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Comparisons of Some Multi-Hop Routing Protocols in Wireless Sensor Networks

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Abstract: In wireless sensor networks (WSNs), reducing sensor node energy consumption and increasing network lifetime are becoming more and more challenging due to large scale in Internet of Things (IoT). Hierarchical protocols, especially Low Energy Adaptive Clustering Hierarchy (LEACH), are considered as the best energy-efficient for WSNs. However, LEACH need to be enhanced to support scalability in large WSNs. In this paper, we advise gateway based energy-efficient routing protocol (M-GEAR) for Wireless Sensor Networks (WSNs). the sensor nodes are divided into four logical regions on the basis of their location in the sensing field. Base Station (BS) be out of the sensing area and a gateway node at the center of the sensing area. We put that if the distance of a sensor node from BS or gateway is less than predefined distance threshold, then the node uses direct communication. nodes are divided into two equal regions whose distance is beyond the threshold distance. cluster heads (CHs) have been selected in each region which are independent of the other region. These CHs are selected on the basis of a probability. The performance of the protocols with gateway based energy-efficient routing protocol (M-GEAR), Multihop-LEACH and LEACH are compared. Performance analysis and compared statistic results show that the M-GEAR is bitter in large network for lifetime and energy. But the MultiHop-LEACH protocol performs well in terms of energy consumption and network lifetime in small network.
Keywords:Wireless sensor network, Lifetime, BS, Gateway, Energy, M-GEAR, LEACH, MultiHop-LEACH.

1 Introduction

Wireless Sensor Network (WSN) is a novelty technology for researchers because of the recent developments in WSN. The development of technologies, RFID and so on increases the WSN applications in IoT with the recent updates. The improvements in WSN applications such as solar equipped WSN, rechargeable WSN, IoT and so on shows the need of WSN. In more addition, applications for military, disasters, smart homes and offices, home security and other daily using applications are needs to WSN developments. WSN composites of sensor nodes which are grouped to form clusters to communicate and forward the data to the base station. Sensor nodes are containing battery, memory, processor and so on [1,2].

Divided and merging sensor nodes as cluster is one of the boring task. Forwarding the collected data to base station is a method of clustering. So clustering algorithms are always in developing. The routing protocols develops various possibilities to achieve efficient clustering process. Also some protocols utilize most of the energy of the sensor nodes. So the energy efficient clustering techniques are needed to develop an effective clustering protocol for IoT networks [3].

Q. Nadeem and et al 2013 [4], design a gateway based energy-aware multi-hop routing protocol (M-GEAR). In their work they are dividing the network into four regions for trim down the energy consumption of sensor nodes. They are used different regions for communication hierarchy. So nodes in first region communicate directly to BS and the nodes in second region communicate directly to gateway node. Also the nodes still in other two regions use clustering hierarchy and sensor nodes sent their data to gateway node thru their CHs. Gateway node supports to clusters and issues a TDMA schedule for CHs. Every CH issues its own TDMA schedule for its member nodes [4].

The rest of the paper is ordered as follows: section 2 briefly review the related work. In section 3, we describe the system model. Section 4 describes the simulation results and

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discussions. In section 5 gives conclusion, Finally, section 6 gives references.

2 Related Works

Most important features for wireless sensor network measurements are Energy consumption and network lifetime. many studies have presented clustering based routing for WSNs like DEEC [5], LEACH [6,7], SEP [8] and TEEN [9]. Q. Nadeem and et al 2013 [4] presents many related work for comparisons and results. They are divide the sensor nodes into four logical regions on the basis of their location in the sensing field. they install Base Station (BS) out of the sensing area and a gateway node at the center of the sensing area. Due to the fact that clustering protocols consume less energy. The protocol that has been presented called (M-GEAR). Also Paper [10] analyzed the energy consumption, traffic bandwidth, delay and make some comparisons for cluster based routing protocols such as LEACH, CBHRP, MH-LEACH and LEATCH. The CBHRP protocol has the best results. All of these protocols for WSNs have gained wide acceptance for applications. Paper [11] also uses lifetime and overhead for measure the network performance also. In many situations WSN protocols exploit cluster based scheme at manifold levels to minimize energy disbursement.

