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A Study and Evaluation of Various Routing Mechanism for an Efficient Wireless Sensor Network

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Abstract: Wireless sensor network is a resource constrained network widely used in various applications where human intervention is not possible. Wireless sensor network works with a battery as the energy source and hence it is not possible to replace or recharge frequently. So an energy efficient technique is desirable for enhancing the network lifetime. In this paper, a study and evaluation of the various energy efficient techniques used in the literature is made. A new fuzzy based routing protocol is also proposed to enhance the network lifetime.

Keywords: Network lifetime, fuzzy based routing, Energy conservation, Wireless Sensor Network.

I INTRODUCTION

Wireless Sensor Network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location called base station. These sensor nodes have limited computation capability, limited power and small size [12]. The major components of a WSN are microcontroller, transceiver, external memory, power source and one or more sensors. WSN can be applied to a wide range of applications namely area monitoring, healthcare monitoring, environment and earth monitoring, air pollution monitoring, forest fire detection, agriculture, landslide detection, natural disaster prevention, data logging, industrial scenes and control applications etc.

Energy is one of the predominant features in wireless sensor networks that have to be seriously monitored. Since each sensor node has a limited battery that cannot be replaced. Many research works has been carried out for increasing the energy efficiency of WSN. Energy conservation is achieved by incorporating efficient techniques in routing, cluster head selection, topology control, congestion control etc. Various soft computing tools like Fuzzy Logic, Neural Network Genetic Algorithm were also used along with the above mentioned techniques to increase the energy efficiency of the network. An energy efficient network results in enhanced network lifetime, reduced energy consumption, reduced Channel Contention, increased packet delivery ratio and reduced Delay.

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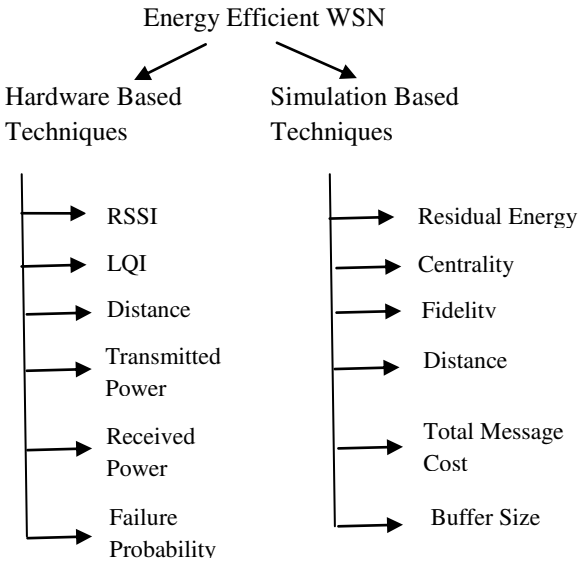

Fig 1. Parameters used for energy conservation in WSN

In this paper, various techniques and prominent parameters that are responsible for energy conservation in a WSN is studied from the existing methodologies. A comparison study is also made to understand the impact of the node parameters on the various strategies used in the literature. Fuzzy based neighbour node selection technique for providing an energy efficient routing is also proposed.

This paper is organised as follows. Section 2 provides various strategies related to hardware setup and its implementation. Comparative study on the existing hardware techniques is also made. Soft computing based energy efficient strategies in the literature and its comparative study is discussed in section 3. An outline on the proposed methodology is dealt in section chapter 4. Section 5 concludes this paper with a future work.

II RELATED WORKS ON HARDWARE BASED TECHNIQUES

Diallo, Marot and Becket (2010) proposed an efficient algorithm for reducing the Channel Contention. In this paper an analytical model is proposed based on Link Quality Indicator (LQI), to determine effective set emissary nodes that connect two cluster heads. During the clustering process, the cluster head selects a emissary node which may be its 1-hop neighbour. Then a connection between the two adjacent nodes is established by selecting the best emissary node among the respective cluster heads. All the cluster heads and the best emissary nodes are combined together to form a communication subnet. Similar results were obtained corresponding to the theoretical analysis [1].

