ENERGY EFFICIENT UNDERWATER WIRELESS ACOUSTIC SENSOR NETWORKS: A REVIEW

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Abstract - During last two decades, underwater acoustic sensor networks (UwASNs) are widely being deployed undersea to sense the environmental variations and objects for security use. Unlike the wireless sensor networks, UwASNs use acoustic channel for the communication. Limited battery-driven sensors compelled to develop the energy efficient UwASNs for the continuous operation of monitoring. Therefore, this paper reviews the energy efficient UwASNs exist in the literature.

Keywords - Underwater sensor networks, Scheduling, Energy efficiency, Optimization algorithms

I. INTRODUCTION

Underwater acoustic communication has been a persistent field of research for more than 50 years now. The first initiative for under water communication was initiated by the United StatesNavy after 2nd World War [1]. Due to the immense benefits of underwater communication in applications like scientific, military and commercial uses, it has been an active research topic in the past decade. The applications vastly includes unmanned vehicle communication, water and air pollution monitoring, oil extraction process etc.
Traditionally to communicate successfully in underwater wireless sensor networks (UwASNs) [2],[3] the Electromagnetic signals, optical signals and acoustic signals are utilized. In contrary, due to high attenuation in water radio frequency (RF) waves need higher transmission power and also bigger antennae. Another option is to use optical waves. But the main shortcoming of optical waves is they are easily scattered and absorbed by water. This enables it to be used only for short range communications [4].

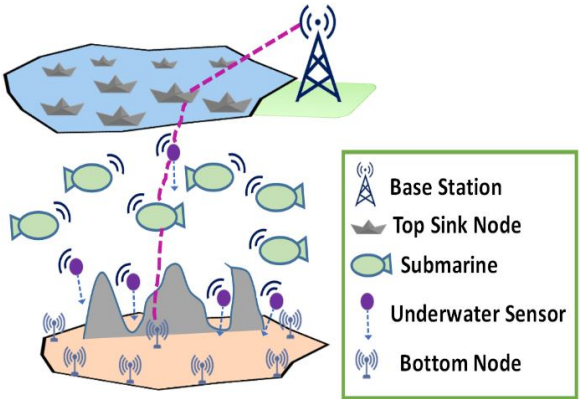


Figure 1: An example of UwASNs in which different sensors observe the atmosphere and send data to ground station via an acoustic link. Submarine acts as a relaying node which gather information from the sensors and transmit to the base station through a surface sink node.

Generally the design of underwater acoustic sensor networks (UwASNs) includes a set of sensor nodes installed under water, forming a wireless link between them and communicate amongst them [5][6]. This ability helps us to discover resources, monitor water pollution which is on the rise these days and detect targets etc[7][4]. Traditionally UwASNs hosts a variety of sensor nodes with the need to transmit acoustic waves.

Figure 1 in UwASNs shows that the sensors can monitor the targets, further AUVs are taken to be as relay nodes. This enables the underwater sensor to transmit messages to AUVs which acts as relay and transmit datato sensing nodes or base stations in neritic zones or above the level of sea. Similar to the wireless sensor networks (WSNs), the sensor nodes in UwASNs operate in batteries and are resource constrained. Unlike the WSNs, which can be powered by solar energy UwASNs cannot be recharged by solar energy [5].Thereby, extending the lifetime of UwASNs is a challenging task. Research works on extending the lifetime of UwASNs have focussed on scheduling the sleep cycles of the sensors deployed. This sleep cycle is deployed among the sensors where only few of the sensors are active while the others sleep. After a period of time, after a particular schedule, when the active sensors are depleted on power, the sensors in sleep become active. This will help in extending the lifetime of UwASNs [6], [7].The purpose of this review is to provide the current research on the energy efficient UwASNs.

II. ENERGY EFFICIENT UWASNS

In both, the terrestrial WSNs as well as UwASNs, energy utilization is one of the crucial feature, because limiting the energy utilization can prolong the existence of network of the longest period of time. In current years, different energy utilization models have been suggested to achieve the energy efficient UwASNs.
Authors in [8], suggested a convincing energy utilization model for the sensing devices by

integrating the features of classic low-energy consumed transceivers. Authors in [9], suggested a specific energy utilization model that only contemplates two modes for the microcontroller and transceiver. The work in [10] develops a combination of finite state machines to characterize the modes and changes occurred in the hardware of the sensing devices. For example, work in [11], suggested an energy efficient model based on the shallow and deep undersea conditions for the UwASNs.

Different from the above researches which focuses on energy utilization models for sensing devices, the other existing works [12-15] proposed an optimization algorithms for the energy efficient UwASNs. For example, the authors in [12], proposed a technique whose main purpose is to reduce the number of sensing devices while maximizing the sensing coverage and minimizing the energy utilization rates for an energy efficient UwASNs. For an energy efficient UwASN, both the number of sensing devices and their locations are needed to perform the task of object surveillance [13].

