Novel Scheme for Node Localization of Underwater Acoustic Networks

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Abstract- The underwater acoustic network is the type of network which is deployed under the deep sea to sense ocean conditions like pressure etc. The networks are deployed underwater for providing communication such that the important information can be easily transmitted across regions. Due to the presence of limited bandwidth, higher multi-path, higher fading, huge time-variations as well as Doppler shifts, it is difficult to perform high-speed communication within underwater acoustic channels. Thus, in order to make them appropriate for underwater channels, there is a need to modify these techniques. In the previous research, the fry fly algorithm is applied for the node localization. In the fry fly algorithm the optimal value is calculated for the node localization. In this research work, distance based technique is applied for the node localization. The proposed and existing algorithms are implemented in MATLAB. The simulation results show that proposed algorithm performs well in terms of certain parameters.

Keywords- Wireless sensor networks (WSN) · Node localization · Butterfly optimization algorithm (BOA) · Particle swarm optimization (PSO) algorithm · Firefly algorithm (FA)

I. INTRODUCTION

A network that consists of various sensor nodes and base station for collecting data from surroundings is known as a wireless sensor network. The power, memory as well as computational capacity of sensor nodes in these networks is very less [1]. There is a random distribution of the sensor nodes within these networks such that the surrounding conditions can be sensed and the important information can further be forwarded to be the base station of the network. To aggregate the data, the base station is deployed centrally within these wireless networks. The data that is received from the base station by end users is accessed and then passed on to the server further. There are huge areas in which the sensor networks are deployed and to ensure that such huge amount of gathered data is passed on at single time duration, several base stations are deployed in these networks. Uni-directional and bi-directional are the two different types of communications supported by wireless sensor networks [2]. The information is transmitted to the base station by the sensor nodes which then again communicate directly with the base station also, within bi-directional type of communication. The applications that cannot include human surveillance for monitoring the environment use wireless sensor networks. The networks are deployed underwater for providing communication such that the important information can be easily transmitted across regions [3]. Due to the presence of limited bandwidth, higher multi-path, higher fading, huge time-variations as well as Doppler shifts, it is difficult to perform high-speed communication within underwater acoustic channels. Within the sea waters, the propagation of electromagnetic waves is very poor. Originally for the terrestrial wired and wireless channels, the communication techniques were designed. Thus, in order to make them appropriate for underwater channels, there is a need to modify these techniques. There has been huge research proposed in last few centuries on underwater acoustic communication [4]. The development of underwater phone for US navy at the time of World War II was one of the initial discoveries of underwater communication devices. Further, various scientific, military and commercial applications have been utilizing this technology within them to provide better communication. The electromagnetic waves, optical waves as well as the acoustic waves are used within the underwater acoustic sensor networks. Each of these has their own merits and demerits. Due to the dynamic nature of WSNs, one of the major issues that arise is known as node localization. For ensuring efficient data communication, the location of sensor nodes is shared through node localization mechanism. By proposing efficient solution to the node localization issue, the data aggregation issue is resolved [5]. For performing several tasks like tracking of target, monitoring the environmental conditions, WSNs are deployed in various applications. To fulfill the various applications of WSN, an important requirement is node localization. Due to the dynamic nature of these networks, node localization is known to be the major issue. The task in which the coordinates of nodes are collected for identifying unknown nodes is known as node localization. The distance approaches can be utilized to perform this technique along with the coverage area in which sensor nodes are deployed. For generating queries from sensor nodes for several events, forwarding data within the groups, and routing the data, the generation of queries is important within this technique. Anchor nodes are deployed within the network for localizing the position of sensor nodes. Thus, an estimated value is calculated to determine the localization distance amongst the sensor node and anchor [6]. Several optimization approaches are implemented on anchor nodes for estimating the exact position of sensor nodes. Ranging errors is the major issue of node localization in which the exact position estimation of unknown nodes is to be minimized. There is reduction of mean square error due to the identification of position of unknown nodes. For estimating the exact location of sensor nodes, there is a need to minimize the optimization issue using the fitness value known as mean square error. On the basis of mobility and nature of swarms, a stochastic mechanism is proposed that has high flexibility [7]. It is known as Particle swarm optimization (PSO). An algorithm that is used for optimizing the functions through the enhancement of candidate solution in stochastic and repeated manner is known as Biogeography-based optimization (BBO). For localization, the trilateration is utilized widely. The utilization of three or more numbers of anchor nodes is the major principle of this approach. The radiuses of circles are known as the computed distances from known points to the unknown object. The sensor nodes of WSNs are localized using Bee Optimizations Algorithm (BOA). The normal allocation of Time of Arrival (TOA) measurements and received signal strength (RSS) measurements are used for various topologies by conducting various tests.

