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Adaptive Transmission based Geographic and Opportunistic Routing in UWSNs

Saba Gul[1], Nadeem Javaid[1],∗, Arshad Sher[1], Zahid wadud[2],[3], and Sheeraz Ahmed[4],[5]

1 COMSATS Institute of Information Technology, Islamabad 44000, Pakistan 2 University of Engineering & Technology, Peshawar 25000, Pakistan 3 Capital University of Science and Technology, Islamabad 44000, Pakistan 4 Faculty of Engineering and Technology, Dera Ismail Khan 29050, Pakistan 5 Career Dynamics Research Center, Peshawar 25000, Pakistan ∗ Correspondence: nadeemjavaidqau@gmail.com, www.njavaid.com

Abstract

UWSNs are frequency selective and energy-hungry due to the underwater acoustic communication links. We propose adaptive transmission based geographic and opportunistic routing (ATGOR) for efficient and reliable communication. Opportunistic routing is utilized along with geographic routing to select a set of forwarders from the neighboring nodes instead of a single forwarder. We propose a 3D network model logically divided into small cubes of equal volume with a goal that the sensed data is transmitted by the unit of small cubes.

Keywords: Underwater wireless sensor networks, opportunistic routing, potential neighbor number, current cube, neighbor cube, communication void, local maxima, energy consumption, packet delivery, latency, depth adjustment, communication void recovery

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1. Introduction

In this regard, depth-controlled routing protocol (DCR) performs depth adjustment-based topology control for void recovery [1]. The proposed protocol organizes the network topology and the number of connected nodes in a proactive manner to overcome the voids. Similarly, for energy efficiency, weighting depth adjustment forwarding area (WDFAD-DBR) for UWSNs is proposed to maintain the balance of energy consumption among the sensor nodes for prolonging network lifetime [2]. The selection of forwarder node based upon the depth leads to the selection of same node due to which the energy of the node depletes quickly, and void hole is created. In order to cater the void hole in the discussed existing state of the art work, we have proposed an algorithm named adaptive transmission based geographic and opportunistic routing (ATGOR) protocol for UWSN. We have adjusted the transmission range based on the location of the neighbour node. We will consider depth and energy both parameters for the selection of the forwarder node in order to ensure that cyclic selection of the forwarder node is avoided. This selection assures that energy is efficiently utilized.

2. Related work

A void aware pressure based routing technique is proposed by Noh et al. (VAPR). VAPR utilizes geographic and opportunistic routing for transmitting the sensed data from sensor nodes to the sonobuoys at water surface. The next-hop forwarder is set to continue the forwarding process by selecting the forwarders in a vertical direction towards the surface sinks based on pressure levels [3]. Noh et al. presented another pressure based anycast routing algorithm (HydroCast) for underwater sensor networks [4]. The next-hop forwarder selection is based on the pressure levels at different sensor nodes. The proposed scheme performs void recovery and limits the co-channel interference. In [5], a depth based routing (DBR) protocol is proposed that utilizes multisink architecture. DBR is a greedy routing algorithm in which sensor nodes selects the next-hop forwarder based on the depth of neighboring sensor nodes. Jor et al. propose focused beam routing (FBR) protocol that is suitable for both static and mobile sensor nodes [6]. In vector based forwarding (VBF) data packets are routed along a virtual pipeline of fixed radius [7]. The radius of the virtual pipeline is calculated based on the source, local distribution of sensor nodes and the destination position location.

3.System Model

We assume that ‘i’ number of sensor nodes are random uniformly distributed over a 3D network field forming a cube having volume ‘V ’. Network field is logically divided into uniform ‘M’ small cubes volume ‘v’, denoted as $C_1,C_2,\cdots,C_M$.

4 The proposed transmission scheme

In this section we describe the adaptive transmission based geographic and opportunistic routing (ATGOR) in detail.

Enhanced periodic beaconing The periodic beacon message of each sink includes, the sequence number, its ID, and its X and Y location. The sequence number of beacon message is used to identify the most recent beacon of the sink. The value of Z coordinate of sinks is omitted because the sinks are deployed over the surface and the vertical movement of the sinks is negligible. Likely, each sensor node embeds a sequence number, the corresponding CID, node’s ID, and X, Y and Z position. Each node includes the sequence number, ID, and X and Y coordinate of its reachable sinks. The sequence number of the beacon message is incremented periodically after a fixed periodic interval of 30 s. Each entry is refreshed upon receiving the most recent beacon message based on the sequence number.

