Ternary-Tree Based Static Multi-hop (TTBSMH) Leach Energy Efficient Routing Protocols in WSN's.

Dr. Hanumanthappa .J[1], Mr.Abdulmalek maresh hasan ali[2]
[1]*DoS in CS, University of Mysuru, Manasagangothri, Mysuru, Karnataka, India*
[2]*Research Scholar, Departmet of CS & E, VTU, Belgaum, Karnataka, India.*

Abstract- Latest advances in energy efficient routing protocols have increased the popularity and success of WSN's. Throughout the study of this research work the authors have studied the Ternary-Tree Based Static Multi hop (TTBSMH) Leach energy efficient routing protocol in wireless sensor networks. In this research work we are comparing and contrasting the performance metrics of ternary-tree based energy efficient routing protocol such as Packet Loss (Drop) Rate,Throughput and Dead Node Rate.We are also calculating best case time complexity, average case and worst case time complexities of the currently proposed research work.

Keywords- *Energy efficient, multi-hop, static, ternary tree etc*

I. INTRODUCTION

Wireless Sensor Networks (WSNs) become popular recently due to their applications in unattended tracking and detection of undesirable objects, hazard identification, data searching environment management and so on. In wireless sensor networks, some sensor hops are kept in sleep mode while other sensor hops are kept in active mode for sensing and communication jobs in order to diminish energy consumption and extend network life time. WSNs have a wide variety of applications such as fault tolerance, military, clustering technology, underground wireless sensor networks, tubectomy, vasectomy, blood cancer treatment, heart cancer treatment, caesarean, agriculture domain, nuclear technology, body area networks, environmental monitoring, temperature sensing, battle field awareness, industrial sensing, infrastructure protection and civil applications. We consider a WSN consisting of a great number of sensor nodes (sns). The sensor nodes are powered by batteries with limited quantity of energy. The number of sensor nodes in the WSN is abundant to provide sufficient sensing coverage and connectivity.

II. RELATED WORK

This section sheds light on the previous approaches deployed for computing performance issues of energy efficient static multi hop routing protocol using WSNs with its merits, demerits and results. A.Iqbal, N.Javid et al propounded and estimated advanced low energy adaptive clustering hierarchy (Ad-Leach),which is static clustering based heterogeneous routing protocol. Wendi Rabiner Heinzelman, Anantha chandrakasan et al [1] have studied communication protocols which can have significant impact on the overall energy dissipation of these networks. Their research work simulation results also confirm that LEACH can achieve as much as a factor of 8 reductions in energy dissipation compared with conventional routing protocols. They have also explained the advantages of application specific protocol architectures by designing and evaluating protocol architectures for two different application spaces: large scale micro sensor networks and wireless transport of compressed video. B.Manzoor, N.Javaid have propounded Quadrature (Q-Leach) for homogeneous networks enhance stability period, network life time,and throughput quiet significantly. K. Latif, N. Javaid propounded Divide and Rule (DR) based static and dynamic clustering routing protocol. Prf. Dr. Hanumanthappa .J.et al [2] proposed graph theory based quad tree static multi hop leach routing protocol for an energy efficient wireless sensor networks. Their proposed DCQMS-Leach routing protocol overcomes the dearth of all the previous LEACH energy efficient routing protocols. He has also propounded Tree Based Static Multi hop Leach (TBSMH-Leach) Energy Efficient Routing Protocol: A Novel Graph Theoretic Approach using divide and conquer technique. In this research work we are comparing and contrasting the ternary tree based energy efficient routing protocol for WSNs.

Lujuan Ma,Henry leung et al have propounded hybrid TDMA/CDMA MAC protocol for WSNs. Anindita ray,Debashis De [12] have proposed an energy efficient clustering protocol based on K-means algorithm named EECPK-means for WSNs where midpoint algorithm is used to initial centroid selection procedure. In [17] an algorithm has been propounded to compute initial cluster centres. It has been identified that using this algorithm,the calculated cluster centres are very close to the necessary cluster centres. However this approach is fail to produce balanced cluster. In [18] the authors have propounded an energy efficient routing protocol based on the effective ensemble data and optimal cluster head chosen. In [19] the author has proposed a cooperative communication method. His experimental result shows that the total energy consumed by the network is minimized when cooperation exists than without cooperation. But the traffic overhead is enlarged at the beginning of each round when the number of sensor hops in cluster areas are relatively high. B.Baranidharan et al [20] have proposed to found clusters and shortest path for the data transmission using minimum spanning tree.

III. GRAPH THEORETIC SPECIFICATION OF CLUSTER HOPS.

By using graph theoretic approach the cluster hops are specified using the equation --------(i).

According to the graph theoretic approach one of an idea to create a sensor network is G=(V,E) ------(i)

where the vertices V specify the sensors and the set of links E specify the connection between vertices if they are specified

within a given area. According to the graph theoretic approach a cluster is any subset of hops such as C⊆V,y∈V is a cluster head and G_c =(C,E_c) is a type of cluster graph.

$$Ec=\{(u,v) \mid u,v \in C \wedge (u,v) \in E\} \text{-----(ii)}$$

When cluster graph G_c is connected then the cluster is called as a connected graph. $d_c(u,v)$ is the shortest road inside a cluster. The cluster radius is the maximal distance between y and any other hop v ∈ C.

$$max_v \in Cd_c(y,v) \text{---(iii)}$$

The energy computation of each cluster group is equal to E_{cl}. By using two levels of energy equation the cluster energy is calculated using equation (iv)

$$E_{cl}=N_{cl}E_0(1-j)+N_{cl}\, jE_0(1+h) \text{ ----(iv)}$$

Where E_0:-initial energy of a normal hop,(1-j) Ncl:sum of quantity of normal hops,N_{cl} j:Number of advanced hops and their energy is:E_0(1+h) and the sum of hops present in each cluster:$N_c$ls. The modified energy of each cluster is calculated by the following equation (v).

$$E_{cl} = N_{cl}E_0(1+hj) \text{ -- (v)}$$

The sum of an initial energy of a cluster is provided by equation – (vi).

$$E_{tot} = \sum_{cl=1}^{n} Ecl \text{ -- (vi)}$$

Where n:-sum of cluster hops.

