Energy Cost Calculations for Enhanced Power Efficient Gathering in Sensor Information Systems Algorithm with Mobile-Sink

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Abstract

The issue of energy consumption in wireless sensor networks is an important issue nowadays, Power efficient gathering in sensor information systems (PEGASIS) acts as routing protocols improve the energy consumed, which is one of the most important hierarchical directives used and that works to collect and transfer data to and from a neighbor to reduce duplication of data transfer by transferring data to bypass the dead node.

In this research paper, experimental results have been made to improve the performance with new location for nodes trajectory to mobile sink,

Finally, minimum cost for data gathering calculated to optimize network performance and life time with parameters of enhanced PEGASIS criteria to show the impact of factors changing.

Keywords-Wireless Sensor Network (WSN), Mobile Sink (MS), Energy Consumption, PEGASIS, Base Station (BS).

INTRODUCTION

Power consumption is important in WSNs which node transmits, process, and sensing used for monitoring or any other WSNs applications by send data packet to BS or cluster node via channel.

There are many hieratical routing protocols using for energy efficiency, one of essential protocol is Pegasis [**1**] which is hierarchical routing protocol, chain based data delivery approach, very high network life time, no data aggregation, high power consumption, low overhead, no quality of service, specified path, scalable, no query based, and often greedy algorithm used to organize nodes [**2**].

Figure 1 below demonstrates basic structure of pegasis showing the head cluster which collects data to send it together to BS based on distance.

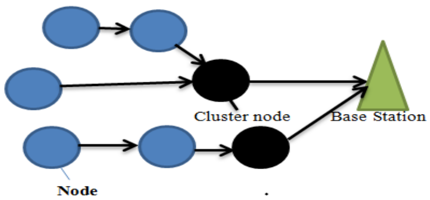

Fig. (1): PEGASIS basic structure protocol

Hierarchical in routing shows in means priority gives to some specific node rather than rest other nodes. To find shortest path, Fareast distance of cluster head among all clusters transmitted the data packets to the nearest cluster head to pass it to the base station. Each particular node receive and transmit packet from nearest neighbor with chain sensor arrangement, then gathering of all packets from sensor nodes to be as one packet in head cluster to send it finally to BS.

Mobile sink may be one or more depend on structure of network, load balance among whole nodes is required if there are multiple sink while power distributed evenly among mobile node one mobile sink.

The problem of energy consumption in wireless sensor networks is one of the important issues that many researchers are still trying to find solutions on in various situations and environments, where the cost and energy consumed of the nodes will be calculated with a specific movement in certain proportions of the radius of the nodes towards the sink. The results show a new pattern of calculations based on energy, environmental, carrier and sojourn parameters taking into consideration the weight coefficient as there is a beta coefficient to clarify the contribution. Where the energy consumed and remaining during the movement of the nodes was calculated with a specific path and finding the least residual life of the network, and finally the cost was calculated with different values of α & β.

II- Related Work:

The mechanism of Pegasis's work depends on the chain based approach, in which the network is divided into clusters, one of the clusters is chosen to be the head [**3**] and the choice of which depends on the value of the threshold: if the chosen value is less than the threshold value, it becomes the head of the Cluster, otherwise it is a normal node which collects data and send it to nearest neighbor which transmits data to the BS [**4**] , also in[**5**] collect data from node to node then send it via head cluster to base station. in[**6**]chain is reconstructed to head cluster to transmit data to BS in case of any node is dead.

The authors S. Sasirekha and S. Swamynathan in [**7**] proposed to send and receive data to the head cluster using the threshold value if selected value is less than threshold value.

Clustering technique [**8**] efficiently optimize the power consumption in WSNs by dividing network sensors into specific clusters which depend on the type of those sensor, also in [**9**] clustering balance the energy based routing algorithm EEMSRA while balance of energy consumption data collection [**10**] which proposed TSP based best path routing for MS .

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In [**3**] prove the relation is increasing network lifetime by increasing number of mobile sink number.

