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A Secure and Localized Cluster based Underwater Sensor Network

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Abstract: ***Underwater Sensor Networks (UWSNs) deals with issues unlike terrestrial networks such as , a long propagation delay, a narrow bandwidth as well as high packet loss. In underwater environment, implementation of an efficient communication mechanism is a significant problem. The main issue in underwater sensor network is that nodes cannot be fixed due to continuous flow of water which ultimately affects data transmission. Localization and security are one of these issues to be considered in underwater sensor network design. In the proposed work the implementation of localization and security aspects in cluster based underwater sensor network is done in order to improve the network performance.***

Keywords: Underwater sensor network, routing, clustering technique, localization, security

1. Introduction

Nowadays, Sensor networks are usually consists of small devices which are having the capabilities of processing, sensing and storing , communicate wirelessly and. Efficient and high speed communication in the underwater acoustic channel is a substantial challenge because of various issues like limited bandwidth, extended multipath, refractive properties of fading, rapid time variation. An Underwater Sensor Network (UWSN) is a network which consists of a number of underwater sensor nodes and Autonomous Underwater Vehicles (AUVs) that are deployed to perform collaborative monitoring and resource exploration tasks over a given area. The past three decades have seen an increasing interest in underwater acoustic communications because of applications in marine research, the offshore oil industry, marine commercial operations and defense. Continued research over the years has resulted in improved performance and robustness. The underwater sensor networks applications can monitor the health parameters of underwater environments. The underwater sensing has a wide range of application like aquaculture, oil industry and include instrument that perform monitoring, recording of climate, predicting the natural disturbances, pollution control and study of marine life. Recent advances in wireless and electronic technologies have enabled a wide range of applications of WSNs in military, traffic surveillance, target tracking and monitoring in field like environment monitoring, healthcare and so on.

Unauthenticated nodes may affect the security of the collected data and frequent movement of special nodes which collects data from other nodes for transmitting it to sink may suffer due to energy inadequacy. The UWSNs are also vulnerable to various attacks like Denial-of-Service, Replay attack and Wormhole attack. [11] Lack of localization may lead to more power consumption by nodes for transiting data towards the unpredicted sinks. So the efficient localization mechanism is required to decrease the transmission time as well as for avoiding the wastage of power and security mechanism is required to prevent data transmission to unauthorized node.

Recently, different routing protocols are available for terrestrial wireless sensor networks. As far as the underwater sensor network is concerned, specific properties of underwater medium make existing routing protocols inappropriate for under water. The main challenges in developing efficient routing protocols for underwater environments are:

- Propagation delays – As the efficiency of radio signals is not that much under water and this problem gives encouragement to the use of acoustic communication. Still the acoustic channel is also having problems like low bandwidths and long propagation delays.
- Mobility of node – In underwater environment, nodes can move because of water currents. This situation results in a dynamic network topology. Moreover, autonomous underwater vehicles and robots used for exploration and controls can be utilized to route data.
- Error prone Acoustic underwater channels –Due to very low bandwidth capacity, acoustic channels suffer from high bit error rates.
- Energy constraints - Like in terrestrial wireless sensor networks, most of sensor nodes in UWSNs are powered by battery.
- Harsh deployment environment-In addition to these challenges, while developing an underwater routing protocol .As the energy and bandwidth consumption of these techniques is high, it is necessary to avoid the usage of exchanging overhead messages or flooding-based route discovery mechanisms

The arrangement of this paper is as follows: Section II focuses on some work done before that relates to the proposed work. A brief overview of some of the clustering technique, localization techniques and security mechanisms is given in section III followed with the analysis of the reviewed papers on UWSN in section IV. Our proposed work is described in Section V. The working of our system is described in section VI including the simulation results and conclusion in section VII.

2. Related work

In [6] a "Temporary Cluster Based Routing" has been proposed for data gathering which is a mobility aware routing protocol. Also, location information of sensor nodes is not required and only few nodes participate in the end-to-end routing process, which makes it suitable for stationary networks, mobile networks and hybrid networks as well.

In [3] a data aggregation technique for the underwater sensor networks has been proposed. The overall process includes the 3 steps: (i) clusters Formation (ii) cluster heads Election (iii) Transmitting the data to the sink node without aggregation and by applying the aggregation technique.

