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RESEARCH ARTICLE

NODE RECOVERY IN WIRELESS SENSOR NETWORK USING GENETIC ALGORITHM AND FUZZY LOGIC

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Abstract: Wireless Sensor Network (WSN) is an emerging technology for data transfer through a number of sensor nodes. The goal of the sensor node is to collect the data at regular intervals and transfer data to the desired sink node. The consumption of power is the biggest issue in WSN because each sensor node has a limited computational power. The reduction in power leads to the depletion of the sensor nodes which will affect the data transmission. The energy of the sensor nodes will be depleted by either due to sudden dropping of energy in the sensor node or due to any other natural disaster. The dropping of the sensor nodes during transmission will burden the other sensor nodes in the network which are all performing the same task. Thus the node recovery is necessary in the WSN to increase the transmission rate. This paper is to intensify the lifetime of the network when some of the sensor node's are depleted. In this paper Genetic Algorithm (GA) is used to recover the fault node and the fuzzy logic is to define the fuzzy set which defines the set of rules for node selection in a network. These algorithm leads to the fewer replacement of the sensor nodes and increase in reusing routing paths.

Keywords: WSN, Genetic Algorithm, Fuzzy Logic

I. INTRODUCTION

A fault node recovery using genetic algorithm and fuzzy logic in WSN, is to reduce the packet loss and to improve the transmission rate. Each sensor nodes will sense the environment and transfer the sensed data to the other nodes or the sink node in the network. The nodes communicate wirelessly and often self-organized after being deployed in an ad-hoc fashion.

The components of WSN are Processor, Memory, RF Transceiver, Power Source, Sensor. The goal of the sensor node is to collect the data at regular time, then transform the data to the sink or the destination node. The computational power for each sensor node is small in number. One of the biggest disadvantages of large scale wireless sensor networks lies on the complexity of logistics involving selective replacement of sensors that have run out of energy. The power issue in the WSN is one of the source of power which is also hard to replace or recharge. WSN has a large number of sensor nodes to increase the coverage area. When the energy of the sensor node is tired out ,then the depleted sensor nodes will not relay data to the other sensor nodes in the network which lead to the hectic workload to the other sensor nodes. The failed nodes will decrease the Quality Of Service (QOS) of the WSN network.

In WSN it is necessary to maintain a strong connected network all the time. The power consumed by each sensor nodes will be either useful consumption or wasteful consumption. The power consumed during Transmitting or receiving data processing query and forwarding data and query to the neighbor node are useful power consumption while during idle listening to channel, retransmitting because of collision ,generate and handle control packets are wasteful power consumption.

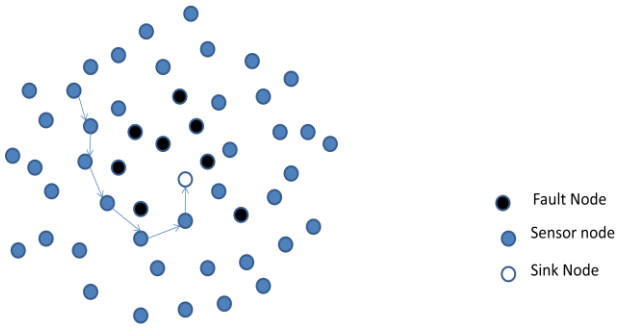

Fig.1 .WSN Routing when some of sensor nodes depleted

Fig.1 describes the effects of the depleted sensor nodes during the transfer of data. This paper on Genetic Algorithm and fuzzy logic is to recover the depleted node in the network. The node depletion may be due to no available power or it may reached the threshold level. By using this method the fault node will be replaced by the fewer changes in the sensor node and more changes in the routing path which leads to the lower cost for the replacement of sensor nodes.

This section describes the technologies adopted for a fault node recovery using genetic algorithm and fuzzy logic in WSN . Section 2 describes the System Model. Section 3 describes the Genetic Implementation. Section 4 describes Fuzzy Process. Section 5 describes Route Maintenance.

