I J C T A, 9(16), 2016, pp. 8159-8169

A Novel Approach to Maximize Network Lifetime using LCNs

Manas R. Mallick*, Jagamohan Padhi*, Sushree S. Pradhan and Seema Panigrahi

ABSTRACT

For any Wireless Sensor Network (WSN), it has become a critical issue to deal with a node failure, one node failure may cause the total network's operational failure. Therefore, each node's lifetime is as important as the total network lifetime. This has happened in the network basically due to uneven distribution of load during sending the traffic, when some nodes in the network dissipate heavy power than other nodes, causing dry of battery early and results in the node failure. The battery associated with any node is having fixed value Electro-Motive Force (EMF) and it is not flexible enough to replace or recharge the battery once the node deployed in the network, that drag a critical issue in context to power consumption in a WSN. The lifetime of WSN strongly depends on the lifetime of the battery. To deal with the said load balance issue we have introduced some pseudo node in the network in between the most heavily loaded node and the sink to compensate the loads sharing, we called them as Load Compensating Nodes (LCNs). Also, we have proposed an algorithm for routing the traffic for a uniformly distributed homogeneous wireless sensor network which will send traffic following power aware balanced approach routing. In this paper, we have tried to distribute the load evenly on each node to Maximize Network Life Time(MNLT) as a whole keeping in mind to maximize the lifetime of each node and to minimize the average power consumed by the network, also to the individual node. Here, we have simulated our proposed model and have been found that by a small increase in the LCNs percentage we are able to increase a large percentage in terms of total network lifetime when we compared it with the conventional routing approach and able to reach closer to get an evenly loaded network traffic distribution on nodes in a WSN.

Keywords: LCN, MNLT, EMF, Power Level Variance, Coalition Routing.

1. INTRODUCTION

In this real world, the wireless sensor network is nothing but a large number of hundreds or thousands of nodes where typically each node embedded with low power unit, micro-controller unit, small memory, transmitter, receiver, sensor, ADC, DCA, global position system. Each sensor nodes have limited power and it is randomly deployed as per specification or requirement. It is not possible to replace the dead battery in the sensor field. Each node of the sensor consumes battery power in sensed data, receiving data, sending data, processing data [13] [14] [16] [17] [18].

In WSN, it has one base station which communicates with all other nodes in the same network. Each sensor node senses the environmental pheromone like light, sound, pressure, temperature, vibration, motion etc. The base station is nothing but one type of Cluster head which is communicated with other nodes in the same network. Clustering is used for load balancing and extends the network lifetime of all sensor nodes. In each sensor that has global position system (GPS) and local positioning algorithm which can use for the location and position information to the base station. Generally, each sensor node does not directly sends data or message to the base station because it has not had enough power. Therefore, they are routing the sensing data through the neighbor node [13]. In a large network, the sensor node can be grouped into the small network which is called as a cluster. Each cluster has at most one cluster head, which communicates

* SUIIT, Sambalpur University, Sambalpur, Odisha, INDIA, *Emails: manas.mallick@suiit.ac.in, jagmohan.padhi@suiit.ac.in*

with the own network of the node and another cluster of cluster head or directly communicated to the base station [13]. WSN are used in many applications such as military application, area monitoring, transportation, environmental sensing, structural monitoring, industrial monitoring, agriculture sector etc. [16] [17] [18]. Where the sensor node is basically an embedded system which is fixed to a power source, analog to digital converter, digital to analog converter, application specific sensor and data processing devices and radio transceiver. As the system is a small embedded system, it has limited processing speed, communication bandwidth, and limited storage capacity. Once sensors have deployed in the network, these small embedded systems are responsible for self-organizing of an appropriate network infrastructure [11] [13]. Global Positioning System (GPS) and local positioning algorithms can be used to obtain location and positioning information. The battery power consumption and battery power management of a WSN are the key research area so far, where the value of EMF biased to the network has to decide before deployment. In the practical ground, the energy harvesting is not possible in most of the cases. Therefore, it has become a challenging task to optimize the use of battery power in a wireless sensor network. Most of the power drop from battery take place while packets routing. If we will efficiently route the traffic with having a balanced power aware routing approach, the network lifetime hence can be maximized [13] [14] [17].

1.1. Our Contribution

We have implemented our approach designed by taking 25 uniformly distributed compensating nodes forming a square network distribution with having distance between the nodes as unity, as per the shortest path algorithm implemented in the paper of Rutul K. Guha [10]. In addition to the initial model of 25 nodes we have taken four pseudo nodes that we have placed in the mid diagonal distance between sink to the first layer, where we have taken node number 13 as the origin and is been treated as the center. We have calculated the total power consumption and the variance of the power of our proposed model with compared to another existing model subsequently, we have done the manual calculation and also have done the simulation to figure out the impact of additional pseudo nodes LCNs in context to increase the lifetime of the network.

