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Clustering Protocols in Underwater Wireless Sensor Networks: A Communication Approach Overview

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Abstract: Underwater Wireless Sensor Networks (UWSNs) reveal a diverse range of applications among varied networks where sensors are deployed for exploring resourceful activities such as tactical surveillance, ocean monitoring, offshore analysis, oceanographic data collection and instrument observing. All these activities are based on the number of sensors deployed in ocean for data collection and communication. Naturally, underwater medium through which the data transmits from source to destination i.e. network is volatile. Despite, sensing and transmitting over a selective range in UWSNs signifies to be challenging with relevance to limited bandwidth, long propagation delay and severe multipath fading. This research explicitly defines the recent proposed routing protocols in terms of clustering techniques. In addition, the research work revealed the summary of clustering protocols in UWSNs together suggesting future research exploration in the field of underwater environments.

Keywords: UWSNs, Sensors, Clustering, Routing Protocols, Underwater Communications.

I. INTRODUCTION

The earth surface is covered by 70% of water exists in rivers, glaciers, sea and oceans [1]. Underwater applications such as mineral reconnaissance, marine mammal behavior, underwater sound and disaster prevention are examined using autonomous underwater vehicle (AUV) equipped with underwater sensors [16]. The fundamental components of the underwater sensor networks are underwater sensors, surface station and AUV collects data from the sensors and communicate with onshore sink over acoustic or satellite communication [7] as depicted in Figure 1.

On the other hand, less than ten percent of the entire ocean volume is being investigated while the remaining area is still not explored. Also, communication is vital with relevance to underwater environment because of node scattering and limited bandwidth. Generally, existing UWSNs architectures figure out the state of overall working principles of the network [11]. Each architecture are listed as follows

One-dimension UWSNs **-** The reference architecture for underwater network employs sensor nodes with fixed AUV confined for data transmission to the remote station over a single hop [12].

Two-dimension UWSNs **-** The organization of sensor nodes form a cluster, where Cluster Head (CH) is chosen in a random fashion. Once all the nodes are coordinated into clusters, sensor collects the underwater data and transmits to CH. Subsequently, CH sends data to the Base Station (BS) [14]. Communication is suggested in two solutions, namely horizontal and vertical transceiver i.) sensor communicates with CH by cause of horizontal communication link. ii.) Consequently, CH communicates with the BS over vertical communication link.

Three-dimension UWSNs **-** Sensor nodes are in the form of clusters at distinct extents [8]. Thereby, three dimensions are employed for data collection and transmission such as intercluster, intracluster and CH to BS communication.

Four-dimension UWSNs **-** The combination of three-dimension UWSNs and mobile UWSNs has been introduced [9]. Remotely operative underwater vehicle (ROV) is involved for data collection from CH and relay data over the BS. In contrast, underwater communication medium Radio Frequency (RF) signal and Optical signal inadequate for underwater communication due to immediate attenuation [10]. Thereby, the acoustic signal is employed in underwater environment with range and speed is (1km, 1500m/s) [13]. Also, acoustic signal transmission greatly complements for dynamic network topology that inherently supports multi-hop transmission of data.

In the relevance to UWSNs, design of routing protocol in underwater environment requires intelligent system performance. However, hierarchical communication to the BS [15] encounters high delay bound due to

Limited Bandwidth – Communication bandwidth is shortened over extended range by varying aspects which holds high medium absorption of sound at below density and low medium absorption at above density.

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Propagation Delay – Acoustic signal is employed in underwater environment where nodes move on water irrespective of distance, temperature and salinity thereby transmission speed is around 2x10^5 times slower than the terrestrial Wireless Sensor Networks (WSNs).

Limited Energy – Sensors operate on batteries which require large amount of energy for communication. In turn, replaced and recharged batteries are crucial with relevance to underwater environment.

The research paper is further organized as follows. Section 2 describes existing routing protocols. Section 3 covers security issues in UWSNs. Simulation results are presented in section 4 and finally the conclusion is given in section 5.

increase energy efficient data transmission which is crucial for underwater networks. Furthermore, the research work primarily focuses on clustering based routing protocol and parameters in underwater environment.

Energy efficiency network has been made possible through an Energy-balanced Unequal Layering Clustering (EULC) algorithm [2]. The algorithm involved (i) initially, the network is partition into unequal layer spacing from top to bottom thereby increases regularly. In turn, sensor nodes clusters deployed in the layers towards the sink node. (ii) EULC capitalize on a Cluster Head (CH) selection based on residual energy, node degree and distance to the sink node (iii) Forwarded nodes broadcasts message within its transmission range are further presentable in cluster establishment phase (iv) Data transmission id is transmitted across the network. Cluster Member nodes in a cluster send data to CH nodes together incorporate the information table of immediate neighboring CH.

