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Proposed ST-Slotted-CS-ALOHA Protocol for Time Saving and Collision Avoidance☆

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Abstract

Time Saving and energy consumption has become a vital issue that attracts the attention of researchers in Underwater Wireless Sensor Networks (UWSNs) fields. According to that, there is a strong need to improve MAC protocols performance in UWSNs, particularly enhancing the effectiveness of ALOHA Protocol. In this paper, a time-saving Aloha protocol with slotted carrier sense proposed which we called, ST-Slotted-CS-ALOHA protocol. The results of the simulation demonstrate that our proposed protocol can save time and decrease the average delay when it compared with the other protocols. Moreover, it decreased energy consumption and raised the ratio of throughput. However, the number of dropped nodes does not give better results compared to other protocols.

1 Introduction

Underwater Wireless Sensor Networks (UWSNs) researches are considered to be an important task in these days. The performance of UWSNs can be enhanced by improving the routing protocols as in [1, 2] or by enhancing the MAC protocols [3]. The general classification of MAC protocol in UWSNs is classified into three parts [4] including contention-based MAC protocols, contention-free MAC protocols, and hybrid MAC protocols [5]. In this paper, we focused on one of the contention-based approaches called the Random-Access approach [6].

In the Random-Access technique, whenever a node has data ready to be sent; it simply starts the transmission [7]. As soon as the receiver receives a data packet if this receiver is free from receiving other packets and there is no incoming packet in the period; this data packet can be received successfully by the receiver [8]. Through the Random-Access techniques, the transmission medium can be randomly shared by more than one node in the absence of control. Random-Access protocols divide into Carrier Sense Multiple Access (CSMA) and ALOHA protocols [9]. In this paper, we emphasise on the ALOHA protocols and how to improve its behaviour.

The remainder of this paper is organized as follows. In Section 2, different types of random access ALOHA protocols are discussed. Section 3 presents the details of the proposed protocol. In Section 4, we show the performance results of the proposed protocol in comparison with the other closest protocols.

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Finally, we draw the main conclusions and present the expected future work in Section 5.

2 Random Access ALOHA Protocols Background

ALOHA considered becoming the simplest Random-Access MAC protocol. The implementation of this protocol can be done easily; therefore, it could not try to prevent collisions of a packet as shown by [10]. The protocol works as follow. If a node has a packet ready for sending, it will send the packet immediately. A collision occurs if two nodes are simultaneously sending packets. In this case, a node will retransmit this packet again. In this Section, different types of Aloha protocols are presented by giving a brief introduction of the main features of them [11]. The main task is to determine how to send the packet without caring if a collision occurs or not.

2.1 Pure Aloha Protocol

In the Pure Aloha protocol, whenever any data is ready to be sent, the node can do. According to this process, a great issue can occur, especially when two nodes or more sending the packets simultaneously [12]. Hence, the collision arises, the node resends the packet after a random time delay that supports avoiding a new collision. The process of Pure Aloha protocol is divided into three stages: frame initialization and sent, increase and check the back-off technique, and feedback [13].

2.2 Slotted Aloha Protocol

In order to enhance the efficiency of Pure Aloha, it is important to decrease the probability of packet collision [14]. Therefore, the node can send one packet at the start of each time slot; otherwise, a collision arises. The case of two nodes start sending at the same time a collision also appears. Indifference to the Pure Aloha, Slotted Aloha does not allow packet transmission when the node has packets ready to be sent but, it enforces the node to wait until the start of the next slot time [15].

2.3 Propagation Delay Tolerant (PDT) Aloha Protocol

he PDT Aloha protocol was presented by [16]. It is considered to be a simple improvement of slotted Aloha protocol; the main modification is that at the termination of each slot time it has a protector band. Explicitly, all the network transmitters keep synchronized time slots for the PDT-Aloha protocol connection. At the start of a time slot, a node sends a packet whenever it has one ready to send, then waiting the next slot time to begins even though the queue has another data packet or not [17]. Hence, to accomplish packets reception with better throughput, the Slotted Aloha performance has been enhanced by the methodology of PDT Aloha protocol. According to this improvement, the throughput of the PDT-Aloha protocol is better than the standard Slotted Aloha, with appropriate protocol features.

