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Efficient Clustering using Concentric Rings and Rectangular Region Formations in Wireless Sensor Networks

Sumedha Sirsikar[1], Manoj Chandak[2]

[1]*PhD Scholar, Faculty of Engineering and Technology, Sant Gadge Baba Amravati University, Amravati, Maharashtra, India.*
[2]*Shri Ramdeobaba College of Engineering and Management, Nagpur, Maharashtra, India.*

Abstract

Sensor node deployment is vital in cluster formation. It is sensitive for a large area of sensor field. Hence there is a need to divide sensor field into small regions and then form clusters. Regions are characterized by area of sensor network, number of sensor nodes and fair distribution of nodes within each region. This paper focuses on two types of sensor field region formations, namely, concentric rings and rectangular region formation. Concentric rings region formation is based on the distance from sink which is at the center of sensor field. Rectangular regions are formed by continuously partitioning sensor field into equal parts. Both formations are evaluated for energy consumption and network lifetime for various transmission ranges. Results for energy consumption and network lifetime are compared. The results depict that clustering within rectangular region is better than concentric rings.

Keywords: Concentric Rings, Rectangular Region, Clustering, Network Lifetime, Energy Consumption

INTRODUCTION

Many applications in daily life such as remote monitoring of environment, habitat, agriculture, healthcare, automobiles, disaster prone zones and military applications are developed using sensor network. The gap between physical world of human and its surroundings is bridged by WSN as it makes human life easier [1] [2]. Sensor nodes have limited processing power, communication bandwidth, energy and storage space hence WSNs have to utilize these resources efficiently. Conservation of energy of sensor nodes is one of the problems to be solved to increase the network lifetime which depends on energy level of sensor nodes [3][4].

In most of the WSN applications, substantial amount of sensor nodes are randomly deployed in a huge area in unobstructed manner to form an ad-hoc network. Designing such large size network requires scalable architecture and energy aware protocol [5]. Single-hop data forwarding is costly for nodes that are away from the sink as it depletes their energy quickly, thus limiting the network lifetime [6] [7]. This can be avoided by partitioning the sensor field into various types of regions [8] [9]. Topology Control Algorithm is effective in reducing the uneven energy consumption and prolonging the survival time of the network [10] [11].

In this paper, we proposed Concentric Rings Clustering (CRC) and Rectangular Region Clustering (RRC) algorithms to reduce energy consumption. The clustering inside concentric rings and rectangular region is based on node parameters like node distance, node residual energy and degree of a node. Sensor network gets self-organized into new clusters when energy level of Cluster Head (CH) goes below the threshold value in each region. An individual region can have more than one cluster [12].

Rest of the paper is organized as follows: State of the art is described in the related work section. Concentric Rings Clustering and Rectangular Region Clustering methodology is described in next section followed by simulation, result analysis and conclusion.

RELATED WORK

One of the important issues in the design of wireless networks is to balance the energy load among the sensors in the network. This is done by using Self-organizing clustering protocol, Low-Energy Adaptive Clustering Hierarchy (LEACH) to improve energy [5]. Energy levels have been compensated by dividing the sensor field into some segments based on the distance from the sink. Distributing the energy among the nodes in the network is effective in reducing energy dissipation from a global perspective and enhancing network lifetime. However, hierarchical protocols like LEACH do not consider the effect of distance parameter on sensors energy dissipation [8]. Multi-hop transmission is also used to reduce energy consumption but it generates heavy traffic at intermediate nodes. The node closer to the sink relays the huge traffic. This energy imbalance is distributed in various parts of sensor field by dividing it into different kinds of regions. Sensor nodes drain their batteries from different region at different times, resulting into early loss of coverage and potential partitioning of the underlying network.

Hierarchical clustering is used to save the energy in tree structured sensor network. Clustering is the primary approach that conserves communication bandwidth and stabilizes network topology and maximizes energy efficiency and network lifetime [13] [14][15][16]. In various Clustering schemes energy is saved by selecting nodes with maximum energy as the Cluster Head (CH). Energy efficient distributed clustering periodically selects CH that is based on residual energy and its node degree that does uniform distribution of CH across the network [13] [17] [18][19].

The clustering algorithms are classified based on various parameters that have diverse impact on energy consumption [13] [20]. Hence there is a need to identify various reasons of energy wastage [4]. Many routing protocols exist to handle network dynamics to achieve energy efficiency in WSN. There is unequal energy depletion in CHs as they are located at different distance from sink. Two level dynamic clustering is formed in Dynamic Distance Aware Routing protocol DDAR to minimize energy consumption [21] [22]. Further Clustering scheme is developed with fully distributed manner to balance load among CHs using weighted function that also lowers control overhead [23]. Energy Efficient Unequal Clustering (EEUC) for periodical data gathering organizes network into unequal clusters and multi-hop routing to balance energy consumption and also to eliminate hot-spot problem [24] [25].

Non-uniform region formation based clustering methods have been presented [26]. Divide-and-Rule protocol splits the network area into logical regions such as concentric squares which are further split into equal quadrilaterals to reduce the communication distance between node to CH and CH to sink [27]. Two-Tier Cluster Based Routing Protocol (TTCRP) configures nodes in the form of clusters at two levels where CHs are equipped with two channels [28]. Multi-tier hierarchical clustering form clusters of cluster heads using cluster size and degree of overlap to handle dynamic environment [13].

Uniform region based clustering methods are effective when sensor field is divided into tiers in which optimal number of CHs is identified for data aggregation that significantly reduces the amount of energy consumption [3] [29][30]. Sensor area is divided into equal zones [31] and rectangles so as to cover all nodes and to reduce energy consumption and distance between nodes and CHs [32].