The Received Signal Strength Indicator (RSSI) has been largely realized by the WSN as an inadequate method and metric for determining link communication between any two neighbouring nodes. In this paper, Hussain and Rahman (2009) analysed the feasibility of using RSSI at receiver node to detect node replication, replacement and man-in-middle attacks. The results show that the location change of the sender node can be easily identified by the variation in

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RSSI values. Also they have identified that fuzzy logic based approach can be used to find a rogue node in the network [2].

Benkic et al (2008) used RSSI metric for the estimation of distance using wireless Zigbee based models. For distance evaluation and routing, RSSI has a vital role in deciding the neighbour node for data forwarding to obtain an optimum energy consumption. They have concluded that RSSI gives a precise distance value only when the terrain variables and conditions are static [3].

Mon and Lin (2013) constructed a LQI based Wireless sensor network for position monitoring using Recurrent Fuzzy Neural Network (RFNN). The author analysed the performance of LQI and developed a ZigBee positioning system (ZPS) to identify the nodes location. They studied the performance of ZPS in an indoor location. Finally they combined ZPS with a RFNN to obtain dynamic response and better information storing. They have implemented the proposed WSN for children's position monitoring and achieved good performance [4].

Xu et al (2010) presented a Log-normal shadowing model (LNSM) which provides an accurate relationship between RSSI and distance. Using the method of least squares, the coefficients in the model is dynamically adjusted considering the change in the environment. The results obtained by applying this concept experimentally proved that the above method reduced the probability of error and is also self-adaptable. This system can be further enhanced for position identification [5].

Oliveria et al (2012) described a distance estimation system using the two metrics RSSI and LQI. RSSI is the main source for the estimation of distance and localization. In order to make more precise estimates, the authors combined RSSI and LQI for decreasing the delay and estimation cost. Fuzzy logic and Transferrable Belief Model (TBM) were used for improved decision making. The proposed model showed a 100% accurate distance estimation in an indoor scenario [6].

Localization scheme is presented by Sazena, Gupta and Jain (2008), in which the Received Signal Strength is analysed for distance estimation. They used the empirical relationship between relative error and distance to obtain the RSS. It is observed that the RSSI model in wireless sensor network provides precise location estimation [7].

Table 1 compares various hardware based techniques based on the problem addressed, metrics used, tools used and their inference.

III RELATED WORKS ON SOFTWARE BASED TECHNIQUES

Chain and Han (2009) illustrated a hierarchical approach to obtain and aggregate the residual energy in the form of energy map. The energy consumed by various sensor nodes is monitored continuously in the form of energy map. The sensor nodes are split into many clusters, with a cluster head being allotted for every cluster. The topology tree is then created based on the energy consumed by the cluster nodes, from which the energy map is obtained at the base station .The main feature is the In- network aggregation which combines the adjacent polygons of the same energy map thereby minimising energy map and reducing the message cost. Additionally by reorganizing the energy distributed evenly, the battery life of the sensor nodes are also increased [8].

Chakraborty, Mitra and Naskar (2011) designed an effective genetic algorithm inspired routing protocol called "GROUP" which provides good network performance and also a good life time when compared to other available schemes. A sub-optimal energy dissipation is assumed for the random deployment of nodes. This increases the network

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lifetime and energy efficiency of the network. Simulated Annealing is also used to provide efficient routing paths for the further enhancement in the network performance [9].

Jiang et al (2013) developed an energy efficient routing algorithm for WSN. The transceivers used in a WSN consumes large amount of energy when compared with the other components. So it is of great importance to design energy optimised routing algorithm. The author in this paper proposed an algorithm for data transceiver in which routing is done by the single-hop forwarding scheme, rather than multihop forwarding within a particular range. The energy balance can also be determined based on the energy inequality. In addition to this a fuzzy-based decision making is done, considering multi parameters observed from the sensor nodes. Proposed algorithm proves to be more energy conservative when compared with similar ones [10].

