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TREE BASED STATIC MULTI HOP LEACH (TBSMH-LEACH) ENERGY EFFICIENT ROUTING PROTOCOL: A NOVEL GRAPH THEORETICAL APPROACH.

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ABSTRACT

Research on tree based static multi hop leach energy efficient routing protocol focused on efficiency and effectiveness of data dissemination. Furthermore, previous research work on wireless sensor network mainly focused on homogeneous wireless sensor networks where all wireless sensor networks have the same capabilities. It was learnt that homogeneous wireless sensor networks have poor basic performance limits and scalability. To achieve excellent performance, a Heterogeneous Wireless Sensor Network (HWSN) model was deployed. In the present paper a secure and an efficient protocol for HSNs (Homogeneous/Heterogeneous-Tree Based Static Multi hop Leach Energy Efficient Routing Protocol (TBSMH-Leach) is proposed for supporting different kinds of trees such as binary trees or ternary trees, or quadrant trees etc. A tree based static multi hop leach energy efficient routing protocol can be implemented. A novel graph theoretic approach using greedy approach/divide(division) and conquering technique. In this research, an investigation and a comprehensive comparison between three different tree based energy efficient routing protocols such as, binary tree, ternary tree and quad tree is demonstrated . By considering packet loss rate(plr)(packet drop rate)(pdr) and dead hop rate(dhr), results have indicated that quad tree based energy efficient routing is better than ternary and binary tree based static multi hop energy efficient routing protocols for the various rounds from 100 to 1000. By referring the throughput, it is proved that binary based energy efficient routing protocol is better than ternary/quad tree based static multi hop leach energy efficient routing protocol for WSNs, when the number of rounds hikes from 100 to 1000. Finally, the time complexities is computed for best case, average case and worst case, for BTBSMH-LEACH, TTBSMH-LEACH, QTBSMH-Leach is O (n log n).

key words: *Binary tree, energy efficient, multi-hop, quad tree, static, ternary tree.*

1. INTRODUCTION

In recent years, the wireless sensor network (WSNs) have become the most favorite because of their application in unattended trails of tracking and exposure of annoying objects, risk identification, information searching, and environmental management, some sensor in wireless network are generally kept in sleep modes, meanwhile, others are stay active for communicating tasks to diminish the consumption of energy and extend the life time of the network.

WSNs may have a wide variety of uses in vasectomy, blood and heart cancer treatment, caesarean ,agriculture fields, nuclear power fields, battlefields, civil applications and infrastructure building, the WSNs are consisting of a great number of sensor Hops (SHs) which are powered by limited energy quantity batteries. The sufficient sensing coverage and connectivity is measured by the number of SHs in the WSNs. The level of efficiency of WSNs energy is one of the important evolving technology in WSNs. Yick et al., (2008) and ZuH (2012) explained that sense hops that monitor physical and environmental activities using the vibe humidity, temperature or the sound in a specific area of deployment. In WSNs the level of the efficiency of energy is well-accepted as NP-Hard optimization problems. The limited storage sensor receives the sensed data through an analogue to where data can be analyzed for decision making in different and divested applications.

As a result of the continuous raise of cost of cellular communication, using short range radio is the most recommendable solution especially for the large scale WSNs. The entire size of collected data and the number of hops goes rapidly due to the rapid increasing of network sizes. Creating sensing data in multi hop is usually depends on the sink hop by multi manner to have the comprehensive view of network. Not only the sensing process is interrupted if the battery is decreased but also data is broken off. An enough quantity of research and well dedicated efforts have been devoted to energy efficient wireless sensor networks which turn off redundant sensors for energy saving [10]. There are many research work efforts on energy efficient wireless sensor networks to enhance the life time for WSNs [1] [2] [3] [4] [5] [6][7] [8] [9].

Unlike previous research work, this research manuscript gives importance to the efficiency of energy in wireless sensor networks to improve the life span of WSNs. Network life span is the elapsed time during which the network functions well, and the formal definition is given in (10) in a later portion. As it is known, routing is an essential activity in energy efficient static multi hop wireless sensor networks. Providing routing in wireless sensor networks is really a challenging task due to plenty of research issues.

To achieve more efficiency of wireless energy, companies have come up with different routing protocols such as directed diffusion and LEACH. Since most sensor hops have limited capability in processing or storing data, energy, and band width, conventional desktop computers and server challenges are faced. Most of the subsisting work on energy efficiency static multi hop routing considers consistent sensor network the place where all sensor hops are modeled to get the sand capabilities in energy supplying, communicating, computing, storing in a memory, and many different aspects.

The rest of the research manuscript is organized as follows: since we often compare and verify the simulation results for proving whether binary tree based static multi hop leach is better than ternary tree/quad tree based static multi hop leach energy efficient routing protocol in WSNs. However, the second part of this work elaborates the published various research and oriented articles related to energy efficient static multi hop leach protocol for WSNs. In the third section, it is explained, in depth, a data set necessary for the energy efficient static multi hop routing protocol for WSNs. Moving on to the fourth section, a proposed technique and its working principle on a benchmark data set is introduced. Before summing up, the fifth section briefly discusses the experiments which are conducted. Finally, the sixth section shows the experimental results and their analysis.

2. 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. proposed and evaluated advanced low energy adaptive clustering hierarchy (Ad-Leach), which is static clustering based heterogeneous routing protocol.

Wendi Rabiner Heinzelman, Ananthachandrakasan et, al. [1] have inspected communication protocols which can have a 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 demonstrated 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 proposed Quadrature (Q-Leach) for homogeneous networks enhance stability period, networks life time, and throughput quiet significantly. K.Latif and N.Javaid introduced Divide and Rule (DR) based static and dynamic clustering routing protocol. Their methodology chooses a fixed number of CHs in each round instead of probabilistic selection of CH. The simulation results of DR based routing protocol outperform its counterpart routing protocols. Hanumanthappa.J. et al. [2] proposed a graph theory based quad tree static multi hop leach routing protocol for an energy efficient wireless sensor networks. Their proposal of DCQMS-Leach routing protocol overcomes the dearth of all the previous LEACH energy efficient routing

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protocols. Lujuan Ma, Henry Leung et al. have propounded hybrid TDMA/CDMA MAC protocol for WSNs.