There are problems with the existing region based clustering approaches. In circular regions all nodes are not covered [32]. In LEACH, there is possibility to select CH with minimal energy after several rounds because it does not take into account energy consumption [5] [6][26]. Also it is not suitable for large area as it uses single-hop for data communication [30]. As there is only one CH in each region, there is no CH to CH communication from different regions and data is directly sent to sink [31].

Our Contribution is:

- Developed Concentric Rings region formation algorithm based on distance from Sink
    - Primary and Secondary Cluster Heads to support Multi-hop data communication
- Developed Rectangular Region formation algorithm based on size of sensor field
    - Self-organization based clustering using the concept of cluster range and cluster diameter

A basic energy dissipation model is briefly described here. The total energy consumed by the sensor network is the combination of four components that includes energy spent for sensing the channel, transmission, listening during TDMA-slots and receiving data. Out of which, energy consumption during transmission and reception are considered. A simple energy model [33] is shown in Figure 1 where the transmitter dissipates energy to run the radio electronics and the power amplifier, and the receiver dissipates energy to run the radio electronics. The energy required to send data depends on the distance between the nodes and the number of bits which are being transmitted. The energy required for receiving also depends on the number of bits being received. Using this radio model, to transmit k-bit of message at distance'd' the radio expends energy as per equation (1) and (2):

$$E_{Tx}(k, d) = E_{Tx\text{-}elec}(k) + E_{Tx\text{-}amp}(k, d) \quad (1)$$

$$E_{Tx}(k, d) = E_{elec}*k + \varepsilon_{amp}*k*d^2 \quad (2)$$

Where E_{Tx} is the total energy needed to transmit a single k-bit packet to a receiver over a single link of distance d; E_{elec} is the basic energy to run the transmitter; ε_{amp} is the multi-path fading coefficient that depends on the transmitter amplifier model and it is the energy required for transmitter amplifier circuit. To receive this message, the radio expends energy as per equation (3) and (4):

$$E_{Rx}(k) = E_{Rx\text{-}elec}(k) \quad (3)$$

$$E_{Rx}(k) = E_{elec} * k \quad (4)$$

Where E_{Rx} is the total energy needed to receive a single k-bit packet from a transmitter [24].

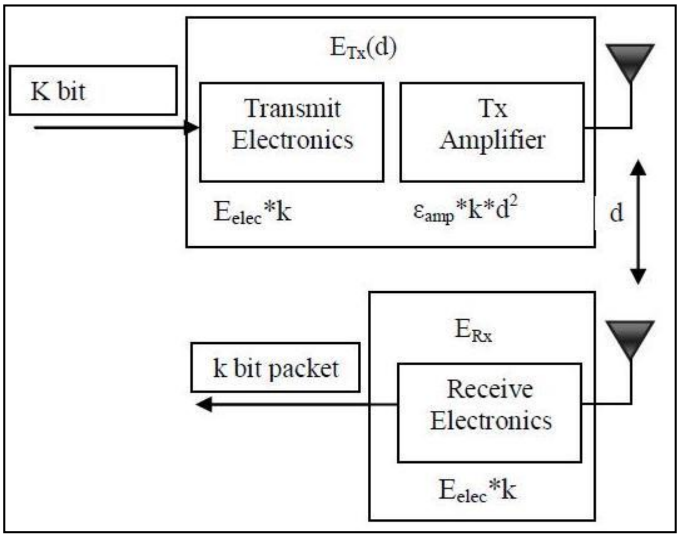


Figure 1. Radio energy dissipation model

3. Research Methodology for Region Formation

Proposed methodology speaks about formation of various regions within sensor field. Region formation can be done on the basis of various parameters such as height and width of sensor field in case of rectangular region formation whereas distance from centrally located sink is considered for concentric rings regions. Table 1 summarizes the region formation in CRC and RRC.

Table 1. Comparison of region formation in CRC and RRC

Concentric Ring formation	Rectangular Region formation
Network field is divided into Concentric Rings	Network field is divided into Rectangular Regions
All nodes are not covered	All nodes are covered
Size of Concentric Rings is on the basis of distance from sink	Size of Regions is based on the height and width of sensor field

This section describes methodology for Concentric Rings Clustering (CRC) and Rectangular Region Clustering (RRC).

Concentric Rings Clustering (CRC) Methodology:

In CRC, number of rings is based on the number of nodes, topology and area of network. In this technique, the sensor network field is divided into concentric rings on the basis of distance from the sink node which is placed at the center. Innermost ring is called as Ring-0 where sink is placed. Cluster heads that belong to Ring-1 are indicated as R1CH and treated as Superior CHs. Cluster heads from Ring-2 onwards are called as Minor CHs and designated as R2CH. CHs from Ring-n are termed as RnCH. Further in each ring CH is selected by considering highest residual energy. If CH energy goes below threshold energy then re-clustering is done. Nodes coming in the transmission range of CH will form a cluster.

Rectangular Region Clustering (RRC) Methodology:

In RRC, sensor nodes are grouped into clusters based on the node energy and node distance i.e. coverage and cluster diameter. In RRC algorithm network field is divided into fixed 16 regions. Cluster head is elected based on two parameters namely highest residual energy and highest node degree. At the most 2-hop cluster communication is used to reduce number of message transmission from member nodes to sink. Within a cluster, member nodes send data to CH. After sometime CH's energy goes below threshold value then next CH is selected and clusters are reformed within each rectangular region. 2-hop clustering reduces the amount of power required by the member nodes to communicate with the CH. All the member nodes those are away from the sink by 2-hop, forwards their data to the CH via 1-hop nodes. Data aggregation is done at CH which significantly reduces the amount of energy consumption [3] [29].

