An Improved Energy Efficient Routing Through a Rotated and Polled Clustering Protocol (GCRCHS) in WSN

[1]Ms. G. Pattabirani [2]Dr. K. Selvakumar
[1]Assistant Professor, Department of Computer Science and Engineering, Government College of Engineering, Sengipatti, Thanjavur, Tamilnadu, India
[2]Professor, Department of Information Technology, Annamalai University Annamalai Nagar, Chidambaram, Tamilnadu, India
prvijayaraja@gmail.com [2]kskaucse@gmail.com

Abstract

Wireless sensor networks have been gaining widespread significance both in terms of research as well as its widespread utility due to its immense potential that could be effectively harnessed for a number of remote applications which include monitoring and surveillance followed by control. Nodes form the backbone for any wireless sensor network and are provided with limited power and processing capabilities. These nodes sense the information from source and relay them to the destination or base station. Routing is an integral part of any WSN implementation as it defines the flow of data path from source to destination in an optimal manner. Clustering have been researched actively in recent times due to their inherent ability to drastically reduce the network complexity by grouping them based on some similarity measure. The issue of clustering has been effectively utilized in this research paper by proposing a partition based clustering and rotated clustering policy based routing mechanism for a typical wireless sensor network. This algorithm has been compared against benchmark techniques such as LEACH, C-LEACH, E-LEACH and HEED protocols which are a class of hierarchical routing methods. Performance comparison with respect to network lifetime justifies the superiority of the proposed GCRCHS (graph cut rotated cluster head selection model) over the other techniques.

Keywords: *Wireless sensor networks, Clustering, network lifetime, Dead time analysis.*

---

1. Introduction

Communication technologies have witnessed a great revolution in the past two decades with state of the art communication networks and standards. One such application oriented innovation in the past decade is the wireless sensor networks which are a class of ad hoc networks and find widespread utility due to its immense potential [1]. Nodes form the backbone of a typical wireless network implementation and their primary advantage lies in their inherent capability to be deployed in almost all types of remote environments for continuous monitoring and control applications. It is because of this they have found widespread utility in defense sector for unmanned and remote monitoring of hostile territory or military unit movements, remote monitoring in health care sector followed by remote home based automation systems and monitoring scenes of natural disaster where human presence is not possible. Nodes deployed near the place of deployment are commonly termed as sensor nodes or terminal nodes and primarily vested with the responsibility of sensing information around the scene of installation and relaying them to the base station located in a remote place through a set of nodes known as forwarding nodes. Each nodes is provided with some limited amount of battery power and processing capabilities depending on the application for which they are being utilized. A typical wireless sensor network with nodes is depicted in figure 1 shown below.

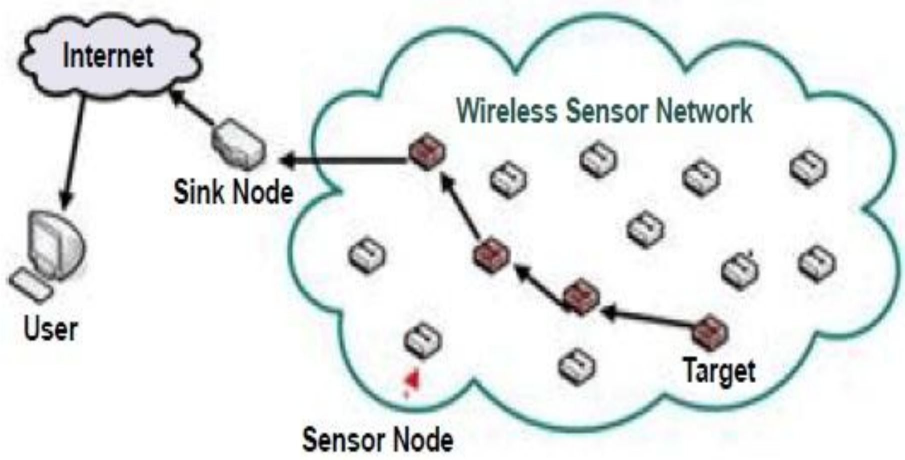

Figure 1. Illustration of A Simple Scheme Of Wireless Sensor Network

As depicted in figure 1 shown above, information regarding the scene of interest is sensed by the terminal node and transmitted to the destination or the sink node through a set of relay nodes or forwarding nodes which form a part of the transmission path. Routing [2][11] forms an important and integral part of any wireless network communication model as it defines the transmission path as shown in figure 1 from source to destination by taking into consideration a host of various attributes such as shortest path [9], transmission rate parameters [3], available bandwidth for transmission [4], power consumption of nodes on par with the limited battery power provided to each node [1] etc. The overall efficiency of the wireless sensor network (WSN) is defined by an efficient routing strategy or protocol implemented in the network collectively termed as the quality of service (QoS). An essential research issue amongst the various challenges behind a successful implementation of WSN is the routing protocol which is taken up for investigation in this research paper. As discussed above, there are a number of attributes which define the performance of the routing algorithm out of which the performance of router in presence of very large number of sensor nodes which is typical of practical WSN applications [6] has been a challenging research issue as observed from the literature [17] [19]. Issues such as computation complexity, latency, cost of transmission, power savings are some of the important factors which are found to be on the rise in presence of large of nodes. Concepts of clustering [10] have been found to be quite an ideal solution to such large node scenario issues and has been investigated through an efficient cluster based routing protocol algorithm which is investigated and experimented in this research paper. The rest of the paper is organized into a brief survey of literature related to cluster based routing methods followed by the proposed rotated cluster head based routing algorithm with experimental results provided at the latter part of this article.

