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An Algorithm To Design Resilient Energy Routing Protocol For WSN

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Abstract-- For a WSN systems moving packets is just a medium to access an end but not the actual purpose. Rather Wireless Sensor Networks is useful if they provide meaningful information and actions for fulfilling a given task. Additionally mechanism related to protocols like scoping of interactions to specific geographic regions or to time intervals is getting important. Hence, new mechanism of applications of wireless sensor network is required, along with new interfaces and new ways of thinking about the service of a network. Quality of Service Closely related to the type of a network's service is the quality of that service. Traditional quality of service requirements usually coming from multimedia-type applications like bounded delay or minimum bandwidth are irrelevant when applications are tolerant to latency or the bandwidth of the transmitted data is very small in the first. In some cases, only occasional delivery of a packet WSN systems are now a day's handling a very wide range of telecommunications application types. Due to this it is hardly be possible with any single mechanism to decide data propagation of a WSN. However many common features appear in correspondence of the characteristics and the parametric mechanisms of such systems during routing and energy management scenarios. This work focus on utilizing node characteristics with fuzzy logic based intelligent decision mechanism for mitigate the major challenges of the nodes selection for establishing the multi hop routing of the wireless sensor networks. The node characteristics are considered in terms of nodes data forwarding success rate probability evaluation by simple and flexible fuzzy rules.

Keyword—Fuzzy Energy Aware Routing Protocol, MEMS, Routing, Clustering, WSN.

1. Introduction:

Wireless Sensor Networks are composed of a large number of sensor nodes with limited resources in terms of energy, memory, and computation. They are operated by a small battery attached to it. This battery has some initial energy, and in every communication it dissipates a fraction of the energy. Many such communications take place during the network lifetime, and every time sensor node consumes some energy which makes battery exhaust eventually. When nodes are deployed in hostile environment or in a kind of environments where it is hard to reach, in most of the cases there is no way to recharge these batteries [1].

Sensors are regarded as significant components of electronic devices. In most applications of wireless sensor networks (WSNs), important and critical information must be delivered to the sink in a multi-hop and energy-efficient manner. Inasmuch as the energy of sensor nodes is limited, prolonging network lifetime in WSNs is considered to be a critical issue. In order to extend the network lifetime, researchers should consider energy consumption in routing protocols of WSNs.

Recent advances in micro-electro-mechanical systems (MEMS) and wireless communications have highlighted the significance of WSNs as essential reporting devices. Indeed, sensor nodes in WSNs are deemed to be resource constrained in terms of energy, communication range, and memory capacity and processing capability. WSNs include specifications and applications such as target tracking, environmental monitoring and battlefield applications. The main purpose of WSNs is to disseminate the information from the source to the sink in multi-hop scheme [6]. Figure 1 shows a typical WSN.

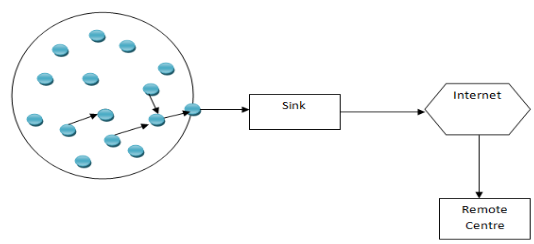


Fig. 1. Architecture of WSN

A sensor node typically consists of five main parts: one or more sensors gather data from the environment. The central unit in the form of a microprocessor manages the tasks. A transceiver communicates with the environment and a memory is used to store temporary data or data generated during processing. The battery supplies all parts with energy. To assure a sufficiently long network lifetime, energy efficiency in all parts of the network is crucial. Due to this need, data processing tasks are often spread over the network, i.e. nodes co-operate in transmitting data to the sinks. Although most sensors have a traditional battery there is some early stage research on the production of sensors without batteries, using similar technologies to passive RFID chips without batteries [13] (Fig. 2.).