IV. PROPOUNDED METHODOLOGY.

As noted in section-1 and related literature sections ternary tree based static multi hop energy efficient routing protocol for heterogeneous or homogeneous networks is a complex problem and is hard to find a solution with conventional techniques. The propounded technique makes use of ternary tree based multi hop energy efficient routing protocol using WSNs and its effectiveness has been identified and incorporated,to enhance the performance issues of said approach by reducing energy consumption, optimize the selection of CHs,diminishing the redundant data and also by rotating all the CHs. The proposed research work involves the tree based static multi hop energy efficient routing protocol using WSNs. As explained in section-2 the various vital issues of this research work are how to reduce energy consumption for data transmission,how to reduce the duplicated data or information flow,how to rotate all the CHs and how to optimize the selection of CHs. This propound research work encourages us to invent highly flexible and an efficient Ternary TTBSMH-Leach,to resolve all these conditions using ternary tree. The main contributions of our research work are as follows:

(i)It computes the optimum number of desired clusters based on the size of sensing jurisdiction and the number of sensors presented in it. Let us consider T_{sh} the total number of sensor hops distributed uniformly in a J x J square sensing jurisdiction. The optimum number of clusters C_{opt} is computed as follows.

$$C_{opt}=\frac{\sqrt{Tsh}}{\sqrt{2\prod}}\sqrt{\frac{\varepsilon fs}{\varepsilon mp}}\frac{J}{d^2bs} \text{ ----------(ii)}$$

Where d_{bs} is the distance computed from CHs to the BS (Sink),ε_{fs} is the parameter for free space model,ε_{mp} is the parameter for multipath model.

(ii).In the first scenario this propounded research work also considers an Euclidean distance as an important parameter to choose CHs. The one more choice to select the CHs is the residual energy of sensor hops.So that the CHs can successfully render the aggregated data to the BS. If suppose sensor hops (shs) residual energy is less than the threshold value,then such kind of sensor hop will not be considered as CH. In this approach we have considered a quantity of threshold residual energy which is an amount of energy necessary to receive, aggregate and transmit an average number of sensor hops in a cluster.

(iii).This research work also diminishes the energy consumption of CHs for data or information communication. The energy consumption of CHs is reduced by maintaining a minimum cost or distance between CH and BS. If the distance cost between BS and CHs is greater than the threshold distance then such CH will not directly communicate to the BS. In this scenario multi hop communication happens via other CHs. Because of this reason it enhances the network lifetime in WSNs.

a. Ternary tree based static multi hop energy efficient routing protocol using greedy approach.

The ternary tree based approach has been designed to investigate and outperform other contemporary approaches like binary tree based methodology or quad tree based technique or K-means static multi hop energy efficient routing protocol for wireless sensor networks. Low Energy Adaptive Clustering Hierarchical Protocol (LEACH) is an important pioneering protocol which was first applied in clustering approach for an effective energy management in WSNs. The below Fig-1 shows ternary tree based static multi hop energy efficient routing protocol.

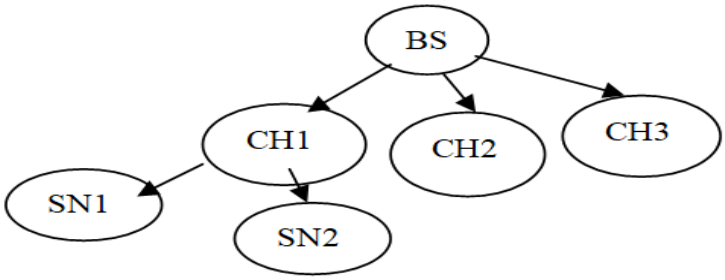

Fig.1: Ternary tree representation of static multi hop energy efficient WSNs.

In a TTBSMH-Leach energy efficient routing protocol we have considered a wireless region consists of n number of sensor hops. According to the analysis and design of algorithms/data structures the ternary-tree has exactly three children in both left hand side and right hand side.

4.2.Mathematical modeling of Ternary Tree based static multi hop energy efficient routing protocol.

In this section we are explaining some probabilistic clustering algorithms for energy efficient WSNs. First we will describe the network model which is used in the analysis and simulations of WSNs. If suppose n sensor hops are scattered in an area of M x M square meters and a base station is installed at the centre of sensing area. The deployment technique of sensor hops is divided into two types namely Hand (sensor hops are uniformly distributed to a district) and random way (hops are stochastically installed to a specific area). Let us consider that the least initial energy of all the hops is H_0. When each hop S_j have α_j times more initial energy i.e.$H_0(1+\alpha_j)$,the total energy of whole network is indicated by

$$H_t=T_{otal}=\sum_{i=1}^{n} Ho(1+\alpha j). \text{----------(vii)}$$

If $\alpha_j=0$ for all hops which corresponds to the case of homogeneous networks. In case of two level heterogeneous networks α_j has two values. In case of three levels of heterogeneous networks α_j has three values where as in case of different α_j values it supports for multilevel heterogeneous wireless sensor networks.

4.3.Threshold calculation of leach protocol.

