Energy Efficient and Reliable Data Transmission in Underwater Wireless Sensor Network: A Survey

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***Abstract*—The data transmission in wireless technology on earth is through electromagnetic waves or radio waves. But, this is not possible in underwater or oceanographic environment. The data transmission can be done through optical signals or acoustic signals. The power utilization in underwater sensor network is the major issue. The power inefficiency leads to delay in packet delivery, error rate is high, loss of packet which causes retransmission, failure of battery in sensor nodes, and transmission rate is low when compared to terrestrial environment. This paper surveys the various energy efficient mechanisms in Underwater Wireless Sensor Network (UWSN).**

Keywords- UWSN; Energy Efficiency; Packet size; Distance.

I. INTRODUCTION

Two third of the earth surface is composed of water. So, it is widely believed that wider access to the aquatic environment enhances human knowledge and understanding of the world's oceans. Hence, the current development of communication systems produces scientific, economic and social benefits. New applications enable deeper ocean observation, environmental monitoring, surveying or search and rescue missions.

A. Underwater Wireless Sensor Network

In UWSN, the sensor nodes are with acoustic modem. They are densely distributed in the 3D aqueous space. The multiple gateway nodes with both acoustic and radio frequency modems are deployed at the water surface. Each underwater sensor node detects or monitors the change in the environment. As shown in Figure. 1 when a data is received, the sensor nodes transmit data to the gateway nodes through the acoustic link. The surface gateway nodes receive the data and transmit it to the radio links. Compared to acoustic link the radio link are much reliable, faster and more energy efficient.

The station where the information required is collected is called sink or base station. Multi-sink is deployed in larger applications. The multi-sink network is helpful in traffic balance and multiple path finding. Multi-sink help to find more path to the virtual sink (surface gateway) and can reduce packet collision and packet loss.

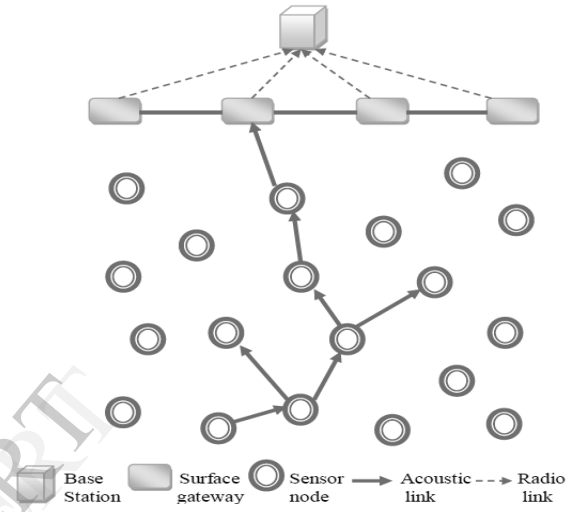

Figure 1. *UWSN Model*

B. Energy Efficiency

The energy can be used efficiently by optimizing the packet size, transmit the packet in multipath channel; transmit the data via shortest distance nodes.

By optimizing the packet size or length, increase the energy efficiency which improves effective and efficient transmission. The acoustic channel is used to transmit data, since communication is done in Deep Ocean. The energy in the sensor node must be taken into consideration because the recharging cannot be done by solar. The optimization of packet length and effective data transmission is proven in acoustic channel.

Multipath routing is used to transmit data in multipath channel. The source node has some packets to send via intermediate nodes to the destination node. The source node sends the route request to destination node. In response to the request destination node sends route reply to the source node. The packets are forwarded in multipath channel and efficiency of data transmission.

The data loss can be prevented when there are dense nodes in the network. The source node checks for the available neighboring nodes in the network. The node which is nearer gets the highest priority and data are forwarded. The intermediate node serves as the forwarding candidates. The

data are transmitted without transmission with the accurate interval of time.

Some definitions,

- The sensor node in wireless sensor network is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network.
- Bandwidth is the carrying capacity of a channel or the data transfer speed of the channel in the network.
- Throughput refers to how much data can be transferred from one location to another in a given amount of time.
- Clustering is the grouping of similar objects or sensors. In other words, nodes belonging in a group execute different functions from groups.

II. RELATED WORKS

A. Related works on packet size

The researchers have done research on optimizing the packet size for efficient data transmission. In [3], [4], [7], [8], [9], [10] the authors have implemented algorithms and unique techniques for achieving reliable data transfer by reducing the packet size, transferring the packets in network with low energy sensor nodes.

B. Related works on reducing the distance between the nodes

The distance between the sensor nodes is reduced to improve the efficiency. The low cost and nearest nodes are selected for data transmission. In [1], [6], [11], [12], [14], [15] authors have discussed various techniques, algorithms, network design and protocols to find the shortest distance between the nodes which enable reliable communication with low energy consumption.

