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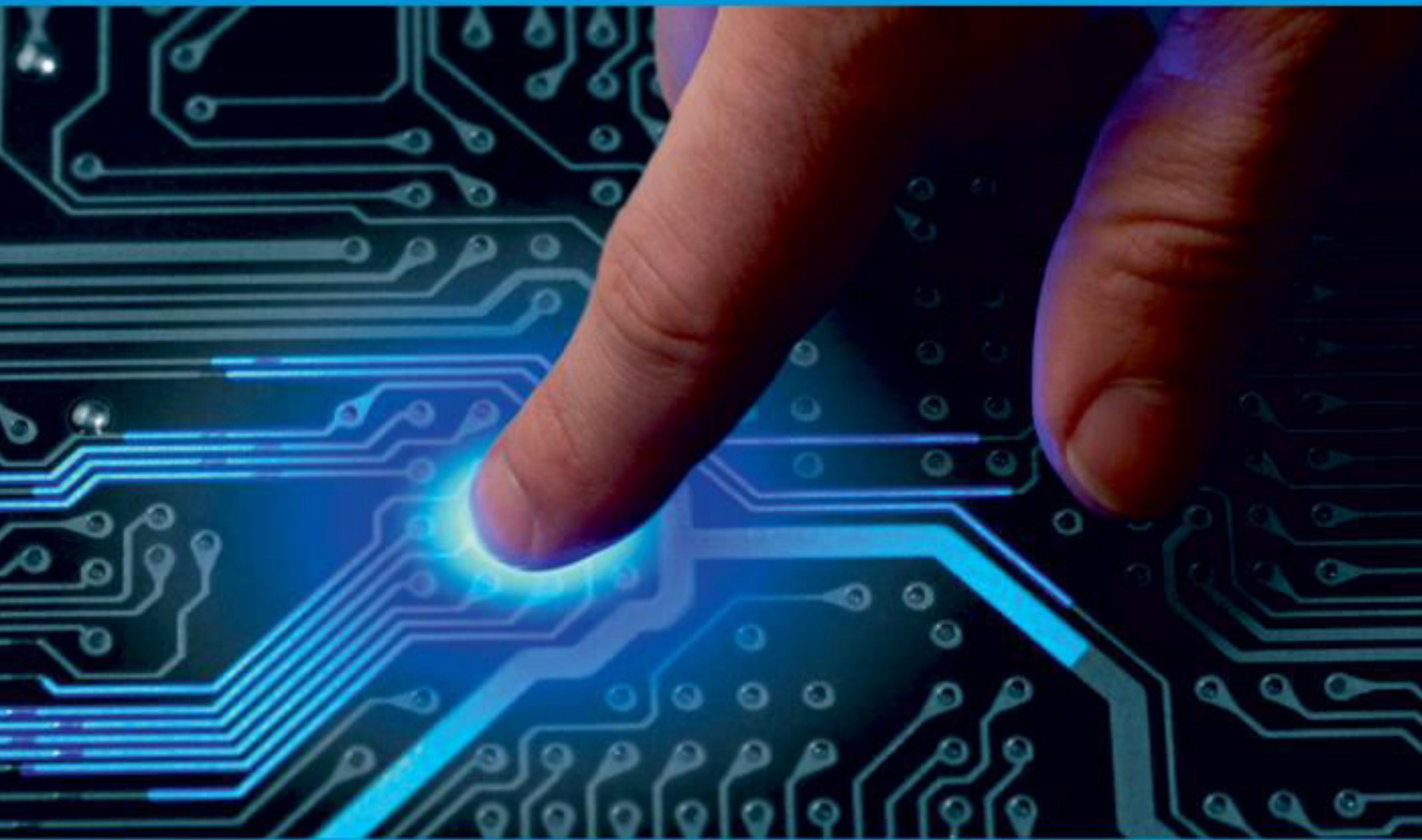

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Energy Efficient Pegasis Protocol using Genetic Algorithm

