Advances in Wireless and Mobile Communications.
ISSN 0973-6972 Volume 10, Number 5 (2017), pp. 1059-1066

http://www.ripublication.com

A Review on Efficient Opportunistic Forwarding Techniques used to Handle Communication Voids in Underwater Wireless Sensor Networks

Varun G Menon
Department of Computer Science and Engineering
Sathyabama University, India

Joe Prathap P M
Department of IT, RMD Engineering College
Chennai, India.

Abstract

Underwater wireless sensor networks (UWSNs) have emerged as one of the most popular researched areas in the networking field due to its numerous applications in ocean exploration, underwater surveillance and pollution detection. Efficient collection and transfer of data between the sensor nodes defines the success of these applications. A number of advanced routing protocols have been proposed for efficient data delivery and reliable routing of data packets between the nodes in UWSNs. Communication void is one of the major obstacles preventing these routing protocols from achieving the required Quality of Service in UWSNs. This problem occurs when the source node is unable to find out next forwarder nodes to forward the data packet towards the destination node leading to packet loss and frequent retransmissions. The objective of this article is to review the most efficient opportunistic techniques involved in routing of data packets in UWSNs with communication voids.

Keywords: Communication Void; Efficient; Review; Routing Protocols; Underwater sensor networks;

1. INTRODUCTION

Underwater wireless sensor networks (UWSNs) consist of a group of sensor nodes deployed under the ocean to collect data for many applications in ocean exploration, underwater surveillance, pollution detection etc. As radio signals do not work well due to its quick attenuation in water, acoustic channel is used for communication [1-2]. All the nodes are equipped with acoustic transceivers to communicate with each other. UWSNs differ from the traditional sensor networks in many ways. The sensor nodes in traditional sensor networks are more static while the sensor nodes deployed under the ocean are dynamic because of ocean currents and sudden changes in the ocean. The propagation delay is higher in UWSNs while the data transfer rate is much lower compared to traditional sensor networks [3-4]. Due to these special characteristics, routing protocols proposed for traditional ad hoc and sensor networks [5-7] does not perform well in UWSNs and delivering data from the source to the destination sensor nodes has become one of the major issues in underwater sensor networks.

In recent years a number of advanced routing protocols have been proposed for efficient data delivery and reliable routing of data packets between the nodes in UWSNs [8-9]. Geographic routing protocols [10-11] using location information of the nodes and pressure routing protocols [18] using the pressure level information are the major categories of protocols proposed for UWSNs. Majority of these protocols use opportunistic forwarding mechanism [12-17] in routing the data packet. These protocols suffer from communication void [19-21] or communication hole problem especially in sparse networks and are unable to provide the required Quality of Service to various applications. Also known as the unreachability problem, this occurs when the source node is unable to find out next forwarder nodes to forward the data packet towards the destination node leading to packet loss and retransmissions. This problem is much prominent in geographic routing protocols using the greedy forwarding strategy. This paper reviews the working of the most efficient opportunistic techniques proposed to handle the communication voids in UWSNs. The paper is organized as follows. Section 2 describes the communication void problem in detail. Section 3 discusses the most efficient opportunistic techniques proposed to handle the communication voids in UWSNs. Further the issues and challenges existing with these methods are discussed. The paper concludes in Section 4 with new research directions.

2. COMMUNICATION VOID

Most of the routing protocols proposed for UWSNs use a simple technique to forward the data packets. Each forwarder node forwards the data packet to the neighbor node that is nearest to the destination and has maximum positive progress to the destination node. But in some cases the source node may not find any suitable forwarder node nearer to the destination to forward the data. Also the source node may suffer from the absence of neighboring nodes in its transmission area that are located in the direction of the destination. This is called the communication void or routing void or communication hole problem. Often this problem is referred as the unreachability problem. Figure 1 shows an example of a communication void in UWSN. Here the sensor node 'v' is unable to find out any neighbor node in the direction of the destination node SN2 to forward the data packet. The node 'v' is referred as the void node.