A. *Assumptions for Region (Rings/Rectangle) based clustering algorithms*

For designing sensor network following few assumptions are considered:

- All sensor nodes are homogenous with same initial energy
- Sensor nodes and CHs are stationary and location aware
- Sink is stationary and placed at the center of region

B. *Energy Consumption of Sensor network*

This section describes formula for energy and distance.

Consider N be the set of all nodes present in the network.

$$N = \{n1, n2, n3, \ \ldots\}$$

Energy consumed by a node Ec is given by equation (5).

$$Ec = Ei - Er \qquad (5)$$

where, Ei = Initial Energy of a node and Er = Residual Energy of a node

Total energy consumed TEC is given by equation (6).

$$TEC = \sum_{i=1}^{N} [Ei - Er] \qquad (6)$$

Average Energy Consumption (AEC) is given by equation (7).

$$AEC = \frac{\sum_{i=1}^{N} [Ei - Er]}{Number\ of\ Nodes} \qquad (7)$$

The distance 'D' between any two nodes with x & y coordinates (X1, Y1) and (X2, Y2) is calculated by using the Euclidean distance formula and is given by equation (8).

$$D = \sqrt{(X2 - X1)^2 + (Y2 - Y1)^2} \qquad (8)$$

CONCENTRIC RINGS CLUSTERING ALGORITHM

The sink rests at the innermost centre of Concentric Rings. Clusters are formed within the various rings. Sensor node with highest energy is designated as cluster head. Data from member nodes is transmitted to sink via cluster heads from each ring using multi-hop communications. Concentric Rings Region formation is as shown in Figure 2.

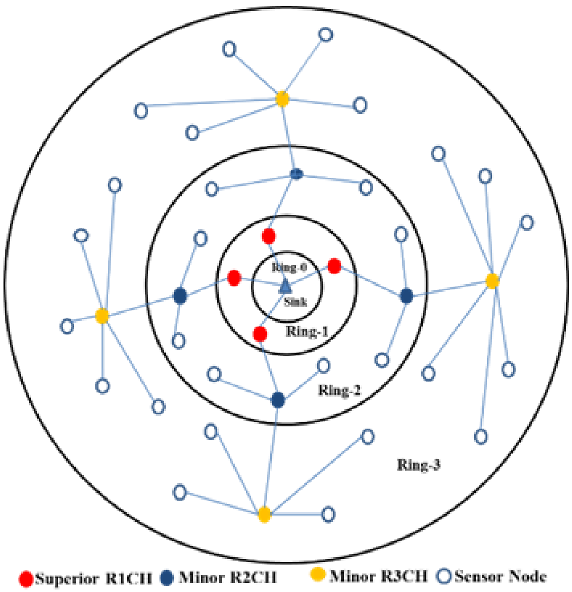


Figure 2. Concentric Rings Region formation

CRC Network Model

A homogenous wireless sensor networks that comprises of fixed 'N' number of sensor nodes where all nodes have same energy level. Three Concentric Rings (CR) are formed for a given sensor field that is defined as follows:

CR= {RID, r, Area, RN, TCH}

- ***RID:*** *Ring Identifier*
- ***r:*** *Radius of Ring*
- ***Area:*** *Area of Ring*
- ***RN:*** *Number of nodes in each ring*
- ***TCH:*** *Types of Cluster Heads as superior and minor*

Network Setup for CRC

In CRC clustering, sensor field is divided into 'n' Concentric Rings. Here, we assumed n = 3, [8] hence sensor network is divided into three Concentric Rings as shown in Figure 2, where radius of each Concentric Ring is assumed in the ratio 1:2:4.

Sensor nodes are deployed randomly in the multiple rings. Each ring is having fair distribution of nodes because it should not happen that one area is densely deployed with nodes and other remains sparse. Hence it is assumed that number of sensor nodes deployed within Concentric Rings is in the ratio 1:3:6. Determination of area of rings is a major concern from the point of view deployment and location identification of node. The area calculation of ring is based on radius of Ring-1. Sensor network is setup by calculating area of rings as follows:

- ***Area of Ring-1*** $= \prod r^2$
- ***Area of Ring-2*** $= \prod(2r)^2 - \prod r^2 = 4\prod r^2 - \prod r^2 = 3\prod r^2$
- ***Area of Ring-3*** $= \prod(4r)^2 - \prod(2r)^2$

$$= 16\prod r^2 - 4\prod r^2$$

$$= 12\prod r$$ where, r is radius of the Ring-1.

As per the requirement of the application, before nodes are deployed in sensor field area needs to be calculated by entity who is interested in monitoring of the surrounding. Our CRC approach can be used for such kind of applications.

CRC phases

CRC algorithm is divided into four different phases.

Phase 1: Concentric Rings Formation

Formation of Concentric Rings for a given sensor field is carried out as follows:

i. Calculate Euclidian Distance (ED) between each node and sink
ii. Compare ED with the radius of rings
iii. If ED < radius of Ring then that node ∈ Ring
iv. Innermost ring is called as Ring-0 (Sink) and next rings are Ring-1, Ring-2 and Ring-3

Phase 2: CH selection and Cluster formation

Selection of cluster heads is based on highest residual energy and non-zero degree. Degree of the node is the number of neighboring nodes falling in its transmission range. If a node is falling in transmission range of other node then it means distance between those two nodes is less than transmission range. Consider n1, n2, and n3 are three different sensor nodes. If n2 is in the range of n1and n3 is not in the range of n1 then the node degree of n1 is one. Sensor nodes n1 and n3 are in the range of n2 then node degree of n2 is two.