2. PRELIMINARIES AND LITERATURE SURVEY

Francesco Carrabs et al. [1] have proposed a new approach to guarantee a fair level of coverage for each sensor type which is based on a column generation algorithm whose sub-problem is either solved heuristically by mean of genetic algorithm or optimally by an appropriate ILP formulation which can able to dramatically speed up the procedure, enabling the resolution of large-scale instances within reasonable computational times. A lifetime of wireless sensor network enhanced by Sudhanshu Tyagi et al. [2] by cognitive radio based clustering for opportunistic shared spectrum access where they have selected the energy efficient route to transfer data from sensor node to the base station by using hierarchical cluster based data transmission using multi-hop communication. They also proposed another clustering method named Distance–based multi-hop clustering and routing (DB-MCR) protocol for the heterogeneous environment to enhance the network lifetime and the stability of the wireless network. Behnam behdani et al. [3] also tried to increase the lifetime of wireless sensor networks where sink is mobile by using decomposition algorithm, using his algorithm they could able to increase the efficiency by generating column where it forms special structures of the linear programming formulation as a result of which all sub-programs are problem of shortest distance with having positive costs. Keqin Li et al. [4] maximized the sensor network lifetime by design an efficient network where they have taken a lifetime of the network as a function of annuli's number m, with m = R(alpha-1/c)1/ alpha where R is the radius of the area of interest and alpha and c are constant. Shu Li et al. [5] have investigated both deterministic forwarding and random forwarding in wireless sensor network and has constructed a Markov chain model for random forwarding and has derived deterministic expression. Through his analytical model, they could able to identify the situation for either forwarding where they could perform better in context to increase network lifetime. Zhen Zuo et al. [6] have proposed a scheme where they have clustered two hops and transmit them as an image for improving network lifetime in multimedia wireless sensor networks to bypass the energy hole problem, generally appear when a node with a camera or the cluster head compresses the images. Huseyin Ugur Yildiz and his group [7] have optimized energy of accepted security service in terms of node level with respect to network level where they could able to extend network lifetime more than twenty percent by applying node level optimal strategy as compared to a network level optimal strategy. Pengfei Zhang et al. [8] have extended the lifetime of a network by using a clustering algorithm where the sensor can harvest energy. They proposed an algorithm where energy harvesting node for cluster head serves as a dedicated relay node, as a result, they get an efficient solution in optimally and also in sub-optimally. Rahim Kacimi et al. [9] have proposed an approach to balance the node by balance the energy consumption of that node and they have compared both heuristic and optimal results with general techniques like equipotential and shortest path routing, combining balanced node and power of transmission that ensured maximum network lifetime. R. K. Guha et al. [10] have proposed a Pareto efficient condition based on max-min fairness which they called fair coalition routing for group sharing. They have stated that the area where a WSN group shares resources with the nearest group will be efficient only when each group experiences power consumption reduction. K. Das et al. [11] have proposed an approach to bypass the load whose average power consumption is maximum and which affects the network lifetime, as a result of which they have succeeded to minimize the total power of the network by reducing the variance of consumed powered. K. Das et al. [12] have also proposed another way to minimize the variance by selecting a different path to forward network traffic from one node to the next node chosen by the shortest path algorithm to maximize network lifetime.

3. MATHEMATICAL POWER MODEL

3.1. Power Model

In each sensor node, the power consumption (PC) during transmission in the WSN is directly proportional to d^α [4] [10] [11] [12] [18]. Where d = Distance of two sensor node. α is depending on the environment, which value is lies between 2 to 6, i.e. $2 \le \alpha \le 6$. $\alpha = 2$ is for small distance or free space model of WSN and $\alpha = 6$ is for long distance or shadowing model.

Here, α value has taken as constant and is equal to 4. Each sensor node in a group has a finite range of transmission and each node should obey flow balance condition to transmission data.

$$\text{PC} \propto d^\alpha$$
$$\Rightarrow PC = k \times r \times d^\alpha \tag{1}$$

Where k = Constant which value is 1.

r = Rate of Outgoing Traffics of the sensor nodes.