2.4 Aloha-CS Protocol

Although this protocol uses the term carrier sense, the Aloha-CS does not spend extra time to recognize the channel state. As an alternative, it simply checks if its half-duplex modem is getting a packet or not at this time [18]. Hence, a node with a new data packet instantaneously senses the carrier. It first checks; if the carrier is free and idle, then the node transmits its packet immediately. If the carrier is busy, it postpones transmission of that packet. After retransmission attempt by the maximum allowed intervals, a packet will be dropped.

2.5 Aloha-AN and Aloha-CA Protocols

Aloha with advance notification, which called Aloha-AN protocol and Aloha with collision avoidance that called Aloha-CA protocol are similar to each other. Both of them were designed to dissolve the disadvantages of Aloha-CS. Aloha-AN protocol needs to collect more information and additional resources than Aloha-CA [19]. Aloha-AN and Aloha-CA protocols can raise the value of the network throughput better than pure Aloha protocol. In addition, no need for using handshake and synchronization approaches [20]. However, by reducing the packet size and increasing the number of nodes, the value of the throughput is decreased quickly.

2.6 Slotted-CS-Aloha Protocol

Authors in [21] proposed a Slotted-CS-Aloha protocol to enhance the ALOHA protocol performance by saving energy consumption. Although the protocol gives better performance in reducing energy consumption, increasing the ratio of throughput, and reducing the number of dropped nodes, but still there is a delay problem occurred due to using a buffer before entering the Aloha cycles [22]. The Slotted-CS-Aloha protocol could not reduce the value of the average delay and achieves week performance in that feature.

From the previous six protocols, we choose the closest protocols to our proposed one, which are Slotted Aloha, Aloha-CS, and Slotted-CS-Aloha protocols. In the next Section, the proposed protocol presented and discussed in details.

