Energy Efficient Directed Region based Cooperative Communication for Prolonging the Lifetime of Clustered Wireless Sensor Networks

Bappaditya Das [#], Tanushree [*], Koustava Goswami*, Soubarna Biswas*, Utpal Biswas[$]

[#]*Assistant Professor, Department of Computer Science & Engineering*
Dr.B.C.Roy Engineering College, Durgapur
Fuljhore, Jemua Road, Durgapur- 713206, West Bengal, India

[*]Final Year B.Tech Student, Department of Computer Science & Engineering
Dr.B.C.Roy Engineering College, Durgapur
Fuljhore, Jemua Road, Durgapur- 713206, West Bengal, India
[$] *Associate Professor, Department of Computer Science & Engineering*
University of Kalyani, Kalyani, West Bengal, India

ABSTRACT
Wireless Sensor Networks (WSN) are self-organizing system consists with tiny, battery powered sensor nodes with limited processing, storage and communication capabilities that are often deployed in very harsh and inaccessible environment in order to gather data about some phenomenon from the outside world. The cluster based architecture is an efficient way for extending the lifetime of a WSN. The message transfer between two cluster head consumes more power than, between a cluster head and an intermediate node, as the distance of communication is greater in former. The power consumption of node can be lowered by passing message through the intermediate nodes i,e. cooperative communication and hence prolonging the network lifetime. The network lifetime can further be enhanced by restricting the area of flooding by a node, to find the next hop. Our proposed method defines the region of flooding depending on the location of the source node and the destination node, in a cluster grid defined network. Flooding in a small area is observed to be far more power economic than flooding in the entire cluster for prolonging the network's life time. Partitioning the destination cluster grid into different size of sub clusters depending on the location of destination node is more power economic as well as useful for faster communication as compared with existing algorithm that has been further confirmed by the simulation result and by analysis.

Keywords
Cluster grid, cooperative communication, flooding, network lifetime.

1. INTRODUCTION
WSN may be considered a subset of Mobile Ad-hoc NETworks (MANET) with the characteristics of frequently changing network topology, multi-hop communication with extremely restricted energy [1]. WSN consists of hundreds to thousands number of tiny, low power, cheap sensors embedded with sensing, data processing and wireless communication components. In a sensor field the nodes are distributed in a scattered way to communicate among themselves through the wireless channel to self-organize into a multi-hop network and forward the gathered data towards one or more base stations which are connected with the network. Sensor networks can be applied in a large variety of applications like: battlefield surveillance, wildlife reserves, office buildings, biological detection [2] [3]. WSN are usually deployed in very harsh environment where node failure occurs frequently. Since each sensor node has limited amount of energy, therefore, it is most challenging issue in designing sensor networks for maximum utilization of power to prolong the network lifetime.

Many routing algorithm have been proposed for the task of efficient routing the data packets in terms of QoS and energy and bandwidth consumption. Earlier on-demand routing protocols were based on flooding the routing packets in all directions irrespective of the position of the destination node, result more bandwidth consumption where as table driven protocol maintains large amount of information as well as they perform large computations in order to select the best node which results in premature loss of battery life. This bandwidth consumption was reduced by the Location Aided Routing Protocols. These location based protocols uses the Global Positioning System (GPS) to find the direction of propagation of the packets. By finding the direction of propagation and ignoring the backward propagation we are proposing a Directed Region Power Efficient Based Cooperative Communication for Prolonging the Lifetime of Clustered Wireless Sensor Network with minimum number of hops.

In a typical clustered Wireless Sensor Network (Figure 1), all members of a cluster are directly connected to the Cluster Head (CH) of that cluster. Sensor nodes in the same cluster can communicate directly with their CH. CH can transmit gathered information to the Sink. Each sensor node is assigned a unique ID number by the base station before deployment. Usually node with maximum residual energy is selected as a CH. During the network operation, the CH is responsible for integrating and transmitting data, gathered by its own members to the sink node which stores the cluster's ID number as well as ID numbers of its members. Member nodes communicate directly with their CH, and there is no data exchange between sensor nodes. The Sink is typically a gateway to another network for data processing or storage centre, or an access point for human interface and to collects the sensor readings.

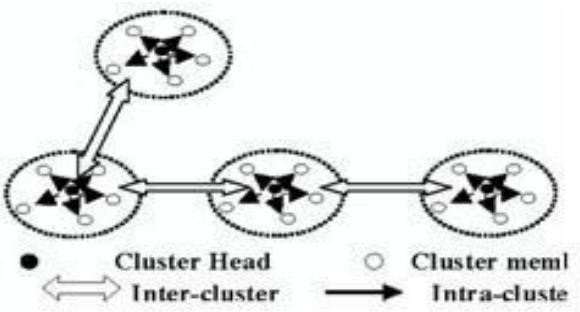

Figure 1: Typical clustered Wireless Sensor Network [4]

The distance between the intercluster transmission is large as compared to intra cluster transmission introduces the concept of relay transmission by selecting the intermediate node depending on the position of the source node and the destination node.