The rate of Income Traffics + Rate of Origination Traffics = Rate of Outgoing Traffics. [11], [12]

Let $K = 1, \alpha = 4, PC = K \times r \times d^\alpha$

Unit of PC $= (\mu\text{W/M bit} \times \text{m4}) \times (\text{Mbps}) \times (\text{m4}) = \mu\text{W/sec}$

3.2. Network Model

R.K Guha et al. [10] have been proposed a model of network lifetime nodes are uniformly distributes of 25 nodes and nodes are distributed in a square form. In the network, 13 number node is the destination node which has supplied power source. All other nodes have an own source which has limited power. Here every node has a limited power source and limited range of transmitting data using shortest path routing from source to nearest node until the data packets reach the destination node have the same distance. Each node generates 1Mbps of data traffic. The distance calculation has been done by either in the orthogonal or diagonal path. For example, in fig. 1, the shortest path from node 3 to node 8 is $1m^4$ which is an orthogonal path and the shortest path from 1 node to 7 node is $\sqrt{2m^4}$ which is a diagonal path. All the nodes are sending a data packet to the destination node 13 whose coordinate is (0, 0).

For example, if we taking the orthogonal path between two nodes the value will be calculated as K = 1, $\alpha = 4$, d = $1m^4$, PC = K × r × d^α the power consumption is 1 µ*W/Sec* and the diagonal path between two nodes the value will be calculated as K = 1, $\alpha = 4$, d = $1m^4$, PC = K × r × d^α, the Power consumption is 4 µW/Sec.

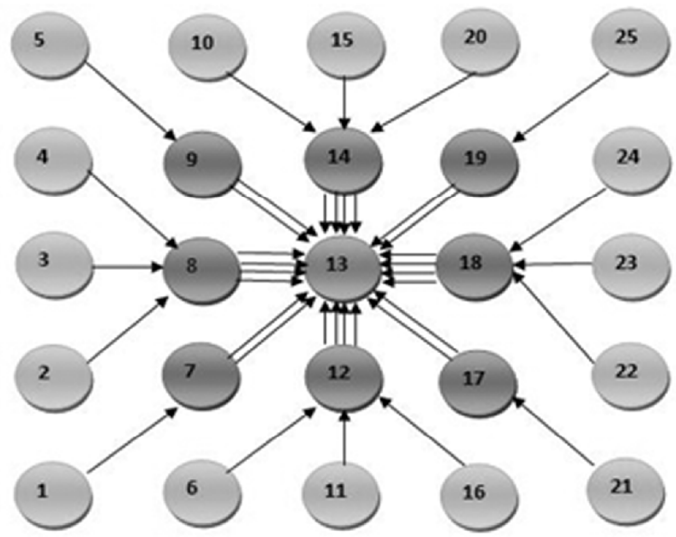

Figure 1: Nodes are distributed uniformly [10].

The 1 node PC = 4 µW/Sec, 2 node PC = 4 µW/Sec, 3 node PC = 1, 4 node PC = 4, 5 node PC = 4, 6 node PC = 4, 7 node PC = 8, 8 node PC = 4, 9 node PC = 8, 10 node PC = 4, 11 node PC = 1, 12 node PC = 4, 14 node PC = 4, 15 node PC = 1, 16 node PC = 4, 17 node PC = 8, 18 node PC = 4, 19 node PC = 8, 20 node PC = 4, 21 node PC = 4, 22 node PC = 4, 23 node PC = 1, 24 node PC = 4, 25 node PC = 4. The total power consumption is 100 µW/Sec..

In K-M model the author [11] has implemented the same network for his routing algorithm, taking all the network parameter same as the previous model. The difference he made in his routing is that he has been

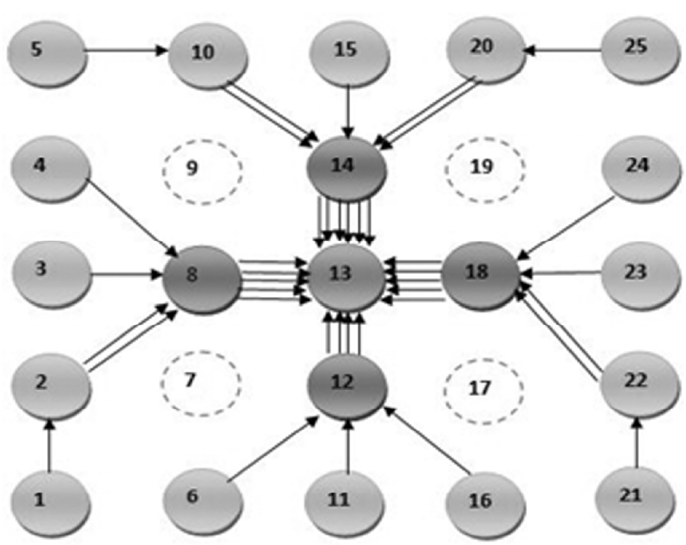

Figure 2: Nodes 7, 9, 17 and 18 not taken which will dry soon on previous model [11].

eliminated the heavily loaded nodes, node number 7, 9, 17 and 19 from the network where the battery power consumption is more as compare to other nodes power consumption. Which happened to early battery failure, leads to complete network failure. He has come up with a node balanced approach, which is shown in fig. 2.

