An Energy Efficient Multipath Routing Protocol to improve Networks Lifetime in WSN for Railway Environment Monitoring

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Abstract - For the application of railway environmental monitoring, the sensor has to be placed in linear wireless sensor networks, in single path routing protocol requires more energy consumption, and it takes a more sensor to deploy on the environment. It also reduces the robustness of the network lifetime. To overcome the cons of single routing protocol, multipath is used, comparatively it takes a lesser time and it will choose the priority of the packet are sent over the network. It also improves the better efficiency while sending the high priority packets. Results of simulation shows that will improve in a lifetime of sensor networks

Keywords - Wireless Sensor Networks, Routing protocol, Multipath routing, Railway environment, Monitoring system.

I. INTRODUCTION

In wireless sensor networks (WSN) have been used for tracking and monitoring an application. Sensors are deployed in outside environment, it senses the information. Routing algorithm takes a majority role to send the data from source node to sink node, it has been designed in network layer.

Wireless sensor Networks (WSN) are highly sensitive on energy, there is an relation between energy and network lifetime, if anyone of node is depleted it will affect the whole network lifetime therefore balancing the energy consumption to be taken as consideration .while using single hop node it takes an more energy consumption as well as it will affect in an single point of failure.Inorder to save the energy during transmission the multipath transmission has been used [1].

If the path is failed or node gets shutdowns not only affect the data loss, but also leads to rerouting of the packets to the networks, it causes the imbalances and the overloaded to the wireless sensor networks [2].

By establishing a multipath routing protocol can able to improve the efficiency of the network lifetime. Establish the multipath based on the information is sensed over the networks. In multipath routing protocol has been divided into two types: centralized and distributed multipath routing. Centralized multipath routing protocol will works well for small area networks whereas to achieve in large scale network area distributed multipath routing protocol is used.

Different paths are attained in the networks, based on the correlation it has be divided into disjoint multipath and braided multipath [3].the disjoint multipath is independent not to share their state information to at least one node, where braided are dependent have to share at least one node.

The paths are different, there are two types of path has been classified based on their relationships. Master slave path has an optimal path, to transmit the data under normal circumstances. If one path fails, the slave path has transmitted for one path is used [1][4].

In non- master slave routing protocol uses multiple paths to transfer the data, it is efficient. Routing protocol is different from one application to the other application. There is a problem to adopt in environment monitoring areas when we compared with existing protocols.

II. ANALYSIS AND NETWORKS ESTABLISHMENT MODELS

A. Network Design

In railway environment monitoring it is typical narrow linear wireless sensor network are placed. In WSN it consists source node, relay node and sink node along with GSM –R is placed with high speed railway lines for fixed distances. Choosing the sink node must contain a transmitting power, receiving power, data storage and processing capacity are shown as fig 1 and fig 2.

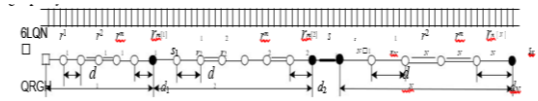


Figure.1 Nodes deployment diagram

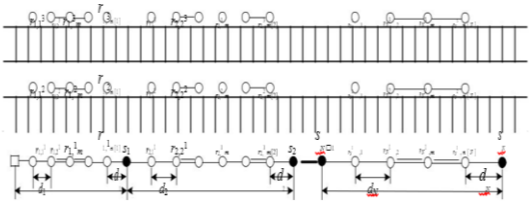


Fig.2 Improved nodes deployment diagram

In this above figure black node is denoted as sensor node and whit node is denoted as relay node and rectangle represents the sink node. Let the Nth is sensor node, all sensor nodes are in the first row.

The relay node in the ith row, which is the first mth column before the N th sensor node. Between the i-1th sensor node and the ith sensor node, the relay nodes are deployed at a distance of di [7].