2. RELATED WORK

Most of the routing techniques in WSN are classified into four categories viz., hierarchical routing, geographic routing, energy aware routing and stateless flat routing.

LEACH [5] and PEGASIS [6] are the examples of Hierarchical routing deals with clusters and CH. These schemes divide the network into regions and then route the traffic from one region to the other. Regions can be clusters as in [5] or can be in the form of zones as in the case of adhoc routing schemes. Protocols like GPSR [7] and GEAR [8] which try to minimize the energy consumed by considering both energy and distance.

Geographic routing also known as localized algorithms as these algorithms use the location information [7] and [8] and transmit the information towards the geographic direction of destination via multiple paths. In Location Aided Routing (LAR) [9], intended to support topology-based reactive routing protocol uses location information to restrict flooding to request zone from where nodes are selected to find the routes between source and destination. ILAR (Improved Location Aided Routing) is another location based routing algorithm, selects the closet neighbor to the base line as an intermediate node.

In [10, 11] the authors choose the minimum energy path from source to destination resulting the problem that the nodes along the path will run out of batteries quickly rending other nodes useless due to the network partition even if they do have sufficient energy to become the member of alternative path. In case of direct transmission, CH broadcast the data directly to the sink node or next CH of different cluster; as a result node that is far away from the sink would die first. To overcome the problem, in [4], author suggest successful data transmission by using cooperative transmission scheme through transmitting and receiving node through proper synchronizing the sleep mode and wake up mode of the node by flooding the packet to all directions to maximize the network's lifetime.

In flat routing [12], [13] source node floods the packets to their neighbors taking energy and distance as parameters without having the concept of CH.

3. SYSTEM MODEL

In [14], [15] routing algorithms for networks with randomly deployed sensors grouped into equally sized and equally spaced square grids in a two dimensional plane. Some of the pre assumptions for our system model are,

All the nodes of requested zone are aware of its position through GPS technique.

The nodes are assumed to be static during the data gathering phase.

The WSN is assumed to be a homogeneous network i.e. all the nodes are having same computational power, storage capacity and communication range.

The node that will be selected as a cluster head must have residual energy greater than threshold energy value.

Each sensor is identified by its two-dimensional Cartesian Coordinates (x,y) with 4 neighbors of coordinates (x+a,y),(x-a,y),(x,y+a) and (x,y-a) where a is the distance between two neighboring nodes. As in Figure 2, thirty six number of nodes (for 6 x 6 dimensions) are deployed excluding sink node in a zigzag manner starting from bottom left to top right such that sink node having unlimited energy assumed to be located at top right corner of the network. Node number 1,2,3,7,8,9,13,14,15 belonging to cluster 1. Node number 4,5,6,10,11,12,16,17,18 belonging to cluster 2.

Node number 19,20,21,25,26,27,31,32,33 belonging to cluster 3 and node number 22,23,24,28,29,30,34,35,36 are in cluster 4.

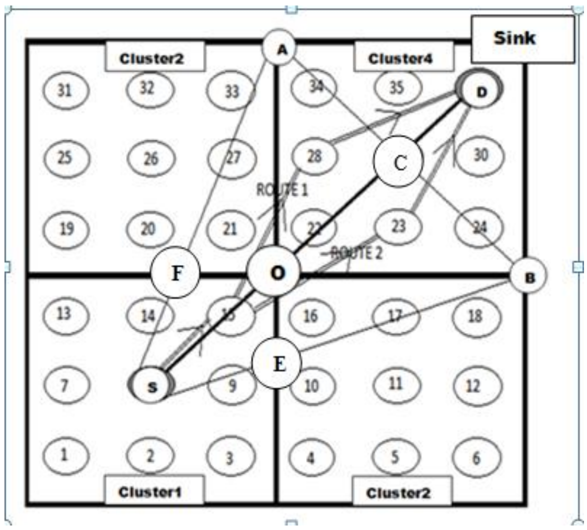

Figure 2: Proposed Model

To transmit a l-bit message a distance d meters the radio expends [16]:

$$E_{Tx} = lE_{elect} + le_{fs}d^2 \quad for \quad 0 \le d \le d_{crossover}$$

$$E_{Tx} = lE_{elect} + le_{mp}d^4 \quad for \quad d > d_{crossover}$$

Where efs and emp is the energy consumed by amplifier for short and long distance respectively. Eelect is the electrical transmission/reception energy and dcrossover is the limit distance for it parameters must be changed. The energy expended in receiving an l-bit message is given by

