Novel Energy Efficient and High Network Lifetime Route Discovery Algorithm

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***Abstract*—In this paper, a novel fault node route discovery algorithm based on grade diffusion algorithm and genetic algorithm is proposed. The proposed approach enhances the lifetime of wireless sensor network by replacing fewer sensor nodes when some of the sensor node shutdown either because they no longer have battery power or they have reached the threshold value. The proposed approach also reuses the routing paths and various performance metrics in terms of alive nodes, route discovery time, power consumption, energy consumption and packet loss are used to demonstrate the performance of the proposed approach.**

Index Terms*—Genetic algorithm (GA), grade diffusion (GD) algorithm, Fault node route discovery algorithm (FNR) wireless sensor networks (WSN).

I. INTRODUCTION

WIRELESS technologies, battery technologies and micro processing [3], [11], [13] have revolutionized the world of communications. It started with the use of radio receivers or transceivers for use in wireless telegraphy early on; and now the term *wireless* is used to describe technologies such as the cellular networks, MANETs (Mobile Adhoc networks) [3] and wireless broadband Internet. Wireless Sensor network [2], [5] is used for random and rapid deployment of a large number of sensor nodes. Each sensor node has limited wireless computational power to process and transfer the live data to the base station [2], [5], [8]. Hence, to increase the sensor area and the transmission area [1], [12] the wireless sensor network usually contains many sensor nodes. A mobile WSN network (WSN) consists of mobile hosts equipped with wireless communication devices. The use of wireless WSN networks also introduces additional security challenges that have to be dealt with. In the previous approaches two algorithms were considered namely Grade Diffusion algorithm [13] and Direct Diffusion algorithm [9].

In the current approach, a route discovery approach is proposed which reduces amount of power consumption and number of nodes becoming obsolete (dead) will be less as compared to Grade Diffusion algorithm. This paper proposes a Fault Node Route Discovery algorithm to enhance the lifetime of a wireless sensor network (WSN) when some of the sensor nodes shut down, either because they no longer have battery energy or they have reached their operational threshold. Using the Route Discovery algorithm can result in fewer replacements of sensor nodes and more reused routing paths. Thus, the algorithm not only enhances the WSN lifetime but also reduces the cost of replacing the sensor nodes.

This paper is organised as follows: section II presents related work, section III introduces the fault node route discovery algorithm, section IV demonstrate results and discussions and finally section V gives the conclusion.

II. RELATED WORK

The traditional approaches to route discovery algorithm include the directed diffusion (DD) [9] [10] algorithm and the grade diffusion (GD) [13] algorithm. The algorithm proposed in this paper is based on the GD algorithm, with the goal of

replacing fewer sensor nodes that have depleted batteries, and of reusing the maximum number of routing paths.

Fig. 1 demonstrates the routing in WSN. Fig. 2 demonstrates the routing when some of the nodes are not functional.

C. Intanagonwiwat, R. Govindan, D. Estrin, J.Heidemann and F. Silva [9] proposed "Directed diffusion for wireless sensor networking". The goal of the DD algorithm is to reduce the data relay transmission counts for power management. The DD algorithm [14] is a query-driven transmission protocol. The collected data is transmitted only if it matches the query from the sink node. In the DD algorithm, the sink node provides the queries in the form of attribute-value pairs to the other sensor nodes by broadcasting the query packets to the whole network. Subsequently, the sensor nodes send the data back to the sink node only when it fits the queries.

J. H. Ho, H. C. Shih, B. Y. Liao, and J. S. Pan [7], [13] proposed "Grade diffusion algorithm" for Wireless Sensor Networks [6]. The GD algorithm not only creates the routing for each sensor node but also identifies a set of neighbour nodes to reduce the transmission loading. Fig. 3 shows the Data flow diagram for GD algorithm. Each sensor node can select a sensor node from the set of neighbour nodes when its grade table lacks a node able to perform the relay. The GD algorithm can also record some information regarding the data relay. Then, a sensor node can select a node with a lighter loading or more available energy than the other nodes to perform the extra relay operation. That is, the GD algorithm updates the routing path in real time, and the event data is thus sent to the sink node quickly and correctly.

M. Gen and R. Cheng [4] proposed "*Genetic Algorithms and Engineering Design*". In the computer science field of artificial intelligence, **genetic algorithm (GA)** [1] is a search heuristic that mimics the process of natural selection. This heuristic (also sometimes called a metaheuristic) is routinely used to generate useful solutions to optimization and search problems.

