Journal of Network and Innovative Computing
ISSN 2160-2174 Volume 1 (2013) pp. 310-319

An Energy Efficient Analysis using Spatial Correlation Method for Wirelesss Sensor Networks with Hierarchical Routing Protocols

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Abstract— **Sophisticated design methodologies are established in Wireless Sensor Networks (WSNs) where energy efficiency is the major target and the protocols are concentrated to achieve energy efficiency in an enhanced way. The proposed scheme provides an idea about energy efficient analysis using spatial correlation method for WSNs with Hierarchical Routing Protocols. The protocols explored in this paper are LEACH and PEGASIS. The parameters focused in this work are Energy Consumption, End to End latency, Packet drop and Packet delivery ratio and Throughput. In the end, the paper concludes with open issues about the novel energy efficient mechanisms in wireless sensor network.**

Keywords- Wireless Sensor Networks (WSN), Routing Protocols, Energy Efficiency, LEACH, PEGASIS

I. *INTRODUCTION*

WSNs plays vital role in our lives. WSNs are useful across a extensive range of applications. The infrastructure of WSN consists of sensing, communication, computation. Main intension of WSNs is to reliably detect and estimate event features from collective information provided by sensor nodes. Random deployment and dense nature and unattended mode of operation, varying nature of radio links, course limited energy resource are the major features of the WSNs. The position of individual sensor nodes in WSNs need not be predetermined The energy consumption in WSNs is increased due to sensing process. To save the energy of the network , the total number of sensor nodes to send data on the medium access layer is to be reduced thereby decreasing the transmission of redundant data. Wireless Sensor nodes are being energy constrained, to enhance the life time of WSNs energy efficient protocols are primarily important. LEACH and PEGASIS are well designed solutions to this problem. These two protocols try to minimize overall dissipation by the nodes in the network. To achieve equal energy dissemination LEACH protocol randomizes the cluster heads and PEGASIS protocol forms a chain of cluster heads taking rounds in transmitting to the base station. The lifetime of sensor node strongly depends on battery lifetime. The sensor node needs to collect data to sink in the remote applications of WSN. Hierarchical routing Protocols have good energy conservation and adaptability than plane routing protocols. One of the major application of WSNs is data collection On the basis of network structure, routing protocols are divided into three main groups. They are Flat and Hierarchical and Location based routing. Hierarchical routing protocols have achieves total energy consumption of WSNs. In Hierarchical routing protocols, Clusters are created and head node is assigned to each cluster. The idea of forming the cluster based routing protocol is to reduce the network traffic toward the sink. Cluster based protocols exhibit better energy consumption and performance than flat routing in WSNs.

II. *RELATED WORK*

A brief literature survey is presented in the following section:

The method of exploitation of spatial correlation on the medium access control layer is explained [1]. Many sensor nodes are observing the correlated data and a single sensor node can act as a representative node for those nodes who observing the correlated data. It improves the unnecessary channel access contention thereby improves the packet drop rate. The drawback of the work is only one type of phenomenon is sensed by the sensor nodes. Multiple correlation radius values for different phenomenon is impossible [1]. Novel way of spatial correlation based medium access control layer is proposed along with the method of selection of the sensor nodes [5]. To filter out the redundant data, priority node selection algorithm is utilized. Therefore energy consumption of the network is reduced [5]. Cluster protocol based energy –aware spatial correlation is proposed in [8]. Only cluster heads are responsible for exploitation of spatial correlation between the member nodes. Distortion and tolerance are the two parameters which are responsible for correlation [11]. The correlation region can be resized according to distortion and tolerance. These parameters can be measured by sink node [11].To measure the link quality in WSN ,Weighted regression algorithm has been proposed. Quality of a link to a neighbor node is identified [8]. To evaluate the algorithm the variance of the link with respect to time and spatial locations are considered. The parameters such as window size and number of classes can be added and the same algorithm cannot be explored in cross layer and different system layer. This may be considered as one of the drawback of the algorithm [8]. The prominent on demand routing protocols such as Dynamic Source Routing (DSR) and Ad hoc On-demand Distance Vector Routing (AODV) are compared [10]. DSR and AODV share the on demand behavior but they differ in routing mechanisms. Under minimum energy usage the spatio-temporal sampling rate of the network is determined [9].An energy efficient protocols to enhance the performance of LEACH and PEGASIS are discussed [18]. New chaining algorithm EB-PEGAIS is proposed [7].EB-PEGASIS uses distance threshold to achieve energy balance and prolong network lifetime. Multihop routing protocol with distributed clustering (ELDRL) is proposed [3].ELDRL spreads the workload across WSNs. The Protocol not only increases the scalability but also decreases the traffic of WSN. A new clustering protocol entitled Energy Efficient Distributed Centralized Cluster Routing Algorithm (EEDCCRA). EEDCCRA is also compared with LEACH and LEACH-C[4]. Novel Token based routing protocol adapted with a multicluster based architecture is proposed [2]. Token based routing protocol deals with intracluster communication and data aggregation, multihop data transmission. Comparative study of hierarchical routing protocol is proposed [6].

