











is negligible considering resource utilization performance achieved by ERA. Further, no prior work has considered such energy performance evaluation. From result achieved it can be sated the ERA is very efficient when adopted under highly dynamic jamming environment with presence of multiple jammers. Future work would consider employing more heuristic and optimal solution to further enhance of lifetime UWSN sensor motes.

## References

- [1] Aman, Waqas & Rahman, Muhammad Mahboob Ur & Qadir, Junaid. Impersonation Detection in AWGN-limited Underwater Acoustic Sensor Networks, 2018.
- [2] I.F. Akyildiz, D. Pompili, T. Melodia, Underwater acoustic sensor networks: research challenges, *Ad Hoc Netw.* 3 (3) (2005) 257–279, 2005.
- [3] Wood A, Stankovic J, Zhou G (2007) DEEJAM: Defeating energy efficient jamming in IEEE 802.15.4- based wireless networks. In: 4th Annual IEEE Communications Society Conference on Sensor, Mesh and Ad Hoc Communications and Networks, pp 60–69.
- [4] O. A. Osanaiye, A. S. Alfa and G. P. Hancke, "Denial of Service Defence for Resource Availability in Wireless Sensor Networks," in *IEEE Access*, vol. 6, pp. 6975-7004, 2018.
- [5] W. Xu, K. Ma, W. Trappe, and Y. Zhang. "Jamming sensor networks: Attack and defense strategies." *IEEE Network*, 20:41–47, 2006.
- [6] M. Wilhelm, I. Martinovic, J.B. Schmitt, V. Lenders, Short paper: reactive jamming in wireless networks—how realistic is the threat? in: *Proc. of WiSec*, Hamburg, Germany, pp. 47–52, 2011.
- [7] M. Strasser, B. Danev, S. Capkun, Detection of reactive jamming in sensor networks, *ACM Trans. Sens. Netw.* 1–29, 2010.
- [8] K. Pelechris, M. Iliofotou, S.V. Krishnamurthy, Denial of service attacks in wireless networks: the case of jammers, *IEEE Commun. Surv. Tutor.* 13 (2) (2011) 245–257.
- [9] S. Misra, S. Dash, M. Khatua, A.V. Vasilakos, M.S. Obaidat, Jamming in underwater sensor networks: detection and mitigation, *IET Commun.* 6 (14) (2012) 2178–2188.
- [10] D. Giustiniano, V. Lendersy, J.B. Schmittz, M. Spuhler, M. Wilhelmz, Detection of reactive jamming in DSSS-based wireless networks, in: *Proc. of WiSec*, Budapest, Hungary, 2013.
- [11] F. Campagnaro, R. Francescon, P. Casari, R. Diamant, and M. Zorzi, "Multimodal underwater networks: Recent advances and a look ahead," in *ACM International Conference on Underwater Networks & Systems (WuWNet)*, Nov. 2017.
- [12] P. Tague, S. Nabar, J. A. Ritcey, and R. Poovendran, "Jamming Aware Traffic Allocation for Multiple-Path Routing Using Portfolio Selection", *IEEE/ACM Transactions on Networking*, 2010.
- [13] Y. Xuan, Y. Shen, N. P. Nguyen and M. T. Thai, "A Trigger Identification Service for Defending Reactive Jammers in WSN," in *IEEE Transactions on Mobile Computing*, vol. 11, no. 5, pp. 793-806, May 2012.
- [14] Bhavathankar, Prasenjit, Subhadeep Sarkar and Sudip Misra. "Optimal decision rule-based ex-ante frequency hopping for jamming avoidance in wireless sensor networks." *Computer Networks* 128 (2017): 172-185.
- [15] Diamant, Roei & Casari, Paolo & Tomasin, S. (2018). Cooperative Authentication in Underwater Acoustic Sensor Networks.
- [16] M. A. Maleki Sadr, M. Ahmadian-Attari, R. Amiri and V. V. Sabegh, "Worst-Case Jamming Attack and Optimum Defense Strategy in Cooperative Relay Networks," in *IEEE Control Systems Letters*, vol. 3, no. 1, pp. 7-12, Jan. 2019.
- [17] C. Lal, R. Petroccia, K. Pelekanakis, M. Conti and J. Alves, "Toward the Development of Secure Underwater Acoustic Networks," in *IEEE Journal of Oceanic Engineering*, vol. 42, no. 4, pp. 1075-1087, Oct. 2017.
- [18] R. Diamant, R. Francescon and M. Zorzi, "Topology-Efficient Discovery: A Topology Discovery Algorithm for Underwater Acoustic Networks," in *IEEE Journal of Oceanic Engineering*, vol. 43, no. 4, pp. 1200-1214, Oct. 2018.
- [19] S. Jiang, "State-of-the-Art Medium Access Control (MAC) Protocols for Underwater Acoustic Networks: A Survey Based on a MAC Reference Model," in *IEEE Communications Surveys & Tutorials*, vol. 20, no. 1, pp. 96-131, First quarter 2018.
- [20] H. U. Yildiz, V. C. Gungor and B. Tavli, "Packet Size Optimization for Lifetime Maximization in Underwater Acoustic Sensor Networks," in *IEEE Transactions on Industrial Informatics*. doi: 10.1109/TII.2018.2841830
- [21] R. Diamant, P. Casari, F. Campagnaro and M. Zorzi, "Leveraging the Near-Far Effect for Improved Spatial-Reuse Scheduling in Underwater Acoustic Networks," in *IEEE Transactions on Wireless Communications*, vol. 16, no. 3, pp. 1480-1493, March 2017.
- [22] Aman, Waqas & Rahman, Muhammad Mahboob Ur & Qadir, Junaid & Pervaiz, Haris & Ni, Qiang. (2018). Impersonation Detection in Line-of-Sight Underwater Acoustic Sensor Networks. *IEEE Access*. 6. 1-1. 10.1109/ACCESS.2018.2863945.
- [23] Anjana P Das, Sabu M Thampi, "Simulation Tools for Underwater Sensor Networks: A Survey," Published 2016 in *Network Protocols & Algorithms*, Vol 8, No 4 (2016), DOI:10.5296/npa.v8i4.10471.
- [24] Kang, Seokyeon & Aldwairi, Monther & Kim, Ki-II. (2016). A survey on network simulators in three-dimensional wireless ad hoc and sensor networks. *International Journal of Distributed Sensor Networks*. 12. 10.1177/1550147716664740.
- [25] "Macosim: Matlab-based acoustic underwater simulator," <http://www.sit.iitkgp.ernet.in/smisra/swan/tre/macsim.htm> 1, [Online; accessed on 15-Dec-2016].
- [26] Sheetal Bagali, R. Sundaraguru, "Maximize resource utilization based channel access model with presence of reactive jammer for underwater wireless sensor network", Vol 10, No 3, 2019. DOI: <http://doi.org/10.11591/ijece.v10i3.pp3284-3294>
- [27] Sheetal Bagali and R. Sundaraguru, "Efficient Channel Access Model for Detecting Reactive Jamming for Underwater Wireless Sensor Network," 2019 International Conference on Wireless Communications Signal Processing and Networking (WiSPNET), Chennai, India, 2019, pp. 196-200, doi: 10.1109/WiSPNET45539.2019.9032861.