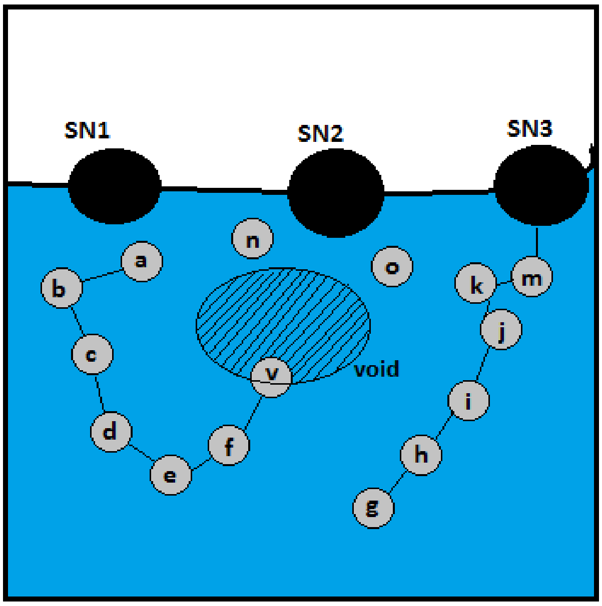

Figure 1: Communication Void in UWSNs

Communication voids degrades the performance of routing protocols and leads to serious data loss in UWSNs. In figure 1, void node 'v' is unable to forward the data packet intended for the SuperNode2 (SN2) located at the surface due to the communication hole in the direction of SN2. Frequent retransmissions, data loss, reduced data delivery rate and increased delay in data transmission are the major consequences of communication voids in UWSNs. Quality of Service offered by many protocols in UWSNs protocols decreases considerably due to their inability in handling communication voids in the network. This problem is much worse in sparse networks with fewer number of sensor nodes. This issue is also caused due to frequent movement of sensor nodes from one place to another resulting from ocean currents and sudden changes in the ocean. Next section discusses the most efficient opportunistic routing protocols proposed for UWSNs with communication voids.

3. VOID HANDLING TECHNIQUES

3.1 HydroCast [18]

Geographic routing protocols proposed for UWSNs require the location information of nodes in the network. Obtaining location information of neighbor node might result in drainage or loss of energy in sensor nodes. Motivated by this problem Uichin Lee et al. (2010) presented HydroCast, a hydraulic pressure based routing protocol that worked based on the pressure level information. HydroCast protocol worked with a simple strategy. Every node used the pressure level information and forwarded the incoming data packet to the sensor node with the lowest pressure level among the neighbor nodes. A new metric based on the probability of progress to the destination was used for candidate selection and prioritization.

The major advantage offered by HydroCast over all previous pressure based protocols was its unique recovery mechanism to handle communication voids in the network. A new concept known as the local minimum was introduced by this protocol to counter the communication voids. Every node can determine whether it is in its local minimum. A node is in local minimum if there is no neighboring node with a lower pressure level. HydroCast protocol enables each local minimum node to maintain a recovery route to a node whose depth is lower than itself. After one or more path segments go through the local minima, a packet can be routed out of the void and can switch back to the greedy mode.

3.2 VAPR [22]

Void Aware Pressure Routing is another latest pressure based routing protocol proposed to handle communication voids in UWSNs. The protocol works in two stages. It has an initial beaconing stage followed by the opportunistic forwarding stage. In the beaconing stage every node in the network broadcast beacon messages that include the depth, hop count and direction information of the node into the network. Every node that receives the beacon message updates its information and rebroadcasts the beacon message with updated information. In the second stage every node in the network uses the opportunistic forwarding technique to route the data packet from the source to the destination node.

The unique advantage of VAPR over all previous protocols is that it uses a prevention approach rather than a recovery approach in case of communication voids. The VAPR algorithm is designed to avoid void nodes in the data forwarding path from the source to the destination and thus utilizing only the best forwarder nodes in data transmission from the source to the destination nodes.