III. PROBLEM DESCRIPTION

A wireless radio is the most energy consuming unit of a sensor node in WSN. Primary source of energy to sensor node is the battery. It can operate in four different states. They are transmit, receive and idle and sleep. When the nodes are in active state, almost all the nodes consume the same energy . There are several ways to reduce the energy consumption in WSN. One way of reducing the energy consumption is, by using only a required set of nodes as active and thereby reducing redundant network traffic, decreasing packet forwarding delay, to help in avoiding packet collisions. The other way is to put few sensor nodes into sleep state and use only necessary node to be in active mode for sensing and communication. Sensor nodes are spatially distributed in nature and the ambient conditions related to surrounding environment of the sensors are measured by sensing circuitries in sensor network .

In the proposed work, the routing protocols such as LEACH and PEGSIS are considered only to analyze the behavior of CC-MAC protocol also the proposed work considers spatial correlation based Method which is exploited on the medium access control layer. In the proposed work, the necessary analysis is performed on MAC layer i.e., CC-MAC and the performance results are reflected on the Network layer from that we can calculate the value for the four parameters such as End-End delay, Packet drop, Packet delivery ratio, Energy Consumption, Throughput. A model for wireless sensor network has been designed and shown in Figure 1. Event source is represented as S. Total number of nodes available in an event area is N, Each node in the sensor field observes the noisy version of event information X_i (n) , S_i (n) is spatially correlated to event source S. Each node has to encode its observation for the purpose of reporting an event information to sink node. Sink is available at the other end which is responsible for decoding the information to get an estimated value of $\hat{S}$ [1].

In Figure.1, shows the model for wireless sensor network

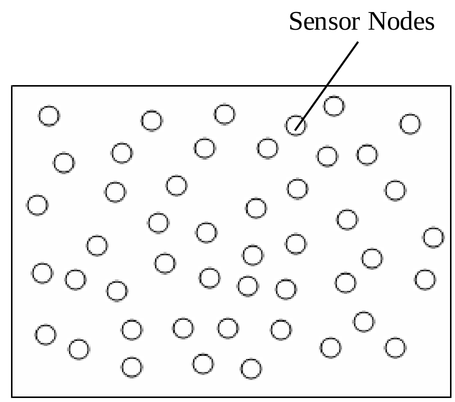

Figure. 1 Model for Wireless Sensor Networks

Total number of nodes available in an event area is N, where the event source is S. Each node in the sensor field observes the noisy version of event information $X_i(n)$, $S_i(n)$ is spatially correlated to event source S. Each node has to encode its observation for the purpose of reporting an event information to sink node. Sink is available at the other end which is responsible for decoding the information to get an estimated value of $\hat{S}$. At a time n, each observed sample is denoted as $X_i(n)$, equation is formed as,

$$X_i[n] = S_i[n] + N_i[n] \quad \textbf{(1)}$$

where the symbol i denotes the spatial location of the node n_i.

IV. HIERARCHICAL ROUTING PROTOCOLS

Hierarchical routing protocols have proved to have considerable savings in total energy consumption of the WSN. In hierarchical routing protocols, clusters are created and a head node is assigned to each cluster. The head nodes are the leaders of their groups having responsibilities like collection and aggregation the data from their respective clusters and transmitting the aggregated data to the BS. This data aggregation in the head nodes greatly reduces energy consumption in the network by minimizing the total data messages to be sent to BS. The less the energy consumption, the more the network life time. The main idea of developing cluster-based routing protocols is to reduce the network traffic toward the sink. This method of clustering may introduce overhead due to the cluster configuration and maintenance, but it has been demonstrated that cluster-based protocols exhibit better energy consumption and performance when compared to flat network topologies for large-scale WSNs.

Challenges of Clustering:

Wireless Sensor Networks present vast challenges in terms of implementation. There are several key attributes that, designers must carefully consider, which are of particular importance in wireless sensor networks.

