

Reliable Transmission with Fault Node Recovery Algorithm in Wireless Sensor Network

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Abstract: *This paper given a Fault node recovery algorithm to enhance the lifetime of a wireless sensor network when some of the sensor nodes shut down. The algorithm is based on the grade diffusion algorithm combined with the genetic algorithm. The algorithm can result in fewer replacements of sensor nodes and more reused routing paths. In sensor networks, each sensor node has limited wireless computational power to process and transfer the live data to the base station or data collection center. Therefore, to increase the sensor area and the transmission area the wireless sensor network usually contains many sensor nodes. Generally, each sensor node has a low level of battery power that cannot be replenished. When the energy of a sensor node is exhausted, wireless sensor network leaks will appear, and the failed nodes will not relay data to the other nodes during transmission processing. Thus, the other sensor nodes will be burdened with increased transmission processing. A trust model is presented that allows the evaluation of the reliability of the routes.*

Keywords: Genetic algorithm, grade diffusion (GD) algorithm, Fault node recovery algorithm, Trust, wireless sensor networks (WSN).

1. Introduction

In wireless sensor networks, every sensor node has limited wireless computational power for processing and transferring the live data to the base station or data collection center. So that, to increase the sensor area or processing area and the transmission area in which data transfers from one node other node, the wireless sensor network have to many sensor nodes. Generally, each sensor node has a low level of battery power so that it cannot be recovered. When the energy of a sensor node is completed, wireless sensor network leaks will appear, and the failed nodes which have not anymore power to transfer data is done. The sensor node which failed to transfer data will not relay data to the other nodes during transmission processing. Thus, the other sensor nodes will be load with increased transmission processing. This paper proposes a fault node recovery (FNR) algorithm with trust value to increase the lifetime of a wireless sensor network (WSN) and reliable transmission. At time when some of the sensor nodes shut down in transmission area & they do not have longer battery power (energy) or they have reached their operational threshold. Using the FNR algorithm we have result in some replacements of sensor nodes and more reused routing paths. This, algorithm not only increases the WSN lifetime but also reduces the cost of replacing the sensor nodes.

2. Related Work

2.1 Literature Survey

In [1], Author has been devoted to aggregation in sensor networks with the purpose of optimizing its performance. Author has mostly concentrated on maximizing network lifetime within a user-given error bound. In general, the greater the error bound, the longer the lifetime. Aggregation protocol and related algorithms are used to increase the lifetime of a WSN.

In [2], An Enhancement Grade Diffusion (EGD) Algorithm for composite event aggregation is proposed to solve the problem of detecting composite events in wireless sensor networks. The EGD algorithm extends the traditional data aggregation algorithm to detect composite events, and this algorithm can eliminate redundant transmission and save.

In [3], the energy efficiency is the foremost requirement of a sensor network. The network life, communication and the QOS are the factors that all are affected based on energy requirements of a network. To improve the network life there are number of existing routing mechanism to improve the QOS. Cache improvement in WSN has been defined by author to satisfy all these goals.

In [4], Author proposes a solution to fault management for Wireless sensor networks because of their own limitations and the scalability issue. By introducing new network equipment, one can improve the traditional distributed hierarchical management structure, the equipment can quickly locate the failure and analyze the cause of the failure, therefore can greatly improve the efficiency of network maintenance.

In [5], Author proposes an algorithm based on ladder diffusion and ACO is proposed to solve the power consumption and transmission routing problems in wireless sensor networks. The proposed ladder diffusion algorithm is employed to route paths for data relay and transmission in wireless sensor networks, reducing both power consumption and processing time to build the routing table and simultaneously avoiding the generation of circle routes.

In [6], the proposed algorithm considers recovery of each node based on the distance of each node from cluster heads, remained energy of cluster heads and member number of each cluster head and selects the best cluster head to recovery.

In [7], a trust model is presented that allows the evaluation of their liability of the routes, using only first-hand information.

3. Proposed Work

3.1 System Design:

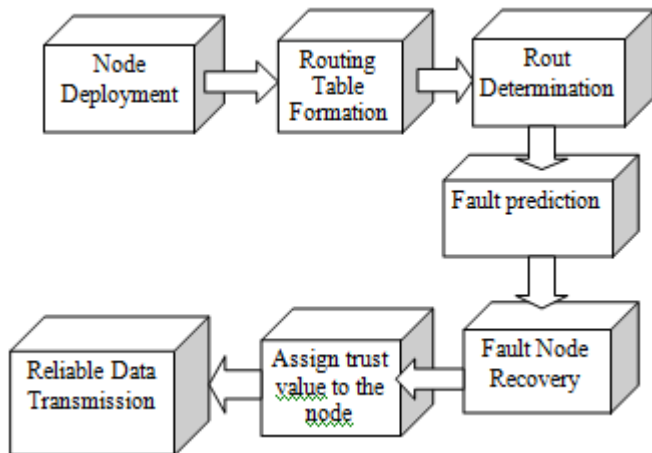


Figure 1: System Design

1. Node Deployment Algorithm

This algorithm is responsible for deployment of nodes in a particular area. This will position the nodes in the given area

2. Routing Table Formation

This is the algorithm which is used to form routing tables for each of the nodes. The routing table will contain information about other nodes in the network in terms of node id and distance of each node w.r.t other nodes in the network.

