International Journal of Electrical and Electronics Engineers
Vol. No. 8, Issue No. 02, July-December 2016
ISSN (O) 2321-2055
ISSN (P) 2321-2045

PERFORMANCE ANALYSIS OF ENERGY EFFICIENT NODE DEPLOYMENT IN UNDERWATER WIRELESS SENSOR NETWORK

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ABSTRACT

In setting up an underwater acoustic network the first and foremost task is node deployment. In underwater acoustic sensor networks, localization is one of the most important technologies to increase the coverage area and also to reduce the energy consumption of the node. Localization plays a critical role in many applications. This paper aims at analysing the node deployment strategies on localization performance in underwater wireless acoustic sensor networks (WASN). The tetrahedron node deployment technique is proposed to preserve the energy of the node. In this paper particle swarm optimization (PSO) and location dispatch based on command nodes (LDBCN) algorithm is proposed. Moreover specifically the simulation results shows large communication coverage, increased network connectivity, throughput and end to end delay is reduced.

Key Words*: Energy *Consumption, Connectivity, Coverage, Localization, Underwater Wireless Sensor Network.

I INTRODUCTION

In the recent years there has been an accumulative interest in the development of Underwater Wireless Sensor Networks (UWSNs) .UWSNs exhibit several architectural differences with respect to the terrestrial ones, which are mainly due to the transmission medium characteristics and the signal to transmit data (acoustic ultrasound signals). Basically, a sensor node in UWSN is formed by the backing among several network nodes that establish an acoustic link that are bidirectional and maintains the network. Since acoustic signals are mainly used in UWSNs, the key aspects taken into reason involved in the propagation of acoustic signals in underwater wireless sensor network environment are: (1) the propagation speed of sound,(2) phase and magnitude fluctuations lead to higher bit error rates,(3) bandwidth constraint; (4) interference in multipath .acoustic communication in underwater is severe due mainly to the surface tides or receptacle activity, this becomes a severe problematic to attain better bandwidth efficiency.

The main differences between terrestrial and underwater sensor networks [10] can be enumerated as follows:

COST: sensors used in underwater sensor networks are more expensive than the terrestrial sensor

DEPLOYMENT: The deployment is estimated to be more sparse in underwater wireless sensor networks.

POWER: Powerin underwaterwireless sensor network high power is needed for processing the data since the node are placed at longer distance

BATTERY: Battery power is limited in underwater and also cannot be replaced

The other major differences are bandwidth is limited, multipath and fading effects occurs and sensor nodes can be prone to failure due to corrosion

The applications of acoustic sensor networks are [10],

OCEAN SAMPLING NETWORKS: Sensors that are connected through the network and autonomous unnamed vehicle(AUV) can monitor the synoptic, cooperative adaptive sampling of the coastal ocean environment.

POLLUTION MONITORING:pollution monitoring and other environmental monitoring such as ocean exploration and to measure the salinity and temperature.

DISTRIBUTED TACTICALSURVEILLANCE AUVs and fixed underwatersensors can collaboratively monitor areasfor investigation, inspection, and targeting,interruption exposure

.

The major disadvantages are:

- Real time monitoring is difficult especially in environmental monitoringapplications such as seismic monitoring
- Data cannot be accessed until the instrument is taken from the underwater.
- Detection of failure is difficult
- On board storage device like disk and memory will decide the capacity of amount of data recorded by sensor during monitoring mission

In the marine, military defence area, the location, identification and tracking of the incursion objects must depend on the nodes. Since energy is strictly limited the batteries of underwater sensor nodes can never be replaced. so under normal circumstances, in an underwater environment it is difficult to achieve higher localization accurateness and localization coverage rate .localization of underwater mobile nodes in a large-scale network present great difficulties and challenges. Compared to radio communication acoustic communication has a larger propagation delay, lower bandwidth and higher error rate.

II RELATED WORKS

The underwater sensor networks has two communication architectures i.e., two dimensional architecture and three dimensional architecture [9].