2. Related Work

Routing is one of the most critical process which determines the overall efficiency of the wireless sensor network under investigation. Typically wireless sensor nodes are characterized by a varying number of node count depending on the topology of the environment [5] [17] where it is being installed. This usually is directly related to the distance [18] component from the terminal nodes to the base or control station where data aggregation takes place. Node topology also depends on the input traffic conditions [9] [13] and the type of data which it's going to probably handle [20]. Increasing node count demands an efficient and intelligent mechanism to route the data from source to sink either through single hop or multi hop propagation depending on the distance and cost associated with it [14] [18]. Concepts of clustering [11] have been gaining wide spread significance in many fields involving multiple feature points of interest [8] [11] and is well suited for the proposed routing problem in wireless sensor networks. Clustering typically refers to grouping of node points into members or clusters with a single node among each cluster assuming a major responsibility of providing coordination between the member nodes and normally termed as the cluster head [12] [15]. Literature has presented several cluster based routing methods out of which quite a few and recent contributions have been discussed in this section. Cluster based algorithms derive their motivation from the existing non optimal energy consumption among nodes due to their non-uniform distribution pattern observed in the literature [18][20]. In a typical WSN implementation, distribution pattern of nodes is non uniform in nature depending upon the topology as well as the type of data to be collected from the scene of interest. Hence, energy consumption presents itself to be a limiting factor to the overall efficiency of the routing methodology as these randomly distributed nodes consume energy in a variable manner irrespective of their state of activeness or idle state.

Predominantly used clustering protocol are based on a hierarchical [3] structure in which low energy adaptive clustered hierarchical routing protocol (LEACH) is most commonly used in the literature [4] [16]. LEACH protocols are quite ideal for small scale networks as they do not provide an optimal solution in case of large scale applications due to their inability to adapt towards changing dynamic input conditions. This includes the fact that the each node in LEACH protocol is given uniform probability to become a cluster head which poses a serious constraint in influencing and affecting the network lifetime [17] [19]. Under a uniform mode of cluster head selection procedure [11], a node with very low battery power may be forced to become a cluster head which may result in its quick die over time thereby affecting the network lifetime and increasing the traffic congestion overhead [7] [14]. Another issue observed in LEACH is the uneven distribution of cluster heads as their generation process is typically random in nature [16]. This results in an imbalance as some clusters with minimum number of nodes may have two or more number of cluster heads which is more than required resulting in wastage of resources and power.

Energy savings has been observed to be the major motivation in providing several improvements and modifications on the existing routing methodologies [10] [16]. Several variants have been brought about in the LEACH protocol based on the requirements which have been extensively found in the literature. Node dead time has been focused in the literature [6] where the time before it dies has been extended by involving a weighted election method for choosing the cluster head among the cluster. Concept of advanced energy nodes which have energy levels more than normal nodes is taken as the factor of heterogeneity in this model to improve the stable period of routing. However, election process of cluster head is random in nature which poses to be a limitation. This method is derived from the IBLEACH protocol [17] or the improved and balanced LEACH protocol where specialized nodes are defined to be having more energy than normal nodes and these specialized nodes are elected to be cluster or gateway nodes. The process of election is however random in nature resulting in uneven distribution of cluster heads. The main drawback of ignoring the energy levels during election of CHs in conventional LEACH protocols has been overcome in the E-LEACH or energy LEACH method [18] which defines a factor known as residual energy for decision making regarding a particular node of interest to be a cluster head or not. On the other hand, the drawbacks of LEACH related to unevenness in distribution of CHs have been addressed to a certain extent through C-LEACH [13] [15] which defines a centralized distribution pattern thus improving the stability period and to a certain extent the power consumption. On the lines of E-LEACH, HEED algorithms or the hybrid energy efficient distributed clustering algorithms have been extensively experimented in the literature [7] [9] which takes the residual energy as the main scheme of computing the cluster head. The previous history of the CH with respect to its last time of being a CH is one of the factors used in the election process. Other merits of HEED observed in the literature [10] includes a uniform CH distribution pattern resulting in energy savings followed by consideration of extra parameters in addition to residual energy to determine the CH election process. Such parameters may include distance to the base station, shortest path, mobility in case of mobile nodes as in MANETS [12], hop distance etc.

Other algorithms include hybrid combinations of clustering algorithms together with decision making models and training models which help in automating the entire process [12]. Some of them include fuzzy based clustering models in the form of FCM or fuzzy C means clustering [21] which define the cluster head depending on the minimization of an objective function related to the degree assigned to the node belonging to a cluster group. Cluster heads are identified by base station through reception and analysis of HELLO packets broadcast by the sensor nodes which contain their geographic location. The distance between the BS and cluster head is computed in terms of Euclidean distance and the election of CH depends on minimized Euclidean distance which ultimately reduces the energy consumed. Optimization models have also been used in recent times in a hybrid combination with existing hierarchical clustering model to optimize the feature vectors used to compute the cluster head. Supervised learning models [15] have been found to best improve the automation process of election of CH whose efficiency is defined and tested by the precise nature of feature vectors such as proximity to BS, hop count, residual energy which is given as input to the neural network model. Deep learning models [18] have also been used in recent times especially when the WSN structure under study is quite complex in nature. Optimization algorithms [21] together with PEGASIS [20] which represent an efficient power gathering clustering algorithm have been used in the literature and found to optimize the energy balancing criteria. PEGASIS based routing models help to improve the network lifetime by optimal selection of chain of communication through its adjacent neighbors.

3. Proposed Work

As observed from an exhaustive study of literature in the previous section, it could be seen that various hybrid and standalone clustering techniques have been proposed and experimented successfully in the literature. However, most of cluster based methods aim to improve the life time of networks through one or more number of means at the cost of another failing to reach a balanced trade off. For example, certain research contributions provide optimal transmission rate but the cost of increasing BER, while some provide improve life time at the cost of failing to utilize all the available nodes in an equal and uniform manner. One such motivation of providing a uniform and polled method of cluster head selection has been taken up for investigation and experimentation in this research paper through a rotation and graph partitioning strategy which has been elaborately discussed in this section. Clustering refers to the process of grouping nodes into groups based into similarity features selected on some predefined criteria. In spite of using state of art clustering algorithms, it could be found from literature that some clustering algorithms provide optimal clustering with no redundant nodes only after some prescribed number of iterations which is quite time consuming and not suited for real time WSN applications involving large data and nodes. Moreover, they do not ensure a uniform distribution of nodes in the real sense. More closely resembling nodes in the clusters may be selected in the same cluster resulting in increasing number of redundant nodes which results in energy wastage. Considering the above mentioned research issues, a graph cut based rotated cluster head selection model (GCRCHS) is formulated and proposed in this research paper. The proposed GCRCHS model is implemented in three phase's namely partitioning, cluster head selection and rotated CH implementation as depicted in the time line depicted in figure 2.