In [4] a hybrid localization scheme has been proposed which is integration of two different localization schemes. Those two schemes are localization of anchor node and localization of ordinary node.

In [1] the issue of localization in the context of underwater sensor networks has been focused which several anchor nodes with exact knowledge of their position, but asynchronous clocks.

In [3] an improved positioning algorithm for underwater environment is proposed by the factors that limits the positioning accuracy of underwater acoustic sensor network. Authors proposed an improved single node localization method based on maximum likelihood estimation and design an improved algorithm for underwater acoustic sensor networks using the improved single node localization method. In [10] the digital signature schemes for underwater sensor network have been analyzed for end-to-end authentication.

3. Techniques

3.1 Clustering In UWSN

a. Temporary Cluster Based Routing [6]:
The architectural design of network for implementing this protocol is based on multiple sink phenomenons. The packets that are received by any one of the sinks are considered as delivered successfully at the destination. Surface buoys are equipped with radio and acoustic modems. For the communication within each other with the Courier nodes, the RF modems is used. For communication with the sensor nodes other than surface buoys, the acoustic modems are used.

Two types of nodes are deployed for implementing this protocol i.e. ordinary nodes and Courier nodes. Ordinary nodes perform the function of sensing the information and try to forward these data packets to the Courier node which are nearer to them. Courier nodes are can perform the work of sensing as well as receiving the data packets from other ordinary nodes and it delivers those packets to a surface sink. These Courier nodes are having the capability of vertical movement.

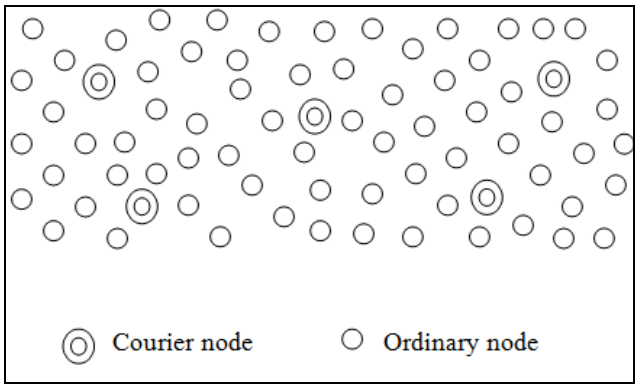

Figure 1: Nodes Deployment

3.2 Localization in UWSN

3.2.1Anchor free localization (ALPHA) [7]:
ALPHA algorithm is designed considering active-restricted underwater sensor environment into consideration. To implement this algorithm, anchor node's information is not necessary.It makes use of the relationship of adjacent nodes to calculate node positions. This algorithm could be feasible for static as well as dynamic networks. From underwater environment point of view AFLA is an effective localization scheme.

AFLA Design
While doing localization at first time, a node broadcasts coordinate of its spherical canter's, meanwhile receives other nodes' information along with depth and cable length. The node carries out location calculation process when it has received two other node messages.

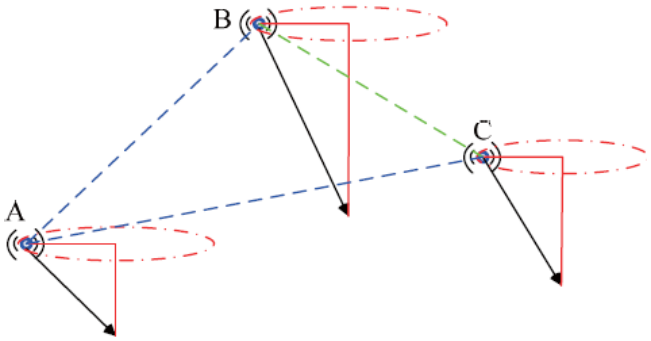

Figure 2: Communication process in AFLA

3.2.2 An Adaptive Self Organizing Localization Algorithm for Large Scale UWSN [8]:
In adaptive self-organizing localization algorithm for UWSN, the randomly deployed underwater sensor nodes self-localize to be location-aware. The nature of this algorithm is completely decentralized and distributed. This localization technique helps to reduce errors in the localization for UWSN.
A deployment is assumed in such a way that all the nodes are randomly deployed in an underwater area which is grounded to the bottom of the ocean using anchors. All the UW sensors have same communication range. Considering that the deep under water current are mild, the Deployment algorithm is initiated at regular time of interval or at the detection of a target/event by any one sensor node.

