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FRRSCR -Fuzzy Based Robust Reliable and Scalable Clustered Routing Protocol for WSN

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ABSTRACT
Energy consumption is of crucial concern while designing a routing protocol for wireless sensor networks(WSN). In this paper Fuzzy Based Robust, Reliable and Scalable Clustered Routing Protocol(FRRSCR) is proposed, which reduces the total energy required for the network to prolong the lifetime of network considerably. The clustering is done only once for the entire network lifetime. The clusters are formed as levels and the Cluster Heads are selected very efficiently by introducing fuzzy. In order to reduce the delay during transmission, data is forwarded to the upper level Cluster Heads if the distance is less. In addition backward transmission is avoided to minimize the energy consumption and also to improve the bandwidth utilization. By simulation it is proven that the proposed protocol outperforms the other existing protocol in network life time, efficient utilization of bandwidth, data transmission rate,minimal delay and processing overhead.

Keywords: Routing, Energy Efficiency, Fuzzy, Cluster Head

1.INTRODUCTION

A Wireless Sensor Network[1]in a computer network consists of a collection of dedicated transducers with a communication'sfor monitoring and recording conditions at various locations. The processor has many number of roles including: managing data collection from the sensors, performing power management functions, interfacing the sensor data to the physical radio layer and managing the radio network protocol. It provides a bridge between the real physical and virtual worlds.

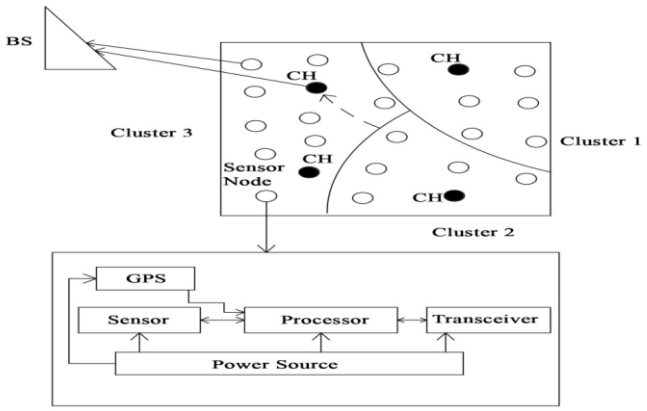

Figure 1:Simple Wireless Sensor Network

Commonly observed factors of sensors are temperature, humidity, pressure, wind direction and speed, illumination intensity, vibration intensity, sound intensity, power line voltage, chemical concentrations, pollutant levels and vital body functions.A sensor node may differ in size from that of a shoebox down to the size of a grain of dust. The cost of sensor nodes is similarly variable, ranging from hundreds of dollars to a few pennies, depending on the size of the sensor network and the complexity required of individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and bandwidth. Wireless sensor networks can also develop remote access to sensor data by using Base stations which connect them to other networks, such as the Internet, using wide-area wireless links. If the sensors communicate their data to the base station, users can access it from Base stations to observe and manage the environment.

Routing in WSNs is a very demanding technique owing to the intrinsic features that differentiate these networks from other wireless networks like mobile, ad hoc networks or cellular networks. Due to the reasonably huge number of sensor nodes, it is good to have a global addressing scheme for the operation of a huge number of sensor nodes as the overhead as ID maintenance is high. So conventional IP-based protocols will not be useful to WSNs.

A key element of any wireless sensing node is to minimize the power consumed by the system. There are a lot of approaches that can be used to reduce the normal supply current of the radio,that includes :minimizing the number of transmissions by data compression and reduction, minimizing the transceiver duty cycle and frequency of data transmissions, reducing the processing overhead, introducing harsh power management mechanisms and introducing an event driven transmission policy.

Fuzzy rule based system also included in the routing of WSN for the less consumption of energy. As any fuzzy rule based system Mamdani type is used for inference processes due to its simple structure[2][3][4][5][6][7]. It consists of two components:i)the fuzzy interference system that implements the fuzzy reasoning process that is used to give the input to the system to get the output from the system,ii)the fuzzy knowledge base which includes the knowledge about the problem to be solved. The knowledge base consists to two components:i)the fuzzy rule base which consists of fuzzy IF THEN ELSE rule that includes linguistic variables that values

with a real world meaning,ii)fuzzy data base that contains the membership function of the fuzzy partitions associated to the linguistic variables. There are four stages toget the crisp value from the fuzzy interference system. The firststep is to assess the antecedent for each rule. Thesecond step is to get the conclusion of each rule.The third step is to aggregate conclusions and thelast step is defuzzification.