The 1 node PC = 1 μW/Sec, 2 node PC = 8 μW/Sec, 3 node PC =1, 4 node PC = 4, 5 node PC =1, 6 node PC = 4, 7 node PC = 0, 8 node PC = 5, 9 node PC = 0, 10 node PC = 8, 11 node PC = 1, 12 node PC = 4, 14 node PC = 6, 15 node PC = 1, 16 node PC = 4, 17 node PC = 0, 18 node PC = 5, 19 node PC = 0, 20 node PC = 8, 21 node PC = 1, 22 node PC = 8, 23 node PC = 1, 24 node PC = 4, 25 node PC = 1. The total power consumption is 75 μW/Sec. In the mode the value of PC is 0 μW/Sec means that the nodes (7, 9, 17 and 19) absent of the network model.

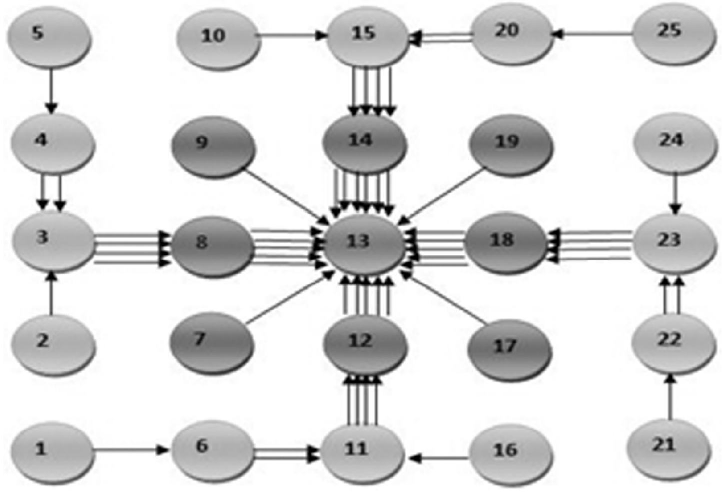

Figure 3: Nodes are selected different and particular path [12].

In K-J model the author [12] has proposed a new routing techniques, where he has subjected his routing by selecting a definite path to send traffic in network that has been shown in fig. 3 and the PC of each node can be calculated as, 1 node PC = 1, 2 node PC = 1, 3 node PC = 4, 4 node PC = 2, 5 node PC = 1, 6 node PC = 2, 7 node PC = 4, 8 node PC = 5, 9 node PC = 4, 10 node PC = 1, 11 node PC = 4, 12 node PC = 5, 14 node PC = 5, 15 node PC = 4, 16 node PC = 1, 17 node PC = 4, 18 node PC = 5, 19 node PC = 4, 20 node PC = 2, 21 node PC = 1, 22 node PC = 2, 23 node PC = 4, 24 node PC = 1, 25 node PC = 1. The total Power Consumption is 71 μW/Sec.

In our proposed model using LCN, the network has been reconfigured keeping the base node distribution unaltered, having 25 main nodes and the parameter to calculate the PC, TPC and APC are same. In our approached model we have placed few pseudo nodes in the mid-distance between the highly loaded first

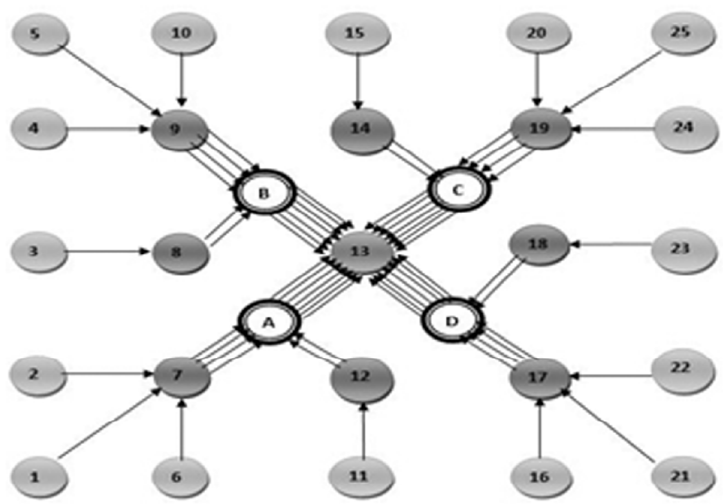

Figure 4: MNLT using LCNs models.

layer nodes and the sink to compensate the load on the node for sending traffic. A, B, C and D here are the compensating node which has been placed at distance 0.707 from node number 7, 9, 17 and 19 respectively towards the origin (node 13), that has been shown in fig. 4.

