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Enhanced DRFN Failover Scheme Using Artificial Bee Colony Based Optimization in Wireless Sensor Networks

Rajneet Kaur, Shaveta Angurala,
Research Scholar, Asst. Professor, Dept. of computer science, DAVIET, Jalandhar

***Abstract-** The Wireless sensor network consist of sensors nodes that are distributed over large geographic region. Since, sensor nodes are deployed in harsh environment with low power batteries. This can lead to an occurrence of failure due to lack of energy. Number of techniques has been proposed to detect and recover the failed node with limited resources. In this paper we proposed an enhanced DRFN technique by enhancing its failover scheme. The failover scheme will be enhanced using Artificial Bee Colony (ABC) based optimization. It will reduce the overall energy consumption further, and also reduce the number of displacements occur in order to replace the failed node. The proposed technique is designed and implemented in the MATLAB 2013 using data analysis toolbox. Various kinds of experiments will also be done by considering standard performance metrics. The results have clearly shown that the proposed technique outperforms over the available techniques.*

Index Terms: **Artificial Bee Colony algorithm (ABC), Failover mechanisms, Mobile sensor nodes, Wireless sensor network (WSN).**

I. INTRODUCTION

Recent technology development in wireless sensor networks has started to receive considerable research attention [17], [24]. It has been growingly being deployed in many application areas in which reliable communications are important such as health care, environmental and structure monitoring [1], [18], [19]. Wireless sensor networks consist of a large number of tiny, self powered sensor nodes that form sensing and data administration networks that gather information about the surrounding environment [9], [21]. The Purpose of WSNs is to sense the physical phenomena such as temperature, sound level, vibrations with the end goal of sending their processed data to a specific node for analyzing called Base Station (sink) [5], [23], [15].The collected data from nodes are then sent out by the sink to end users [5]. The issues of node failure in wireless sensor networks are very common due to the temperament of the sensor devices and perverted environments in which nodes are placed [6]. Sensor Nodes are in danger to different failures which may harm the normal operations of the network [8]. Sensor node failures are caused by following reasons: deployment in harsh environment such as in volcanic areas or battle fields; powered by batteries having a limited lifetime; being out of the communication range and sensing failure [16], [20], [25]. The failure of node might result in suspension of the collected data to flow to the sink and also scale down network connectivity [16]. Failure of link in WSNs may cause the loss of shortest path between a sender and receiver node thus the data will have to travel through longer route give rise to longer transmission delay and enlarged energy consumption [18]. Diagnoses of failure in wireless sensor network is challenging problem since once it is deployed, its inner conditions are not directly encountered [22]. It motivate us to develop fault tolerant algorithm that detect and replace the failed node as well as find the best path to deliver the data from source to base station. In this paper, we have proposed an improved DRFN technique by improving its failover scheme using Artificial Bee Colony Based Optimization. Artificial Bee Colony technique is applied to find best path between sender & receiver and in case of failure of node within that route DRFN technique is used for detection and replacement of failing node. The remainder of the paper is organized as follows: Section II presents the related work. Section III presents the proposed algorithm and section IV describes the experimental results. Finally, section V concludes the paper.

II. RELATED WORK

Failures in Wireless Sensor Networks are inescapable due to the lack of monitoring, low energy and memory of sensor nodes.. The existence of faults is mostly due the occurrence of faulty sensor nodes. For diagnose and replacement of fault node, many techniques are proposed [26].In [6] different failures and fault tolerant in wireless sensor networks are described. It define probabilistic combinatorial optimization problem in order to effectively management of energy consumption and improve the lifetime of wireless sensor networks. In [2] scheme, it observed that the combination of Periodic route maintenance algorithms and deterministic routing is better than other combination for mixture of failure. Fault Tolerant LEACH for diagnosing nodes failure and then obtaining the adaptive recovery is discussed in [5]. Cluster based failure detection and recovery mechanism for large scale distributed wireless sensor networks is presented in [8]. This grid based clustering method is compared with existing schemes and results shows that this method has low communication cost, better network connectivity and more detection accuracy. [3] Shows usage of mobile sensor nodes to cover regions in which