An algorithm named EECPK-means (energy efficient clustering protocol based on k-means) has been proposed by Anindita ray and Debashis de [12]. In this algorithm a midpoint is used for the first centroid selection procedure. Their simulation results outperform LEACH. Balanced alongside K-means(BPK-means). Moreover, parks approach and MK-means regarding the network life time and energy efficiency and also their simulation outcomes manifest that the proposed approach may diminish the energy consumption to 50% at most parallel to 14% to LEACH_B 10% to BPK-means protocol and 6% to MK-means relay hop placement [13] tree based data aggregation [14] and an efficient sensor movement [15]. To raise the power of a network, a number of CH in a cluster aiming for reducing the time and energy for re clustering is chosen in this methodology [16]. In [17] an algorithm has been propounded to find out the initial cluster centers. It is identified that the calculated clusters one very close to necessary cluster centers by using algorithm which fails to produce balanced cluster.

Authors in [18] have adopted the energy efficiency routing protocol based on effective accumulated data and optimal cluster head is chosen. Although this protocol increases the life time of the network, it suffers from the delay which comes as a result of multifaceted processes. A cooperative communication approach has been introduced by the author in [19]. He shows that the amount of energy used up by the network is more abbreviated in cooperation than noncooperation. It is worth to mention that the traffic over head starts to enlarge gradually till the number of sensor hops in cluster areas become approximately high.

3. DATA SETS.

This research work has been carried out on a highly standard size wireless sensor network which consists of varying numbers of hops such as 30,120,126 and 5460 etc. In order to implement tree based static multi hop leach energy efficient routing protocols, we have also considered different categories of rounds such as10,25,50,75,90,100,200,300,400,500,600,700,800,900,1000,5000,10000,50000,100000,1000000,10000000,100000000 etc. The other kinds of data sets, which are highly essential to implement this research work are threshold energy of 200000 joules, varying numbers of cluster heads 2-6 and initial sensor energy of 499900-500000 joules.

4. NETWORK MODEL AND ITS ASSUMPTIONS.

As it is well known, the crucial substance which affects many operation systems and network regarding their security, routing and energy efficiency PS tree based static multi hop energy efficiency routing protocol. The life span of WSNs is based on the hop deployment methodology. The sensor hops which are very nearer to the sink consumes energy faster than other hops because they have received and retransmit from and to other neighboring hops. The whole network is impacted by energy consumption problem. In order to overcome this problem, the position of sensor hops and the sink is represented by 2D Gaussian distribution function. It has already confirmed that the Gaussian distribution is obtaining more energy balancing and enhancing network life time, because standard deviation factor has a standard impact on both network and network lifetime. In this innovative research work the wireless sensor network model is elaborated.

In general, creating a cluster of efficient energy in wireless sensor network is accomplished by different types of constraints such as the proximity between the sensors determined by the radio frequency signals which they release. The choice of the hop to be as a cluster head (CH) or a saving energy hop PS one of the predicaments in EEWSNs, this research works on the power of signals, conveyance of schedules, placement of hops and networks functions.

There are many benefits of using EEWSNs for example the cost of forwarding data to the sink hop is not very high. Moreover, the consumption of energy power of advice will be reduced. It does not only facilitate the gathering of routing process execution but also it allows scalability. The idea of sensor networks in EEWSNs is to use the graph theory concept which is G=(V,E) where G is wireless sensor network graph ,V is vertices of EEWSNs and the edge of EEWSNs is indicated by E. There are two kinds of energy efficiency wireless sensor network based on the level of the energy homogenous and heterogeneous. The main difference between those two types is that the heterogeneous network is built on hops with varied energy levels, on the contrary, the homogenous network contains hops which maintain the same level of energy. Regarding the TBSMH-leach protocol which divides the energy levels into two different kinds: advanced hops and normal hops. The hops that keep the level of energy at maximum point are named advanced hops

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(hadv). Contradictorily, the ones that keep the power minimum are known as (hadv). The ratio of the real energy of advanced hops is H.Usually each advanced hop (hadv)shows K times of higher energy level than (hnrm.)The actual energy ratio of advanced hops is H. Usually each advanced hop (hadv) represents k times of higher energy level than(hnrm).

4.1. Graph theoretic specification of cluster hops.

By using graph theoretic approach, the cluster hops are specified using the equation -(1).
According to the graph theoretic approach one of an idea to create a sensor network is G=(V, E) ------(1)
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

$$Ec=\{(u,v) \mid u,v \in C \wedge (u,v) \in E\} \quad (2)$$

$\subset V, y \in V$ is a cluster head and Gc=(C,Ec) is a type of cluster graph.

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 hopv$\in C$.

$$\max_{v} \in C d_c(y,v) \quad (3)$$

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 (4)

$$E_{cl}=N_{cl}E_0(1-j)+N_{cl}\, jE_0(1+h) \quad (4)$$

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 (5).

$$E_{cl} = N_{cl}\ E_0\ (1 + h_j) \quad (5)$$

The sum of initial energy of a cluster is provided by equation – (6).

$$E_{tot} = \sum_{cl=1}^{n} E_{cl} \quad (6)$$

Where n:-sum of cluster hops.

5. PROPOSED METHODOLOGY.

As noted in section-1 and related literature sections 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 Tree Based Static Multi hop Leach Energy Efficient Routing Protocol (TBSMH-Leach), to resolve all these conditions using an either binary tree/ternary tree/quad tree etc. The main contributions of our research work are as follows:

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 Tsh the total number of sensor hops distributed uniformly in a J x J square sensing jurisdiction. The optimum number of clusters Copt is computed as follows.

$$\frac{C_{opt}}{\sqrt{\pi}} = \sqrt{Tsh}\ \frac{\sqrt{\varepsilon fs}\frac{J}{\varepsilon mp}}{d^2\, bs} \quad (7)$$

Where dbs is the distance computed from CHs to the BS (Sink),εfs is the parameter for free space model, εmp is the parameter for multipath model.

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

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of sensor hops. So that the CHs can successfully render the aggregated data to the BS. If the supposed 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.