Again, some protocols use recourses proficiently by unequal clustering and try to use recourses proficiently. Multiple level clustering hierarchy has following major drawbacks.

3 System Model

This model represents the energy dissipation of sensor nodes for transmitting, receiving and aggregating data. The transmitter dissipates more energy than receiver as it requires more energy for the transmitter electronics and amplifier. On the other hand, in receiver, only electronic circuit dissipate energy, as shown in figure 1.

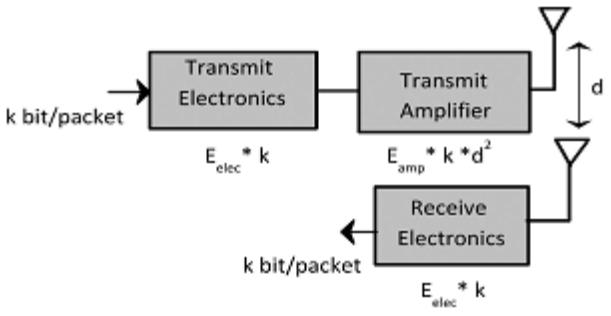

Fig.1: First order radio system model.

For each node set to sleep according to E_{th} which calculated from

$$E_{th} = \left(\left(E_{Tx} + E_{pA}\right) * D\right) + \left(E_{amp} * D * d^4\right) \quad (1)$$

where D is the data packet length and d is the distance between maximum distance node and sink. the energy consumed by a sensor node in sending k bits/packet to a node which distance d meters between can be written [9].

$$E_{Tx}(k,d) = E_{Tx_{elec}}(k) + E_{Tx_{amp}}(k,d) \quad (2)$$

$$E_{Tx}(k,d) = \begin{cases} E_{elec} * k + E_{fs} * k * d^2, & d \le d_0 \\ E_{elec} * k + E_{amp} * k * d^4, & d > d_0 \end{cases} \quad (3)$$

$$E_{Rx}(k) = E_{Rx-elec}(k) E_{Rx}(k) = E_{elec} \times k \quad (4)$$

$$E_{Rx}(k) = E_{elec} \times k \quad (5)$$

Table1: simulation parameters value.

Symbol	Parameters	Values
Xm, ym	Network Area	100*100
N	Number of Nodes	300,100
P	Cluster head probability	0.1, 0.01
E0	Energy for each node	0.5 j
ETX	transmitter energy	50*0.000000001
ERX	receiver energy	50*0.000000001
EDA	Aggregation Energy	5*0.000000001
Eamp	amplification energy	0.0013*0.000000000001
	Number of Rounds	3000

3.1 MGEAR Protocol

We deploy a gateway node in the middle network domain. The function of the gateway node is to collect data from CHs and from nodes near the gateway and aggregation and Send to BS. Our results ensure that the network lifetime and Optimize energy consumption with the addition account gateway node [4].

A. Initial Phase Algorithm

1-BS broadcast a HELLO packet

2- sensor nodes response forward their location to BS.

3- The BS calculates the distance of each node

4- save all information of the sensor nodes into the node data table.

5- data table consists of node ID, residual energy of node, location of node and its distance to the BS and gateway node.

B. Setup Phase Algorithm

In this section

1- divide the network field into logical regions based on the location

2- BS divide the nodes into four different logical regions.

3-Nodes in region-one use transmit their data directly to BS If the distance of these nodes from BS is very short.

4- nodes near gateway form region-two and send their data directly to gateway

5- end

C. CH Selection Algorithm

1- BS divides the network into regions.

2- CHs are elected in each region separately.

3- Let ri represent the number of rounds to be a CH for the node Si.

4- Each node elect itself as a CH once every

ri = 1/p rounds.