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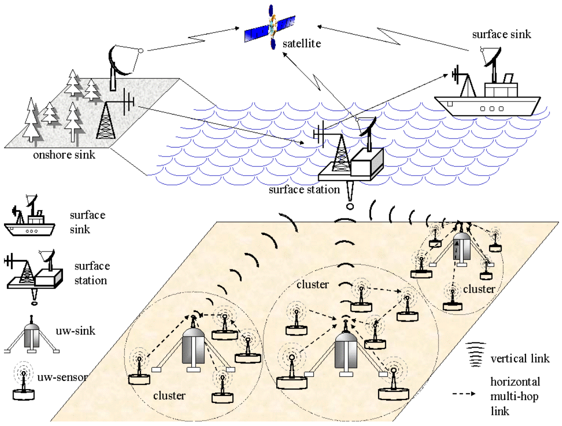

Fig 1 Underwater WSN Architecture

The main challenge in 2D architecture is the minimum number of sensors and gateways that are deployed for achieving communication coverage.[8] It is important to provide communication coverage in underwater wireless sensor network so that each sensor node should establish a multi hop paths to the sink and sensing coverage to monitor the area covered by the sensors. In underwater sensor network the nodes are of three types they are unknown nodes, anchor nodes, reference nodes .the anchor nodes that are also sensor nodes are known with the locations.in advance the anchor nodes can get their position by GPS system or artificial arrangement. Referenceis a node in a sensor network that is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network. The unknown known determines its position by communicating with the reference or anchor nodes. The localization algorithm used for terrestrial wireless sensor network is not suitable for underwater wireless sensor network. The major difference is the signal used for communication. The terrestrial wireless sensor network uses the radio signal which is not suitable for UWSN. In underwater radio signal propagates longer distance only between the frequency 30Hz to 300 Hz. This low frequency radio signal requires very large antenna and also more transmission power. The acoustic signal is more suitable for underwater wireless sensor networks. Acoustic signal attenuates less and travels faster than radio signal. Hence acoustic signal is used for communication in UWSN.

TABLE 1: Bandwidth for Acoustic Sensor Networks

	RANGE(km)	BANDWIDTH (kHz)
Very long	1000	<1
Long	10-100	2-5
Medium	1-10	10
Short	0.1-1	20-50
Very short	<0.1	>100

Many localization algorithms have been proposed for underwater wireless sensor network. The [11] localization algorithm is classified into two categories: one is distributed localization algorithm the other is centralized localization algorithm. The infrastructure is not available for the distributed schemes i.e., anchor free. The anchor nodes arerandomly distributed throughout the network and the network has 5-20% of the anchor nodes. In distributed schemes the location of the each nodes is calculated by three phases(a)the distance estimation phase, in distance estimation phase nodes estimate the distances to theirneighbours.(b) the position estimation phase, this uses a least squares approach to estimates the position of the node.(c) a refinement phase, iterative algorithm is used to improve the accuracy. In the centralized schemes the base station or the sink node estimates the location the unknown node. The above two categories are further divided into subcategories (i) estimation based and (ii) prediction based algorithm. Estimation based algorithm compute the node location based on the current information, where the prediction based algorithm predict the node location based on previous and current information. Depending on the deployment strategies the sensor nodes can have different depths. The different deployment schemes are random and cube deployment and regular tetrahedron. Grid structure deployment is not feasible for underwater sensor networks.[6] however the node reliability model is used for determining the network connectivity and coverage[6]. After an initial random deployment the sensor nodes are moved to achieve the sensorcoverage. However [8] requires dynamic sensor nodes or redeployment of nodes this is not feasible in under water acoustic sensor networks.

