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ENHANCING THE STABILITY OF UNDERWATER WIRELESS SENSOR NETWORKS USING FIREFLY SWARM INTELLIGENCE APPROACH

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Abstract--- The wireless sensor networks have become a vital part of environmental monitoring and prediction. These sensors identify the changes that take place around the area where it is deployed and transmit the sensed data to the base station it is connected. The main drawback of the wireless sensor networks is they are remotely installed and are prone to frequent failures and mass collapse. In this paper we propose a clustering technique based on the Firefly Swarm Intelligence Approach (FSIA) to improve the stability of the Under Water Wireless Sensor Networks (UWSN). The firefly algorithm helps in keeping the sensor nodes intact and produces fewer failures in network connectivity. The simulation results are convincing and the same has been given at the end.

Keywords: clustering, firefly, stability, sensor networks, throughput

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I. Introduction

The sensor networks in general can be divided into two types namely wired and wireless. Wired sensor networks are used in places where the sensor nodes are closely installed to each other. Wireless Sensor Networks (WSN) is used where the distance of each sensor nodes in the network are longer. The wireless sensor networks when deployed under water they behave like mobile adhoc networks. This deployment is called Underwater Wireless Sensor Networks.

The sensor nodes installed under water tend to move dynamically due to wave currents and easily move from the network. The sensor nodes detach themselves from the network due to high currents in the water which results in loss of connectivity between the nodes. In the past many reseaches have been done to improve the throughput and Packet Delivery Ratio (PDR) of Underwater Wireless Sensor Networks (UWSN).

But the less interpreted fact is that the throughput and PDR increases only when the stability of the sensor nodes are high. The high stability helps in improving the connectivity among the nodes which in turn optimises the routing options available within the network.

The sensed data is sent to the base station not directly, but through other intermediate nodes. Apart from stability and connectivity, there are other factors which affect the performance of the

Underwater Wireless Sensor Networks. The factors need to be optimized for a better performance of UWSN is energy, memory, location and topology [7].

Energy required to transmit a data from the sensor nodes to the base station is much high [5]. In general the memory in a sensor node is very limited, so that they transfer the data as soon as possible after it is collected and processed [6]. They cannot run a complex algorithm to process the data [8]. Usually the nodes are employed in a remote area where regular maintenance is impossible. The nodes get physically damaged due to environmental conditions. The topology of the UWSN is highly dynamic in nature such that they are easily prone to wear and tear. When a node moves out of place it takes lot of human effort and money to install a new node in that place.

II. 2. Related Work

Gowrishankar et al (2008) studied and presented their findings about the issues associated with the wireless sensor networks. The findings of the paper suggested various problems to be rectified in alleviating the performance of the sensor networks. The main issues identified were synchronization and power exhaustion. The integrity among the sensor nodes plays a vital role in syncing the network. When sensor nodes stay intact and help the network in routing the data quickly, the throughput and packet delivery ratio of the network increases. The power consumption of the sensor nodes should be reduced. This review paper motivated many to develop cluster based routing protocols for wireless sensor networks.

Jaydip Sen (2009) surveyed on the various security techniques in wireless sensor networks. The focus of the paper was primarily only on the security issues. The paper proposes multiple security flaws and the state of the art of security structure in the sensor networks. Though many have been identified the one that caught our attention was self-organisation. The term self-organisation refers to the sensor nodes and their integrity. This integrity helps not only in multi-hop routing of data but also facilitates in developing a trusted wireless sensor network. The self-organisation is applied in the sensor network as a clustering approach. The clustering technique keeps the sensor nodes linked to one another and reduces the routing overhead and increases the lifetime of the network.

Bilal Abu Bakr & Leszek T. Lilien (2014) extended the life time of the wireless sensor networks by adding some spare nodes to the network. The idea was to provide an enrgy full node as a spare node when any existing primary node in the network goes out of power. The work proposed a modified form of LEACH – Spare Management (LEACH-SM) protocol to manage these spare nodes. The LEACH-SM focus was selection of spare nodes and energy management in those spare nodes. The method brought out the two most drawbacks of the LEACH protocol namely hotspot problem and redundant data transmission. The cluster heads need to look up everything in the cluster which leads to communication and processing overhead in the cluster. The sensor nodes in LEACH tend to overlap other nodes in the area. This intersection of nodes results in redundant transmission of data to the cluster heads. This also leads to extra and unnecessary energy consumption. To overcome all these cons LEACH-SM had three goals, selection of optimal spare nodes, management of spare nodes and estimating the life time of WSN. By this method the lifetime of the WSN increased by 23% when compared to the LEACH.