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.

5.1 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 Figure -1 shows ternary tree based static multi hop energy efficient routing protocol.

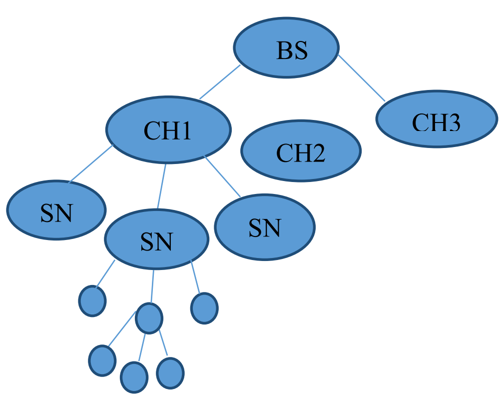

Figure 1: Ternary tree representation of static multi hop leach energy efficient WSNs.

In a TBSMH-Leach energy efficient routing protocol we have considered a wireless region consists of n number of sensor hops. The TBSMH-Leach is broadly divided into 1-ary static multi hop-leach energy efficient routing protocol, BBSMH-Leach, TTBSMH-Leach, QTBSMH-Leach and finally n-ary based static/dynamic multi hop leach routing protocol. According to analysis and design of algorithms/data structures the 1-ary tree has exactly only one child hop, binary (2-ary) static multi-hop leach tree has two children in both left hand side and right hand side.

5.2 Mathematical modeling of 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 H0. When each hop Sj have αj times more initial energy i.e. H0(1+αj),the total energy of whole network is indicated by

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

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 Hoptto become cluster head. Although leach does not consider energy consumption yet it introduces a threshold Ts to rotate the responsibility of cluster head in order to equally distribute energy consumption through the whole network.

$$(Ts) = \begin{cases} H_{opt}/\left(1 - H_{opt}\right) (r \bmod)\left(1/H_{opt}\right) & \\ 0 & \text{otherwise} \end{cases}$$

(8)

$$if \; s \in G$$

Where Hopt is the desired percentage of CHs.forex: Hopt = 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 Tsit becomes a cluster head. Due to the introduction of Ts the main role of cluster head is rotated between every two rounds. Meanwhile an optimal number of cluster heads achieved in every round of leach is calculated by the following formula.

$$J_{opt} = N_x H_{opt} = (N - \sum\_(i = 1)^{(r \bmod)(1 / H\_opt)} [(Ci) \; X \; H\_(opt.)) / ((1 - H\_(opt.)) \; (r \bmod)(1 / H\_opt)) \,]) \quad (9)$$

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

$$J_{opt} = \frac{\sqrt{N} \sqrt{\varepsilon fs} \; M}{\sqrt{2\pi} \sqrt{\varepsilon_{mp}} \; d^2 \, tobs} \quad (10)$$

Where $\varepsilon_{fs}$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.

5.3 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.

$$P_{nrm} = H_{opt} \; X \; E_{nrm} = \frac{H_{opt} \; X \; NE_0}{E_t \, N(1-m)E_0 + NmE_0(1+\alpha)} \quad (11)$$

$$H_{opt}/1 + m \cdot \alpha \quad (12)$$

$$P_{adv} = H_{opt} \; X \; E_{nrm} = \frac{H_{opt} \; X \; NE_0(1+\alpha)}{EN(1-m)E_0 + NmE_0(1+\alpha)} \quad (13)$$

$$H_{opt} \cdot (1-\alpha)/1 + m \cdot \alpha \quad (14)$$

Where m is the fraction of advanced hops, Hopt 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 TBSMH-Leach. It is confirmed that when the probability changes dynamically, the residual energy of every hop rapidly decreases as the time passes. The probability Pi for hop Si is given as

$$P\_(i) = H\_(opt) \, E\_i \, ((r)) / (E\_(avg)(r)) \quad (15)$$

$$E_{avg}(r) = 1/N \sum_{i=1}^{N} Ei(r) \quad (16)$$

$$P\_(i) = H\_(opt) \, E\_i \, ((r)) / (E\_(avg)(r)) \quad (17)$$

$$E_{avg}(r) = 1/N \sum_{i=1}^{N} Ei(r) \quad (18)$$

$$= H\_(opt) \, E\_i \, ((r)) / (E\_(avg)(r)) \quad (19)$$

$$E_{avg}(r) = 1/N \sum_{i=1}^{N} Ei(r) \quad (20)$$

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

$$P(S_i) = H_{opt} \cdot NE(S_i)/E_t \quad (21)$$

$$\frac{H_{opt} \, NE_0 \, (1+\alpha_i)}{E_0 \left(N + \sum_{i=1}^{N} \alpha_i\right)} = \frac{H_{opt}(1+\alpha_i)}{\left(N + \sum_{i=1}^{N} \alpha_i\right)} \quad (22)$$

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

$$P_i(r) = \frac{H_{opt} \; N(1+\alpha_i) E_{i(r)}}{\left(N + \sum_{i}^{N} \alpha_i\right) E_{avg}} \quad (23)$$

5.4 Proposed ternary tree based static multi hop EEWSNs algorithm:Scenario-1:(Homogeneous networks).

Step-1:(Initialization)
Initialize the hop list to empty.

Step-2:(How to choose Cluster Heads(CHs)).
Initially all nodes have same energy level hence choice of CHs is not only dependent on distance from hop to the BS.

Step-3:(Compute distance from any suitable sensor hop to the BS to decide whether the distance is minimum).

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Therefore, for every hop n_i in the network calculate distance to BS.

Step-4:(Sorting of all the sensor hops).

Sort all the nodes based on distance to the BS.

Step-5:(Choosing of First Three Sensor hops as CHs).

Pick the first 3 nodes from the sorted list as CHs.

Step-6:(Adding of CHs).

Add the 3 CHs to the hop list.

7.For each of the remaining nodes say n_j to each hop in hop list.

1. Compute distance from n_j to each hop in the list
2. Sort the hop list based on the distance from nj
3. Pick a hop ni from hop list such that distance $d(n_i,n_j)$is minimum. Then make n_i the parent of n_j where

$d(n_i,n_j)$ is an Euclidian distance. If number of children of n_i=3, mark n_i as visited and remove it from node list.