3.3 An Efficient Mobility Based Localization in underwater sensor networks (EMBL) [9]:

Efficient Mobility Based Localization scheme is divided into two parts:

- Localization of Anchor node
- Localization of Ordinary node.

During the localization process, future mobility pattern is predicted by every node corresponding to its past known location information to estimate its future location.

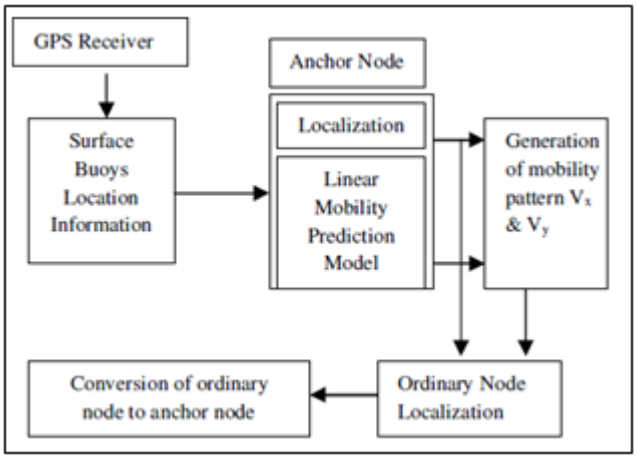

Figure 3: Block diagram of proposed EMBL algorithm

Figure 3 illustrates Block diagram of Efficient Mobility Based Localization (EMBL) scheme. As mentioned initially, the EMBL scheme is divided into two parts. First is localization of anchor node and then localization of ordinary node. The surface buoys acts as satellites for the whole network .An anchor nodes are localized by these surface buoys. Anchor nodes are more powerful. The locations from the surface buoys can be directly measured by the anchor nodes in every localization period. Complex mobility prediction algorithms are implemented on them. For the ordinary node localization, recursive range-based scheme is used. Ordinary nodes are limited in computational power and memory. Hence it is difficult to implement complicated prediction algorithms on them.

3.4 Security in UWSN

3.4.1Digital Signature Schemes

Computation required for signature generation is inversely proportional to the hardness of their underlying security problems. [12] As a result, traditional signature schemes based on sub exponential problems demand a great deal of computation and are not adequate for resource constrained devices such as sensor nodes. [13]

3.4.2Elliptic Curve Cryptography (ECC) schemes [10]

There are different classes of ECC signature schemes. Forvinstance, there are (i) those able to leverage on special parameters to speed computation up (e.g. Elliptic Curve Digital Signature Algorithm [14] - ECDSA) [14]; and (ii) those that produce shorter signatures (e.g. the Zhang-Safavi-NainiSusilo [15] - ZSS). Among "short signature" schemes, there is also the Boneh-Lynn-Shacham [16] (BLS), which also belongs to the class of aggregate signatures schemes. These schemes have the additional capability of aggregating - combining - different signatures from different signatories (or not) into a single one. The result is referred to as aggregate signature. In BLS, aggregation is very efficient and the resulting signature has the same length as the original ones (aggregate and non aggregate signatures have the same bit-length).

4. Analysis

Papers are reviewed and studied related to clustering, localization n UWSN. The reviewed techniques are different from each other.

In Temporary Cluster Based Routing, the temporary cluster formation gives the efficient way to avoid the barriers of cluster formation within fixed nodes. Also some localization techniques are also reviewed. In hybrid localization scheme the integration has been done to improve the efficiency by providing both anchor and ordinary node localization. In on demand localization asynchronous clock with pre knowledge of location has been implemented.

The Anchor-Free localization technique gives the scope in future to examine the applicability of ALPHA algorithm more underwater environments.

The Self Organizing Localization Algorithm eliminates errors encountered during localization process which makes it an efficient localization scheme. Efficient Mobility Based Localization the proposed EMBL scheme helps to reduce the communication cost of the network which ultimately leads to reduction in the cost of the whole network .This influences the bandwidth requirement, which is limited in acoustic communication. Elliptic Curve Cryptography (ECC) schemes are more adequate for underwater environment as compared to traditional signature based schemes.