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static sensor nodes failed. This method for handling faults describes different policies according to which mobile sensor nodes fill the gaps created by failed static sensor nodes. [7] Introduced Node Self Detection by History data and Neighbors (NDHN) algorithm and MDRN for node fault recovery in fault management of WSNs. NDHN method is used to detect the energy of the sensor node and when energy is lower than threshold value, nodes in the system will stop transmitting data and be declared as faulty. MDRN technique is applied to recover the coverage hole. In [1] Coverage conscious connectivity restoration (C3R) method is proposed. In this, each neighbor of failed node temporarily takes its place one at a time and performs function of failing node and then returns to its original location. This scheme is developed to achieve energy- centric recovery (ECR). [9] Proposed a distributed algorithm for detection and replacement of failing node that consumes low energy and improves the percentage reduction in field coverage. This approach has been based on connectivity restoration by carrying out chain replacements. [14] Discussed the general principles of swarm intelligence (artificial bee colony) and of its application to wireless sensor routing. [4] Introduced cluster based Wireless sensor network routings using artificial bee colony algorithm. This approach is based on a centralized control method applied at base station. The performance test and complexity analysis of cluster based Wireless sensor network routings with ABC algorithm has been presented. [10] Presented Binary Artificial Bee Colony algorithm based on the original Artificial Bee Colony technique. This algorithm uses bitwise operation for the motion of the employed and onlooker bees. In this, comparison had been taken between binary artificial bee colony algorithm and three binary ABC variants DisABC, norm ABC and Bin ABC and binary search technique GA. This algorithm proved to be robust, achieved better accuracy and convergence speed as compared to other algorithms. [11] proposed Artificial Bee Colony algorithm on which crossover operator is applied. Artificial bee colony algorithm with crossover operator applied to travelling salesman problem. In this method, Results shows that distance achieved by ABC algorithm is smaller as compared to other algorithms without ABC. Artificial Bee Colony Algorithm is more flexible and used to find the shortest path effectively, compared to other algorithm. [12] Deals with Improved Binary Artificial Bee Colony algorithm (IDisABC).Results of this method is tested on the dynamic clustering issue, in which the clusters number is obtained automatically. This method is compared with binary artificial bee colony algorithm (DisABC), Genetic Algorithm (GA), binary particle swarm optimization (DCPSO) and its output is also compared with K-means and Fuzzy C-means (FCM) algorithms. [13] Proposed a novel binary version of the artificial bee colony algorithm based on genetic operators (GB-ABC) .Main advantage of this algorithm is that it is does not only used for particular binary problems But also for general problems.

III. PROPOSED ALGORITHM

This section presents the various steps of the proposed technique.

A. ***Deployment of sensor nodes:*** Sensor nodes are deployed randomly in a wireless sensor network and these nodes are placed in square area to form WSNs.

B. Apply Artificial Bee Colony for finding path between sender and receiver nodes:

Artificial Bee Colony method has been applied to find the best or shortest path between sender and receiver. It discovers and establishes the best route to send data packets to the base station. In the ABC system, the population consists of three groups of bees: employed bees, onlooker bees and scouts. Each bee in the colony stands for sensor nodes and searches for optimized path.

The main phases of ABC algorithm are as follows:

i. Initialization: All routes are initialized in the range $[l_j, u_j]$ by Eq. (1)

$$x_{ij} = l_j + rand\,(0,1)(u_j - l_j) \qquad (1)$$

Where l_j and u_j is lower and upper bound of route x_{ij} and $rand\,(0,1)$ is a random number between 0 and 1.

ii. Employed bees Phase :Each employed bee is associated with the route and determine new path in its neighborhood by Eq. (2)

$$n_{ij} = x_{ij} + \varphi_{ij}(x_{ij} - x_{kj}) \qquad (2)$$

Where j is a randomly chosen parameter and k is a randomly chosen solution different from i and φ_{ij} is random number within [-1,1].

iii. Onlooker bees phase : onlooker bees are probabilistically moved to the routes based on the following Eq.(3)

$$prob_i = \frac{fit_i}{\sum_{j=1}^{sn} fit_i} \qquad (3)$$

Where $prob_i$ refers to probability of the x_i route to be selected, sn is the number of routes and $fitness_i$ is the fitness value of the route x_i .

Then Greedy selection procedure is applied between the current route x_i and its new neighbor route. If the neighbor route is better than the current route x_i, replace the path with the neighbor.

iv. Scout bee phase: Randomly initialize path by a scout bee using Eq. (1)

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C. *Apply DRFN on node failure:* If any sensor node fails in the route discovered by ABC method to send data packets from sender to receiver then apply detection and replacement of failing node approach.

D. *Rerouting using bee colony:* Once failed node is replaced by its neighbor node by using DRFN technique then Rerouting is applied by using bee colony to find alternative best path.

E. *Evaluate number of displacements:* In this step number of displacements of sensor nodes to replace the failed nodes is evaluated.

F. *Evaluate and Update Energy Consumption:* In this step energy that is consumed to send or receive a data is calculated. Consumption of energy is calculated according to the basic energy formula:

$$E_i = \begin{cases} E_i - (l * E_{TX} + l * d^2), & d < d_0 \\ E_i - (l * E_{TX} + l * d^4), & d \geq d_0 \end{cases} \quad (4)$$

Where $d_0 = \sqrt{\frac{E_{freespace}}{E_{multipath}}}$

Where E_i is current energy of sensor node , l is length of data packet E_{TX} is the energy consumed by the radio electronic circuit, $E_{freespace}$ is the energy consumed by the power amplifier on the free space model, $E_{multipath}$ is the energy consumed by the power amplifier in the multipath model.