III LOCALIZATION ALGORITHM

3.1 Particle SWARM Optimization

The localization algorithm that use reference nodes are classified into: range based schemes and range free schemes.in range based schemes to estimate the location of the nodes in the network the precise distance or angle measurement are calculated. To estimate their distance to other nodes the range based schemes that relay on range/bearing information that use time of arrival (TOA), angle of arrival (AOA) or received signal strength indicator. The range free schemes do not use range i.e., they do not make use of techniques such as AOA, TOA. However only the coarse estimate of nodes location is calculated in the range free schemes. Particle swarm optimization (PSO) is a multi-step localization algorithm and it is divided into beacon node localization and unknown node localization. By measuring the distances from the nodes to the buoys the beacon nodes are located. The next moment the location of the unknown nodes are predicted by estimating the speed of the movement of the nodes. In particle swarm optimization (pso) each node keeps track of its best solution i.e., best solution and best value of any node i.e., global best. Each node tries to modify its position using the following information the current positions, the distance between the current position and the personal best, distance between the current position and global best. The modification of the node position can be mathematically modelled according to equation 1

$$V_i^{k+1} = wV_i^k + c_1\,\text{rand}_1(\ldots) \times (\text{pbest}_i - s_i^k) + c_2\,\text{rand}_2(\ldots) \times (\text{gbest} - s_i^k) \ldots.(1)$$

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Where v_i^k: velocity of node i at iteration k,w: weighting function,c_j: weighting factor,rand : uniformly scattered chance number between 0 and 1,s_i^k : current position of node i at iteration k,$pbest_i$: pbest of nodei,gbest: gbest of the cluster.

The beacon nodes broadcast a packet in the network after getting their velocities, and the packetcontains the identity, velocity and time identification information. Time identification represents the moment of positioning for this node. Since all the nodes cannot complete their positioning at the same time, the referenced nodes selected should be in the same positioning round as the unknown nodes, that is to say they should have the same time identification. The unknown node W receives the packets from different beacon nodes, and it will sign the beacon node which has the same time identification as a referenced node. Finally the list of reference nodes will be set up, and it includes the identity, velocity, time identification information, and the received signal strength.