Karimi et al (2013) describes the combination of fuzzy logic and chaotic based genetic algorithms to extend the lifetime of sensor nodes. Fuzzy logic is used to identify the best node as cluster head (CH) by the base station. the CH selection is based on the variables energy, density and centrality. Using Genetic algorithm the number and position of cluster heads is computed. The proposed technique is simulated in a heterogeneous WSN that has increased network life time, increased network reliability and decreased transmission delay [11].

Li, Leith and Malone (2011) demonstrate the undesirable channel under-utilization or unnecessary high delays caused by the use of fixed size buffers in wireless networks. Buffers are used to accommodate short term packet bursts. Packets are dropped if many arrive in a short interval of time where there is a lack of capacity to process all of them. By the use of a dynamic buffer sizing algorithm, a high throughput and a low delay is obtained under various network conditions [12].

An energy efficient mechanism is provided by Pandey and Varma (2012), which maintains the privacy of the base station's location so that intruders do not access these nodes. In the proposed technique fake packets are introduced to the traffic generated. The probability of fake packet generation by each sensor node is based on the residual energy of the neighbouring nodes. When a data packet is received by the sensor node, it generates and propagates the fake packets to all its neighbouring nodes having maximum residual energy. This method overcomes the energy overhead introduced by the previous techniques that uses uniform probability for fake packet generation. Also it is difficult to trace a packet by estimating the transmission times between the nodes [13].

Kumar et al (2012) proposed Dual Fuzzy Logic Cluster Protocol (DFLCP) forming a cross layer energy efficient architecture. The approach exploit the design of hierarchical clustering with sleep scheduling, range free localization using convex optimization and Hybrid Adhoc routing protocol to maximize energy efficiency of wireless sensor nodes. The results show that DFLCP outperforms LEACH (Low-Energy Adaptive Clustering Hierarchy) in terms of network lifetime and power consumption minimization. The proposed technique provides less routing overhead and better localization estimation.

Table 2 compares various software based techniques based on the problem addressed, metrics used, tools used and their inference.

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TABLE 1. COMPARATIVE TABLE FOR THE VARIOUS HARDWARE BASED TECHNIQUES

Methodology	Problem Addressed	Metrics Used	Tools Used	Inference
Diallo et al 2010	Improve cluster head location	Link Quality Indicator	Zigbee	Reduce channel contention between clusters
Hussain and Rahman 2009	Using RSSI at receiver end to detect attacks.	Received Signal Strength Indicator	Crossbow's MicaZ nodes	Identify the location change of sender node
Benkic et al 2008	Distance estimation	Received Signal Strength Indicator, Standard deviation	Zigbee nodes	RSSI gives a precise distance value only when the terrain variables and conditions are static.
Mon and Lin 2013	To develop a Zigbee positioning system	Link Quality Indicator	Zigbee, Neural network, Fuzzy Logic	Can be applied for children's position Monitoring
Xu et al 2010	To develop a model for finding accurate relationship between RSSI and distance.	Distance, transmitted power, received power, transmission factor	MicaZ nodes	Reduce probability of error and self-adaptable
Oliveria et al 2012	Distance estimation using RSSI/LQI and fuzzy logic for decision making on distance	Distance, Failure Probability	Crossbow's TelosB mote, MATLAB	100% accurate estimation on the distance is attained
Sazena et al 2008	To analyse the RSS model for distance estimation	Received power,Distance	MicaZ mote	Accurate estimation on the location of a cooperative target is achieved

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TABLE 2. COMPARATIVE TABLE FOR THE VARIOUS SOFTWARE BASED TECHNIQUES