8.Add n_j to hop list.

9.Go to step-6.

Proposed Ternary tree based Static Multi hop EEWSNs Algorithm: Scenario-2:(Heterogeneous networks).

Step-1:(Initialization)

Initialize the hop list to empty.

Step-2:(Determining CHs).

Sensor hops do not have similar energy level. Hence the choice of CHs is based on both distance from BS and the residual energy (remaining energy after transmission).

Step-3:(Identification of Sensor hop is Alive or Dead).

For every hop n_i compute distance from BS if n_i is not dead (i.e residual energy is >20% of an initial energy).

Step-4:(Sorting of alive nodes).

Sort all the alive nodes based on distance to BS and residual energy.

Step-5:(Choosing of First Three Sensor hops as CHs).

Pick the first 3 Sensor hops as CHs from the sorted list as Cluster Heads (CHs).

Step-6:(Adding of Sensor hops).

Add the 3 nodes to the hop list.

6. 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 environment and algorithm-2 for heterogeneous environment in TBSMH-Leach energy efficient wireless sensor networks. The simulation results produced by this approach namely algorithm-1 and algorithm-2 can be employed on public Figure ures, which are downloadable on social networking sites. The procedure followed for the conduction of experiments is described in the following subsections.

6.1. 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 theoretical 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 modules.

7. 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 tree based static multi hop leach energy efficient routing protocol in WSNs with binary, ternary and quad tree etc. As we know that an innovative tree based static multi hop leach energy efficient routing protocol in WSNs does not support the different kinds of trees such as binary, ternary and quad trees but also supports n-ary trees. The simulation results obtained by executing OMNET++ code confirm that the binary tree based energy efficient static multi hop leach routing protocol throughput increases from 20.92% to 2.93, the ternary tree based static multi hop leach routing protocol throughput varies from 12.97% to 2.74% and quad tree based static multi hop leach routing protocol throughput varies from 6.72% to 1.35% when the number of rounds are 100, 200, 300, 400, 500, 1000, 1500, 2000, 3000 and 4000.

Results and Analysis.

Simulation parameters

In this research work as we know that OMNET++ is used as an object oriented simulation platform to get excellent results based on tree based

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static multi hop leach energy efficient routing protocol using greedy technique. Our newly proposed research works on rounds. The total numbers of rounds considered we have used in our experiment are 100000000. The simulation results of TBSMH-Leach in comparison with LEACH, MH-LEACH and SEP are performed to observe the frequency of dead hops, alive hops, PLR, CHs per round, network life time and an overall throughput of WSN. The Figure ures 9-13 demonstrates that quad-tree based static multi hop leach (QTBSMH-Leach) energy efficient routing protocol has greater stability time as compared to binary (BTBSMH-LEACH) and ternary (TTBSMH-LEACH) based static multi hop leach (DCQMS-Leach) energy efficient routing protocol but lower stability as compared to BTBSMH-LEACH, TTBSMH-LEACH, LEACH and SEP protocol. The number of rounds before first hop dies in DCQMS-Leach dies are 54 where as in BTBSMH-LEACH the first hop dies after 39 rounds and in TTBSMH-LEACH the first hop dies after 41 rounds respectively. By considering the total 100000000 rounds. We use the following various performance metrics for simulation purpose to evaluate and simulate the energy efficient heterogeneous/homogeneous static/dynamic routing protocol algorithms:

The number of dead nodes for each round.

The Stability Period (SP) is defined as the period starts from the network operation and ends between the first dead node.

The Instability Period (ISP) (Unstable Jurisdiction) (UJ) is the period that exists between the first dead node and the last dead node.

The number of alive nodes/round.

The number of dead nodes/round.

Throughput=Number of packets sent from CH (Source) to the BS (Destination).

Network Life Time=An interval exists between beginning of network operation and the death of last sensor node.

Reliability: Reliability depends on the measurement of Stable Jurisdiction (SJ) and Unstable Jurisdiction(UJ). When SJ is larger and UJ is smaller the reliability.

The number of cluster heads/round: The total number of nodes chosen as CHs from the whole wireless sensor network in each round. The CHs are usually responsible for accepting data from the member node and send all data after aggregation to the sink hop.

TABLE I :SIMULATION PARAMETER SETTINGS.

Sl.No	Parameters	Corresponding values
1	N(Maximum number of nodes)	5460
2	A	1
3	M	0.3
4	H_{opt}(Optimal probability)	0.1
5	K(Packet size)	4000
6	E_o(Energy for normal nodes)	0.5 J
7	Eelect(Radio electronics energy)(Transmitter/receiver electronics)	50nJ/bit
8	EDA (Data aggregation energy cost).	5nJ/bit/message
9	εfs(Transmit amplifier) if $_{dmax\ to\ BS} <= d_o$	10pJ/bit/m^2
10	εmp(Transmit amplifier) if $_{dmax\ to\ BS} >= d_o$	0.0013pJ/bit/m^4
11	Network size	500m x 500m
12	b(Proportion of intermediate nodes with μ times more energy than normal nodes)	0.3
13	Maximum number of rounds	100000000
14	Minimum number of rounds	10
15	Threshold energy	200000 joules
16	Number of CHs	2-4

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 of tree over an initial quantity of energy, residual energy and threshold energy levels in different figures such as figured from 2-10 respectively.

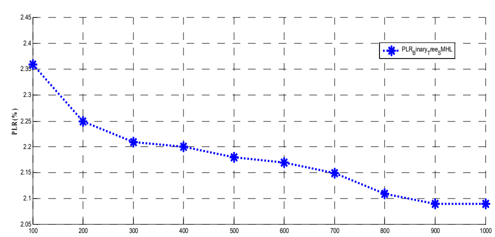

Figure. 1: Comparison of PLR with respect to number of rounds for ternary tree based multi hop energy efficient routing protocol WSNs with 120 different numbers of sensor hops,CHs=3 and levels= 4.