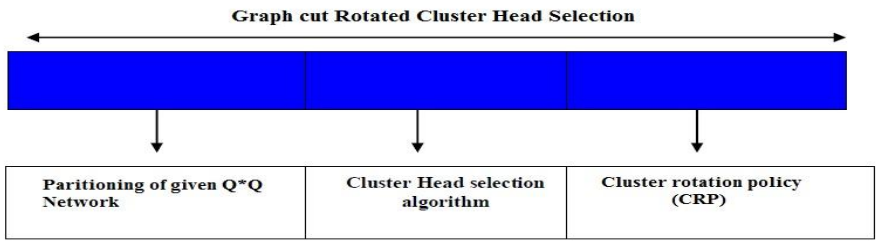

Figure 2. Proposed GCRHCS – Time line of implementation

3.1. Network model assumption

The following network model assumptions are taken into consideration before implementation of the proposed GCRCHS protocol.

- The given WSN contains nodes distributed in a Q*Q environment which is static and does not change with respect to time.
- The nodes in the Q*Q square area are quite isomorphic indicating similarity with respect to their functionality and structural geometries.
- All nodes are homogenous provided with equal computing and processing capabilities and are quite static and not mobile unlike MANETs.
- The nodes could communicate to a single sink in the environment through free space or multipath fading model which is Rayleigh model in the proposed case.
- Nodes are provided with limited battery power and cannot be replaced nor moved once deployed at a particular coordinate(x_0, y_0).

3.2. Problem formulation

The basic motivation behind the proposed work is to project the merits of conventional LEACH routing protocol and address the existing two major issues or constraints bounding the performance of LEACH. One research issue is to avoid the equal probability of cluster head selection criteria allotted to the cluster members which may result in drastic reduction of network lifetime and wastage of nodes by using a poll based and rotated cluster head selection method based on a tuple factor of residual energy, proximity and hop count. The second research issue is to improve the cluster quality by proposing a graph cut based partitioning method prior to clustering which is quite effective when the node count and node density is quite large at hand. Partitioning ahead of clustering helps in uniform distribution of nodes and to a certain extent contributes to reduction of overall energy consumption thus removing the uneven node distribution and thereby the cluster head distribution problem in conventional LEACH protocol. Allocation of cluster heads primarily depends on the precise nature of attributes used to define the nature of the nodes which make them ideal candidates to be CHs. Hence, spectral partitioning helps to reduce the dimensionality of the given problem and spectral clustering helps to improve the quality of attributes in the less dimensional N-space model.

3.3.Graph Cut Partitioning

The proposed work consists of three phases namely portioning using a graph cut method, cluster head selection followed by cluster rotation policy. The scheme of work flow is depicted in figure 3 shown below.

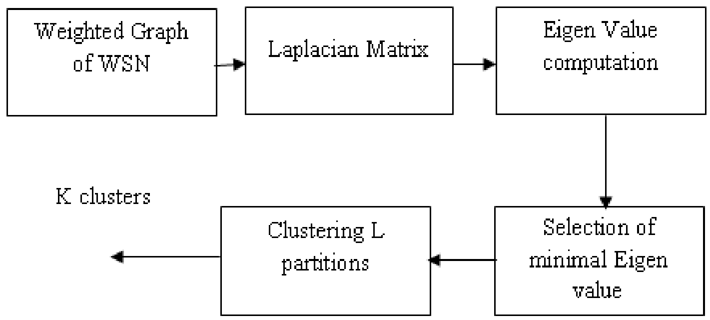

Figure 3 Flow Process Of Proposed GCRCHS Algorithm

Partitioning is the key to reducing the dimensionality of the feature vectors and thereby improving their quality prior to any other further processing. Moreover, partitioning enables to have a uniform distribution of nodes across the given network thus ensuring the CH is also uniform and dependent on the density of nodes in that cluster. The proposed work scheme is illustrated in figure 3 where the given network is equated to a graph containing vertices and edges which represent the connectivity of nodes followed by the spectral mapping which generates the required number of partitions in the resulting network. This partitions are given to the clustering algorithm to generate the required number of *M* clusters with *H* cluster heads.

The partitioning process is a quite straight forward approach with an objective to obtain the Laplacian matrix L_{Gm} from the degree matrix D_{Gm} and the adjacency matrix A_{Gm} as

$$L_{Gm} = {D_{Gm}}^{Q(i)} - {A_{Gm}}^{Q(i)} \qquad (1)$$

The above formulation is based on considering a WSN as a uni-directed graph $G(N, E) \in R_n$ where N denotes the nodes in the WSN and E denotes the edges representing the connectivity in a wireless environment. ${A_{Gm}}^{Q(i)}$denotes the adjacency matrix of the finite graph model and ${D_{Gm}}^{Q(i)}$ denotes the degree matrix associated with each vertex. It is essentially a diagonal matrix. A typical graph model for WSN is shown in figure 4 indicating the connectivity or non-connectivity of one node with every other node.