Leach is the most popular clustering protocol based on probability of homogeneous wireless sensor networks. In leach every hop is equipped with same initial energy and it contains the same probability H_{opt} to become cluster head. Although leach does not consider energy consumption yet it introduces a threshold T_s to rotate the responsibility of cluster head in order to equally distribute energy consumption through the whole network.

$$\text{Threshold } (T_s) = \begin{cases} H_{opt}/(1-H_{opt}.(r \bmod)(1/H_{opt})) & \text{if } S \in G \\ 0 & \text{otherwise} \end{cases} \text{---(viii)}$$

Where H_{opt} is the desired percentage of CHs. for ex:H_{opt} = 0.05,r is a current round and G is the sequence of nodes which are not picked as cluster heads in the previous 1/p rounds. Each hop in the current set G selects a random number from 0 to 1.When this number is lesser than threshold T_s it becomes a cluster head. Due to the introduction of T_s the main role of cluster head is rotated between every two rounds. Mean while an optimal number of cluster heads achieved in every round of leach is calculated by the following formula.

$$J_{opt} = NxH_{opt} = (N-\sum_{i=1}^{rmod\left(\frac{1}{Hopt}\right)} Ci)\ X\ Hopt\ /\ (1-Hopt.(r\ mod)(1/Hopt)) \text{ (ix)}$$

According to the literature the best J_{opt} is derived by

$$J_{opt} = \frac{\sqrt{N}\ \sqrt{\varepsilon_{fs}}\ M}{\sqrt{2\prod}\ \sqrt{\varepsilon_{mp}}\ d^2_{toBs}}$$

Where ε_{fs} and ε_{mp} are two important parameters of radio energy dissipation model.d^2_{toBS} is an average distance between a CH and a BS.

4.4.Probability calculation of heterogeneous normal and advanced hops.

In DCQMS-leach clustering routing protocol, the nodes are broadly categorized into two types according to the amount of an initial energy. The first type of hop is normal hop with little energy and the second type of hop is an advanced hop,with α times more energy than a normal hop. Their selecting probabilities are as follows.

$$P_{nrm} = H_{opt}\ X\ \frac{E_{nrm}}{E_t} = \frac{H_{opt}\ X\ NE_o}{N(1-m)\ E_o + NmE_o(1+\alpha)}$$

$$H_{opt}/1+m.\alpha$$

$$P_{adv} = H_{opt}\ X\ \frac{E_{adv}}{E} = \frac{H_{opt}\ X\ NE_o(1+\alpha)}{N(1-m)\ E_o + NmE_o(1+\alpha)}$$

$$= H_{opt}.(1+\alpha)/1+m.\alpha$$

Where m is the fraction of advanced hops,H_{opt} is the optimal clustering probability for corresponding homogeneous WSNs. By comparing equations (11) and (12) we can confirm that normal hops are assigned smaller probability while advanced hops are accorded higher probability. In DEEC algorithm,cluster head selection is based on residual energy rather than an initial energy of TTBSMH-Leach. It is confirmed that when the probability changes dynamically,the residual energy of every hop rapidly decreases as the time passes. The probability P_i for hop S_i is given as

$$P_i=H_{opt}\ E_i(r)/E_{avg}(r)$$

$$E_{avg}(r)= 1/N \sum_{i=1}^{N} Ei(r)$$

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$$=H_{opt}\ E_i(r)/E_{avg}(r)$$

$$E_{avg}(r)= 1/N \sum_{i=1}^{N} Ei(r)$$

Where E_i is the residual energy of hop S_i in round r and E_{avg} is average residual energy of hop in round r. For heterogeneous hops H_{opt} will be replaced by

$$P(s_i) = H_{opt}\ .NE(S_i)\ /\ E_t$$

$$\frac{H_{opt}NE_o(1+\alpha_i)}{E_0\ (N+\sum_{i=1}^{N}\alpha i)} = \frac{H_{opt}\ (1+\alpha_i)}{(N+\sum_{i=1}^{N}\alpha i)}$$

The more generalized P_i can also be expressed by the following equation

$$Pi(r) = Hopt\ \ N(1+\alpha i)Ei(r) \text{ (xxiii)}$$

$$(N +)Eavg$$

4.5.Propounded Ternary Tree (TT) based static multi hop EEWSNs algorithm:Case-1:(Homogeneous environment).

Step-1:(Initialization)
Assign the hop list to empty.
Step-2:(How to pick Cluster Heads (CHs)).
Initially all hops have same energy level hence criteria of CHs is not only dependent on distance from hop to the BS.
Step-3:(Calculate distance from the necessary sensor node to the BS to check whether the distance is minimum or not).
Therefore for every hop hi in the network calculate distance to BS.
Step-4:(Sort of all the sensor hops).
Sort all the hops based on distance to the BS.
Step-5:(Criteria to select first three sensor nodes as CHs).
Select the first 3 nodes from the sorted list as Cluster Heads (CHs).
Step-6:(Adding of CHs).
Insert the 3 CHs to the node list.
7.For each of the remaining nodes say hj to each node in node list.
i.Compute the distance from hj to each hop in the list
ii.Arrange the hop list based on the distance from hj
iii.Choose a node hi from node list such that distance d (hi,hj) is minimum. Then make hi the parent of hj where d(hi,hj) is an euclidian distance. If number of children i.e hi=3,mark hi as contacted node (cn) and remove it from node list.
8.Insert hj to node list.
9.Goto step-6.
4.6.Propounded Ternary Tree based Static Multi hop EEWSNs Algorithm:Case-2:(Heterogeneous environment).
Step-1:(Assigning)
Initialize the node list to empty.
Step-2:(Consider the CHs).
As we know that all the sensor hops do not have same energy level.
Hence choice of CHs is based on both distance from BS and the
residual energy (remaining energy after transmission).
Step-3:(Calculate all the sensor hops are alive or dead).
For every hop hi calculate the distance from BS if hi is not dead (
i.e residual energy is > (more than) 20% of an initial energy).
Step-4:(Sorting of alive hops).
Arrange all the alive hops based on distance to BS and a residual
energy.
Step-5:(Choose the First three Sensor hops as CHs).
Pick the first 3 Sensor hops as CHs from the sorted list as Cluster
Heads (CHs).
Step-6:(Insert the of Sensor hops).
Insert the 3 hops to the node list.