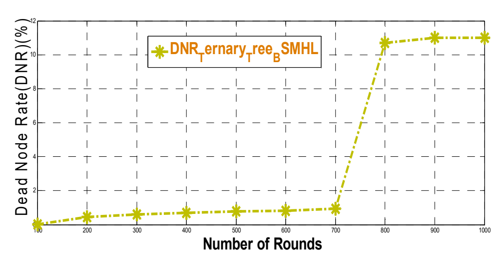

Figure. 2: Comparison of DHR with respect to number of rounds for ternary tree based multi hop

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energy efficient routing protocol WSNs with 120 different numbers of sensor hops,CHs=3 and levels=4.

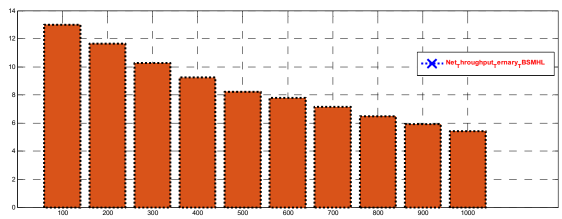

Figure. 3: Comparison of network throughput with respect to number of rounds for ternary tree based multi hop energy efficient routing protocol WSNs with 120 different numbers of sensor hops, CHs=3 and levels=4 using bar graph.

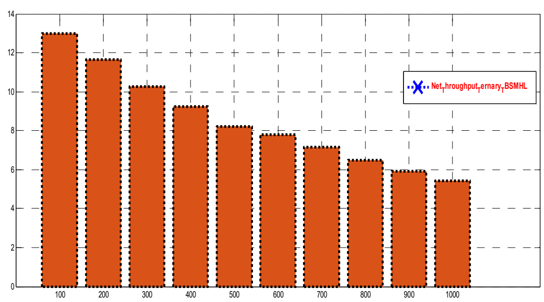

Figure. 4: Comparison of network throughput with respect to number of rounds for ternary tree based multi hop energy efficient routing protocol WSNs with 120 different numbers of sensor hops, CHs=3 and levels=4 using bar graph.

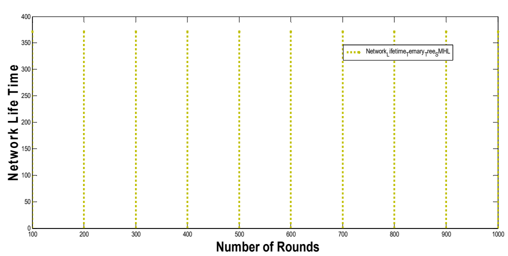

Figure. 5: Comparison and contrast between network lifetime with respect to number of rounds for ternary tree based multi hop energy efficient routing protocol WSNs with 120 different numbers of sensor hops,CHs=3 and levels=4 using stem graph.

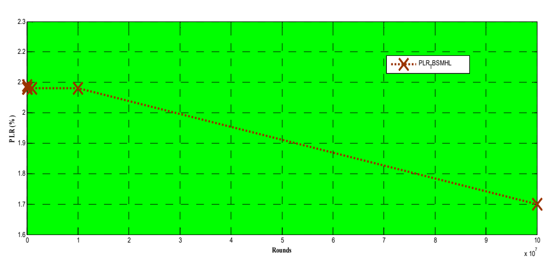

Figure. 6: PLR with respect to rounds for ternary tree based static multi hop leach energy efficient WSNs with different numbers of sensor hops=120,CHs=3 and number of level=.4

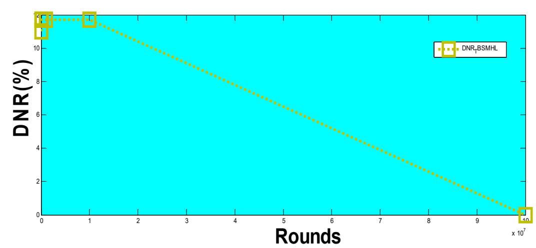

Figure. 1: DNR with respect to rounds for ternary tree based static multi hop leach energy efficient WSNs when different numbers of sensor hops=120, CHs=3 and number of levels=4.

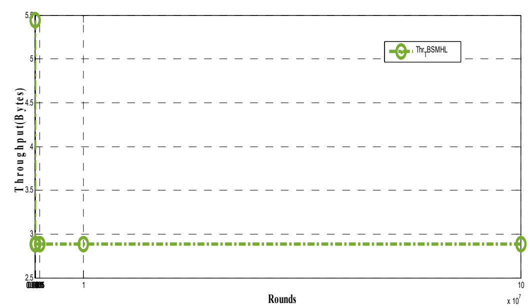

Figure 8: Comparison of throughput with respect to rounds for ternary tree based static multi hop leach energy efficient WSNs with SNs=120, CHs=3 and levels=4.

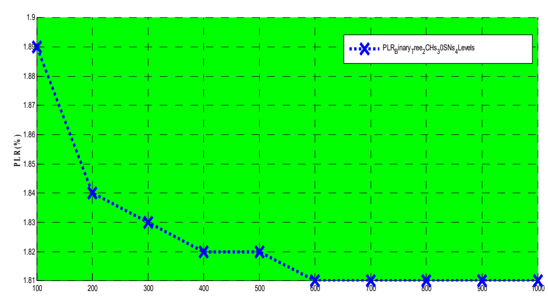

Figure 9: Comparison of PLR (%) with respect to number of rounds for binary based static multi-hop each energy efficient routing protocol for WSNs with 2 different CHs, 30 sensor hops and 4 different levels.

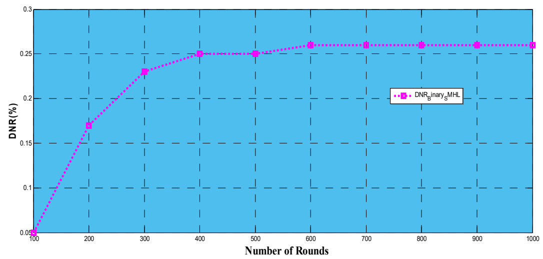

Figure 10:Comparison of DNR(%) with respect to number of rounds for binary based static multi-hop leach energy efficient routing protocol for WSNs with 2 different CHs,30 Sensor hops and 4 different levels.