To determine the sparse and dense region by deploying Mobile Sinks (MSs) over extended range for UWSN has been proposed [3]. Sensor nodes are positioned and static sink is located at the mean of the network field. The research emphasizes on i) sparsity-aware

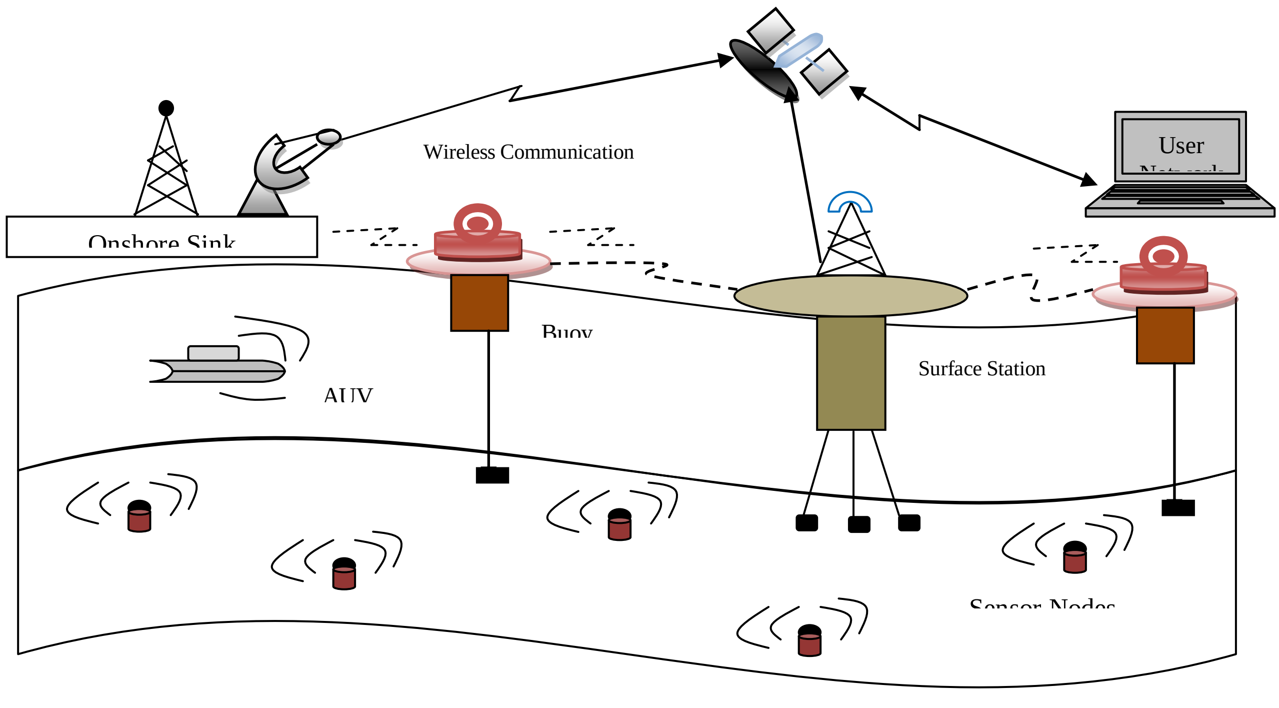

Figure 1. Underwater wireless sensor network architecture

II. SURVEY OF LITERATURE

Discrete routing protocols have been designed for data collection in both compatible and divergent networks. Grouping of sensors that perform similar functions are referred as clustering. Clustering is an effective approach to

energy-efficient clustering (SEEC) that involve hello packet based on its position. On the other hand, sensor nodes forward hello packet within their transmission range together enclosing the hop count from a sink thereby sparse and dense region are

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evaluated over multiple path and forward data packets at different regions. Also,

Cluster Head (CH) nodes are chosen based on two parameters, residual energy and low depth. ii) To ensure an energy efficient communication to maximize the network coverage is accurately derived in circular sparsity-aware energy-efficient clustering (CSEEC) which in turn divided into concentric circle of equal parts. Further the approach seem to prevent energy hole formation. iii) circular depth-based sparsity-aware energy efficient clustering (CDSEEC) has two phases: lower semi-circle and upper semi-circle phase. During lower semi-circle phase CHs never broadcast their data packet to the static sink; in a contrast nodes send data to MSs. Moreover, sensor nodes at the closest proximity to the static sink transmit data based on depth threshold value which seems to be substantial network lifetime and stability period.