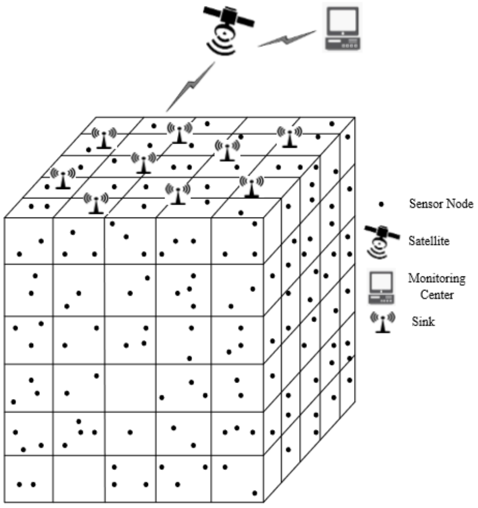
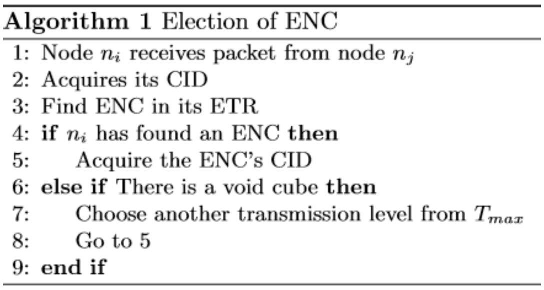


