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Standardization Of Security In Geographic Routing Protocol Using Blockchain And Optimization Based Clustering Technique

M. Sridhar* , P. B. Pankajavalli*

Ph.D. Research Scholar, Department of Computer Science, Bharathiar University, Coimbatore

Assistant Professor, Department of Computer Science, Bharathiar University, Coimbatore

Abstract: A wireless sensor network (WSN) is a collection of nodes linked via wireless link. Environmental variables, adversary assaults, battery power loss, and other reasons can contribute to node failure. Recovery after a node failure is difficult and it necessitates a robust node recovery scheme. In this research, a Blockchain-based node recovery strategy and an optimum cluster head (CH) selection with the assistance of Bacterial Foraging Algorithm (BFA) for WSNs is suggested. It's a reliable and quick algorithm for solving discrete optimisation issues. The recovery of failed node is initiated based on node's degree. The main function of proposed scheme is to discover the failed node that is initiated by the node state (active or inactive) of Cluster Heads (CHs). The recovery procedure for inactive nodes begins in the second phase. The major goal of this phase is to recover the failing CH, which will then result in the active statuses of its member nodes that are restored. Furthermore, a security analysis is carried out to guarantee that the suggested system is secure. The simulation results demonstrate the effectiveness of the suggested model.

Keywords: CH selection, cluster, optimization, energy consumption, BFA and node recovery.

1. Introduction

Wireless Sensor Networks (WSN) are vastly dispersed systems with small, light-weight wireless sensor nodes that is deployed in large number to maintain the environment. WSN is one of the well-explored research areas, which is highly suitable for numerous real-time applications [1, 2]. Today's technological advancement necessitated instantaneous communication and it is possible with the help of WSN. The sensor nodes are used to sense the atmosphere and shares the accumulated data with the base Station (BS) or the sink node [3]. The sink node is also called as destination node. The sensor node can be either source node or intermediate node or cluster node or sink node or destination node [4].

The WSN is based on the sensor nodes that is equipped with sensing capability, memory, limited energy and processing ability [5]. In WSN, sensor nodes can be deployed anywhere, without any location restrictions, as there are no wired connection. Wireless sensors can be deployed even in hostile environments, which is not possible in the case of wired networks. With the advent of WSNs, the issues of cabling and addition of sensors got resolved and, thus, there has been a paradigm shift from a single point sensing to multipoint as well as flexible multivariable sensing in various applications namely environmental monitoring, habitat monitoring, home and building automation, health care services, defence and security, forest fire detection and structural health monitoring [6].

Communication is the most significant activity of sensor nodes (SNs) and the main objective of the network is to share the collected information with the powerful node. However, the process of communication is not possible in a direct mode always [7]. This makes sense that the source cannot reach the destination directly, but it is made possible by means of intermediate nodes. The role of intermediate nodes is to forward the message to the destination quickly and without any alteration. The entire process of propagating a message from source to destination is called as routing [8].

The number of sensor nodes will form a network and perform the operation inside the network. The sink node is connected to the base station and it will provide the service to the users. The routing processes in WSN is divided into many categories such as flat-based routing, hierarchical-based routing and location-based routing [9]. In flat-base routing, all the nodes are assigned with same functions. Here, Sensor Protocol for Information Negotiation (SPIN) takes place. It will send large collections of data to the neighbour nodes. It avoids redundant data transmission. By saving the node energy, it will increase the network lifetime. By diffusion, the base station sends the query to the remaining nodes [10, 11].

In WSN, the process of data transmission is influenced by the node failure and it result in time and energy consumption. To overcome this issue, mechanism of Blockchain is used for node recovery. In this research work, nodes are clustered and the CH selection process is initialised with the bio inspired Bacterial Foraging Algorithm (BFA) and the CH failure is recovered with the assistance of Blockchain based peer-to-peer approach.

This research article is highlighted as follows: The clustering and optimization geographic routingprotocols are given in the related work section, the framework of cluster-based and Blockchain based node recovery scheme in geographic routing protocol is given in section 3, the diagrammatical depiction of existing and proposed scheme is demonstrated in section 4 and the conclusions, as well as the future suggestions, are given in section 5.

