Fuzzy Based Faulty Link Isolation Technique in Dynamic Wireless Sensor Networks

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Abstract: - Transmission link failures are common in both static and dynamic wireless sensor networks due to factors such as sensor node failure, mobility of the nodes, network congestion and interference. These faulty links in a network are needed to be localized and repaired to sustain the health of the network. It is necessary to maintain the dynamic topology of the network to monitor the link quality. Hence, in this paper we adopt the Kinetic PR Quad tree and modify it to maintain the network topology and we have also proposed a Fuzzy-Link Quality Assessment (F-LQA) algorithm to estimate the link quality by considering parameters like asymmetry, energy level of nodes and delay. The proposed algorithm zeroes down to the link responsible for the faultiness of the bad topology. The F-LQA algorithm computes the Malfunction Index (MI) Value which is found to possess an increased reliability due to the inclusion of a variety of parameters for ascertaining the link quality. Therefore the conclusion obtained regarding the link reliability is accurate. The proposed algorithm is found to be more energy efficient than other existing approaches thus extending the network lifetime.

Key-Words: - Sensor Networks, Localization, Faulty links, Link Quality Assessment, Fuzzy Logic, Malfunction Index.

1 Introduction

A sensor network is composed of a large number of small sensing, self-powered nodes, which gather information or detect special events and communicate in a wireless fashion, with the end goal of handing their processed data to a base station. Sensing, processing and communication are the three key elements whose combination in one tiny device gives rise to a vast number of applications [1]. Sensor networks find applications in diverse fields such as environmental monitoring, warfare, child education, surveillance, micro-surgery, and agriculture [2].

The number of nodes in a typical sensor network is much higher than that in a typical ad hoc network, and dense deployments are often desired to ensure coverage and connectivity; for these reasons, sensor Network hardware must be cheap. The position of sensor nodes need not be engineered or pre-determined. This allows random deployment in inaccessible terrains or disaster relief operations [3]. On the other hand, this also means that sensor network protocols and algorithms must possess self-organizing capabilities.

The topology is assumed to be dynamic in nature. As the node moves in the network, links between the nodes are altered. In a highly dynamic network (frequent and drastic changes in topology) the cost involved in finding a new route from the source to the sink is high, thereby reducing the performance of the network [4]. A proper trade-off between topology control and performance has been achieved using the Kinetic PR Quad tree to store the network structure and updating periodically depending on the mobility of nodes.

Failures in wireless sensor networks can occur due to various reasons [5]. First, sensor nodes are fragile, and they may fail due to depletion of batteries or destruction by an external event. In addition, nodes may capture and communicate incorrect readings because of environmental impact on their sensing components.

Secondly, as in any adhoc wireless networks, links are failure-prone, causing network partitions and dynamic changes in network topology [6]. Links may fail when blocked by an external object or environmental condition.

Link failure can be identified using a number of parameters like packet delivery, asymmetry, channel quality, stability, delay, packet loss, residual energy and a number of evaluation techniques including PRR, RSSI, and SNR. The presence of faulty links in wireless sensor network reduces the network performance tremendously. It is essential to identify the faulty links in the shortest possible time in order to adapt to the rapid changes in topology due to the mobility of the nodes. The two classical approaches used to detect faults in the total network are mentioned in [7],[8].

The major contributions of this paper are the results of experimental measurement of link quality estimation using a fuzzy logic algorithm. Fuzzy logic formulates a mathematical model to give areas of reasoning, inference, control and decision making under uncertainty.

In this paper the F-LQA algorithm identifies the faulty links using an aggregation of various parameters using the fuzzy approach. A special emphasis is given to find out how the link quality behaves during the movement of sensor nodes.

2 Related Works

The problem of localizing and correcting faulty links in a deployed sensor network is considered. Most of the existing studies pertain to only static nodes and not mobile nodes.

Christopher Farah et al. [9] proposed a novel approach to detect any change in the topology of the network by logically setting a Boolean value for every node in the network. Changes in topology have its impact on the boundary, i.e., boundary level may change or a new boundary may occur. A new data structure called neighborhood ring is introduced for every node which is a series of Boolean values of neighbor nodes, which are at a one-hop distance from the particular node. Any topological movement of a node results in changes in the neighborhood ring of the corresponding node and its neighbors.