Variant MS speed and direction: random MS trajectory moving [11], static route moving as in [12], controllable moving as in [13], and [14] carry all types features using ETDC by balance energy during data collection then send it to mobile sink. The sink mobility technique [15] that exists with routing protocols for the purpose of solving the problem of hotspots after a sink moves with a specific path and spent energy is optimal during the process of sending and receiving data. Optimize network lifetime done using heuristic algorithm in [16] to improve the performance. In [17] the sparse networks used for enhancement of network connectivity with mobile sink. The use of the sensor networks [18] increased recently due to its ability, sensitivity, low price and increase memory storage, in addition to self-regulation in wireless sensor networks and smart homes in [19]. Authors in [20] present ACO-MCC3D deployment optimization method ACO based single static sink with Centralized topology control for small networks. Mobile Agent based routing protocols in [21] which proposed balance energy between two trajectory mobile agents with constant velocity and the direction to collect data with spiral route. In [22] optimize best path for mobile agent moving, HM-ACOPSO which is hybrid method consists of both ant colony optimization and particle swarm optimization. A Hop based Energy Aware Routing algorithm present in [23] for WSNs to find shortest path algorithm with minimum energy consumption and maximum network lifetime up to 125% from existing algorithm at that time.

3. Problem Statement & Network Model:

3.1. Problem description:

Failure in energy depletion for WSNs especially in much sensor nodes to cover large area, the packet length, energy for electronic consumption for send and receive circuit, distance, operation amplifier coefficients, and path loss represent the main factors.

Energy consumption in receiving side can obtained by multiply the packet length by transmitter/receiver represents electronic energy consumption, while in sending side will clearly describe in equation 2 from next section .

3.2 Network Model:

Nodes in sample network {n1, n2 ,….} arrangement as a circular shape distribution each group of nodes belong to one head cluster depend on the distance from each other carry initial power and sink velocity showed in table 2, nodes access mobile sink wireless any node within network with specific movement in table 1.

3.3 Energy Model:

MS exchange collected data with circular around the center of nodes to choose cluster head, energy equations 1 to 9 used in this paper to simulate results in section 4 later as listed as following below:

1- Transmission consumption and reception consumption calculated for 500 bits data packet length as shown:

$$E_{Tx}(l,d)= \begin{cases} L.E_{elec} + L.\alpha_{fs}.\ d^n \text{ if } d_i < d_{i+1} \\ L.E_{elec} + L.\alpha_{amp}.\ d^n \text{ if } d_i \geq d_{i+1} \end{cases} \quad ..\ \textbf{(1)}$$

Where:

Eelec: transmitter/receiver represents electronic energy consumption.

α_{fs} : amplification coefficient for the free space model.

α_{mp} : denotes multi path fading.

d_i : represent distance of single hop communication.

The energy consumption as in [24] depends mainly on the energy consumed by the receiving circuit and the transmitter circuit shown in equation (1) and radio model as in [25] to find energy consumption.

2- Formula 2 below used to calculate network life time:

$$network\ lifetime = \frac{initial\ energy\ level\ of\ node\ i}{enrgy\ consumption\ of\ node\ in\ each\ rounds} \ .....\textbf{(2)}$$

3- Find new energy for active node by equation 3 after energy consuming of node needed for movement.

New energy node i = initial energy - MCE. ….. **(3)**

MCE. represents consumption energy after movement

4- Energy consumption calculated after movement to next portion towards MS determined in equation 4.
$M.C.E. = L.E_{elec} + L.\alpha_{amp}.d^n \text{ if } d_i \geq d_{i+1}$ … **(4)**

5- Remaining energy for active node after communicate directly with MS After movement calculated in equation 5 below:
R.E. I =New energy node- ST. *(MCE.) .. **(5)**
R.E. represents remaining energy.
ST. Sink time in specific location (in case of movement).

6- Remaining energy of active node after MS move from one point to another.

$$R.E_i = \sqrt{\frac{\sum_{i=0}^{N}(initial\ energy - remaining\ eenrgy)^2}{N}} \ .....\textbf{(6)}$$

i: nodes start with 1 end with 250.
d: distance from specific node to sink.
d_{i+1}: distance after movement of node as in table 2 listed in section 4.
Other parameters assigned table 1 in section 4.

7- Cost calculation with each factor in this equations use other rest of equation to show the contributions.

Cost =min (α. $(RE_i)2 + \beta.\sum_{n=1}^{n}(weight_i * \text{dMS new}_i)$ ….. **(7)**
dMS new: distance to mobile sink with new movement.
Where weight_i will explain in next section.