The paper is planned as follows :Section 2 provides the detailed information of the related work. Overview of the new algorithm and the FRRSCR protocol has been outlined in section 3. Simulation results are discussed in section 4 and section 5 describes the conclusion and future enhancement.

2. RELATED WORK

Chunyao FU et. al, proposes LEACH[8], that is the first implemented hierarchical routing protocol for energy efficient WSN is LEACH. In this, LEACH, nodes send their data to Sink regularly which is situated far away from the sensor field. IT is a self adaptive and self-organized protocol. In order to consume low energy it uses few number of cluster heads to collect and transmit data. In LEACH protocol, the cluster heads transmit their data directly to the Sink.Since the sink nodes are placed far away from the sensor field cluster head requires more energy to transmit data and it will go off quickly than that of other nodes. So reclustering occur very often to select a new cluster head and it is increasing the processing overhead.

The operation of a LEACH protocol is done as rounds and each round consistsof two stages. They are setup phase and steady state phase. In the first stage clusters are formed and Cluster Heads are identified. In order to become a cluster head a node has to select a random number between 0 and 1. If the nodes random number is less than the threshold value T(n) then it is eligible to become a CH for the current node. The node can act as a CH for one time only. The threshold value T(n) is calculated as:

$$T(n)= T(n)= \begin{cases} \frac{p}{1-p(r \bmod \frac{1}{p})} & if\ n \in G \end{cases} \quad (1)$$

Where, G is the set of nodes that wants to participate in the CH selection, r is the random number have the value between 0 and 1, 1/p is the set of nodes that have not participated in the last rounds for CH selection. In the second stage data transmission will happen from Cluster Head to sink node. The identified Cluster Heads will broadcast an ADV message informing their status to the non cluster head nodes. By seeing this message nodes will join with the appropriate CHS to become a member node for the same. The CH generates a TDMA schedule and assign the same to the member nodes. Now the member nodes transmit data in the assigned time slot. Even though LEACH can increase the lifetime of network, still it is having more issues. First it is not applicable for large networks due to its required computational power. In LEACH, reclustering is required and the identification of CH in every round gives more processing overhead.

Chung-Horng Lung et. al, proposes DHAC [9] whichis a clustering approach without the need of a global information about the network. The key focus is that it requires only one hop information to form a cluster. It is a bottom up approach. To execute DHAC the location information is a optional one. The CHs are identified only once and reclustering is not required. Due to this energy consumption is minimized and network life is prolonged. In DHAC, clustering is done first then the CHs are identified in a reverse order. There is no control over backward transmission. The operation of DHAC consists of several steps. In the first step either quality or quantity data is obtained as input data set. Secondly, the resemblance coefficients are computed. In the third step similar nodes are found by distributed clustering algorithm. The last three steps are cutting the cluster tree with the threshold, merging the smaller cluster, and electing the CHs.

3. PROPOSED SYSTEM

The most important crisis of LEACH is that it identifies the cluster heads using a probability value and it is not bothering nodes'residual energy, delivery ratio and connectivity. It requires reclustering often, thus increasing the processing overhead. Also it is not suitable for large networks due to the area coverage. In DHAC reclusteringdoes not happens but for the selection of CH nodes'residual energy, delivery ratio and connectivity are not considered. This type of approaches are not suitable for an energy efficient routing protocol. For reduced consumption of energy, wide network coverage and an efficient cluster head, a new protocol is required for WSN. So the new protocol FRRSCR is proposed to minimize the energy consumption, reduced delay and processing overhead. This protocol associated with the concept that cluster heads send data directly to the Base Station. Since the transmission is single, hop energy consumption is minimized and the network life time is increased. Initially levels are formed and in each level Cluster Heads are selected efficiently with fuzzy. Then nodes will join with their appropriate CHS. After that transmission starts in which sensor nodes will transmit the data to the CH and they will forward the same to the BS.

3.1. CLUSTERING

In this proposed system clustering is done in three stages. In the first stage levels are formed with hop distance and the nodes are grouped as clusters. In the second stage Cluster Heads are identified in each level so that nodes can communicate to the BS towards CH. Clustering is done in the last stage and the data is transmitted to the BS.

3.1.1 Level Formation Phase

Initially nodes are randomly deployed in a sensor network and the Base Station transmits an ADV message with some required information like hop count etc. While receiving this ADV message with one hop distance the sensor nodes are called as top layer nodes and they set their level value as 1. Now the nodes in level 1 will forward the same ADV message to their neighbours with an incremented hop count value. The nodes receiving the same with a two hop distance are called as second layer nodes and they set their level value as 2. This process continues until this ADV message reaches all nodes in a network and the same sets their level values too[10][11]. So totally ‘l’number of levels are there in a sensor field and each

level consists of some specific number of nodes. The nodes in a level can communicate with the cluster head in the same level or to their upper level.