Debasmita Sengupta & Alak Roy (2014) studied about the various topology control approaches in the wireless sensor networks and issues associated with them. The key points that are raised in maintaining the topology of the sensor networks are power control and power management. If the available power within the wireless sensor networks are utilised properly then the topology of the network could be controlled easily. The paper discussed about various power management schemes, routin approaches, sensor coverage and sensor connectivity topology. The study clearly listed the advantages and drawbacks of the methods and suggested that power management and power control are the key issues in the topolgy control of wireless sensor networks.

Mohsen Taherian et al (2015) proposed an optimal and secured routing protocol for the wireless sensor networks using the Particle Swarm Optimization (PSO) algorithm. The main focus on the work was to find a safe, efficient and secure routing scheme for the wireless sensor networks using the clustering algorithm and PSO. The cluster is formed among the nodes with the selection of cluster head based on the factors residual energy, number of neighboring nodes and quality of communication link. Then an efficient and shortest path for transmission of data is found using the Particle Swarm Optimization approach. The best position for a node is found and the data is routed using the best position of the node. The method had three phases namely clustering phase, data aggregation phase and data transfer phase. The work helped many researchers to take up clustering and optimization algorithms for increasing the performance of the wireless sensor networks.

Mohammed Abo-Zahhad et al (2014) experimented their idea of a Genetic Algorithm based clustering protocol for improving the life time of the sensor networks and the stability among the sensor nodes. The approach proposed is Genetic Algorithm-based Energy-Efficient adaptive clustering hierarchy Protocol (GAEEP). The operation of the GAEEP is executed in phases namely set-up phase, steady-state phase and the data transfer phase. In the set-up phase the optimum number of cluster heads is found and the member nodes are assigned for each cluster head. Then the sensed and collected data by the sensor nodes are sent to the cluster heads and the data is grouped. In the data transfer phase the grouped data is transferred to the base station. The simulation results showed that both in homogeneous and heterogeneous network, the approach performed better in terms of energy consumption and stabiltiy among sensor nodes. The experimental results revealed that first node died after 364 rounds and all nodes died after 739 rounds in LEACH. But in GAEEP, first node died after 1017.7 rounds and all nodes died after 1175 rounds. It was clear that the proposed approach extended the stability period and shrinked the instability period as compared to the LEACH by 653.7 and 217.7 rounds respectively. The work prolonged the network lifetime more than the LEACH protocol by 58.9986 %. Moreover the residual energy of the sensor nodes dissipated comletely after 739 rounds in LEACH, but only 70% energy dissipated after 739 rounds in GAEEP.

The rest of the paper will be organised as follows. In section 3 we describe the clustering approach Firefly Algorithm and in section 4 we present the experiment scenario. In section 5 we present the results and compare it with existing techniques to the proposed method's superiority. In section 6 we conclude with future work.

III. Firefly Algorithm

In this section we present the basic concept of Firefly Swarm Intelligence Algorithm (FSIA) and its principles. This meta heuristics approach was given by Xin-She Yang and it is a mathematical optimization technique. The algorithm was inspired from the lighting behaviour of the fireflies [1].

3.1 Working Principle

Generally the fireflies flash light signals to attract other fireflies. The basic firefly algorithm is based upon the following considerations.

1. Fireflies are unisexual in nature
2. A firefly's flash attarcts all the other neighbourhood fireflies.
3. The brightness of the firefly is directly proportional to the attraction level of the firefly. The less glowing one is attracted towards the high glowing one.
4. In a given neighbourhood area, if no firefly is glowing beyond a threshold all fireflies move randomly.