- Cost of Clustering
- Selection of Cluster heads and Clusters
- Real-Time Operation
- Synchronization
- Data Aggregation
- Repair Mechanisms
- Quality of Service (QoS)

Hierarchical or cluster-based routing, originally proposed for wired network to enhance scalability and efficiency. In WSNs, Hierarchical routing techniques is used to enhance energy-efficiency and hence prolong the network lifetime. Reservation-based scheduling, collision avoidance, data aggregation by cluster head, uniform energy dissipation, fair allocation of channel and lower latency are some characteristics of hierarchical topology routing protocol

A. LEACH Protocol

The LEACH protocol presents an elegant solution to energy utilization problem where nodes are randomly selected to collaborate to form small number of clusters.

In the network, hundreds and thousands of wireless sensors are dispersed that collects and transmit the data. The cluster heads are elected out of the sensors to transmit the data collected to base station. LEACH performs local data fusion to compress the amount of data being sent from the cluster heads to the base station. Further reducing the energy dissipation and enhancing the lifetime of the network.

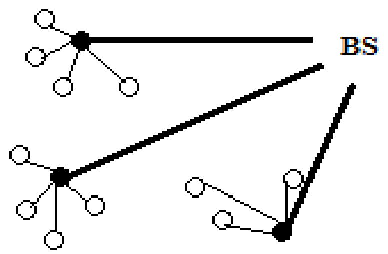

Figure. 2 LEACH Protocol Model

In Figure.2, Dark circle represents cluster head. Other circle represents sensor nodes in the each cluster. LEACH network is made up of nodes which are collectively called as cluster heads. The job of the cluster head is to collect the data from the surrounding sensor nodes and pass it on to the Base Station (BS).LEACH is dynamic because the job of the cluster head rotates.

The LEACH network has two phases, They are (i) Set up phase (ii) Steady State Phase. In the set up phase. In the set up phase, cluster heads are chosen. In steady state phase, cluster head is maintained when the data transmission is occurred between the sensor nodes. The key features of LEACH protocols are, Localized coordination, control for cluster setup and operation. Local compression to reduce global communication.

B. PEGASIS Protocol

PEGASIS is the improved protocol where only one node is chosen. A head node which sends the fused data to the BS per round. It is near optimal chain based protocol. It has an improvement over LEACH. Each node communicates only with close neighbor and takes turn transmitting to the base station. Data fusion helps to reduce the amount of data transmitted between the sensor nodes and the base station. Data fusion combines one or more data packets from different sensor measurements to produce single packets. PEGAIS forms a chain among the sensor nodes so that each node will receive from and to transmit to a neighbor. Gathered data moves from node to node and get fused and eventually designed node transmits to the BS.

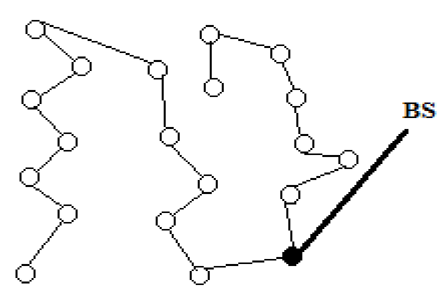

Figure.3 PEGASIS Model

Figure.3 shows PEGASIS model. First step in PEGASIS protocol is chain construction and Second step is gathering the data. When a node dies the chain is reconstructed to bypass the dead node. Head node receives all the fused data and sends to the BS.

The PEGASIS distribute the energy load evenly among the sensor nodes in the network. We initially place the nodes randomly in the play field, and therefore, the i –th node is at a random location. The nodes will be organized to form a chain, which can either be accomplished by the sensor nodes themselves using a greedy algorithm starting from some node. Alternatively, the BS can compute this chain and broadcast it to all the sensor nodes. Compare to LEACH the transmitting distance is reduces in PEGASIS. Since each node selected once, energy dissipation is balanced among sensor nodes.

LEACH, PEGASIS avoids cluster formation and uses only one node in a chain to transmit to the BS (sink) instead of using multiple nodes. A sensor transmits to its local neighbors in the data fusion phase instead of sending directly to its CH as in the case of LEACH. In PEGASIS routing protocol, the construction phase assumes that all the sensors have global knowledge about the network, particularly, the positions of the sensors, and use a greedy approach. When a sensor fails or dies due to low battery power, the chain is constructed using the same greedy approach by bypassing the failed sensor.

In each round, a randomly chosen sensor node from the chain will transmit the aggregated data to the BS, thus reducing the per round energy expenditure compared to LEACH. Simulation results showed that PEGASIS is able to increase the lifetime of the network twice as much the lifetime of the network under the LEACH protocol. Such performance gain is achieved through the elimination of the overhead caused by dynamic cluster formation in LEACH and through decreasing the number of transmissions and reception by using data aggregation. Although the clustering overhead is avoided, PEGASIS still requires dynamic topology adjustment since a sensor node needs to know about energy status of its neighbors in order to know where to route its data. Such topology adjustment can introduce significant overhead especially for highly utilized networks.