V. CONDUCTION OF EXPERIMENTS.

In this research work the experiments are conducted on datasets of tree based static multi hop energy efficient routing protocol for WSNs using OMNET++ simulation software for the purpose of reducing energy consumption using Algorithm-1 for homogeneous condition
and Algorithm-2 for heterogeneous condition in TBSMH-Leach energy efficient wireless sensor networks. The simulation results produced by this approach namely Algorithm-1 and Algorithm-2 are possibly inserted on public figures which are very easily downloadable on social networking sites. The procedure followed for the conduction of experiments is described in the following subsections.
5.1. Procedure of experiments.
The procedure followed to conduct an experiment has been described in the following phases. The proposed tree based static multi hop leach energy efficient routing protocol a novel graph theoretic approach has been simulated in various network scenarios. We developed our research work simulation program in OMNET++.The program is an implementation of discrete event simulation. The locations of sensors are derived basically from uniform distributions.
Simulation environment for the proposed research work consists of the following module .

VI. PERFORMANCE EVALUATIONS

We have conducted an extensive simulation using an OMNET++ an object oriented simulation environment to compare and contrast the performance issues of our newly proposed ternary tree based static multi hop leach energy efficient routing protocol in WSNs. As we know that an innovative tree based static multi hop leach energy efficient routing protocol in WSNs only supports ternary tree architecture. The simulation results obtained by executing OMNET++ code proves that the ternary tree based static multi hop leach routing protocol throughput varies from 12.97% to 2.8823% when the number of rounds are 104(100),204(200),304(300),404(400),504(500),1004(1000),1504(1500),2004(2000),3004(3000) and 4004(4000).

VII. EPILOGUE

In this research work we have studied the ternary tree based energy efficient routing protocol for WSNs. We analyze the problem of maximizing network lifetime under various constraints such as Throughput, End to End delay and Packet Loss (Drop) rate. This work also lays a foundation for our future work on tree based static multi hop energy efficient routing protocols for WSN's to use for various applications such as Audio,Video,Multimedia etc. This research article addresses an important research issue such as an implementation/simulation of tree based energy efficient routing protocol using ternary tree in a wireless sensor network environment.

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Authors Profile:

Prof. Dr. Hanumanthappa .J. received his BE degree in Computer Science and Engineering at Kuvempu University,Shankarghatta,Karnataka,India in 1998 and his M.Tech Degree in Computer Science and Engineering from the National Institute of Technology,Surathkal,Karnataka,India in 2003 and Ph.D in Computer Science and Technology from Mangalore University,Mangalagangothri,Mangalore in 2014(Ph.D awarded date(03/12/2014)). Presently he is working as *Associate Professor* at DoS in CS,University of Mysuru,Manasa gangothri,Mysuru-6 since 04/06/2017.He has presented and published more than 52 refereed research papers in IEEE Transaction Journals/IEEE International Springer Journals/Science Direct Journals,Elsevier Journals. He has also published his highly repetitive research articles in both National and International Conferences. He is also working as a Life Member of Institute of Engineer's,M.I.S.T.E.,CSI,Senior Life Member of IACSIT,IAENG,IEEE,IPv6 forum India etc. He has also reviewed more than 220 research papers for refereed IEEE/ACM/Science Direct/Elsevier/Springer journals and International and National conferences/seminars/symposiums/workshops. He is Visiting Faculty of Huang Huai University,Zhumadian,Henan,People Republic of China. His area of research his "Performance issues of Protocols",Wired/Wireless Sensor Networks,Clustering Algorithms etc. Currently he has around 20 Years of Teaching Experience covering highly reputed engineering colleges in Karnataka and DoS in CS,University of Mysuru. He will host 3 days National level workshop on Artificial Intelligence (AI),Machine Learning (ML) and Deep Learning (DL) sponsored by Department of Science and Technology (DST),Govt of India on 18,19 and 20th of 2019 at DoS in CS,University of Mysore,Manasagangothri,Mysore-6. He has been serving as an Editor,Associate Editor,Guest editor,co-editor,Session chair in International/National conferences and programme committee member and reviewer of many International journals and conferences. He has supervised large number of students at M.Sc,MCA and M.Tech level. He has also provided services to advisory boards in several International and national level conferences.

Mr.Abdulmalek Maresh Hasan ali is presently working as a Research Scholar in Visveswaraya Technological University (VTU),Belgaum,Karnataka,India.He passed his Bachelor of Engineering (BE) in Computer Programming in the year 2007 from Al_Yemenia University, Sanaa,Yemen,and his Master's Degree in Master of Technology (M.Tech) in Computer Science and Technology in 2015 from the University of Mysuru. He has presented/published three research papers in reputed National Conferences and International Journals. His area of research interest his Wireless Sensor Networks, a Clustering algorithms, Performance issues of Protocols,Wired networking etc.