The algorithm of the firefly based technique is given below

Step 1: Generate an objective function *f(x)* and *I* denoting light intensity linked to *f(x),* where *I* is either directly proportional or equal to *f(x).*
Step 2: Distribute the *n* fireflies in the space
Step 3: Define the absorption coefficient γ for the population
Step 4: Vary the light intensity with respect to the distance
Step 5: depending upon the intensity, the fireflies are attracted to each other
Step 6: The fireflies form clusters among themselves
Step 7: After several iterations the fireflies are clustered and form a strong bond based on the light intensity.

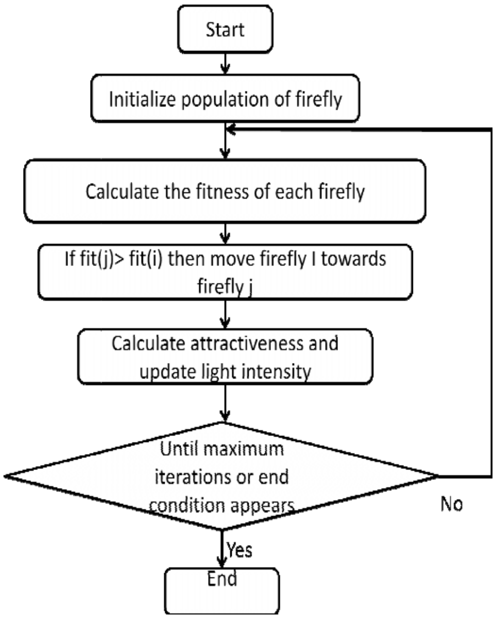

Figure1. Process Flow of Firefly Algorithm

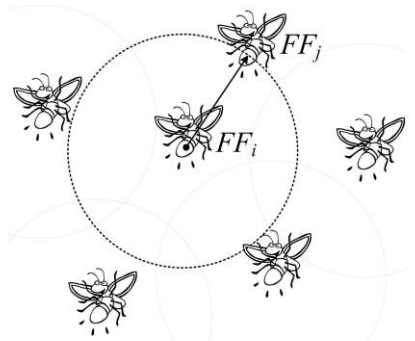

Figure 2. Picture showing the firefly attraction

IV. Firefly Swarm Intelligence Algorithm for UWSNs

The altered FSIA for UWSN is given in this section. The flash in a firefly is calculated based on the following factors like energy level, mobility and distance from the base station. These factors are respectively denoted by *e, m* and *d*.

$$F = \sqrt{\frac{e}{m+d}}$$

Where F is denoted as the flash of the firefly. Here it denotes the power of the sensor nodes. The factors *e* need to be high and *m* and *d* need to be low. The optimum flash value for a sensor node is estimated at close to 2.23.

The figure below shows the deployment of sensor nodes in a two dimensional plane.