Clustering is carried out on the basis of node distance and transmission range. All nodes participate in the CH selection and Cluster formation process, which reflects self-organization in WSN. Sink is not involved in the Clustering process, i.e. clustering is not centralized, thus solving the network bottleneck problem.

Select Superior CHs from Ring-1 (R1CH) and Minor CHs from Ring-2 and Ring-3 based on highest residual energy. CHs from Ring-2 and Ring-3 are designated as R2CHs and R3CHs.

The steps for CH selection and Cluster formation are as follows:

i. All nodes send their ID and current residual energy to its neighboring nodes.
ii. The node with highest residual energy and node degree (>=1) broadcasts its ID as CH to other nodes.
iii. It may happen that one node receive two broadcasted message for joining CH, this decision is taken by node to join which CH. It will join the nearest CH. Nearest distance is determined by ED.

Phase 3: Data Transmission

Steps for data transmission are as follows:

i. If Minor CHs are within the range of Superior CHs then Minor CH finds nearest Superior CH and sends data to Superior CH
ii. Minor CHs collect data from its cluster members, aggregates it and sends to Superior CH and then to sink
iii. Superior CHs collect data from its member nodes and Minor CHs and directly sends to sink after aggregation

```
// Code for Data collection at CH within Rings:
  for (h=1; h<=M; h++)   // h is loop variable
    {
     for (ring=3; ring>=1; ring - -)
          {
            CH [ring-1][h]=CH[ring][h]
          }
     }
        where, ring is Ring number i.e. 1, 2 or 3
 M  is Number of cluster heads within range of R1CH
 CH[][] is two dimensional array to store ring number and cluster head within that ring
```

Phase 4: Re-clustering

After data transmission of all sensor nodes, energy of CHs decreases significantly. When it falls below its threshold value then it cannot function as a CH. So as to forward data from remote nodes still there is a need to select CH. Hence CH repeats the procedure of clustering which is done as follows:

i. If Sensor node's Energy <= Threshold Energy

Then

Sensor node not suitable for the role of CH

ii. Free all nodes in cluster

iii. If Sensor node with highest energy

Then

Select it as CH and Form cluster

Else

Not eligible for CH selection process and Declare as member node

RECTANGULAR REGION CLUSTERING (RRC) ALGORITHM

Figure 3 shows the various possible scenarios for node deployment inside Rectangular Region. Red circles represent cluster head and various colored circles represent member nodes in different regions. This rectangular region is further divided into fixed sixteen rectangular regions of equal size. Each divided region consist of sensor nodes distributed uniformly. Within each region, the parameters for CH selection are clustering methodology and residual energy. Clusters are formed within the various small regions based on node energy, node distance, transmission range, cluster diameter and degree of adjacent node connectivity. Parameters for cluster formation (Link joining Member node to CH) are distance and number of hops (1-hop, 2-hops). The cluster head selection is dynamic, based on highest residual energy and highest node degree. Sink is fixed at the center of sensor field. Sixteen regions are formed as four quadrants will be relatively large. Therefore each quadrant is further partitioned into four equal regions.

Here we have added concept of cluster range and cluster diameter as shown in Figure 3. Cluster range is same as the transmission range of node selected as CH. Cluster diameter is based on cluster range, so as to cover few more nodes in cluster using two-hop connectivity. Clustering is one-hop in case of cluster range and two-hop in case of cluster diameter. Cluster range and cluster diameter varies as per transmission range, which is a single hop for cluster range and for two hops in case of cluster diameter. Three-hop or more-hop connectivity will increase number of nodes per cluster, burden on CH and energy consumption in cluster. Thus, the reason behind the use of two-hop connectivity is to handle these issues and reduce energy consumption.

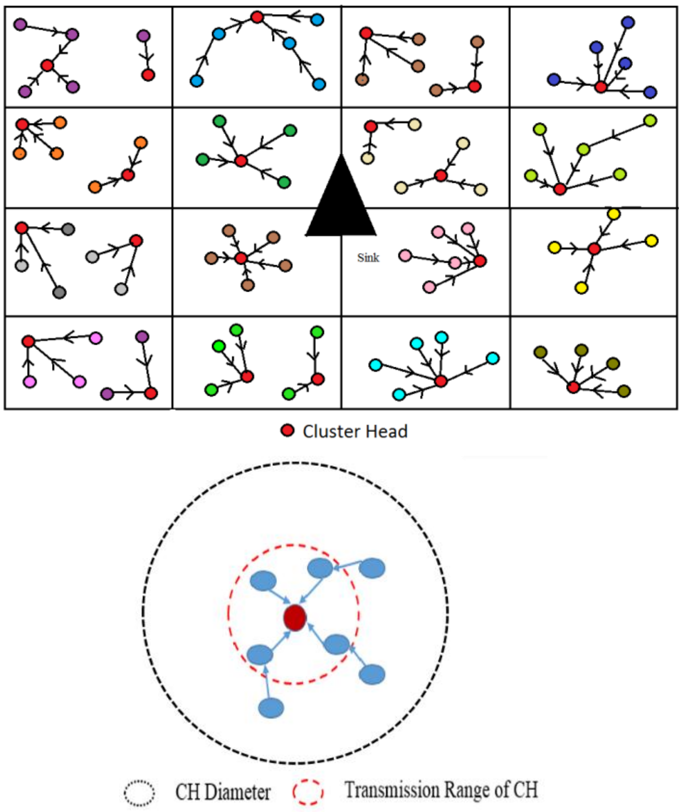


Figure 3. Rectangular Region Formation

Rectangular Region Clustering Network Model

A Rectangular Region is defined as follows: Each region consists of more than one cluster. Each rectangular region is distinguished by a 3-tuple set:

RR = {RID, NC, TNR}

- RID: Region Identifier
- NC: Number of Clusters in the region
- TNR: Total Number of Sensor Nodes (NSN) in each Region, given by,

$$TNR = \sum_{k=1}^{NC} NSN$$

where, NSN is number of sensor nodes in a cluster and NC is number of clusters

Network Setup for RRC:

As shown in Figure 3 sink node is fixed at the center of sensor field which is divided equally into 16 rectangular regions. Sensor node which is selected as CH within each region is shown in red color and other member nodes are shown with different colors.

Rectangular Region Formation (RRC) Phases:

RRC algorithm is divided into four different phases.

Phase 1: Rectangular Region Formation

Sensor field is considered to be in the form of Rectangular Region as the area of distribution of sensor nodes is more realizable in the form of rectangular regions compared to concentric ring formations. Also nodes placed at the corners are excluded in concentric ring formation but get covered in rectangular region. It is divided into sixteen equal rectangles based on height and width of sensor field.

Phase 2: Cluster Head Selection and Cluster Formation

Cluster Head Selection and Cluster Formation within each region is as follows:

i. Cluster Head is selected dynamically based on highest residual energy and node degree

ii. Once CH is selected, it broadcasts its ID to its member nodes to inform them about its location

iii. Nodes receive join message and calculate Euclidian Distance to CH

iv. The member nodes which are in the range of CH joins to CH with one-hop and nodes which are within cluster diameter joins to CH through two-hop connectivity

v. Here single hop member within the transmission range of the CH, joins the CH. Next hop nodes which are within cluster diameter are allowed to join cluster. These next hop nodes which are in the cluster diameter join cluster with the help of one-hop member nodes (which are already joined to that cluster) by using two-hop communication.

Phase 3: Data Transmission

In this phase, member nodes transmit data to their respective CH.

i. Each node sends data to CH during specified time slot

ii. CH sends collected data to sink node by using multi-hop communication

iii. Two-hop member nodes send data to one-hop member node which forwards it to the CH

iv. Routing is done by using shortest path

Phase 4: Re-clustering

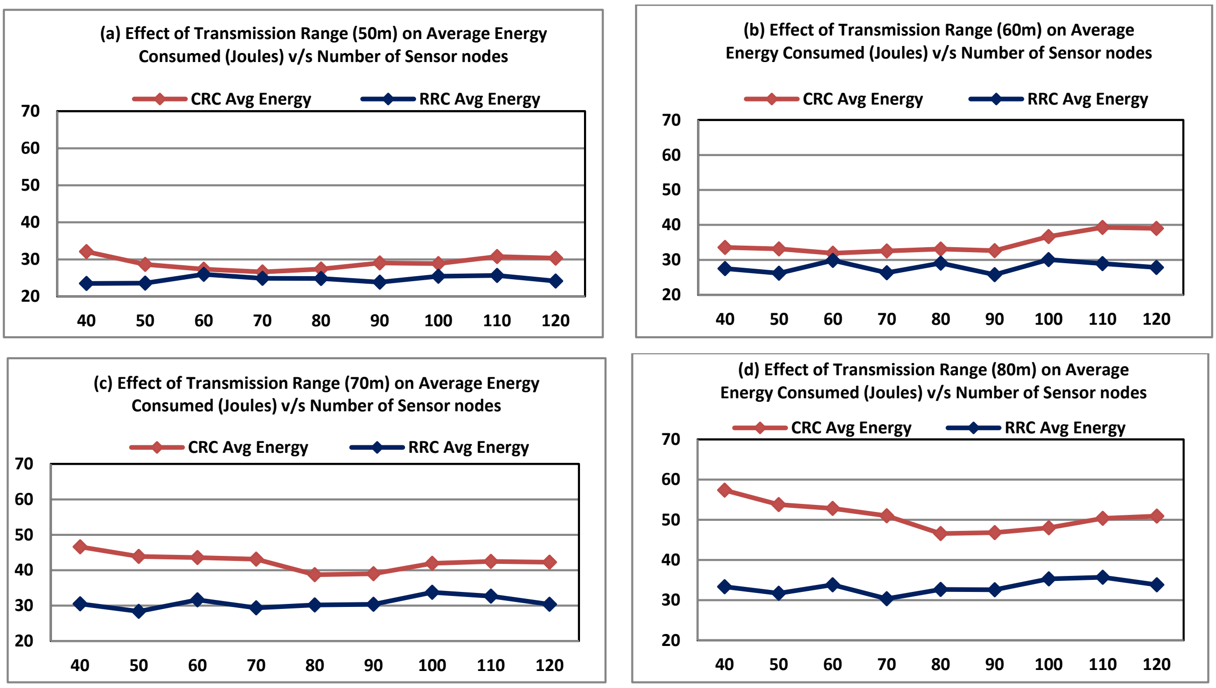
Re-clustering sensor node is based on threshold energy and similar to Concentric Rings Clustering.

SIMULATION AND RESULTS OF CRC AND RRC

Analysis of CRC and RRC algorithms is done by NS-2 simulator. The number of nodes is considered as 40, 50, 60, 70, 80, 90, 100, 110 and 120. Transmission range is considered in the range of 50 m to 100 m with the interval of 10m. The initial energy of each node is assumed to be 1000 J and threshold energy as 100 J.