The characteristics have to be followed based on railway environment monitoring systems are:

- Each and every node has its unique id and need to transmits the data
- Each sensor node must work with heterogeneous and sensors should not be in ideal state and need to send the information periodically to the sink node
- The selection of sink node has an capable for communication, storage and processing
- The values has been fixed for the relay nodes for its initial energy, processing power and storage space is too limited.
- The state information of node should be periodically broadcast to other nodes. According to the sink nodes, the other nodes distances can be adjusted in order to save the energy during a transmission.

B. Model Analysis

According to the WSN, there is a major problem in designing a routing protocol; it can be simplified with robustness with high reliability and capacity. The simplified network in WSN is shown as fig 3.

Fig.3 Simplified network diagram

The energy consumption model has been formulated as [8].

$$E_{Tx} = \begin{cases} k \times E_{elec} + k \times \varepsilon_{fs} \times d^2, d < d_0 \\ k \times E_{elec} + k \times \varepsilon_{mp} \times d^4, d \geq d_0 \end{cases} \quad (1)$$

$$E_{Rx} = k \times E_{elec} \quad (2)$$

- ETX - energy consumed in transmission of k bits
- E ELEC - energy consumed in transmitter circuit
- D0 – threshold distances

The model following characteristics is:

- The energy consumption of information transmission between nodes in one layer can be neglected
- The size of every data packet is the same after data fusion.
- Due to the limit of transmitting power, each node can only transfer data to the nodes in its next layer or transfer data to the nodes in its next layer but one. When there is no node failure, there's no communication between nodes within one layer, thus there are m independent path for data transmission.

C. Model Establishments

Considered the first row it is denoted as relay node

One step hop as data transmission from Li and Li+1 and two step hop is Li and L i+2. For each relay node, let σ to be the transmission energy consumption of one-step-hop, let μ to be the transmission energy consumption of two-step-hop.

$$R = \frac{\mu}{\sigma} \quad (R > 1)$$
$$r = \frac{\eta}{\sigma} \quad (r < 1)$$
$$E = \frac{\varepsilon}{\sigma} \quad (E > 1)$$

Let the nodes is li and Pi is the one step packet and qi is the two step packet.

$$\begin{cases} p_1 + q_1 \cdot R + p_A \cdot r \le E \\ p_2 + q_2 \cdot R + (q_A + p_1) \cdot r \le E \\ p_3 + q_3 \cdot R + (q_1 + p_2) \cdot r \le E \\ \cdots \\ p_{n-1} + q_{n-1} \cdot R + (q_{n-3} + p_{n-2}) \cdot r \le E \\ p_n + (q_{n-2} + p_{n-1}) \cdot r \le E \\ q_n = 0 \\ R > 1, r < 1, E > 0, n > 2 \end{cases} \quad (4)$$

The total number of packets are sending and received by the nodes are

$$\begin{cases} Q = p_A + q_A \\ Q = q_A + p_1 + q_1 \\ Q = q_1 + p_2 + q_2 \\ \cdots \\ Q = q_{n-2} + p_{n-1} + q_{n-1} \\ Q = q_{n-1} + p_n \\ n \ge 2, Q > 0 \end{cases} \quad (5)$$

To simplify the expression, let $\varphi = {}^{R-1}/_{r+1}$, then we can obtain the maximum value of Q as follows.

$$Q_{\max} = \frac{E}{1+r} + \frac{E}{R+r} \cdot \frac{\varphi - 1}{\varphi^{n-1} - 1} \quad (6)$$

D. Packet Priority Level

To achieve an optimal level in network by using (7) equation. The maximum number of data are send over the relay network, it will take an priority because each and every applications are based on different priority levels.