8- Weight of node limited by node time to be alive, lowest node life time has the first priority, Threshold life time node equation 8 is radius equal to 300 because it has been saved lesser power in sample network.

$$weight_i = \frac{Remaining\ life\ time\ for\ threshold\ node}{Remaining\ life\ time\ for\ active\ node} \ .....\textbf{(8)}$$

Where RL_i will explain in next point

9- Remaining life time of node described in equation 9 below:

$$RL_i = \frac{Res_i}{L\ (E_{elec} + \alpha * \text{dMSnew}_i^n)} \quad ....\ \textbf{(9)}$$

3.2: Procedure Description:

Based on distance ion [26] from node to mobile sink power is calculated required to communicate with neighbor node to send packet to M.S.
In [27] one of important routing protocol has been presented to increase network life, it also discussed the life time of network with adjusting parameter, so that this paper focus on finding the cost using nearly same parameters and procedure listed in table:
1- Chain construction.
2- MS determines the distance for each node location by calculating time to reply request from each node to choose head of cluster.
3- Each group of nodes assigned to one cluster depends on distance (x, y) formula and remaining energy for each node in the network.
3.1- Procedure for distance node to MS as workflow steps (with in network range):
. Allow node lowest distance for node to send data to sink
. Allow node equal distance fattest reply time send data to sink.
. Allow node Highest distance allow it first send data to sink.
3.2 Lowest remaining energy for each node in the network.
4. Repeat step 2.
5. End 2.
6. Minimum remaining node energy= remaining energy.
7. End.
8. MS gets best distance and lowest node remaining energy.
9- In case of node dies start new round.

4. Experimental and Simulation of result:

The idea of adding the cost calculation to the energy consumption ratio with the mentioned transactions is unique in this type of network, as it was not previously done over the extent of the research carried out in the same field referred to in the second part of the research in particular, as these transactions are an important factor in determining the course The transfer of data to the drain with the least amount of energy consumption.
Parameters and new location used for experimental results of each node towards the M.S demonstrates in table 1 and 2 consequently, radius node trajectory with different R is showed in table 1. measuring network life time explain performance of much time particular node would be alive. Simulation from in

figure3 to figure 10 covers range of 300 nodes, packet=500 bytes, same initial power, and other parameters showed in table 2.

Parameter	Value	Unit
Number of nodes	**300**	
Moving speed of sink	**Pi/5**	**m/s**
E_{elec}: Electrical energy consumption	**50e -9**	**J**
L: Packet length	**500**	**bit**
Communication radius nodes	**0,75,150,225,300**	**m**
Path loss	**4**	
Time interval of packet sending	**5**	**s**
Energy consumption in operational amplifier	**5e -10**	**J**
E_{ini}: Initial Energy	**0.05**	**J**
Free space channel parameter (α_{fs})	**10e-12**	**Bit/m^2**
Multipath channel parameter (α_{amp})	**0.0013 e-12**	**Bit/m^4**
Adjusting parameter (α) and (β)	**0.2,0.5**	

Table 1: values of simulation parameters

Adjusting parameter (α) and (β) is 0.2 to get better life time as proved in [27], also 0.5 for both will used later in cost experimental at the end of section 4 later .

Table 2 shows select a subset of sensor locations adaptively for mobile sink trajectory with various radiuses.

Table 2 contains various selected positions to prove that changes occur in energy consumption with distance which lead to decrease node power level, changes in position supposed to be after each 75 nodes location start from 0 ends with 300, simulation results suppose movement of nodes direction towards the sink node to find energy consumption after movement.

Radius (R)	**Movement trajectory towards M.S.**			
	0.25R	**0. 5R**	**0.75R**	**R**
0	**0**	**0**	**0**	**0**
75	**18.75**	**37.5**	**56.25**	**75**
150	**37.5**	**75**	**112.5**	**150**
225	**56.25**	**112.5**	**168.75**	**225**
300	**75**	**150**	**225**	**300**

Table 2: nodes movement to M.S. trajectory of simulation parameters

4.1 Network life time:

Increasing network life time is important in far places from battery charger resources, so that increase the time for each node is still essential issue. based on equation (2) and table 2 to deplete node power consuming through different radius to center MS, network life time calculate in figure 3 that balance in energy consumption of node in each rounds calculated.