3.1.2 Cluster Head Identification Phase with Fuzzy Inference Rule

While identifying the cluster heads the things to be considered for the most part are number of cluster heads, parameters used like residual energy, reliability, density, communication cost and mobility, reclustering required or not, size of the cluster and the balanced clusters. In the proposed method CH identification depends mainly on the nodes' energy, density and reliability. First in each level of the network all the nodes'energy, density and reliability are calculated.To reduce the number of cluster heads in each level a minimum of two hop distance is included while choosing the cluster heads. Number of Cluster Head selection in each level is predetermined and if there is no eligible CH in a particular level then it can be choosen from the upper layer also. In order to make this cluster head identification as a efficient one fuzzy concept is incorporated.

For fuzzy rule based system, nodes energy is considered as the deciding parameter because the cluster head must have adequate energy. Secondly density is taken as the next parameter due to the need of enough number of neighbour nodes for the robust communication. Finally nodes delivery ratio is considered as the third parameter for decision. The linguistic variables used are LOW, MEDIUM and HIGH for nodes energy, density and delivery ratio. As per the information on the linguistic variable IF THEN ELSE fuzzy rules are used to made a decision for an efficient cluster head selection. In this proposed system Mamdani linguistic rule is used because it includes expert knowledge. This knowledge depicts the relation between system inputs and output, also it can be simply combined with rules. All the nodes are compared on the basis of chances and the node with the maximum likelihood is elected as the clusterhead.

The proposed fuzzy rule based system takes three parameters for the decision to identify the CH is given in table.

Table 1.Fuzzy Decision Value

Energy	Reliability	Density	Possibility to Identify as CH
LOW	LOW	HIGH	LOW
LOW	LOW	MEDIUM	LOW
LOW	LOW	LOW	LOW
LOW	MEDIUM	HIGH	LOW
LOW	MEDIUM	MEDIUM	LOW
LOW	MEDIUM	LOW	LOW
LOW	HIGH	HIGH	MEDIUM
LOW	HIGH	MEDIUM	MEDIUM
LOW	HIGH	LOW	MEDIUM
MEDIUM	LOW	HIGH	LOW
MEDIUM	LOW	MEDIUM	LOW
MEDIUM	LOW	LOW	LOW
MEDIUM	MEDIUM	HIGH	MEDIUM
MEDIUM	MEDIUM	MEDIUM	MEDIUM
MEDIUM	MEDIUM	LOW	LOW
MEDIUM	HIGH	HIGH	MEDIUM
MEDIUM	HIGH	MEDIUM	MEDIUM
MEDIUM	HIGH	LOW	MEDIUM
HIGH	LOW	HIGH	LOW
HIGH	LOW	MEDIUM	LOW
HIGH	LOW	LOW	LOW
HIGH	MEDIUM	HIGH	HIGH
HIGH	MEDIUM	MEDIUM	HIGH
HIGH	MEDIUM	LOW	MEDIUM
HIGH	HIGH	HIGH	HIGH
HIGH	HIGH	MEDIUM	HIGH
HIGH	HIGH	LOW	HIGH

4.1.3 Cluster Formation Phase and Data Transmission

Once the CHs are identified it will broadcast a HELLO message informing their existence to the non cluster head nodes in the same level and to their lower level nodes.Upon seeing this message, a node who wants to join with a CH will send a joining request with the calculation of distance to the CH. Nodes can join with a minimal distance CH in the same level or with the upper level towards the BS to reduce the transmission delay. To minimize the energy consumption and to reduce the processing overhead the number of nodes to each CH is also balanced with a predetermined value. Now the nodes can transmit the data when event occurs. The nodes can transmit the data to the CH in the same level as well to the upper level CH. So the delay is reduced considerably thus minimizing the energy consumption also.