3.3 GEDAR [23]

GEographic and opportunistic routing with Depth Adjustment-based topology control for communication Recovery over void regions (GEDAR) is one of the latest routing protocols proposed to achieve good performance in UWSNs. GEDAR protocol integrates the concept of geographic routing with opportunistic forwarding techniques. The main advantage of GEDAR protocol is the incorporation of a recovery phase to handle communication voids in the network. The protocol works in opportunistic forwarding mode in normal conditions and switches to recovery mode on detecting communication voids in the network. Void node recovery procedure is used when the node fails to forward data packets using the location based greedy forwarding technique. The unique feature of GEDAR is that it uses node depth adjustment technology to move void nodes to new depths to recover from communication voids. It does not rely on message-based void node recovery procedures. Every node in the network determines whether it is in a communication void region by examining the neighbor node information. If the node is in a void region it informs this condition to the neighborhood. It then and waits for the location information of two hop nodes in order to decide which new depth it should move into and the greedy forwarding strategy can then be resumed. After, the void node determines a new depth based on two-hop connectivity such that greedy forwarding strategy is resumed. Table 1 summarizes the issues and challenges faced by all the three opportunistic forwarding techniques in UWSNs with communication voids.

Table 1: Issues and Challenges Faced by Opportunistic Forwarding Techniques in UWSNs

Void Handling Technique	Year	Type	Candidate Coordination	Issues and Challenges
HydroCast [18]	2010	Location Based	Timer Controlled	Energy of the sensor nodes are not considered in the forwarding strategy. Collection and updating of depth and delivery probability information at every node is tedious and impractical
VAPR [22]	2013	Pressure Based	Timer Controlled	Energy drainage caused by beacon messages.

GEDAR [23]	2014	Location Based	Timer Controlled	Does not consider the energy level of the nodes during the forwarding process. Redundant or duplicate forwarding at the intermediate nodes in the network

4. CONCLUSION

This research paper analyzed the working of the most efficient opportunistic techniques involved in routing of data packets in UWSNs with communication voids. Initially we discussed about the communication void problem in UWSNs. We discussed the issues caused by these voids in data transfer between the sensor nodes. Further the working of three efficient and latest opportunistic forwarding mechanisms used to handle communication void in UWSNs were discussed. The advantages offered by each of the technique were discussed. The issues and challenges faced by each of the techniques was highlighted and discussed. This analysis and study would further help in designing many efficient and optimized opportunistic routing protocols for the future UWSNs.

REFERENCES

[1] E. M. Sozer, M. Stojanovic and J. G. Proakis (2000), "Underwater acoustic networks," IEEE Journal of Oceanic Engineering, vol. 25, no. 1, pp. 72-83.

[2] Jun-Hong Cui, Jiejun Kong, M. Gerla and Shengli Zhou, (2006), "The challenges of building mobile underwater wireless networks for aquatic applications," IEEE Network, vol. 20, no. 3, pp. 12-18.

[3] I. Akyildiz, D. Pompili and T. Melodia, (2005), "Underwater acoustic sensor networks: research challenges", Ad Hoc Networks, vol. 3, no. 3, pp. 257-279.

[4] Jun-Hong Cui, Jiejun Kong, M. Gerla and Shengli Zhou, (2006), "The challenges of building mobile underwater wireless networks for aquatic applications," in IEEE Network, vol. 20, no. 3, pp. 12-18.

[5] Menon V. G. and Joe Prathap P. M., (2013), Performance of various Routing Protocols in Mobile A Hoc Networks-A Survey, Research Journal of Applied Sciences, Engineering and Technology, 6(22), pp. 4181-4185.

[6] Menon V. G. and Joe Prathap P M, (2016), "Routing in Highly Dynamic Ad

Hoc Networks: Issues and Challenges", International Journal of Computer Science and Engineering,vol.8, no. 4, pp.112-116.

[7] Menon V. G. et. al, (2013), "Performance Analysis of Traditional Topology based Routing Protocols in Mobile Ad hoc Networks", International Journal of Computer Science Applications,vol. 2, no.1, pp. 1-6.

[8] G. Han, J. Jiang, N. Bao, L. Wan and M. Guizani (2015), "Routing protocols for underwater wireless sensor networks," IEEE Communications Magazine, vol. 53, no. 11, pp. 72-78.