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ABSTRACT*:* Wireless Sensor Network (WSN) is one of the underlying mechanics of IoT (Internet-of-Things) which has recently seen a worldwide interest by its use in several domains as military, automation, agriculture, environment, underwater and etc. Energy efficiency and reliability of transmitted messages are two of the major requirements for the surveillance and wireless detection applications in WSN. For this reason, a growing number of research studies are carried out. Several routing protocols have been developed to furnish better performance for optimizing the network's energy consumption in WSN; most of them are based in clustering and hierarchical topology. However, most of these routing protocols cannot consider all required and important metrics to increase the lifespan of the network. This work introduces an enhanced algorithm of the Low Energy Adaptive Clustering Hierarchy (LEACH) protocol called Balanced Current Energy-LEACH (BCE-LEACH) which aims to equity the power consumption of sensor nodes of the network due to extend the lifetime of the network. The proposed protocol is based on the residual energy of sensor nodes to pick out cluster heads (CHs) that means only nodes with sufficient current energy can participate in CH selection, and then it is focused on both current energy and the distance toward the base station (BS) to select a parent CH which has current energy greater than the mean energy of CHs and the distance to the BS is fewer than the average. This parent CH groups all data from other CHs. The root CH after doing data aggregation sends compressed information to the BS using the multi-hop process between CHs. The improved algorithm is simulated in MATLAB R2016b simulation tool. Simulation results in this paper indicate that the introduced protocol works better than LEACH through extending the lifetime of the WSN.

KEYWORDS: Pegasis Protocol, Leach, WSN, Genetic Algorithm, Dead node

I. INTRODUCTION

The development of WSN started in the 1950s when US military developed the Sound Surveillance System (SOSUS) used in submerged acoustic sensors [1]. For seismic activity surveillance, some of the sensors of SOSUS are still in use. After a gap of nearly three decades the Defense Advanced Research Project Agency (DARPA) in USA started the Distributed Sensor Network (DSN) program that focused on further developments on newly invented technologies and protocols in context of their use for sensor networks [2]. Simultaneously, Advanced Research Projects Agency Network (ARPANET) started research and development in the WSN by involving many institutions and industries [3]. The research and development on small sensor nodes were initiated by NASA 'Sensor web project' and 'Smart dust project' in the year 1998 [4]. One of the objectives of the above project was to create autonomous sensing and communication device within a cubic millimeter of space. Other early projects in this area started around 1999 was primarily in academia at several places, including MIT, Berkeley and University of Southern California [3].

Wireless Sensor Network contains hundreds of thousands of low-cost sensor nodes. A sensor node has constraints like storage, energy, limited processing and transmitting capability [5]. Routing technique plays a vital role in the wireless sensor network. It is extremely difficult to assign the global ids for a large umber of deployed sensor nodes. Thus, traditional protocols may not be applicable for WSN. Unlike conventional wireless communication networks (MANET, cellular network, etc.), WSN has inherent characteristics. It is highly dynamic network and specific to the application, and additionally it has limited energy, storage, and processing capability. These characteristics make it a very challenging task to develop a routing protocol [1–6]. In most of the scenarios, multiple sources are required to send their data to a particular base station. The nodes near to the sink, depleted more energy and hence eventually die. This causes partitioning of the network; consequently, the lifetime of the network gets to reduce. The main constraint of the sensor node is energy [4,5]. The sensors are battery-powered computing devices. It's hard to replace the batteries in many applications. Therefore, WSN requires an energy-efficient routing protocol. Due to dense deployment, the sensor nodes generate the redundant data, and the base station may receive multiple copies of the

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same data. Therefore, it unnecessarily consumes the energy of the sensor nodes. WSN does not have any fixed infrastructure and is highly dynamic [6].