V. SPATIAL CORRELATION METHOD

Spatial correlation is used to prevent redundant data during transmission between the sensor nodes. Spatial correlation improves the distortion and utilizes the wireless channel due to spatial reuse property of wireless channel [1]. In wireless sensor network, when an event occurs in a sensor field, the nodes which are very nearer to that event area detect the event information and it is sensed by the neighborhood nodes. Every node transmits its own data to sink which is highly correlated that results in redundant transmission. It is not requisite for all the nodes in the sensor field to send the data to the sink. Redundant transmission in a network is reduced by decreasing the selecting the subset of sensor nodes. Node selection technique is used to identify the representative nodes resulting in minimum energy consumption in WSN. For this identification, an improved Spatial Correlation Based method is presented in this paper. The spatial correlation region is defined as the region in which all the sensor nodes send the readings which are similar in nature and therefore it is enough to send a single report to represent the correlation region.

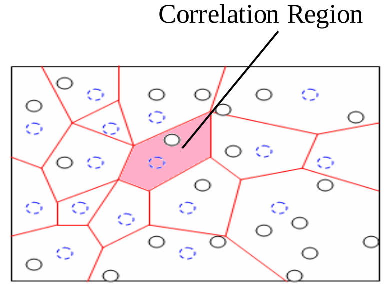

Figure.4 Representation of Correlation Region

Figure.4 shows the representation of correlation region.

In this paper, Power exponential model has been considered for the analysis of correlation region [1]. The power exponential model is given by the expression,

$$K_{\vartheta}^{PE}(d) = e^{(-d/\theta_1)^{\theta_2}} \quad \theta_1 > 0,\ \theta_2 \in (0,2] \qquad \textbf{(2)}$$

For θ_2 =1 The model becomes an exponential

For θ_1 =1 , the model becomes an squared exponential

$$\text{corr}\{ S_{i,}, S_j \} = \rho_{i,j} = K_v(d_{i,j}) = \frac{E[S_{i,}S_j]}{\sigma^2_s} \qquad \textbf{(3)}$$

The correlation between the two nodes n_i and n_j located at the coordinates S_i, S_j .where $d_{i,j}$ = $\rho_{si} - \rho_{sj}$. where ρ denotes the distance between nodes n_i and n_j respectively, and $k_v(\cdot)$ is the correlation model or covariance model. The covariance function is assumed to be non-negative and decreases monotonically with the distance.

- Correlation Neighbor – A node n_j is said to be the correlation neighbor of node n_i if the distance $d_{i,j}$ of the node ni is smaller than r_{corr}
- Correlation Radius – It is represented by r_{corr}. It is the radius of correlation region

Spatial correlation based CC-MAC reduces the unnecessary channel access contention by filtering correlated data transmission. CC-MAC contains two primary components. They are Event MAC and Network MAC protocol. Event MAC filers out the correlation in sensor network and Network MAC protocol prioritize the route through packets. E MAC forms the correlation based clusters. N MAC prioritizes the route through packets when the medium access is in usage. The Data Packet Structure of CC – MAC protocol is given in Figure 5.

MAC Header	FH	Frame Body	FCS
Bits 240	1	0 - 18496	32

Figure.5 Data Packet Structure

CC-MAC distributed operation is based only on rcorr, where rcorr is the correlation radius. Sink sends the rcorr value to each sensor node in the network. CC – MAC protocol has the capability to decrease redundant data and energy consumption. The representative node selection algorithm in CC-MAC protocol is random in nature. Total number of representative nodes is decreased automatically when the correlation value is increased.

VI. Distortion Constraint and Simulation Results for Distortion Constraint

Distortion is one of the reliability constraint. The distortion increases when the sensor nodes fail to report the event from within the defined correlation region. The correlation region is changed dynamically according to the observed reliability. At sink node, the distortion is given by,

$$D = E[d(S, \hat{S})] \quad \textbf{(4)}$$

where D is the Distortion value and S is the event and is the estimated value of S. Mean-squared error is used as the distortion metric

$$D(M) = E[(S - \hat{S}(M))^2] \quad \textbf{(5)}$$

D(M) shows the distortion achieved at the sink as a function of number of nodes M that send information to the sink and correlation coefficients ρ(i,j). and ρ(s,i) between nodes ni and nj, and the event source S and node ni, respectively [1]. It is denoted as,

$$D(M) = \sigma_S^2 - \frac{\sigma_S^4}{M(\sigma_S^2 + \sigma_N^2)}\left(2\sum_{i=1}^{M}\rho_{(s,i)} - 1\right) + \frac{\sigma_S^6}{M^2(\sigma_S^2 + \sigma_N^2)^2}\sum_{i=1}^{M}\sum_{j \neq i}^{M}\rho_{(i,j)} \quad \textbf{(6)}$$

The wireless sensor network is implemented in Ns2 with fifty nodes in random deployment. Representative nodes are selected randomly among 40 nodes and the distortion function is calculated according to the locations of these nodes. From the simulation, the correlation coefficient between the sensor nodes and the event and also the average distortion are calculated, the distribution of the distortion for each number of representative nodes is shown in Figure 5. For the analysis, $\theta_2 = 1$ and $\theta_1 = \{10, 50, 100, 500, 1000, 5000, 10000\}$ have been considered in the covariance model for the covariance function.