5. Proposed work

The entire analyses of proposed system have been analyzed by mean of simulation. We have implemented our work in following flow:

- First module includes the deployment of sensor nodes to create network. There are two types of nodes below the water surface, ordinary node and special nodes. Ordinary nodes are those who continuously collect data from water and special nodes are the nodes which collect the aggregated data from clusters and transmit it to sink nodes. The special nodes are having more capabilities as compared to ordinary one as they will move vertically also.
- In second phase we studied various Clustering algorithms will be studied as per feasibility of underwater network environment and we have selected the temporary cluster based routing for our network. From the underwater characteristics of network point of view this protocol we found this protocol more feasible.
- In third phase we studied various Localization Schemes as per feasibility of underwater network environment. Instead of selecting only one localization scheme we have implemented two schemes so that according to the

availability of cluster head, the primary nodes can select the proper localization schemes I order to save energy and decrease the localization error. We have implemented different localization approach at different levels. We have used the multiple choice strategy only at cluster level. The two algorithms that we have use at lower level i.e. localization between cluster head and the primary nodes are Self Organizing Localization Algorithm and the Localization Using Received Signals Power. It switches between these two algorithms according to situation. If the primary node gets three nearby cluster head at time of localization then it uses the centroid method otherwise it uses method based on received signal strength .The snapshots below gives the overview of localized network after our work done. At the sink level we have implemented only one localization scheme based on received signal strength.

- In fourth phase we studied security mechanisms for underwater network environment. As we have already implemented more than one localization algorithms, in order to decrease the computation and overload on network we have implemented the simple handshaking mechanism for authentication.
- In final phase of our work we analyzed the working of our proposed work.

6. Working

The working of the proposed system is based on the performance of the two types of the nodes. First is primary node and special node i.e. cluster head .First of all the primary nodes will collect data from the underwater environment and go for localizing the proper cluster head to which it can send the data it has collected. Then it will check for availability of cluster heads. It will selects among two algorithms according to situation. If the primary node gets three nearby cluster head at time of localization then it uses the centroid method otherwise it uses method based on received signal strength .The snapshots below gives the overview of localized network after our work done. Similarly, at the sink level where the there is only one localization based on received signal strength, the cluster head will move upward. If both localization and authentication flags are 1, then only the data will be sent to sink. In case of unauthorized sink, the sink will be blocked permanently in network.

7. Result and Conclusion

This paper reviewed various techniques related to localization, clustering and security in under water sensor network. Figure 4.shows the network setup in the initial phase of the proposed work. We have studied the various localization techniques and we are trying to integrate them .The aim behind combining them is to increase the feasibility in the sense that according to condition the proper localization technique will be used and data transmission will be proceed among the different types of nodes. In proposed work we have implemented the two techniques for localization i.e angle of arrival technique and second based on the received strength signal. We have used simple shaking security mechanism. The following snapshots give the view of work and the results.