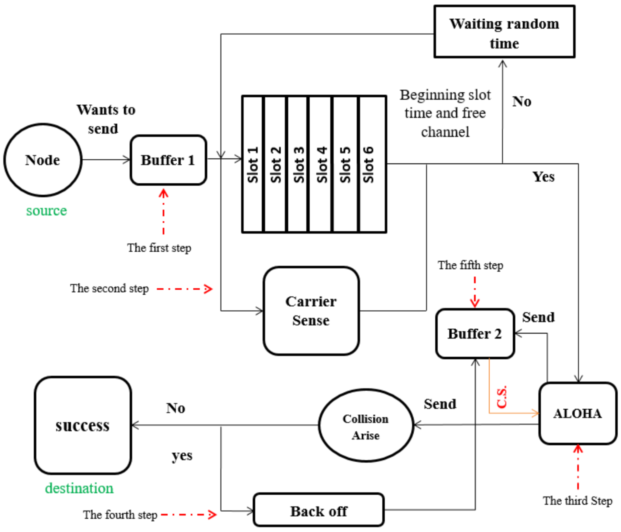

Figure 1. The Structure of the Proposed ST-Slotted-CS-Aloha Protocol

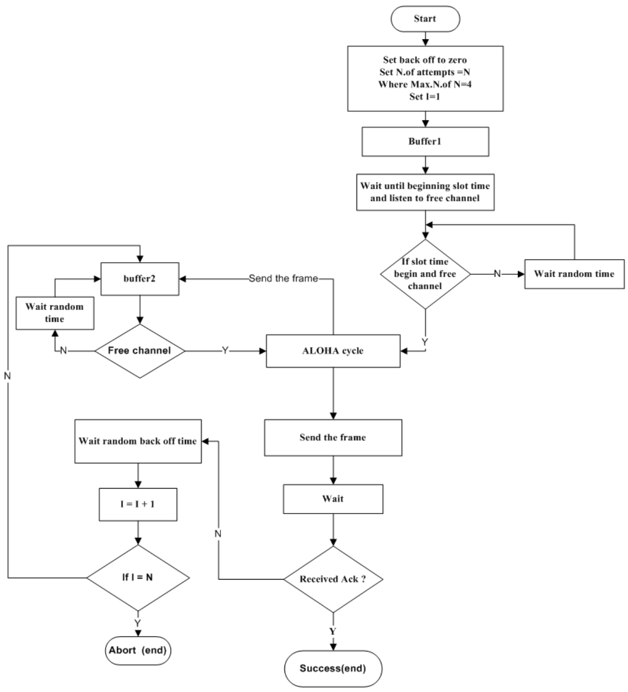

Figure 2. The Flowchart of The ST-Slotted-CS-Aloha Proposed Protocol

3 The Proposed Protocol: ST-Slotted-CS-ALOHA Protocol

Most of the current Aloha protocols still suffering some unsolved issues. The Slotted Aloha protocol is simple and can transmit the packets at the full rate of the channel, but there are some problems still unsolved like collisions, wasting time, and clock synchronization. The Aloha-CS protocol has a delay problem of the packet and sometimes packet dropped. For the Slotted-CS-Aloha protocol, although it has good performance in energy consumption throughput ratio; however, a delay problem occurred due to using two buffers before and after the Aloha cycle step. Our proposed protocol aims to dissolve the common problem that appeared in the chosen protocols; which is the time delay, especially with the rising of nodes' number. It is also important to avoid the collision that is one of the main reasons for time delay problems.

Figure 1 illustrates the structure of our proposed ST-Slotted-CS-Aloha protocol and Figure 2 illustrates the flowchart of the proposed protocol. ST-Slotted-CS-Aloha protocol can be presented by four steps starting with the source node that initialize the connections. Then, the steps sequentially performed until the final destination. We suppose that we have six time slots. The four steps described as follows:

The first step: initialization for all the parameters and check both the start of the time slot and whether the channel is free or not. Then, the transmission of the data packets from the sender node to the main buffer begins. According to this action, the node can move into a sleeping mode; this mode makes the consumption of energy very low. The first in first out (FIFO) scenario is used to arrange packets entry and exit whether inside or outside the buffer.

The second step: Buffer 1 existing on the first step and propagating the packets to the second buffer, Buffer 2 resides in the third step passing over the second step.

The third step: starting the Aloha phase with sending the frame and waiting for receiving the acknowledgment. The operation of the Aloha cycle and the packet will be sent to two sides; the first is Buffer 2 and the second is to its target and waiting for the acknowledgment. In this step, which is considered as Aloha cycle, after sending the packet it waits until receiving an acknowledge signal (ACK) which means that the data packet arrived safely without any collision to the destination. Otherwise, the fourth step will be active.

The fourth step: increase the back-off and check the slots, we increase the value of the back-off and check all of the other parameters. This work uses the back-off approach for data retransmission to accomplish improved value for the throughput. This process can be applied easily and it is appropriate to be used with more complex protocols with more than one channel.

The fifth step: this is the final step in our ST-Slotted-CS-Aloha proposed protocol, which is the feedback process and buffer2. It is an important process within our proposed protocol where by using this process, we ensure that the packets have sent back.