Protocol	Problem Addressed	Metrics Used	Tools Used	Inference
Chan and Han 2009	For continuous residual energy monitoring	Residual reachable nodes, fidelity ,total message cost	C++,CSim-18	By reorganizing the energy distributed evenly, the battery life of the sensor nodes is increased.
Chakraborty et al 2011	To propose a genetic algorithm based routing protocol	Distance, energy consumption	Matlab ,tossim	Enhances the network life time and energy consumption
Jiang et al 2013	To propose fuzzy logic based energy optimised routing algorithm	Degree of closeness of node to the shortest path, degree of closeness of node to sink, degree of energy balance.	MATLAB	Energy efficiency and energy balance is achieved
Karimi et al 2013	For efficient cluster head selection using fuzzy and genetic algorithm	Energy, density, centrality	Network Simulator2	Enhanced network lifetime is achieved.
Li et al 2011	To develop a novel dynamic buffer sizing algorithm	Buffer size	Network Simulator 2	High throughput and load delay over various conditions is achieved.
Pandey and Verma 2012	To maintain privacy of base station's location	Residual energy	Castalia	Reduces energy over head
Kumar et al 2012	Effective routing approach using fuzzy logic	Power level, number of nodes in transmission area, Centrality, Proximity to data sink, Distance between cluster leader	MAT LAB	Provides less routing overhead, size of routing table is less, better localization estimation, minimum localization error

IV PROPOSED WORK

From the literature surveyed, it is clear that the parameters namely Residual Energy, RSSI, LQI, Distance and Buffer Size play in reducing the energy consumption in WSN. So a new fuzzy based routing protocol that considers, the above parameters for enhancing the network life time and to reduce the energy consumption is proposed. Fuzzy Logic is used for deciding the best set of data forwarding nodes based on the key node parameters. The zigbee network scenario in which the proposed technique is to be implemented is given in figure 2.

In the figure 2, the end device is responsible for data gathering and forwarding it to the coordinator through any of the routers. Each router computes the values of Residual Energy, RSSI, LQI, Distance and Buffer Size. Based on fuzzy

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logic, best neighbour node is selected and data forwarding through that node takes place. Other nodes not involved in data forwarding are made to sleep mode. By doing this power management, the network lifetime can be enhanced.

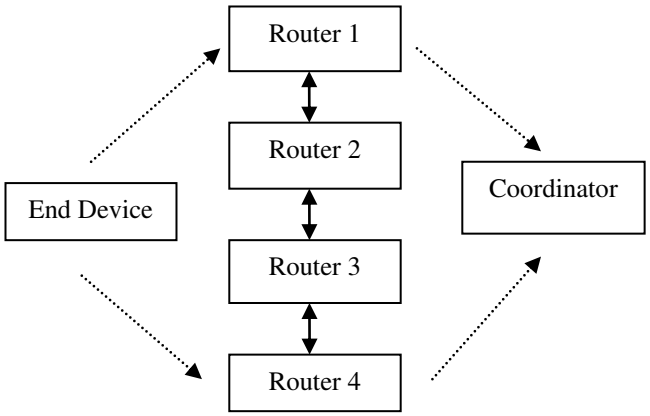

Fig 2. Network scenario for the proposed methodology

V CONCLUSION AND FUTURE WORK

Network lifetime is the key characteristic in a WSN. Many research works has been carried out with an aim of enhancing the network lifetime. In this paper, a detailed survey on the existing energy efficient techniques for a WSN is made. From the analysis on the various strategies, a new fuzzy based routing protocol is also proposed for a real time environment. This methodology is to be implemented for smoke detection application using Zigbee nodes.

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BIOGRAPHY

Cynthia James is doing her final year B.E- Electronics and Communication Engineering in Sathyabama University. She completed her Higher Secondary in C.S.I Bain School, Chennai in 2010. She has secured first place in State Level Mathematics Contest-2004. Her area of interest are mobile communication and wireless sensor networks.

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Dr. N. M. Nandhitha is currently working in the Department of Electronics and Communication Engineering in Sathyabama University. She has graduated from Government College of Technology, Coimbatore in Electronics and Communication Engineering. She has completed Post Graduation in Power Electronics and Industrial Drives with gold Medal. She completed her Ph.D. in Development of wavelet based tools and NeuroFuzzy control software for on-line weld Monitoring by Thermal Imaging, a project sponsored by IGCAR, Kalpakkam. She is also co-investigator in two projects sponsored by IPR, BRFST, DST, TNSCST to Sathyabama University. She has won best paper award four times in International/national conferences.