3.3. Algorithm

- Take scale of the model network 'G' denoted as (K), where K = 3, 5, 7… and N is the total nodes deployed in that network = ρ^2.
- Distributed all nodes n_{ij} with equal distance 'd' orthogonally to $n_{i(j+1)}$, $n_{i(j-1)}$, $n_{(j+1)j}$, $n_{(i-1)j}$,Where $ni \in N$, i, j = 1, 2, 3 …
- In G(N, E) for all n ε N, determine the shortest path between nodes and nodes to sink.
- Layer the whole network (G), total layers 'Ω' in a network with scale ρ(K)is i where $K(i)$ = 3, 5, 7... And i = 1, 2, 3....
- Introduce compensating nodes at the mid between sink and the corner nodes of innermost 'Ω'.
- If n_{ij} is Conner node of Ω shortest diagonal routing is used to send traffic towards the sink.

  Else

  n_{ij} follow shortest orthogonal routing towards the sink.
- Calculate PC, PC is Power Consumption which is directly proportional to d^{α}, where $\alpha = 4$.
- Repeat the previous step until the packet traffic will reach to the sink node in the network.

4. IMPLEMENTATION

We have implemented the whole network design in MATLAB to realize the Total Power Consumption for all existing model with our proposed routing having extra compensating nodes (LCNs). Table 1 is showing the simulated result of power consumption of each node with their respective distance and rate of traffic in our proposed model. And the value has been plotted in Matlab, shown in fig 5.

Table 1
The rate of outgoing traffic, a distance of two nodes and power consumption of our proposed model.

S.n.	Nodes No.	Rate of Outgoing Traffice [r(μW/M bit × m4)]	Distance Of Two Nodes [d (Mbps) × (m4)]	Power Consumption [Pc μw/sec]
1	1	1	1.414	4
2	2	1	1	1
3	3	1	1	1
4	4	1	1	1
5	5	1	1.414	4
6	6	1	1	1
7	7	4	0.707	1
8	8	2	0.707	0.5
9	9	4	0.707	1
10	10	1	1	1
11	11	1	1	1
12	12	2	0.707	0.5
13	13	X	X	X

(*contd...*)

(*Table 1 contd...*)

S.n.	Nodes No.	Rate of Outgoing Traffice [r(μW/M bit × m4)]	Distance Of Two Nodes [d (Mbps) × (m4)]	Power Consumption [Pc μw/sec]
14	14	2	0.707	0.5
15	15	1	1	1
16	16	1	1	1
17	17	4	0.707	1
18	18	2	0.707	0.5
19	19	4	0.707	1
20	20	1	1	1
21	21	1	1.414	4
22	22	1	1	1
23	23	1	1	1
24	24	1	1	1
25	25	1	1.414	4
26	A	7	0.707	1.75
27	B	7	0.707	1.75
28	C	7	0.707	1.75
29	D	7	0.707	1.75
TOTAL POWER CONSUMPTION is 41 μW/Sec.				

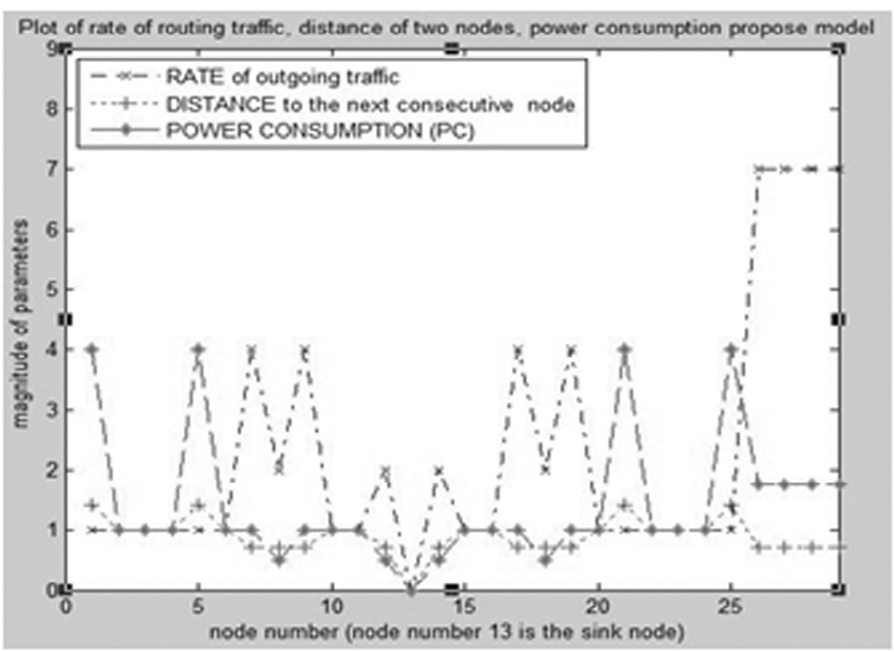

Figure 5: Plot of rate of routing traffic, distance of two nodes, power consumption proposed model.