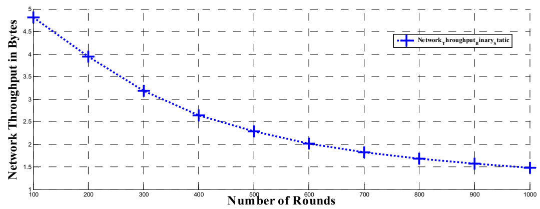

Figure 11:Comparison of network throughput with respect to number of rounds in bytes for binary based static multi-hop leach energy efficient routing protocol for WSNs with 2 different CHs, 30 Sensor hops and 4 different levels.

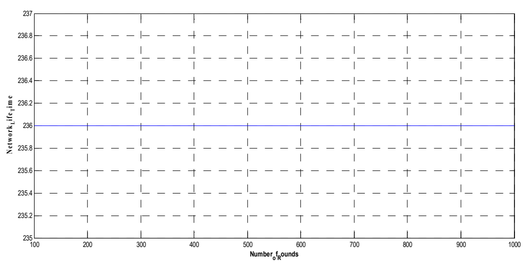

Figure 12: Comparison of network lifetime with respect to number of rounds for binary based static multi-hop leach energy efficient routing protocol for WSNs with 2 different CHs,30 sensor hops and 4 different levels

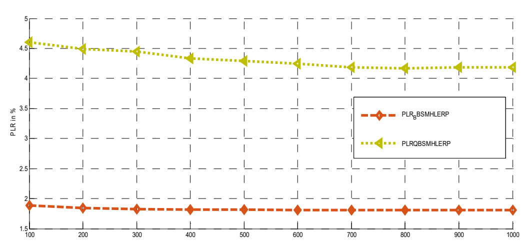

Figure 13: Comparison of Binary and Quad tree PLR(%) with respect to number of rounds for tree based static multi-hop leach energy efficient routing protocol for WSNs with 2 different CHs,30 sensor hops, height=4(Binary) and 4 different CHs, height=4 and sensor hops=340.

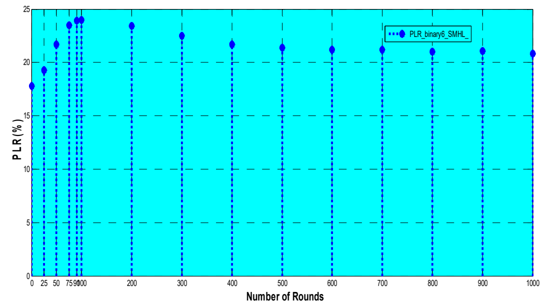

Figure 14:PLR for binary tree based static multi hop leach energy efficient routing protocol using stem graph when the CHs=2 and levels=6.

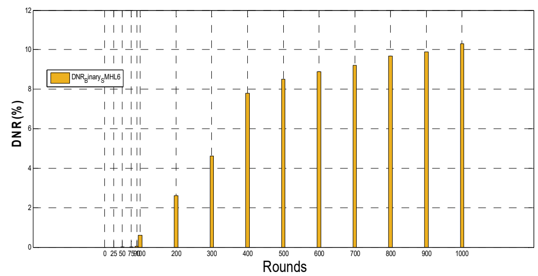

Figure 15:DNR for binary tree based static multi hop leach energy efficient routing protocol using bar graph when the CHs=2 and levels=6.

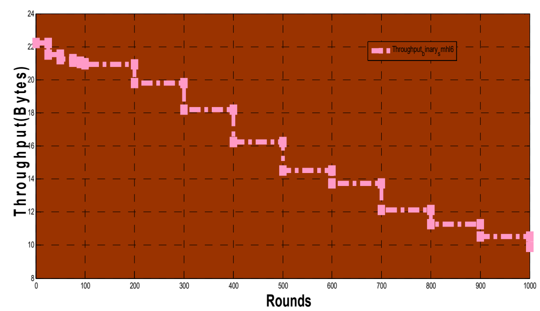

Figure 16:Computed Throughput for binary tree based static multi hop leach energy efficient routing protocol using area graph when the CHs=2 and levels=6.

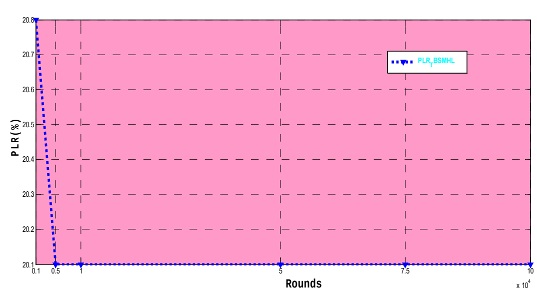

Figure 17: PLR for binary tree based static multi hop leach energy efficient routing protocol using line graph when the CHs=2 and levels=6 for various rounds such as 1000, 5000 etc.

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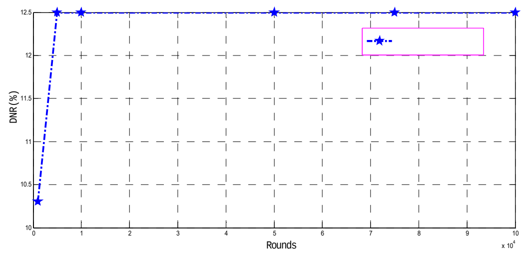

Figure 18: DNR for binary tree based static multi hop leach energy efficient routing protocol using line graph when the CHs=2 and levels=6 for various rounds such as 1000, 5000 etc

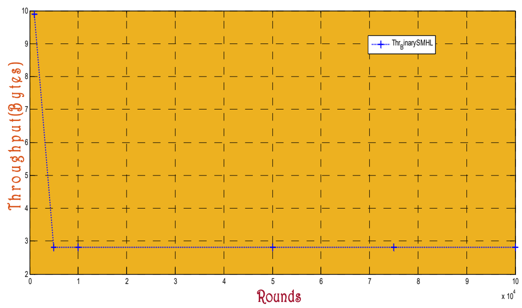

Figure 19: Throughput for binary tree based static multi hop leach energy efficient routing protocol using line graph when the CHs=2 and levels=6 for various rounds such as 1000, 5000 etc

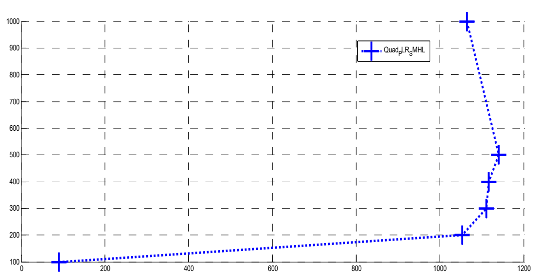

Figure 20: Comparison of PLR with respect to number of rounds for quad tree based multi hop energy efficient routing protocol WSNs with 4 different CHs and heights = 6.