II. SYSTEM MODEL

In WSN each sensor nodes will be placed within coverage area of a network, where the data will be transferred between the nodes. It's necessary to define the number of nodes to be active within a network. When a number of sensor nodes are smaller for a large coverage area then the energy loss will occur in all sensor nodes .Then there will be increase in traffic during the data transmission ,this will lead to the loss of data packets. Thus the consideration of network area and the number of sensor nodes which are participating in the network is the important task to initiate the network.

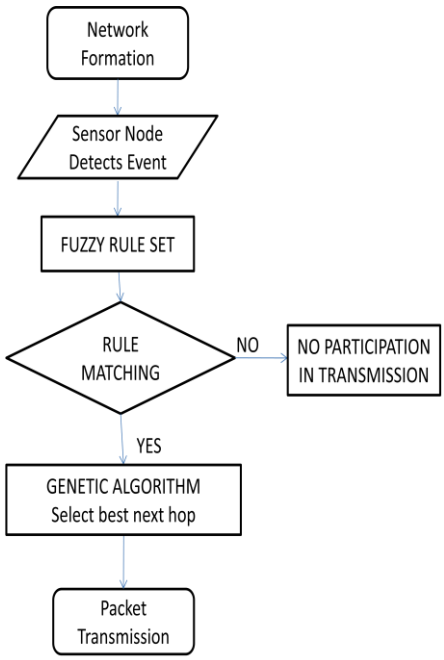

Fig 2. System Model

Fig.2 describes the overall process in the transmission of packet using Fuzzy Logic and Genetic Algorithm . The network is formed with the n number of sensor nodes along with its own residual energy. Then each sensor nodes will detect the event in the network. After event detection the Fuzzy rule will be set to the detected event . The sensor nodes which satisfy the Fuzzy rule will perform the Genetic Algorithm , from which the sensor node with best fitness value will be selected for the event transmission.

III. FUZZY IMPLEMENTATION

Fuzzy logic is to provide the partial value rather than the exact values. The fuzzy logic will define the truth and false value along with the various values of truth value in between them. The fuzzy rule set may be formed based on the physical properties of each sensor nodes which include the nodes residual energy and energy bandwidth . The fuzzy logic will not recover the fault if any problem has occurred, it will define only the satisfaction of the fuzzy rule.

Fuzzy logic is used in the network to define the neighbor nodes which satisfy the fuzzy rule. The sensor nodes residual energy, traffic control, bandwidth usage is taken into account to testify the sensor nodes satisfaction of rule set. If the sensor node meets the rule set condition then the sensor node will be taken into account. The sensor nodes which does not satisfy the condition will not be taken into account. Based on the selected sensor nodes from the fuzzy set the Genetic Algorithm will be done to define the best sensor node from the selected sensor nodes.

The sensor nodes which satisfy the fuzzy rule set will be taken into account in the network transmission. The sensor nodes which do not satisfy the rule will not be taken into part. The fuzzy rule set will define the satisfying sensor nodes in the sequence of order with the highest Residual energy . Based on which the Genetic Algorithm will be performed to define the best sensor node to transfer the packet to the sink node.

IV. GENETIC IMPLEMENTATION

Genetic Algorithm(GA) is one of the approach to find the optimal solution for a problem. GA algorithm is a type of searching algorithm where the optimal solution for the problem will be identified.GA generates a population which is a possible solution for the problem. Population is the group of possible solutions to the given problem. Each possible solution of the population is called individual. Population is formed by the number of possible individuals. Individuals contain a string or bit of values called as genes. The best solution of the problem from the solution is identified by analyzing the fitness value for the population. The individual with the best fitness value is used for recovery of the fault nodes in a network. The Evaluation function is also used in GA to evaluate the each individual. The fitness function is used to select the best fitting individual to the given problem. In WSN, the main problem is the depletion of the energy in the sensor nodes. GA focus on the nodes with best residual energy for this energy depletion problem.