The total power consumption in our model we have found is after simulation in MATLAB, which is much less than that of all other models of its kind available so far up to our knowledge.

The comparison of our proposed model's total PC to that of existing model has been tabulated in Table 2, where it is clearly visible that our model with additional LSNs is consuming less power and is about half of the standard model, hence the total lifetime of the network could be increased up to the double of the standard model [10].

Table 2
Total power consumption in (µw/sec.) of r.k. ghua's model [10], k-m model [11], k-j model [12] and our proposed model.

Model	*Total Power Consumption µW/Sec*
R.K. Ghua Model [10]	100 µW/Sec.
K-M Model [11]	75 µW/Sec.
K-J Model [12]	71 µW/Sec.
Our Propose Model	41 µW/Sec.

In Fig. 6, the height one (bar 1) is the total power simulated the output of Rutul K. Guha [10] which is 100 µW/Sec. the second height one (bar 2) is the total power simulated the output of K-M [11] which is 75 µW/Sec. The third height one (bar 3) is the total power simulated the output of K-J [12] which is 71 µW/Sec and the small height i.e. the fourth bar is our proposed model with LCNs, showing the huge difference in total power consumption with its competent existing models.

We have drawn a plot matrix of different parameter with total power consumption for our model i.e. for 'r', 'd' and PC to demonstrate that our proposed model is closing towards a balanced node power distribution.

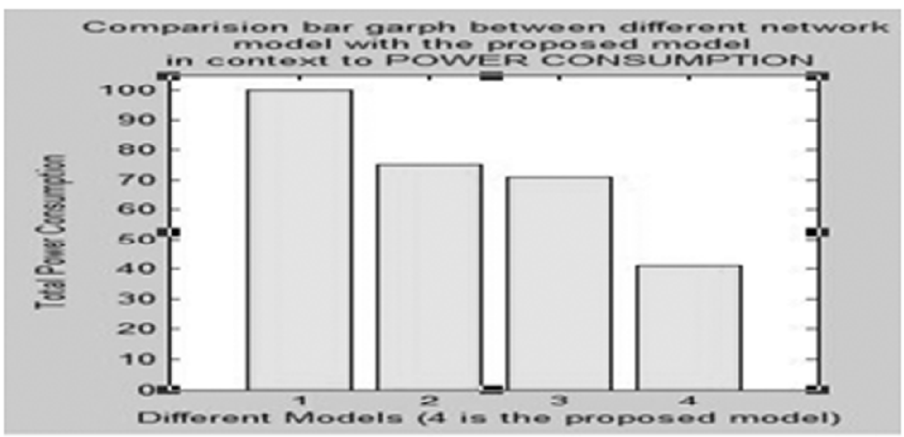

Figure 6: Total power consumption of different models.

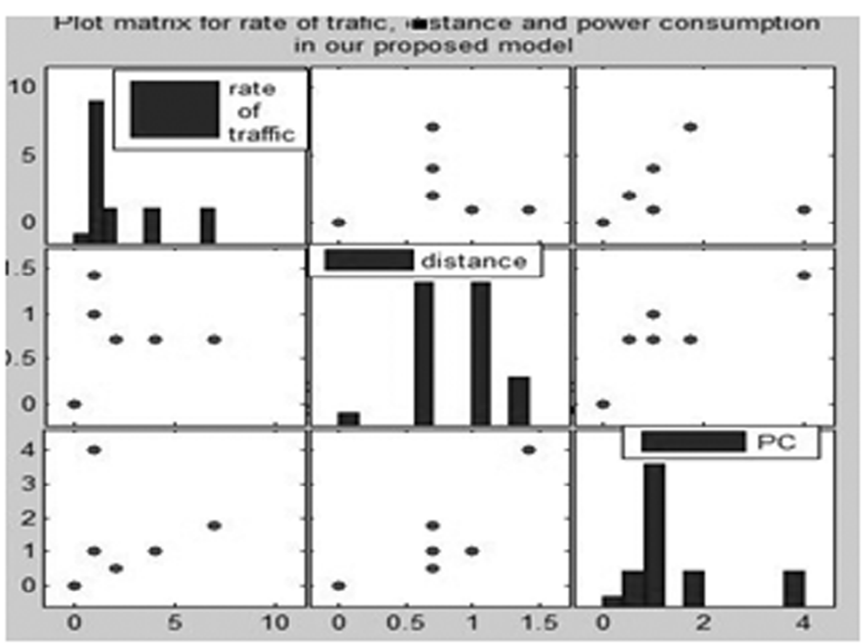

Figure 7: Plot matrix for r, d and PC for proposed model.

