Power Optimization in Ad hoc Sensor Networks using Clustering Approach

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Abstract— **Considering operational lifetime and load balancing as major constraints in the transmission of signals in the sensors of underwater ad hoc networks, we put forward in this paper a novel idea of using clustering approach to optimize the power consumption of the batteries in the sensors of the underwater ad hoc networks. The networks in underwater consists of a number of sensors and vehicles that are deployed to perform numerous tasks. One of the major challenges is the efficient utilization of the battery power which is limited and underwater sensor batteries usually cannot be recharged. In this paper we present use the multi hop to transmit the acoustic signals to minimize the distance and cluster sensors into groups as to communicate information only from one sensor aggregating the information for optimal utilization of power. We use a combination of Energy efficient hierarchical clustering and HEED clustering approach to cluster the sensors in the network as to minimize the distance and get maximum utilization of the operational life time of the battery.**

Index Terms— **Power Optimization, Ad hoc networks, HEED, Energy Efficient Hierarchical Clustering**

I. Introduction

Underwater sensor networks are visualized to enable applications ranging from oceanographic data collection, early warning systems for natural disasters like tsunamis, ecosystem monitoring, oil drilling, and military surveillance have been looked into. The deployment and management of large scale wireless sensor networks is a challenge because of the limited processing capability and power constraints on each sensor. In literature, research issues pertaining to underwater sensor networks, from the physical layer to the application layer have been discussed [1]. Wireless underwater acoustic ad hoc networking is enabling technology for these applications.

Many researchers are currently engaged in developing networking solutions for terrestrial wireless ad hoc and sensor networks [3]. Although there exist many recently developed network protocols for wireless sensor networks, the unique characteristics of the underwater acoustic communication channel, such as limited bandwidth capacity and variable delays [4], require very efficient and reliable architecture, algorithms and new data communication protocols. The deployment and management of large scale wireless sensor networks is a challenge because of the limited processing capability and power constraints on each sensor.

Under Water Acoustic Sensor Networks (UW-ASNs) consist of a variable number of sensors and vehicles that are deployed to perform collaborative monitoring tasks over a given area. To achieve this objective, sensors and vehicles self-organize in an autonomous network which can adapt to the characteristics of the ocean environment [2].

The main differences between terrestrial and underwater sensor networks can be itemized as follows:

- Cost: Underwater sensors are more expensive devices than terrestrial sensors.
- Deployment: The deployment is deemed to be more sparse in underwater networks.
- Spatial Correlation: While the readings from terrestrial sensors are often correlated, this is more unlikely to happen in underwater networks due to the higher distance among sensors.
- Power: Higher power is needed in underwater communications due to higher distances and to more complex signal processing at the receivers.

One of the major challenges in the design of Underwater Acoustic Networks is the optimal utilization of Battery power as the battery power is limited and usually batteries cannot be recharged, because solar energy cannot be exploited and this is the criteria taken up in this paper.

II. Architecture of Underwater sensor networks

The figure 1 illustrates our generalized network topology to analyze the tradeoffs of accurate underwater environmental indicator monitoring and power efficiency [8]. The network in Figure 1 has a multi-hop centralized topology in which several trees are rooted at the base station, and data flow is always toward the base station. The convergence of data at the base station is appropriate for underwater sensor networks because sensor data in these networks is typically sent to shore for collection and analysis.

In the topology of the above figure, nodes monitor their surrounding environmental conditions, and periodically send the collected information towards a central shore or surface station, which subsequently collects and processes the data

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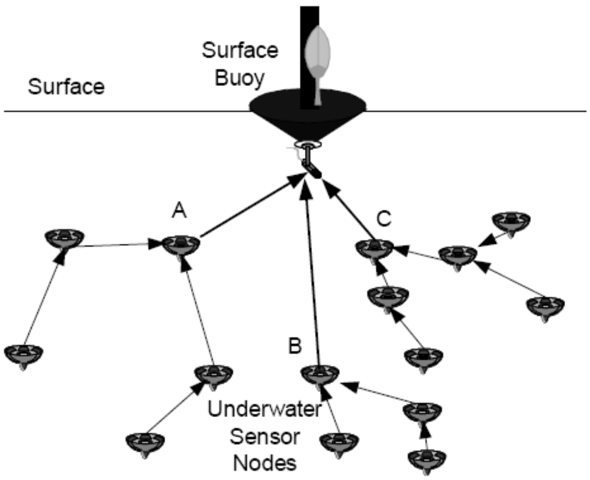

Fig.1. Generalized network of an underwater sensor network

If the sensors are of ad hoc networks and need to send the data to the central station every time then the power consumed is more and more for direct links. So in order to optimize the power we prefer the sensors to find the other sensors near and send the data in a multi hop way. A multi-hop topology extends the range of operation of the network, but it raises the issue of increased power overhead at intermediate nodes, which have to forward the data of nodes further away. For example, if traffic routing is based solely on distance, then the nodes closest to the base station must forward the data of all the other nodes in the network.