GENE	5	6	12	15	17	19	24	32	46
VALUE	1	1	0	0	1	0	1	0	1

Fig 3. Individual

From Fig.3 the general form of the Individual can be known where the gene value 0 represents the no replacements of the desired sensor node and the value 1 represents the replacement of sensor node. It's an example of one possible solution for the sensor nodes in the network.

Initially the GA generates the P number of population for the problem. Each population will have the N number of individuals. Then the fitness Function will be evaluated on the each individuals in the population. The number of individuals which do not meet the fitness value will be eliminated from the population. Then the population will have the M number of individuals. The recovery of the GA is to generate the (N-M) number of new individuals. Then the generated new individuals will be added to the population.

The Individuals which satisfy the fitness function has to perform the cross over and mutation. The cross over will be done by selecting the two individuals from the new population where the fitness value is checked, then the individuals will be cross over by any one of the methods. The cross over methods which can be done over the fitness selected individuals are single point cross over, double point cross over or multi point cross over. In our algorithm we have used multi point cross over. The cross over will randomly select the gene of the each individuals then swap the selected gene value and concatenated with each other, the resulted value will generate the new two individuals. The random selection of genes will be done by the roulette-wheel selection and based on the fitness value.

After the cross over the mutation function will occur, where the gene value of the newly generated individuals will randomly change the value. By which the sudden generation of the new individuals will be slow down to avoid problems. The newly generated individuals should also satisfy the fitness value if it does not ,then the process has to repeat until the generated individuals meets the fitness value. By which the node can be recovered using the genetic algorithm.

By using these methods the Genetic Algorithm will select the best neighbor/sensor node for the packet transmission to the destination node from the fuzzy set selected node. By which the dropping of the packet can be reduced throughout the transmission and the depletion of energy in the sensor nodes during transmission will also be reduced, which will increase the lifetime of the network.

V. ROUTE MAINTENANCE

Routing is the important consideration in the WSN while transferring the data packets to the desired sensor node. The routing will maintain each and every movement of changes in the network and also provide information about the shortest routing paths to the destination from the source node. The routing information has to be managed throughout the entire transformation of the network. In WSN the network may be changed due to the depletion of the sensor nodes or by the movement of the each sensor nodes. These depletion will lead to the leak in the coverage of the network then the route information will become invalid if the routing is not updated periodically.

The routing information has to be updated and transferred to the each sensor nodes in the network. If the route is not maintained periodically, then the hop count of the each sensor node will vary, which will lead to the assumption of false shortest distance and also the faulty nodes will take place in the transmission. This will arise the dropping of the data packets which will reduce the transmission rate.

The route Link state changes has to be periodically updated by all nodes to maintain the active nodes in the network. If any node in the network found link failure, it has to be informed to all of its neighbor node through control messages. On receiving the control message , each node has to update its route information. Also each entry has some timeout value after that it needs to be purged out from the table by which the random updating will perform automatically. The route maintenance will reduce the occurrence of packet rerouting and it will also perform the regular update of routing table in the network.

VI. SIMULATION

A simulation of the fault node recovery using Genetic Algorithm and Fuzzy Logic is performed to verify the defined algorithm. The experiment is designed based on 3-D space, using 100× 100 × 100 units. The transmission range of the sensor nodes are set to 30 units which is the each sensor nodes coverage area. Each sensor node can transmit the packets to the nodes which are within the distance range of 30 units. In each of these simulations, the sensor nodes are distributed uniformly over the space. There are 100 nodes in the Wireless Sensor Network and the sink node was defined randomly over the network. The movement of the sensor nodes are made randomly over the simulation.

The number of sensor nodes in the network is set to 100 nodes. In the network, multiple source node and sink nodes are defined. Therefore the data packages are exchanged between random source/destination . In our simulations, the energy of each sensor node was set to 100 joules that is the actual available energy of each sensor node at the starting of the simulation. The dropping of the sensor node energy is defined with the changing of color in the nam animator.