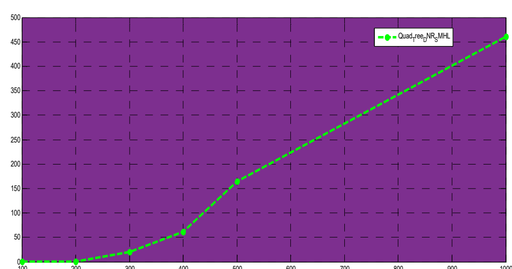

Figure 21: Comparison of DNR with respect to number of rounds for quad tree based multi hop energy efficient routing protocol WSNs with 4 different CHs and heights = 6.

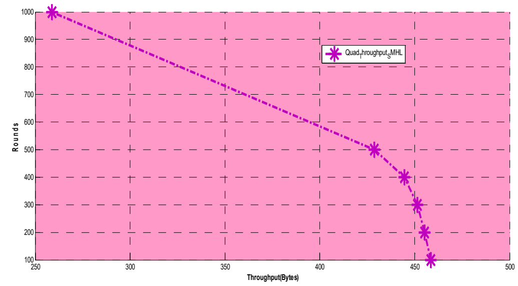

Figure 22: Comparison of throughput with respect to number of rounds for quad tree based multi hop energy efficient routing protocol WSNs with 4 different CHs and heights = 6.

Table 6:Comparison of throughput for binary, ternary and quad tree based energy efficient routing protocols.

Sensor hops	Number of Rounds	Throughput		
		Binary	Ternary	Quad
100	100	16.71	10.81	8.35
100	200	16.18	9.75	8.17
100	300	14.93	8.54	7.61
100	400	13.09	7.66	6.77
100	500	11.62	6.95	6.09
100	600	10.43	6.35	5.49
100	700	9.433	5.83	5.02
100	800	8.57	5.31	4.59
100	900	7.87	4.86	4.22
100	1000	7.29	4.47	3.92

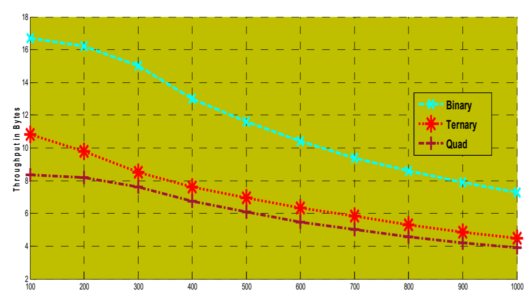

Figure 23: Comparison and contrast between the throughput of binary, ternary and quad tree static multi hop energy efficient routing protocols using line graph

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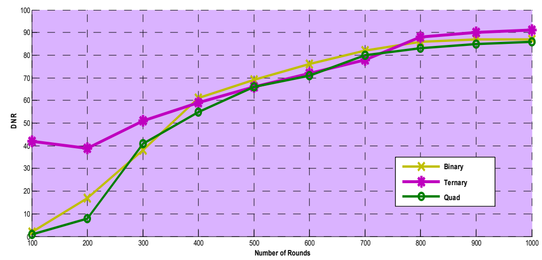

Figure 24: Comparison and contrast between the DNR for binary, ternary and quad tree based static multi hop energy efficient routing protocols using line graph.

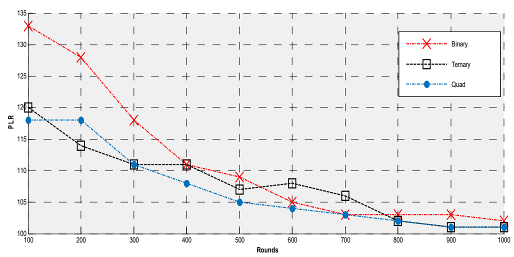

Figure 25 : Comparison and contrast between the packet loss rate for binary, ternary and quad tree based static multi hop energy efficient routing protocols using line graph.

Table 8 :comparison of packet loss rate (plr) for binary, ternary and quad tree based energy efficient routing protocols in wsns using line graph.

Sensor hops	Num of Rounds	Packets Lost Rate (%)		
		Binary	Ternary	Quad
100	100	133	120	118
100	200	128	114	118
100	300	118	111	111
100	400	111	111	108
100	500	109	107	105
100	600	105	108	104
100	700	103	106	103
100	800	103	102	102
100	900	103	101	101
100	1000	102	101	101

8. CONCLUSION AND FUTURE WORK.

In this research paper we evaluate and compare and contrast the tree based static multi hop leach energy efficient routing protocols for WSNs, using graph theoretic approaches such as; the binary tree based static multi hop energy efficient routing protocol for WSNs with ternary tree based static multi hop energy efficient routing protocol for WSNs and quad tree based static multi hop energy efficient routing protocol for WSNs through both analysis technique and simulation methodology. We analyze the problem of maximizing network lifetime under various constraints such as throughput, end to end delay and packet loss rate. This work also lays a foundation for our future work on tree based static multi hop energy efficient routing protocols for WSNs 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 binary, ternary and quad tree in a wireless sensor network environment. It is obvious that the performance salient features of energy efficient wireless sensor networks are very complex and changing all the time. We plan to extend this proposed research work in many folds by considering more performance metrics and revised algorithms. We also plan to revise tree based static multi hop energy efficient routing protocol using singly linked list, doubly linked list, circular linked list, reversed linked list, list ranking concept, dynamic programming concept, divide and conquer methodology, minimum spanning trees etc. One more vital work is to test and validate the proposed algorithms using real world data.