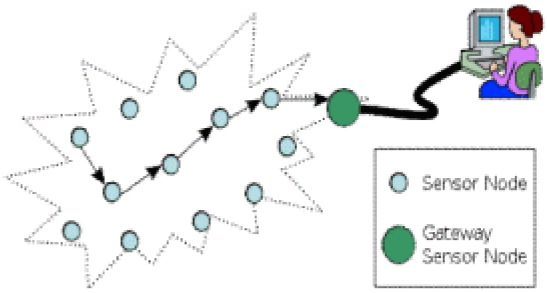

Fig. 1 *Routing in Wireless sensor network*

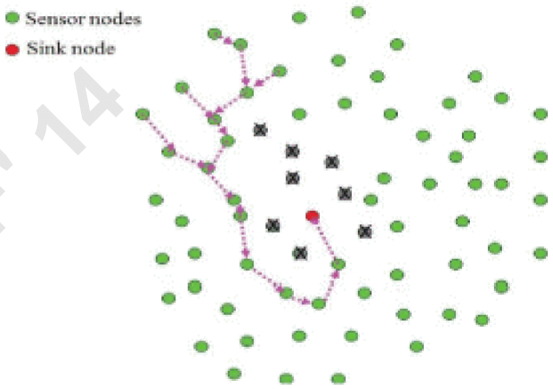

Fig. 2 *Routing in WSN when some nodes are not functioning.*

Fig. 3: *Grade Diffusion Algorithm*

Genetic algorithms [4] belong to the larger class of evolutionary algorithms (EA), which generate solutions to optimization problems using several techniques.

The goal of the proposed Fault node route discovery algorithm is to route a single packet from source node to destination node and it is integral part of Fault Node Detection and Recovery Algorithm to send packets from source node to destination node.

III. FAULT NODE ROUTE DISCOVERY ALGORITHM

The proposed FNR approach reuses the routing paths and finds only a single route to reach the destination node, whereas the GD Algorithm finds all the possible routes to reach the sink node by reducing the battery power of all sensor nodes.

The FNR consists of following modules node deployment, routing table formation, fault node route discovery, node failure detection and node recovery.

A. Node Deployment Algorithm:

The algorithm is used for placement of the nodes in WSN. Every node is separated by some distance and is assigned a battery power.

B. Routing Table Formation

The Routing table formation algorithm is used to form the routing tables for all the nodes in a WSN. The routing table contains the node ids and distance.

C. Fault node route discovery

The FNR is responsible to route a single packet from source node to destination node and it is integral part of Fault Node Detection and Recovery Algorithm to send packets from source node to destination node.

The algorithm follows the following steps:

1. The sensor node maintains a single hop list, which contains the ids of all nodes within its transmission range.
2. When a source node wants to send control packet to the sink, it includes a packet threshold with initial value N in each control packet.
3. The RREQ packet is flooded to the single hop list.
4. Each neighbour will then send the RREQ packet by picking the nodes which has highest battery power. This process is repeated until the link is established till the destination.
5. If packet threshold is zero then a process is followed by picking a node which helps us to reach the destination faster.

D. Node Failure Detection

In node failure detection process, the node whose battery power is below certain threshold is determined and will also determine set of nodes known as "grades" which has two values namely 0 or 1. Each node will become 1 if battery is greater than threshold otherwise it will be 0. This process of finding the set of nodes whose battery power is less than threshold is called node failure detection.

E. Node Recovery

The node recovery takes the set of nodes which have failed from the node failure detection and replaces them with new one with maximum battery power but with the same node id.

IV. RESULTS AND DISCUSSION

The Fault node route discovery (FNR) algorithm and GD algorithms were implemented. The FNR is compared with GD algorithm based on the route discovery time, Number of Hops, Power Consumption, Energy Consumption, Number of Alive Nodes, Number of Dead Nodes and Packet Loss.

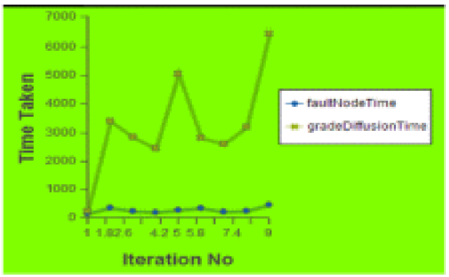

Fig. 4: *Comparison between FNR and GD algorithms with respect to time.*

The FNR algorithm defines the route discovery time which is defined as the time between when a packet was sent and when the route reply packet was received by the source node. Fig. 4 shows the route discovery time for GD and FNR algorithms.

In a WSN a hop represents the total number of devices a given piece of data (packet) passes through. As shown in the Fig. 5, the FNR uses less number of hops as compared to GD.

From the results one can prove that the Fault Node Route Discovery Algorithm finds only one

best route from source to sink rather than all possible routes as in case of GD algorithm.