X. RESULTS AND ANALYSIS

The various results of the proposed Ternary Tree based static multi hop energy efficient routing protocol for WSNs with different number of rounds with different levels (heights) of tree over an initial quantity of energy, residual energy and threshold energy levels in different figures such as figure 4,figure 5,figure 6, figure 7,figure 8,figure 9 and figure 10,figure 11,figure 12,figure 13 respectively.

Table(Relation)-I:Evaluation of PLR and TT(Ternary Tree) based static multi hop Leach energy efficient WSNs with different number of sensor nodes=130,CHs=3,and number of heights=4.

No of Nodes	Total Packets	Total Packets	Total Pack	PLR in (%)	No of Rounds	No of Dead	DNR in (%)	No of Rounds	Networ k Life	Net Throughpu

(NoN)	Received (TPR)	Transmitted (TPT)	ets Lost (TPL)		Before First Node Dies (NoRBFND)	Nodes (NoDN)		(NoR)	Time (NLT)	t (NT)
130	11588	11824	240	2.40	45	16	0.016	104	375	12.9752
130	20878	21103	229	2.29	45	47	0.47	204	375	11.6509
130	27657	27878	225	2.25	45	65	0.65	304	375	10.2822
130	33138	33358	224	2.24	45	73	0.73	404	375	9.23682
130	37827	38045	222	2.22	45	82	0.82	504	375	8.23498
130	41879	42096	221	2.21	45	86	0.86	604	375	7.77901
130	44979	45194	219	2.19	45	99	0.99	704	375	7.16055
130	46699	46910	215	2.15	45	111	11.1	804	375	6.50482
130	47810	48019	213	2.13	45	114	11.4	904	375	5.91978
130	48810	49019	213	2.13	45	118	11.8	1004	375	5.43950
130	56211	56429	208	2.12	45	111	12.1	5004	375	2.88225
130	56220	56428	208	2.11	45	120	12.0	10003	375	2.88224
130	56220	56428	208	2.11	45	120	12.0	50003	374	2.88224
130	56220	56428	208	2.11	45	120	12.0	75003	371	2.88224
130	56220	56428	208	2.11	45	120	12.0	100003	371	2.88224
130	56219	56427	208	2.10	45	119	11.9	1000002	371	2.88223
130	56219	56427	208	2.10	45	119	11.9	1e+008	371	2.88223
130	56219	56427	208	2.10	45	119	11.9	1e+009	371	2.88223
130	1271	1441	171	1.71	0	0	0.1	11	0	14.2575
130	3041	3241	201	2.00	0	0	0.0	26	0	13.7289

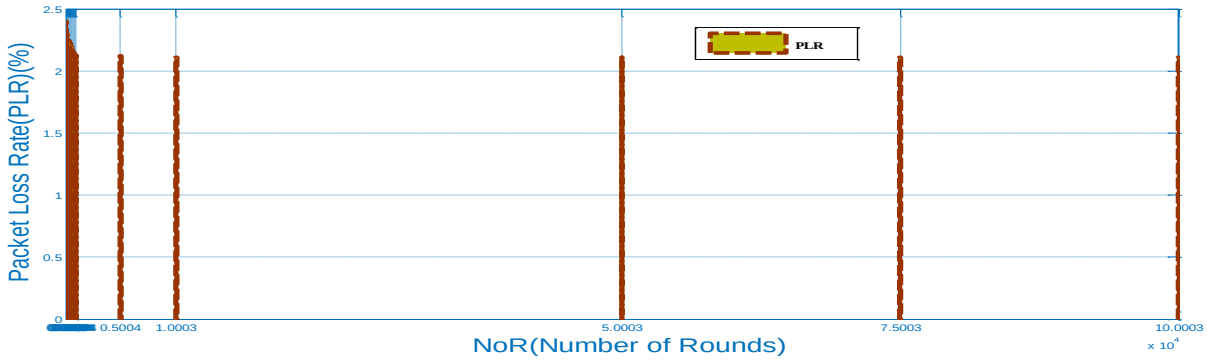

Fig.2: PLR with respect to NoR for ternary tree based multi hop energy efficient routing protocol WSN's with 130 different number of sensor hops,CHs=3 and phases=4 using bar graph.

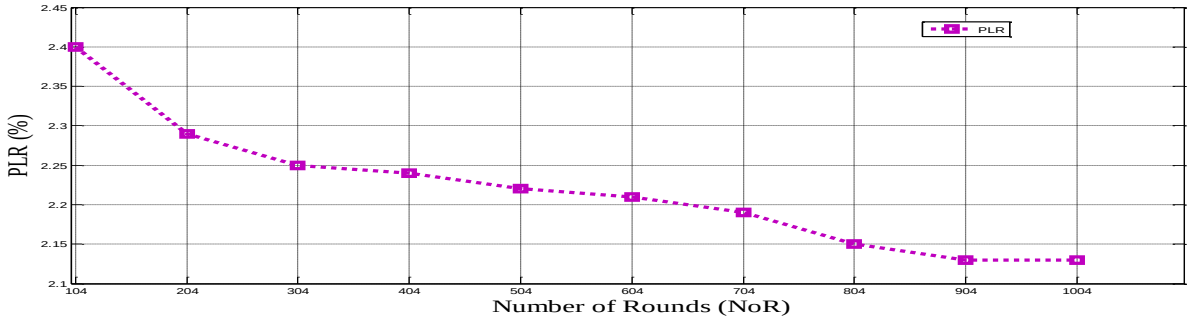

Fig.3: PLR with respect to NoR for ternary tree based multi hop energy efficient routing protocol WSN's with 130 different number of sensor nodes,CHs=3 and phases=4 using line graph.