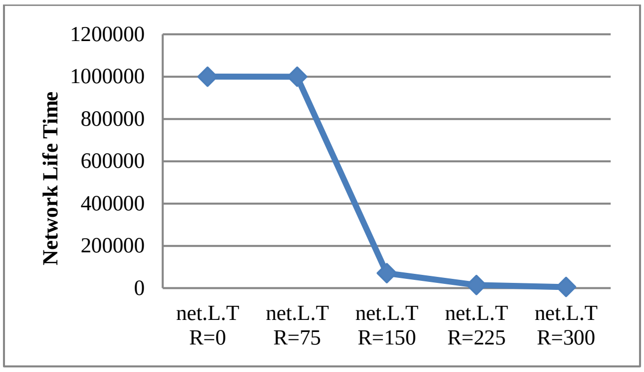

Fig. 2: Network life time (net.L.T) for various radiuses

4.2 Performance of remaining energy with mobile sink using proposed method:

Figure 3 describe consumption energy of active node with different radius distance, when R=0 value goes to initial value of power.

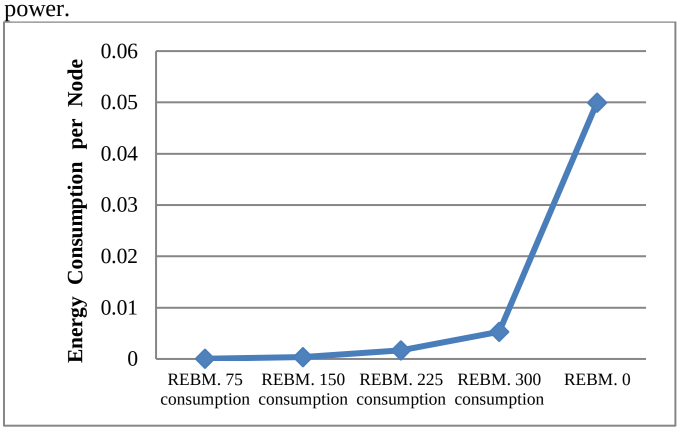

Fig. 3: energy consumption before movement

REBM. Stand for remaining energy before movement.

Remaining energy after decrease consumption in fig. 3 above per node showed in figure 4 below with R=0 with same initial power and less power at R=300 highest radius in proposed network. MS is near the lowest remaining energy node to keep network alive with its velocity.

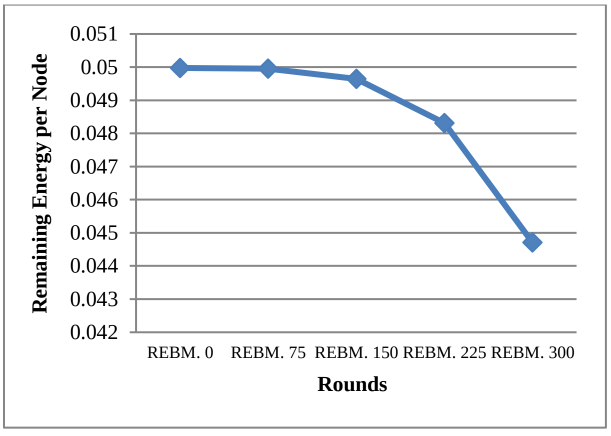

Fig. 4: Remaining energy per node (before movement)

Consumption power after movement of node showed in fig. 5 a, b, c, and d respectively. Experimental results with various radiuses listed in table 2 portions and relation with consumption power in each case.

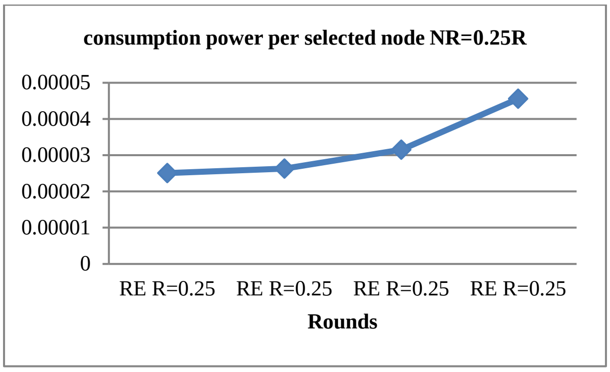

Fig. 5 a Consumption power radius (new radius=0.25 R)