Liu et al. [10] proposed a dynamic topology management scheme based on mobility prediction. This centralized technique is implemented by the sink. The current location, velocity and direction of the moving node are considered based on which location of the next prediction interval is fixed. The Mathematical model for mobility prediction is proposed, but prone to prediction errors. And this is mainly suitable only for single target tracking. In case of multiple tracking system energy consumption is higher.

Rogaia Mhemed et. al [11] proposed a novel approach for cluster formation in WSNs that use Fuzzy Logic which enhance the network lifetime. Fuzzy Logic Cluster Formation Protocol (FLCFP) prolongs the lifetime of WSNs by using the Fuzzy Inference System (FIS). The main difference between FLCFP and LEACH lies in the cluster formation phase. In FLCFP, the non-CH nodes compute a chance value for each CH by applying the FIS.

In Fuzzy logic based performance optimization (FBSDA) [12], a tree based and cluster based selection of best route is achieved based on the path length power of node and reputation. Best and normal nodes are selected for data aggregation and worst nodes are neglected by cluster head .Each parameter is taken as a fuzzy input set and the final decision is based on the output of the intersection of the corresponding fuzzy set members. The FBSDA algorithm shows the better delivery rate and less energy consumption but does not ignore the data from malicious or fault links.

Ali Barati et.al [13] uses an adaptive fuzzy inference system to detect faulty readings in WSN. Also, to reduce the effect of faulty readings, a confidence number is used applying the Debraj De Algorithm. The shortcoming of this technique is it performed only static localization and is based on distance, hence very vulnerable to faulty links.

Roghayehabbasi [14] fuzzy algorithm solved two objectives. The first is the reduction of energy consumption, which results in an increase in the network operations life span and the second is to meet a defined end-to-end delay and hence increasing reliability by reducing the number of packet losses considerably. By using different fuzzy parameters and if-then rules, each node can make a decision to choose its next step for routing towards the destination (sink).This algorithm is only for static nodes and hence need to be extended to mobile nodes and different energy of nodes.

Kannan and Sree Renga Raja [15] proposed Reliable Power aware Scheme (RPAS) for the node to transmit and receive packets. The energy consumption of different node components in different operating modes are modeled and analyzed for WSN nodes and for the entire network. In this algorithm only energy consumption is taken for extending the network lifetime and the nodes are considered to be static and hence it need to be improved for dynamic topology.

Kapitanova et. al [16] proposed fuzzy based robust event detection in wireless sensor network to increase the event detection accuracy. In this paper, to reduce the memory size, rule based approach is implemented and it is limited to static approach.

It has been observed that an efficient sensor network, preferably has a dense deployment of nodes in order to obtain a tight coverage and it is necessary to check that the nodes are capable of self-reconfiguration in case of mobility. It is to be noted that such sort of topology changes due to node mobility cannot be discretely quantified as it depends on instantaneous changes. Hence it is necessary to obtain a non-quantifiable approach for mobility control and topology management.

3 Problem Definition

In a wireless sensor network, most of the power is consumed due to improper routing of packets especially in case of dynamic topology. For proper routing without delay, loss and with minimum energy, the links related to that path are checked and the status is maintained at sink level. For that a Fuzzy based approach is used to check the quality of the link.

In case of mobile sensor networks the node data is lost, once the node moves out of the coverage region and hence it is impossible to obtain data from the region where the node was primarily designated. The objective of this work is to formulate an approach that contains an effective localization mechanism which is dynamic in nature. This enables the network topology to be constantly monitored irrespective of the changes that it undergoes due to the mobility of the network .This approach also maintains the data about the link. This approach guarantees a considerable decrease in the data loss rate due to node mobility and reduces the power wasted during improper routing thus extending the lifetime of the network.

4 Proposed Work

Here we have assumed a two dimensional Dynamic network topology which is used to model a more general sensing area where the mobile stations placed on a plane or surface can move in any direction. There is a sink or the gateway node for the whole sensor network whose function is to listen to other sensor nodes and transmit the event to the external control centre. It is also meant for maintenance and repair operations in the network. The sink is assumed to be immobile or static in nature.

The network is initially considered in the shape of a 2D grid. The grid is constructed by the geometric projection of a circle, drawn with sink at the centre and the range of the sink as the radius, into a square. Then the topology is maintained only in terms of the grid structure provided. There is a record called a topology table, maintained in the sink consisting of entities to track the movement of nodes. Additionally, failure of sensor nodes and links contribute to the change in topology of the network. Node failure may occur due to malicious attacks on the nodes, draining of battery power or technical fault in the nodes which in turn has a direct impact on the link quality between the nodes [17].