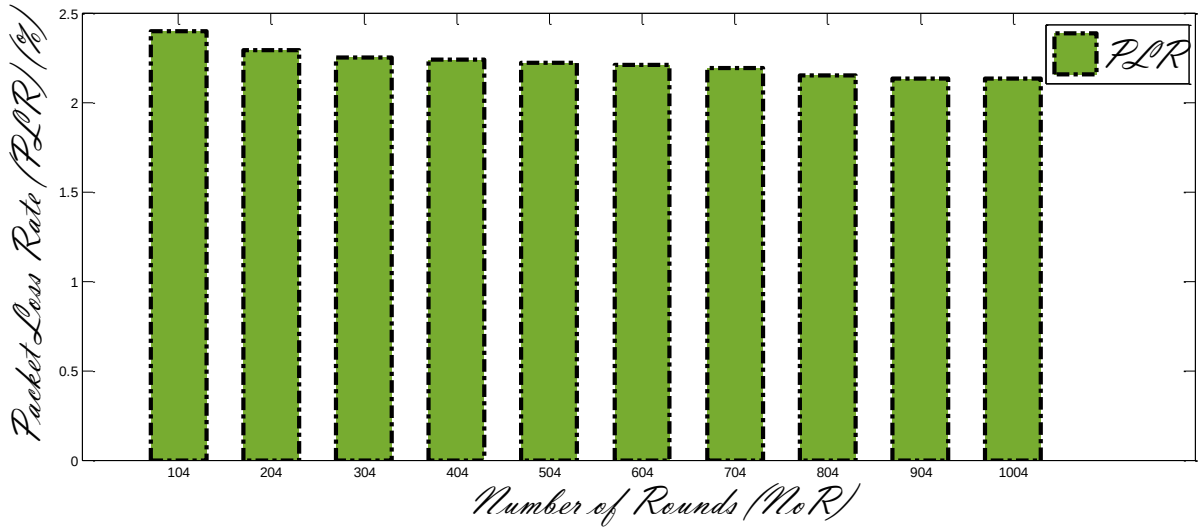

Fig.4: PLR with respect to NoR for ternary tree based multi hop energy efficient routing protocol WSN's with 130 different number of sensor hops,CHs=3 and phases=4 using Bar graph.

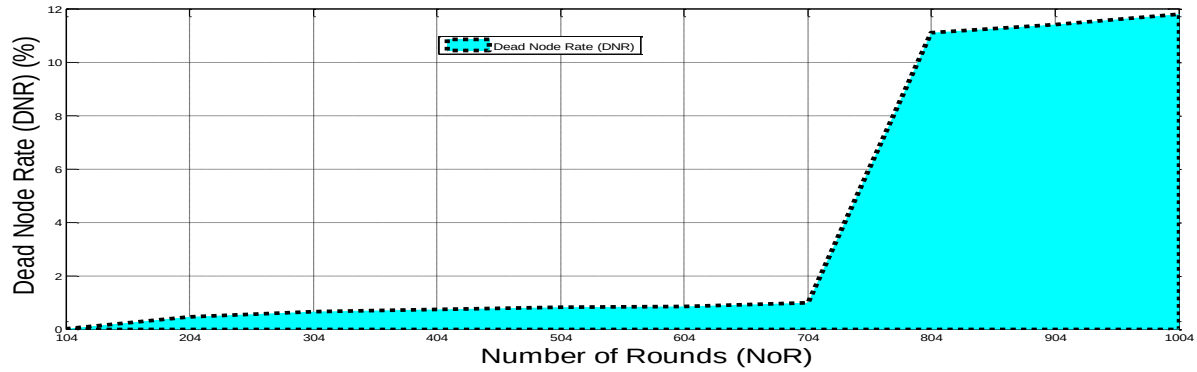

Fig.5: The variation between DNR with respect to NoR for Ternary Tree (TT) based multi hop energy efficient routing protocol WSN's with 130 different number of sensor nodes,CHs=3 and phases=4 using area graph.

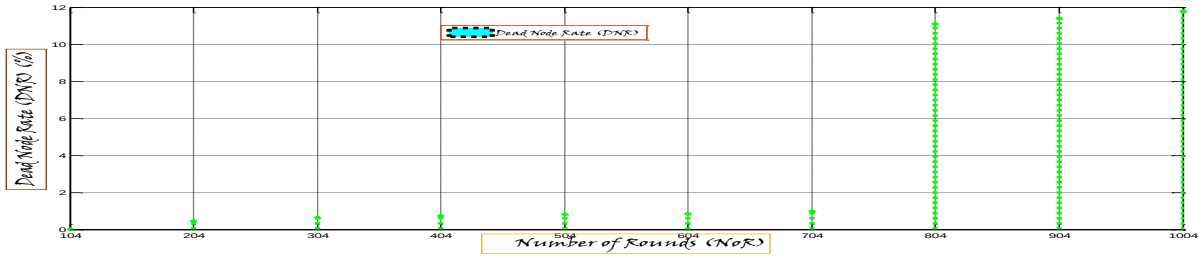

Fig.6: The variation between DNR with respect to NoR for Ternary Tree(TT) based multi hop energy efficient routing protocol WSN's with 130 different number of sensor nodes,CHs=3 and phases=4 using stem graph.