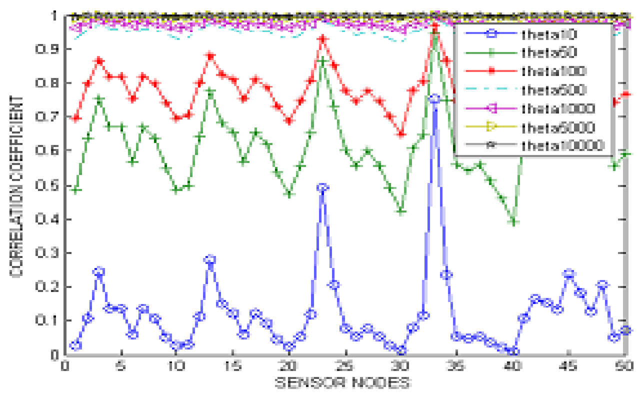

Figure 6. Correlation Coefficient between the sensor nodes and the event

Figure.6 shows the correlation coefficient between the sensor nodes and the event.

As shown in Figure.6 , the achieved distortion stays relatively constant when the number of representative nodes is decreased above 50. This behavior is due to the highly redundant data sent by the sensor nodes that are close to each other. In addition, with increasing θ_1, the observed event distortion decreases since close nodes become less correlated with increasing θ_1.

VII. Vector Quantization Method

Node selection technique is used to identify the representative nodes resulting in minimum energy consumption in WSN. For that, Iterative Node Selection (INS) algorithm is introduced in this paper. The INS algorithm running at sink, determines the minimum number of representative node to complete the task based on the distortion constraint $D_{max.}$ Average distance between the sensor node is determined and informed to all the sensor nodes in the event field. Each node in WSN field then performs spatial correlation based collaborative MAC operation. The INS requires the statistical properties of the node distribution as input. They are density of the network , type of the network and type of node distribution. The selection of locations of correlated points based on a distortion constraint has been analyzed by means of vector quantization (VQ) algorithm.

Code book and partition are initially identified by VQ algorithm. Based on the values of code book and partition the distortion value is reduced. The code book represents the locations of the representative node and partition represents the areas of which representative nodes are responsible. Significant improvement is achieved in distortion by selecting the location of representative node using VQ algorithm. The spatial correlation region is defined as the region in which all the sensor nodes send the readings which are similar in nature and therefore it is enough to send a single report to represent the correlation region. Correlation Radius and Correlation Region are two important observations in spatial correlation based iterative node selection algorithm.

Pseudo code for the proposed model is ,

- **Start Calculating D(M) by setting M=N**
- **Check if D(M) < D_{max}**
- **Run Vector Q uantization**
  - **(i) Generate Multiple Topologies with M nodes**
  - **(ii) Locations of Sensors nodes will be changed for each topology**
  - **(iii) Calculate r(s,i), r(i,j) using q_1**
  - **(iv) Calculate D(M)**
- **Repeat the above steps while D(M) < D_{max}**
- **End the result by calculating the values of M***
  M* = argmin { D(M) < D_{max}

VIII. SYSTEM MODEL

A model for wireless sensor network has been designed and shown in Figure 7. Event source is represented as S. Total number of nodes available in an event area is N, Each node in the sensor field observes the noisy version of event information X_i (n), S_i (n) is spatially correlated to event source S. Each node has to encode its observation for the purpose of reporting an event information to sink node. Sink is available at the other end which is responsible for decoding the information to get an estimated value of $\hat{S}$ [1].