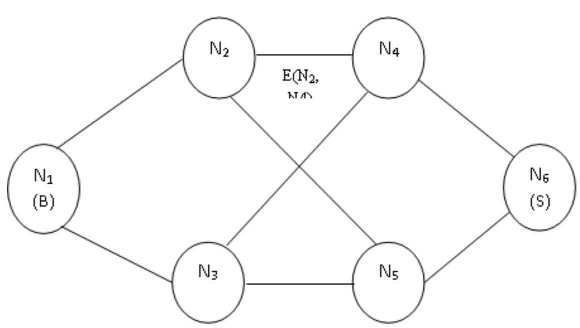

Figure 4. A Graph Model for Wireless Sensor Network

As seen from figure 4, S denotes the source node and D denotes the destination node while $E\ (N_2,N_4)$ denotes the wireless edge connectivity between any two nodes N_2 and N_4. The adjacency matrix for the above model is formulated as

$$A_{Gm}{}^{Q(i)} = \begin{vmatrix} 0 & 1 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 1 & 1 & 0 \\ 1 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 1 & 0 & 0 & 1 \\ 0 & 1 & 1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 & 1 & 0 \end{vmatrix} \quad (2)$$

Since the given network as shown in figure 4 is a simple graph, the diagonal elements of (2) are zeroes with 1s and 0s forming the rest of the entries. The essential importance of Laplacian matrix is to define the sparsest cut that could be generated by utilizing the second smallest Eigen value. Following (2) the degree matrix is generated as

$$D_{Gm}{}^{Q(i)} = \begin{vmatrix} 2 & 0 & 0 & 0 & 0 & 0 \\ 0 & 3 & 0 & 0 & 0 & 0 \\ 0 & 0 & 3 & 0 & 0 & 0 \\ 0 & 0 & 0 & 3 & 0 & 0 \\ 0 & 0 & 0 & 0 & 3 & 0 \\ 0 & 0 & 0 & 0 & 0 & 2 \end{vmatrix} \quad (3)$$

The main objective of the spectral graph partitioning is to reduce the cut size between the two graphs which have same number of nodes in a heterogeneous dataset. The cut size of the node is given as

$$C_s(X,Y) = cut(X,Y) \quad (4)$$

The indicator variables used in the model is $I_v = [1,-1]$ and it depends upon the nodes X,Y. The cut size including the indicator variable is given as

$$C_s(X,Y) = \sum_{v\in E} \frac{(I_u - I_v)^2}{4} W_{uv} \quad (5)$$

The optimal or minimum cut is given as a linear search problem and defined as the objective function given as

$$Min_Q N_{cut}(X,Y) \geq \rho_2 \quad (6)$$

The pseudo code of the proposed graph cut partitioning is given below

$input: G(N,E) \in R_n$

$Output = L\ partitions\ \in R_n$

$begin\ \{$

$compute\ L_{Gm} = D_{Gm}{}^{Q(i)} - A_{Gm}{}^{Q(i)}$

$Check\ L_{Gm} == Eigen\ value\ (j); j < \min (j+1)$

$Find\ optimal\ cut\ L_{opt} == Min_Q N_{cut}(X,Y)$

$\}end$

3.4.Clustering process

On obtaining the L partitions belong the real set of integers, the next phase deals with generation of K-clusters from these L partitions. Eigen distance is used to compute the optimal value of K unlike Euclidean distances used in previous methods. Computation of Eigen distance follows a maximization criteria and defined as

$$\Delta_k = |\lambda_k - \lambda_{k-1}| \quad (7)$$

With the objective function defined as a minimization of this Eigen valued function and formulated as

$$J = \frac{1}{n}\sum_{i=1}^{k}\sum_{I}|I - n_i|^2 \quad (8)$$

Where k is the given number of clusters, n_i is the prototype of cluster

The proposed algorithm for clustering the L partitions is given as

$input: L_{opt}(L_1, L_2, \ldots\ldots L_M) \in R_n$

$Output = K\ clusters\ \{K_1, K_2, \ldots\ldots K_N\}; K < L_{opt} \in R_n$

$begin\ \{$

$for\ i = 0\ to\ C\ \{$

$Compute\ Fiedel\ vector\ and\ Eigen\ value\ for\ all\ values\ \in R_n$

$\}$

$Compute\ Cluster\ Centroids\ \{K_{C1}, K_{C2}, \ldots\ldots\}\ for\ each\ K$

$Compute\ Eigen\ distance\ \ \Delta_k = |\lambda_k - \lambda_{k-1}|$

$Compute\ K_{opt} = \frac{1}{L}\sum_{i=1}^{k}\sum_{I}|I - n_i|^2$

$repeat\ until\ K = \{\}$

$\}end$

It could be observed from above code that L partitions obtained from graph cut partitioning are grouped into K optimal clusters which is now followed by selection and rotation of the cluster head selection process.

3.5.Cluster Head Selection and Rotation

On completion of the clustering process, the cluster head is elected based on a N-tuple for every Kth cluster and rotated using a cluster rotation policy to ensure that the CHs role is uniform and also that low energy cluster heads are not over utilized. The pseudo code for the rotation policy is given below.

$input: K\ clusters\ \{K_1, K_2, \ldots\ldots K_N\}; K < L_{opt} \in R_n$

$Output = CH_{opt}$

$begin\ \{$

$intialize\ N_{tuple} =$
$\{node\ density\ (n_d), residual\ energy\ (E_{res}), distance\ to\ base\ station\ (l$

$for\ i = 1\ to\ N + 1\ clusters$

$Broadcast\ 'HELLO'$

$call\ clusterhead(N_{tuple})$

$if\ CH_1 \in K_1 \leq \Delta_k$

$select\ CH_{opt} = CH_1$

$else$

$CH_{next} = CH_{prev} + 1$

$while\ CH\{LIST\}! = 0$

$\}$

$intialize\ t(0) = time\ instant$

$while\ t(n)! = 0$

$for\ j = 0\ to\ t(n)$

$if\ CH_k(t) \leq CH_{opt}$

$call\ clusterhead(N_{tuple})$

$X1: check\ energy\ (CH_n \in CH_K)! = 0$

$update\ CH_{opt}$

$else$

$goto\ X1\ on\ t(0) > t\_max$

$\}end$

As seen from the above pseudo code it could be observed that the cluster head selection process is based on a N-tuple considering distance, residual energy etc. and after the selection process, the cluster head is utilized and rotated on a frequency basis prevent overutilization or underutilization to save energy through a rotating policy determined by a time out period t_max defined in the code. If either of the two conditions, namely, the battery power or time of activity exceeds a prescribed threshold, the cluster head is rotated based on the tuple factor. This algorithm reduces the time complexity and network complexity and tends to increase the network lifetime. The proposed algorithm has been implemented and tested in NS2 software and compared against LEACH, E-LEACH, C-LEACH and HEED algorithms for various performance metrics presented d in the next section.