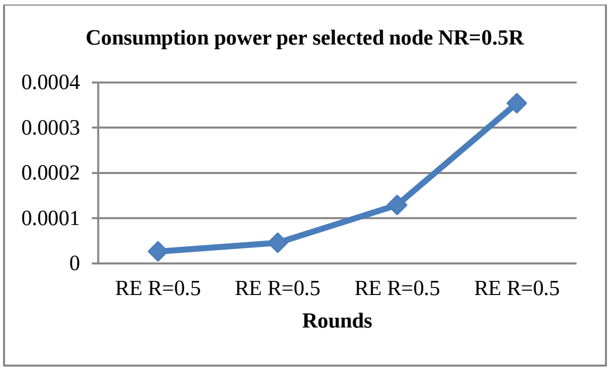

Fig. 5 b Consumption power radius (new radius=0. 5 R)

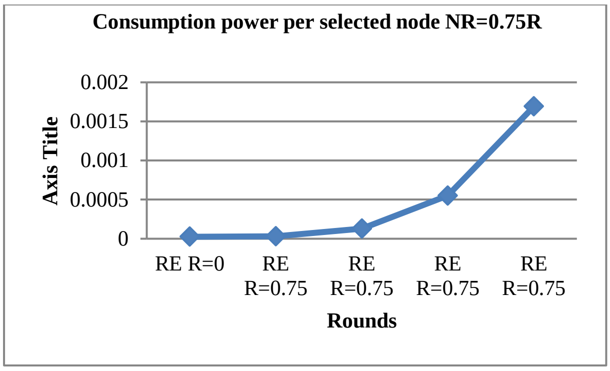

Fig. 5 c Consumption power radius (new radius=0.75 R)

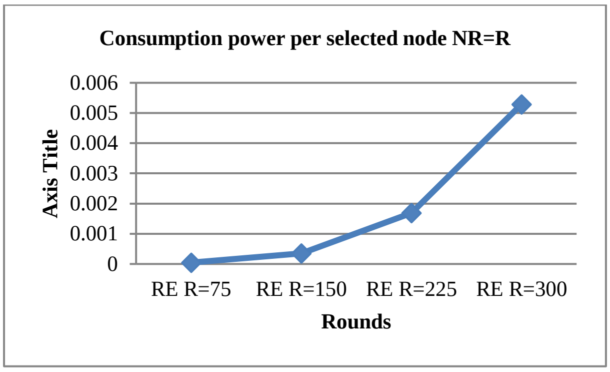

Fig. 5 d Consumption power radius (new radius=R)

Remaining energy after decrease consumption depicted in fig. 5 a,b,c, and d for each node new position showed in figure 6 a,b, and c below with R=0 in c which equal to original power and less power at R=300 "distance of network". Experimental results prove whenever MS Velocity is near lowest remaining energy node to keep networking alive as much as possible.

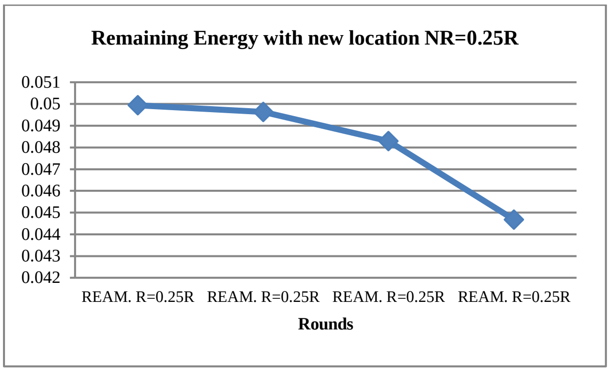

Fig. 6 a Remaining energy radius (new radius=0.25 R)

Where: REAM. Stand for remaining energy after movement.

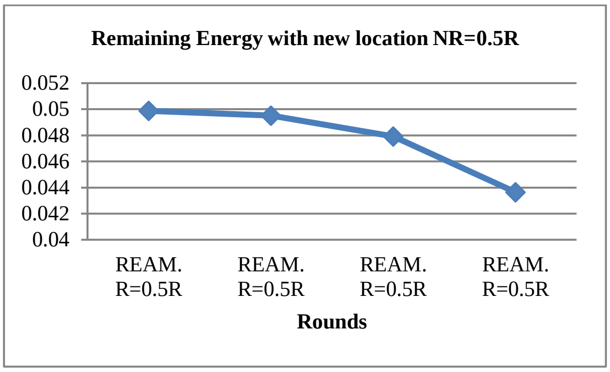

Fig. 6 b Remaining energy radius (new radius=0. 5 R)