There are mainly two reasons responsible for the dynamic infrastructure. The first reason is the energy; the sensor nodes have limited energy in the form of batteries. If the protocol is unable to balance the load among the nodes, the sensor node could die. It leads to the dynamic network structure. The second reason is the mobility; in many scenarios after the deployment, sensor nodes are static but sink can move within the network. It makes the network dynamic, and the protocol that works for static sink may not be applicable for mobile sink [7]. In many applications, sensor nodes are required to know their location information. It is not feasible to enable all nodes with Global Positioning System (GPS) [5]. So the protocol should have to take the help of the techniques like triangulation based positioning [6], GPS-free solutions [7], etc. to get the approximate location information. In the routing protocol with static sink, the sensor nodes close the sink always forward a large amount of data; as a result they die. Finally, the network is partitioned, and the sink can not receive any data. This phenomena is known as crowded center effect [8] or energy hole problem [6]. A mobile sink is used in the network to overcome this problem. The mobile sink makes the network dynamic, and routing becomes difficult. In this section, a study on the existing routing protocols with mobile sink is done. They are categorized and explained. The routing protocol with mobile sink can be classified into hierarchical-based, tree-based and virtual-structure-based.

Lin et al. [2] have proposed a hierarchical cluster-based data dissemination protocol. It uses a clustering structure to track the location of the mobile sinks and finds the paths from the source to the sink for data transmission. A mobile routing algorithm in cluster-based architecture has been proposed by Wang et al. [3]. Each sensor node finds the neighbor information like its residual energy and location by broadcasting a small control packet. The cluster heads are elected based on the higher residual energy among the neighbors. A mobile-sink based energy-efficient clustering algorithm has been proposed by Wang Yin et al. [8]. In this approach, the cluster head is selected based on the residual energy. The cluster head aggregates the data and transmits it to the mobile sink. The mobile sink sends their location information just for once. The sink follows the paths that are easily predictable by the sensor nodes. Wang et al. [65] have proposed an energy-aware data aggregation scheme. It is a hierarchical hybrid routing protocol that comprises of on-demand data dissemination tree with grid structure. Sensor nodes enabled with Global Positioning System (GPS). A gateway node is selected with highest residual energy around the sink.

In this work, we present a new clustering protocol that considers a hybrid of current energy and distance to the sink. We introduce BCE-LEACH clustering protocol.

BCE-LEACH has five mainly goals:

a) Increasing the lifetime of the sensor nodes by equalize power consumption.
b) Minimize overload on weak energy nodes. Selecting a root CH with maximum current energy and minimum space to the sink.
c) Using the multi-hop method to optimize the communication cost.
d) Balancing energy consumption through the effective choice of CHs depending on the current energy of nodes.
e) Consideration of distance between CHs and BS including CH's residual energy.

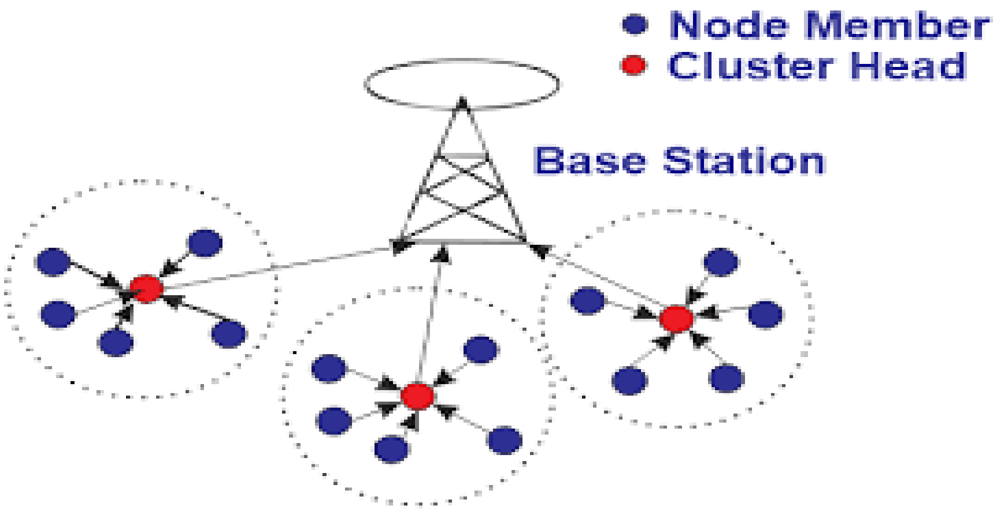

Fig. 1: Pegasis protocol model

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II. BACKGROUND WORK

A. LEACH (Low Energy Adaptive Clustering ierarchy)

LEACH is the first clustering routing protocol proposed by Heinzelman et al.[6] in 2000 for WSN. LEACH furnished a conception of clusters, where the CH is elected randomly according to (1). In each iteration, every normal node gathers information since the milieu then forwards it toward his corresponding CH. Role of CH was receiving all data from its cluster member, regrouping them, compressing them then sending them immediately toward the sink through a single communication [7].