The Energy Model is defined with the Transmission power of 0.2 watts , then the Transmission time of 0.005 ms , Sleep power of 0.001 watts , Transmission power of 1.0 watts & the receiving power of 1.0 watts. By defining these in the Energy Model the depletion of each nodes residual power can be defined. In the GA algorithm, the population size is 100; the crossover rate is 80%; and the mutation rate is 15%. The active node means that the sensor node has enough energy to transfer data to other nodes during the transmission. But some sensor nodes cannot be active throughout the entire network because of the residual energy resides in the node may reach its threshold level. In the simulation plot graph the Existing defines the Fault Node Recovery (FNR) algorithm and the proposed defines the node recovery with fuzzy logic and Genetic Algorithm.

The packet loss based on the increase of the packet size is defined in the Fig .4 where it defines the loss of packet in the network based on the increase in packet size. The proposed algorithm has low packet loss when compared to the FNR algorithm. In WSN the same event will be transferred to the sink nodes. So the sensor node will detect the event which has already reached the sink node. So the sensor node will drop the event, which will be taken into the account of the dropping of packets. The packet loss will become low when the size of the packet is increased. Both the algorithms have low packet loss ratio when the packet size is 250. But defining the high packet size will also become the problem for the small event. Based on the event the packet size has to be defined.

In Fig.5 the energy variance of each sensor node on the Wireless Sensor Network is defined. The proposed algorithm has the lower energy difference in the average sensor nodes energy in the network when compared to the FNR algorithm. The FNR algorithm has more energy variance after the simulation time of 30 s . The proposed algorithm will reduce the replacement of sensor nodes by selecting the sensor nodes with the higher residual energy using fuzzy and Genetic Algorithm in the network.

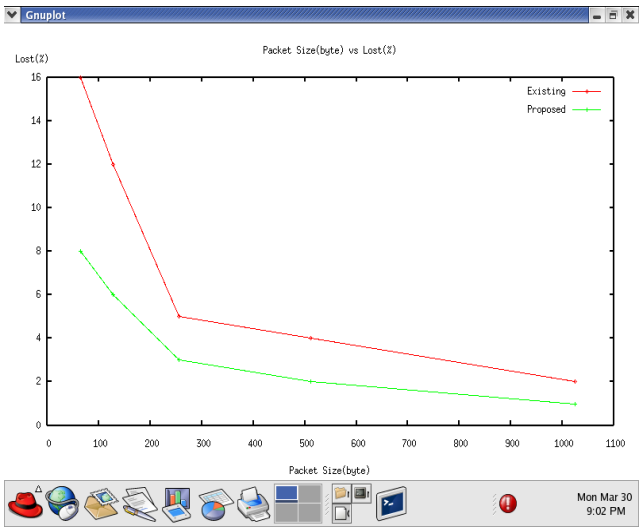

Fig. 4 Packet Loss

The energy of the sensor nodes will be dropped based on the energy transmission and receiving energy. The higher energy drop is caused by the idle power. If the sensor nodes dropping the high energy during the idle time in the network then the energy of the sensor node will deplete high.