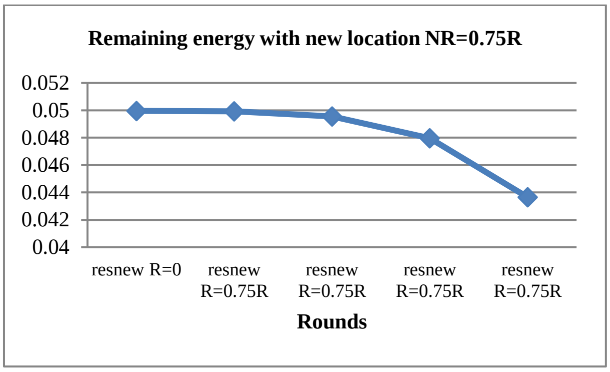

Fig. 6 c Remaining energy radius (new radius=0.75 R)

Difference in remaining energy showed in fig.7 a, b, c, and d respectively, all depicts changes of remaining energy node after movement of MS, while in fig.7 d refers to the remaining energy without movement.

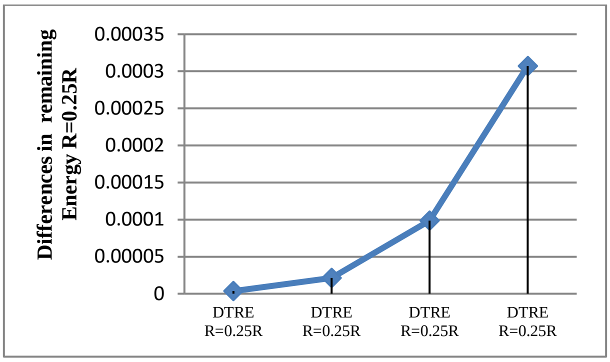

Fig. 7 a Differences in total remaining energy radius (new radius=0.25R)

Where DTRE: represent differences in total remaining energy.

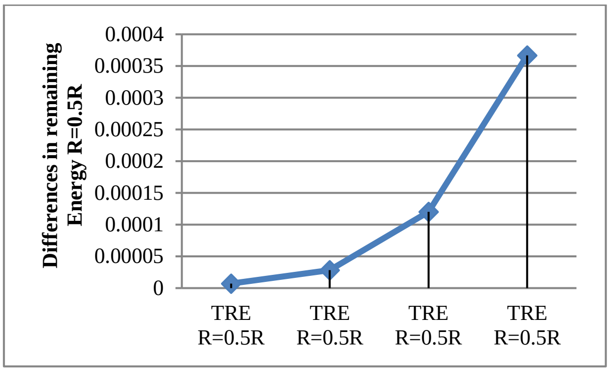

Fig. 7 b Differences in total remaining energy radius (new radius=0. 5R)

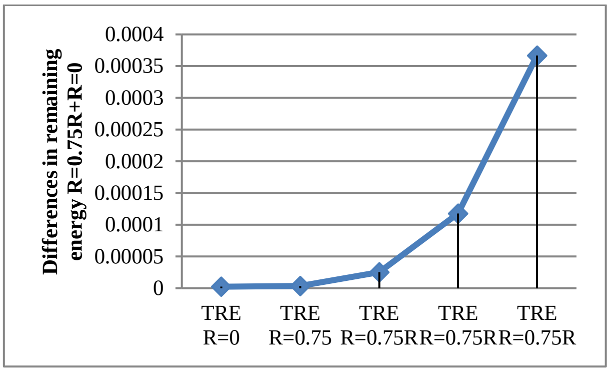

Fig. 7 c Differences in remaining energy radius (new radius=0.75R+R=0)

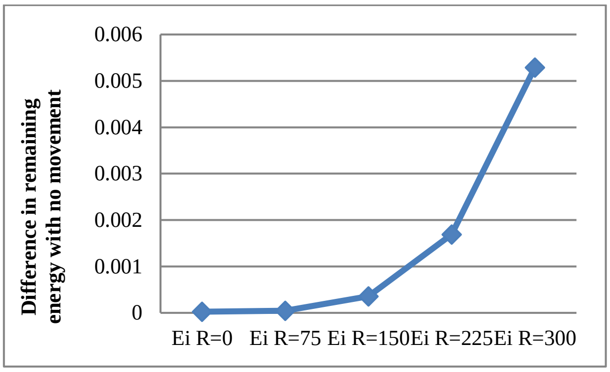

Fig. 7 d Differences in remaining energy radius (new radius=R&R=0)

The highest priority of node gives to less remaining energy node for each node describe in figure 8.

