD approach*
21. **}**
22. **Else**
23. **{**
24. Search $\boldsymbol{P(l)}$ && $\boldsymbol{P(t)}$ in nearest $\boldsymbol{CN}$
25. Check $\boldsymbol{Q}$ (1, 2, 3, 4) for nearest $\boldsymbol{CN}$
26. Enable $\boldsymbol{CN}$
27. **}**
28. **If** $(\boldsymbol{communication} \neg \boldsymbol{established})$
// *within* $\boldsymbol{Q}$ (1, 2, 3, 4) *for* $\boldsymbol{CN}$
29. **{**
30. Goto step 6
31. **}**
32. **Else**
33. Exit and send info to nearest ⊡
34. **Stop**

ote:

- **a.** $\boldsymbol{T_s}$ and $\boldsymbol{T_d}$ must be determined as per each $\boldsymbol{Q}$ (1, 2, 3, 4) for nearest $\boldsymbol{CN}$.
- **b.** Communication Failure situation: i) $P(f) > \boldsymbol{SNR}$ ii) $S \neq \boldsymbol{D} \parallel \boldsymbol{D} \neq \boldsymbol{S}$
- **c.** Considered Viscosity level as below ~10KHz
- **d.** Time of communication within the $\boldsymbol{Q}$ (1, 2, 3, 4) for nearest $\boldsymbol{CN}$ is out of scope of this paper.
- **e.** The communication in $\boldsymbol{CN}$ is based on DDD approach.

References

[1] V. Kumar and V. K. Sinha, "Underwater wireless sensor network Routing Protocols: The Survey," 2020 2nd International Conference on Advances in Computing, Communication Control and Networking (ICACCCN), 2020, pp. 359-362, doi: 10.1109/ICACCCN51052.2020.9362749.

[2] S. R. Vignesh, R. Sukumaran, T. C. Subash Ponraj, T. T. Manikandan and M. Saravanan, "Analysis on Energy Harvesting Techniques for Underwater Wireless Sensor Networks," 2021 Third International Conference on Intelligent Communication Technologies and Virtual Mobile Networks (ICICV), 2021, pp. 153-156, doi: 10.1109/ICICV50876.2021.9388519.

[3] A. Al Guqhaiman, O. Akanbi, A. Aljaedi and C. E. Chow, "A Survey on MAC Protocol Approaches for Underwater Wireless Sensor Networks," in IEEE Sensors Journal, vol. 21, no. 3, pp. 3916-3932, 1 Feb.1, 2021, doi: 10.1109/JSEN.2020.3024995.

[4] K. G. Omeke, M. S. Mollel, L. Zhang, Q. H. Abbasi and M. A. Imran, "Energy Optimisation through Path Selection for Underwater Wireless Sensor Networks," 2020 International Conference on UK-China Emerging Technologies (UCET), 2020, pp. 1-4, doi: 10.1109/UCET51115.2020.9205429.

[5] X. Li, X. Hu, R. Zhang and L. Yang, "Routing Protocol Design for Underwater Optical Wireless Sensor Networks: A Multiagent Reinforcement Learning Approach," in IEEE Internet of Things Journal, vol. 7, no. 10, pp. 9805-9818, Oct. 2020, doi: 10.1109/JIOT.2020.2989924.

[6] R. Bakr, A. A. Aziz El-Banna, S. A. A. El-Shaikh and A. S. Tag Eldien, "Energy Efficient Spectrum Aware Distributed Cluster-Based Routing in Cognitive Radio Sensor Networks," 2020 2nd Novel Intelligent and Leading Emerging Sciences Conference (NILES), 2020, pp. 159-164, doi: 10.1109/NILES50944.2020.9257972.

[7] D. Han, X. Du and X. Liu, "CELR: Connectivity and Energy Aware Layering Routing Protocol for UANs," in IEEE Sensors Journal, vol. 21, no. 5, pp. 7046-7057, 1 March1, 2021, doi: 10.1109/JSEN.2020.3039808.

[8] J. Qadir, U. Ullah, B. Sainz-De-Abajo, B. G. Zapirain, G. Marques and I. de la Torre Diez, "Energy-Aware and Reliability-Based Localization-Free Cooperative Acoustic Wireless Sensor Networks," in IEEE Access, vol. 8, pp. 121366-121384, 2020, doi: 10.1109/ACCESS.2020.3006194.

[9] K. Saeed, W. Khalil, S. Ahmed, I. Ahmad and M. N. K. Khattak, "SEECR: Secure Energy Efficient and Cooperative Routing Protocol for Underwater Wireless Sensor Networks," in IEEE Access, vol. 8, pp. 107419-107433, 2020, doi: 10.1109/ACCESS.2020.3000863.