II. LITERATURE REVIEW

Sankalap Arora, et.al, (2017) presented that accurate localization of sensor nodes has a strong influence on the performance of a wireless sensor network. In this paper, a node localization scheme using the application of nature-inspired meta-heuristic algorithm, i.e., butterfly optimization algorithm, is proposed. In order to validate the proposed scheme, it is simulated on different sizes of sensor networks ranging from 25 to 150 nodes whose distance measurements are corrupted by Gaussian noise [8]. The performance of the proposed novel scheme is compared with performance of some well-known schemes such as particle swarm optimization (PSO) algorithm and firefly algorithm (FA). The simulation results indicate that the proposed scheme demonstrates more consistent and accurate location of nodes than the existing PSO- and FA-based node localization schemes.

Ranjit Kaur, et.al, (2017), presented a study related to node localization which plays a very important role within wireless sensor networks. On the basis of distance, the location of sensor nodes is estimated within the localization approach. The value of estimated value is just an approximation and not real. The important information from base station is very difficult to be generated in case if the estimation of position of node is not correct. Because of huge sizes of the sensor networks, the complexity of node localization is very high also. An optimization issue caused here commonly is node localization. For node localization, a nature inspired optimization approach is proposed by author [9]. Comparisons are made amongst various optimization algorithms in order to identify appropriate mechanisms with respect to accuracy and computation time they provide.

S.R.Sujatha, et.al, (2017), proposed in this paper a novel dynamic weight based mechanism for node localization in WSN. Mainly, a hybrid approach is proposed here through which the improvements are achieved. When there is equality of the estimated and measured positions of nodes, the bit error rate is minimized. For gathering the accurate locations of nodes, the anchor nodes are utilized. For localization, DE algorithm is proposed by author here with whom the accuracy of localization is increased here [10]. With respect to accuracy and execution time, the proposed algorithm provides better simulation results.

Meng Joo Er, et.al, (2016), presented research related to node localization within WSNs. To provide highly accurate position of nodes, the density of network needs to high. The accuracy of node localization is directly affected due to the node density. There is minimization of number of hops of network when the density of nodes is minimized in the area. Thus, the accuracy of network is also minimized here. For providing node localization, node density based estimation approach is proposed [11]. The node density is calculated for anchor nodes and regions within sub-regions are divided on the basis of node density of anchor node. To estimate the position of nodes, the distance amongst the anchor node and sensor node is computed. In comparison to already existing approaches, the performance of proposed approach is shown to be better as per the simulation results.

Eva Tuba, et.al, (2016), presented that an important part of WSNs is the estimation of position of sensor nodes. A mechanism in which the location of unknown nodes can be estimated is known as node localization. In order to predict the location of sensor nodes, the distance amongst the anchor nodes as well as the sensor nodes is computed as per the RSSI approach. On the basis of firework swarm intelligence optimization algorithm, the node localization mechanism is proposed in this paper [12]. There are three different phases in which this algorithm performs. The location of each node is compared within the initial phase. Further, the best location is computed within the second step. Further, for node localization, the value of MSE is estimated within the final phase. It is seen through the comparisons that with respect to accuracy and execution time parameters, the performance of proposed algorithm is better that already existing approach.