It is expected that our proposed protocol will save

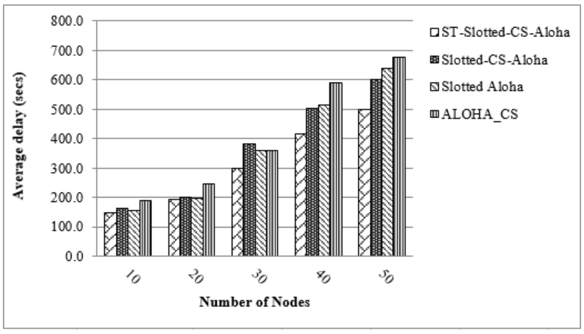

Figure 3. The Average Delay vs. Number of Nodes

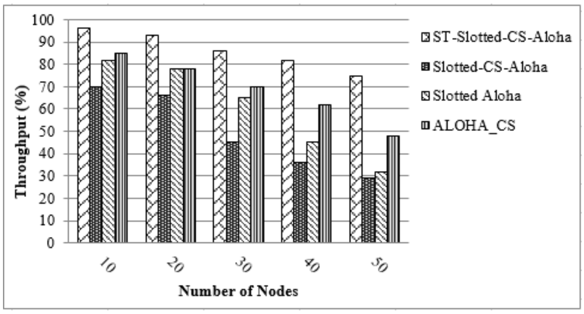

Figure 4. The Throughput vs. Number of Nodes

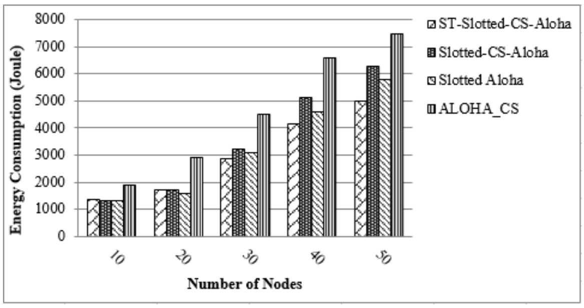

Figure 5. The Energy Consumption vs. Number of Nodes

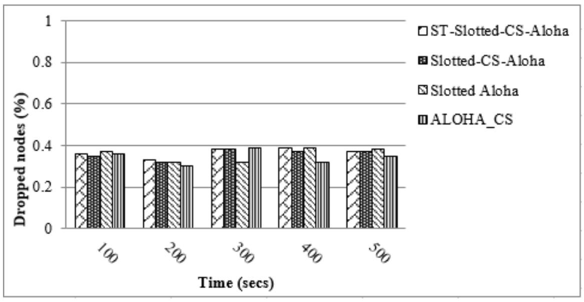

Figure 6. The Number of Dropped Nodes vs. Time

the time that wasted in case of using a buffer after the Aloha cycle is done. In the next Section, the performance analysis and evaluation is presented to test the proposed protocol and compare its performance with the other existing protocols.

4 Performance Assessment

In the simulation process, the AquaSim package which depends on the NS2 Network Simulator is used in building the UWSNs as in [23]. The parameters of the experiments are similar to UWM 1000 LinkQuest Underwater Acoustic Modem [24]. Each node has a 100m range and average bit rate of 10kbps. The proposed energy consumption is 0.5J, 0.2J, and 0.02J for sending, receiving, and idle modes, respectively. We generated the topology randomly with 30 runs and took the average results with a total of 600 s simulation time for each run.

ST-Slotted-CS-Aloha protocol gives minimum average delay than other compared protocols specifically with the increasing of nodes number, as described in Figure 3. Throughput measuring is done by calculating how many units of information can reach the destination in a given amount of time. Figure 4 illustrates that our proposed technique gives throughput result higher than the other protocols. In Figure 5, we found that the proposed technique reduced the energy consumption with the rising of the number of nodes. This happened according to the reduction of the collision process that saved the energy of the nodes. While in Figure 6, the proposed protocol does not achieve good performance in comparison with the other protocols. The reason is that our proposed protocol modifying the place of the buffers causing increasing the number of dropped nodes little bit.

5 Conclusion

In this paper, ST-Slotted-CS-Aloha protocol was proposed to enhance the efficiency of the currently Aloha protocols, especially in the time-saving feature. The proposed protocol is divided into four steps starting from the source node until the destination. The previous works closest to our proposal suffering from the average delay problem due to incorrect usage of the inter buffers. We ignore using the buffer if the Aloha cycle successfully passed. Otherwise, we use the second buffer before waiting for the channel to become free. The results of the simulation validate that our proposed technique can decrease the average delay and saving time in comparison with the other closest protocols. Moreover, it results in reducing energy consumption and increasing the ratio of the throughput. Nevertheless, the number of dropped nodes does not give better results when compared to other protocols. As future work, it is important to focus on the collision problems to enhance the results related to the dropped nodes.

References

[1] Ibrahim D. M., Fahmy M. M., ElTobely T. E., and Sallam E. A. Enhancing the vector-based forwarding routing protocol for underwater wireless sensor networks: A clustering approach. In

International Conference on Wireless and Mobile Communications (ICWMC2014), pages 98–104, 2014.

[2] Ibrahim D. M., ElTobely T. E., Sallam E. A., and Fahmy M. M. Bounded side-based clustering vbf routing protocol in underwater wireless sensor networks. *International Journal on Advances in Networks and Services*, 8:130–138, 2015.

[3] Pompili D. and Akyildiz I. F. Overview of networking protocols for underwater wireless communications. *IEEE Communication International Magazine*, pages 97–102, 2009.

[4] Shah G. A. A survey on medium access control in underwater acoustic sensor networks. In *Proceedings International Conference on Advance Information Networking and Application Workshops (WAINA'09)*, pages 1179–1183, 2009.