[10] Q. Wang, J. Li, Q. Qi, P. Zhou and D. O. Wu, "A Game-Theoretic Routing Protocol for 3-D Underwater Acoustic Sensor Networks," in IEEE Internet of Things Journal, vol. 7, no. 10, pp. 9846-9857, Oct. 2020, doi: 10.1109/JIOT.2020.2988503.

[11] Mohammad Sharif-Yazd1, Mohammad Reza Khosravi2, Mohammad Kazim Moghimi; Journal of Computer and Communications; A Survey on Underwater Acoustic Sensor Networks: Perspectives on Protocol Design for Signaling, MAC and Routing, pg 12-23 (2017).

[12] Geetangali Rathee, Ankit Mundra, Nitin Rakesh, and S.P. Ghrera, “Buffered Based Routing and Resiliency Approach for WMN”, IEEE International Conference of Human Computer Interaction, Chennai, India, 1-7, 2013.

[13] Nishit Walter, Nitin Rakesh, Rakesh Matam, Shailesh Tiwari, “KRUSH-D Approach for the Solution to Node Mobility Issue

in Underwater Sensor Network (UWSN)", International Conference on Recent Advancements in Computer Communication and Computational Sciences (ICRAC3S-2016), Networking Communication and Data Knowledge Engineering, Springer Singapore, 2018, Book Chapter.

[14] Kanika Agarwal, Nitin Rakesh, "Node Mobility Issues in Underwater Wireless Sensor Network". In: Bhatia S., Mishra K., Tiwari S., Singh V. (eds) Advances in Computer and Computational Sciences. Advances in Intelligent Systems and Computing, vol 553, 2017, Springer, Singapore.

[15] Kamal Nayan Chaturvedi, Ankur Kohli, Akshat Kamboj, Shobhit Mendiratta, Nitin Rakesh, "NS2 Based Structured Network Attack Scrutiny in MANET", International Conference on Recent Advancements in Computer Communication and Computational Sciences (ICRAC3S-2016), Networking Communication and Data Knowledge Engineering, Springer Singapore, 2018, Book Chapter.

[16] Sharif, B.; Neasham, J.; Hinton, O.; Adams, A.; Davies, J. Adaptive Doppler compensation for coherent acoustic communication. *Proc. IEE Radar Sonar Navig.* 2000, *147*, 239–246.

Rani Astya is serving the organization as a role of Assistant Professor in the Department of Computer Science & Engineering. She pursued her graduation (B.E.) in computer science Engg from Jiwaji University (Gwalior, MP) and post-graduation (M.Tech) in Information Technology from IIT Roorkee. Her research domains are optimal path planning for mobile robots by quad tree method.

Prof. Chandra Kumar Jha is working as a Professor in the department of Computer Science, Banasthali Vidyapith, and Rajasthan. He is having 22 years of teaching, research and 07 years of Industry experience in Advanced Networking, Cloud Computing, IOT, Data science to name a few. He has guided 20 Ph.D. students under his credit. Currently, 04 students are pursuing Ph.D. under him. A three time CISCO recipient for best instructor, he has delivered enormous number of invited lectures in many top rated institutions. He has more than 100 research papers published in (high impact factored, Scopus indexed, Web of Sciences) journals, conferences, chapter in a book etc. He has also executed three research projects sponsored by MCIT and UGC as principal and Co-Investigator.

Apart from Academics and Research, he is also HOD of Computer Science department. He is active member of various committee of Banasthali Vidyapith

Prof. (Dr.) Nitin Rakesh is an experienced professional in the field of Computer Science. He is PhD in Computer Science & Engineering with Network Coding as his specialization. Dr. Nitin is Master of Technology Degree in Computer Science & Engineering from and received Bachelor of Technology in Information Technology. Dr. Nitin is a recipient of IBM Drona Award and Top 10 State Award Winner. He is active member of professional society like IEEE (USA), ACM, SIAM (USA), Life Member of CSI and other professional societies. He is reviewer of several prestigious Journals/Transactions like IEEE Transactions on Vehicular Technology, The Computer Journal, Oxford Press, many SPRINGER/other Scopus indexed International Journals. His research outlines emphasis on Network Coding, Interconnection Networks & Architecture and Online Phantom Transactions. Dr. Nitin has accorded several other awards for Best Paper Published, Session Chairs, Highest Cited author, Best Students Thesis Guided, and many others.