The problem in this method is that the nodes closes to the base station will be over loaded with data and requires more power. This problem can be addressed with the solution of making clusters of the nodes that are related by its propinquity. Many works have been done on clustering of sensor nodes in the underwater technology [8, 9, 10] and Grouping sensor nodes into clusters has been widely pursued by the research community in order to achieve the network scalability objective. Every cluster would have a leader, often referred to as the cluster-head (CH). Although many clustering algorithms have been proposed in the literature for ad-hoc networks [11–15], the objective was mainly to generate stable clusters.

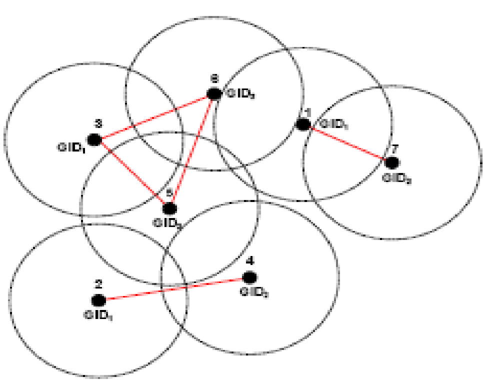

Fig. 2 Grouping of the nodes based on sensing coverage

The nodes are clustered which were initially randomly deployed at the bottom of the water based on their node IDs. The basic idea is that each node in a neighborhood picks the highest ID in that neighborhood as its cluster ID (CID). This means that each node exchanges its ID with its 1-hop neighbors and keeps a list of its neighbors' IDs. The node with the highest ID will be the cluster head. Within each cluster, nodes can be further segmented into tiers. [8] Figure 3 and figure 4 below shows a network topology with four clusters and three tiers per cluster. The nodes at the lowest tier (tier 3 in Figure 3) are the furthest away from the base station and transmit messages to other nodes in the same cluster at the next higher tier (tier 2)

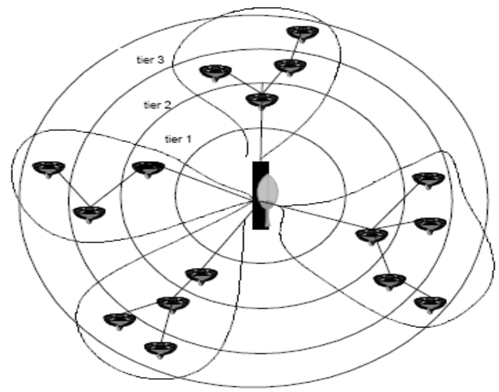

Fig. 3. A network with clusters and three tiers

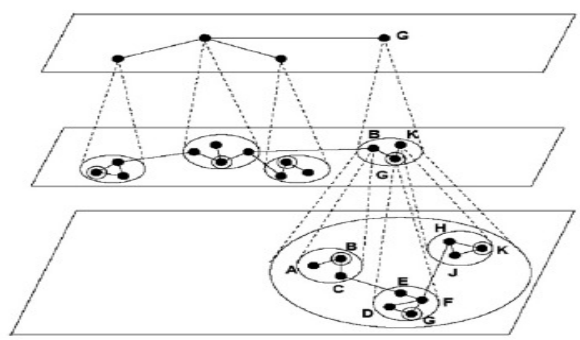

Fig. 4. Lateral View

Using the layered structure and multi-hop with clustering gives an optimal utilization of the resources but though much work has been done on clustering and Ad hoc sensor networks, the clustering in underwater ad hoc networks itself utilizes more power to find the nodes in the proposed regions as the nodes are self organizing in nature. The main setback is the choice of an algorithm suited for the underwater ad hoc networks.

In this paper we propose to use the *Energy Efficient Hierarchical Clustering (EEHC).* Bandyopadhyay and Coyle [17] proposed EEHC, a distributed, randomized clustering algorithm for WSNs with the objective of maximizing the network lifetime. CHs collects the sensors readings in their individual clusters and send an aggregated report to the base-station. Their technique is based on two stages; initial and extended. In the initial stage, also called single-level

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clustering, each sensor node announces itself as a CH with probability p to the neighboring nodes within its communication range. These CHs are named as the volunteer CHs. All nodes that are within k hops range of a CH receive this announcement either by direct communication or by forwarding. Any node that receives such announcements and is not itself a CH becomes the member of the closest cluster. Forced CHs are nodes that are neither CHs nor belong to a cluster. If the announcement does not reach to a node within a preset time interval t that is calculated based on the duration for a packet to reach a node that is k hops away, the node will become a forced CH assuming that it is not within k hops of all volunteer CHs.