CRC and RRC algorithm is executed for various numbers of nodes and transmission ranges. Values for average energy consumption and network lifetime are obtained and graphs are plotted as shown in Figure 4 and Figure 5. X-axis represents number of nodes and Y-axis represents energy consumed and network lifetime.

In Figure 4a to 4f, CRC Avg Energy and RRC Avg Energy indicate Average Energy Consumption for Concentric Rings and Rectangular Region Clustering at ranges 50 m to 100 m. For example, Figure 4a shows that the Average Energy Consumption for CRC is more as compared to RRC. This proves that Rectangular Region Clustering consumes less energy and is more scalable in terms of number of nodes compared to concentric ring formation.



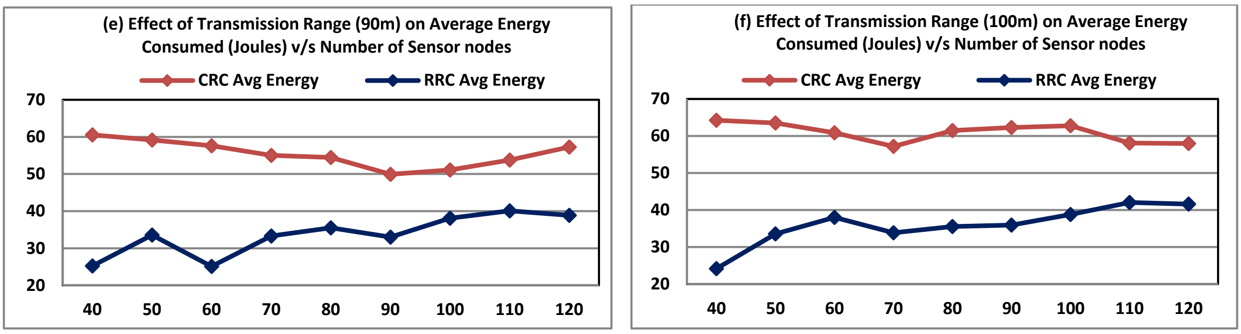


Figure 4. Comparison of Average Energy Consumption for CRC and RRC

In Figures 5a to 5d, CRC NL and RRC NL indicate Network Lifetime for Concentric Rings and Rectangular Region Clustering at ranges 50 m to 100 m. It shows that the Network Lifetime for RRC is more as compared to CRC.

From Figures 5e and 5f, it is observed that the Network Lifetime for transmission range 90 m and 100 m in CRC for number of nodes from 90 to 120 is more as compared to RRC. This led towards inference of optimal transmission range to increase the network lifetime.