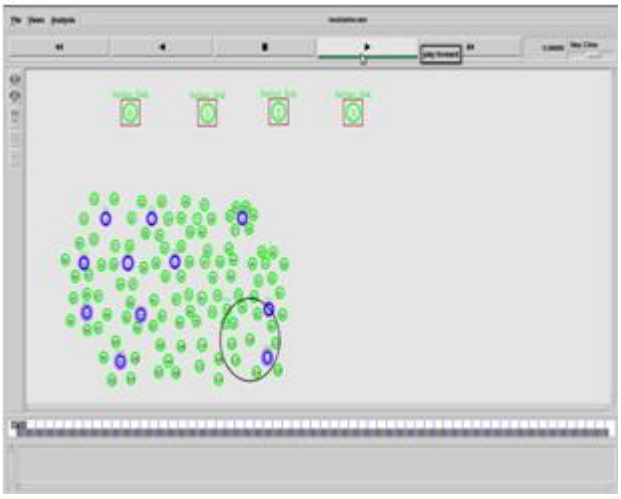

Figure 4: Network Setup

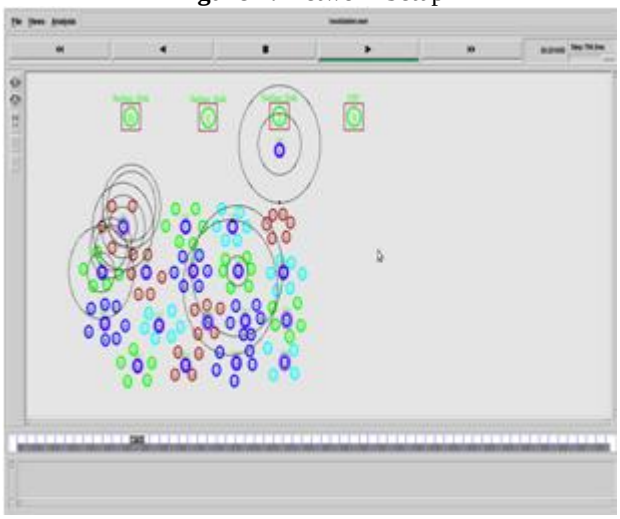

Figure 5: Localized Network

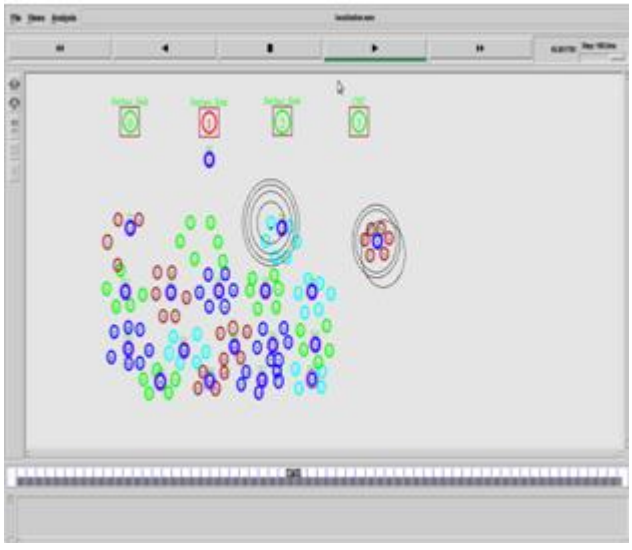

Figure 6: Invalid node in network

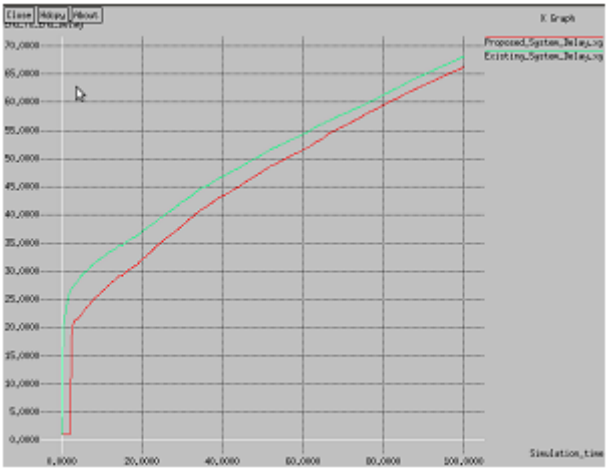

Figure 7: Delay Graph

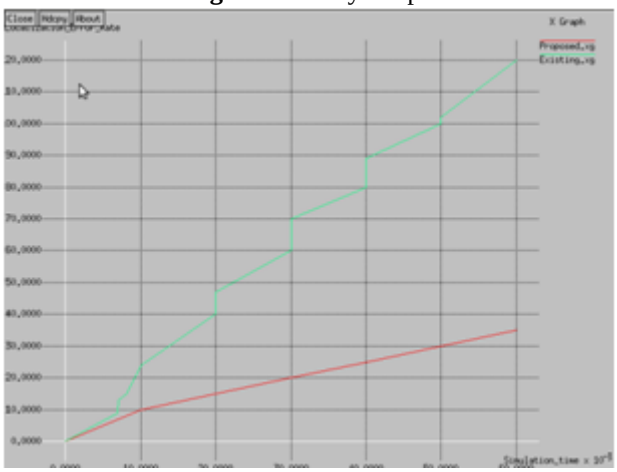

Figure 8: Accuracy Graph

Figure 4 shows the initial setup of network. Figure 5 describes the network view while the localization and authentication are going on simultaneously and the upward movement of cluster head and transmission of data after authentication. Figure 6 shows the invalid sink node by red colour. The last figure 7 and 8 shows the graph of the delay in end to end communication system accuracy of existing and proposed work.

8. Future Scope

In future, the some improved techniques can be used to improve the network performance in order to reduce the calculation to the more extent.

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