5- all nodes in both regions has equal energy level.

6- end

D. Scheduling Algorithm

1-all nodes are structured into clusters,

2- each CH creates TDMA based on time slots.

3-All the associated nodes transmit their sensed data to CH in its own scheduled time slot.

4-Otherwise nodes switch to idle mode.

5- Nodes turn on their transmitters at time of transmission.

6- end

E. Steady-State Phase Algorithm

1- all sensor nodes transmit their sensed data to CH.

2-CH collects data from member nodes.

3-Gateway node receives data from CHs, forwards to BS.

4- two regions are referred to as non-clustered regions.

5- nodes away from the gateway node and BS are divided into two equal half regions.

6- Sensor nodes in each clustered region organize themselves into small groups known as clusters.

7- end

4 Simulation Results and Discussion

The network is contained 300 and 100 nodes in two simulations respectively that are deployed randomly in area 100 × 100. Also the probability of cluster head nodes changed between 0.1 and 0.01 in two simulations randomly. The parameters have been listed in table 1. Simulation is produced by Matlab for 3000 rounds iterations. we use homogenous sensor nodes that are dispersed randomly in network area. In response, the sensor nodes forward their location to BS. In M-GEAR the distance is calculated by BS of each node and save all the sensor nodes information into the node data table. The node data table consists of distinctive node ID, residual energy of node, location of node and its distance to the BS and gateway node.

4.1 Simulation with Node Density 300 and Probability 0.1

This subsection describes the simulation results. The simulations are running and comparing the results with LEACH, Multihop-LEACH and M-GEAR. Figure 2 depicts the dead nodes number of LEACH, Multihop-LEACH and M-GEAR protocols. LEACH protocol is the minimum numbers of dead nodes but Multihop-LEACH is the largest dead nodes number of the comparisons.

Dead Nodes:

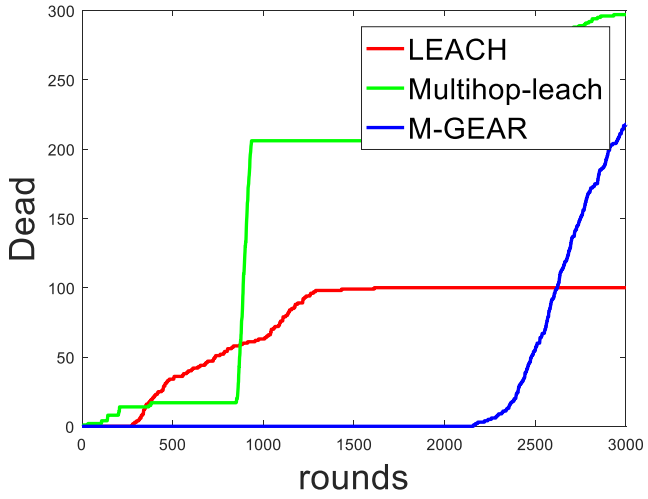

Fig. 2: depicts the dead nodes with 300 density nodes

In figure 3, we show the results of the network lifetime. M-GEAR protocol is the best network lifetime. Because the distribution of the energy is good distributed among nodes.

The network is divided into logical regions. two regions are sub divided into clusters. M-GEAR topology balance energy consumption among sensor nodes. But nodes die quickly in LEACH, as stability period of network ends. Multihop-LEACH is good lifetime protocol other than LEACH. Figure 3 shows interval plot of network lifetime interval. we note that, the M-GEAR protocol are performing well other than LEACH and Multihop-LEACH but we note also that the Multihop-LEACH statically different and perform well other than LEACH.