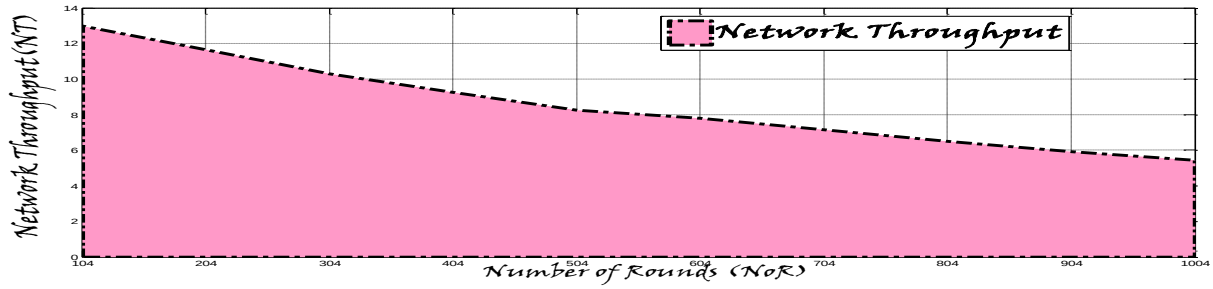

Fig.7: Differences between NT with respect to NoR for ternary tree based multi hop energy efficient routing protocol WSN's with 130 different number of sensor nodes,CHs=3 and phases=4 using area graph.

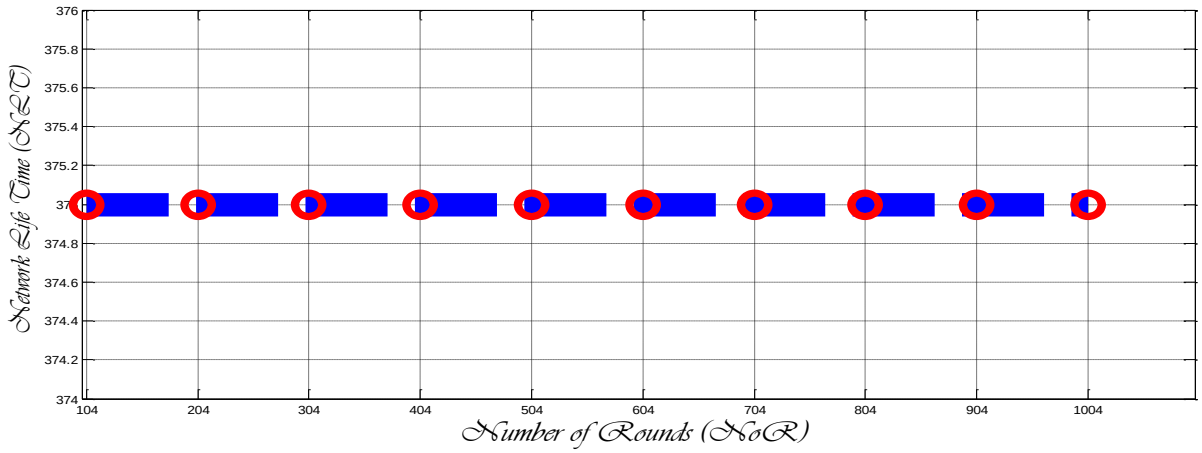

Fig.8: Comparison between NLT with respect to NoR for ternary tree based multi hop energy efficient routing protocol WSN's with 130 different number of sensor hops,CHs=3 and phases=4 using stairs graph.

Relation-2:Computation of PLR,DNR for TT based static multi hop Leach energy efficient WSNs with different number of sensor nodes are 45.

NN	TPR	TPT	TPL	PLR in (%)	NoRBFND	NDR	DNR in (%)	NR	NTL	NT
45	3835	3966	136	1.36	89	06	0.06	100	1515	2.17642
45	7570	7700	135	1.35	84	08	0.08	200	1519	2.12574
45	10654	10791	137	1.46	84	23	0.23	300	1519	1.9903
45	12894	13029	135	1.44	84	31	0.31	400	1519	1.80341
45	14288	14420	132	1.40	84	30	0.34	500	1518	1.59831
45	15473	15603	133	1.36	84	28	0.31	600	1517	1.44190
45	16501	16633	132	1.35	84	29	0.32	700	1517	1.31778
45	17500	17632	132	1.34	84	29	0.31	800	1516	1.22263
45	18500	18632	132	1.34	84	29	0.31	900	1516	1.14860
45	19444	19576	132	1.33	84	30	0.31	1000	1515	1.08630
45	21334	21466	132	1.33	84	38	0.38	5000	1515	0.864688
45	21330	214460	132	1.32	84	42	0.40	10000	1514	0.864692

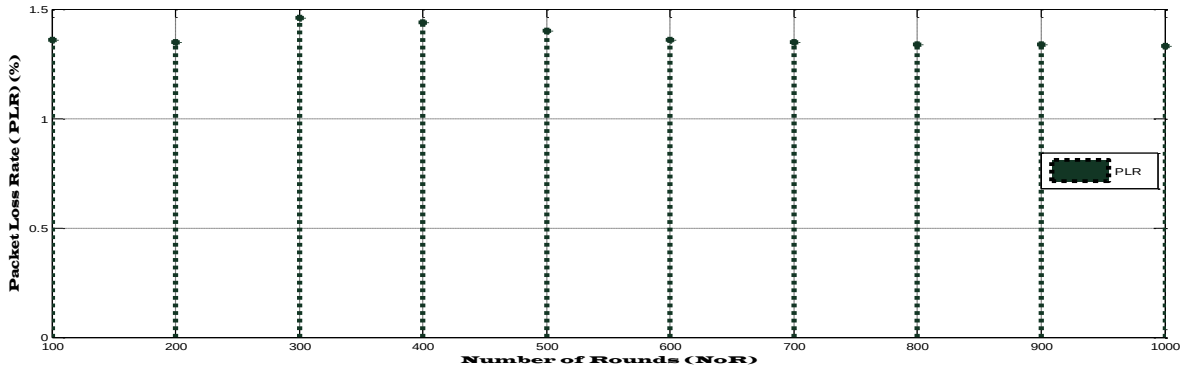

Fig.9: Computation of PLR with respect to NoR for TT based multi hop energy efficient routing protocol WSN's using stem graph in Matlab when the number of sensor hops are 45.

