A Survey on Energy Efficient Routing in UWSN

[1]Neha Kawale, Monali Dadhe, [2]Prof. Reena Thakur, [3]Prof. Dhiraj Gupta
[1,2,3]Department of Computer Science and Engineering GNIT Nagpur Maharashtra, India

Abstract-Underwater wireless sensor networks (UWSNs) have been showed as a promising technology to monitor and explore the oceans in lieu of traditional undersea wireline instruments. Nevertheless, the data gathering of UWSNs is still severely limited because of the acoustic channel communication characteristics. One way to improve the data collection in UWSNs is through the design of routing protocols considering the unique characteristics of the underwater acoustic communication and the highly dynamic network topology. In this paper, we propose the GEDAR routing protocol for UWSNs. GEDAR is an anycast, geographic and opportunistic routing protocol that routes data packets from sensor nodes to multiple sonobuoys (sinks) at the sea's surface. When the node is in a communication void region, GEDAR switches to the recovery mode procedure which is based on topology control through the depth adjustment of the void nodes, instead of the traditional approaches using control messages to discover and maintain routing paths along void regions.

Keywords-*Underwater WSN; GEDAR.*

I. INTRODUCTION

OCEANS represent more than 2/3 of the Earth's surface.These environments are extremely important for human life because their roles on the primary global production, carbon dioxide (CO2) absorption and Earth's cli-mate regulation, for instance. In this context, underwater wireless sensor networks (UWSNs) have gained the attention of the scientific and industrial communities due their potential to monitor and explore aquatic environ-ments. UWSNs have a wide range of possible applications such as to monitoring of marine life, pollutant content, geo-logical processes on the ocean floor, oilfields, climate, and tsunamis and seaquakes; to collect oceanographic data, ocean and offshore sampling, navigation assistance, and mine recognition, in addition to being utilized for tactic surveillance applications .Acoustic communication has been considered as the only feasible method for underwater communication in USWNs.High frequency radio waves are strongly absorbed in water and optical waves suffer from heavy scattering and are restricted to short-range-line-of-sight applications. Nevertheless, the underwater acoustic channel introduces large and variable delay as compared with radio frequency (RF) communication, due to the speed of sound in water that is approximately 1:5 103m/s (five orders of magnitude lower than the speed of light (3 108 m/s)); temporary path loss and the high noise resulting in a high bit error rate; severely limited bandwidth due to the strong attenua-tion in the acoustic channel and multipath fading; shadow zones; and the high communication energy cost, which is of the order of tens of watts.In this context, geographic routing paradigm seems a promising methodology for the design of routing protocols for UWSNs . Geographic routing, also called of position-based routing, is simple and scalable. It does not require the establishment or maintenance of complete routes to the destinations. Moreover, there is no need to transmit routing messages to update routing path states. Instead, route decisions are made locally. At each hop, a locally optimal next-hop node which is the neighbor clos-est to the destination, is selected to continue forwarding the packet. This process proceeds until the packet reaches its destination. Geographic routing can work together with opportunistic routing (OR) (geo-opportunistic routing) to improve data delivery and reduce the energy consumption relative to packet retransmissions.Using opportunistic routing paradigm, each packet is broadcast to a forwarding set composed of neighbors. In this set, the nodes are ordered according to some metric,defining their priorities. Thus, a next-hop node in the for-warding set that correctly received the packet, will forward it only whether the highest priority nodes in the set failed into do so. The next-hop forwarder node will cancel ascheduled transmission of a packet if it hears the transmis-sion of that packet by a higher priority node. In OR paradigm, the packet will be retransmitted only if none of the neighbors in the set receives it.The main disadvantage of geo-opportunistic routing isthe communication void region problem. The communication void region problem occurs whenever the current forwarder node does not have a neighbor node closest to the destination than itself, i.e., the current forwarder node is the closest one to the destination . The node located in a communication void region is calledvoid node. Whenever a packet gets stuck in a void node, the routing protocol should attempt to route the packet using some recovery method or it should be discarded.

In this paper, we propose the GEographic and opportu-nistic routing with Depth Adjustment-based topology con-trol for communication Recovery over void regions (GEDAR) routing protocol. GEDAR utilizes the location information of the neighbor nodes and some known sono-buoys to select a next-hop forwarder set of neighbors to con-tinue forwarding the packet towards the destination. To avoid unnecessary transmissions, low priority nodes sup-press their transmissions whenever they detect that the same packet was sent by a high priority node. The most important aspect of the GEDAR is its novel void node recovery methodology. Instead of the traditional message-based void node recovery procedure, we propose a void node recovery depth adjustment based topology control algorithm. The idea is to move void nodes to new depths to resume the geographic routing whenever it is possible. To the best of our knowledge, this work is the first that consid-ers depth adjustment node capabilities to organize the net-work topology of a mobile underwater sensor network to improve routing task. Simulation results showed that GEDAR is able to reduce the amount of void nodes through the depth adjustment based void node recovery strategy. Consequently, GEDAR improves the packet delivery ratio and decreases the end-to-end delay for the critical scenarios of low and high densities and diverse network traffic load, when compared with the state-of-the art routing protocols and the simple geographic and opportunistic routing (GOR) without any recovery mode.This work significantly enhances our previous solutions by investigating the routing problem and the maxi-mum local problem in mobile underwater network scenarios. Moreover, in this work we design an opportunistic routing protocol to cope with underwater acoustic communication impairments. In a static underwater sensor network scenario was considered with sensor nodes attached into buoys and anchors. In those solutions, routing decisions and the topology organization were done in a pro-active way, before the monitoring phase. The contributions of this work are i) an enhanced beaconing algorithm to disseminate the location of the neighbor nodes and known sonobuoys to avoid overloading the acoustic channel;ii) an anycast geo-opportunistic routing protocol advancing the packet, at each hop, in a directed way towards to the closest sonobuoy;iii)a novel reactive maximum local routing strategy based on the depth adjustment of the nodes, to improve the packet delivery ratio by avoid long hop paths, which can increase packet collisions and, consequently, the packet error rate, end-to-end delay and energy consumption.