The LEACH procedure is split to two stages: cluster formation stage and steady stage. In the first stage, every sensor node selects a value belongs to the interval [0, 1]. If this value is inferior to the threshold giving in (1), this node becomes as CH next turn. On the other hand, it remains as a common sensor node.

$$Th(i) = \begin{cases} \dfrac{P_e}{1 - P_e * (R \% (1/P_e))} & i \in N \\ 0 & \end{cases}$$

The signification of every symbol in (1) is as following: Pepresents the percentage of the overall number of CH.

R defines the residual turn.

N introduces all sensor nodes which have not been CH in the $1/Pe$ turns.

LEACH is based on a dynamic selection of CHs, which can result in an imbalance of energy consumption because the CH consumes more energy than a normal node. It can also lead to not giving the possibility of being CH at all nodes. Owing to this imbalance, nodes may exhaust their energy early than others, which influences the network's lifetime. The energy is generally seen as a factor strongly related to the network lifetime. Thereby in LEACH, each CH communicates directly with the BS in unique hop whatever the conditions of distance and current energy which is not applicable to CHs at the edge of the network. The distance is an important factor in energy consumption.

B. PEGASIS (Power-Efficient Gathering in Sensor Information Systems)

PEGASIS is an enhancement form also called a prolongation of the LEACH algorithm. It serves to avoid the formation of several clusters. In PEGASIS algorithm, every sensor node has overall news about its entire detection network and perfect knowing of the emplacement of neighboring sensor nodes. Every sensor node can deliver and take data since a neighbor and just one sensor node is elected in one channel at a round to communicate with the receiver [5]. The packets is united and passed since node to other, assembled and delivered to the receiver. Contrary to LEACH, PEGASIS averts the construction of multiple clusters and adopts a single sensor node in the chain to deliver toward the collector instead of using numerous CHs. The construction of the chain is done greedily. At every round, the sensor node that will transfer all grouped data to the sink is randomly selected [14], [15]. Fig. 2 presents the structure topology of the PEGASIS routing protocol.

This figure exhibits that node C1 receives data from C0, aggregates it with its proper and then transfers them to the leader C2. Afterwards, the node C3 receives C4's data when C2 gives the token to the node c4, then the node C3 regroups this data with its owner then forwards to C2. Afterwards The leader C2 receives information since the neighbors nodes, regroups it with its own and then sends only one packet to the BS [6].

PEGASIS protocol avoids clustering overload. But, every node sends its information to another neighbour without knowing the energy state of the latter then; it may be that the node that will regroup its own data to others does not have enough energy to do. In fact, PEGASIS needs again a reorganization of the topology [7].

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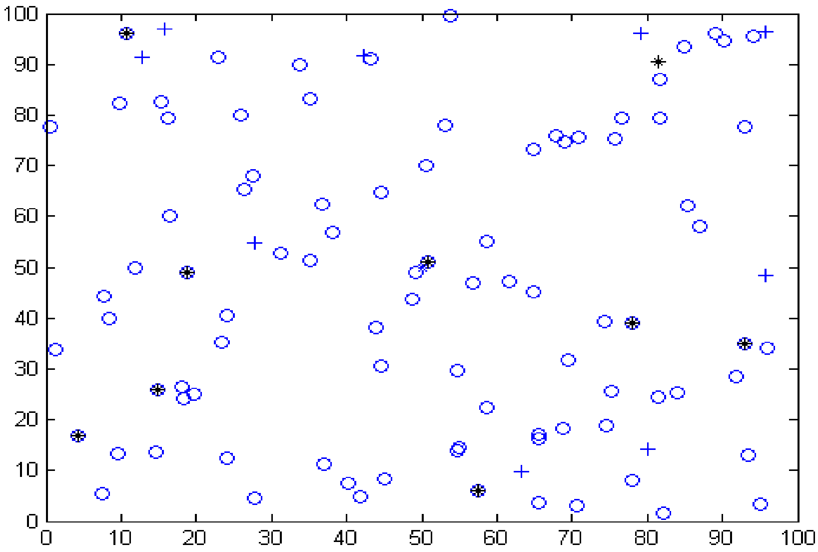