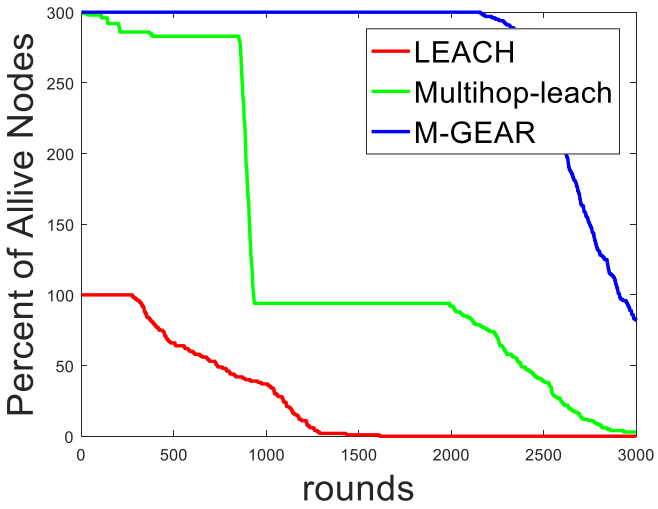

Fig 3: shows the alive nodes with 300 nodes.

Figure 4 depicts the average residual energy of network per round. M-GEAR protocol yields minimum energy consumption other than protocols. Figure 4 clearly depicts that M-DEAR protocol outperforms in terms of energy consumption per round and the performance is improving. Multihop-LEACH outperforms well other than LEACH protocol in all comparisons.

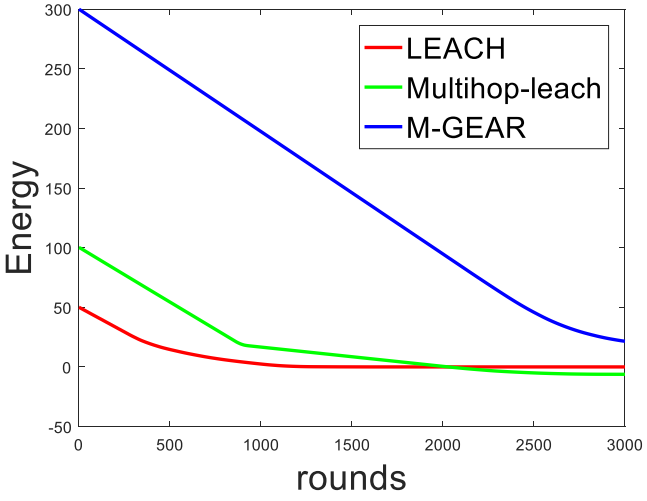

Fig. 4: explain the residual energy with 300 nodes.

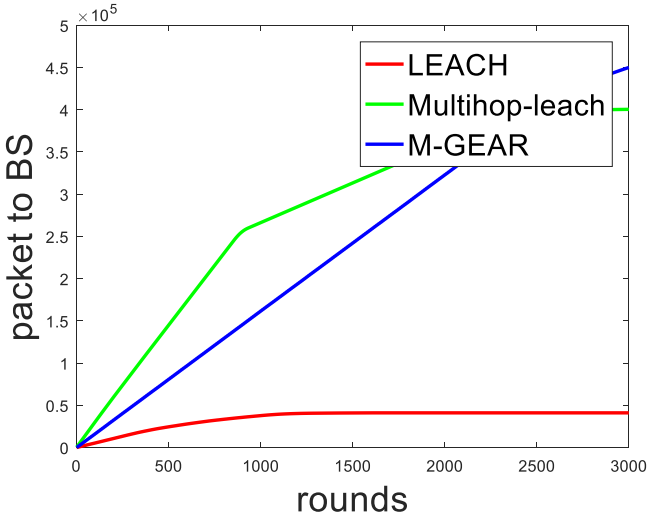

Fig. 5: shows the packet to BS comparisons with 300 nodes.

Sensor nodes near gateway send their data directly to gateway, also the nodes near BS are transmit data directly to BS. Sensor nodes in both regions consume less transmission energy therefore, nodes stay alive for longer period. More alive nodes contribute to transmit more packets to BS. Multihop-LEACH sends packet to BS more than M-GEAR but M-GEAR is more stable and still send packet to BS more than the other in final rounds. LEACH protocol is the worst other than protocols.