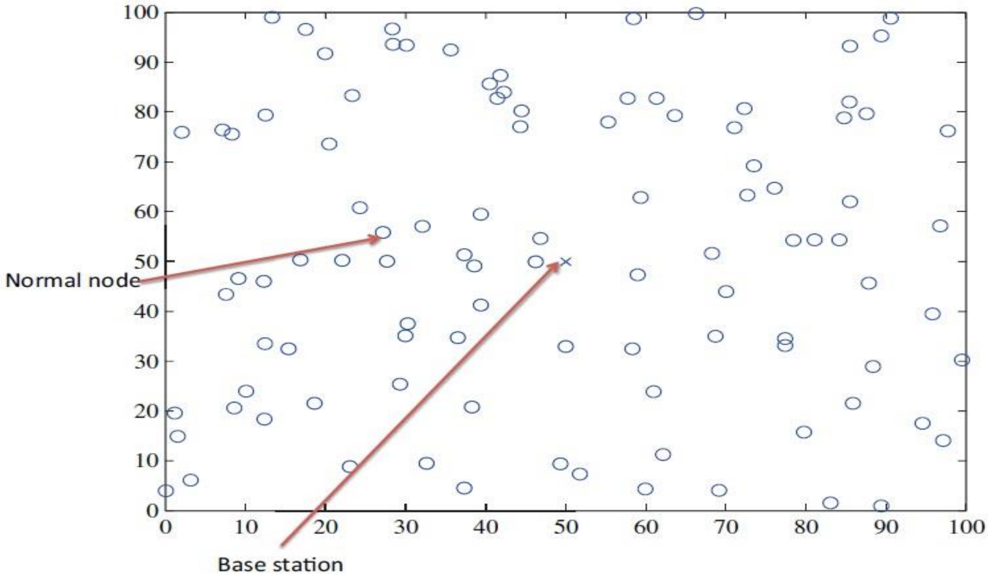

Figure 3. Deployment of Sensor Nodes in a 2-dimensional Plane

The step by step process of forming a cluster in UWSNs using Firefly based swarm intelligence technique is given below.

Step 1: Determine the population space of the sensor nodes

Step 2: Estimate the flash value of the sensor nodes using the factors energy level, mobility and distance from the base station.

Step 3: The flash value is displayed to all the sensor nodes

Step 4: The nodes which have optimum flash value will attract other nodes around and form a cluster.

Step 5: The process is repeated untill all nodes are into a cluster.

Step 6: The moment the cluster formed is found to be stable and close to the base station, the sensed data are sent to the base station.

Step 7: Like wise in future iterations, the data are sent once the cluster formed is stable.

The pseudocode of the algorithm is given below

INITIALIZE all the sensor nodes with equal *e*, *m* and *d*.

INITIALIZE the position of sensor nodes *p*

DRIVE nodes along the waves of the water P_w

FOR all nodes (where F~2.23)

INFORM neighbouring nodes as HEAD

form clusters during upwave as $C_u()$

nodes other than HEAD join one or more clusters form clusters during downwave as $C_d()$ nodes other than HEAD join one or more clusters

REPEAT

Nodes ϵ ((F~2.23) AND ($P_w > P_5$))

REMOVE from respective clusters

UNTILL stable cluster is formed

P denote the initial position of the nodes. (it can keep track of upto 10 positions)
P_w denote the path generated by the waves for the nodes.
$C_u()$ and $C_d()$ denote the clusters formed during the upwave and downwave respectively.

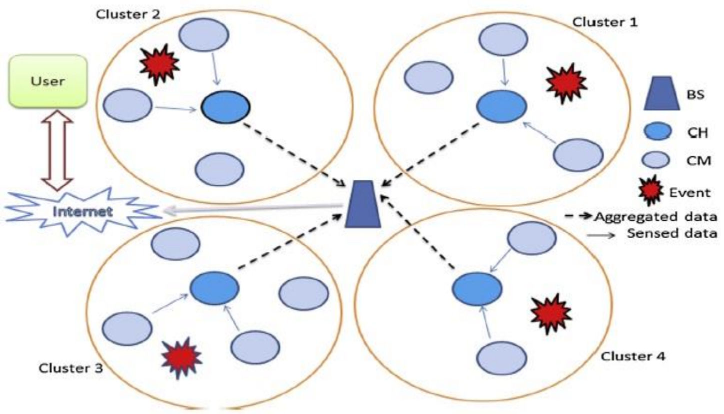

Figure 4. Clusters formed in UWSN using FSIA

V. EXPERIMENTAL SETUP

Parameters	Value
Simulation Area	100*100
Initial energy	0.5J
Base station	50m∗50m and 99m*99m
Transmitter/Receiver	50 nJ /bit
Number of nodes	100 and 300
εfs	10pJ/ bit/m
εmp	0.0013 pJ/bit/m

The algorithm is tested in Matlab simulation tool. The method is tested with different number of nodes in a 100m x 100m field. Each sensor node is assigned an initial energy of 0.5 joules. A node is declared dead if its energy level reaches 0 joules. The
general simulation parameters are

VI. RESULTS AND COMPARATIVE ANALYSIS

This section presents the simulation results of the approach and has been compared with the different existing methods to prove the superiority of our method. The figure 5 below shows the initial deployment of sensor nodes in the water body.