$$E_{Rx} = l*E_{elect}$$

4. PROPOSED ALGORITHM

If (Destination Node Id = = Source Node Id)
Consume packet.
Else
{
Check whether Destination Node belongs to region (Cluster 4 ∩ Δ OCB) or Δ OCB
If (Destination Node is in Δ OCB)
{
If(d(source node, destination node) ≤ $(2\sqrt{2} + ½)a$)
{
Send the packet directly to the Destination Node from the Source Node.
}
Else
{
If(any node not present in the request zone of source cluster)
{
Send the packet to the destination node directly
}
Else
{
Select an intermediate node according to Residual energy from request zone of source cluster i,e. from the region SEOF. Treat it as a $(CH)_{SEOF}$ Send the packet to Destination Node via $(CH)_{SEOF}$.
}
}
}
Else if (Destination Node belongs to region (Cluster 4 ∩ Δ OCB))
{
If (d(source node, destination node) > $(2\sqrt{2} + ½)a$)
{
If(any node not present in the region SEOF, Δ OCB and Δ OCA)
{
Send the packet directly to the skipping that region where no node found.
}
Else
{
Select $(CH)_{SEOF}$, $(CH)_{OCB}$ and $(CH)_{OCA}$ according to Residual energy from the region SEOF, Δ OCB and Δ OCA respectively.
}
If (d ($(CH)_{SEOF}$, $(CH)_{OCB}$) < (($(CH)_{SEOF}$, $(CH)_{OCA}$))
{
Send the packet from source to destination via $(CH)_{SEOF}$ and $(CH)_{OCB}$
}
Else
{
Send the packet from source to destination via $CH)_{SEOF}$ and $(CH)_{OCA}$
}
}
}
}

5. EXPERIMENTAL RESULTS AND PERFORMANCE ANALYSIS

In order to validate the proposed algorithm and to show its competence we present simulations using MATLAB using the following simulation parameters:

Table 1: Simulation Parameters

Number of nodes	36
Deployment area	Square
Network type	Homogeneous
Network Topology	Grid
Node mobility	Stationary
MAC Protocol	IEEE 802.11
Propagation model	Two Ray Ground
Node distribution	Uniform
Initial Energy	5J
Eelect	50 nJ/bit/m2
e_{fs}	10 pJ/bit/m4
εmp	0.0013 pJ/bit/m4

Figure 3 shows the residual energy of source node between our proposed technique and with existing CH to CH direct communication with respect to number of iteration. From the Figure 3, we observe that as number of iteration increases proposed model consumes less energy than the existing CH to CH direct communication.

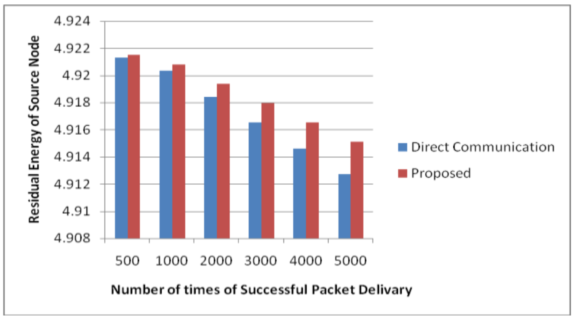

Figure 3: Source node Residual Energy Vs Number Iteration

Figure 4 shows the average residual energy of entire network between our proposed technique and with existing communication model via cooperative routing with respect to number of iteration. From the Figure 4, we observe that as number of iteration increases proposed model consumes less energy than existing model.

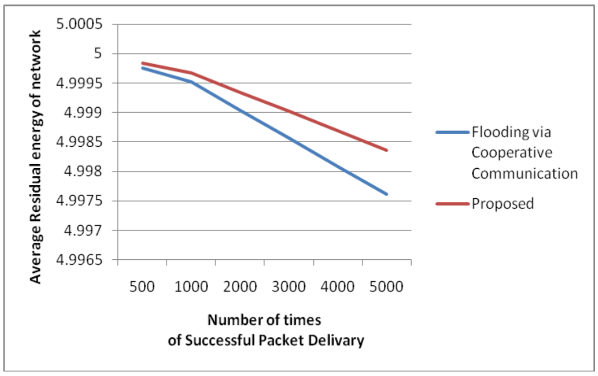

Figure 4: Average Residual Energy Vs Number of Iteration

6. PERFORMANCE ANALYSIS

Best Case: In our method and in [4] gives the same result if intermediate node A lie on the straight line SD.