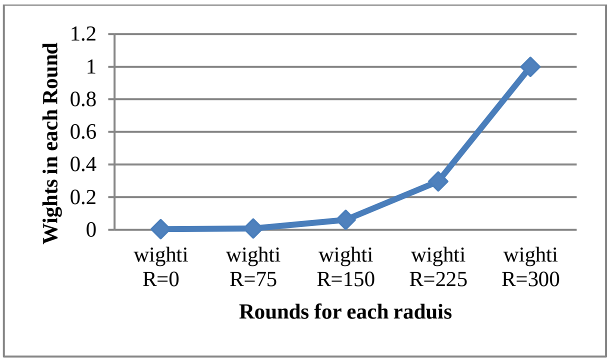

Fig. 8 Weights in each Round

To evaluate the performance cost of EPEGASIS, we simulated Figure 9 a, b, and c shows analytic the results of contribution a random 300 nodes within network, MS is located after moving trajectory at (0.25R, 5R, 0.75R, and R) portion from its portion to next portion.

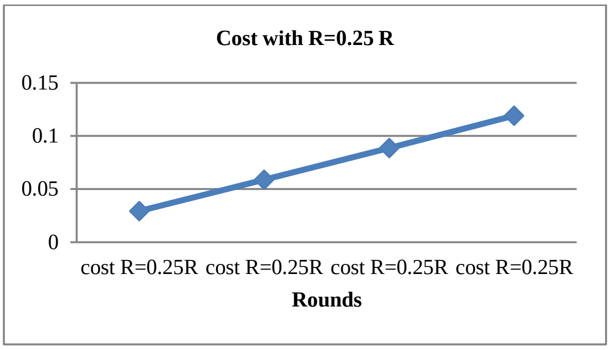

Fig. 9 a Cost with (new radius=0.25R)

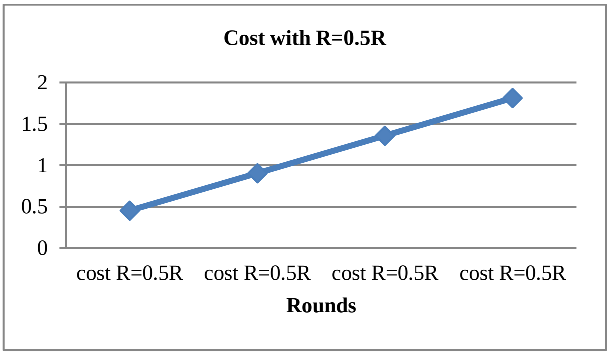

Fig. 9 b Cost with (new radius=0. 5R)

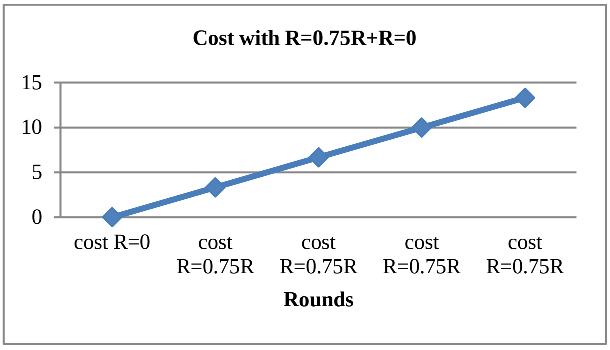

Fig. 9 c Cost with (new radius=0.75R+R=0)

Table 3 contains the cost with different life two adjusting parameters, impact of changing value is clearly showed.

Minimum cost with R=0, α=β=0.2	Minimum cost R=0, α=β=0.5	Minimum cost R=0.25R, α=β=0.2 with node trajectory	Minimum cost R=0.25R, α=β=0.5 with node trajectory
0.000307	0.003382	0.029286	0.073216246

Table 3: Minimum cost with variant value of α&β

5. Conclusion:

In this paper, the main contribution is that calculation of numerical cost to show the effect of changing value parameters on performance of whole network as well as factors "mentioned in section 3" in each step required using closely parameters in enhanced pegasis by presented in table 1 and selecting specific position listed in table 2 with various conditions to optimize network life time.
Eventually, the calculations used for finding better path, for send and receive transmission data changing position to save power by managing transfer of packet; all of these factors have impact on network life time.

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