4. Results and Discussion

The proposed GCRHCS protocol has been implemented in NS2 with certain experimental settings and simulation settings to justify the superior performance of the proposed cluster based routing methodology. Table 1 depicts the simulation settings used for the experimentation in the proposed work. Performance comparison has been done against 4 other benchmark techniques as discussed above in terms of node dead time analysis, average energy consumption and packet loss.

Table 1 Simulation Settings for the Proposed Experimentation

Parameter	Numerical Value
Simulation area	1000 x 1000m
Channel Type	Wireless
Radio propagation model	Two ray ground
Number of nodes	100
Cluster head probability	0.5
Energy source	Battery
Initial node power	0.5J
Node pattern	Random
Location of BS	100x250
Data packet size	1500bits
Transmitter Energy	$5x10^{-9}$J/bit
Receiver Energy	$5x10^{-9}$J/bit
Sink Location	0,0

As listed in table 1, a 1000m x 1000m area has been taken as the environment for simulation in the proposed work with 100 nodes and the node at (0,0) forming the sink node with base station located at (100,250). The data byte size is 1.5KB and a two ray ground model has been taken as the transmission model. HELLO packets have been used for initial broadcasting with an initial node power of 0.5J supplied by a battery. Maximum simulation time has been configured at 900seconds and the distribution of nodes forms a random pattern. As defined in the previous section, the proposed model is implemented in three stages namely partitioning using a graph cut method, followed by clustering the partitioned sub spaces and concludes in selection and rotation of cluster heads so as to minimize the energy consumption and maximize the network lifetime, Node dead time analysis and energy consumption analysis directly reflect the performance of proposed rotated clustering scheme and hence used as major projectors in this research article. Figure 5 depicts the snapshot of a 100x100 node scenario implemented in NS2 simulator which is an open source simulator. Each nodes are provided with an initial energy of 0.5J and partitioned and clustered output is reflected in figure 6.

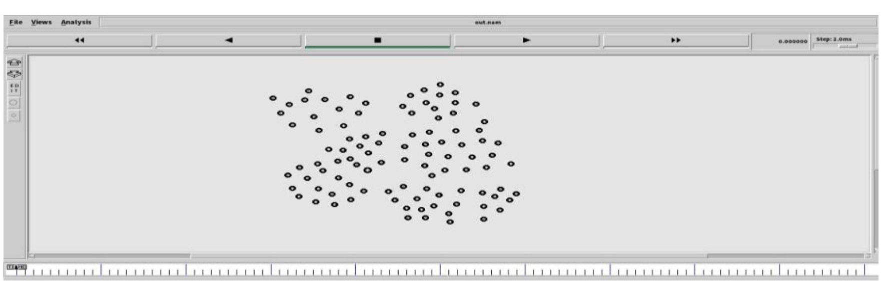

Figure 5. Implementation of 100 Node Configuration Scenario in NS2

100 nodes with an initial energy of 0.5 over a area of 1000x1000 sq.m has been implemented as depicted in figure 5.

Figure 6 depicts the cluster formation with 5 clusters using the proposed graph cut based clustering model. Figure 7 illustrates the choice of cluster head denoted in red based on cluster head selection method.

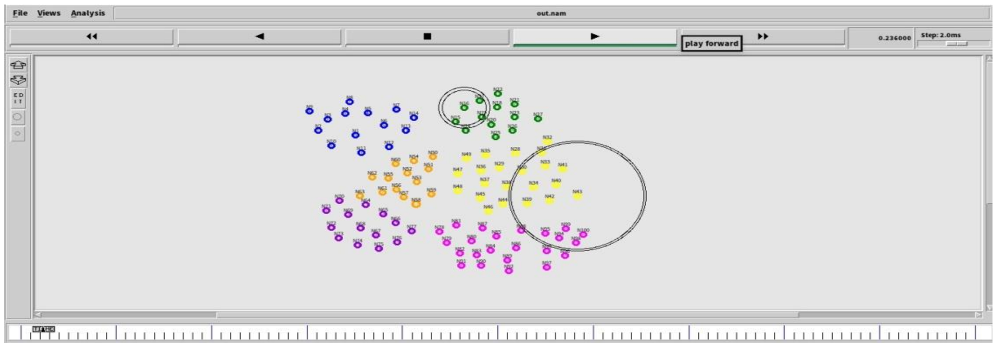

Figure 6. Implementation of Clustered Output Using Proposed GCRCHS

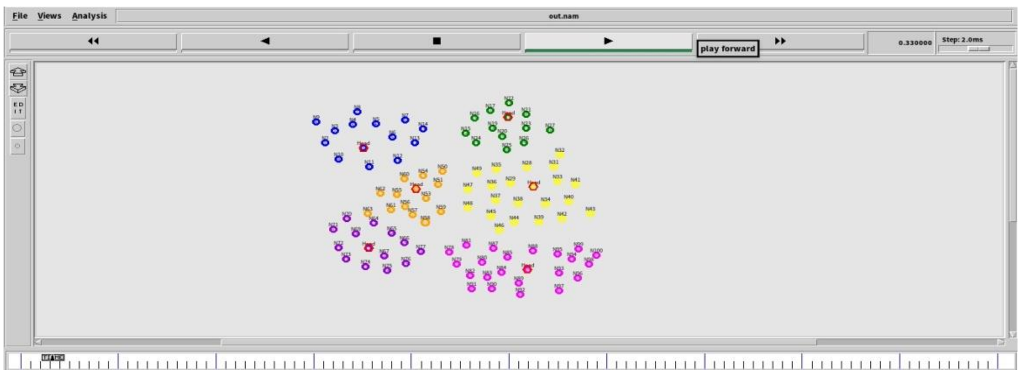

Figure 7. Cluster Formation Using Proposed Graph Cut Based Clustering Method

Final phase involves rotation of cluster head as shown in figure 8 based on residual energy, proximity to base station and hop distance required for transmission of packets from source to destination.

