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On energy hole and coverage hole avoidance in Underwater Wireless Sensor Networks

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Abstract: Due to limited battery capacity of each sensor nodes, minimization of energy consumption is a potential research area in Underwater Wireless Sensor Networks (UWSNs). However, energy hole and coverage hole creation leads performance degradation of UWSNs in terms of network lifetime and throughput. It address the hole creation issue due to lack of energy in depth based routing techniques, and devise a technique to overcome the deficiencies in existing techniques. Besides addressing the energy hole issue, proposition of coverage hole repair technique is also part of this research work. In areas of dense deployment, sensing ranges of nodes redundantly overlap. Coverage-aware sensor automation (CASA) protocol is proposed to realize an automated smart monitoring network. Two centralized algorithms are included in the CASA protocol suite: enhanced virtual forces algorithm with boundary forces (EVFA-B) and sensor self-organizing algorithm (SSOA). Unlike most previous works that tackle the deployment problem only partially, we intend to address the problem from both global deployment (EVFA-B) and local repairing (SSOA) perspectives.

Keywords: Sensor, automated, routing, protocol.

I. INTRODUCTION

Wireless Sensor Networks (WSNs) are rapidly emerging as an important area in wireless and mobile computing research. Applications of WSNs are numerous and growing, and range from indoor deployment scenarios in the home and office to outdoor deployment scenarios in adversary's territory in a tactical battleground. For military environment, dispersal of WSNs enables the detection and tracking of enemy soldiers and vehicles. For home/office environments, indoor sensor networks offer the ability to monitor the health of the elderly and to detect intruders via a wireless home security system. In each of these scenarios, lives and livelihoods may depend on the timeliness and correctness of the sensor data obtained from dispersed sensor nodes. As a result, such WSNs must be secured to prevent an intruder from obstructing the delivery of correct sensor data and from relay to sensor data.

II.RELATED WORKS

Balanced Load Distribution with Energy Hole Avoidance in Underwater WSNS [1] describes a hybrid routing mechanism is adopted and a two dimensional network model is proposed. BTM balances the data load among all sensor nodes by dividing the energy of each sensor node into energy levels. EEBET presents an Efficient and Balanced Energy consumption Technique (EBET) to avoid direct transmission at long distances for saving energy and calculates an optimum number of energy levels to enhance the network lifetime. Spherical Hole Repair Technique (SHORT) to repair coverage holes which are created due to energy holes. The technique has three phases: Knowledge Sharing Phase (KSP), Network Operation Phase (NOP) and Hole Repair Phase (HRP).

Autonomous Deployment of Sensors for Maximized Coverage and Guaranteed Connectivity in Underwater Acoustic Sensor Networks[2] describe a novel remote deployment of acoustic sensors which can maximize the coverage in 3-D while guaranteeing the connectivity among the sensors and a surface sink node to collect data. The approach assumes a randomly deployed UWASN on the surface of the water in 2-D. This can be achieved with random dropping of a certain number of sensors in a targeted area. The approach then determines the connected dominating set (CDS) of the whole UWASN at 2-D plane using a distributed approach [9]. The main goal here is to determine a backbone of the network consisting of dominators and then maintain the very same backbone connected underwater by exploring the third axis.

DSH-MAC: Medium Access Control Based on Decoupled and Suppressed Handshaking for Long-delay Underwater Acoustic Sensor Networks[3] describe a propose MAC protocol, DSH-MAC, designed for UW-ASNs to address their long propagation delay issue, based on active selection of sender by the receiver in an intelligent way. In DSH-MAC, The two control packets, namely NOTE and GRANT, are analogous to RTS and CTS packets, respectively. The NOTE packets are used to notify others of the sender's transmission intention, including the number of packets buffered for each receiver and the data generation rate. The two control packets are decoupled so that parallelism is allowed between handshaking/handshaking and handshaking/data transmissions, leading to higher network throughput.

Scheduling Multiple Mobile Sinks in Underwater Sensor Networks [4] describes Acoustic communications are used as a medium but they are only good for transmitting e.g. signaling information. Autonomous Underwater Vehicles (AUVs) can serve as mobile sinks that gather and deliver larger amounts of data from the underwater sensor network nodes. Value of Information (VoI) is a data tag that encodes the importance and time-based-relevance of a data chunk residing at a sensor node. VoI, therefore, can serve as a heuristic for path planning and prioritizing data retrieval from nodes.The use of multiple mini-sized AUVs has certain advantages as compared to the use of a single large AUV. Using multiple AUVs helps in the scalability of the area coverage and also provides the advantage for the fault-tolerance ability of the acoustic sensor network - an AUV can reschedule and complete the tasks for another AUV that has malfunctioned. Further, with the use of appropriate scheduling algorithms, one can use the heterogeneous abilities of different AUVs as an advantage

Efficient Camera Selection for Maximized Target Coverage in Underwater Acoustic Sensor Networks [5] describes an approach that can coordinate the movement of appropriate cameras through the on-surface gateway. Each camera provides its location and orientation information to the gateway in advance so that the gateway can process this information in real-time when a request comes from the sensors to actuate cameras. When a target is detected, an approximate bounding box which contains the target is computed. The gateway then runs an algorithm to determine the cameras that are qualified to be covering the bounding box by vertical movement. Specifically, for each camera the gateway determines the set of discrete points it can cover with the least vertical movement. This problem is similar to minimum set cover where the discrete points for the bounding box constitute the set to be covered by the subsets owned by each camera. They model the problem as a weighted minimum set cover to also accommodate the distances of cameras to the target. Since weighted minimum set cover is also an NP-hard problem, they used a greedy heuristic for faster processing.