2. Related Works

WSN faces numerous issues during data transmission and routing. Due to advancement of technology, WSN has grabbed wide attention and researcher also focuses on WSN protocols. Table 1. Describes a comparative analysis of numerous bio-inspired WSN protocols.

Table 1. Comparison of WSN Protocols

Routing Protocol	Classification	Energy Efficiency	Location Awareness	Data Aggregation	Scalability	QoS	Fault Tolerance
RRS [12]	Classical	Moderate	Yes	No	Yes	Yes	No
ANS [12]	Classical	Moderate	Yes	No	Yes	Yes	No
DWGRP [13]	Classical	Moderate	Yes	No	Yes	Yes	No
ALR-EDGR[14]	Classical	Moderate	Yes	No	Yes	Yes	Yes
QoS-PSO [16]	Swarm Intelligence	Good	No	No	Very Good	Yes	Yes
PSO [17]	Swarm Intelligence	Good	No	Yes	Good	No	No
PSO-ECHS [18]	Swarm Intelligence	Very Good	No	Yes	Good	No	No
HSA-PSO [19]	Swarm Intelligence	Very Good	No	Yes	Moderate	No	No
SIF [20]	Swarm Intelligence	Good	Yes	Yes	Limited	No	No
PECE [21]	Swarm Intelligence	Very Good	No	No	Limited	No	Yes

IHSBEER [22]	Swarm Intelligence	Very Good	No	No	Moderate	No	No
PDORP [23]	Swarm Intelligence	Good	No	Yes	Very Good	Yes	No
LWTC-BMA [24]	Swarm Intelligence	Good	No	Yes	Good	No	No
ABC-SD [25]	Swarm Intelligence	Very Good	No	Yes	Good	Yes	No
FAMACROW [26]	Swarm Intelligence	Very Good	No	Yes	Very Good	No	No
BeeSwarm [27]	Swarm Intelligence	Very Good	No	Yes	Limited	No	No
BeeSensor [28]	Swarm Intelligence	Good	No	Yes	Moderate	No	Yes

3. Proposed Methodology- Blockchain based Geographic Routing Protocol

In WSN-GRP, consortium of Blockchain based framework is proposed for node recovery scheme. The proposed system model is graphically illustrated in Figure 1. In this research, initially senor nodes (SN) are clustered and the selection process of cluster head (CH) is accomplished by Bacterial Foraging Algorithm (BFA). The WSN framework is segregated as CHs, Blockchain technology, sensor nodes and sink node. The information from the environment is gathered using sensor nodes. Gathered information's are transmitted to the CH and other than CH can communicate with sink node through CH.

This section depicts the BFA for the selection of CH and the objective function for the process of clustering and the election of CH is discussed initially. The optimized and best solution is acquired with the assistance of BFA. The network lifetime maximization and energy utilization minimization is attained by the selection of optimal CH. The fitness function for CH selection is formulated with certain parameters namely intra-cluster distance's coverage area, node degree, and remaining energy in node. The derivation of these objective functions are given below,

The un-clustered SN's are eliminated with the parameter $CH_{(cov\_area)}$ and the count of the remaining nodes are minimized by these parameters. The coverage of CHs selection process is enriched and investigated as

$$\mathrm{CH}_{(\mathrm{cov\_area})^{(\mathrm{minimize})}} = \frac{(\mathrm{N}_{\mathrm{SN}} - \mathrm{L}) \sum_{\mathrm{cm}=1}^{\mathrm{L}} |\mathrm{CL}_{\mathrm{cm}}|}{\sum_{\mathrm{cm}=1}^{\mathrm{L}} |\mathrm{CL}_{\mathrm{cm}}|} ------(1)$$

where the whole count of SN is indicated as $N_{(SN)}$ and the count of the member in a cluster is indicated as cm that reside in the cluster $|\mathrm{CL}_{\mathrm{cm}}|$.

The node degree $N_{(SN(dg))}$ is determined as the count of SN that is reachable from CH and it is utilized in balancing the load. The estimation is given as follows,

$$\mathrm{N}_{\mathrm{SN(dg)}^{(\mathrm{minimize})}} = \sum_{\mathrm{k}=1}^{\mathrm{L}} |\mathrm{C}_{\mathrm{ct}_{\mathrm{k}}}|$$

where the count of cluster member of k^{th} CH is $|\mathrm{C}_{\mathrm{ct}_{\mathrm{k}}}|$ and the count of CH is indicated as L.