Fig. 2: Node placement of proposed WSN scenario

III. METHODOLOGY AND METHODS

The construction of an original PEGASIS protocol based on three steps: 1. Chain formation, 2. Leader selection, and 3. Data transmission. But construction of proposed EE-PEGASIS protocol are designing by following step. Firstly all PEGASIS sensor network field divided into four part, In a first part node distribute in network field, example out of 100 node, 25 node are distribute in one part of XY coordinate, than provide energy and apply the greedy algorithm for chain formation, than select the leader node that is nearest to the all nodes and sink node. Apply energy and distance formula for communication between the node and select sink node from energy and distance to complete PEGASIS sensor network formation. Remaining sensor node follow all process and formed (100 100) PEGASIS sensor networks.

A. Energy Consumption Model

In the radio model, to send a b bit packet to remote receiver di meters, the channel of emission depletes $E_{Tx}(b, d)$ described in (4). Otherwise, to take a b bit packet, the reception chain depletes $E_{Rx}(b)$ as defined in (6).

$$E_{Tx}(b, d) = \begin{cases} b.E_{elec} + b.E_{fs}.d^2, & d_i < d_0 \\ b.E_{elec} + b.E_{mp}.d^4, & d_i \geq d_0 \end{cases}$$

$$d = \sqrt{E_{fs} / E_{mp}}$$

$$E_{Rx}(b) = b.E_{elec}$$

The signification of every indication in previous formulas is as pursue:
ETx : Energy depleted by sensor node for delivering b bit data from di distance between the emission chain and the receiver.
ERx : Energy consumed by sensor node when receiving b bit from the transmitter.
Eelec: Energy consumed in the electronics system.
Efs: Energy depleted by the amplifier circuit for dispatching 1-bit data to the zone in the free space.
Emp: Energy exhausted by the amplifier circuit for dispatching 1-bit data to the zone in the multipath propagation.
The energy consumption design is shown in Fig. 3.