2. Related Work:

The potential for collaborative, robust networks of micro sensors has attracted a great deal of research attention. For the most part, this is due to the compelling applications that will be enabled once wireless micro sensor networks are in place; location-sensing, environmental sensing, medical monitoring and similar applications are all gaining interest. However, wireless micro sensor networks pose numerous design challenges. For applications requiring long term, robust sensing, such as military reconnaissance, one important challenge is to design sensor networks that have long system lifetimes. This challenge is especially difficult due to the energy constrained nature of the devices. In order to design networks that have extremely long lifetimes, we propose a physical layer driven approach to designing protocols and algorithms. **Eugene Shih, et. al. (2001),** [1] first presented a hardware model for our wireless sensor node and then introduce the design of physical layer aware protocols, algorithms, and applications that minimize energy consumption of the system. Our approach prescribes methods that can be used at all levels of the hierarchy to take advantage of the underlying hardware. **Eugene Shih, et. al. (2001),** [1] also show how to reduce energy consumption of non-ideal hardware through physical layer aware algorithms and protocols.

In a Wireless Sensor Network, sensor nodes may fail for several reasons and the network may split into two or more disconnected partitions. This may deteriorate or even nullify the usefulness and effectiveness of the network. Therefore, repairing partitions is a priority. In this work **Gianluca Dini, Marco Pelagatti, and Ida Maria Savino (2008),** [2], presented a method to repair network partitions by using mobile nodes. By reasoning upon the degree of connectivity with neighbours, a mobile node finds the proper position where to stop in order to re-establish connectivity. Factors influencing the method performance are singled out and criteria for their selection are discussed. Simulations show that the proposed method is effective and efficient notwithstanding packet loss.

Radio transmission and reception consumes a lot of energy in a wireless sensor network (WSN), which are made of low-cost, low-power, small in size, and multifunctional sensor nodes. Thus, one of the important issues in wireless sensor network is the inherent limited battery power within the sensor nodes. Therefore, battery power is crucial parameter in the algorithm design in maximizing the lifespan of sensor nodes. It is also preferable to distribute the energy dissipated throughout the wireless sensor network in order to maximize overall network performance. Much research has been done in recent years in the area of low power routing protocol, but, there are still many design options open for improvement, and for further research targeted to the specific applications, need to be done. In this work, **Shio Kumar Singh, M P Singh, and D K Singh (2010)** [3], proposed a new approach of an energy-efficient homogeneous clustering algorithm for wireless sensor networks in which the lifespan of the network is increased by ensuring a homogeneous distribution of nodes in the clusters. In this clustering algorithm, energy efficiency is distributed and network performance is improved by selecting cluster heads on the basis of (i) the residual energy of existing cluster heads, (ii) holdback value, and (iii) nearest hop distance of the node. In the proposed clustering algorithm, the cluster members are uniformly distributed and the life of the network is further extended.

Wireless sensor networks (WSNs) are mostly deployed in a remote working environment, since sensor nodes are small in size, cost-efficient, low-power devices, and have limited battery power supply. Because of limited power source, energy consumption has been considered as the most critical factor when designing sensor network protocols. The network lifetime mainly depends on the battery lifetime of the node. The main concern is to increase the lifetime with respect to energy constraints. One way of doing this is by turning off redundant nodes to sleep mode to conserve energy while active nodes can provide essential k-coverage, which improves fault-tolerance. Hence, **T. V. Padmavathy, and M. Chitra (2010)** [4], used scheduling algorithms that turn off redundant nodes after providing the required coverage level k. The scheduling algorithms can be implemented in centralized or localized schemes, which have their own advantages and disadvantages. To exploit the advantages of both schemes, we employ both schemes on the network according to a threshold value. This threshold value is estimated on the performance of WSN based on network lifetime comparison using centralized and localized algorithms. To extend the network lifetime and to extract the useful energy from the network further, we go for compromise in the area covered by nodes.