3. Route Determination

This is the process which involves determining the route from the source node to destination node with the aid of using the control packets and the route must be found in such a way that battery consumption is reduced and overall network lifetime is also increased.

4. Fault node Prediction

This is the process in which the node's whose battery power is below than certain threshold is determined

5. Fault Node Recovery

This is the process by which the nodes whose battery power is below threshold are determined and replaced with the new nodes but with same node id.

3.2 Directed Diffusion Algorithm

A series of routing algorithms for wireless sensor networks have been proposed in recent years. The goal of the DD algorithm is to reduce the data relay transmission counts for power management. The DD algorithm is a query-driven transmission protocol. In this algorithm the collected data is transmitted only if it matches the queries which have in 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. This is done by broadcasting the query packets

to the whole network. Query packets have queries in the form of attribute-value pair. After that, the sensor nodes send the data to the sink node only when it fits the queries.

3.3. Grade Diffusion Algorithm

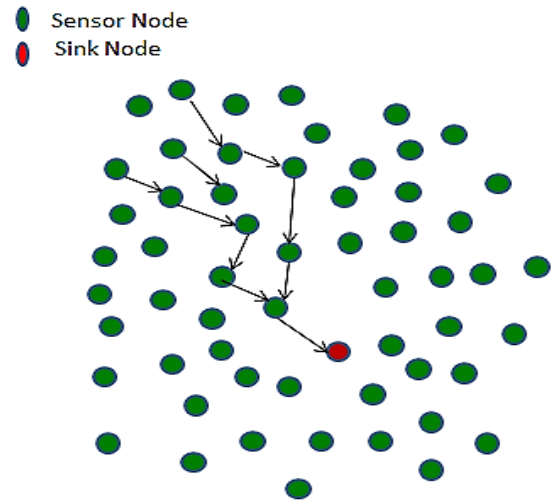


Figure 2: Wireless sensor node routing

The Grade Diffusion (GD) algorithm to improve the ladder diffusion algorithm using ant colony optimization (LD-ACO) for wireless sensor networks. The GD algorithm creates the routing path for each sensor node. It also identifies a set of neighbor nodes to reduce the transmission of data. This algorithm provide grade table for each sensor node. When its grade table defect node able to perform the relay. Each sensor node can select a sensor node from the set of neighbor nodes. The GD algorithm can also record some information regarding the data transmission. Then, a sensor node can select nodes which have a lighter loading or more available energy or power than the other nodes to perform the extra transmission operation. That means, the GD algorithm can updates the routing path in real time, and the data is sent to the sink node quickly and correctly. Whether the DD or the GD algorithm is applied, the grade-creating packages or interested query packets must first be broadcast to all sensor nodes. Then, the sensor nodes transfer the event data to the sink node, according to the algorithm, when suitable events occur. The sensor routing paths are shown in Fig. 3

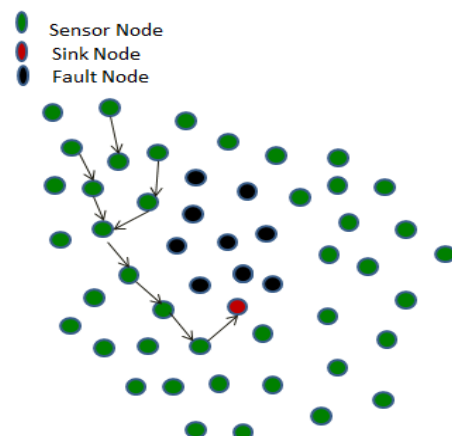


Figure 3: Wireless sensor node routing path when some nodes are not functioning.

The WSN may fail due to a variety of causes, including the following: the routing path might be break; the WSN sensing area might be leak; the batteries of some sensor nodes might be depleted, requiring more relay nodes; or the nodes damaged after the WSN has been in use a long period of time. In Fig. 2, the situation in which the outside nodes transfer event data to the sink node via the inside nodes (the sensor nodes near the sink node) in a WSN to provide the accommodation measures for non-working nodes. The inside nodes thus have the largest data transmission loading, consuming energy at a faster rate. If all the inside nodes reduce their energy or otherwise stop to function, the event data can no longer be sent to the sink node, and the WSN will no longer function. The power of the sensor nodes in WSNs is unavoidable. This paper, however, proposes an algorithm to search for and replace fewer sensor nodes and to reuse the most routing paths. Also using trustworthiness to transmit reliable data to sink node.