4.1 Localization of Mobile Nodes

The sensor topology may change due to movement of nodes or deplaned energy. Therefore, redeployment and the relocation process of sensors are essential for all sensors to fall under the coverage area [18]. Sensor nodes in a dense region need to move to a sparse region to improve coverage and connectivity of a sensor network.

4.1.1 Kinetic Point Region Tree (KPR Tree) construction

The Kinetic PR Quad tree stores data points, i.e. sensor nodes in a 4-ary tree structure. The quad tree divides the data points such that each cell, a square division of finite space also called quadrant, contains at most *n* points (sensor nodes) as shown in Fig. 1.The value of ‘n’ is defined by the user and is usually from 1 to 5.

The position of the node can be scanned by parameters like velocity, time and position. The Kinetic PR tree changes its state whenever there is a change in scanned value.

Assuming the node is aware of its location coordinates and the cluster is a two dimensional grid, the tree is used to monitor the location of nodes. Nodes with non-zero velocity are prone to change their position over time, eventually intersecting the boundary of the cells.

A priority queue is used to store these intersections that a mobile node makes with the quadrant axes, thereby detecting the mobility of the node.

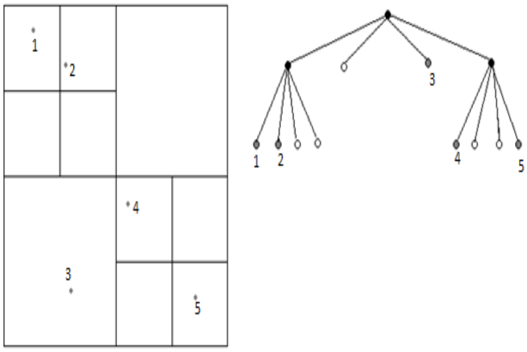

Fig. 1. Topology configuration represented by a Kinetic PR tree

The use of a priority queue to store these intersections is that, it orders them such that the intersection that happens the earliest is accessed first. The KPR Tree changes its structure based on the order of these intersections as in Fig. 2

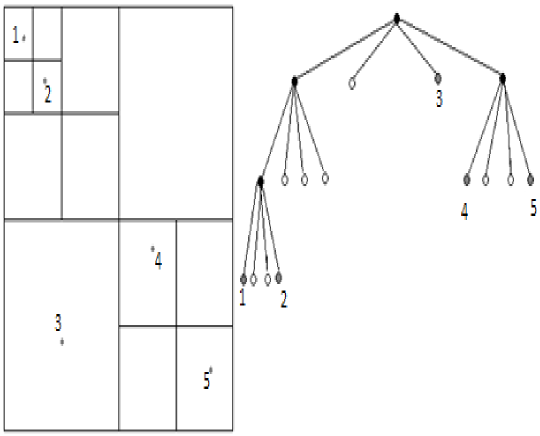

Fig. 2 Topology configuration after Movement of node 2

Thus, as the node moves from its original location, the KPR tree reconstructs itself with respect to the new location of the mobile node and hence has the node in range. This improves the sensing capability as the region is still monitored in spite of the node mobility.

The grid mapping of a sample cluster and the formation of the KPR Tree from the grid mapped cluster is shown in Fig. 3. Considering the parameters like time, initial position and the velocity of the nodes, the topology of the sensor network is defined in terms of a Dynamic Quad Tree [19].

The movement of the nodes over time would change the structure of the PR quad tree's sub trees. This Dynamic Quad Tree is a top-down tree which is hierarchically structured and height imbalanced. The Quad tree takes into account the static as well as the mobile sensor nodes.