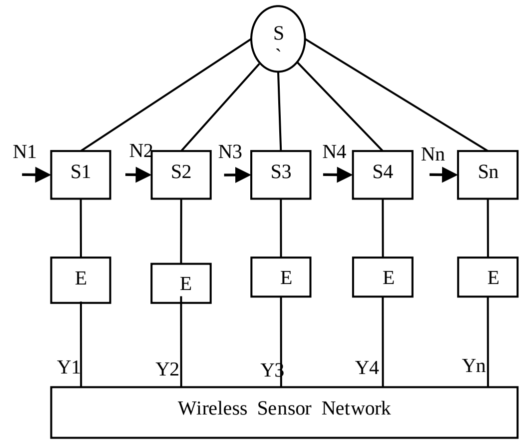

Figure 7. Model for Wireless Sensor Networks – Encoder Part

In Figure 7, The encoder part is labeled as E and the decoder part is labeled as D in Figure 8. Spatial Correlation based MAC protocol is proposed (CC-MAC) to prevent redundant transmission from closely located neighbors and to regulate the medium access. Spatial Correlation MAC protocol achieves high performance in terms energy.

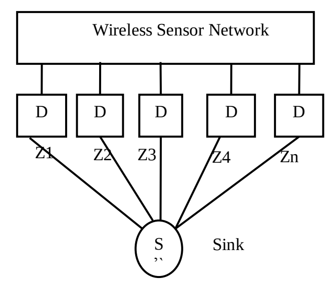

Figure 8. Model for Wireless Sensor Networks – Decoder part

Total number of nodes available in an event area is N, where the event source is S. Each node in the sensor field observes the noisy version of event information $X_i(n)$, $S_i(n)$ is spatially correlated to event source S. Each node has to encode its observation for the purpose of reporting an event information to sink node. Sink is available at the other end which is responsible for decoding the information to get an estimated value of $\hat{S}$. At a time n, each observed sample is denoted as $X_i(n)$, equation is formed as,

$$X_i[n] = S_i[n] + N_i[n] \quad \textbf{(7)}$$

where the symbol i denotes the spatial location of the node n_i , i.e. (x_i,y_i), $S_i(n)$ is the realization of the space-time process s(t,x,y) at time t= t_n and (x,y)=(x_i,y_i) and $N_i(n)$ is the observation noise [1] . {$N_i(n)$} is a sequence of i.i.d Gaussian random variables of zero mean and variance σ_N^2. We assume that the noise each sensor node encounters is independent of each other, i.e., $N_i(n)$and $N_j(n)$ are independent .Each observation Xi (n) is then encoded into Yi(n) by the source-coding at the sensor node as,

$$Y_i[n] = f_i(X_i[n]) \quad \textbf{(8)}$$

The information is transferred to the sink through the network. The sink on the other hand decodes the received data to reconstruct an estimation $\hat{S}$ of the source S.

$$\hat{S} = g(Y_1[n_1],...,Y_1[n_\tau];...;Y_N[n_1],...,Y_N[n_\tau]) \quad \textbf{(9)}$$

Based on the data received from N nodes in the event area over a time period τ, the time difference between t_{n1} and $t_{n\tau}$ is expressed as,

$$\tau = t_{n_\tau} - t_{n_1} \quad \textbf{(10)}$$

IX. *RESULTS AND DISCUSSIONS*

Network Simulator (Ns2) has been used for simulation of comparison of performance of Energy Efficient Analysis using Spatial Correlation Method for Wireless Sensor Networks with Hierarchical routing protocols. Proposed WSN model consisting of 40 sensor nodes deployed in a 1500 x 1500 m^2 sensor field. Network model is Simulated using Ns2 with 1mW of transmitting power and 1 mW of receiving power , 0.001 mw of sleep power and 1mW of idle power. 2 MHz range of bandwidth is considered along with 1Mbps data rate with the initial energy of 1000 joules.The parameters are End to End delay, Packet delivery ratio and Packet loss,Throughput,Energy consumption

A. End to End delay

End to End delay is defined as the ratio between sum of individual data packet delay to the total number of data packets delivered.

End to End delay = [(Sum of Individual data packet delay) / (Total number of data Packets delivered)]

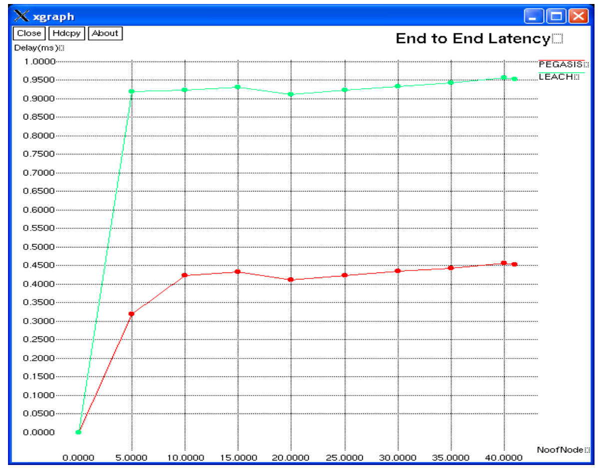

Figure.9 End to End Delay

It is observed from the Figure.9 that PEGASIS has less End to End delay compare to LEACH.