Chin-Shiuh Shieh, et.al, (2016), presented study related to node localization which is a major issue. The gathering of data from the network becomes difficult in case when the position as well as identification of sensor nodes is not estimated. The optimization issue faced within WSNs is node localization which is mainly caused due to the estimation of positions of nodes [13]. Several optimization algorithms that are proposed for node localization are compared within this research to evaluate the performances of each other in comparison to each other. The various optimization algorithms are compared with respect to accuracy as well as execution time. It is seen as per the simulation results that the firefly algorithm performance better in comparison to other algorithms.

III. RESEARCH METHODOLOGY

It is the process of identifying the position coordinates of unknown nodes which can be achieved by using the distance information, and radius of wireless communications. Node localization is required to report the origin of events, assist group querying of sensors, routing and to answer questions on the network coverage. The measured distance between unknown node and anchor node is not the real value. So unknown node position estimation can be treated as a kind of optimization which minimizes the target function of localization error of anchor node to find out the position coordinate of unknown node. The major factor is a ranging error that affects the location error of the unknown node, and decreasing the maximum error which can meritoriously improve the accuracy of localization.

1. Calculate probabilities of the selected sensor nodes

2. for each anchor node

2.1. Produce new coordinates of the sensor nodes with coordination estimation

2.2. Define the objective function $f(x) = [(x-x_i)^2+(y-y_i)^2]^{1/2}$

2.3. Calculate fitness of the coordinate of sensor node by

Fitness function:

$fit_i = \{1/ 1+ f_i \quad \text{if } f_i>=01+ abs(f_i) \quad \text{if } f_i< 0\}$

2.4. If the fitness of coordinate of sensor node is better than old one, memorize new position and reset trial counter; otherwise increase its trial counter by 1.

3. Save the best solution obtained so far.

4. Return best solution as termination criteria

IV. RESULTS

The proposed research is implemented in MATLAB and the results are evaluated by making comparison amongst proposed and existing algorithms in terms of several parameters.

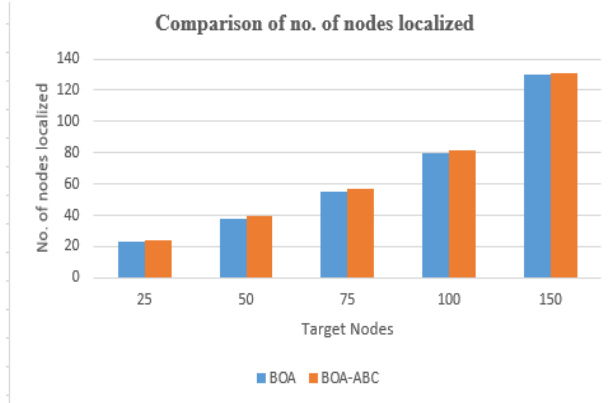

Fig.1: Number of nodes localised versus target nodes

The graph shows the number of nodes localized with the optimization algorithms (BOA and BOA-ABC). It shows that the nodes localized with the (BOA-ABC) are comparatively more than the BOA optimization algorithm.