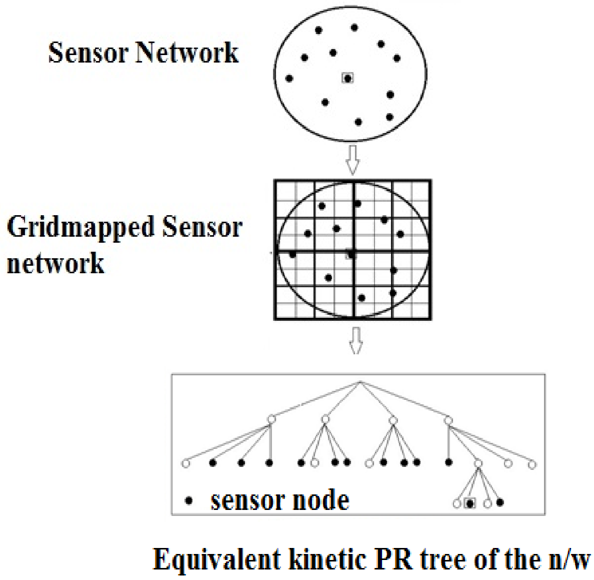

Fig. 3 Construction of KPR Tree from sensor cluster

If a particular cell or quadrant contains more than one sensor node, then it should be further subdivided into four equal sized quadrants based on the principle of recursive decomposition.

Every quadrant is assumed to be a node of the quad tree and the sub-quadrants, its children. Any division in the quadrants leads to an increase in the depth of the quad tree. In any event, when the node moves from one quadrant to the other, the quad tree reconstructs itself.

At regular time intervals, the Dynamic Quad tree algorithm is iterated so that the mobile nodes in dynamic network are tracked precisely by the parent child relationship of the tree.

4.1.2 Topology management

In dynamic wireless sensor networks, the nodes tend to move with a well-defined velocity in a particular direction. The topology table consists of node ID (N_{id}) and quadrant ID(Q_{id}). The node ID is the unique number the node is assigned during deployment.

Every node also has the corresponding Q_{id} denoting the quadrant to which it belongs to.

The length of the quadrant id purely depends on the number of levels into which the quadrant division happens.

If there is only one level of division the length of the Q_{id} is one. Supposing there are n levels of quadrant division there are n digits in the Q_{id}, with each digit representing the quadrant in its corresponding level of division. The initial and the updated topology table for Fig 1 and 2 are shown here

Node ID (N_{id})	1	2	3	4	5
Quadrant ID (Q_{id})	Q_{11}	Q_{12}	Q_4	Q_{31}	Q_{33}

Table 1: Topology table for Fig 1

Node ID (N_{id})	1	2	3	4	5
Quadrant ID (Q_{id})	Q_{111}	Q_{113}	Q_4	Q_{31}	Q_{33}

Table 2: Topology table for Fig 2

4.1.3 Reconfiguration of Nodes

During the topology update phase, the topology table is updated. This phase gets repeated in the periodic intervals. Apart from periodic updating, certain events like depletion of energy in nodes, node failure, link failure, querying the nodes or nodes moving out of range triggers the topology update phase.

4.1.4 Construction and Reconstruction of Topology Tree

The KPR tree is a dynamic tree whose structure changes dynamically with the changes in network topology. The topology of the network mainly depends on the node position, and as the node velocity increases and the node changes its position, the topology of the network changes.

The change in the topology of the network is detected when a node moves and hits the boundary of a sub-quadrant. The intersection of a node at a boundary is stored in a priority queue. These intersections are prioritized and based on the priority, reconstruction queries are kindled. Hence, when a node moves, it intersects with the boundary, and the entries in the intersection queue are serviced based on priority thereby instantaneously reconstructing the tree.

Algorithm : Construction of KPR Tree from Network

```
Kpr:begin
    terminate = false;
    map network area into grid
        begin
            repeat
            split grid into quadrants
                if there is only one node in each quadrant then
                terminate=true
                until terminate=false
                end
            assign each quadrant to a quad tree node
            if velocity of node != 0 then
            goto Kpr
end
```

Fig.4. Construction of KPR Tree

As the reconstruction of the tree happens dynamically, node mobility is addressed and hence data loss due to node movement is reduced or even trivialized thereby improving network reliability.

4.2 Fuzzy Link Quality Assessment Algorithm (F-LQA)

Fuzzy logic imitates the logic of human thought, which is much less rigid than the calculations performed by computer. It is a decision making logic that maps the input variables that need to be analyzed to the corresponding optimized output based on the rules set for fuzzy. It offers several unique features that make it a good alternative for many control problems. It deals with the analysis of information by using fuzzy sets, each of which may represent a linguistic term like “Warm”, “High” etc.