The proposed scheme uses the node with maximum energy for effective candidate and the CH is selected based on the energy. To facilitate the energy utilization across the balanced network. The remaining energy across SN is determined as follows,

$$\mathrm{N}_{\mathrm{SN(re\_eg)}^{(\mathrm{minimize})}} = \sum_{\mathrm{k}=1}^{\mathrm{L}} \frac{1}{\mathrm{RE\_EG}_{\mathrm{C}_{\mathrm{H}_{\mathrm{k}}}}}$$

where the remaining energy of a node at k^{th}CH is indicated as $\mathrm{RE\_EG}_{\mathrm{C}_{\mathrm{H}_{\mathrm{k}}}}$.

BFA is inspired from the nature of E.Coli bacteria movements namely swimming and tumbling whereas it moves in a straight line in the assigned direction of swimming movement but in the tumbling movement, the directions are altered randomly.The count of SN's are initialized randomly and it act as a input for the BFA. The random generation of input information's are given as,

$$In\_p_{rang_{(N_{SN})}} = \begin{bmatrix} In\_p_{11(N_{SN})} & In\_p_{12(N_{SN})} & \cdots & In\_p_{1n(N_{SN})} \\ In\_p_{21(N_{SN})} & In\_p_{22(N_{SN})} & \cdots & In\_p_{2n(N_{SN})} \\ \vdots & \vdots & \ddots & \vdots \\ In\_p_{m1(N_{SN})} & In\_p_{m2(N_{SN})} & \cdots & In\_p_{mn(N_{SN})} \end{bmatrix}$$

where the generation of random input parameter at the time of incidence of error is indicated as $In\_p_{rang_{(N_{SN})}}$.

The position of bacteria is evaluated based on the fitness of the generated population and the objective function is estimated as follows,

$$\text{fitness of BFA(f)} = \min\{CH_{(cov_{area})}, N_{SN(dg)}, N_{SN(re\_eg)}, PDR\}$$

where the packet delivery ratio is indicated as PDR.

The process of enrichment of swimming (energy level) and movement of tumbling of bacterium lifetime is accomplished by the search of nutrient whereby the process is denoted by

$$\emptyset^{p}_{(q+1,r,l)} = \emptyset^{p}_{(q,r,l)} + c_1(p).\left(\delta(p) \Big/ \sqrt{\delta^t(p)\delta(p)}\right)$$

where the bacteria movement of chemotactic is indicated as $\emptyset^{p}_{(q+1,r,l)}$, p[th] bacterium at q[th] chemotactic in the r[th] reproduction and dispersal of elimination l[th] is indicated as $\emptyset^{p}_{(q,r,l)}$, the size of the steps assigned at random position is indicated as $c_1(p)$ and arbitrary directional vector is indicated as $\left(\delta(p) \Big/ \sqrt{\delta^t(p)\delta(p)}\right)$. The vector element lies in the range of [-1, 1].

The half portion of the bacteria is utilized to endure where the remaining bacteria is divided into two similar position that is placed as their parent. At their lifetime after evaluation of fitness $N_{SN(C)}$ for the p[th] bacterium is determined as

$$R_{q^{p}_{health}} = \sum_{q=1}^{(N_{SN}(c)+1)} R_q(q, r, l)$$

where the health of the bacteria is indicated as $R_{q^{p}_{health}}$ and bacteria are sorted in ascending order. The bacteria with best range is divided into two and highest value will die whereby the ratio remains constant during the reproduction process.

The possibility of BFA accomplishes bacteria to remove and disperse the count of the reproductive actions. The capability of bacteria increases the global search and preserve the local optimum solutions. The positions are updated and the CH is elected based on the optimized parameters. The algorithm for the CH selection using BFA is given in Algorithm 1.