Let us considered the priority level it starts with o and committed with hp or f values .the 0 denoted as low level priority and hp denoted the high level priority.

$$\begin{cases} p_A = \frac{E}{R+r}, q_A = \frac{E}{R+r} \cdot \left(\frac{\varphi - 1}{\varphi^{n-1} - 1} + \frac{R-1}{r+1}\right) \\ p_1 = 0, q_1 = \frac{E}{R+r} \\ \cdots \\ p_{n-i} = \frac{E}{1+r} + \frac{E\left[(\varphi - 1) - (\varphi^i - 1) - (\varphi^{i+1} - 1)\right]}{(R+r) \cdot (\varphi^{n-1} - 1)}, q_{n-i} = \frac{E}{R+r} \cdot \frac{\varphi^i - 1}{\varphi^{n-1} - 1} \\ p_i = \frac{E}{1+r} + \frac{E\left[(\varphi - 1) - (\varphi^{n-i} - 1) - (\varphi^{n-i+1} - 1)\right]}{(R+r) \cdot (\varphi^{n-1} - 1)}, q_i = \frac{E}{R+r} \cdot \frac{\varphi^{n-i} - 1}{\varphi^{n-1} - 1} \\ p_n = \frac{E}{1+r}, q_n = 0 \end{cases} \quad (7)$$

By using two step transmission, there are n number of layers are there, eliminate the first level of layers.to reduce the delay in network always choose a high priority of data are sent over the network [8].

$$M_f = \left[\frac{n+1}{2}\right] \quad (8)$$

$$M_f = \left[\frac{n+1}{2}\right] - f + 1 \quad (9)$$

The two step packet priority level are formulated as

$$F+1 \text{ priority level, where } F = \left[\frac{n+1}{2}\right] \quad (10)$$

For an example A node is considered as transmitting a data, before assign and allow only the high priority of data to be travelled over a network and find the shortest path using an Dijkstra's algorithm.

After finding a shortest path take an adjacency path to travel over a network, there should be an alternate path, if one nodes gets shutdowns, before it should broadcast their state information with its id to their adjacent node .the broadcasting should be done periodically

III. FAILURE MECHANISM

A. Failure Classifications

According to the state of fault nodes, it can be classified into three types namely, single path failure, continuous path failure and intact path failure.

1. Intact Path

Intact path is defined as states of all the nodes are working properly .there is no failure in the path is said to be an intact. For an example are shown in Figure 4.

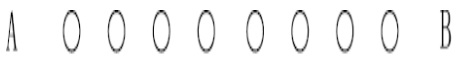


Figure 4 Intact path

2. Single Path Failure

There is a failure in path either an linear or adjacency node not more than two nodes of failure .if it fails there is a problem in data transmission. Figure 5 are shown below

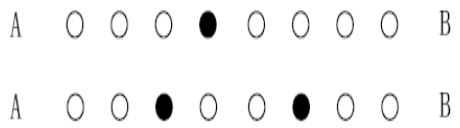


Figure 5 Single fault path

3. Continuous Path Failure

Continuous path failure is defined as path which failures an node continuously or more than two adjacency nodes are said to be an continuous path failure. Example figure 6 is shown as below.

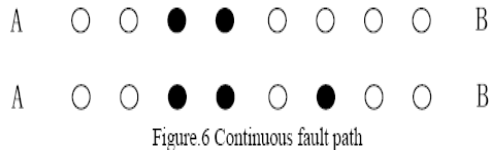


Figure.6 Continuous fault path

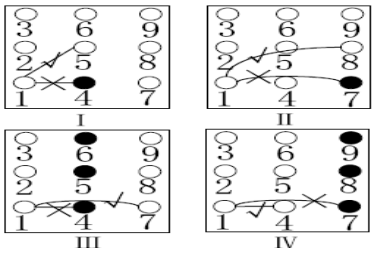
B. Node Fault Detection

Let Td be the average time interval can be calculated between node A and node B. There are certain conditions to meet the criteria.

1. When two packets are continuously received the difference should be greater than threshold value
2. No packet are received in the time interval Td.D
3. Node fault detection starts and it broadcast their flooding based on faulty nodes
4. When an relay nodes receives a query packet it will add it particular node packet number to the direction A node acts as a source node.
5. Let us considered p be the first hop and Two be the two step hop. If node fails set the values of p and q will be 0. If there is a failed node in the same path layer l i-1 and again set the values 0 and recalculate it up to layer 2 until its meets the criteria.
6. If all the nodes in two adjacent layers fail in network, entire network has been collaborated.