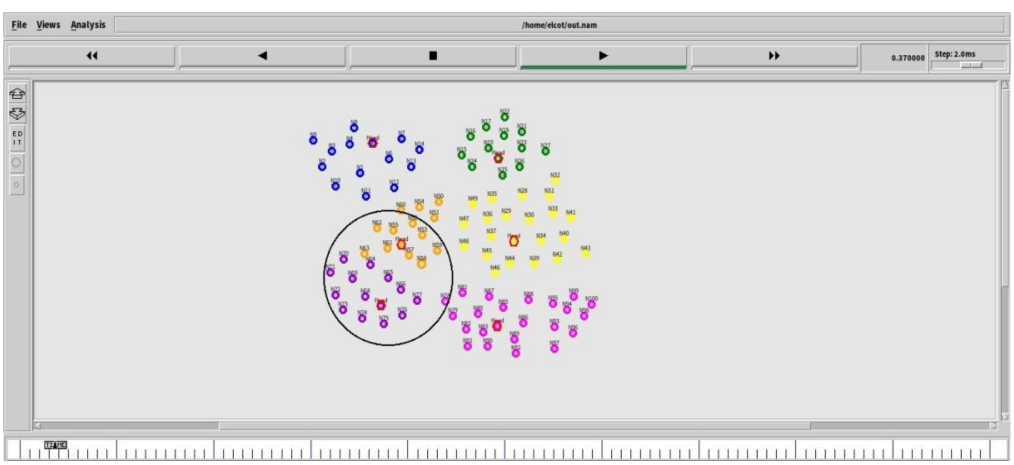

Figure 8 Cluster head rotation using proposed GCRCHS

4.1.Dead Time Analysis

Dead time analysis is done based on three essential metrics namely, lifetime of first node or first node dead time, half of node alive time and half of node dead time which have been projected in figures 9 to 11. It could be seen that figure 7 depicts the dead time of first node and graphical observations indicate that alive time increases with increasing node density which has been varied from 50 to 200 in steps of 50 nodes. Moreover, it could be observed that the proposed GCRCHS outperforms the other techniques by an average improvement of 19% in its lifetime with a node density of 50 while recording an improvement of nearly 5% for a node density of 200 nodes.

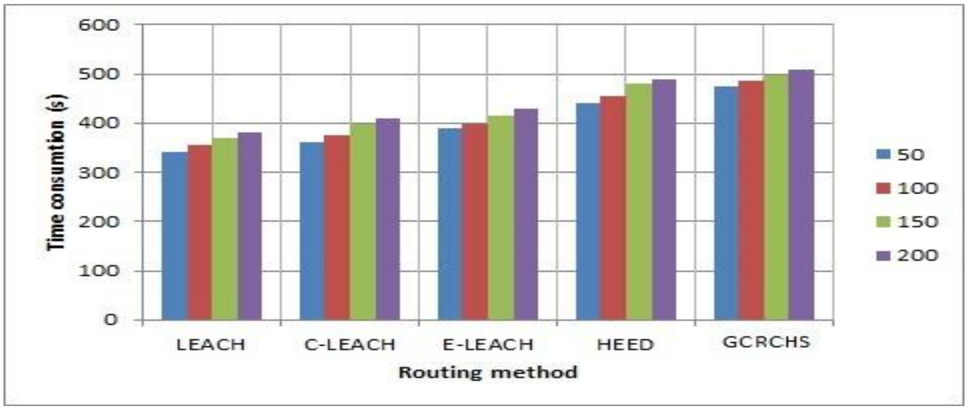

Figure 9.Comparative Performance of First Node Dead Time Analysis

In a similar pattern, the next metric taken for quantification of proposed work is the half node dead time analysis which depicts the time period at which half of the available nodes in the network go dead or in other words, the time period for which the other half remains alive due to significant energy savings through the proposed clustering based routing method. On observing figure 10, it could be seen that the proposed GCRCHS method of cluster based routing outperforms conventional LEACH and modified LEACH algorithms by remaining alive for up to 600s in contrast to 280s alive time for LEACH and 510s alive time for enhanced LEACH. A marginal improvement in alive time is observed over HEED which itself is an energy efficient algorithm. An improvement of nearly 37% alive time is recorded on an average.

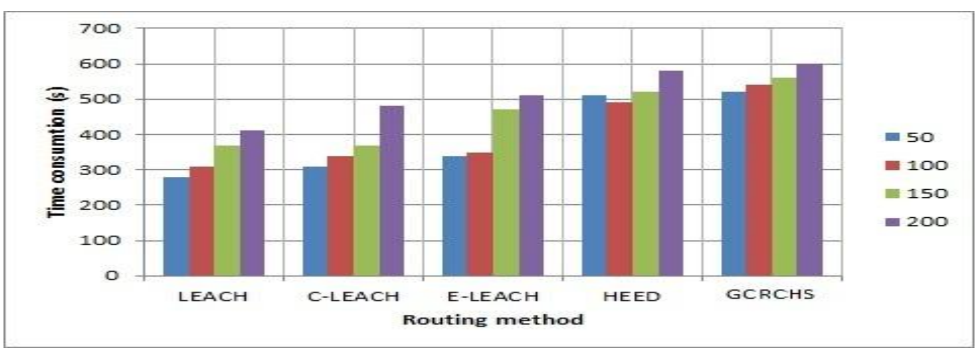

Figure 10. Comparative Performance of Half Node Dead Time

The final analysis into dead time analysis is the last node dead time which is a measure of how long the network exists before the last node in the network dies. Superior performance is observed with respect to the proposed GCRCHS mechanism over the other conventional clustering methods with an average increase of 29% recorded for an average node density of 100-120 nodes. This observation is depicted in figure 11 shown below.