IV. EXPERIMENTAL RESULTS

A MATLAB simulation of ABC-DRFN algorithm is done to evaluate the performance. In this section we have evaluated the performance of the proposed ABC-DRFN scheme and compare it with the existing DRFN method on the basis of number of displacements and energy consumption.

A. Displacement number: Table.1 shows the comparison between numbers of displacements occur for DRFN and ABC-DRFN in function of time. Figure.1 shows the comparison graph where x-axis represents time period (rounds) and y-axis represents number of displacements. Red color in the graph represents proposed ABC-DRFN approach and blue color represents existing DRFN approach.

Table.1 Comparision of displacements number in DRFN and ABC-DRFN.

Rounds	DRFN	ABC-DRFN
40	7.1750	5.5000
50	8.8400	6.7600
60	10.5000	8.0000
70	12.1714	9.2571
80	13.8375	10.5000
90	15.5000	11.7556
100	17.1700	13.0000
110	18.8364	14.2545
120	20.5000	15.5000
130	22.1692	16.7338

The graph obtained in Figure.1 shows the importance of our proposed ABC-DRFN approach compared to existing DRFN approach in terms of number of displacements. In our ABC-DRFN approach, there are less number of displacements as compare to existing DRFN approach.

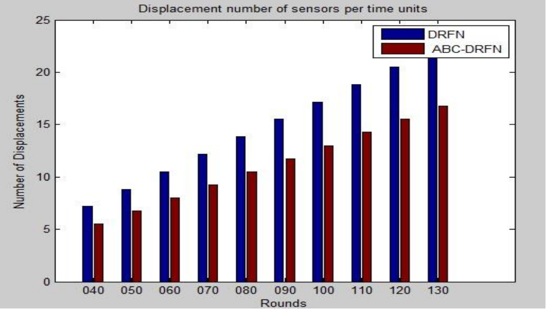

Fig.1 Number of displacements in DRFN and ABC-DRFN.

B. ***Energy Consumption:*** Table.2 shows the diff-erence in the Energy Consumption between DRFN and ABC-DRFN .Our proposed ABC-DRFN scheme consumes less energy as compared to DRFN technique.

Table .2 Comparision of Energy Consumption in DRFN and ABC-DRFN.

Rounds	DRFN	ABC-DRFN
30	05.7244	5.4776
40	06.5727	6.3260
50	07.3049	7.0730
60	07.9312	7.7474
70	15.5069	8.3687
80	09.8659	8.9463
90	14.2591	9.4915
100	26.9191	10.0077

The graph obtained in Figure.2 shows that our ABC-DRFN approach consumes less energy than DRFN approach during the replacement of failed node.

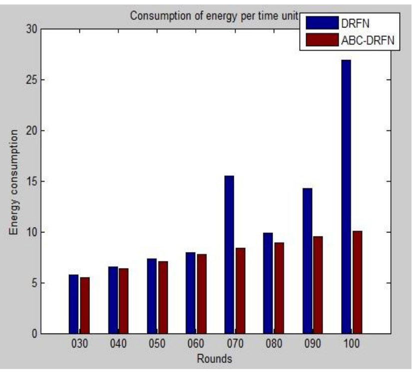

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Fig..2 Energy Consumption in DRFN and ABC-DRFN.

V. CONCLUSION

The failure of sensor node may occur in WSN due to lack of energy, low power batteries or harsh environment in which they are deployed. In this paper we have proposed an enhanced DRFN technique by enhancing its failover scheme. The failover scheme has been enhanced using Artificial Bee Colony (ABC) based optimization. This method has reduced the consumption of energy, and also reduce the number of displacements occur in order to replace the failed node. The Experimental output shows that the proposed technique provides better results as compared to other technique.

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AUTHOR BIOGRAPHY

Rajneet Kaur received the B.Tech degree in Computer Science and Engineering in 2013 from the Punjab Technical University, Jalandhar. She is preceding the M.Tech degree in Department of Computer Science and Engineering at DAV Institute of Engineering & Technology, Jalandhar under Punjab Technical University. Her research interests include Wireless Sensor Networks.

Shaveta Angurala is currently working as Asst. Prof. in Computer Science Department, DAV Institute of Engineering & Technology, Jalandhar. She has done B.Tech, M.Tech and has experience of 9 years in teaching. Her research interest includes Adhoc Networking, Computer Networks and RDBMS. She has published 4 paper in International Journals, 03 in National Conference, 01 in International Conferences .She is life Member of Punjab Academy of Sciences.