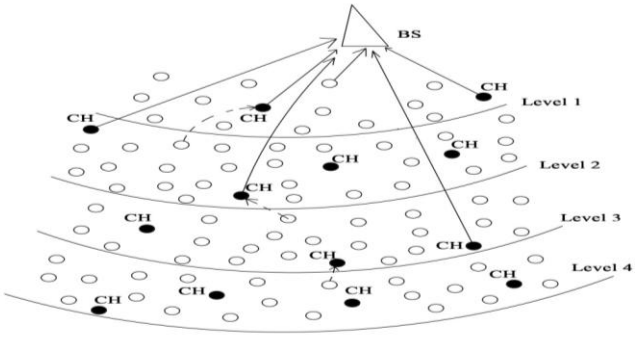

Figure 2.Data Transmission

In order to avoid backward transmission,advanced forward aware factor is also included in the proposed method. So while transmission, the nodes will check the distance to the Base Station also. If it is less,the data will be forwarded straightaway to the Base Station not to the Cluster Head[12]. The algorithm for the proposed method FRRSCR is given below:

No. Of Nodes N
No. Of levels L
Step 1: Randomly Deploy N number of nodes in a sensor network
Step 2: BS Broadcast ADV message
Step 3: Assign L number of levels as $l_1, l_2 .... l_n$, where l
Step 4: For each level l_i
Step 4.1: Calculate nodes energy, reliability and density
Step 4.2: Find number of CHs required
Step 4.3: Find CHs by fuzzy interference system
Step 5: Send HELLO packet from each CH to non cluster head nodes in level i and level i+1
Step 6:Clusters are formed with CHs in level i or level i-1
Step 7: Transmit data when event occurs

Algorithm 1.Cluster Formation and Data Transmission

5. RESULTS AND PERFORMANCE ANALYSIS

The performance of the proposed method is tested with NS2.34. The resultant graphs have been compared with LEACH and DHAC protocols. The network lifetime has been compared in terms of number of sensor nodes.

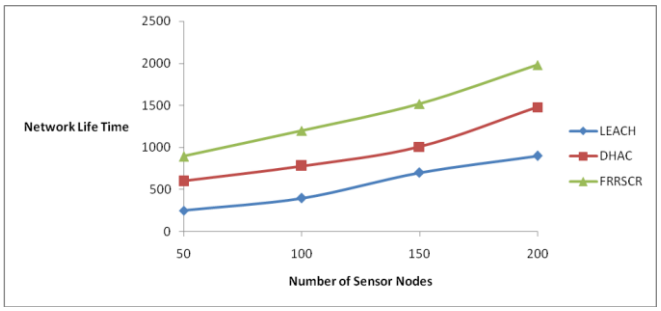

Figure 3.Network Life Time Versus Number of Sensor Nodes

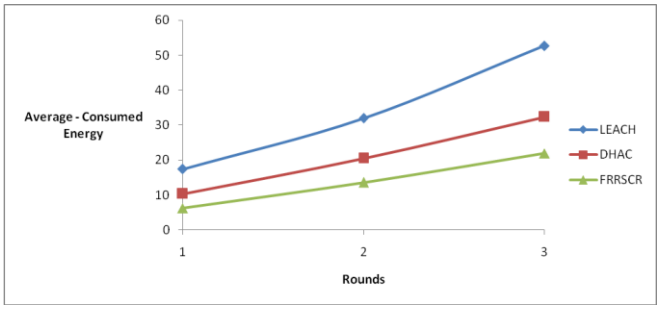

Figure 4.Average-Consumed Energy Versus Number of Rounds

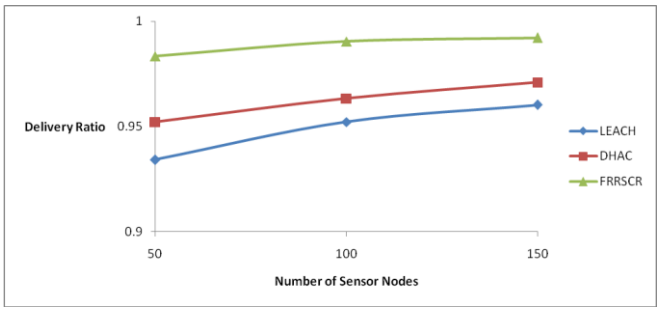

Figure 5.Delivery Ratio Versus Number of Sensor Nodes

From all the simulation results it is proven that the fuzzy logic based cluster head selection minimizes the consumption of energy and for this reason the proposed routing protocol FRRSCR is able to operate more number of rounds. Clearly, the proposed method of cluster head selection giving advantage to FRRSCR than other protocol LEACH and DHAC in terms of energy consumption and delivery ratio. It it is proven that the network life time is prolonged significantly and it is shown in Figure 3.

6. CONCLUSION AND FUTURE ENHANCEMENT

In this proposed work, a fuzzy inference rule is used for the efficient identification of cluster heads. Simulation is made in NS2.34 and found good in terms of energy consumption, reduced delay, less processing overhead and efficient bandwidth utilization. Thus the network life time is also extended considerably. In the future research work, more decisive parameters will be considered for cluster head election and the system performance will be studied with measured data for a particular WSN.

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