III. METHODOLOGY

Area coverage in WSN focuses on monitoring the entire region of interest, whereas target coverage concerns monitoring only certain specific points in a given region. Target coverage can be categorized as simple coverage problem. . In addition, ANT colony optimization technique is used to make the system more adaptable. This increases the network node lifetime to a greater extent. This makes the dynamic criteria changing environment system such that different charge level in different nodes. The main objective of the project is sensor coverage is important while evaluating the effectiveness of a wireless sensor network. A lower coverage level (simple coverage) is enough for environmental or habitat monitoring or applications like home security. Higher degree of coverage (k-coverage) will be required for some applications like target tracking to track the targets accurately or if sensors work in a hostile environment such as battle fields or chemically polluted areas.

A. Find Coordinates of New Location

Initializations due to random deployment in UWSNs, nodes are densely deployed in few regions of the target area and sparsely in others. Nodes death is obvious during network operation due to many reasons. To energy hole or due to exhaustion of the battery and irrespective of the reason, coverage hole is created. SHORT fills this hole by moving nodes from densely populated region(s).

•A node which is going to be mobile must not lose its existing connectivity.
•Mobility of candidate node must not create any coverage hole.

B. Heuristic for Sensor Deployment

If any sensor node is idle (without monitoring any target), the node is moved to the least monitored targets' location. This is to ensure that all sensor nodes play their part in monitoring the targets. The sensor nodes are then sorted based on the number of targets it cover. The sensor node is placed at the middle of all the targets it covers. The next nearest arget is identified and the sensor node is placed at the middle of all these targets. If it is able to cover the new target along with targets that was already monitoring, allow this move, and else discard the move. This is done till the sensor node cannot cover any new target. At the end, upper bound is computed. The drawback of this approach is that it depends on the initial position of the sensor nodes.

1: Place sensor nodes randomly
2: for i = 1 to m do
3: if Si does not monitor any target then

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4: Move Si to the least monitored target
5: Recomputed sensor-target coverage matrix
6: end if
7: end for
8: S = Sensor nodes sorted in ascending order of number of targets it covers
9: for i = 1 to m do
10: repeat
11: Place Si at the center of all targets it covers
12: Move Si to the center of all targets it covers and its next nearest target
13: if Si can cover a new target then
14: Recompute sensor-target matrix
15: else
16: Discard move
17: end if
18: until Si can cover another target
19: end for
20: Compute upper bound of network lifetime using

C. ABC Based Sensor Deployment

Artificial Bee Colony (ABC) Algorithm is an optimization algorithm based on the intelligent behavior of honey bee swarm. The colony of bees contains three groups: employed bees, onlookers and scouts. The employed bee takes a load of nectar from the source and returns to the hive and unloads the nectar to a food store.

After unloading the food, the bee performs a special form of dance called waggle dance which contains information about the direction in which the food will be found, its distance from the hive and its quality rating.

Algorithm 3 ABC Algorithm
1: Initialize the solution population B
2: Evaluate fitness
3: cycle = 1
4: repeat
5: Search for new solutions in the neighborhood
6: if new solution is better than old solution then
7: Memorize new solution and discard old solution
8: end if
9: Replace the discarded solution with a new randomly generated solution
10: Memorize the best solution
11: cycle = cycle + 1
12: until cycle = maximum cycles

E. PSO Based Sensor Deployment

Particle Swarm Optimization (PSO) consists of a swarm of particles moving in a search space of possible solutions for a problem. Every particle has a position vector representing a candidate solution to the problem and a velocity vector. Moreover, each particle contains a small memory that stores its own best position seen so far and a global best position obtained through communication with its neighbor particles.

Algorithm PSO Algorithm
1: Initialize particles
2: repeat
3: for each particle do
4: Calculate the fitness value
5: if fitness value is better than the best fitness value (pbest) in history then
6: Set current value as the new pbest
7: end if
8: end for
9: Choose the particle with the best fitness value of all the particles as the gbest
10: for each particle do
11: Calculate particle velocity according to velocity update
12: Update particle position according to position update
13: end for
14: until maximum iterations or minimum error criteria is attained.

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D. ACO for Sensor Scheduling

As mentioned earlier, another objective of this paper is to schedule the sensor nodes such that the theoretical upper bound of network lifetime can be achieved.

To achieve this, we propose a weight-based method for determining the cover sets. It includes the following main steps:

1: Input M, B
2: Initialize k/Q, max_run, priority calculated using battery power
3: for r = 1 to max_run do
4: for iteration = 1 to mi=1 bi do
5: if cover possibility exists then
6: Determine cover based on priority
7: Optimize cover
8: Activate optimized cover and reduce battery power
9: else
10: break
11: end if
12: end for
13: Calculate network lifetime (nlife)
14: if nlife < U then
15: Consider weight due to covered targets to compute priority to check for better lifetime
16: else
17: break
18: end if
19: end for

IV.CONCLUSION

Wireless sensor networks are expected to be intensively utilized in the future since they can greatly enhance our capability of monitoring and controlling the physical environment. Sensor networks are revolutionizing the traditional methods of data collection, bridging the gap between the physical world and the virtual information world. Due to the inextricable relation with the physical world, the proper deployment of sensors is very important for the successful completion of the sensing tasks issued.

After discovering a coverage hole, the proposed protocols calculate the target positions of the sensors where they should move. They used Voronoi diagrams to discover the coverage holes and design three movement-assisted sensor deployment protocols, VEC (vector-based), VOR (voronoi-based), and Minimal based on the principle of moving sensors from densely deployed areas to sparsely deployed areas. Their results showed that their protocols can provide high coverage within a short deploying time and limited movement.

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