C. Failure Handling Strategy

In case of single fault path, following cases for the nodes before fault node to send packets, as figure 7.



- Case I shows if node 1 will use one-step-hop transmission to send packets but node 4 fails. In this case,
- node 1 will send packet to node 5 or node 6, which are in the same layer of node 4. Case II shows if node 1 will use two-step-hop transmission to send packets but node 7 fails. In this case, node 1 will send packet to node 8 or node 9 which are in the same layer of node 7.
- Case III shows if will use one-step-hop transmission to send packets but all the nodes of the layer next to node 1 fail, then node 1 could use two-step-hop transmission to send packets to node 7, node 8 or node 9.
- Case IV shows if will use two-step-hop transmission to send packets but all the nodes in the next layer but one fail, then node 1 could use one-step-hop transmission to send packets to node 4, node 5 or node 6.

In case of continuous fault path, there're 3 following

Cases for the nodes before fault node to send packets, as the figure 8 shows.

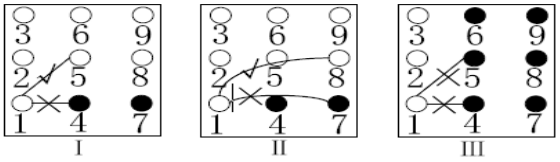


Figure.8 Cases of continuous fault path

- Case I shows if node 1 will use one-step-hop transmission to send packets but node 4 and 7 fails. In this case, node 1 will send packet to node 5 or node 6, which are in the same layer of node 4.
- Case II shows if node 1 will use two-step-hop Transmission to send packets but node 4 and 7 fails. In this case, node 1 will send packet to node 8 or node 9 which are in the same layer of node 7.
- Case III shows if all the nodes in two adjacent layers fail, the whole relay network collapses [6].

IV. ROUTING AND PACKETS TRANSMISSION RESULTS

Set the initial energy value initial to all the nodes is constant. At first, node A calculates the p value and qvalue of all the nodes and sends them to all the nodes.

Each relay node maintains routing information includes just the path number, its own p value and q value and information of4 adjacent nodes in the same path. The simulation results shows that improved in network lifetime are shown .

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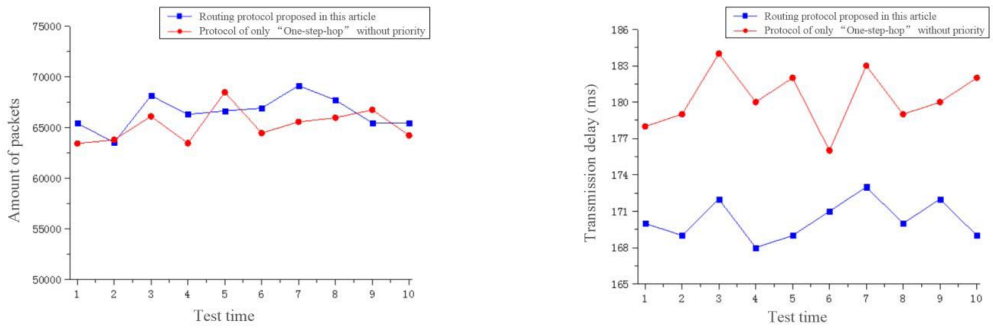

V. CONCLUSION AND FUTURE WORK

In order to improve a network lifetime, two step hop is best, while considering a only an high priority packet is sensitive in an network, still there is an cons while using nodes without clustering algorithm. In a future work, there is a fuzzy clustering algorithm [9] is used to cluster a node with a cluster quality. There is an no security in the packet of transmission from an source to sink node. In order to provide an security Minutiae Extraction Algorithm (MEA) is used to create an session key with an data confidentially and integrity to be achieved [10].

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