Fuzzy sets are described by the range of real values over which the set is mapped called domain and the membership function. The membership function assigns a truth value between 0 and 1 to each point in the domain of fuzzy sets. A fuzzy system has three process, namely fuzzifier, inference engine and defuzzifier [20][21]. The fuzzifier maps each input value to the corresponding fuzzy sets and thus assigns a degree of membership for each fuzzy set. These fuzzied values are processed by the inference engine, which consist of a rule base. The rule base is simply a series of IF – THEN rules that relate the fuzzy variables with the output fuzzy variables. Defuzzifier performs defuzzification on the fuzzy solution phase [22]. That is, it finds a single crisp output value from the solution fuzzy set using techniques like centroid, composite maximum, composite mass, etc.

Fuzzy Variables:

From the list of parameters affecting the link quality, the three parameters that greatly impact the performance of the link are *Asymmetry, Delay* and *Residual Energy of the nodes.*

Asymmetry:

Asymmetry is the difference in connectivity between the uplink and the downlink. The communication between the sensor nodes is usually bidirectional. Asymmetry is mainly because of the discrepancy in terms of hardware calibration, i.e. nodes do not have the same effective transmission power, reception sensitivity and noise floor. Therefore, it is not sufficient to estimate the link quality as the quality of the link in one direction. *F-LQA* takes into account link asymmetry by measuring the difference between the uplink *PRR* (PRR_{up}) and the downlink (PRR_{down}), where PRR is the Packet Reception Rate which is the ratio of the number of data packets received to the total number of packets sent:

$$AsymmetryLevel(A) = \left| PRR_{up} - PRR_{down} \right| \quad (1)$$

Average Energy Level (E):

Average Energy level (E) of the nodes forming the link is assumed to be the virtual energy of a link. The energy required to sense events is usually a constant and cannot be controlled. Hence, the energy expended to keep the communication system on (for listening to the medium and for control packets) is the dominant component of energy consumption. The Energy level is a normalized value between 0 and 1.

Delay (D):

It is important to measure packet transmission delays inside the network so that real-time control strategies can be adjusted (e.g., in plant automation and control), and abnormal delays can be detected and corrected in a timely manner. Delay is the difference between the time in which the packet is sent to the time in which packet is received.

$$Delay(D) = Time_{received} - Time_{sent} \quad (2)$$

$Time_{received}$: Time in which data packet is received by a receiver node.

$Time_{sent}$: Time in which the same data packet is sent to the receiver by a transmitter node.

Fuzzification

Consider sensor network G(S,L) where S are the sensor nodes $s_1,s_2,s_3,.....s_n$ deployed randomly in the environment and links l_1, l_2, ... l_n are the links connecting the nodes.

Let us assume the universal fuzzy set as $S=\{s_1,s_2,s_3......s_n\}$. During the formation of quad tree, nodes are aligned under parent node and are considered as elements in subsets.

Let us take the subset A where node s_1 is placed. Then its subset is given by Z (A) =$\{\mu_A(S), 0, 0....0\}$.

For subset B having elements as s_2 & s_4 then Z(B)=$\{0,\mu_B(S),0.\mu_B(S),0,0...0\}$, where μ(S) is the membership function of sensor node S_i for the respective subset. This value lies between 0 and 1 depending on D, A and E.

The membership function describes the membership of the elements ‘s’ of the base set ‘S’ in the fuzzy set ‘A’, whereby for $\mu_A(S)$, a large class of functions can be taken[23][24].

Here Hammacher’s function which is one of the Fuzzy Intersection operations is used to convert the input parameters into crisp values.

$$MalfunctionIndex(MI)_{(A,E,D)} = \frac{A.D}{E+(1-E)(A+D-A.D)} \quad (3)$$

Where

A is the asymmetry in a link

D is the delay between the nodes in a link

E is the residual energy.

The Hammacher's function yields a Malfunction index (MI) . Much lower the value of MI is, much better the link is. The resulting value after fuzzification is computed for each link. The MI value which is the output of F-LQA acts as a decision maker in Optimal Sequential testing in categorizing the link to be good or bad. The expected testing cost of this approach is computed using Equation (4).

$$T = \sum_{i=1}^{n} c_i + (1-p_i)c_{i+1} + c_M \quad (4)$$

Where

c_i - cost of testing a link (includes the computational overhead like control packets)

p_i - probability of the link being faulty

c_M- cost of computing the Malfunction Index for each link.

The F-LQA algorithm used for the computation of the MI Value is found to be more reliable than any of the classical approaches of link quality assessment as it considers three parameters, namely Delay, Asymmetry, Residual energy level of nodes for link quality evaluation in the network rather than a single parameter.