The flow diagram of the particle swarm optimization is as follows

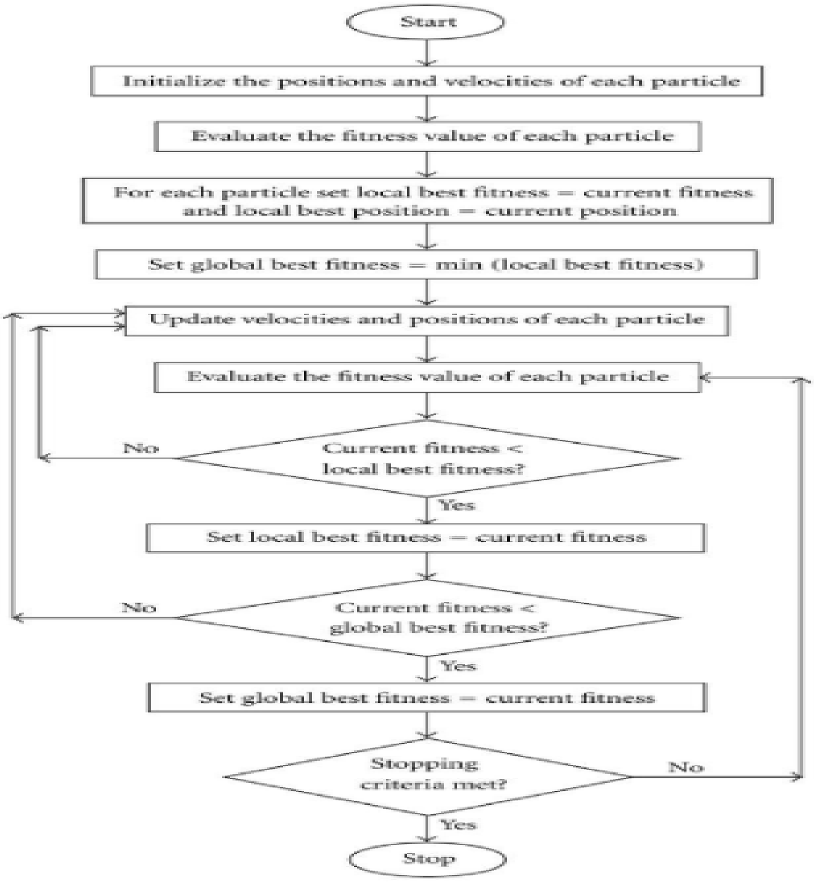

Figure1. Flow Chart for PSO

3.2 Location Dispatch Based on Command Nodes

The sink node and the command nodes are used to determine the location of the common nodes.
LDBCN algorithm is used to preserve energy of the common nodes The major difference between the PSO and LDBCN is that PSO has only one sink node which corrects and analyzes the information from other nodes. In LDBCN the sink node are randomly scattered on the surface of water. The other type of node is the command node used for network connectivity and also to report to the location of the common nodes. The command nodes are also randomly distributed on the surface of the water and then the command nodes are moved to the predetermined locations to connect with the sink node. The common nodes are used for monitoring purposes and the common nodes are also divided into two types, one is coverage node and the other is connectivity node. The coverage node is used to improve the overall network coverage rate. To make the whole network fully connected the connectivity nodes are used. The destination locations of the common nodes, command nodes and the sink nodes are stored in the memory of the nodes. This process helps to preserve the energy of the node when it moves from the initial random position to the corresponding destination. The command nodes report to the common nodes to choose the destination location from the destination set for the common node to preserve the total energy. The connectivity rate of the network is defined as the ratio M to N where M is the number of common nodes that can communicate with the sink node with sink hop or multi hop, and N is the number of common nodes.

Connectivity rate= M/N

If the network connectivity rate is 1 the network achieves full connectivity so that all the common nodes can communicate with the sink node. The destination set of locations of the nodes are calculated with the help of GFCND algorithm. The locations of the nodes are set into memory of the nodes and these nodes are scattered on the surface of the water by plane or ships. When the command nodes moves to the destination locations, the total distance covered by all the common nodes will be too large. By using the dispatch algorithm the distance covered by all the common nodes to reach the destination is reduced. The process of LDBCN is the sink node and command node move to their destinations. The common node sends their register information to the nearest command nodes, if there are more than one command node then the common node select the command node with the smaller ID. Each command nodes knows the number of the common nodes and the destination locations. Each command node selects the correct destination location from the common node.

IV SIMULATION RESULTS

In this section we produce the simulated output for the particle swarm optimization (PSO) and location dispatch based on command node (LDBCN) algorithm. The parameters measured are network coverage, network connectivity, and throughput.

4.1 Network Coverage

The number of nodes covered by the LDBCN is large compared to pso and throughput is increased and the latency get reduced for the location dispatch based on common nodes

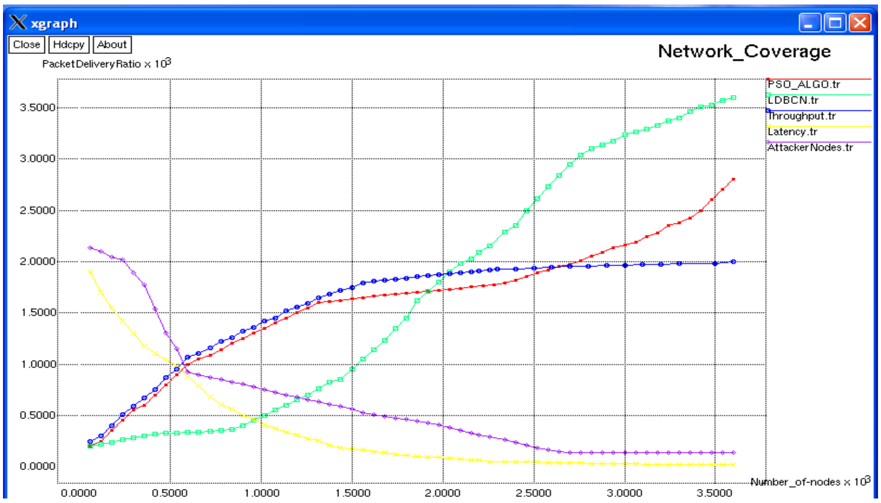

Figure 3. Network coverage

4.2 Network Lifetime

The network lifetime is the connectivity of the nodes in the network. By using the LDBCN algorithm the connectivity of the network can be increased