Fig. 1. Network Model



Algorithm 1 Election of ENC

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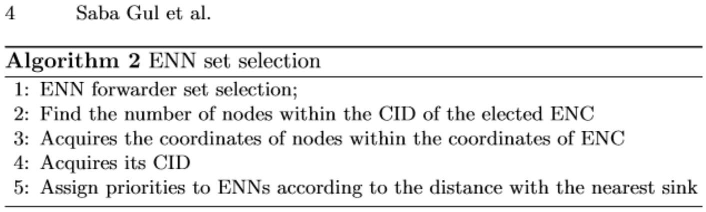
Node $n_i$ receives packet from node $n_j$
Acquires its CID
Find ENC in its ETR
if $n_i$ has found an ENC then
    Acquire the ENC's CID
else if There is a void cube then
    Choose another transmission level from $T_{max}$
    Go to 5
end if
```

Determine the next-hop small cube
The process of small cube selection is shown in algorithm 1. While choosing a forwarder set selection, When a forwarder is selected from the ENN other nodes suppress their communication on overhearing the packet transfer. If the highest priority node is failed to forward the packet then the rest of the low priority nodes transmit the packet. Algorithm 2 shows all the steps of forwarder set selection.



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Algorithm 2 ENN set selection

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ENN forwarder set selection;
Find the number of nodes within the CID of the elected ENC
Acquires the coordinates of nodes within the coordinates of ENC
Acquires its CID
Assign priorities to ENNs according to the distance with the nearest sink
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5 Simulation results and discussion

In the simulation, we deploy 150−450 sensor nodes randomly in 1500m×1500m× 1500m region and the number of sinks is 25. Transmission ranges are set to be 150m, 200m, 250m, 300m, 350m, 400m and 450m. Each sensor node is assigned an initial energy of 10W. In all experiments the packet size is 150 bytes and the data rate is 50 kbps. The energy consumption of transmission, receiving and idle state are 2W, 0.1W, and 10mW, respectively. We determine the performance of proposed protocol according to the following parameters: packet delivery ratio (PDR), fraction of void nodes, energy consumption.

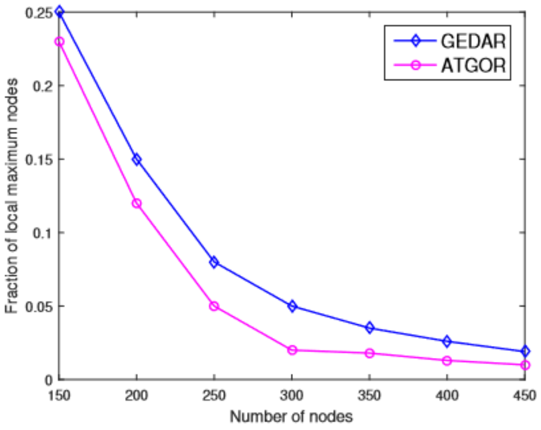

Fig. 2. Fraction of void nodes

5.1 Results and Analysis

Scenario I: Fig. 2 shows the fraction of void nodes in the network. The probability of void holes reduces as the node density increases. Our proposed schemes perform better than the compared scheme. This is due to the adaptive transmission range of sensor nodes. If sensor nodes near the water surface fail to find any forwarder node in greedy strategy, then depth adjustment is performed which causes high energy consumption. While in ATGOR sensor nodes overcome the void hole by adaptively adjusting their transmission range to find the nearest sink. Our proposed adaptive transmission range strategy proves to be useful to avoid the void holes. Fig. 3, depicts the PDR of the network. It can be seen that the PDR increases as the node density increases. The increase in node density results in reduced void nodes due to availability of high number of neighbors. The fixed transmission range causes packet failure, thus adaptive transmission range reduces the packet failures. Energy consumption per packet per node is shown in Fig. 4. In order to avoid the void holes in GEDAR energy consumption per packet per node is high than our proposed schemes.

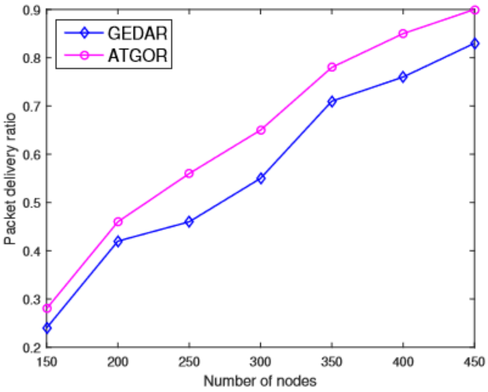

Fig. 3. Packets received at the sinks

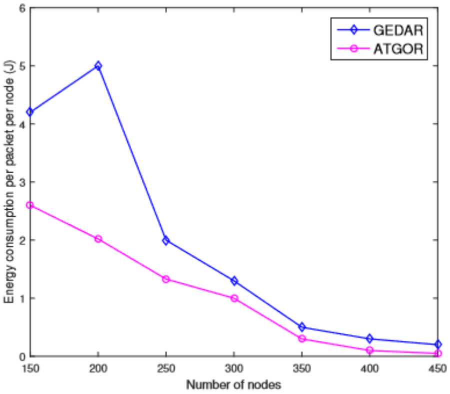

Fig. 4. Energy consumption per packet per node

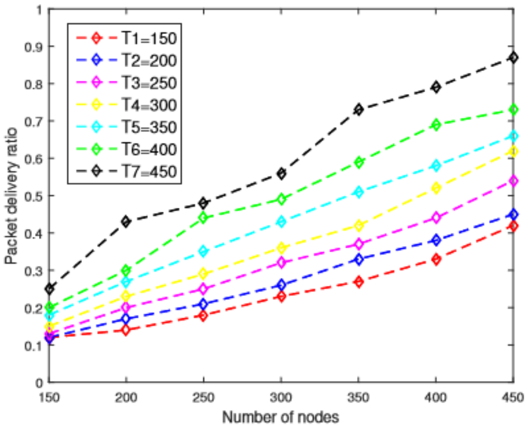

Fig. 5. Packets received at the sinks

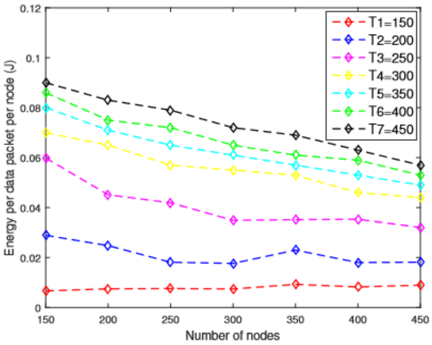

Fig. 6. Energy consumption per packet

Scenario II: Fig. 5 shows the impact of different transmission levels on the PDR. Transmission ranges 150m, 200m, 250m, 300m, 350m, 400m and 450m are represented by T1, T2, T3, T4, T5, T6 and T7, respectively. It can be seen that PDR increases as the transmission range increases. Increased transmission range overcomes the void areas in the source to destination route. In this way, it is ensured that the packet generated from the source reaches the destination. Fraction of local maximum nodes at different transmission levels is shown in Fig. 6. High transmission levels overcome the void areas and greater node density reduces the voids due to more number of neighbors. Energy consumption in the network per packet per node is shown in Fig. 7

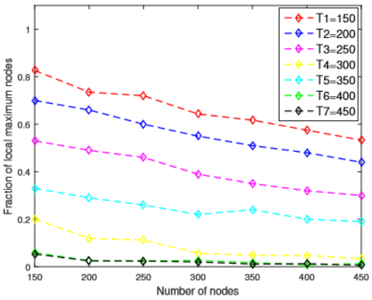

Fig. 7. Fraction of void nodes

6 Conclusion

Our proposed scheme selects the next hop small cube based on the distribution of neighboring nodes. In case of a zero node in the neighboring cube, ATGOR adaptively adjusts its communication range and avoids the void nodes. Our simulation results demonstrate that the concept of adaptive transmission along with geographic and opportunistic routing lead to the improvement of network performance in terms of data delivery ratio, fraction of avoiding the local maximas and minimum energy consumption.

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