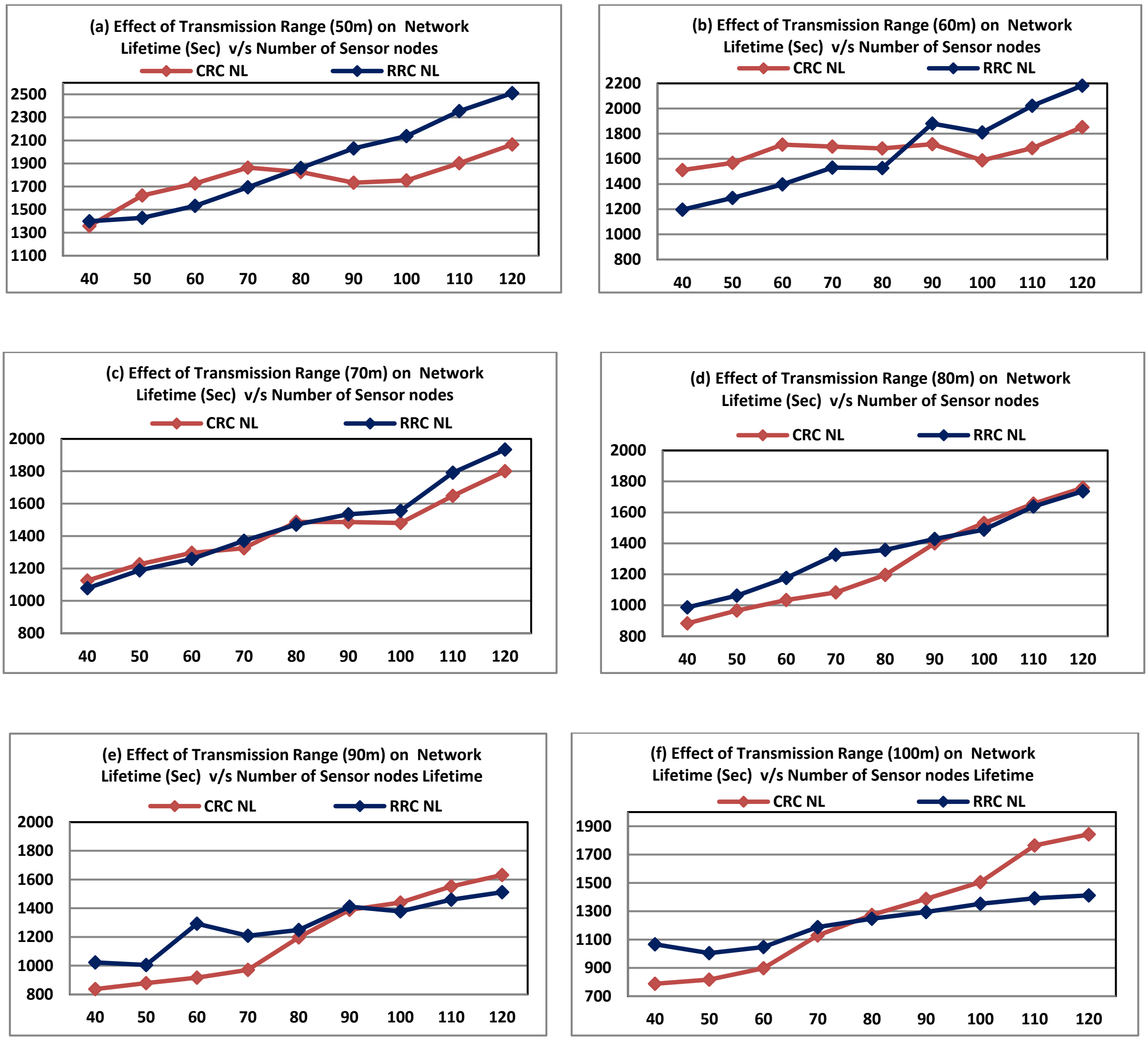


Figure 5. Comparison of Network Lifetime for CRC and RRC

The overall methodology used to conserve network energy is the self-organization clustering technique with change in the way of region formation in sensor network. Table 2 shows the comparison among LEACH, Distance Based Segment with CRC and RRC algorithms.

Table 2. Comparison of LEACH, Distance Based Segment with CRC and RRC

Algorithms → / **Parameter ↓**	**LEACH**	**Distance Based Segment**	**CRC and RRC**
Selection of CH	Node with low probability can be selected as CH, without considering energy	Nodes with more distance from the BS should be cluster heads	CH selected based on highest residual energy and node degree
Wasteful Data Transmission	Yes	Yes, but less as compared to LEACH	No wasteful data transmission
Placement of CH	Depends on probability of node	Fair CH distribution	Fair CH distribution
Dead Region	Yes	Yes	No
Number of Segments	Absent	After 5 segments performance degrades	Considered 3 rings (CRC) and 16 regions (RRC)

CONCLUSION

In this paper, Concentric Rings Clustering Algorithm and Rectangular Region Clustering Algorithm are simulated and compared. Results are obtained for average energy consumption and network lifetime in CRC and RRC by varying number of nodes at different transmission ranges. The results are promising in terms of deciding the region for deployment of sensor nodes. Extensive simulation proves that rectangular region clustering is more efficient in terms of energy consumption and network lifetime. Also Rectangular region formation gives stable results in spite of increasing number of nodes. CRC minimizes energy consumption, increases network lifetime and achieves scalability. But when sensor field is divided into rectangular regions, better results are obtained than concentric rings clustering for energy at all transmission ranges. In case of network lifetime, varying results are obtained.

Future work is to improve the results for network lifetime for transmission range 90m and 100m where expected results are not obtained and find out the optimal transmission range.

REFERENCES

[1] Akyildiz, I. F. (2002) ‘ Wireless sensor networks: A survey’, IEEE Computer Networks, vol. 38, pp. 393-422

[2] Heinzelman, W., Chandrakasan, A., and Balakrishnan, H. (2002) ‘An Application-Specific Protocol Architecture for Wireless Microsensor Networks’, IEEE Transactions on Wireless Communications, vol. 1 no. 4, pp. 660-670

[3] Zeng, Y. and Wang, L. (2014) ‘Energy-saving routing protocol for Wireless Sensor Networks’, IEEE 26th Chinese Control and Decision Conference, pp. 4868-4872

[4] Soua, R., and Minet, P. (2011) ‘A Survey on Energy Efficient Techniques in Wireless Sensor Networks’, Wireless and Mobile Networking Conference (WMNC), 4th Joint IFIP, IEEE, pp. 0-9

[5] W.R. Heinzelman, A. Chandrakasan, and H. Balakrishnan, “Energy-efficient communication protocol for wireless microsensor networks,” Proceedings of the 33rd Hawaii International Conference on System Sciences, 2000, 1-10.

[6] Aslam, M., Javaid, N., Rahim, A., Nazir, U., Bibi, A., & Khan, Z. A. (2012) ‘Survey of extended LEACH-based clustering routing protocols for wireless sensor networks’, IEEE 14th International Conference on High Performance Computing and Communication, pp. 1232-1238

[7] Li, Y., Yu, N., Zhang, W., Zhao, W., You, X., & Daneshmand, M. (2011, April). Enhancing the performance of LEACH protocol in wireless sensor networks. In Computer Communications Workshops (INFOCOM WKSHPS), 2011 IEEE Conference on (pp. 223-228). IEEE.

[8] Amini, N., Fazeli, M., Miremadi, S. G., & Manzuri, M. T. (2007, May). Distance-based segmentation: An energy-efficient clustering hierarchy for wireless microsensor networks. In Communication Networks and Services Research, 2007. CNSR'07. Fifth Annual Conference on (pp. 18-25). IEEE.

[9] Kole, S., Vhatkar, K. N., & Bag, V. V. (2014). Distance based cluster formation technique for LEACH protocol in wireless sensor network. International Journal of Application or Innovation in Engineering & Management (IJAIEM), 3(3), 334-338.

[10] Wang, L., Zhao, W., Li, Y., Qu, Y., Liu, Z., & Chen, Q. (2008, April). Sleep-supported and cone-based topology control method for wireless sensor networks. In Networking, Sensing and Control, 2008. ICNSC 2008. IEEE International Conference on (pp. 1445-1448). IEEE.