In PC section i.e. plot matrix(3-3) shown in Fig. 7, it is clearly visible that PC of each node is not varying much , most of the PC of nodes lies within 1 and few nodes consuming apparently higher value (within PC 4), which can be treated as a marginal figure.

Fig. 8 is an area graph plotted between the variance of the power of our proposed model to the existing models of its kind available, that we have taken in our simulation to compare as tabulated in Table 3. The simulation showing a huge area of the variance of power difference by using LCNs model to other models; it is almost the half of its competent models.

Table 3
The variance of power consumption between the old model and proposed model.

Model	*Proposed Model*	*Old Model*
R.K. Ghua [10]	1.74	4.139
K-M[11]	1.82	2.493
K-J[12]	0.96	2.26

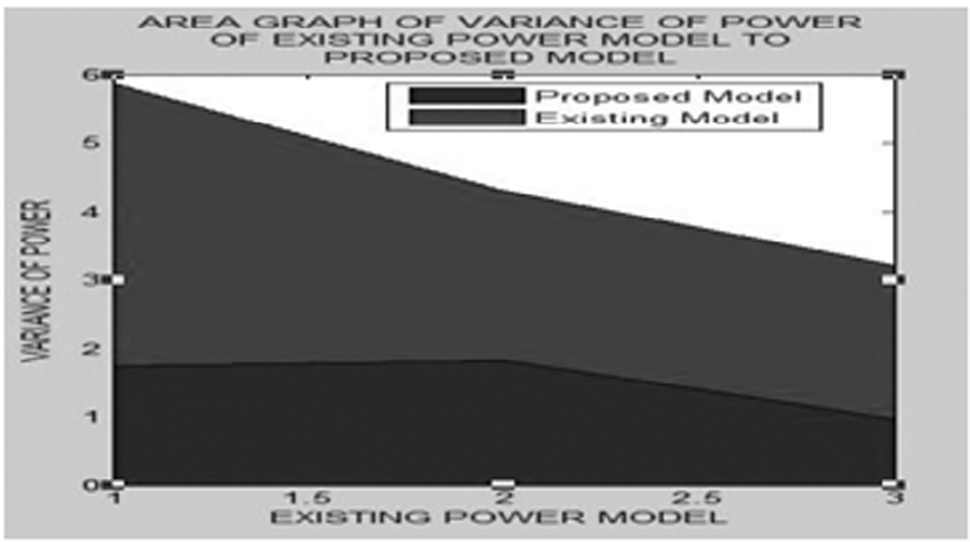

Figure 8: Area plot of variance of power consumption between old model and proposed model.

5. LIFETIME ANALYSIS

If one node of the network failed then it leads to total network failure, it affects the network directly. So while calculating the network lifetime, it is very much important to calculate the power consumption of the node consuming higher power in a network. Keeping assumption that the network will sustain till all node alive, one dead node will be treated as whole network dead. So we need to calculate the power consumption in node level.

We have a homogeneous network, battery associated to each node is having the same power and let us assume that it has a 9-*volt* battery, has about 1000 *mAh* and the highest loaded node in our proposed model is consuming 4 μ*W*/*sec*, in terms of an hour it will be 0.0144 *Wh*. The total power available is 9 *Wh*. According to the above data; our node can work for 625 hours.

In the case of Dijkstra routing as in Ghua [10], we have taken as a standard model that follow Dijkstra shortest path algorithm. The conventional method of network trafficking, in this model the higher loaded node is consuming 8 μ*W*/*sec*, twice the proposed model. That implies the node can work for 312.5 hours only. Likewise, we have calculated the expected hour that the node can work continuously with our battery power assumption, and hence, we can able to calculate the total network lifetime mathematically from the data available and are shown in Table 4.

Table 4
A comparative study based on balancing node in contest to increased network lifetime.

Model	*Highest Loaded Node PC*	*Total hour the Node can run with 9 volts, 1000mAh battery*	*Taking Guha as standard increased lifetime in terms of node balance*
R.K. Ghua [10]	8	312.5 hour	0 %
K-M [11]	8	312.5 hour	0 %
K-J [12]	5	500 hour	60 %
Proposed Model	4	626 hour	100 % (Double)

6. CONCLUSION

By using additional 16.66 pseudo nodes as LCNs and routing as per our approached algorithm to the cluster model we can able to increase 100 percent of its network lifetime i.e. the double of its original. We have simulated our model and could able to increase our network lifetime manageably well enough by reducing heavily loaded traffic node's load to have a balanced loaded node model. Which ensure to have a better lifetime and a congestion free efficient trafficking within WSN.