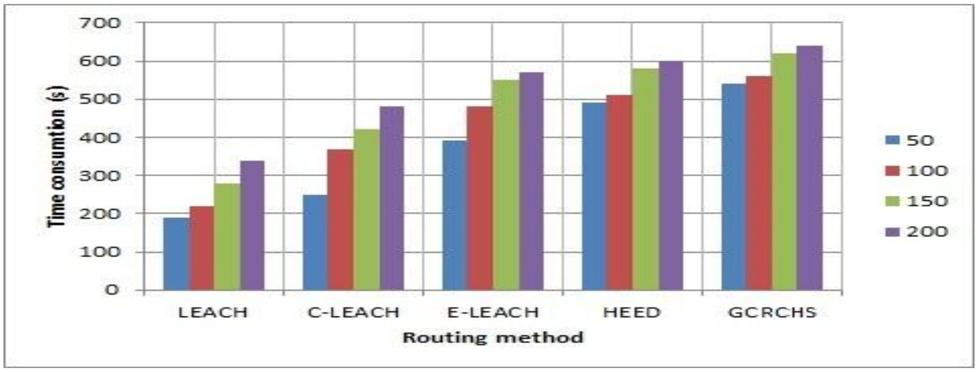

Figure 11.Comparative Performance of Last Node Dead Time

The dead time analysis has also been tested by varying the base station coordinates or distance in the alternate sense and the percentage of nodes that remain alive with respect to time has been observed and presented in table 2 shown below.

Table 2 Dead Time Analysis – Variation of BS

BS coordinates	Routing method	Dead time (s)			
		1%	10%	20%	50%
100,250	LEACH	140	160	175	220
	C-LEACH	165	170	195	260
	E-LEACH	190	235	275	380
	HEED	260	300	380	450
	GCRCHS	410	480	575	640
200,280	LEACH	80	110	125	160
	C-LEACH	110	160	190	240
	E-LEACH	150	240	260	300
	HEED	200	240	290	320
	GCRCHS	380	410	490	590

It could be observed from table 2 that as the distance of BS is increased farther away the energy consumption by nodes also increases due to increasing hop count and superior performance is observed in the proposed GCRCHS with an improvement of over 38% on an average.

4.2. Energy Consumption Analysis

Energy consumption analysis is an essential performance metric which justifies the efficiency of the proposed cluster based routing mechanism. Energy consumption is directly

ISSN: 2005-4238 IJAST

influenced by the number of nodes taking part in the active communication process as decided upon by the routing scheme in an intelligent manner. This derives from the motivation that nodes taking part in the communication process extract and spend more energy than those that are in idle state. However, power savings could be achieved such that power to these idle state nodes are identified at the right time and cutting off the power. Figure 12 depicts the energy efficiency in terms of energy consumption by the nodes which is found to be very minimal using the proposed GCRCHS over the other schemes with an average improvement of over 64% improvement when compared to conventional LEACH and 28% improvement when compared to E-LEACH algorithm. This is attributed to the fact that a more or less uniform energy consumption by all nodes in the proposed model is ensured by incorporating the rotating scheme of cluster heads and to further ensure that the nodes do not die out due to over utilization. This helps to improve the network lifetime of the model.

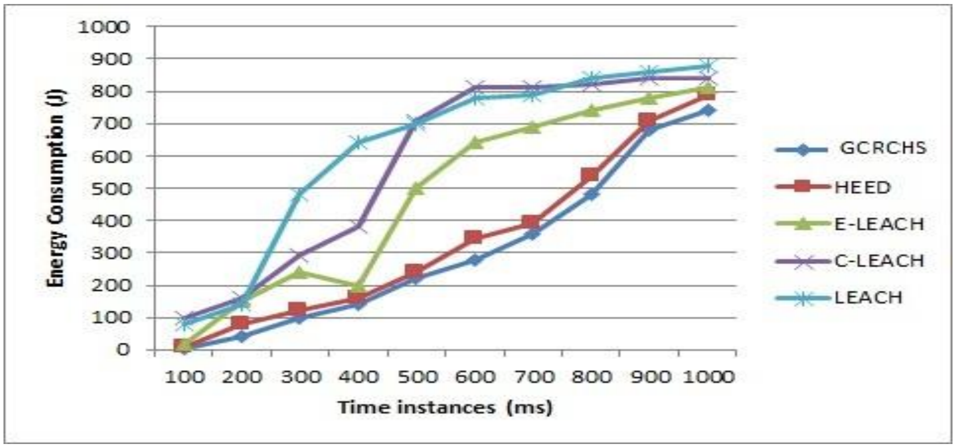

Figure 12. Comparative Performance of Average Energy Consumption

Another essential metric with respect to network performance is the packet drop ratio which defines the number of packets dropped during the communication process. This metric indirectly reflects the network throughput. It could be observed from figure 13 that the packet drop ratio is least for the proposed GCRCHS scheme as minimal number of packets are dropped owing to the extended lifetime of nodes thus ensuring link stability.