Wireless sensor networks (WSN) technologies are widely used in today's world for monitoring purposes. In most applications, the sensors are not plugged in. Instead, they get power from the batteries they carry. To keep the network alive for a long time with such limited power, it is very important to conserve energy while the network is functioning. In this work, **Yuping Dong et. al. (2011)** [5], presented an energy efficient routing algorithm for WSN. In this algorithm, we divide the sensor nodes into several scheduling sets and let them work alternatively. In this way, the sensors do not have to be active all the time which saves a lot of energy. When choosing the next sensor to forward the information to, we consider both the distance from the base station to the sensor and its current energy level. So the network power consumption will be distributed among the sensors. When the network does not have enough sensors that have sufficient energy to run, it generates new scheduling sets automatically. Simulations and comparisons demonstrate that our algorithm outperforms the previous work on energy efficient routing algorithms.

3. Methodology:

3.1 Fuzzy Energy Aware Routing Protocol

- We use Fuzzy logic based enhanced A* algorithm to find the optimal path from source node to destination node.

- At the initial stage each node sends its parameters: residual energy, packet reception rate, node buffer state.
- Based on these parameters the sink node evaluates the node status by fuzzy rules for the current routing schedule.
- If the node status of the node is less than the threshold energy it do not participate in the process and network load is balanced.
- Three input based Fuzzy logic algorithm generates the node status and this is used as cost heuristic function to determine the choice of suitable nodes to find optimal path.
- Our intention is to forward data packets to the next neighbour node which has high residual energy, high packet reception rate, and high free buffer.
- To achieve this we use above mentioned parameters in a fuzzy evaluation system of the normalised input ratios given as:

node_status(n)=fuzzy_evaluation_function_of[(Eres(n)/Eini(n),(Nr(n)/Nt(n)),(Bf(n)/Bini(n))} (3.1)

Where, Eres (n) = residual energy of node n
Eini (n) = initial energy of node n
Nr (n) = number of received packets
Nt (n) = number of transmitted packets
Bf (n) = fixed free buffer
Bini (n) = initial free buffer

In the fuzzy rules higher weightage is given to parameters residual energy of node.

- The value of distance function ,h(n) is calculated as:

  h(n)=1/Min(hcns) (3.2)

  Where, Min (hcns) = minimum hop count from node n to the sink node.
- To compute the minimum hop count we must calculate the distance from node n to sink node:

  d(n,s)=√(xn-xs)^2+(yn-ys)^2 (3.3)
- To calculate the minimum hop count:

  hcns=d(n,s)/avgd(n,j) (3.4)

where, avg d (n, j) is the average distance between node n and its immediate neighbour node j.

Performance Evaluation:

- The energy consumed for transmitting and receiving k bit data can be evaluated as-

  Etx(k)=k(Eelec+εamp.d^2) (3.5)

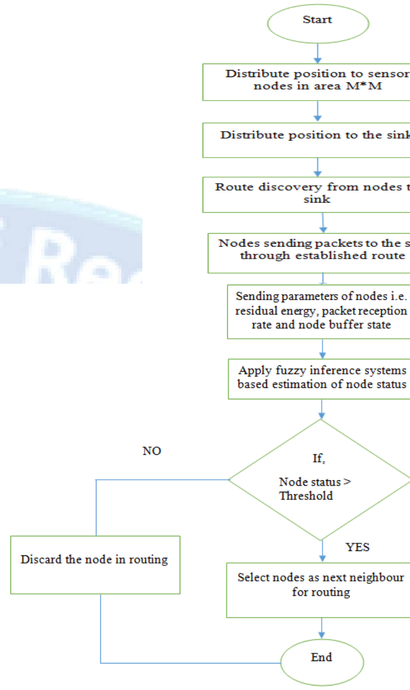
  Erx(k)=k(Eelec) (3.6)

  Where, Eelec= per bit energy dissipated in transmitting and receiving circuitry

  And, εamp= energy required per bit per meter square for the amplifier to achieve acceptable S/N Ratio.