Moreover, this work extends our preliminary solution in that we include

A. An enhanced review of underwater sensor network routing protocols,

B. A more detailed theoretical framework and proposed algorithms description,

C. More simulation results including different traffic load analysis and topology related and opportunistic routing protocol related performance evaluation metrics.

II. RELATED WORK

Underwater sensor nodes will find applications in oceanographic data collection, pollution monitoring, offshore exploration, disaster prevention, assisted navigation and tactical surveillance applications. Moreover, unmanned or autonomous underwater vehicles (UUVs, AUVs), equipped with sensors, will enable the exploration of natural undersea resources and gathering of scientific data in collaborative monitoring missions. Underwater acoustic networking is the enabling technology for these applications. Underwater networks consist of a variable number of sensors and vehicles that are deployed to perform collaborative monitoring tasks over a given area. In this paper, several fundamental key aspects of underwater acoustic communications are investigated. Different architectures for two-dimensional and three-dimensional underwater sensor networks are discussed, and the characteristics of the underwater channel are detailed. The main challenges for the development of efficient networking solutions posed by the underwater environment are detailed and a cross-layer approach to the integration of all communication functionalities is suggested. Furthermore, open research issues are discussed and possible solution approaches are outlined.[1]

In this paper we present a novel platform for underwater sensor networks to be used for long-term monitoring of coral reefs and fisheries. The sensor network consists of static and mobile underwater sensor nodes. The nodes communicate point-to-point using a novel high-speed optical communication system integrated into the TinyOS stack, and they broadcast using an acoustic protocol integrated in the TinyOS stack. The nodes have a variety of sensing capabilities, including cameras, water temperature, and pressure. The mobile nodes can locate and hover above the static nodes for data muling, and they can perform network maintenance functions such as deployment, relocation, and recovery. In this paper we describe the hardware and software architecture of this underwater sensor network. We then describe the optical and acoustic networking protocols and present experimental networking and data collected in a pool, in rivers, and in the ocean. Finally, we describe our experiments with mobility for data muling in this network.[2]

We propose a new link metric called normalized advance (NADV) for geographic routing in multihop wireless networks. NADV selects neighbors with the optimal trade-off between proximity and link cost. Coupled with the local next hop decision in geographic routing, NADV enables an adaptive and efficient cost-aware routing strategy. Depending on the objective or message priority, applications can use the NADV framework to minimize various types of link cost. We present efficient methods for link cost estimation and perform detailed simulations in diverse scenarios. Our results show that NADV outperforms current schemes in many aspects: for example, in high noise environments with frequent packet losses, the use of NADV leads to 81% higher delivery ratio. When compared to centralized routing under certain settings, geographic routing using NADV finds paths whose cost is close to the optimum.[3]

In this paper, we study the geographic collaborative forwarding (GCF) scheme, a variant of opportunistic routing, which exploits the broadcast nature and spatial diversity of the wireless medium to improve the packet delivery ef- ficiency. Our goal is to fully understand the principles, the gains, and the tradeoffs of the node collaboration and its associated cost, thus provide insightful analysis and guidance to the design of more efficient routing/forwarding protocols. We first identify the upper bound of the expected packet advancement (EPA) that GCF can achieve and prove the concavity of the maximum EPA. With energy efficiency as a major concern, we propose a new metric, EPA per unit energy consumption, which balances the packet advancement, reliability and energy consumption. By leveraging the proved properties, we then propose an efficient algorithm which selects a feasible candidate set that maximizes this local metric. We validate our analysis results by simulations, and justify the effectiveness of the new metric by comparing the performance of GCF with those of the existing geographic and opportunistic routing schemes.[4]

III. CONCLUSION

In this paper we introduced the underwater sensor network. We present the main application of underwater sensor network. In this paper we also introduced the architecture of underwater sensor network, routing family and main challenges of underwater sensor network. We plan to continue our UWSN study. We expect a fair amount of time on physical layer, because many challenges outlined in our paper are directly related to UWSN’s physical layer. Also we expect the time on to make efficient routing in underwater sensor network.

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