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Pollination Inspired Clustering Model for Wireless Sensor Network Optimization

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Abstract

Remote and dangerous fields that are expensive, complex, and unreachable to reach human insights are examined with ease using the Wireless Sensor Network (WSN) applications. Due to the use of non-renewable sources of energy, challenges with respect to the network lifetime, fault tolerance and energy consumption are faced by the self-managed networks. An efficient fault tolerance technique has been provided in this paper as an effective management strategy. Using the network and communication nodes, revitalization and fault recognition techniques are used for handling diverse levels of faults in this framework. At the network nodes, the fault tolerance capability is increased by the proposed protocol model and management strategy. This enhances the corresponding data transmission in the network. When compared to the conventional techniques, the proposed model increases the network lifetime by five times. It is observed from the validation results that, with a 10% increase in the network lifetime, there is a 2% decrease in the fault tolerance proficiency of the network. The network lifetime and data transmission rate are improved while the network energy consumption is reduced significantly. The MATLAB environment is used for simulation purpose. In terms of energy consumption, network lifetime and fault tolerance, the proposed model offers optimal results.

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Keywords: Network lifetime, Fault management, Revitalization, Fault tolerance, Wireless sensor networks

1. Introduction

Several nodes are connected together for observing the environment in wireless sensor networks (WSN) [1]. Various crisis situations are observed when the network nodes are unreachable. In order to achieve the desired network lifetime, it is essential to restrain the energy consumption of the network. Complex network management is essential to ensure optimal network performance. In certain failure conditions, the network must be capable of recalling its functionality when required [2]. The WSN management complexity increases with the inaccessibility of network nodes. Faulty nodes and constant need for preserving their optimal functionality in WSN is associated with the fault tolerance models in WSN [3]. In military based and other sensitive and significant applications, the effectiveness of node routine is highly maintained. This is achieved by enabling the nodes with the competency of transmitting sensed data to appropriate locations [4]. Accuracy of transmitted data must be ensured against damages that may be caused by the erroneous decisions taken when incorrect data is transmitted [5].

In failure prone circumstances, optimal network performance must be offered with efficient execution procedures and management structures at the WSN to enhance the network capacity and acceptability, despite the increase in the utilization of quality component structure [6]. The ability of the network is largely dependent on network lifetime and fault tolerance [7]. The capacity of message transmission and reception is monitored for improving the network fault tolerance in most of the existing systems [8]. The network lifetime may be diminished by these energy-consuming functionalities. In order to eliminate the network energy loss, the sensor nodes are clustered. Here, a cluster is formed by a number of network nodes that are within the radio range [9]. Within this

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radio range, one node acts as a cluster head (CH) and the rest of the nodes are non-cluster head nodes.