Thus the decision taken whether the link of the node is classified to good or bad is strong and stable. The Fuzzy set and its membership functions are defined for all the variables delay, Asymmetry and energy are shown is Fig 5 and for various levels the decision states are framed. Based on the conditions observed for fuzzy variables the quality of the link is observed and is decided to be stable or not.

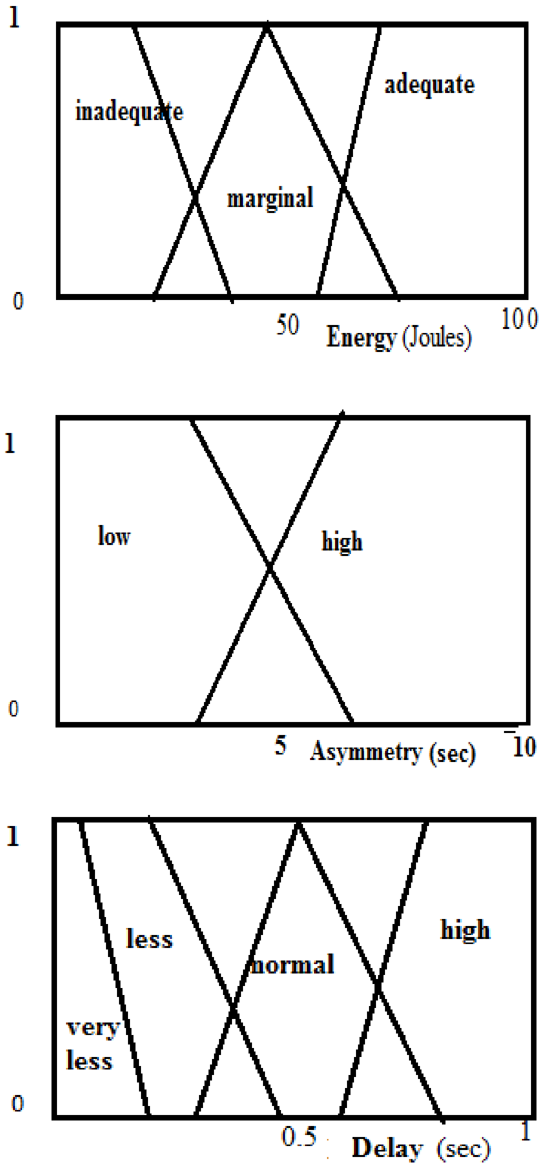

Fig 5. Membership function for fuzzy variables

It is possible for a node to have adequate energy E_a or inadequate energy E_{ia} depending on sensing, processing and communication processes. Symmetry refers to the synchronous communication between two sensor nodes. It may be low (S_l) or high (S_h) depend on the hardware specifications used for nodes. The parameter delay may be considered as very less (D_{vl}), less (D_l), normal (D_n) or high (D_h) depending on environmental factors, traffic, link quality etc.

Based on the fuzzy variables 3×2×4 = 24 fuzzy rules can be implemented to get the optimized result. Some of the fuzzy rule set is given in the following table:

Energy (E)	Asymmetry (A)	Delay (D)	Link Quality (LQ)	Decision states
Inadequate	High	High	Worst	X_0
Inadequate	High	Normal	Poor	X_1
Inadequate	High	Very less	Poor	X_2
Adequate	High	Normal	Good	X_3
Adequate	Low	Very Less	Excellent	X_4
Marginal	High	Normal	Good	X_5
Marginal	Low	Normal	Good	X_6
Inadequate	Low	Very less	Poor	X_7
Inadequate	High	Very less	Poor	X_8

Table 3. Fuzzy rule for fuzzy variables

Based on the fuzzy variables, decision is made about the link quality. Then the node decides whether to follow that route or not.

$$P\,(E_a \cup A_s \cup D_{vl}) = LQ_E \qquad (5)$$

Where LQ_E refers to Excellent Link quality.