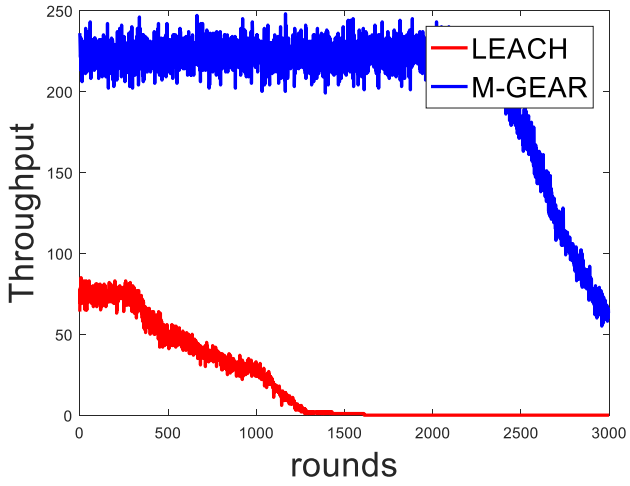

Fig.6: depict throughput with 300 nodes.

Throughput is the average packets rate sent to BS. Simulation comparisons of M-GEAR and LEACH protocols shows the increased throughput. Figure 6 clearly depicts the performance of both protocols. we assume that the CHs could be communicate freely with gateway node. Simulation results show an increase of throughput of M-GEAR protocol other than LEACH.

4.2 Simulation with node density 100 and probability 0.1

In this simulation we tested different value of node density of network. This simulation shows the simulation using 0.1 cluster head probability on the LEACH, Multihop-LEACH and M-GEAR protocols to compare the performance for each protocol. Figure (7) shows the dead nodes number. Multihop-LEACH is the minimum dead nodes number other than protocols. Figure (8) depicts the alive node of network, which is the Multihop-LEACH protocol is the best performance lifetime and the M-GEAR is the second well other than LEACH protocol. Figure (9) shows that the residual energy of protocols, firstly the Multihop-LEACH is the well protocol but at the end rounds all protocols have the same energy. Figure (10) depicts the packet to base station which the Multihop-LAECH is the best other than protocols. The rate of packet-to-base station is high and very well. Figure (11) shows the throughput between LEACH and M-GEAR protocols. it depicts that the M-GEAR throughput rate is more than LEACH protocol. Finally, we could say that the Multihop-LAECH protocol performance is better other than protocols.

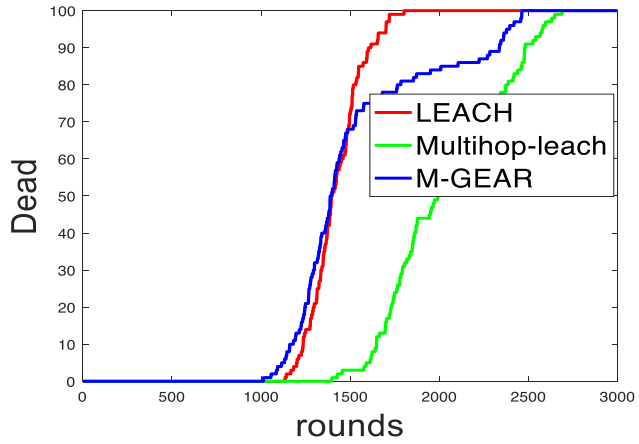

Fig. 7: shows the dead nodes with 100 node density

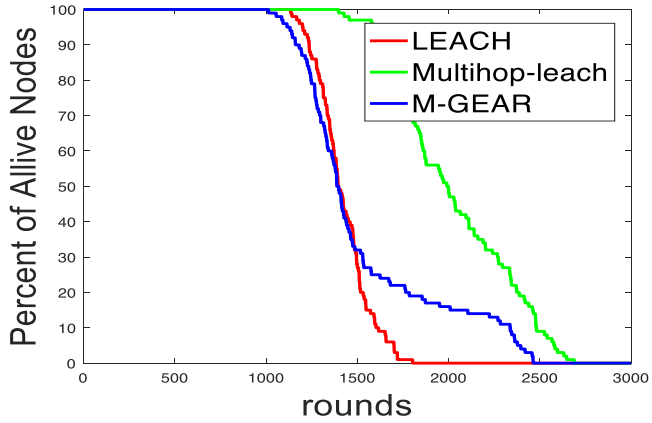

Fig. 8: depicts the alive nodes with 100 nodes density.