[11] Lin, J. Z., Zhou, X., & Li, Y. (2009). A minimum-energy path-preserving topology control algorithm for wireless sensor networks. International Journal of

Automation and Computing, 6(3), 295-300.

[12] Chunawale, A. and Sirsikar, S. (2014), 'Minimization of average energy consumption to prolong lifetime of wireless sensor network' 1st IEEE Global Conference on Wireless Computing and Networking (GCWCN), IEEE Xplore, pp 244-248

[13] Abbasi, A., A., and Younis, M. (2007) 'A survey on clustering algorithms for wireless sensor networks', Elsevier B.V., IEEE Computer Communication vol. 30 no. 14-15, pp. 2826-2841

[14] Chen, H., Chi, K. T. and Feng, J. (2009), 'Impact of topology on performance and energy efficiency in wireless sensor networks for source extraction', IEEE Transactions on Parallel and Distributed Systems, 20(6), 886-897

[15] Doddapaneni, K., Omondi, F., Enver Ever, Shah, P., Gemikonakli, O., and Gagliardi, R. (2014) 'Deployment Challenges and Developments in Wireless Sensor Networks Clustering', 24th International Conference and AINA Workshops, IEEE, pp. 227-232

[16] Liliana M. Arboleda C. and Nidal Nasser (2006) 'Comparison of Clustering Algorithms And Protocols for Wireless Sensor Networks', IEEE CCECE, pp. 1787-1792

[17] Boyinbode, O., Le, H., Mbogho, A., Takizawa, M., and Poliah, R. (2010), 'A Survey on Clustering Algorithms for Wireless Sensor Networks', 13th International Conference on Network-Based Information Systems, IEEE Computer Society, pp. 358-364

[18] Jiang, C., Yuan, D., and Zhao, Y. (2009) 'Towards Clustering Algorithms in Wireless Sensor Networks-A Survey', WCNC 2009, IEEE, pp. 1-6

[19] Younis, O., and Fahmy, S., (2004) 'HEED: A Hybrid, Energy-Efficient, Distributed Clustering Approach for Ad Hoc Sensor Networks', IEEE Transaction on Mobile Computing, vol. 3 no. 4, pp. 366-379

[20] Rana, K. and Zaveri, M. (2013), 'Synthesized cluster head selection and routing for two tier wireless sensor network', Journal of Computer Networks and Communications

[21] Gautam, N., Lee, W., and Jae-Young Pyun (2009) 'Dynamic Clustering and Distance Aware Protocol for Wireless Sensor Networks', ACM, pp. 9-14

[22] Kanwalinderjit, K., Gagneja, Kendall, E. and Nygard (2012) 'A QoS based Heuristics for Clustering in Two-Tier Sensor Networks', IEEE Proceedings of the Federated Conference on Computer Science and Information Systems pp. 779–784

[23] Ye, M., Li, C., Chen, G., and Wu, J. (2005), 'EECS: an energy efficient clustering scheme in wireless sensor networks', 24th IEEE International Conference on Performance, Computing, and Communications Conference (IPCCC), pp. 535-540

[24] Chen, G., Li, C., Ye, M. and Wu, J. (2005), 'An Energy-Efficient unequal clustering Mechanism for wireless sensor networks', IEEE

[25] Gong, B., Li, L., Wang, S. and Zhou, X. (2008), 'Multi-hop routing protocol with unequal clustering for wireless sensor networks', International Colloquium on Computing, Communication, Control, and Management (CCCM), IEEE, vol. 2, pp. 552-556

[26] Singh, K., and Daniel A. K. (2015) 'Load Balancing in Region Based Clustering for Heterogeneous Environment in WSNs Using AI Techniques', Fifth International Conference on Advanced Computing and Communication Technologies, pp. 641-646

[27] Latif, K., Ahmad, A., Javaid, N., Khan Z.A. and Alrajeh, N. (2013) 'Divide-and-Rule Scheme for Energy Efficient Routing in Wireless Sensor Networks', 4th International Conference on ANT, Elsevier, pp. 340-347

[28] Khattak, A., Shah, G., and Ahsan, M. (2010) 'Two-Tier Cluster Based Routing Protocol for Wireless Sensor Networks', IEEE /IFIP International Conference on Embedded and Ubiquitous Computing, pp. 410-415

[29] Nithyakalyani, S. and Kumar, S. S. (2013), 'Data aggregation in wireless sensor network using node clustering algorithms - a comparative study', International Conference on Information and Communication Technologies (ICT), IEEE, pp. 508-513

[30] Din, W. I. S. W., Yahya, S., Taib, M. N., Yassin, A. I. M. and Razali, R. (2014) 'MAP: The New Clustering Algorithm based on Multitier Network Topology to Prolong the Lifetime of Wireless Sensor Network', IEEE 10th International Colloquium on Signal Processing and its Applications (CSPA2014), pp. 173-177

[31] Gangwar, P. K., Singh Y., and Mohindru V. (2014) 'An Energy Efficient Zone-based Clustering Approach for Target Detection in Wireless Sensor Networks', IEEE International Conference on Recent Advances and Innovations in Engineering (ICRAIE), pp. 1-7

[32] Moussa, S., Darazi, R., Atechian, T., and Demerjian, J. (2016) 'Synchronized Region based Clustering for Energy Saving in Wireless Sensor Networks', IEEE International Multidisciplinary Conference on Emerging Technology (IMCET), pp. 15-20

[33] Huang, G., Li, X. and He, J. (2006), 'Energy-efficiency analysis of cluster-based routing protocols in wireless sensor networks', Aerospace Conference, IEEE pp. 8-15