The membership functions for fuzzy variables are

$$\mu(E) = \begin{cases} 0 & ; \quad E < E_1 \\ \dfrac{E-E_1}{E_2-E_1} & ; \quad E_1 \le E \le E_2 \\ 1 & ; \quad E > E_2 \end{cases} \qquad (6)$$

$$\mu(A) = \begin{cases} 0 & ; \quad A < A_1 \\ \dfrac{A-A_1}{A_2-A_1} & ; \quad A_1 \le A \le A_2 \\ 1 & ; \quad A > A_2 \end{cases} \qquad (7)$$

$$\mu(D) = \begin{cases} 0 & ; \quad D < D_1 \\ \dfrac{D-D_1}{D_2-D_1} & ; \quad D_1 \le D \le D_2 \\ 1 & ; \quad D > D_2 \end{cases} \qquad (8)$$

The optimized Link Quality for a link related to the particular path consisting of n_1 nodes is given by

$$\text{LQ} = \frac{\mu_E\left(\sum_{1}^{n_1}(1-\mu_D)/n_1\right)}{1-\mu_S} \qquad (9)$$

For a network of ‘n’ nodes, link quality is given by

$$\text{LQ} = \frac{\sum_{1}^{n}\mu_E\left(\frac{\sum_{1}^{n_1}(1-\mu_D)}{n_1}\right)/1-\mu_s}{n} \qquad (10)$$

This algorithm is implemented and results are compared in the next section.

5. Performance Analysis

We conducted several experiments to compare our algorithm with other protocols. The structure of a simulation model is described using the Tcl scripting language in NS2 Simulator. The experimental setup includes a sink and sensor nodes varying form hundred to thousand nodes. For each run the topology is generated randomly. The nodes are dynamically moving with constant velocity and are assumed to have identical computational power and capability (Homogenous network).

To evaluate the performance, the algorithms are subjected to evaluation under performance metrics of reconfiguration time and Link Quality. The readings obtained from the Network Animator window and trace file are plotted for varying number of nodes and links.

The simulation of F-LQA is implemented in Network Simulator 2 with the following simulation setup given in Table 4.

Parameters	Description
Number of nodes	100
Network Size	100m x 100m
Data size	6400 bytes
Control packet	100 bits
Topology	Dynamic
Initial Energy	0.5J
Simulator	NS-2

Table 4. Simulation Setup Parameters.

The relationship between the various parameters taken and its membership function is analyzed and is plotted in figure 6, figure 7 and figure 8.

Link Quality Over a wireless sensor network is tested and analyzed for various values and the result shows that the achievement of better link quality for optimised values of variables taken.

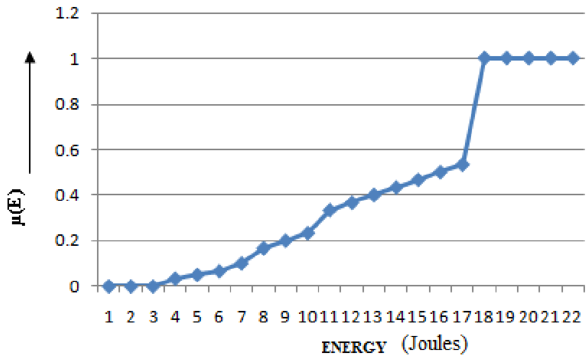

Figure 6. Energy Vs µ(E)

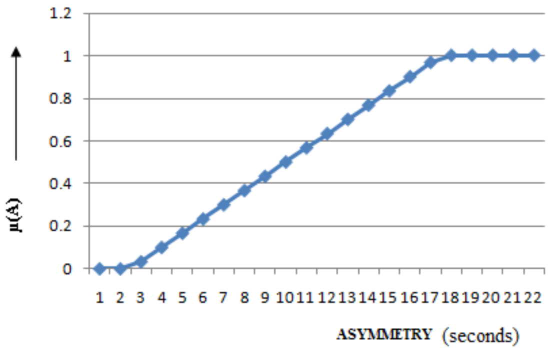

Figure 7. Asymmetry Vs µ(A)

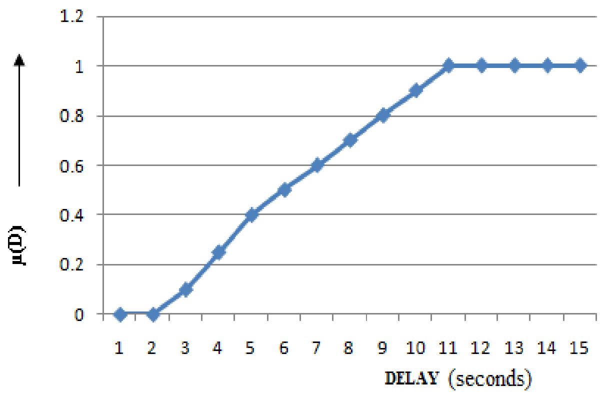

Figure 8. Delay Vs µ(D)

Figure 9 shows the result of Link quality observed for various states stated in Table 3.From Figure 9 it is observed that link quality is excellent when Energy is adequate, Asymmetry is low and the delay is very less and is calculated from equation (9) and it is a quality index.