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Table2:comparison of plr for ternary tree based static multi hop leach energy efficient wsns with different numbers of sensor hops=120, chs=3, and number of levels=4.

No of Nodes	Total packets received	Total Packets Transmitted	Total Packets Lost	PLR in (%)	No of rounds before first hop dies	No of dead nodes	DNR in (%)	No of rounds	Network Life time	Net Throughput
120	11584	11820	236	2.36	41	12	0.012	100	371	12.9748
120	20874	21099	225	2.25	41	43	0.43	200	371	11.6505
120	27653	27874	221	2.21	41	61	0.61	300	371	10.2818
120	33134	33354	220	2.20	41	69	0.69	400	371	9.23678
120	37823	38041	218	2.18	41	78	0.78	500	371	8.23494
120	41875	42092	217	2.17	41	82	0.82	600	371	7.77897
120	44975	45190	215	2.15	41	95	0.95	700	371	7.16051
120	46695	46906	211	2.11	41	107	10.7	800	371	6.50478
120	47806	48015	209	2.09	41	110	11.0	900	371	5.91974
120	48806	49015	209	2.09	41	110	11.0	1000	371	5.43946
120	56217	56425	208	2.08	41	117	11.7	5000	371	2.88221
120	56217	56425	208	2.08	41	117	11.7	10000	371	2.88221
120	56217	56425	208	2.08	41	117	11.7	50000	371	2.88221
120	56217	56425	208	2.08	41	117	11.7	75000	371	2.88221
120	56217	56425	208	2.08	41	117	11.7	100000	371	2.88221
120	56217	56425	208	2.08	41	117	11.7	1000000	371	2.88221
120	56217	56425	208	2.08	41	117	11.7	1e+006	371	2.88221
120	56217	56425	208	2.08	41	117	11.7	1e+007	371	2.88221
120	1270	1440	170	1.70	0	0	0.0	10	0	14.2574
120	3040	3240	200	2.00	0	0	0.0	25	0	13.7288

Table 4: Comparison of PLR for binary tree based static multi hop leach energy efficient WSNs with 2 different CHs, SHs and heights = 4.

No of hops	Total packets received	Total Packets Transmitted	Total Packets Lost	(PLR in (%)	No of rounds before first hop dies.	No of dead hops	(DNR in (%))	No of rounds	Network Life time	Net Throughput
30	2735	2924	189	1.89	39	05	0.05	100	236	4.80921
30	4582	4766	184	1.84	39	17	0.17	200	236	3.94536
30	5579	5762	183	1.83	39	23	0.23	300	236	3.18695
30	6186	6368	182	1.82	39	25	0.25	400	236	2.64452
30	6686	6868	182	1.82	39	25	0.25	500	236	2.28324
30	7096	7277	181	1.81	39	26	0.26	600	236	2.01691
30	7496	7677	181	1.81	39	26	0.26	700	236	1.82438
30	7896	8077	181	1.81	39	26	0.26	800	236	1.67991
30	8296	8477	181	1.81	39	26	0.26	900	236	1.56749
30	8696	8877	181	1.81	39	26	0.26	1000	236	1.47753
30	11191	11372	181	1.81	39	29	0.29	5000	236	0.883056
30	11191	11372	181	1.81	39	29	0.29	10000	236	0.883056

Table 4:comparison of plr for binary based static multi hop leach energy efficient wsns with 2 different cluster heads and heights = 6.

No of hops	Total packets received	Total Packets Transmitted	Total Packets Lost	PLR in (%)	No Of Rounds Before First Hop Dies	No of dead hops	DN(H)R in (%)	No of rounds	Network Life time	Net Throughput
126	1334	1512	178	17.8	0	0	0.00	10	0	22.2353
126	3209	3402	193	19.3	0	0	0.00	25	0	21.5316
126	6329	6546	217	21.7	45	01	0.01	50	272	21.2532
126	9428	9663	235	23.5	45	02	0.02	75	272	21.0983
126	11272	11511	239	23.9	45	04	0.04	90	272	21.0055
126	12481	12721	240	24.0	45	06	0.6	100	272	20.9227
126	23673	23907	234	23.4	45	26	2.6	200	272	19.7906
126	32708	32933	225	22.5	45	46	4.6	300	272	18.2152
126	38928	39145	217	21.7	45	78	7.8	400	272	16.2562
126	43457	43671	214	21.4	45	85	8.5	500	272	14.5183
126	47324	47536	212	21.2	45	89	8.9	600	272	13.7252
126	50813	51025	212	21.2	45	92	9.2	700	272	12.1257
126	53975	54185	210	21.0	45	97	9.7	800	272	11.2698
126	56737	56948	211	21.1	45	99	9.9	900	272	10.5303
126	59242	59450	208	20.8	45	103	10.3	1000	272	9.89514
126	70236	70437	201	20.1	45	125	12.5	5000	272	2.80424
126	70236	70437	201	20.1	45	125	12.5	10000	272	2.80424
126	70236	70437	201	20.1	45	125	12.5	50000	272	2.80424
126	70236	70437	201	20.1	45	125	12.5	75000	272	2.80424
126	70236	70437	201	20.1	45	125	12.5	100000	272	2.80424

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Table 5:Comparison of PLR for quad tree based static multi hop Leach energy efficient WSNs with 4 different CHs and heights= 6.

No of hops	Total packets received	Total Packets Transmitted	Total Packets Lost	(PLR) in (%)	No of rounds before first hopdies	No of dead hops	(DNR in (%))	No of rounds	Network Life time	Net Throughput
5460	547565	556537	8972	89.72	54	16	0.16	100	650	458.432
5460	1.08822e+006	1.09875e+006	10534	1053.4	54	78	0.78	200	650	455.157
5460	1.6204e+006	1.63152e+006	11116	1111.16	54	208	20.78	300	650	451.443
5460	2.12842e+006	2.14004e+006	11618	1116.18	54	617	61.7	400	650	444.544
5460	2.56721e+006	2.57861e+006	11405	1140.5	54	1654	165.4	500	650	428.769
5460	5.11106e+006	5.12171e+006	10647	1064.7	54	4602	460.2	10000	650	258.96