CHAPTER 10

Energy Efficient Opportunistic Routing in Underwater Sensor Networks

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10.1 INTRODUCTION

Although the earth's surface is covered by water over 70% compared to the land, human knowledge about the underwater environment is still too shallow as compared to the land. Due to technological advances in Wireless Sensor Networks (WSNs) nowadays, the exploration of knowledge about the land and its structure is able to grow successfully. This remarkably encourages researcher to venture with the same technology for use in the underwater environment which is called Underwater Wireless Sensors Networks (UWSNs) (Akyildiz & Melodia, 2005). Due to the reasons of harsh underwater environment, vast area and high water pressure, employing the UWSNs is the way for un-manned exploration in that environment (Ayaz et al., 2011).

Due to the unique characteristic of underwater environment, there are several issues or challenges when talking about designing communication network in the underwater environment especially in designing the routing protocol as routing protocol design is one of the crucial problems in UWSNs (Climent et al., 2014; Li et al., 2016; Melodia et al., 2013). First, the distribution area in UWSNs which uses a three-dimensional architecture is so large. However due to the underwater sensor node is very expensive compared to the terrestrial sensor, the deployment of nodes are usually in sparse and the sensor nodes are suffered in the random water current (Casari & Zorzi, 2011;

Heidemann et al., 2006; Khasawneh, K. et al., 2016). Second, most UWSNs sensor nodes are solely run by battery; instead, terrestrial sensor nodes can use solar to extend their usage. Therefore each UWSNs sensor nodes cannot be easily recharged and difficult to be replaced due to water current (Ayaz & Abdullah, 2009b).

Opportunistic Routing (OR) approach is the promising routing approach to be used in UWSNs due to high dynamic network topology in UWSNs compared to traditional routing approach in TWSNs using end-to-end routing (Coutinho et al., 2019; Darehshoorzadeh & Boukerche, 2015; Ghoreyshi et al., 2016). However, OR are suffered from high network traffic with redundant packets which can lead to higher energy consumption (Coutinho et al., 2016; Darehshoorzadeh & Boukerche, 2015; Rahman et al., 2020).

Due to this is the reason why designing energy efficiency routing is so important in UWSNs especially for opportunistic routing method which could improve the packet delivery ratio in UWSNs but in the same time could prolong the network lifetime (Khan et al., 2022).

10.2 UNDERWATER SENSOR NETWORKS

The underwater communication has begun since World War II where, in 1945 there are some underwater telephones are being deployed to communicate with submarines in deep sea but since then there is only little work has been done and makes this underwater communication still an unknown area (Akyildiz et al., 2005). However recently, over the past decades this UWSNs area got so much attention from the researchers around the world which had begun the exploration in this area to monitor the marine environments for scientific, environment and navy tactical needs (Akyildiz et al., 2005; Melodia et al., 2013).

In the near future, UWSNs will take an important role in the future ocean surveillance system whose applications include discovery of objects on the ocean floor, collecting scientific data, pollution control, environment monitoring and transmission of images from remote sites which will benefit many of us. Examples of application are like tsunami monitoring system which uses to monitor a seismic movement of earth and is able to provide tsunami warning to main land early (Akyildiz & Melodia, 2006; Chen et al., 2014; Felemban et al., 2015).

However, there are several limitations and challenges in UWSNs because of the uniqueness of UWSNs as compared to other networking environments.

10.2.1 Communication Architecture in UWSNs

The network topology UWSNS is generally one of the crucial factors for routing designs which can determine the energy consumption, the capacity, and the reliability of a network. Based on the sensor mobility deployment, the network topology UWSNs can be separated into two categories which are namely as static and mobile UWSNs (Ovaliadis & Kanakaris, 2010).

10.2.1.1 Static UWSNs

The main characteristic of static architecture of UWSNs is that the sensor nodes would be absolutely static after arrangement with each sensor is anchored either to the ocean floor (two dimensional UWSNs) or float with the fix depth (three dimensional UWSNs) (Freitag et al., 2002) . In two dimensional UWSNs, all the sensor nodes are anchored to the ocean floor while the sinks are deployed on the ocean surface. Each of the sensor node is equipped by the horizontal and vertical acoustic transceiver. The sensed data from the sensor node are forwarded to the intermediate gateways using horizontal link and later the underwater gateways aggregate the data and transmit to the surface sinks using vertical acoustic links. While in three dimensional UWSNs, sensor nodes are fitted out with acoustic modem and arranged in different depths of water. To control their movement, these nodes are anchored to the ocean bottom or surface buoys so that their movement is relatively small. The