[9] Menon V. G. (2016), "Survey on Latest Energy Based Routing Protocols for Underwater Wireless Sensor Networks", International Journal of Computer Networks and Wireless Communications, 6(6), pp. 52-55.

[10] Menon V. G. and Joe Prathap P.M, (2013) , "Performance analysis of geographic routing protocols in highly mobile ad hoc network," Journal of Theoretical and Applied Information Technology, vol. 54 no. 1, pp 127-133.

[11] Menon V. G., Jogi Priya P M, Joe Prathap P M, (2013), "Analyzing the behavior and performance of greedy perimeter stateless routing protocol in highly dynamic mobile ad hoc networks", Life Science Journal , 10(2): pp 1601-1605.

[12] Menon V. G. and Joe Prathap P M, (2016), "Comparative Analysis of Opportunistic Routing Protocols for Underwater Acoustic Sensor Networks" Proceedings of the IEEE International Conference on Emerging Technological Trends [ICETT], Kerala, India.

[13] Darehshoorzadeh A. and Boukerche A., (2015), "Underwater sensor networks: a new challenge for opportunistic routing protocols", IEEE Communications Magazine, 53(11), pp. 98-107.

[14] Menon V. G. and Joe Prathap P.M, (2016) "Analysing the Behaviour and Performance of Opportunistic Routing Protocols in Highly Mobile Wireless Ad Hoc Networks", International Journal of Engineering and Technology, vol. 8, no. 5, pp. 1916-1924.

[15] Menon V. G. Joe Prathap Pathrose, and Jogi Priya, (2016), "Ensuring Reliable Communication in Disaster Recovery Operations with Reliable Routing Technique," Mobile Information Systems, vol. 2016, Article ID 9141329, 10 pages.

[16] Menon V. G. and Joe Prathap P M, (2017), "Towards Optimal Data Delivery in Highly Mobile Wireless Ad Hoc Networks", International Journal of Computer Science and Engineering,vol.9, no. 1, pp.1-6.

[17] Menon V. G., Joe Prathap P M and Vijay A, (2016), "Eliminating Redundant

Relaying of Data Packets for Efficient Opportunistic Routing in Dynamic Wireless Ad Hoc Networks", Asian Journal of Information Technology,vol. 12, no.17, pp.3991-3994.

[18] U. Lee, P. Wang, Y. Noh, L. F. M. Vieira, M. Gerla and J. H. Cui, (2010), "Pressure Routing for Underwater Sensor Networks," Proceedings of IEEE INFOCOM, San Diego, pp. 1-9.

[19] D. Chen and P. K. Varshney, (2007), "A survey of void handling techniques for geographic routing in wireless networks," in IEEE Communications Surveys & Tutorials, vol. 9, no. 1, pp. 50-67.

[20] S. M. Ghoreyshi, A. Shahrabi and T. Boutaleb, (2017), "Void-Handling Techniques for Routing Protocols in Underwater Sensor Networks: Survey and Challenges," in IEEE Communications Surveys & Tutorials, vol. 19, no. 2, pp. 800-827.

[21] V. G. Menon and P. M. Joe Prathap, (2016), "Opportunistic routing with virtual coordinates to handle communication voids in mobile ad hoc networks," in Advances in Signal Processing and Intelligent Recognition Systems, vol. 425 of Advances in Intelligent Systems and Computing, Springer, pp. 323–334,

[22] Y. Noh, U. Lee, P. Wang, B. S. C. Choi and M. Gerla, (2013), "VAPR: Void-Aware Pressure Routing for Underwater Sensor Networks," in IEEE Transactions on Mobile Computing, vol. 12, no. 5, pp. 895-908.

[23] R. W. L. Coutinho, A. Boukerche, L. F. M. Vieira and A. A. F. Loureiro, (2014), "GEDAR: Geographic and opportunistic routing protocol with Depth Adjustment for mobile underwater sensor networks," 2014 IEEE International Conference on Communications (ICC), Sydney, pp. 251-256.