EEHC has a time complexity of O(k1 + k2+. . .+ kh), which is a significant improvement over the many O(n) clustering algorithms such as LCA, and thus make it suitable for networks of large number of nodes. This clustering algorithm does considers the cluster count, inter cluster connectivity as a parameter for clustering which is must existing in any ad hoc sensor networks, but it does not considers the one of the major parameter node mobility. For ad hoc mobility of the is the important criteria, so we changed the algorithm of EECH by incorporating a part of Hierarchical control clustering, another clustering algorithm, which does consider this parameter but does not considered the other parameter. Hierarchical control clustering forms a multi-tier hierarchical clustering [18]. Figure 4 illustrates the concept of hierarchy of clusters. A number of cluster's properties such as cluster size and the degree of overlap, which are useful for the management and scalability of the hierarchy, are also considered while grouping the nodes. The algorithm proceeds in two phases: Tree discovery and Cluster formation.

So, in this paper we are proposed a clustering algorithm which incorporates both the algorithms which is very much useful in optimizing the life time of the battery which is there in the underwater ad hoc sensor networks.

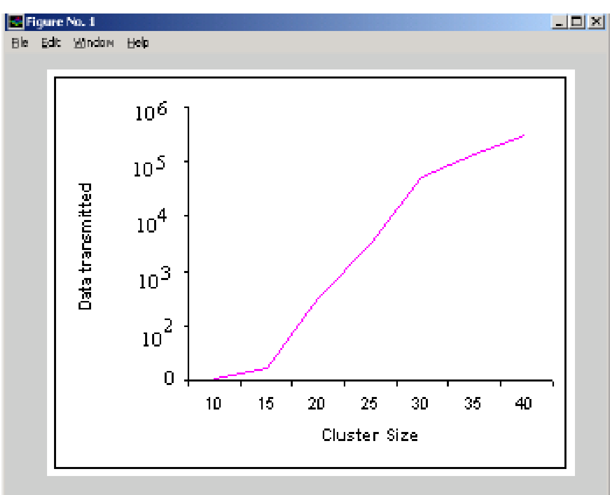

Fig. 5. Screen shot of the Clustering approach using EEHC

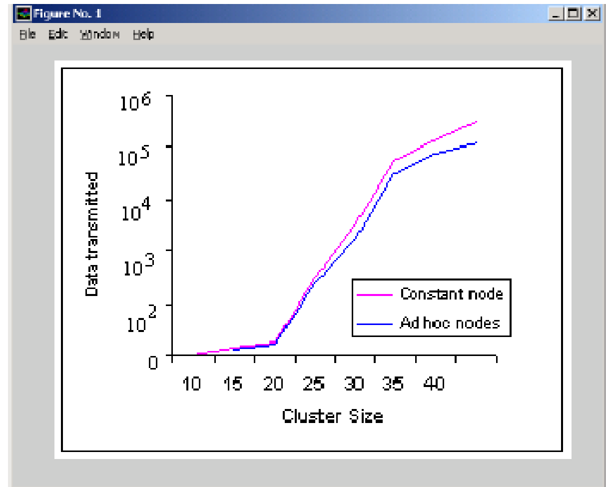

Fig. 6. Screen Shot of the data transferred using the clusters for both ad hoc nodes and static

III. RESULTS AND CONCLUSIONS

In our proposed work we are considering the power optimization of the life of the battery in underwater ad hoc sensor networks. In order to achieve the task, we propose the combination of two clustering algorithms EEHC and Hierarchical control clustering which can optimize the life of the battery.

Figure 5 gives the screen shot of the data transmitted for different cluster sizes using EEHC algorithm where node mobility is not considered. Fig 6 gives the result analysis of the data transmitted for the different clusters where the nodes forming the clusters are static as well as ad hoc.

The self configuring nature of the ad hoc nodes considered gives the information for creating and regrouping the clusters accordingly. The results shows that for regrouping the clusters based on the node mobility takes slightly more utilization of power and gives comparatively lesser data transfer for the same amount of time. But without clustering approach battery utilization is comparable more.

To conclude the Experimental results show that more data can be transmitted for the same amount of time which in turn is utilizing the maximum amount of the battery.

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