  Total energy=k(2Eelec+εamp.d^2). (3.7)

3.2 Flowchart representing Fuzzy Energy Aware Routing Protocol



4. Result and Discussion:

We have considered a network consisting of N nodes randomly distributed in an area of length MxM meters having an initial energy E0 and they have a destination D which is to be accessed by establishing route from various source nodes to the destination for example the algorithm considers an area length (M) in meters of 200 with number of nodes (N) = 10.The x y coordinates of the nodes are generated randomly as shown below:

Table 1: x y Coordinates for Sensor Nodes Network

x coordinates	y coordinates
162.9447	31.5226
181.1584	194.1186
25.3974	191.4334
182.6752	97.0751
126.4718	160.0561
19.5081	28.3773
55.6996	84.3523
109.3763	183.1471
191.5014	158.4415
192.9777	191.8985

After initialization of nodes the sensors sensor sends the data packet by multihop routing and at every transmission and receiving the nodes consumes energy as a result the initial energy E0 reduces and the residual energy becomes lower than initial energy. For example on set up of network as nodes exchanges the hello packets the $E_{residual}$ of the nodes are-

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(etxres) = [4.9516 4.9986 4.9503 4.9818 4.9880 4.8999 4.9445 4.9856 4.9963 4.9990].

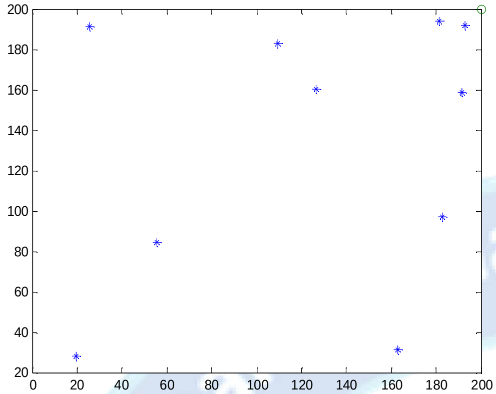

Fig 2. Distribution of nodes wrt to table 4.1 keeping sink at corner(x=M,y=M).

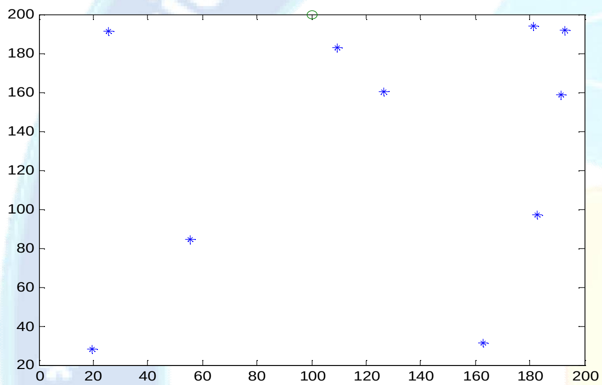

Fig. 3. Distribution of nodes wrt to table 4.1 keeping sink at center (x=M/2, y=M).

Fig. 2 and 3 shows two types of sink positioning one at the corner (fig. 2) and another at the centre (fig. 3).In the table shown below the distance between each node from the sink node is determined using the nodes coordinates and sink coordinates.

Table 2.: Distance between each node from the sink node using the nodes coordinates and sink coordinates.

Node id	x-coordinate	y-coordinate	Distance	Residual energy
1	162.9447	31.5226	172.5043	4.9516
2	181.1584	194.1186	19.7382	4.9986
3	25.3974	191.4334	174.8127	4.9503
4	182.6752	97.0751	104.3728	4.9818
5	126.4718	160.0561	83.6774	4.9880
6	19.5081	28.3773	249.0616	4.8999
7	55.6996	84.3523	184.9243	4.9445
8	109.3763	183.1471	92.1774	4.9856
9	191.5014	158.4415	42.4186	4.9963
10	192.9777	191.8925	10.7213	4.9990

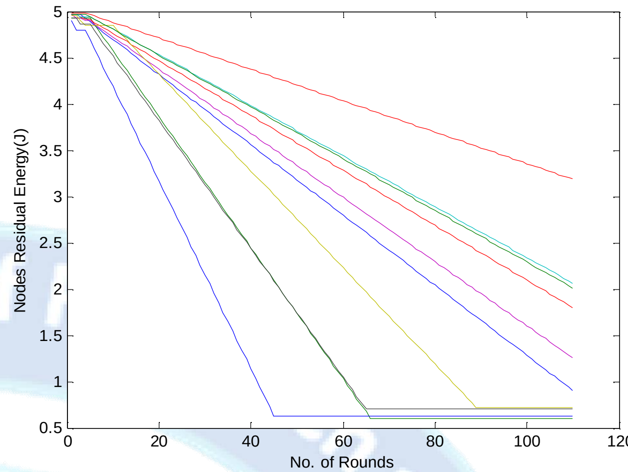

Fig. 4. Residual Energy of all the Nodes at different rounds.