With relevance to the stochastic geometry based capacity research analytic [4], a set of nodes are organized into clusters. The cluster members periodically transmit their data to the corresponding cluster head. Cluster head node aggregates the data and then transmits the concurrence data to the sink node. Primarily, transmission is done in terms of limited bandwidth over carrier frequency thereby interference involve exclusive in cluster head nodes. In consequence, the research addresses the signal to interference ratio (SIR) to avoid the ambient noise on the total network. Subsequently, it is proven that transmission capacity outperforms outage probability in terms of optimal network node density.

Secure data transmission among all the network nodes is clearly analyzed by secure MAC protocol (SC-MAC) has been introduced [6]. Initially, sensors with equal transmission range are well distributed in the network. Sensor node itself can obtain a safe or malicious node without knowing the prior knowledge of the neighboring nodes. The cluster formation procedure here is mostly turn on the communication of nodes with their neighbors which are mainly based on the link quality and residual energy. Sink node transmits the Hello packet to its neighboring nodes. Thereby, RTS/CTS (Request to Send/Clear to Send) mechanism focuses the appropriate computation of Signal-to-Noise Ration (SNR) that criteria also considered for link quality. A node which has maximum former value can become Cluster Head (CH). CH broadcasts updating packet it to all other cluster members in cluster. However, attackers involve in the cluster formation and updating phase through malicious nodes. Such networks need to be facilitated with a unique identifier to transfer message that ensures authenticated in data communication over public key based digital signature. On the other hand, authentication phase has successfully attempted to address the secure communication; node validates to each other then cluster heads are authenticated through sink nodes and cluster members are authenticated to cluster heads. Hence, authentication phase extends to attain secure communication with each other. The synchronized communication mechanism is made possible with direct communication and indirect communication. Sensor nodes are positioned within the transmission range of immediate neighbors to be considered as direct communication. In addition, sensor nodes are arranged at distant transmission range termed to be indirect communication. Therefore, this technique ensures secure data transmission in UWSN in case of different attacks.

Efficient data delivery by avoiding propagation delay over extended range for UWSN has been analyzed with reference to a cluster-based MAC protocol [5]. Here the cluster head (CH) is elected based on energy-efficient hierarchical clustering algorithm. The sensor nodes deployed in three-dimensional space seem to figure out the status of transmission range and distance between sensor nodes and CH. It is therefore sensor that can broadcast the advertisement message to the adjacent message to the neighboring nodes that fall within their transmission range. A node which has maximum energy can become CH. In addition, it avoids collision further necessity of data transmission follows TDMA-based data scheduling. Nodes send data based on time schedule. In a contrast, conflict-free scheduling mechanism minimize virtual time slot. Cluster-based MAC protocol ensures a maximum packet delivery ratio from source to destination. Summary of underwater clustering protocols is laid out in Table 1. Subsequently, Table 2 represents the performance metrics for clustering protocols.

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Table 1. Summary of underwater clustering protocols

Protocol/architecture	**Single/multi sink**	**Synchronization**	**Hop-by-hop/end-to-end**
EULC	Single sink	Yes	Hop-by-hop
SEEC/CSEEC/CDSEEC	Multi sink	Yes	Hop-by-hop
Stochastic Geometry	Single sink	No	Hop-by-hop
SC-MAC	Multi sink	Yes	Hop-to-hop
Cluster-based MAC protocol	Single sink	Yes	End-to-end

Protocol/architecture	Energy Efficiency	Cost Efficiency	Packet Delivery Ratio
EULC	√	±	√
SEEC/CSEEC/CDSEEC	√	±	√
Stochastic Geometry	±	×	±
SC-MAC	±	±	√
Cluster-based MAC protocol	√	±	√

Table 2. Summary of performance metrics

High:√ Fair:± Low: ×

III. CONCLUSION

The research exposed that un-rechargeable batteries is the major constraint in underwater environment in case of continuous movement of water. Moreover, the clustering phenomenon can overcome the limitation by designing an optimal clustering. Besides, this study focuses the clustering based routing protocols in terms of cluster head selection and cluster formation. In addition, comparative analysis of selected underwater clustering protocols seems to be highly influential and also used for future research direction in real time underwater applications.

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