Algorithm 1: BFA based Cluster Head Selection

Input: Set of sensor nodes SN={sn_1,sn_2,……,SN_n} and the total count of the sensor node is indicated as T_{SN}

Output: Optimal position of CH

Initialize the count of sensor nodes SN={sn_1,sn_2,……,SN_n}

Initialized parameters are generated randomly

Fitness function evaluation $\mathrm{fitness}(f_{fn}) = \min\{T_{SN}(deg), T_{SN}(REn), CH_{SN}(cov), Pkt_{dr}\}$

Initialize the chemotaxis, reproduction, elimination and dispersal loops

While termination condition is not met do

For every node update the position and fitness function

Repeat the process for entire node

Optimal CH is selected based on energy and network lifetime

End while

The data from various CHs is received by the sink node, which executes the appropriate processes. The sink is also in charge of starting the execution process of data transmission. Because sensor nodes are coupled to sinks via CHs, failure of CHs can result in sensor node failure. When a CH fails, the sensor nodes associated to it are unable to interact with the sink node. Blockchain is a peer-to-peer distributed technology.Blockchain is primarily used at CHs, and each CH is interconnected to every other CH and to the sink node through a peer-to-peer network. Each CH has a neighbour list that includes the ID, node degree, condition, and opinion of each node. Because the network is spread, all of the CHs will have access to each other's information. When the status of a CH changes from functioning to non-functional, i.e., state=0, other nodes will be notified. The recovery process begins if CH failure is discovered. The node degree and repute of CHs are used to determine recovery. The individual with the least degree and the best reputation gets chosen. The best CH replaces the failed CH.

Sensor nodes collect data in the field where they are placed. The data is collected and then transferred from the source to the CHs. The suggested system verifies the condition of CH at this point. There are two choices: CH is either in the operating state (state=1) or the non-working state (state=0). The decision to alter the state will be made once the CHs reach an agreement. There is a communication gap among sensor nodes and the sink node while a CH is in state=0.

In the case of a functional CH, the CHs will reach an agreement to ensure that state=1. When CH reaches 51 percent consensus, it gets data from sensor nodes and sends it to the sink. Sink node is responsible for doing the required activities. If a failed CH is found, meanwhile, working CHs will come to an agreement about the failed CH. The recuperation process then begins. The first step is to choose the best substitute candidate. The node degree is used to make this decision.

The amount of edges or connections between nodes is referred to as node degree. The CH with the smallest number of nodes is chosen as the best candidate. Because CHs are connected in a peer-to-peer network, the distance between each CH and the failing CH is the same. As a result, we ignored the distance and focused solely on the node degree. The top applicant will now take the position of the failed CH. Once CH has been recovered, its neighbouring sensor nodes are able to connect with the sink node normally.

4. Result and Discussion

In this section, the simulation result of the proposed protocol BBFA is discussed and the results are compared with the approaches namely RRS, ANS, DWGRP and ALR-EDGR. The experiment is executed using Matlab. The simulation parameters applied in the experiment are given in Table 2.

Table.2 Simulation Parameters

Parameters	**Values**
No. of sensor nodes	500
Simulation time	65ms
Simulation area	$1000 \times 1000 m^2$
MAC type	MAC/802.11
Routing protocol	Dynamic Source Routing (DSR)
Initial node energy	70J
Queue type	CMUPriQueue
Initial energy	100Joule
Packet size	300bits
MAC header	34 bytes
ACK length	14 bytes
RTS length	20 bytes
PHY header	16 bytes
CTS length	14 bytes

Delivery Delay

The delivery delay is the time it takes to send data from the source to the destination node. A protocol that has the shortest transmission latency is deemed to be reliable. The cluster-based scheduling technique achieves effective data transmission with minimal latency in the BBFA protocol. The resultant values of delivery delay of the BBFA, RRS, ANS, DWGRP and ALR-EDGR algorithm is given in Table 3 and Figure 1. The delivery delay time of the proposed protocol BBFA is effectively minimized with the clustering based scheduling approach.