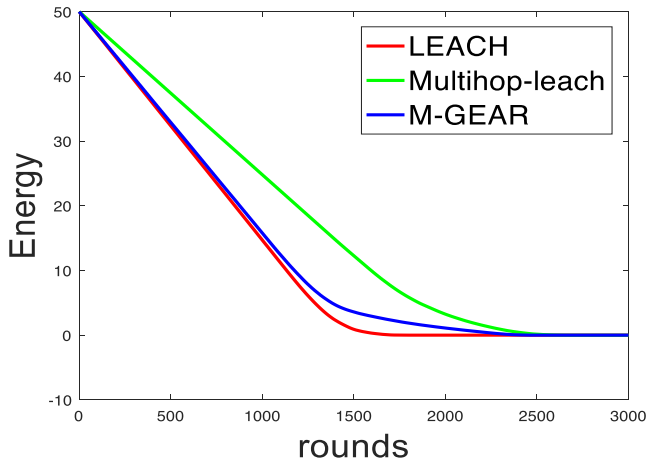

Fig. 9: explains the residual energy with 100 nodes density.

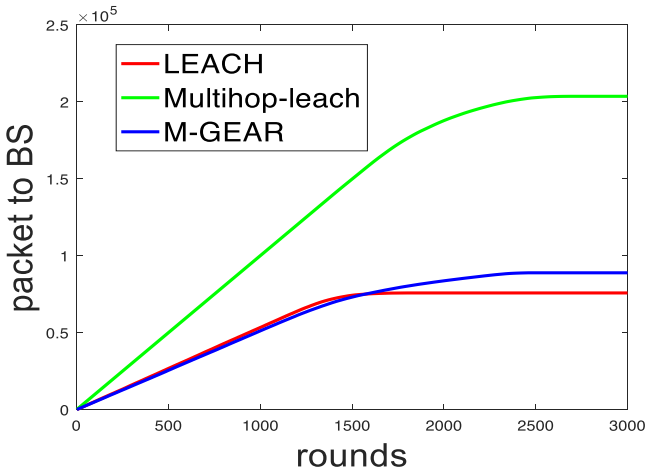

Fig.10: shows the packet to BS with 100 nodes density

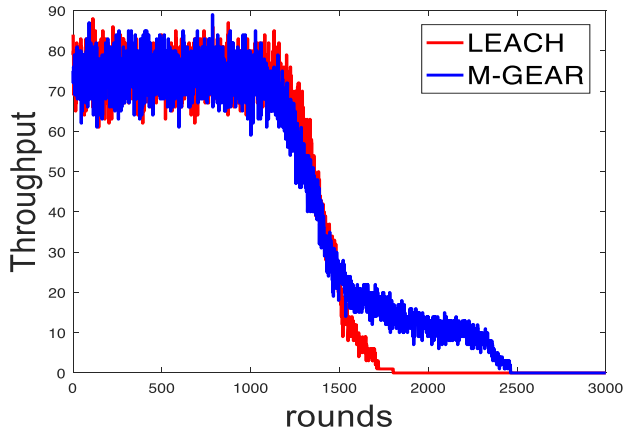

Fig. 11: shows the throughput with probability 0.1.

4.3 -Simulation with node density 100 and probability 0.01

In this simulation we tested different value of cluster head probability in the same density of network of the previous

simulation. This simulation shows the simulation using 0.01 cluster head probability on the LEACH, Multihop-LEACH and M-GEAR protocols to compare the performance for each protocol.