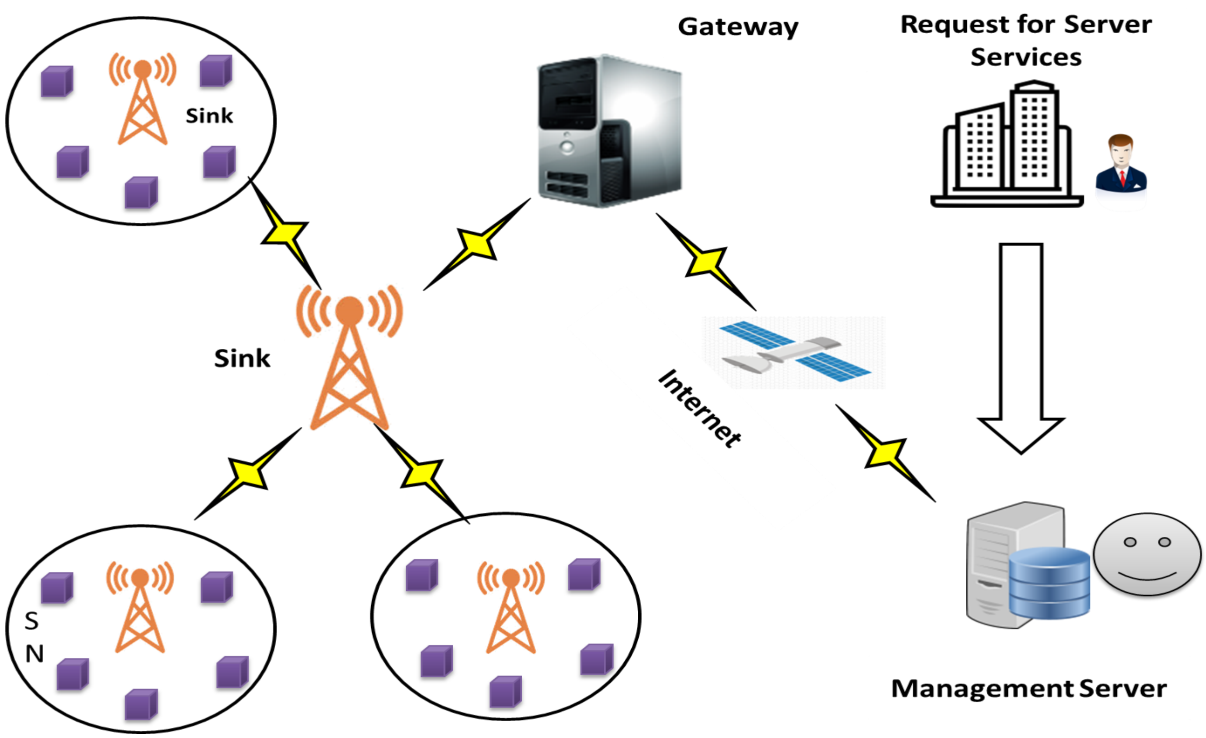

Figure 1. Generic Nodes Clustering

Three levels are used for propagation of the encountered WSN faults. At the network node, fault commencement occurs initially [10]. It is further transmitted towards the network and moves to the sink nodes at the end. Better fault propagation is essential from the primary to secondary level. Early identification and recovery are essential to achieve improved fault propagation. The major contributions of the proposed work include - Simulation of the network modelling in both heterogeneous as well as homogeneous environment for optimal functioning, node clustering for enhancing fault tolerance and reducing energy consumption, effective node transmission by node

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optimization through flower pollination, and inclusion of re-clustering on occurrence of fault during decision making [11]. Data processing is carried out by the backup nodes on identification of fault to improve the fault tolerance. MATLAB environment is used for simulation and validation of the proposed model as well as determining the accuracy, transmission rate, delay, alive nodes and energy consumption.

2. Related Works

An optimal fault tolerance protocol and WSN clustering model is presented by the authors in [12]. The network lifetime of the system is increased largely by this model. Authors in [13] proposed a structural modelling based fault management system to improve the network fault tolerance. Crafting is a structural model-based management used for covering fault tolerance when transmission occurs between the sink nodes and CH. The protocol provided in [14] is similar to the modeling concept provided here. Defending the CH nodes is the major goal of both these approaches. The CH nodes transmit data that is received by the sink. Throughout this transmission, the functions are collectively maintained in a standby mode. Wrong data may be received by the sink when the system encounters an issue [15]. In such cases, a backup version of the data can be used or the operation can be repeated. The network lifetime and fault tolerance outputs are improved while managing the network energy loss and energy consumption with this functionality [16]. Other researchers have worked independently on offering an enhanced management structure or a protocol to improve these parameters in the network. Specific algorithmic techniques are explored in [17] to strengthen the network performance.

Integration of clustering protocols with a structural model for network management is enabled through crafting [18]. Fault tolerance characteristics are considered while the input protocol features as well as the output of the network exhibits similar features on integration of network management structure for fault tolerance along with these protocols [19]. Higher fault

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tolerance can be achieved by improving the level of management, resulting in an improved output protocol with the assistance of the structural models. The data reaches the sink through a stepwise approach according to the model proposed by the authors in [20] where intermediate nodes, maintain the backup data that are aggregated at each level. At certain cluster nodes called the checkpoint node, data are preserved in the structural framework. In certain cases, this node functions as a backup node whereas it acts as a CH in certain scenarios. An alternative node can replace the CH when it cannot function appropriately [21]. Random identification of faults in some nodes is performed with this kind of structural model. Ht, an alternative framework is used in [22-24]. The cause for energy loss is identified in this model as a part of the structural architecture function.

3. Proposed methodology

Wireless Sensor Networks are commonly used as undirected graph G (N,E) such that 'E' denotes bi-directional links and 'N' represents the WSN based sensor nodes set. Moreover N can also be expressed as

$$N= \{1, 2, 3, 4, \ldots, n\}$$

where 'n' is the total sensor nodes connected. The communication range of the WSN is identified with the help of node transmission power [25]. In order to ensure proper communication, the power is modified based on the minimum power. $p_{a,b}$ is the power required for establishing link existences (a, b) such that p:E. → R+ wherein 'E' represents the directional network set. The power factor is represented as:

$$p = (p_1, p_2, \ldots, p_n) : p_a = [0, p_i^{max}]$$

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Here, the maximal transmit power is denoted by p_i^{max}; and p_a represents the transmitting power of the nodes. The maximal power is established by each node as represented by:

$$E_{max} = \{(i,j) | p_i^{max} \geq p_{i,j}, p_j^{max} \geq p_{j,i}$$

where E_{max} denotes the bi-directional network links. However, there are some constraints that need to be satisfied such as:

The graph is bi-connected such that an undirected graph is delivered without cut-points.