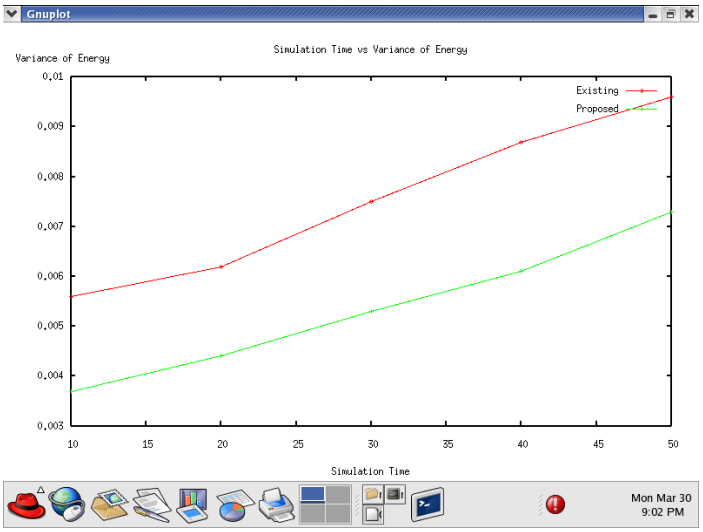

Fig. 5 Energy Variance

In Fig. 6 the packet delivery ratio is defined for the network which varies with the simulation time. The packet delivery ratio is nothing but the number of packets reached the sink node which are generated from the source node. The dropping of the packets will occur due to the depleted nodes in the network. The replacement of depletion energy sensor node will also reduce the number of dropping packets. The Fuzzy logic & genetic algorithm in the network have few dropping packets when compared with the FNR algorithm.

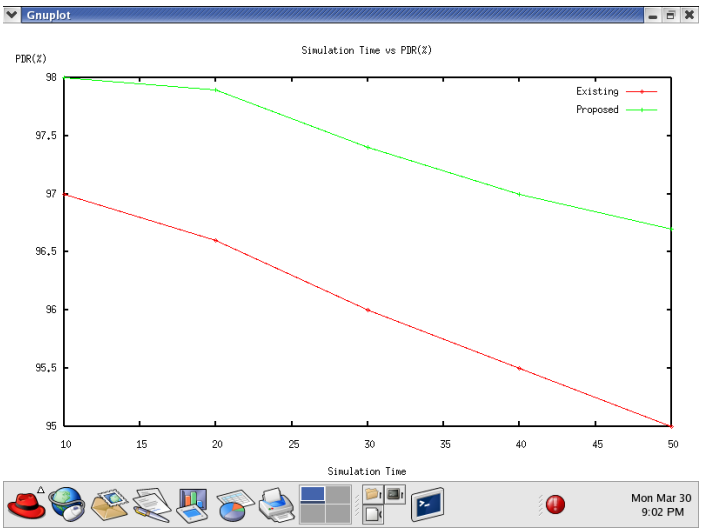

Fig. 6 Packet Delivery Ratio

From the above simulation results the recovery of the sensor node is having better result than the Genetic Algorithm with the Grade Diffusion algorithm. By assigning the fuzzy rule set, the end to end delay will be reduced in number during the transmission. The fuzzy rule set was based on the nodes residual energy during the packet transmission. By assigning the rule set in the network, the overall replacement of sensor nodes in the network will reduce in large number. The fewer replacement of the sensor nodes will increase the each nodes' residual energy. Thus the number of active nodes throughout the network will be large in numbers. By using the GA and fuzzy logic the performance of the network will increase in the network.

VII. CONCLUSION

WSN is the increasing technology to transfer the data and processing the data. In WSN each sensor node use residual energy to perform the transformation. The replacement of energy power in the sensor nodes is the tedious task. The sensor node energy drop will deplete the node in the network, which will lead to the dropping of data packets in the transmission. The packet loss will randomly reduce the transmission rate which will affect the entire network. Thus the recovery of the sensor node is the necessary task in the WSN. The fuzzy logic and Genetic Algorithm are proposed to reduce the dropping of packets and increase the number of active nodes by defining the fuzzy rule set to define the sensor nodes with the high residual energy and throughput ratio from which the Genetic Algorithm is used to select the best sensor node to transfer the packet to the sink node. These algorithms will reduce the number of depleted sensor nodes and number of dropped packets in the network.

VIII. FUTURE WORK

In the future planning on implementing the fuzzy rule with the membership function along with fuzzy rule set in the simulator. Defining the membership function with the if-then-else rule rather than the graphical representation.

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