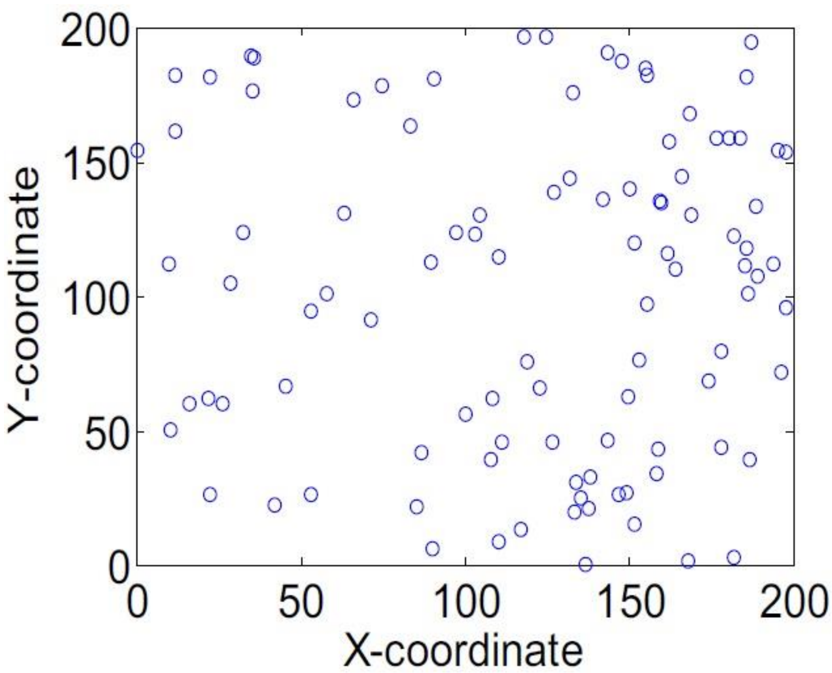

Figure 5. Initial deployment of sensor nodes

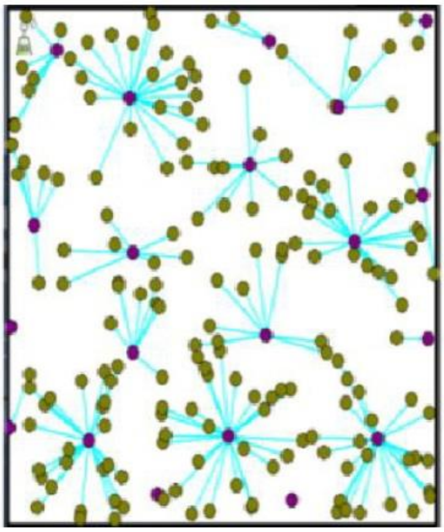

Figure 6. Clustered groups in network

The proposed clustering model was compared with various techniques like Energy Efficient and Safe Weighted Clustering Algorithm (ES-WCA), Energy Balanced Unequal Clustering (EBUC) optimized by Improved Particle Swarm Optimization (IPSO) and Multi-Objective Weighted Clustering Algorithm (IMOWCA).

S.No	Model	Energy Exhaustion rate	Stability
1.	FSIA	0.66	99.31
2.	ES-WCA	1.62	97.21
3.	EBUC-IPSO	1.81	98.56
4.	IMOWCA	2.13	99.09

VII. CONCLUSION

In this paper we have proposed a Firefly Swarm Intelligence based clustering technique for the Underwater Wireless Sensor Networks. The results of the proposed technique was tested and compared with other approaches and the method yielded good results in terms of stability and energy exhaustion rate.

REFERENCES

1. Dahane Amine, Berrached Nassreddine, Kechar Bouabdellah. Energy Efficient and Safe Weighted Clustering Algorithm for Mobile Wireless Sensor Networks, The 9th International Conference on Future Networks and Communications (FNC 2014), Procedia Computer Science 34, 63 – 70.
2. Jaydip Sen. A Survey on Wireless Sensor Network Security, International Journal of Communication Networks and Information Security (IJCNIS), Vol. 1, No. 2, August 2009, pp.55-78.
3. Solmaz Salehian, Shamala K Subraminiam. Unequal Clustering by Improved Particle Swarm Optimization (IPSO) in Wireless Sensor Network, The 2015 International Conference on Soft Computing and Software Engineering (SCSE 2015), Procedia Computer Science 62, 403 – 409

4. Hicham Ouchitachen, Abdellatif Hair, Najlae Idrissi. Improved multi-objective weighted clustering algorithm in Wireless Sensor Network, Egyptian Informatics Journal, http://dx.doi.org/10.1016/j.eij.2016.06.001.