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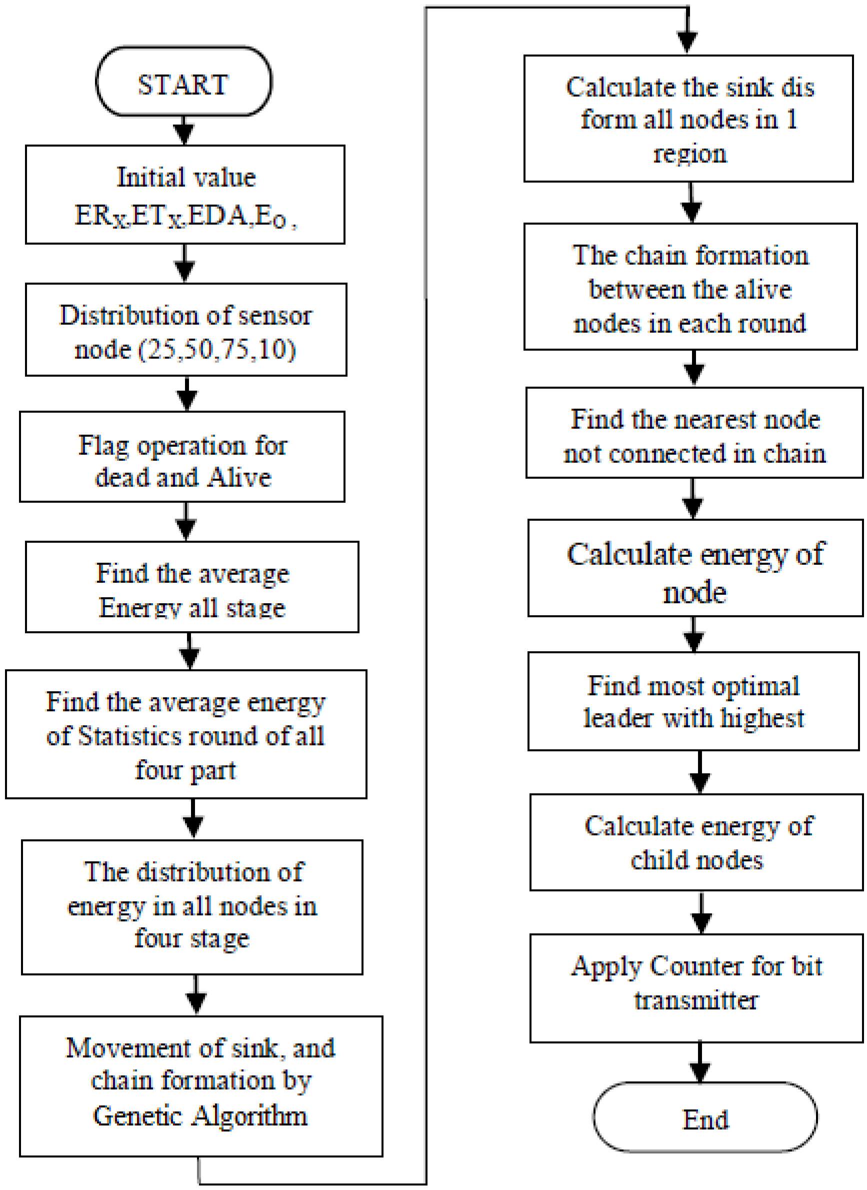

Fig. 3: Flow diagram of proposed energy efficient Pegasis Scheme

IV. SOFTWARE SIMULATION

In order to evaluate the performance of our proposed EPEGASIS algorithm, we use Matlab simulator to conduct the experiment. We will compare our proposed algorithm with typical PEGASIS. And the simulation results are given in figures.

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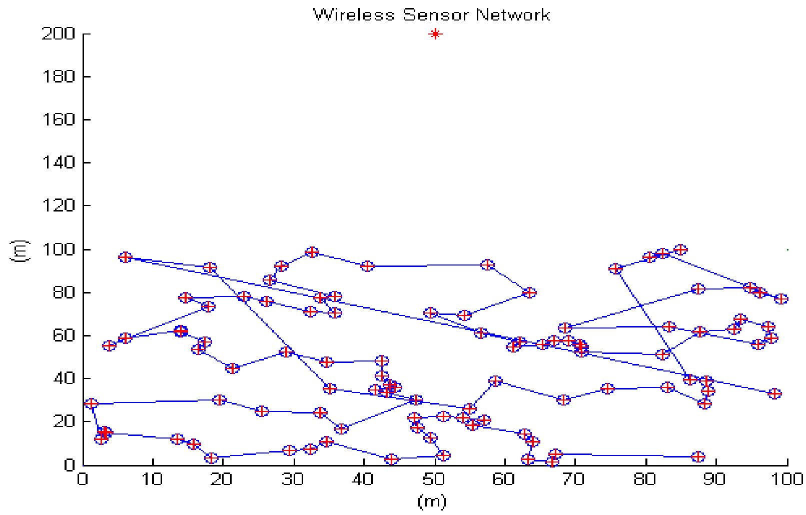