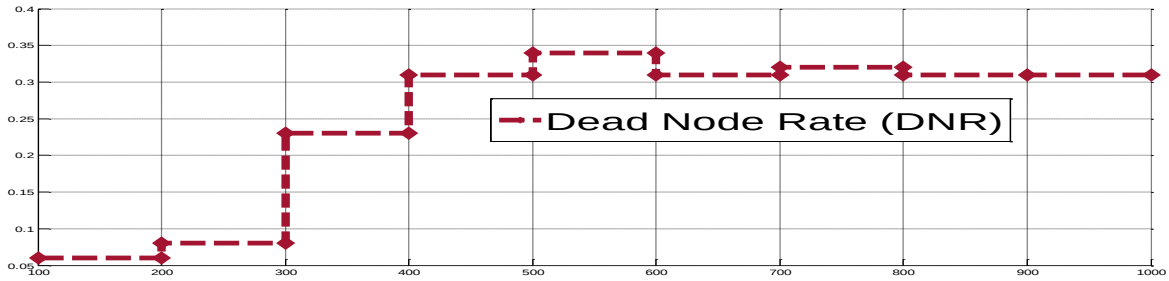

Fig.10: Calculation of DNR in (%) with respect to NoR for TT based multi hop energy efficient routing protocol WSN's when the number of sensor nodes are 45.

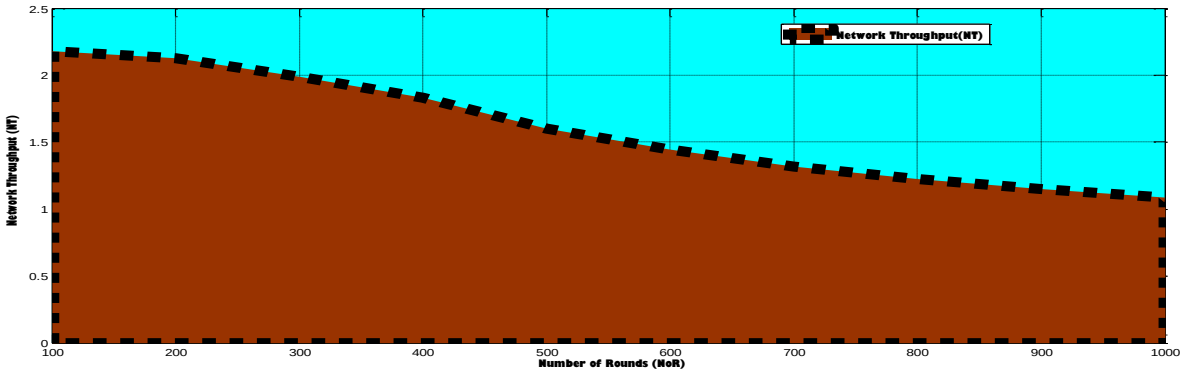

Fig.11:The Differences between the NT and NoR for TT based multi hop energy efficient routing protocol in WSN's.

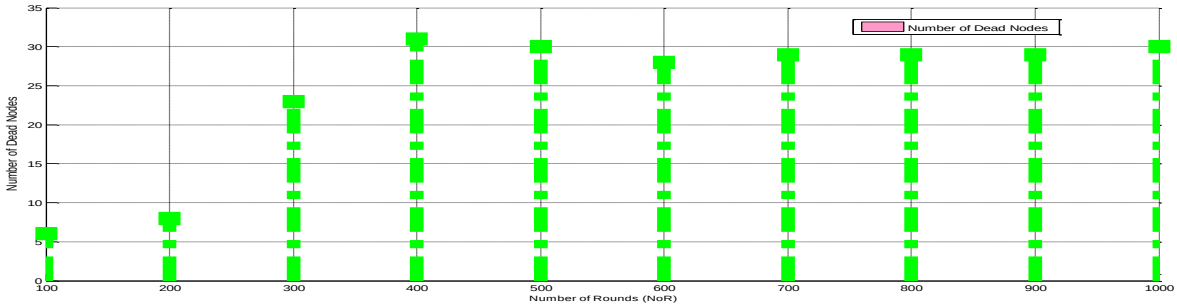

Fig.12: Calculation of NoD with respect to NoR for TT based multi hop energy efficient routing protocol WSN's when the number of sensor nodes are 45 using stem picture.

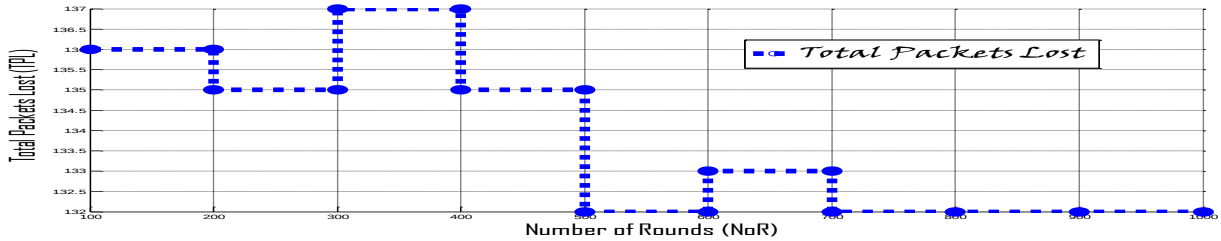

Fig.13: Comprison of Number of Packets Lost with respect to NoR for TT based multi hop energy efficient routing protocol WSN's when the number of sensor nodes are 45 using stair graph.