5. J. Hill, R. Szewczyk, A. Woo, S. Hollar, D.E. Culler, and K. Pister, "System architecture directions for networked sensors", In Proceedings of the 9th International Conference on Architectural Support for Programming Languages and Operating Systems, New York, ACM Press, 2000, pp. 93-104. http://www.xbow.com/wireless_home.aspx, 2006.

6. D.W. Carman, P.S. Krus, and B.J. Matt, "Constraints and approaches for distributed sensor network security", Technical Report 00-010, NAI Labs, Network Associates Inc., Glenwood, MD, 2000.

7. A. Perrig, R. Szewczyk, V. Wen, D.E. Culler, and J.D. Tygar, "SPINS: Security protocols for sensor networks", Wireless Networks, Vol.8 , No. 5, pp. 521-534, September 2002.

8. Shilpa Mahajan, Jyoteesh Malhotra, Sandeep Sharma. An energy balanced QoS based cluster head selection strategy for WSN, Egyptian Informatics Journal (2014) 15, 189–199.

9. Dahane Amine, Berrached Nasr-Eddine, Loukil Abdelhamid. A Distributed and Safe Weighted Clustering Algorithm for Mobile Wireless Sensor Networks, Procedia Computer Science 52 (2015) 641-646.

10. Vrinda Gupta, Rajoo Pandey. An improved energy aware distributed unequal clustering protocol for heterogeneous wireless sensor networks, Engineering Science and Technology, an International Journal 19 (2016) 1050–1058.

11. Chirihane Gherbi, Zibouda Aliouat, Mohammed Benmohammed. À Load-Balancing and self-adaptation clustering for lifetime prolonging in large scale wireless sensor networks, Procedia Computer Science 73 (2015) 66 – 75.

12. K.Hari Krishna, Y. Suresh Babu, Tapas Kumar. Wireless sensor network topology control Using clustering, Procedia Computer Science 79 (2016) 893 – 902.

13. Zhiping Fan, Zhengzhe Jin. A Multi-weight Based Clustering Algorithm for Wireless Sensor Networks, PRZEGLĄD ELEKTROTECHNICZNY (Electrical Review), ISSN 0033-2097, R. 88 NR 1b/2012, 19-21.

14. Gowrishankar.S, T.G.Basavaraju, Manjaiah D.H, Subir Kumar Sarkar, Issues in Wireless Sensor Networks, Proceedings of the World Congress on Engineering 2008 Vol I.

15. Jaydip Sen, A Survey on Wireless Sensor Network Security, International Journal of Communication Networks and Information Security (IJCNIS) Vol. 1, No. 2, August 2009, 55-78.

16. Bilal Abu Bakr, Leszek T. Lilien, Extending Lifetime of Wireless Sensor Networks by Management of Spare Nodes, Procedia Computer Science 34 (2014) 493 – 498.

17. Debasmita Sengupta, Alak Roy, A Literature Survey of Topology Control and Its Related Issues in Wireless Sensor Networks, I.J. Information Technology and Computer Science, 2014, 10, 19-27.

18. Mohsen Taherian, Hossein Karimi, Asma Moradi Kashkooli, Azadeh Esfahanimehr, Tahere Jafta, and Mohammad Jafarabad, The design of an optimal and secure routing model in wireless sensor networks by using PSO algorithm, Procedia Computer Science 73 (2015) 468 – 473

19. Mohammed Abo-Zahhad, Sabah M. Ahmed, Nabil Sabor and Shigenobu Sasaki, A New Energy-Efficient Adaptive Clustering Protocol Based on Genetic Algorithm for Improving the Lifetime and the Stable Period of Wireless Sensor Networks, International Journal of Energy, Information and Communications Vol.5, Issue 3 (2014), pp.47-72.