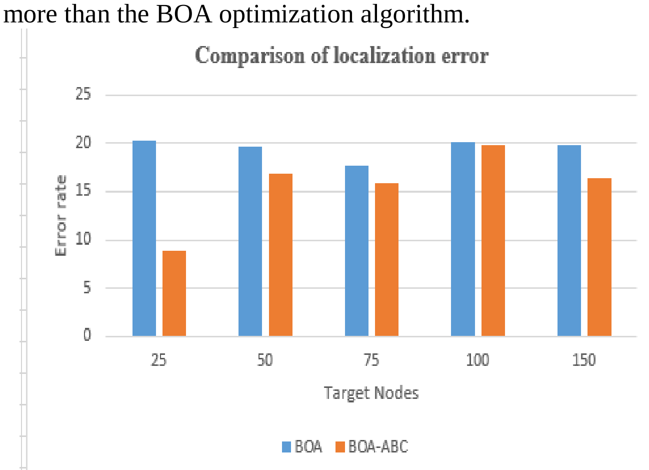

Fig.2: Error rate versus target nodes

The graph shows the results of localization error calculated by BOA and BOA-ABC. It shows that the hybrid optimization algorithm (BOA-ABC) reduces the Mean Square Error (MSE) to the greater extent as compared to the BOA optimization algorithm. Thus, he node localization is improved in the network.

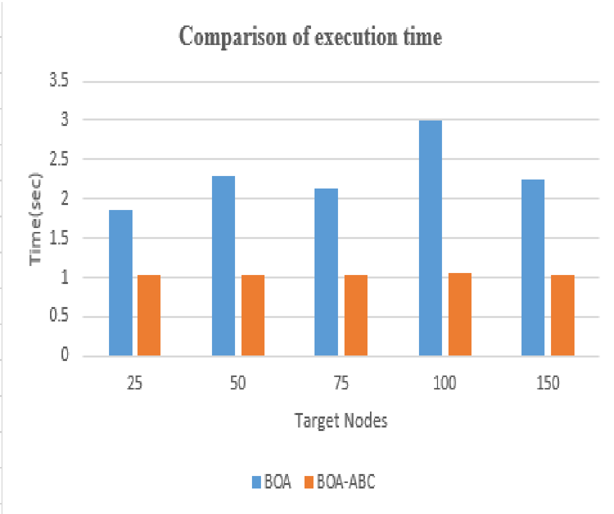

Fig.3: Execution time versus target nodes

The graph shows the computing time used by the optimization algorithms (BOA and BOA-ABC) to calculate the distance between the anchor nodes and the target nodes with the help of beacon messages, to calculate the co-ordinates of the nodes and finding the best solution by reducing the error value. It shows that the computing time of BOA-ABC is almost same and less in comparison to the computing time of BOA. Also, execution time of BOA varies considerably.

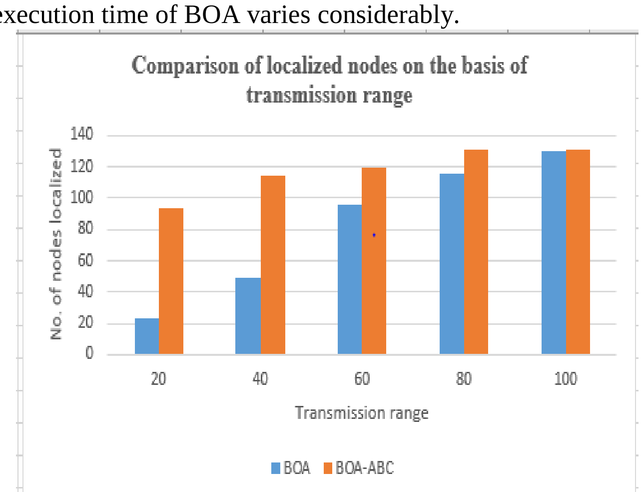

Fig.4: Number of nodes localized versus transmission range

The graph shows that the number of nodes localized increases with the increase in the transmission range that is; with the increase in the transmission range of the anchor nodes the localization of the target nodes also increases.

V. CONCLUSION

In WSN location awareness is one of the important, critical and challenging issues. Knowledge of location among the participating nodes is one of the crucial requirements in designing of solutions for various issues related to wireless sensor networks. Node localization is required to report the origin of events, assist group querying of sensors, routing and to answer questions on the network coverage. The fry fly algorithm is the optimization for the node localization. The fry fly algorithm need large number of iterations for the node localization. In this research work, distance based technique is applied for the node localization. The proposed algorithm is implemented in MATLAB and results are analyzed in terms of certain number of parameters.

VI. REFERENCES

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