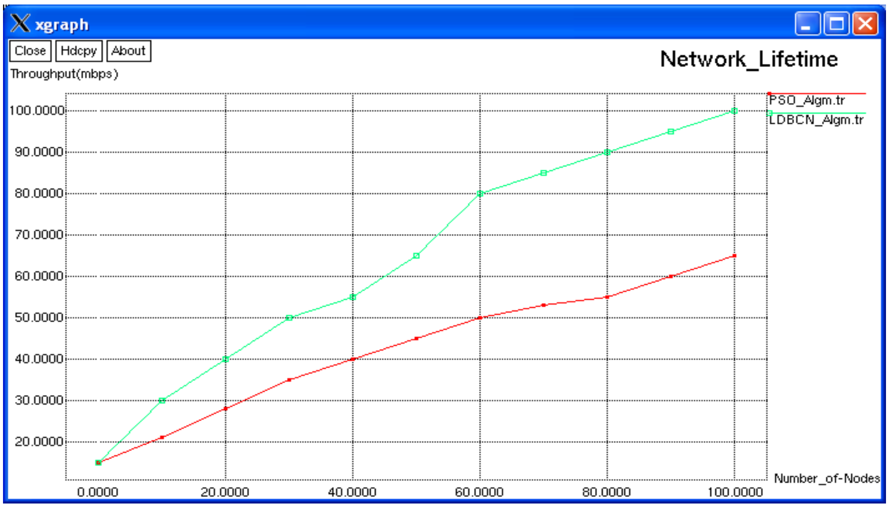

Figure 4. Network Connectivity

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4.3 Throughput

The speed of the data transmission is increased in the LDBCN algorithm

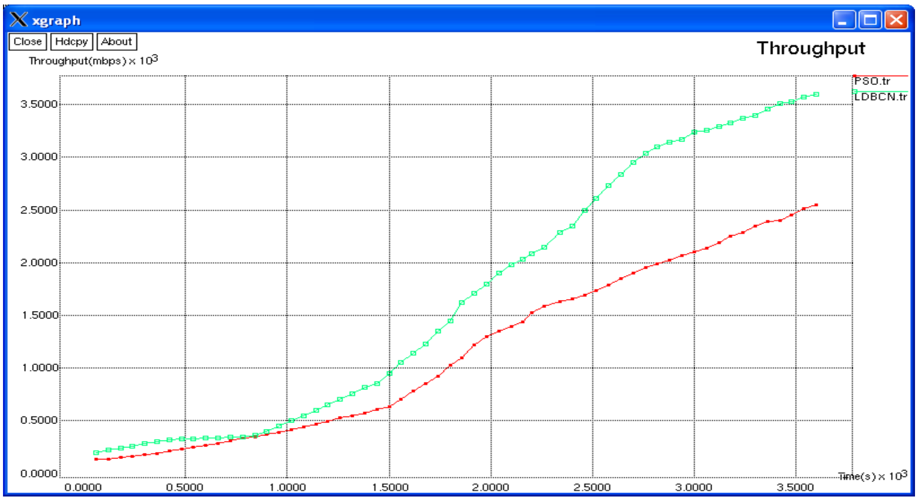

Figure 5. Throughput

4.4 End To End Delay

The delay is reduced for the LDBCN algorithm and the throughput is increased

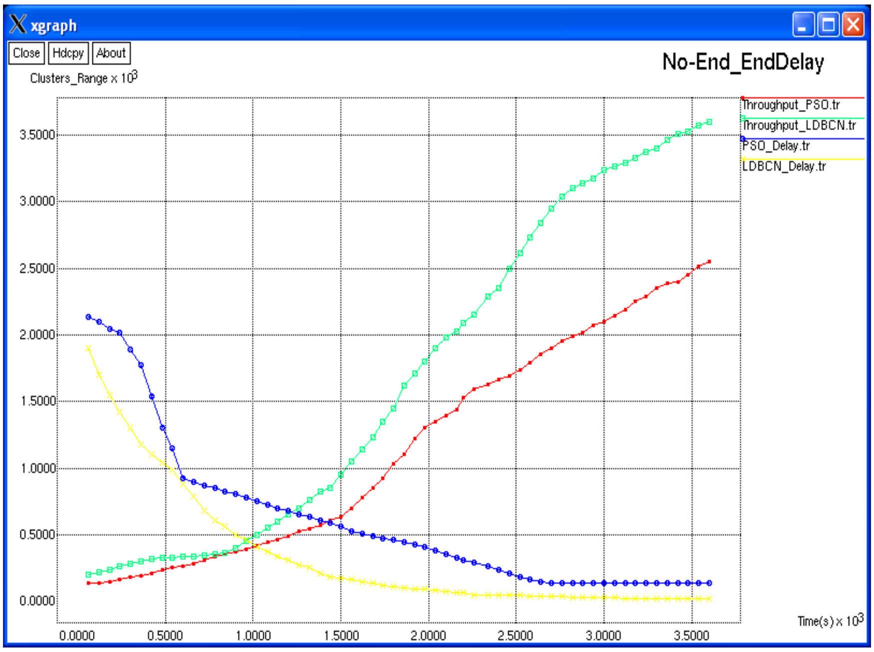

Figure 6. End to end delay

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4.5 Energy Consumption

The energy consumed by the nodes while transmitted data is reduced by the location dispatch algorithm