One connected graph element is divided into multiple components on deleting the nodes along with cut-points and edges.

If only one path exists between the nodes, it is possible to connect in an undirected graph.

3.1 Topological Control

In this topic, a connectivity model is established as a topology, T <X, Y, {z}} where z is the optimal power set [26]. The most important aspects while establishing topological control is the utility function along with factors such as fault tolerance, residual energy, network connectivity and Transmission power.

3.2 Clustering Nodes with Pollination

A population-based pollination algorithm is used based on the pollination of flowering plants which includes self-pollination and cross-pollination. This process is performed independently and follows Levy fight rules. Cross-pollination is used in a global manner while self-pollination is primarily local pollination based on the field in which it takes place. The goal of pollination algorithm is to encourage parallel processing of data at the time of computation and

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transmission. Higher accuracy and quicker convergence is possible with the help of parallel communication, like replacing, moving and copying information.

4. Results and Discussion

In this section, the outcome of the proposed work is discussed and deliberated. The simulation environment used is MATLAB 2018a which provides the essential machine learning tool box. Non-linear as well as non-linear systems can be designed and analyzed with the help of MATLAB software. A WSN environment is created as well as nodes, along with the establishment of network communication with the help of toolbox. Fig. 2 and Fig.3 indicates the level of accuracy of the proposed work with respect to the varying nodes count. Here fault detection is very high due to major voting methods. Based on the simulated output, it is identified that the fault detection probability decreases as the number of nodes increases. Similarly, Fig. 4 shows the False Alarm Ratio (FAR) for the proposed work under diverse cluster nodes.

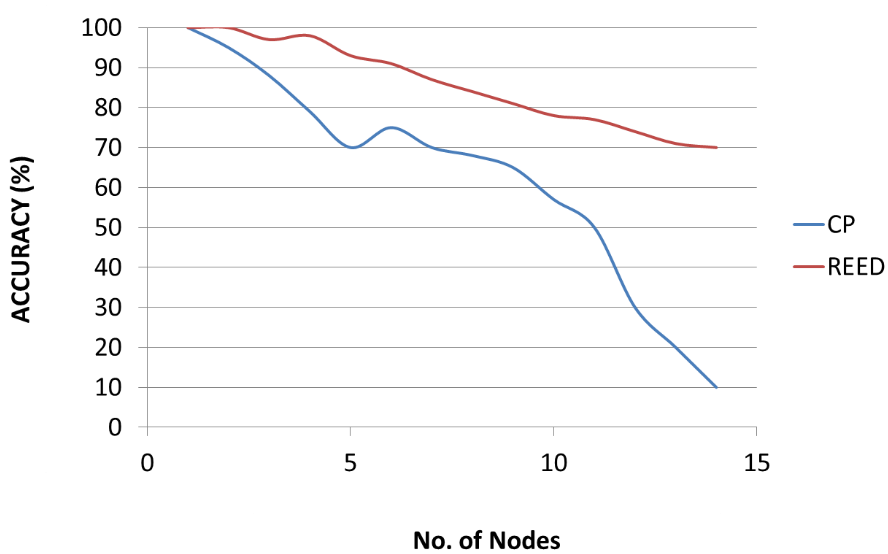

Figure 2. Detection of Accuracy at first round with diverse nodes

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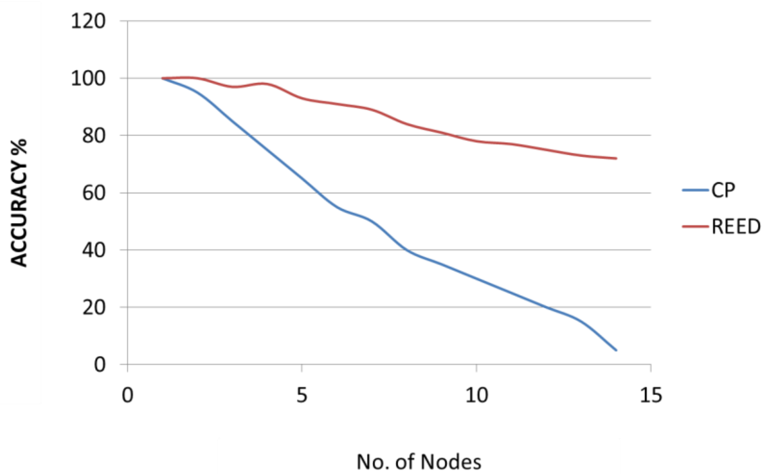