3.4 Route Discovery Process

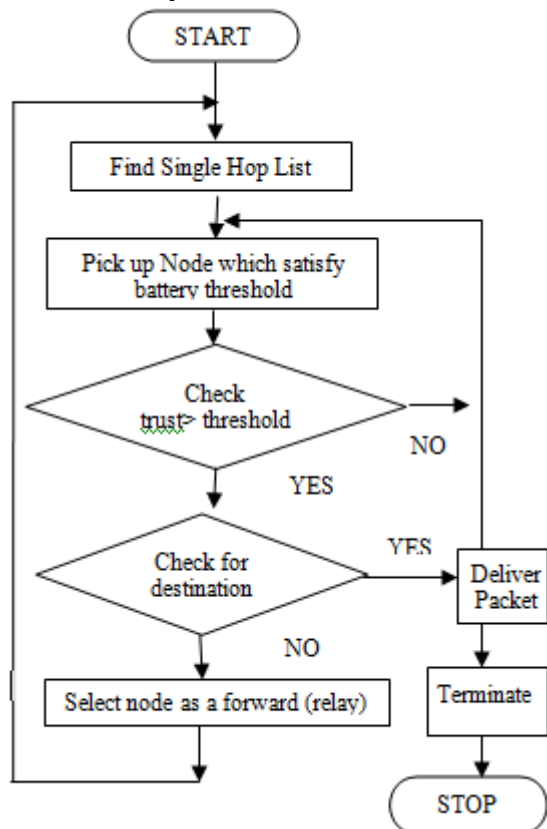


Figure 4: shows the route discovery process using grade diffusion algorithm.

In the current approach, a route discovery approach is proposed which reduces amount of power consumption the process of finding the set of nodes whose battery power is less than threshold is called Fault Node Determination. The nodes will be replaced with new nodes of same node id this process is called Fault Node Recovery. Fault Node Detection and Recovery Algorithm to send packets from source node to destination node. The algorithm has 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 REQ packet is flooded to the single hop list.
- 4) Each neighbor will then send the REQ 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.

3.5 Genetic Algorithm

The Genetic algorithm is one of the best energy efficient algorithms in wireless sensor networks. It optimizes the signal strength of sensor nodes. This algorithm also helps in reducing the energy consumption and thus increases the lifetime of wireless sensor networks. This algorithm consists of five steps i.e., i) Initialization ii) Evaluation iii) Selection iv) Crossover v) Mutation.

i) Initialization

It is first step of the Genetic algorithm. In initialization step the genetic algorithm generate chromosomes. The total number of chromosomes will be the number of non-functioning nodes. The genes values will be 0 or 1.

ii. Evaluation

The second step in Genetic algorithm is Evaluation. Here in this stage fitness function is evaluated by providing fitness values. The fitness function is defined over the genetic representation and measures the *quality* of the represented solution. The fitness function is always problem dependent. The input parameters will be chromosomes itself.

$$f_n = \sum_{i=1}^{\max(\text{Grade})} \frac{P_i \times TP^{-1}}{N_i \times TN^{-1}} \times i^{-1}$$

Where,

N_i = the number of replaced sensor nodes and their grade value at i .

P_i = the number of re-usable routing paths from sensor nodes with their grade value at i .

TN = total number of sensor nodes in the original WSN.

TP = total number of routing paths in the original WSN.

iii. Selection

The third step in Genetic algorithm is Selection. The main aim of this step is to select the chromosomes. Chromosomes having the highest fitness value. First it selects the pair of chromosomes from the node. The selected chromosomes which is having highest fitness value will be send to the mating pool to produce new set of chromosomes which will happen in the crossover step.

iv. Crossover

The Crossover step in Genetic algorithm is used to create individual chromosomes. The two individual chromosomes will be selected from the mating pool to generate a new set

of offspring. A one-point crossover is selected between the two parents and then the fraction of each of the individual according to the crossover will be swapped.

v. Mutation

The mutation step can introduce traits not found in the original individuals and prevents the GA from converging too fast. The sensor nodes will be replaced in the chromosomes with gene of 1 in order to get better network lifetime.