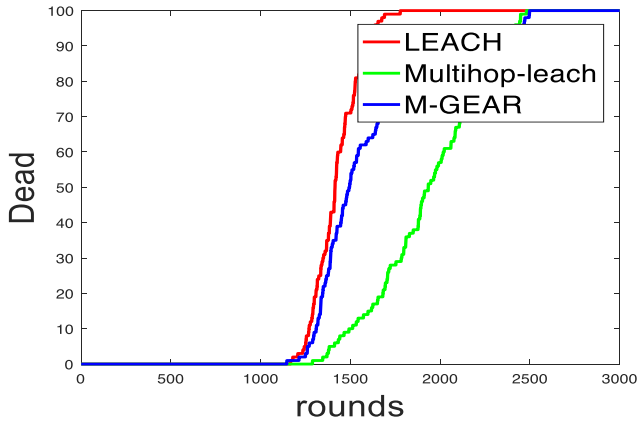

Fig. 12: explain dead nodes numbers with 0.01 probability.

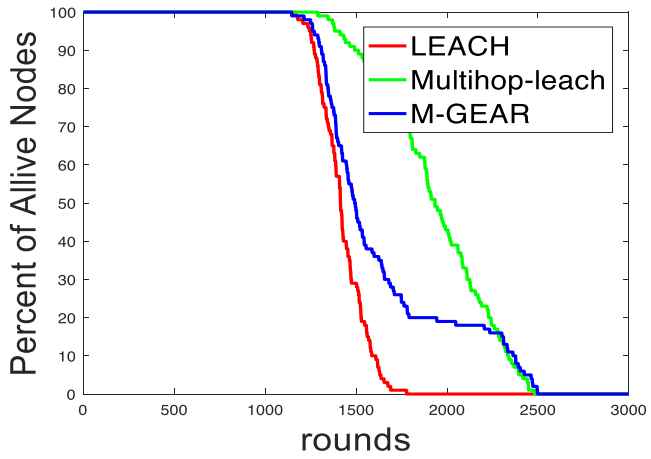

Fig. 13: depicts the alive nodes with 0.01 probability.

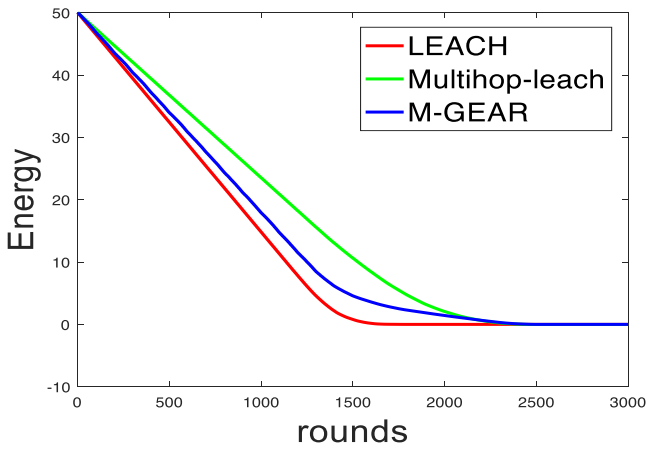

Fig.14: represents the resudiual energy with 0.01 probability.

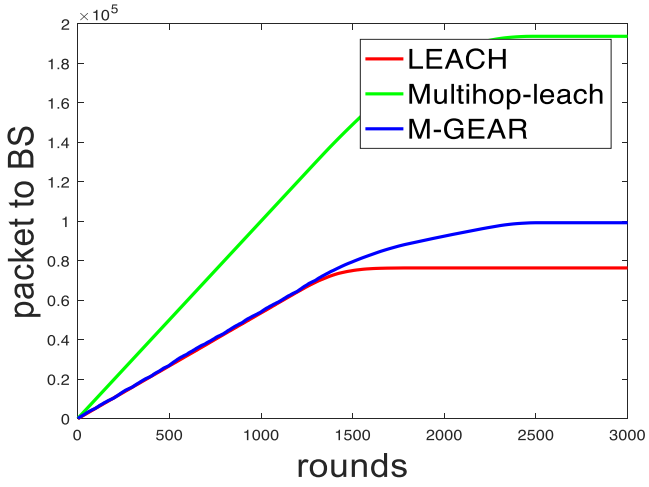

Fig.15: shows the Packet to base station with 0.01 probability.