Figure 3. Detection of Accuracy at first round with less nodes

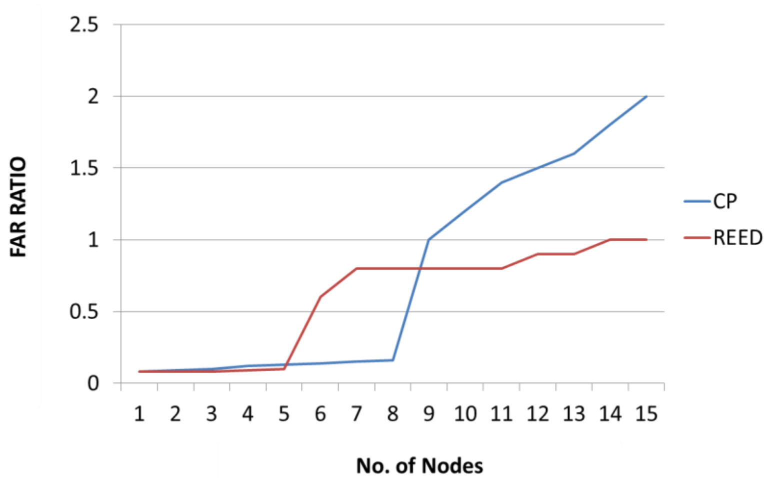

Figure 4. FAR Computation

5. Conclusion

By introducing fault tolerance ability, a WSN structural model is developed in this proposed work. Two diverse fault tolerances are used in this work. A node with cluster head and non-cluster head for effectual communication is included in this node, at network level along with

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sinks and CH network nodes. The model anticipated is enhanced by decreasing energy consumption between the nodes and enhancing the lifetime of the network with the help of a pollination algorithm. This algorithm improves fault tolerance ability and further increases the lifetime by 2-5 times compared to other previously existing algorithms. At nodal level, recovery methods and fault detection are used and at the communication level, communication between CH and N-CH takes place by means of cluster-based pollination algorithm. Future work can be performed by improving and enhancing the structural model by tackling the fault tolerance scale. Some of the applications of the proposed work are wearable communication devices and healthcare monitoring systems.

References

[1] Mittal, N., Singh, U., Salgotra, R., & Bansal, M. (2020). An energy-efficient stable clustering approach using fuzzy-enhanced flower pollination algorithm for WSNs. Neural Computing and Applications, 32(11), 7399-7419.

[2] Jacob, I. Jeena, and P. Ebby Darney. "Artificial Bee Colony Optimization Algorithm for Enhancing Routing in Wireless Networks." Journal of Artificial Intelligence 3, no. 01 (2021): 62-71.

[3] Kumar, B. S., & Rao, P. T. (2021). An Optimal Emperor Penguin Optimization Based Enhanced Flower Pollination Algorithm in WSN for Fault Diagnosis and Prolong Network Lifespan. Wireless Personal Communications, 1-18.

[4] Rai, Ashok Kumar, and A. K. Daniel. "An Energy-Efficient Routing Protocol Using Threshold Hierarchy for Heterogeneous Wireless Sensor Network." In Intelligent Data Communication Technologies and Internet of Things: Proceedings of ICICI 2020, pp. 553-570. Springer Singapore, 2021.

ISSN: 2582-3167
Submitted: 02.10.2021
Revised: 01.11.2021
Accepted: 18.11.2021
Published: 29.11.2021

[5] Shakya, Subarna, and Lalitpur Nepal Pulchowk. "Intelligent and adaptive multi-objective optimization in WANET using bio inspired algorithms." J Soft Comput Paradigm (JSCP) 2, no. 01 (2020): 13-23

[6] Mittal, N. (2020). An energy efficient stable clustering approach using fuzzy type-2 bat flower pollinator for wireless sensor networks. Wireless Personal Communications, 1-27.

[7] Senthilkumar, M., Kavitha, V. R., Kumar, M. S., Raj, P. A. C., & Shirley, D. R. A. (2021, March). Routing in a Wireless Sensor Network using a Hybrid Algorithm to Improve the Lifetime of the Nodes. In IOP Conference Series: Materials Science and Engineering (Vol. 1084, No. 1, p. 012051). IOP Publishing.

[8] Smys, S., Haoxiang Wang, and Abul Basar. "5G Network Simulation in Smart Cities using Neural Network Algorithm." Journal of Artificial Intelligence 3, no. 01 (2021): 43-52.