The results coming out from the simulation has opened a wide area of research, that the life of a WSN can be increased further by other possible way of implementing LCNs for designing a complete load balancing model.

References

[1] Francesco Carrabs, Raffaele Cerulli, Ciriaco D'Ambrosio, Monica Gentili and Andrea Raiconi, "Maximizing lifetime in wireless sensor networks with multiple sensor families", Elsevier, Computers & Operations Research 60 (2015) 121-137.

[2] Sudhanshu Tyagi, Sudeep Tanwar, Neeraj Kumar and Joel J.P.C. Rodrigues,"Cognitive radio-based clustering for opportunistic shared spectrum access to enhance lifetime of wireless sensor network.", Elsevier, Pervasive and mobile computing 22(2015)90-12.

[3] Behnam Behdani,Young Sang Yun, J. Cole Smith and Ye Xia, "Decomposition algorithms for maximizing the lifetime of wireless sensor networks with mobile sinks", Elsevier, Computers & Operations Research 39 (2012) 1054–1061.

[4] Fabian Castano, Eric Bourreau, Nubia Velasco, André Rossi and Marc Sevaux, " Exact approaches for lifetime maximization in connectivity constrained wireless multi-role sensor networks", Elsevier, European Journal of Operational Research 241 (2015) 28–38.

[5] Shu Li and Jeong Geun Kim, "Maximizing the lifetime of wireless sensor networks with random forwarding", Elsevier, Int. J. Electron. Commun. (AEÜ) 69 (2015) 455–457.

[6] Keqin Li, "Optimal number of annuli for maximizing the lifetime of sensor networks", Elsevier, J. Parallel Distrib. Comput. 74 (2014) 1719–1729.

[7] Huseyin Ugur Yildiz, Kemal Bicakci, Bulent Tavli, Hakan Gultekin and Davut Incebacak, "Maximizing Wireless Sensor Network lifetime by communication/computation energy optimization of non repudiation security service: Node-level versus network level strategies", Elsevier, Ad Hoc Networks 37 (2016) 301–323.

[8] Pengfei Zhanga, Gaoxi Xiaoa and Hwee-Pink Tanb, "Clustering algorithms for maximizing the lifetime of wireless sensor networks with energy harvesting sensors", Computer Networks Volume 57, Issue 14, 4 October 2013, Pages 2689–2704.

[9] Rahim Kacimia,Riadh Dhaoub and André-Luc Beylotb, "Load balancing techniques for lifetime maximizing in wireless sensor networks", Elsevier B.V, Ad Hoc Networks, Volume 11, Issue 8, November 2013, Pages 2172–2186.

[10] R.K Guha, S.Sarkar and A Gunter, "Fair Coalitions for power Aware Routing in Wireless Network," IEEE Transactions on Mobile Computing, 2007.

[11] K. Das and M. Panda, "A Novel Approach to Maximize Network Life Time by Reducing the Variance of Power Consumption among Nodes in Wireless Sensor Network."International Journal of Advance Computation and Networking, Oct. 2013.

[12] K.Das, D. K. Mallik, S. Sahoo and J. Padhi, "Increased Network Life Time Algorithm in Wireless Sensor Network," IJIRAE: 2349-2163.

[13] DipakWajgi and Dr. Nileshsingh V. Thakur, "Load balancing algorithms in wireless sensor network: a survey", IRACST – International Journal of Computer Network and Wireless Communication (IJCNWC), ISSN: 2250-3501 Vol. 2 No. 4, August 2012.

[14] DipakWajgi and Dr. Nileshsingh V. Thakur, "Load balancing based approach to improve lifetime of wireless sensor network", International Journal of Wireless & Mobile Networks (IJWMN) Vol. 4, No. 4, August 2012.

[15] Gaurav Gupta and Mohamed Younis, "Load- balance clustering of wireless sensor networks", IEEE, 2003.

[16] Mina Mahdavi, mahamod Ismail and KasmiranJumari, "Load balancing in energy efficient connected coverage wireless sensor network", International Conference on Electrical Engineering and Informatics 5-7 August 2009, Selangor, Malaysia.

[17] Christopher M. Cianci, Vlad Trifa and AlcherioMartinoli, "Threshold-based algorithms for power- aware load balancing in sensor networks.", IEEE 2005.

[18] Manas Ranjan Mallick, Sushree S. Pradhan, Jagamohan Padhi, Seema Panigrahi, "A Novel Approach To Maximize Network Life Time By Reducing Power Consumption Level Using Cgnt Model", IEEE International Conference , ICCPCT, in press.