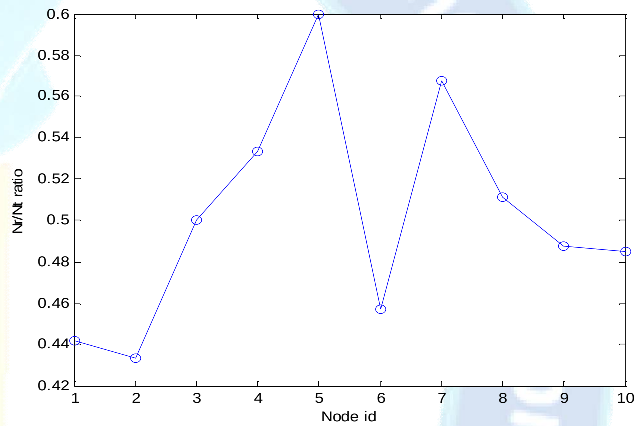

Fig. 5. Nr/Nt ratio for each node at any arbitrary round.

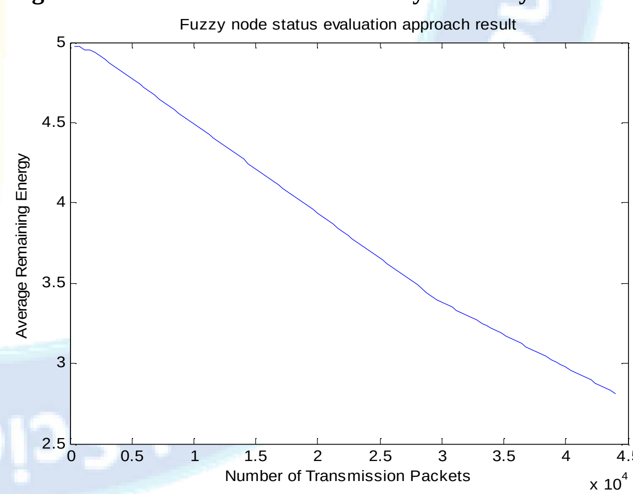

Fig. 6. Average remaining energy at transmission of packets.

Fig 4 represents the residual energy of nodes at different round. We can observe that the nodes having less than a threshold are not allowed to further participate in the data transmission. Initially at round 1 each node has equal initial energy of 5 J.It decreases continuously but at different rate and as the node residual energy approaches a minimum value the node id discarded to participate in further transmission then its energy become steady.

Fig. 5 shows the Nr/Nt ratio of the nodes at any round for all the node ids. The no. of packet received and no. of packets transmitted is measured by keeping account of dropped packet at sink on sending through the sources. Fig. 6 describes the average residual energy of all the nodes at every packet transmission collectively by the nodes.

Similarly fig. 5, 6 and 7 are also shown below when the sink is placed at the centre.

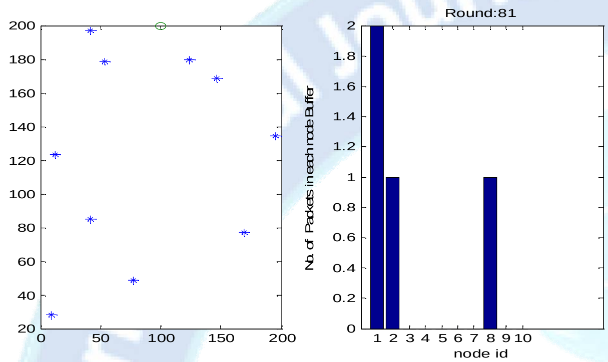

Fig. 7. Network distribution and buffer state on configuration when sink is at centre.