[9] Dao, T. K., Nguyen, T. T., Pan, J. S., Qiao, Y., & Lai, Q. A. (2020). Identification failure data for cluster heads aggregation in WSN based on improving classification of SVM. IEEE Access, 8, 61070-61084.

[10] Sharma, Rajesh, and Akey Sungheetha. "An Efficient Dimension Reduction based Fusion of CNN and SVM Model for Detection of Abnormal Incident in Video Surveillance." Journal of Soft Computing Paradigm (JSCP) 3, no. 02 (2021): 55-69.

[11] Loganathan, S., & Arumugam, J. (2021). Energy efficient clustering algorithm based on particle swarm optimization technique for wireless sensor networks. Wireless Personal Communications, 1-29.

[12] Bendigeri, Kirankumar Y., Jayashree D. Mallapur, and Santosh B. Kumbalavati. "Wireless Sensor Networks and Its Application for Agriculture." In Intelligent Data Communication Technologies and Internet of Things: Proceedings of ICICI 2020, pp. 673-687. Springer Singapore, 2021.

[13] Haoxiang, W., & Smys, S. (2020). Soft computing strategies for optimized route selection in wireless sensor network. Journal of Soft Computing Paradigm (JSCP), 2(01), 1-12.

ISSN: 2582-3167
Submitted: 02.10.2021
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Vol.03/ No. 03
Pages: 196-207
https://www.irojournals.com/irosws/
DOI: https://doi.org/10.36548/jsws.2021.3.006

[14] Nagarajan, L., & Thangavelu, S. (2021). Hybrid grey wolf sunflower optimisation algorithm for energy-efficient cluster head selection in wireless sensor networks for lifetime enhancement. IET Communications.

[15] Jain, Nitin Kumar, and Ajay Verma. "Performance Analysis of Fuzzy-Based Relay Selection for Cooperative Wireless Sensor Network." In Intelligent Data Communication Technologies and Internet of Things: Proceedings of ICICI 2020, pp. 571-582. Springer Singapore, 2021.

[16] Suma, V. "Community Based Network Reconstruction for an Evolutionary Algorithm Framework." Journal of Artificial Intelligence 3, no. 01 (2021): 53-61.

[17] Alekya Rani, Y., & Sreenivasa Reddy, E. (2021). Stability-aware Energy Efficient Clustering Protocol in WSN using Opposition-based Elephant Herding Optimisation. Journal of Control and Decision, 1-16.

[18] Bhalaji, N. (2020). A novel hybrid routing algorithm with two fish approach in wireless sensor networks. Journal of trends in Computer Science and Smart technology (TCSST), 2(03), 134-140.

[19] Amutha, J., Sharma, S., & Sharma, S. K. (2021). Strategies based on various aspects of clustering in wireless sensor networks using classical, optimization and machine learning techniques: Review, taxonomy, research findings, challenges and future directions. Computer Science Review, 40, 100376.

[20] Mugunthan, S. R. (2021). Wireless rechargeable sensor network fault modeling and stability analysis. Journal of Soft Computing Paradigm (JSCP), 3(01), 47-54.

[21] D. R. Anita Shirley, "Systematic diagnosis of power switches," 2014 International Conference on Embedded Systems (ICES), 2014, pp. 32-34, doi: 10.1109/EmbeddedSys.2014.6953045

ISSN: 2582-3167
Submitted: 02.10.2021
Revised: 01.11.2021
Accepted: 18.11.2021
Published: 29.11.2021

[22] Amory, Zahraa Sabeeh, and Haider Kadam Hoomod. "Intelligent Web of Things Based on Fuzzy Neural Networks." In Intelligent Data Communication Technologies and Internet of Things: Proceedings of ICICI 2020, pp. 871-888. Springer Singapore, 2021.

[23] Moridi, E., Haghparast, M., Hosseinzadeh, M., & Jafarali Jassbi, S. (2021). A novel hierarchical fault management framework for wireless sensor networks: HFMF. Peer-to-Peer Networking and Applications, 1-11.

[24] Bashar, Abul. "Artificial Intelligence Based LTE MIMO Antenna for 5th Generation Mobile Networks." Journal of Artificial Intelligence 2, no. 03 (2020): 155-162.

[25] Shankar, A., Sivakumar, N. R., & Sivaram, M. Increasing fault tolerance ability and network lifetime with clustered pollination in wireless sensor networks. J Ambient Intell Human Comput (2020).

[26] Smys, S. (2019). Energy-aware security routing protocol for WSN in big-data applications. Journal of ISMAC, 1(01), 38-55.

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