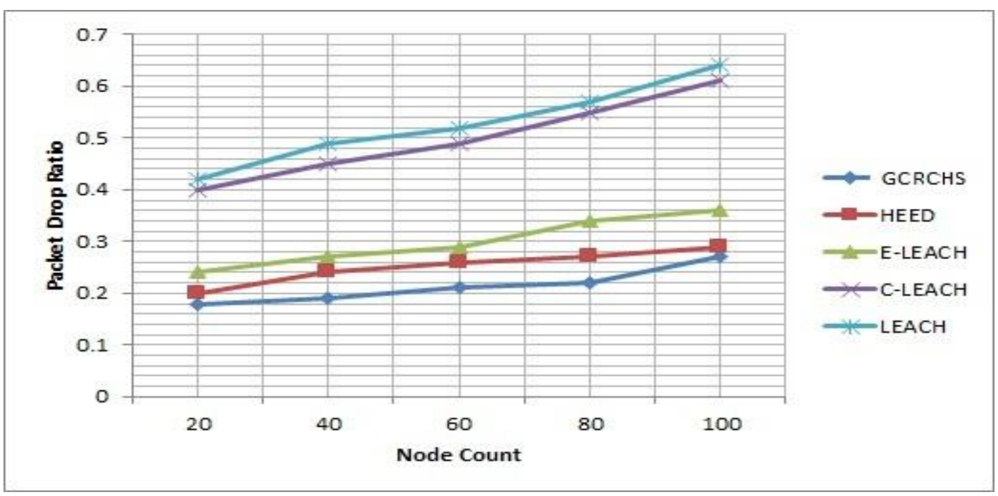

Figure 13.Comparative Performance of Packet Drop Ratio

ISSN: 2005-4238 IJAST

5. Conclusion

Clustering concepts have been actively researched and implemented in this research article towards establishing an energy efficient and simple routing protocol for wireless sensor network. The simplicity of the clustering process and quality of cluster has been improved by introducing a graph cut based partitioning method which helps to reduce the overall network complexity especially for large scale networks and clustering helps to cut down the amount of redundant nodes thereby accounting for the reduced time delay as well as energy consumed by every node. Energy savings in this paper is accounted for by using a rotated cluster head concept which helps in ensuring uniform utilization of all nodes based on the residual energy as well as proximity to base station. An average of 34% energy savings is observed and recorded in this research work. Future scope of this research work could be to improve the energy savings further by utilizing state of the art optimization algorithms.

References

[1] Chen B, Jamieson K, Balakrishnan H and Morris R (2002), "SPAN: An energy efficient coordination algorithm for topology maintenance in Ad Hoc wireless networks", ACM wireless networks, 8(5).

[2] K.VinothKumar, T.Jayasankar, M.Prabhakaran and V. Srinivasan, "Fuzzy Logic based Efficient Multipath Routing for Mobile Adhoc Networks", Appl. Math. Inf. Sci. vol.11, no.2, March 2017, pp.449–455.

[3] Jin Y, Wang L, Kim Y, Yang XZ (2008), "EEMC: an energy-efficient multi-level clustering algorithm for large-scale wireless sensor networks, Computer Networks, 52:542–62.

[4] Linlin Bai, Binyu Yan, Jingwen Luo et al. (2012), "An improved method of selecting cluster heads based on node's trust values in LEACH protocol", Journal of Sichuan University, 44: 218-223.

[5] Yu J G, Qi Y Y (2011), "An energy-driven unequal clustering protocol for heterogeneous wireless sensor networks. Journal of Control Theory and Applications, 9:133–9.

[6] Pawar K, Pawar V and Sharma T (2013), "Enhancement of LEACH protocol using energy heterogeneity concept", International journal of emerging trends and technology in computer science, 2(1): 49 – 56.

[7] Younis O and S. Fahmy (2004), "HEED: a hybrid, energy-efficient, distributed clustering approach for ad hoc sensor networks", in IEEE Transactions on Mobile Computing, 3(4): 366-379.

[8] JyotiRathi, Dagar M S (2016), "Improving LEACH protocol in wireless sensor networks", International journal of science, engineering and technology research, 5(5): 1454 – 1458.

[9] Pawlak R., Wojciechowski B., Nikodem M. (2010)," New Simplified HEED Algorithm for Wireless Sensor Networks. In: Kwiecień A., Gaj P., Stera P. (eds) Computer Networks. CN 2010. Communications in Computer and Information Science, vol 79. Springer, Berlin, Heidelberg.

[10] Lin, C., Tsai, M (2010),"A comment on HEED: a hybrid, energy-efficient, distributed clustering approach for ad hoc sensor networks", IEEE Transactions on Mobile Computing 5(10), 147–1296.

[11] E.Vishnupriya, T. Jayasankar and P. Maheswara Venkatesh, " SDAOR: Secure Data Transmission of Optimum Routing Protocol in Wireless Sensor Networks For Surveillance Applications, *ARPN Journal of Engineering and Applied Sciences,* Vol. 10,Issue. 16, Sep 2015,pp 6917-6931.

[12] Kazerooni, A. A., Jelodar, H., Aramideh, J. (2015),"LEACH and HEED clustering algorithms in wireless sensor networks: A qualitative study", Advances in Science and Technology Research Journal, 9(25), 7-11.

[13] Amit Parmar and Ankit Thakkar (2015), "An improved modified LEACH- C algorithm for energy efficient routing in wireless sensor networks", Nirma University journal of engineering and technology, 4(2):1-5.

[14] K. Vinoth Kumar, T. Jayasankar**,** M. Prabhakaran and V. Srinivasan, " EOMRP: Energy Optimized Multipath Routing Protocol for Wireless Sensor Networks," International Journal of Printing, Packaging & Allied Sciences, Vol. 4, No. 1, December 2016, pp 336-343.

[15] Murugananthan S D, Ma D C, Bhasin R, Fapojuwo A O (2005), "A centralized energy efficient routing protocol for wireless sensor networks", IEEE communications magazine, 43(3):8 – 13.

[16] Lalita Yadav, Ch. Sunitha (2014), "Low Energy Adaptive Clustering Hierarchy in Wireless Sensor Network (LEACH)",International Journal of Computer Science and Information Technologies, 5(3), 4661-4664.

[17] Ben Alla Said, Ezzatti Abdellah, Abderrahim Beni Hssane and Moulay Lahcen Hasnaoui (2010), "Improved and balanced LEACH for heterogeneous wireless sensor networks", International journal on computer science and engineering, 2(8): 2633 – 2640.

[18] Liao Q and Zhu H (2013), "An energy balanced clustering algorithm based on LEACH protocol", Applied Mechanics and Materials, 341:1138 – 1143.

[19] S.Gopinath,K.VinothKumar, T.Jayasankar," Secure location aware routing protocol with authentication for data integrity", **Springer-**Cluster Computing The Journal of Networks, Software Tools and Applications, **.** https://doi.org/ 10.1007/ s10586-018-2020-7.(2018).

[20] Rana H, Sangeeta V, Mohommad A (2014). "Comparative Study of PEGASIS Protocols in Wireless Sensor Network", IOSR Journal of Computer Engineering, 16(5): 25-30.

[21] Ghosh S, S. Mondal and U. Biswas (2016), "Enhanced PEGASIS using ant colony optimization for data gathering in WSN," 2016 International Conference on Information Communication and Embedded Systems,pp. 1-6.