Different from the work in [12], the author in [14], proposed an optimized approach to place the sensing devices on the suitable location in three dimensional space for an energy efficient UwASNs. The research in [15], suggested a metaheuristic approach, termed as Genetic algorithm (GA), to find the suitable locations of sensing device to decrease the transmission delay and energy utilization rate for an energy efficient UwASN.

Unlike the above researches, the work in [13], suggested a modified meta-heuristic approach, termed as multi-population harmony search algorithm (MPHSA), for achieving the energy efficiency ofUwASN. Like GA, HSA[16]refers a metaheuristic approach which can simulate the act ofdifferent musicians how they create the music. The authors in [13], considered 3-D space for the targets monitoring. Their suggested MPHSA finds the possible membership for each sensing devices so that a group of sensing devices having same membership can sense the targets while rest are forced to sleep for later operations.

CONCLUSION

Like the environmental monitoring, underwater acoustic sensor networks are being used for the military surveillance. Battery constraint on sensing devices, restricts the over all lifetime of the network. Therefore, in this paper, we reviewed the existing researches which focuses on energy efficient underwater acoustic sensor networks.

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REFERENCES

[1] Headrick, R.; Freitag, L. Growth of underwater communication technology in the U.S. Navy. IEEE Commun. Mag. 2009, 47, 80–82.

[2] Benson, B. Design of a Low-cost Underwater Acoustic Modem for Short-Range Sensor Networking Appications. Ph.D. Thesis, University of California, San Diego, CA, USA, 2010.

[3] Heidemann, J.; Stojanovic, M.; Zorzi, M. Underwater sensor networks: Applications, advances and challenges. Philos. Trans. R. Soc. A 2012, 370, 158–175.

[4] Akyildiz, I.F.; Pompili, D.; Melodia, T. Underwater acoustic sensor networks: Research challenges. Ad. Hoc. Netw. 2005, 3, 257–279.

[5] D. Pompili and I. F. Akyildiz"Overview of networking protocols for underwater wireless communications"IEEE Commun. Mag., vol. 47, no. 1, pp. 97-102, 2009

[6] M. Chitre, S. Shahabudeen and M. Stojanovic"Underwater acoustic communications and networking: Recent advances and future challenges"Marine Technol. Soc. J., vol. 42, no. 1, pp. 103-116, 2008

[7] P. Salvo Rossi, D. Ciuonzo, T. Ekman and H. Dong"Energy detection for MIMO decision fusion in underwater sensor networks"IEEE Sensors J., vol. 15, no. 3, pp. 1630-1640, 2015

[8] Wang, Q.; Hempstead, M.; Yang, W. A Realistic Power Consumption Model for Wireless Sensor NetworkDevices. In Proceedings of the 3rd Annual IEEE Communications Society on Sensor and Ad-HocCommunications and Networks, Reston, VA, USA, 28 September 2006; pp. 286–295.

[9] Dunkels, A.; Osterlind, F.; Tsifites, N.; He, Z. Software-Based On-Line Energy Estimation for Sensor Nodes.In Proceedings of the 4th Workshop on Embedded Networked Sensors, Cork, Ireland, 25–26 June 2007;pp. 28–32.

[10] Kellner, S.; Pink, M.; Meier, D.; Blass, E. Towards a Realistic Energy Model for Wireless Sensor Networks.In Proceedings of the 5th Annual Conference on Wireless on Demand Networks Systems and Services,Garmisch-Partenkirchen, Germany, 23–25 January 2008; pp. 97–100.

[11] Domingo, M.C.; Prior, R. Energy analysis of routing protocols for underwater wireless sensor networks.Comput. Commun. 2008, 31, 1227–1238.

[12] Z. Yingying, L. Xia and F. Shiliang, "Deployment analysis in two-dimensional underwater acoustic wireless sensor networks", Proc. IEEE ICSPCC, pp. 1-5, 2011.

[13] C. C. Lin, D. J. Deng and S. B. Wang, "Extending the Lifetime of Dynamic Underwater Acoustic Sensor Networks Using Multi-Population Harmony Search Algorithm," IEEE Sensors Journal, vol. 16, no. 11, pp. 4034-4042, June 1, 2016.

[14] S. Iyer and D. V. Rao, "Genetic algorithm based optimization technique for underwater sensor network positioning and deployment", Proc. IEEE UT, pp. 1-6, 2015..

[15] N. Jugen, L. Deshi and H. Yanyan, "Optimization of multiple gateway deployment for underwater acoustic sensor networks", Comput. Sci. Inf. Syst., vol. 8, no. 4, pp. 1073-1095, 2011.

[16] Z. W. Geem, J. H. Kim and G. V. Loganathan, "A new heuristic optimization algorithm: Harmony search", J. Simul., vol. 76, no. 2, pp. 60-68, 2001.

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