Table 3. Comparison of Delivery Delay

No of Nodes	Delivery Delay (Delay/s)				
	RRS	ANS	DWGRP	ALR-EDGR	BBFA
50	165	158	143	111	109
100	187	187	154	116	110
150	191	192	161	121	114
200	198	199	162	126	118

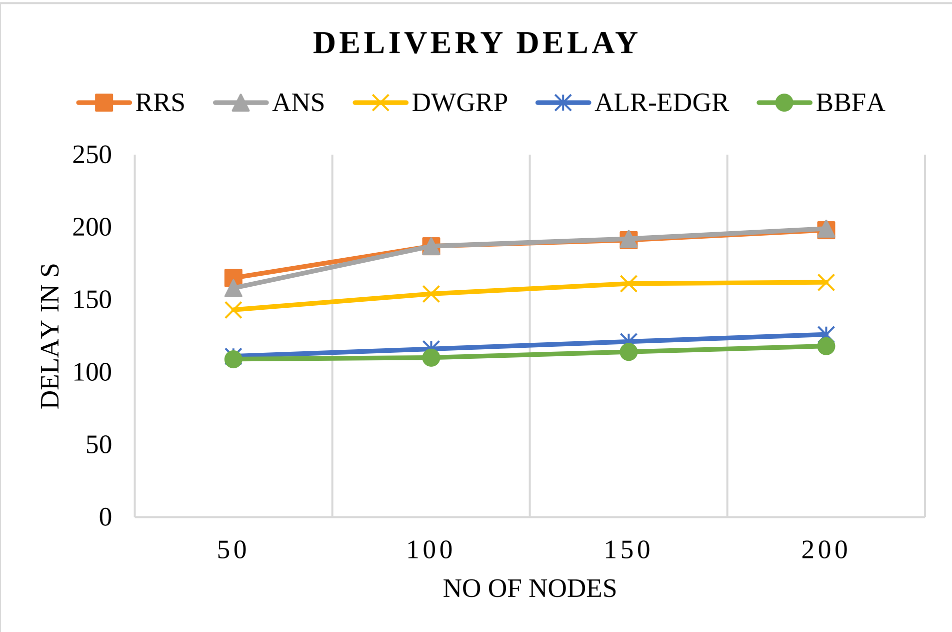

Figure 1. Comparison of Delivery Delay

Packet Drop Ratio

The packet drop ratio denotes the failure of data transmission across the data transmission channel. The proposed scheme has minimized the level of packet drop.The resultant values of packet drop ratio of the BBFA, RRS, ANS, DWGRP and ALR-EDGR algorithm is given in Table 4 and Figure 2. The delivery delay time of the proposed protocol BBFA is effectively minimized with the clustering based scheduling approach.

Table 4. Comparison of Packet Drop Ratio

No of Nodes	Packet Drop Ratio (%)				
	RRS	ANS	DWGRP	ALR-EDGR	BBFA
50	91.5	90	86	80	72
100	92	91.5	89.5	82	73
150	92.5	94	90	83	75
200	94	94.5	93.5	84.5	78