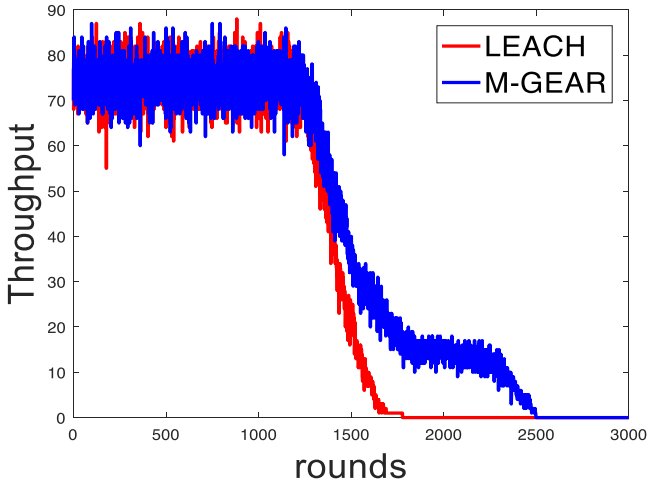

Fig.16: depicts the throughput rate with 0.01 probability

Figure (12) shows the dead nodes number. Multihop-LEACH is the minimum dead nodes number other than protocols but at end rounds all protocols have the same value. Figure (13) depicts the alive node of network, which is the Multihop-LEACH protocol is the best performance lifetime and the M-GEAR is the second well other than LEACH protocol also at the end of round run the M-GEAR and Multihop-LEACH have the same value. Figure (14) shows that the residual energy of protocols, firstly the Multihop-LEACH is the well protocol but at the end rounds all protocols have the same energy. Figure (15) depicts the packet to base station which the Multihop-LAECH is the best other than protocols. The rate of packet-to-base station is high and very well. Figure (16) shows the throughput between LEACH and M-GEAR protocols. it depicts that the M-GEAR throughput rate is more than LEACH protocol and best other the pervious simulation. Finally, we could say that

the Multihop-LAECH protocol performance is better other than protocols.

From the above analysis of the performance of our protocol we could conclude that the Multihop-LEACH protocol shows better performance for small and but in large network the M-GEAR is the best. Also we could increase more attribute of WSN so the protocol is suitable for IoT connection devices and networks.

5 Conclusions

The M-GEAR protocol is more time consuming than LEACH and Multihop-LEACH protocols. This was evident in all simulation with different parameters.

We used several network characteristics on these protocols, which directly affected the dead nodes numbers, packet-to-base station, and alive nodes consumption of the entire network characteristics including network area, probability and node density. Different results have been obtained by different values of these characteristics. We are observed that the M-GEAR protocol good performance in high network density other than protocols that have been compared. For medium and small network density the Multihop-LEACH protocol was the beast performance in all comparisons. After using 0.01 probability cluster head value the performance of M-GEAR become more accurate but the Multihop-LEACH was the efficient in the rate of transfer packets to base station. Finally, the M-GEAR is very good in high network density and the Multihop-LEACH is the beast in medium and small networks density, the changes of these characteristics must be taken into account while developing wireless sensor networks.

5.1 Future Work

Future improvements should focus on network performance so that the deferent parameters are taken in consideration in order to improve the performance of the wireless senor networks. The different parameters that were used proved that the performance of M-GEAR routing protocol is well for high density network, along with cluster head probability changes, node density and network area. Multihop-LEACH is the better with the medium and small networks density. Effects of the protocols performance can be checked, and they can be made more flexible to all kinds of life applications and internet of things.

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