S. Beeno Ancy et al., [1] discussed that the multipath power control transmission has three operations such as multipath routing, source initiated power control transmission and destination packet to be combining. Opportunistic routing protocol is used in which the data are transmitted to the nearest node. The packet forwarder does not follow any time slots but the distance matters.

Yin-guo et al., [2] said about Micro Controller Unit (MCU) which uses electromagnetic coupling. The steel ring is used for power transmission. The overwater machine and underwater machine is used which is controlled by MCU. The coupling coefficient has a great influence on the transmission efficiency. The experiment is tested with changing in transmission distance, power and data transmission.

Junfeng Xu et al., [3] developed Heuristic Algorithm which is used to calculate the power and energy consumption. NS2 simulator is used to analyze the performance with data rate and packet size as parameters. Bit Error Ratio (BER) and Packet Error Ratio (PER) are calculated which help to improve the energy efficiency.

Low Tang et al., [4] explained underwater wireless network energy efficiency and optimal data packet size. Payload length, distance, frequency, bandwidth, protocol, constraint bit rate are the parameter taken for simulation. BER, PER, Energy per Useful Bit (EPUB) is compared to find the relationship between optimal packet size and energy efficiency.

A.Sanchez et al., [5] designed a modem which is of low cost and high efficient. The modulation and demodulation algorithms are implemented. Ultra low power consumption, a small form factor and low cost are the main advantages of low cost and high efficient acoustic modem for underwater sensor network but fails in prototype design.

Jesus Llor et al., [6] elaborated Deterministic Prediction model, Bellhop model and statistical Prediction model. They analyze network design and trace the ray that generates an ensemble of channel response corresponding to varying propagation condition in the network design.

Simranjeet et al., [7] implemented their idea in MAC layer, network layer and network topology. Cross layer approach is proposed to increase network efficiency in underwater networks. The network topology adapts itself for the environment changes while using vector based forwarding Energy consumption. The parameters such as average delay, success rate used to calculate the number of packets received at the sink.

Dario Pompili et al., [8] explored on "Distributed routing algorithm for underwater acoustic sensor network". The delay-insensitive and delay-sensitive algorithms are proposed. The node jointly selects the best next hop, optimal transmitting power, Forward Error Correction (FEC) rate for each packet to minimize the energy consumption. The optimized packet size is set on-line for data forwarding. The packet train is simulated with packet size and time as the parameters.

Mohammed et al., [9] compared the MAC Layer protocols with Aloha, R-MAC, FAMA, UWAN_MAC and Broadcast MAC. The protocol efficiency is calculated. The performance result shows that energy consumption is high in FDMA and throughput is higher in UW-MAC, Broadcast MAC and FDMA protocols. When delay is tested as a parameter FDMA show irregular delay than UW-MAC and Broadcast MAC. The packet drop is higher in Broadcast than UW-MAC and FDMA. Final result proposes that UW-MAC is the optimum protocol in terms of throughput and energy efficiency.

Sankyuk-Dong et al., [10] discussed the Energy Efficient depth-based routing protocol. It consists of two phases such as knowledge acquisition phase and data forwarding phase. In knowledge acquisition phase, the sensor node shares their depth and energy information among neighbors. In data forwarding phase, the data are forwarded on the basis of depth and the energy information from the nodes closer to the sink. The selection of having high energy attempts to balance the energy consumption among the sensor nodes.

Sharad Saxena et al., [11] discussed a cluster based node density in heterogeneous underwater sensor network. Underwater Density Based Clustered Sensor Network which uses heterogeneous sensors. Cluster head checks for the nodes in the coverage region. The distance between the nodes, time

duration of each hop, message size, and sensor node energy are taken as parameter and simulated in MATLAB. Overall network communication cost is reduced with long lifetime of network.

Jiejun Kong et al., [12] implemented a technique called Delay-tolerant Data Dolphin (DDD) to apply delay tolerant networking in the resource constrained underwater environment. DDD exploits the mobility of the small number of capable collector node to gather information sensed by low power sensor devices by saving sensor battery power. Data reports to the nearest dolphin in short one-hop distance. DDD is highly cost effective.

H. Fukuda et al., [13] used electromagnetic signal data that transmit with two antennas for contactless communication and power transmission. By using high-Q EM technique, higher transmission is done for longer distance compared to the induction technique. The power transfer efficiency can be relatively high at the mid-range distance using lower frequency resonance and the high transmission rate can be possible using the higher frequency band.