3.6 Node Failure Detection:

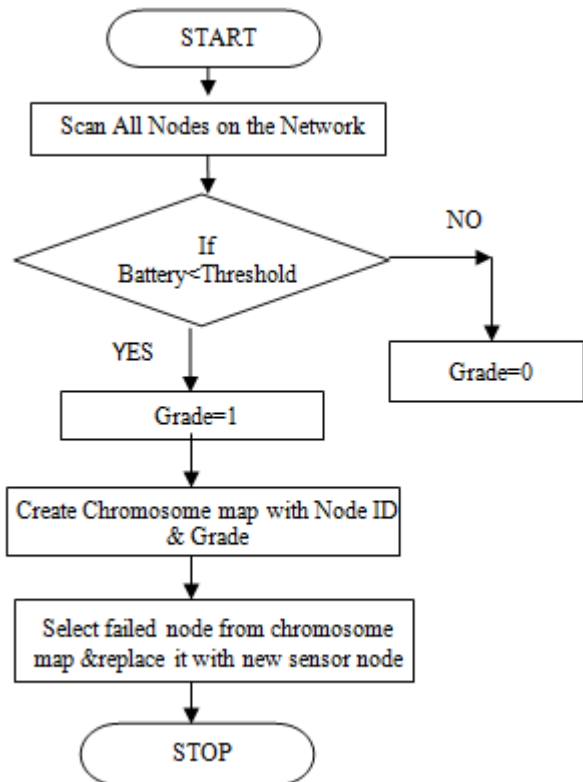


Figure 5: shows Node failure detection using Genetic Algorithm

The above flowchart shows the Node Failure detection process:

- 1) The Nodes are scanned from the first node onwards and link is established to collect data from each single hop list
- 2) The mutation is computed by comparing the battery power with the threshold
- 3) Each node is assigned a grade value of 0 or 1. A 1 is assigned if the battery power of node is less than Threshold otherwise it will be assigned a value of 1
- 4) A chromosome Map is created which will contain key as Node ID and value as the grade value
- 5) Set of nodes are determined from the map which have a value as 1
- 6) The process is repeated until all nodes have been scanned

3.7 Fault Node Recovery Algorithm

This paper proposes a fault node recovery (FNR) algorithm for wireless sensor network based on the grade diffusion algorithm combined with the genetic algorithm.

The FNR algorithm creates the grade value, routing table, neighbor nodes, and payload value for each sensor node using the grade diffusion algorithm. In the FNR algorithm, the number of non-functioning sensor nodes is calculated during the wireless sensor network operation, and the parameter B_{th} is calculated according to equation. The sensor nodes transfer the event data to the sink node according to the GD algorithm when events appear. Then, B_{th} is calculated according to equation in the FNR algorithm. If B_{th} is larger than zero, the algorithm will be invoked and replace nonfunctioning sensor nodes by functional nodes selected by the genetic algorithm. Then the wireless sensor network can continue to work as long as the operators are willing to Replace sensors.

$$B_{th} = \sum_{i=1}^{\max(\text{grade})} T_i$$

$$T_i = \begin{cases} 1, & \frac{N_i^{now}}{N_i^{original}} < \beta \\ 0, & \text{otherwise} \end{cases}$$

Where,

$N_i^{original}$ = is the number of sensor nodes with the Grade value i

N_i^{now} =is number of sensor nodes still functioning at the current time with grade value i

β = value between 0 and 1.

3.8. Trust Opportunistic Routing Protocol:

A trust model is presented that allows the evaluation of the reliability of the routes, using only first-hand information. Trust value of each node should be assigned and computed in advance. If a node joins the network or the network is firstly working, its trust value is set as an initial value 0.5. When network topology changes, the trust value of each node can be updated by formula (1) and (2), and moreover. If trust value of a node is less than Threshold, this node will be elicited as a selfish or malicious node, so it will be omitted in next routing phrase from security of network point of view.

3.8.1. Generate WSN Topology:

Let $G = (V, E)$ denote the topology of the network. Assume that node j is neighbor node i. It is denoted by $T_j(i, n)$ trust on node j assigned by node i. $T_j(i, n)$ is n^{th} topology computed by,

$$T_j(i, n) = \frac{F_{ij}(n)}{N_{ij}(n)} \tag{1}$$

Where,

$N_{ij}(n)$ = the number of packets that have been received by i at time n.

$F_{ij}(n)$ = the number of packets that have been received by i at time n.

3.8.2 Implementation GDA with Trust value:

Calculate trust value of node by using a moving average model. Using $(n + 1)^{th}$ topology

$$T_j(i, n + 1) = \alpha \cdot T_j(i, n) + (1 - \alpha) \cdot T_j(i, n + 1) \quad (2)$$

Where,

$T_j(i, n + 1)$ is node j 's trust value measured by node i during the $(n + 1)^{th}$ topology updating cycle.

$\alpha = 0 < \alpha < 1$ is a weighting factor used to tradeoff between current measurement and previous estimation.

4. 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 research the optimization of sensor node replacement, reducing the replacement cost, and reusing the most routing paths when some sensor nodes are non-functional. The various simulations demonstrate that the round trip time, Number of Hops. The FNR algorithm using Trust value requires replacing fewer sensor nodes and reuses the most routing paths, increasing the WSN lifetime and reducing the replacement cost and transmission of data is reliable.

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