Worst Case: If source id = 1 and destination id = 30 then according to our method the path will be, 1-9-34-30 and total distance covered = ($2\sqrt{5} + \sqrt{17}$) a $\approx$ 8.67a

But [4] follows the path, 1-3-34-30 and the total distance covered = ($2 + \sqrt{26} + \sqrt{5}$) a $\approx$ 9.32a

Average Case: As in Figure 5,

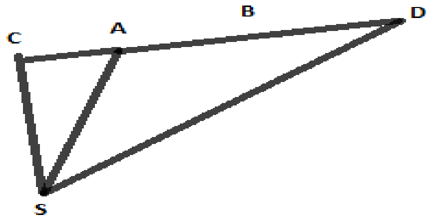

Figure 5: Position of Intermediate nodes in Average Case

Our method follows the path S-A-B-D and [4], follows the path S-C-B-D.

From ΔSAC,

$$SA < SC + CA$$
$$SA + AD < SC + CA + AD$$
$$SA + AD < SC + CD$$

Obviously, our method gives the better performance than [4].

7. CONCLUSION AND FUTURE WORK

Simulation and analysis show that proposed algorithm save much energy of the CH as well as the whole network. So CHs do not died too early due to lack of energy. So it prolong the life time of the network. There are several future works we would like to improve our algorithm by considering the balanced load distribution as well as the mobility of nodes.

8. REFERENCES

[1] F. Khadar and D. Simplot-Ryl, “From theory to practice: topology control in wireless sensor networks,” in *th 10th ACM International Symposium on Mobile Ad Hoc Networking and Computing (MobiHoc '09)*, pp. 347–348, May 2009.

[2] I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, “*Wireless sensor networks: a survey,” Computer Networks*, vol. 38, pp. 393–422, 2002.

[3] I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, *“A Survey on Sensor Networks”, IEEE Communications Magazine*, vol. 40, no. 8, pp. 102-114, 2002

[4] J. Divakaran, S. ilango sambasivan, “ Maximizing the Lifetime of Clustered Wireless Sensor Network VIA Cooperative Communication”, International Journal of Modern Engineering Research (IJMER),Vol.2, Issue.3, pp-612-617, May-June 2012

[5] W. Heinzelman, A. Chandrakasan and H. Balakrishnan, "Energy-Efficient Communication Protocol for Wireless Mi-crosensor Networks," Proceedings of the 33rd Hawaii International Conference on System Sciences (HICSS '00), January 2000.

[6] S. Lindsey, C. Raghavendra, “PEGASIS: Power-Efficient Gathering in Sensor Information Systems", IEEE Aerospace Conference Proceedings, 2002, Vol. 3, 9-16 pp. 1125-1130.

[7] Karp and H. T. Kung, “GPSR: Greedy perimeter stateless routing for wireless sensor networks", in the Proceedings of the 6th Annual ACM/IEEE International Conference on Mobile Computing and Networking (MobiCom '00), Boston, MA, August 2000.

[8] Y. Yu, D. Estrin, and R. Govindan, “Geographical and Energy-Aware Routing: A Recursive Data Dissemination Protocol for Wireless Sensor Networks", UCLA Computer Science Department Technical Report, UCLA-CSD TR-01-0023, May 2001.

[9] Young-Bae Ko and Nitin H. Vaidya. Location-aided routing (LAR) in mobile ad hoc networks. In *Proceedings of the 4th Annual ACM=IEEE International Conference on Mobile Computing and Networking (MOBICOM-98)*, pages 66–75, October 1998.

[10] M. Ettus, “System capacity, latency, and power consumption in multihop-routed SS-CDMA wireless networks”, Proc. of Radio and Wireless Conference, pp.55- 58, Aug. 1998

[11] N. Sadagopan, B. Krishnamachari and A. Helmy, “The acquire mechanism for efficient querying in sensor networks”, Proc. of the SNPA’03, pp.149-155, 2003

[12] C.Intanagonwiwat, R. Govindan, and D. Estrin, "Directed diffusion: a scalable and robust communication paradigm for sensor networks," Proceedings of ACM MobiCom '00, Boston, MA, 2000, pp. 56-67.

[13]] Braginsky and D. Estrin, ”Rumor Routing Algorithm for Sensor Networks," in the Proceedings of the First Workshop on Sensor Networks and Applications

[14] D. M. Ofrim, D. I. Sacaleanu, R. Stoian, Implementation of an Adaptive Synchronizing Protocol for Energy Saving in Wireless Sensor Networks, International Journal of Communications, Issue 4, Volume 4, 2010, pp.103-111

[15] Y. Han Lee, K. Oh Lee, H. Jun Lee, A. Kusdaryono, “CBERP: Cluster Based Energy Efficient Routing Protocol for Wireless Sensor Network”, Proceedings of the 12th International Conference in NETWORKING, VLSI and SIGNAL PROCESSING (ICNVS '10), University of Cambridge, UK, 20-22 February, 2010, pp.24-28.

[16] W.R Heinzelman, A.Chandrakasan, H.Balakrishnan,“Energy Efficient Communication Protocol for Wireless Sensor Networks,” Proceedings of the 33rd Hawaii International Conference on System Science, January 2000.