Hongkun Yang et al., [14] applied Karush-kuhn-Tucker condition which concentrates on the energy consumption and its relations to four parameters such as node distance, communication frequency, packet length and transmitting power in UWSN. The performance metrics is taken into account for reliability and communication delay. The result shows that reliability and communication delay are the crucial factors to the energy consumption for transmission.

Chin-Min Chao et al., [15] proposed a contention-free, multi-channel MAC protocol for UWSNs that works well even when nodes experience uneven and bursty traffic loads. The nodes use multiple channels in a contention-free way that helps reducing transmission collisions. Simulation results verify that the proposed protocol conserves energy and is extremely suitable for a heavy-loaded environment.

III. SUMMARY

By optimizing the packet size and reducing the distance between the sensor nodes, the energy efficiency in UWSN can be improved. Bandwidth, distance, delay and packet size are the parameters considered for efficient transmission. Topology and network design remain challenging and still an unsolved problem.

REFERENCES

[1] S. Beeno Ancy and S. Shahul Hammed "Energy Efficient and Reliable Communication in Underwater Acoustic Sensor Networks", International Journal of Advance Research in Computer Engineering and Technology, Vol. 2, Issue 1, pp.169-173, Jan 2013.

[2] Yin-Guo Huang, Cheng Fang and Xing-Fei Li "Contactless power and data transmission for underwater sensor nodes", Springer open journal, EURASIP journal on wireless communications and networking, pp. 1-7, 2013.

[3] Junfeng Xu, Keqiu Li and Geyong Min "Layered Multi-path Power control in underwater sensor network", in proceeding of IEEE Global Telecommunications Conference (GLOBECOM 2010) ,Miami, FL, pp. 1-5, Dec. 2010.

[4] Low Tang Jung and Azween B. Abdullah "Underwater wireless network energy efficiency and optimal data packet size", IEEE, International Conference on Electrical, control and Computer engineering, pp. 178-182, June 2011.

[5] A. Sanchez, S. Blanc, P. Yuste and J.J. Serrano "A low cost and high efficient acostic modem for underwater sensor network",in proceeding of IEEE OCEANS , Santander, Spain, pp. 1-10, June 2011.

[6] Jesus Llor, and Manuel Perez Malumbres "Statistical modeling of Large-scale signal path loss in underwater acoustic networks", Open Access Sensor, Vol. 13, Issue 2, pp. 2279-2294, Feb. 2013.

[7] Simranjeet Singh Wali and Rohit Sethi "Enhancement of Underwater acoustic networks by using and enhancing vector-based forwarding", International Journal of Engineering Research and Technology, Vol. 2, Issue 3, pp. 1-5, Mar. 2013.

[8] Dario Pompili, Tommaso Melodia and Ian F. Akyildiz "Distributed routing algorithms for underwater acoustic sensor networks", in proceeding of IEEE Transactions on wireless communications, Vol. 9, Issue. 9, pp. 2934-2944, Sept. 2010.

[9] Asst.Prof. Mohammed Najm. Abdullah and Ahmed Mosa Dinar "Performance Assessment of MAC layer protocols in pollution monitoring system based on underwater wireless sensor network", Journal of global research in computer science, Vol. 4, No. 3, pp. 40-45, Mar. 2013.

[10] Sankyuk-Dong and Buk-Gu Daegu "A Energy efficient localization-free routing protocolfor underwater wireless sensor networks", Hindawi Publishing Corporation International Journal of Distributed sensor networks, Vol.2012, pp.1-11, Feb. 2012.

[11] Sharad Saxena, shailendra Mishra and Mayank Singh, "Clustering based node density in heterogeneous underwater sensor network", Modern Education and computer science press, Vol. 7, pp. 49-55, June 2013.

[12] Jiejun Kong, Uichin Lee, Geria et al., "A Mobile delay-tolerant approach to long-term energy-efficient underwater sensor networks", in proceeding of IEEE Wireless Communication and Networking Conferences, Kowloon, pp. 2866-2871, Mar. 2007.

[13] H. Fukuda, N. Kobayashi, k. Shizuno et al., "New concept of a electromagnetic usage for contactless communication and power transmission in the ocean", in proceeding of IEEE Underwater Technology Symposium(UT), Tokyo, pp. 1-4,Mar. 2013.

[14] Hongkun Yang, Bin Liu, Fengyuan Ren et al., "Optimization of Energy efficient transmission in underwater sensor networks", in proceeding of IEEE Global Telecommunications Conference, Honolulu, pp. 1-6, Dec. 2009.

[15] Chin-Min Chao and Ming-Wei Lu, "Energy Efficient transmissions for burst traffic in underwater sensor networks", International Journal of Ad Hoc and ubiquitous computing, Vol. 13, No. 1, pp. 1-9, 2013.