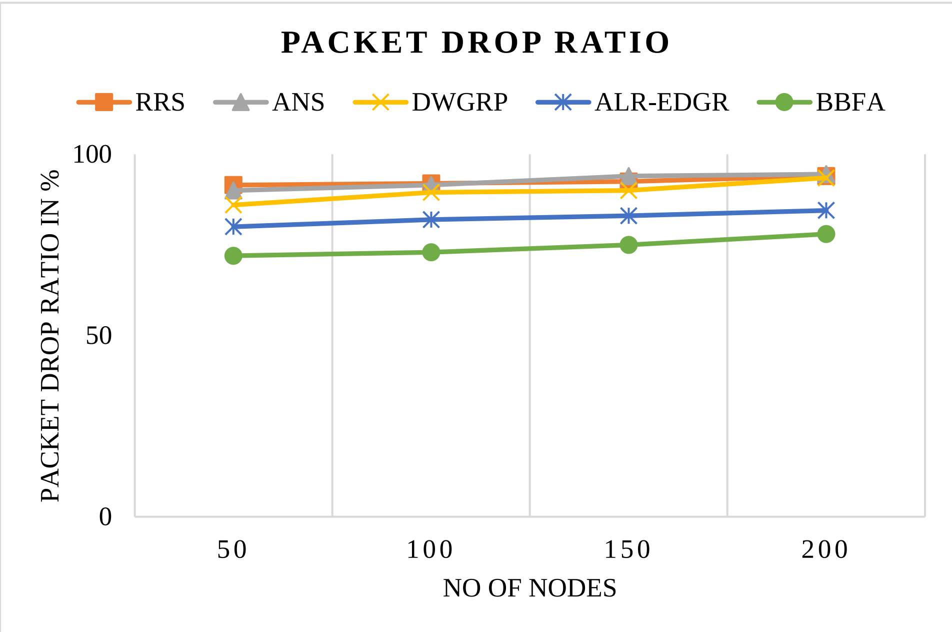

Figure 2. Comparison of Packet Drop Ratio

Packet Delivery Ratio

The Packet Delivery Ratio (PDR) is derived by subtracting the total number of data packets transported from the source to the destination node from the total number of data packets delivered [19]. The data communication technology that delivers the most packets is deemed the best. When compared to alternative geographic and scheduling techniques, the building of the cluster is started to achieve data delivery with the right scheduling mechanism, and the rate of PDR is high. The data transmission schedule in the BBFA is launched based on precedence, which aids in achieving the data transmission delay limitations. Thus, a node with maximal density in BBFA has a higher PDR value than the RRS, ANS, DWGRP and ALR-EDGR methods. The performance of the BBFA, RRS, ANS, DWGRP and ALR-EDGRalgorithm is depicted in Table 5 and Figure 3.

Table 5. Comparison of Packet Deliver Rate

No of Nodes	Packet Delivery Ratio (%)				
	RRS	ANS	DWGRP	ALR-EDGR	BBFA
50	89	91	92	96	98
100	90	91.5	92.5	96.5	98.3
150	90.5	92	93	96.9	98.5
200	91	92.5	93.5	97.9	99

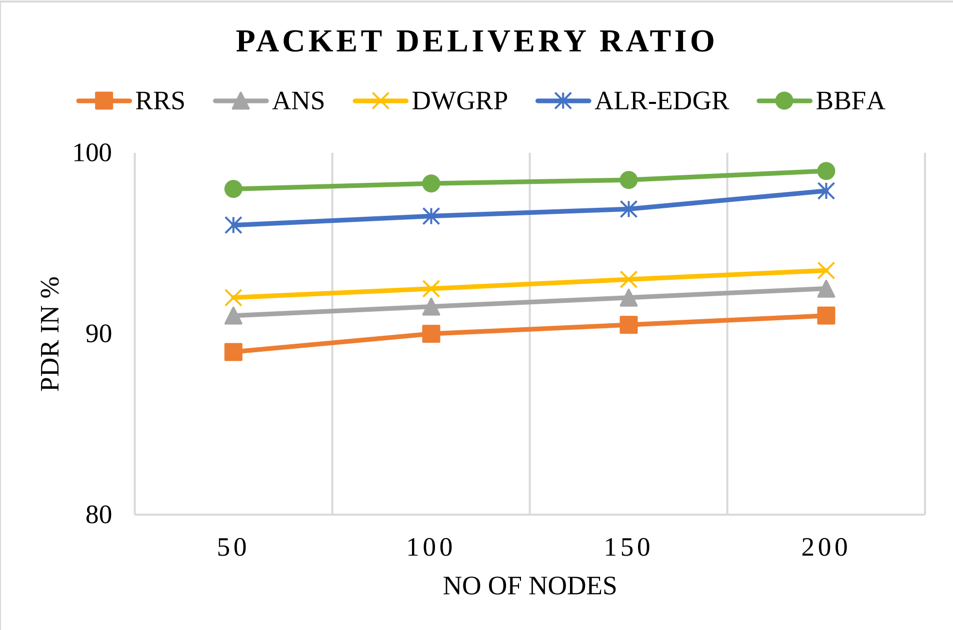

Figure 3. Comparison of Packet Delivery Ratio

5. Conclusion

Blockchain is widely utilised in numerous field that include WSN and node failure is considered as a major issue in WSN. This issue is rectified by the Blockchain based node recovery scheme whereas the failed nodes are recovered. The clusters and CH election is accomplished by the bacterial foraging algorithm and the failure in those selected node is recovered by the Blockchain technology. With the use of the blockchain system, a failed CH is effectively discovered and recovery is accomplished by its status. When the CH is restored, the failed nodes are restored as well, allowing them to connect with the sink once more. The system's effectiveness in recovering failing nodes is demonstrated by the results. In order to ensure the security of the planned system, it is also subjected to a security analysis.

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