B. Packet delivery ratio

Packet Delivery ratio is the percentage of the ratio between total number of data packets successfully delivered to the total number of data packets sent. It is shown in Figure.4.

Pdr= [(Total number of data packets successfully delivered) / (Total number of data packets sent)] * 100%

From the Figure.10 the packet delivery ratio of PEGASIS protocol is high than compared with LEACH protocol because it uses chain construction to form the clusters

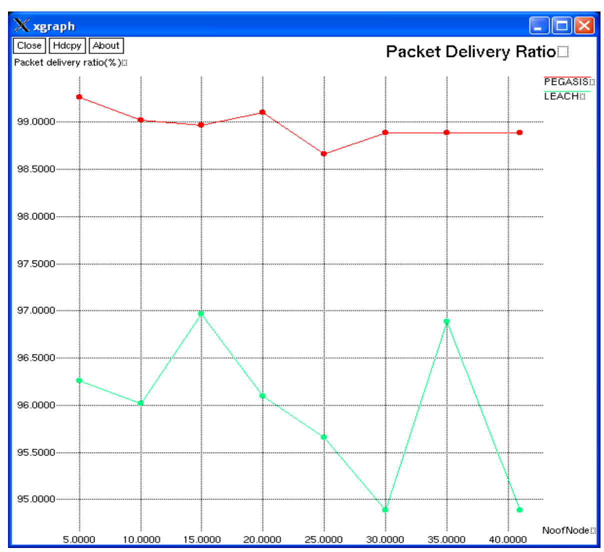

Figure. 10 Packet Delivery Ratio

C. *Packet Drop*

Packet Drop is obtained by subtracting the number of packets sent by the source to the number of packets received by sink.Figure.11 shows the packet drop value for 40 nodes.

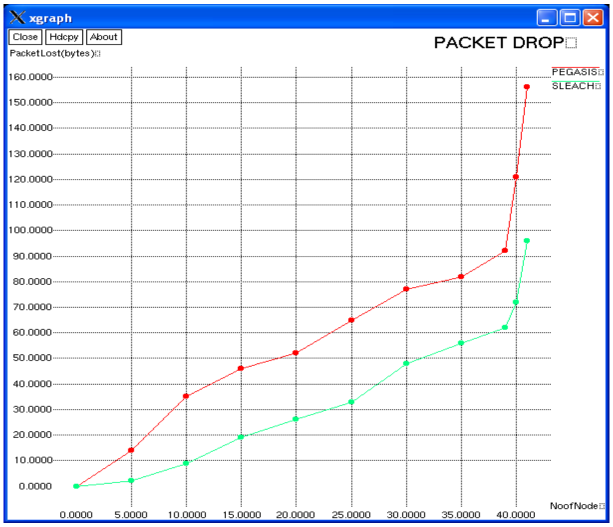

Figure. 11 Packet Drop rate

The packet drop rate for PEGASIS is higher than compared with LEACH.LEACH protocol drops few packets at 40th node than compared with PEGASIS.

D.Throughput

Throughput is defined as the number of packets delivered at sink node per time unit.

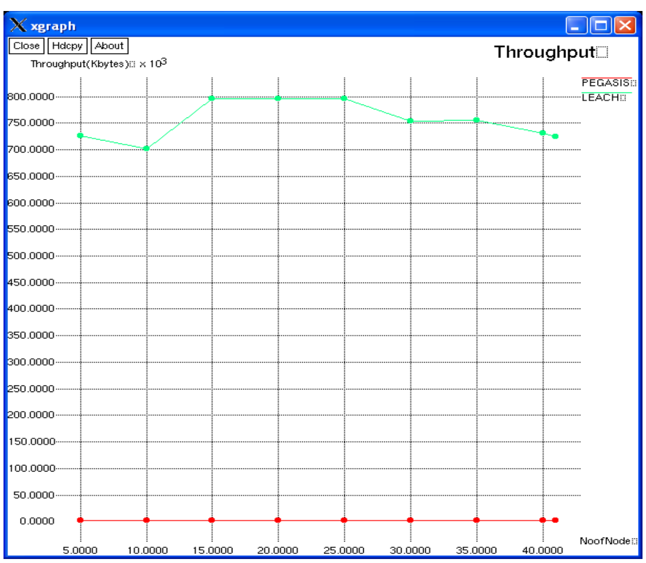

Figure.12 Throughput

Figure.12 shows throughput values of LEACH and PEGAIS. Throughput values are almost constant for all the values of sensor nodes in PEGASIS but LEACH protocol shows better result for all 40 nodes.