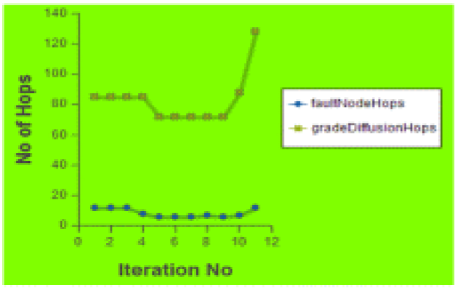

Fig. 5: *Comparison between FNR and GD Algorithms with respect to Hops*

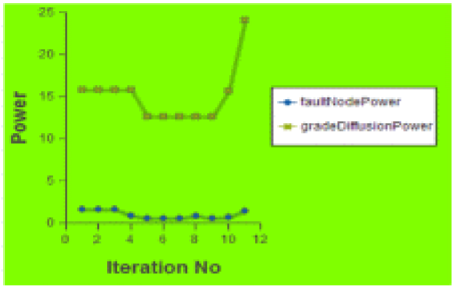

Fig. 6: *Comparison between FNR and GD with respect to Power Consumption.*

Hence the power consumption will be less as compared to GD.

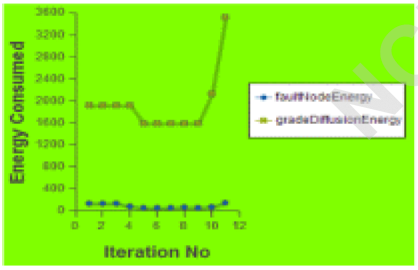

Fig. 7: *Comparison between FNR and GD Algorithms with respect to Energy Consumption.*

Energy Consumption for the routes discovered using GD and FNR. FNR has less Energy Consumption as compared to GD.

FNR algorithm has the least average energy consumption in all case. Hence, it has the best energy saving performance no matter under any node densities.

The sensor node that has battery power below threshold is called dead node. Fig. 8 shows the Number of Dead Nodes for the routes discovered using GD and FNR and from the results one can prove FNR has less Dead Nodes as compared of GD.

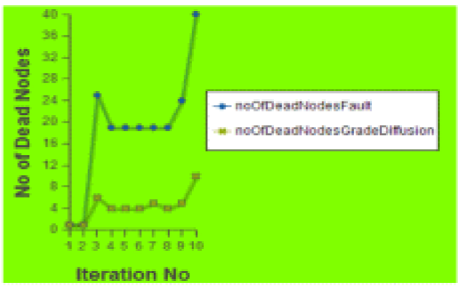

Fig. 8: *Comparison between FNR and GD Algorithms with respect to Number of Dead Nodes*

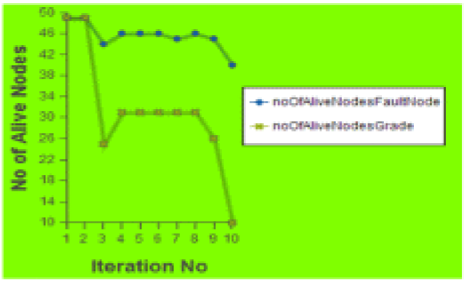

Fig. 9: *Comparison between FNR and GD algorithms with respect to Number of Alive Nodes*

The active nodes or alive nodes are the sensor node has enough energy to transfer data to other nodes. Fig. 9 shows the Number of Alive Nodes for the routes discovered using GD and FNR algorithm. FNR Algorithm has more Alive Nodes as compared of GD. The FNR algorithm has the most active sensor nodes and enhances the number of active nodes compared with GD algorithms because the algorithm can replace the sensor nodes after the number of non-functioning nodes exceeds the threshold, by using the GA algorithm.

Packet loss occurs when one or more packets of data travelling across a computer network fail to reach their destination. Fig. 10 shows the Packet Loss for the routes discovered using GD and FNR and from the results one can prove FNR has less packet loss as compared of GD. Therefore, sensor nodes can detect more events and transfer them to the sink node and hence the WSN lifetime is increased.

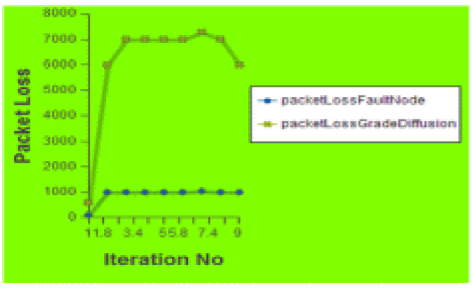

Fig. 10: *Comparison between FNR and GD algorithms with respect to Packet Loss*

V. Conclusion

In real wireless sensor networks, the sensor nodes use battery power supplies and thus have limited energy resources. In addition to the routing, it is important to optimize the sensor nodes replacement, replacement cost, and reusing the most routing paths. The FNR algorithm hence is used to achieve those optimizations. The various simulations described above demonstrate that the route discovery time, no. of Hops, power consumption, energy consumption, no. of alive nodes, no. of dead nodes and packet loss is better as compared to grade diffusion algorithm.

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