[5] Diamant R. and Lampe L. A hybrid spatial reuse mac protocol for ad-hoc underwater acoustic communication networks. In *Proceedings of Communications Workshops*, pages 1–5, 2010.

[6] Baig I. Ayaz M., Abdullah A., and Faye I. A survey on routing techniques in underwater wireless sensor networks. *International Journal of Network and Computer Applications*, 3:1908–1927, 2010.

[7] Volkan R. and Park M. K. Uwan-mac: An energy-efficient mac protocol for underwater acoustic wireless sensor networks. *IEEE/MTS International Journal of Oceanic Engineering*, 32:710–720, 2007.

[8] Peleato B. and Stojanovic M. A mac protocol for ad hoc underwater acoustic sensor networks. In *Proceedings of ACM International Workshop Under-Water Networks*, pages 113–115, 2006.

[9] De S., Mandal P., and Chakraborty S. S. On the characterization of aloha in underwater wireless networks. *International Journal on Mathematical and Computer Modelling*, 53:2093–2107, 2011.

[10] Petrioli C., Petroccia R., and Stojanovic M. A comparative performance evaluation of mac protocols for underwater sensor networks. In *Proceedings of MTS/IEEE OCEANS'08*, pages 1–10, 2008.

[11] Keyu C., Ma M., Cheng E., Yuan F., and Su W. A survey on mac protocol for underwater wireless sensor networks. In *IEEE International Conference on Communication Surveys and Tutorials*, pages 1433–1447, 2014.

[12] Seo J. and Jin H. Optimally controlled pure aloha systems for wireless sensor networks. *IEEE International Journal on Communication Letters*, 21:2460–2463, 2017.

[13] Wong D. T., Chen Q., Peng X., and Chin F. Multi-channel pure collective aloha mac protocol with de-collision algorithm for satellite uplink. In *IEEE International Conference on IoT*, pages 251–256, 2018.

[14] Baiocchi A. and Ricciato F. Analysis of pure and slotted aloha with multi-packet reception and variable packet size. *IEEE International Journal on Communication Letters*, 22:1482–1485, 2018.

[15] Polonelli T., Brunelli D., and Benini L. Slotted aloha overlay on lorawan: a distributed synchronization approach. In *Proceedings of the 16th IEEE International Conference on Embedded and Ubiquitous Computing (EUC 2018)*, pages 1–7, 2018.

[16] Ahn J. and Krishnamachari B. Performance of propagation delay tolerant aloha protocol for underwater wireless networks. In *Proceedings of Intternational Conference Distributed Computing in Sensor Systems (DCOSS)*, pages 1–16, 2008.

[17] Basagni S., Petrioli C., Petroccia R., and Stojanovic M. Choosing the packet size in multi-hop underwater networks. In *Proceedings of Oceans'10*, pages 1–9, 2010.

[18] Yao N., Peng Z., Z. M., and Cui J-H. Improving aloha via back off tuning in underwater sensor networks. In *Proceedings of Communication and Networks (CHINACOM)*, pages 1038–1043, 2011.

[19] Chirdchoo N., Soh W. S., and Chua K. C. Aloha-based mac protocols with collision avoidance for underwater acoustic networks. In *Proceedings of INFOCOM'07*, pages 2271–2275, 2007.

[20] Petrioli C., Petroccia R., and Potter J. Performance evaluation of underwater mac protocols: From simulation to at-sea testing. In *Proceedings of MTS/IEEE OCEANS'11*, pages 1–10, 2011.

[21] Khater E. M., Ibrahim D. M., and Faheem M. T. Contention-based mac protocol in uwsns: Slotted_cs_aloha proposed protocol. In *The 11th IEEE International Conference on Computer Engineering and Systems (ICCES'14)*, pages 73–78, 2016.

[22] Yunus F., Ariffin S., and Zahedi Y. A survey of existing medium access control (mac) for underwater wireless sensor networks (uwsn). In *Proceedings of Mathematical/Analytical Modeling and Computer Simulation (AMS)*, pages 544–549, 2010.

[23] Ns2 network simulator. http://www.isi.edu/nsnam/ns. Accessed: 2018-12-30.

[24] Linkquest underwater acoustic modem. http://www.link-quest.com. Accessed: 2018-12-30.

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