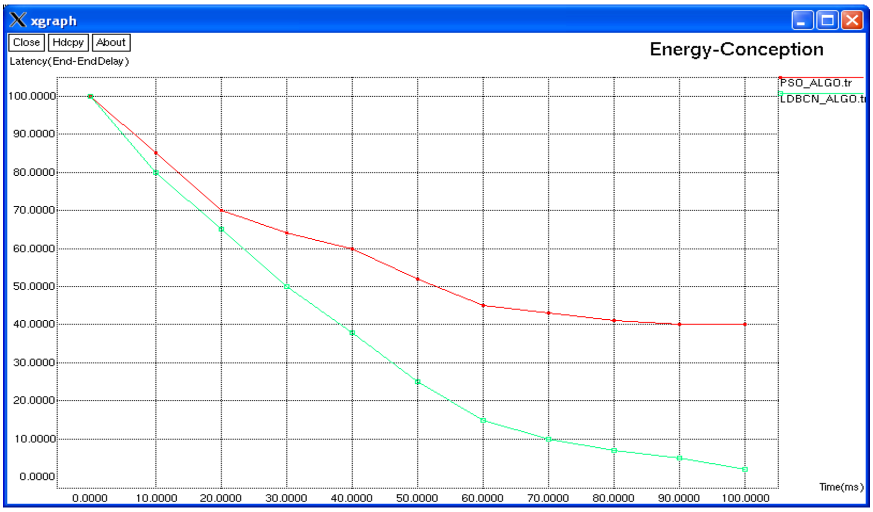

Figure 7. Energy consumption

V CONCLUSION

The simulation result shows that the LDBCN algorithm has high accurate localization with minimum energy consumption of the node. the regular tetrahedron deployment scheme reduces the localization error and increase the localization accuracy by maintaining the average number of neighbouring anchor nodes and also the network connectivity. Also the LDBCN algorithm produces the location adjustment of thecommon nodes with the helpof sink node and thus enabling them to preserve the energy of the node.

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