E.Energy Consumption

Energy Consumption is defined as the ratio between sum of energy expended by each node to the total number of data packets delivered.

Energy Consumption = [(Sum of energy expended by each node) / (Total number of data packets delivered)]

The energy spent in transmission of a single bit is given by

$$e_{tx}(d) = e_{t1} + e_{d1}*d^n \qquad \textbf{(11)}$$

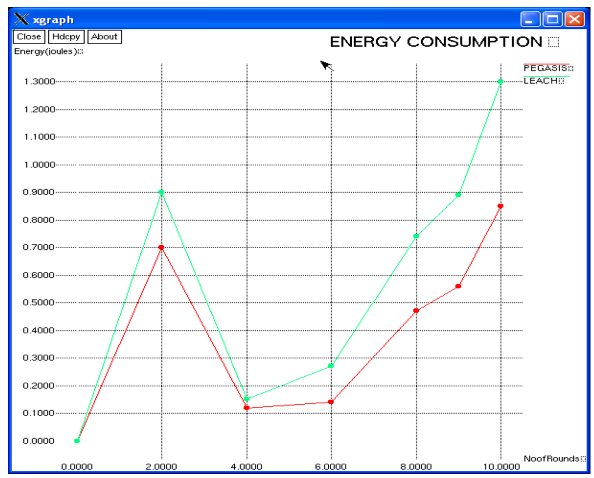

Figure.13 Energy Consumption for Various Rounds

Energy Consumption value for various rounds is shown in Figure.13

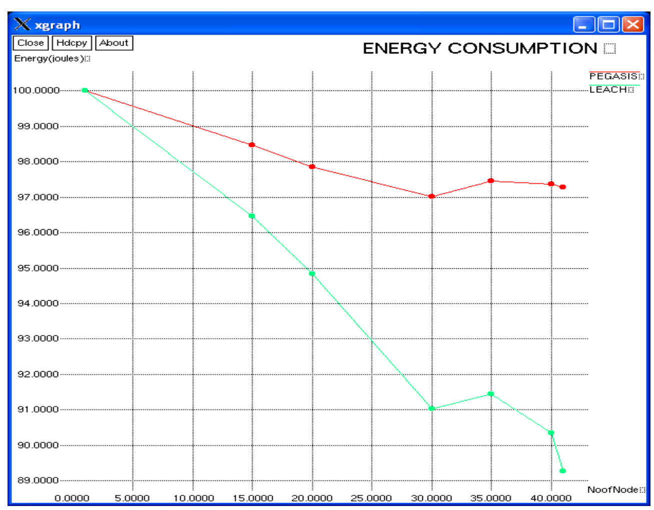

Figure.14 Energy Consumption Vs No.of Nodes

Figure.14 shows energy consumption value of LEACH and PEGAIS for 40 no of nodes. The total energy dissipated for transmitting a K-bit packet is,

$$E_{tx}(K,d) = (e_{t1} + e_{d1}*d) * K \quad \textbf{(12)}$$

When the node numbers are gradually increased the energy consumption level for LEACH is less than that of PEGASIS. At 40^{th} node, energy consumption value of PEGASIS is less than compared with LEACH but when the number of rounds are increased the performance of LEACH is good because the node sense the environment and transmit to BS through the predefined route. LEACH provides better results using spatial correlation method.

From the above Figures 9,10,11,12,13,14, it is observed that the proposed Energy Efficient Analysis using Spatial Correlation Method for Wireless Sensor Networks with Hierarchical routing protocols performs better with higher packet delivery ratio, lesser end to end delay and lesser packet drop, lesser energy consumption using LEACH and PEGASIS.

X. Conclusion and Future Work

An Energy Efficient Analysis using Spatial Correlation Method for Wirelesss Sensor Networks with Hierarchical routing protocols is proposed in this paper. Using Ns2 simulation tool, LEACH and PEGASIS protocols are implemented using spatial correlation method and the performance is analyzed. The redundant data are controlled by deactivating the redundant nodes. Parameters such as, End to End delay and Packet drop rate and Packet delivery ratio,Throughput and Energy Consumption are taken into account for various set of wireless sensor nodes also for different simulation condition. PEGASIS gives better result. In energy consumption LEACH gives better result. By reducing the redundant data from redundant nodes the spatial correlation based iterative node selection algorithm with Vector Quantization method proves that it is the suitable technique to attain energy efficient in WSN . In future work , field of grid and Life time maximization algorithm will be considered. Various set of hierarchical based routing algorithms can also be considered to accomplish the energy efficient operation in a better way. In future, Various Network Topology,Compressive Sensing based Spatial Correlation Techniques may be considered to proceed the work in different directions.

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