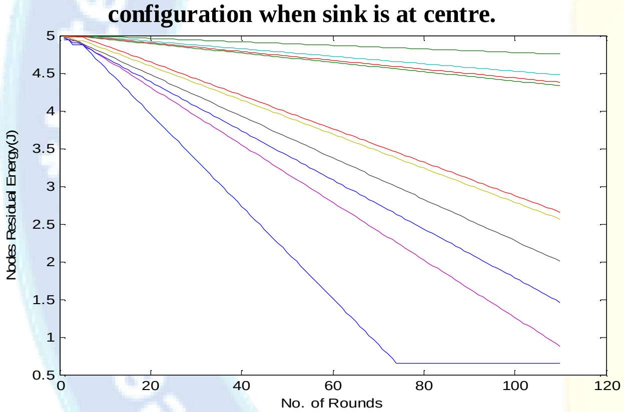

Fig. 8. Residual Energy of all the Nodes at different rounds when sink is at centre.

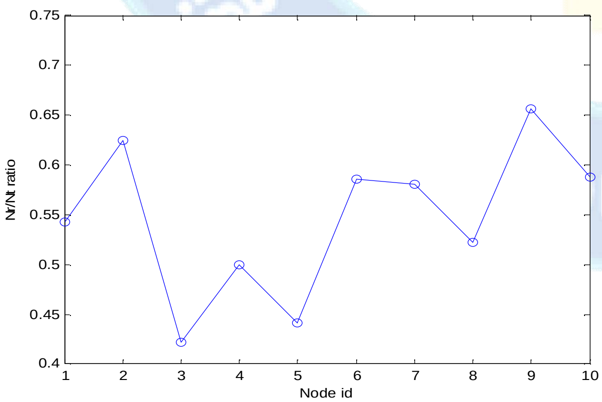

Fig. 9. Nr/Nt ratio for each node at any arbitrary round when sink is at centre.

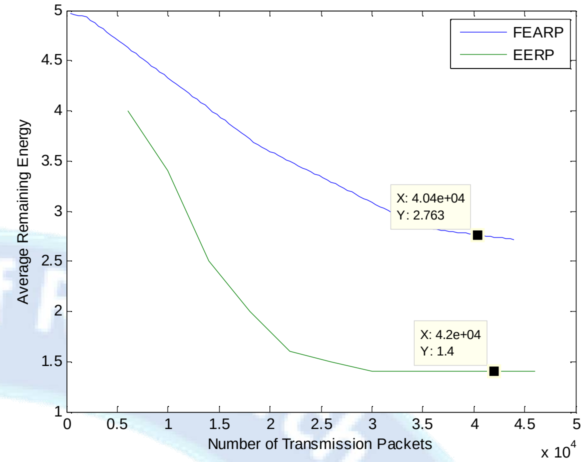

Fig. 10. Average remaining energy at transmission of packets showing comparison of two approaches.

5. Conclusion:

In this work sensor nodes network in the large-scale packet data transmission networks is considered and implemented on MATLAB programming environment. The nodes are considered with initially powered by limited and inexpensive energy source batteries with considerations of existence for a suitable time period. A schematic algorithm of components of a sensor node is simulated that consist of sensing, processing, transmission using limited power units. It also shows the communication architecture of a WSN. Each sensor node makes its decisions based on its mission, the information it currently has, knowledge of its computing, communication, and energy resources. The node in this algorithm are simulated with assumption that they have capability to collect and forward propagate data by systematic routing approach to other neighbouring nodes and consequently to an externally placed far away base station or stations which are fixed or a mobile node with quality of connecting to the sensor network for accomplishing the ongoing communication infrastructure or to the internet. The nodes have limited communication range and the nodes under the communication range are the neighbour nodes our algorithm decides the best neighbour on the basis of surrounding nodes parameters. Sensor nodes forward its sensed data to those node which fulfills the node status criteria related to nodes residual energy factor, nodes packet reception rate standards and the nodes buffer state for deciding the next node for data propagation during establishment of multiple hop routing from source to sink node.

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