It can be seen from Fig.10 that as the density of nodes increases the time consumed for reconstruction of tree topology increases. The increase in time is due to the time incurred for quadrant splitting and configuration of nodes. Once the higher level tree structure is formed new nodes

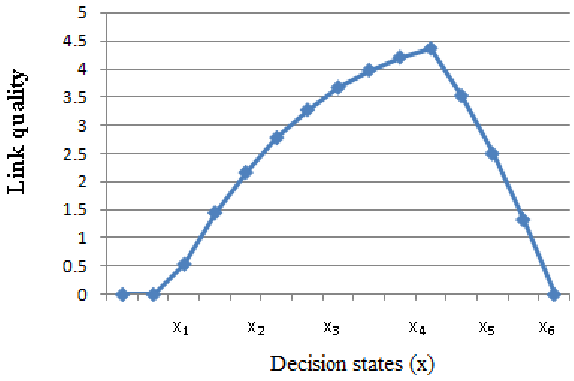

Figure 9 Link Quality for various values of Energy, Asymmetry and delay

are added as leaf nodes with minimal changes in the topology and hence the reconfiguration time is almost constant.

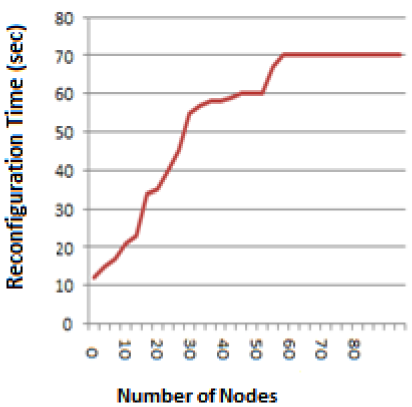

Fig. 10 Reconfiguration Time in KPR Tree for Dynamic Nodes

In general, it is observed that the time taken to detect faults increases as the number of faults in the network increases. But the F-LQA algorithm, only faulty links are tested and it zeroes down the link responsible for the faultiness of the bad topology. So it is found that it consumes less time than any other classical approach for Link Quality estimating techniques like RSSI (Received signal strength indication), PRR (Packet Reception rate) etc. This is because deducing the Malfunction Index involves computation of parameters like delay, Asymmetry, and residual energy which adds up to the time. The traditional methodology of testing the network involves testing of each and every link and hence the cost is higher whereas in our approach we use the fuzzy logic, which incurs only an optimal cost since not all the links need to be tested. Only the links that has a higher probability of being faulty is subjected to testing.

When it comes to cost (computational overhead like control packets, time, etc.), by considering the whole network only fewer links are tested rather than testing all the links and hence, the cost is very much reduced. It is found that the cost of the proposed algorithm is around twenty percent lesser than that of the classical approaches like RSSI and PRR based approaches.

6. Conclusion

The present work demonstrates the usefulness of the F-LQA algorithm for isolation of faulty links in a Dynamic wireless Sensor Network. Different from previous approaches, a new Fuzzy logic has been devised which aggregates various critical parameters which influence the link quality and hence helps in the identification of faulty links in the network. Extensive simulation shows that our heuristic scheme only requires testing a very small set of network components to localize and repair all faults in the network.

Changes in the topology of the network occur due to energy constraints and mobility of nodes. Dynamic Quad tree data structure is used to handle the mobility of the network and store the topology changes. Additional parameters can also be included in the fuzzy logic to enable more accurate estimation of link quality. Hence it reduces the power consumption considerably by managing the quality of the link for the entire network. As a future work we can consider temporal blocking of the faulty links and resuming the transmission once the link quality improves.

The proposed algorithm is used to assess the link quality using energy , symmetry and delay as member functions .The accuracy of this network quality assessment can be improved by considering the link quality parameters like channel noise error, interference and traffic considerations as member functions. The assessed link quality index can also be considered for enhancing the path selection of network routing.

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