Fig. 4: Enhanced Pegasis routing scheme

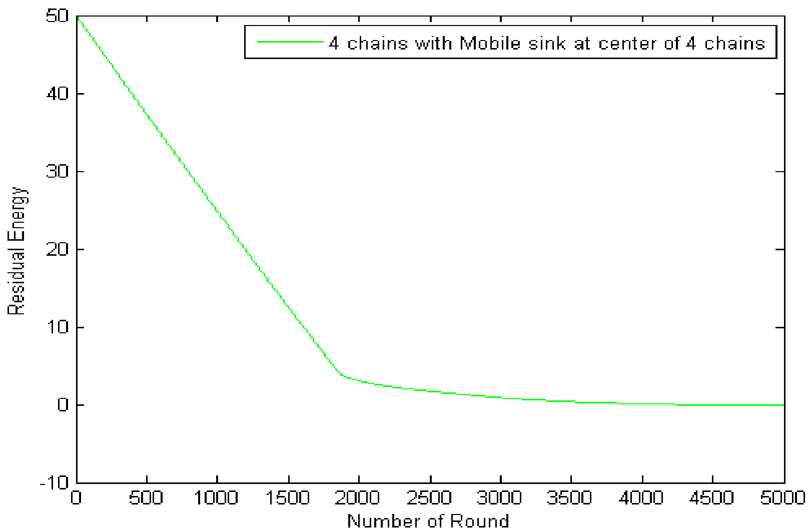

Fig. 5: Residual energy Vs Number of rounds

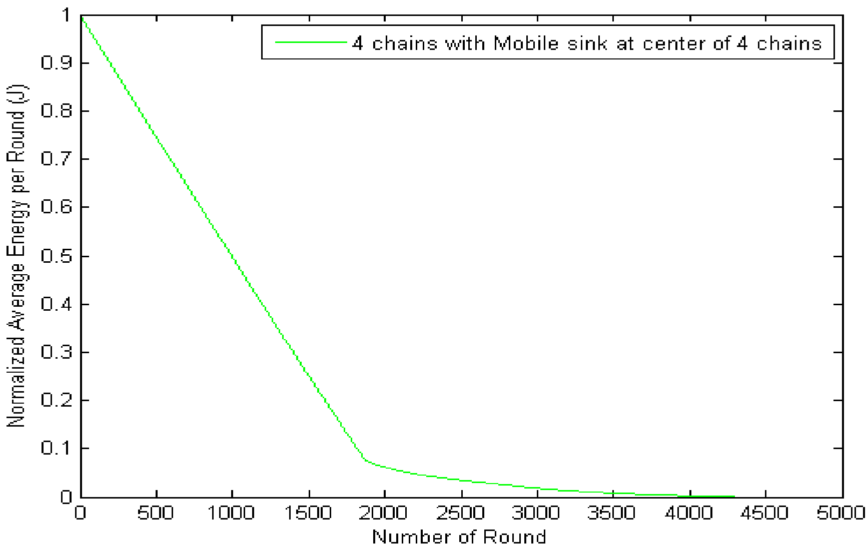

Fig. 6: Normalized Average energy per round graph

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V. CONCLUSION

These protocols has proved efficiently that they are more useful in not only routing the most important data but also in conserving energy resources of a sensor (the batter) using different operation approaches. A detail study of routing and MAC protocols is carried in this thesis which focused on the energy conserving schemes used by protocols and their real time support towards application like surveillance. We have discussed the design tradeoff between energy conserving and quality of service support, results when protocols are tested on the assumption factors like latency, scalability, energy awareness, synchronization, etc. necessary for a wireless sensor network. Contention-based protocols like SMAC, TMAC and TEEM, they use a single radio and change the radio state periodically in order to make the nodes energy efficient. STEM is also a contention-based protocol, but uses two radios (data and wake-up radio) to make the nodes energy efficient. It allows the nodes to wake up the data radio when there is a need to process data, otherwise it stays in sleep state. In contention based protocols transmission suffers from collision and delay because each node is allowed to access the shared medium. Contention-free protocols like DEMAC, PACT and LMAC, they provide collision free communication. Each node has pre-assigned time slots to transmit the data but each node has to listen to the time slots of its neighbors in order to synchronize. This may increase the energy consumption. Contention-free protocols suffer with clock drift problems and require tight synchronization. Most of the protocols show better and efficient features for application like surveillance

but there are still many more challenges that need to be solved in the sensor networks like in MAC protocols there is still need to find out the suitable solution for real time support and energy efficiency because contention based protocols are energy efficient but they don't guarantee the real time support while contention free protocols give real time support but lack in energy efficiency. In routing protocols there is need to achieve desired global behavior with adaptive localized algorithms, time and location synchronization.

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