Cluster Head Selection using Optimised Round Policy in Wireless Sensor Networks

[1]N G Haswani, [2]P J Deore

[1]Research Scholar, [2]Prof. & Head
[1, 2] Department of E&TC,
[1, 2] R C Patel Institute of Technology, Shirpur, MS, India

Abstract:
In Wireless sensor Network (WSN) it has been proven that the clustering algorithms improve the energy efficiency compared to non-clustering algorithms. All state of the art protocols preform clustering and choose the cluster head (CH) in particular time interval. The responsibility of CH rotates among the sensor nodes and periodic re-clustering balances the network load. But during the cluster formation overhead is created due to message exchange. Therefore, to obtain the competent energy consumption model which increases network life time and improvement in load balancing, we present a novel routing protocol which selects the CH on the basis of three attributes i.e. residual energy, density and distance form base station (BS). The simulation result shows that the proposed protocol is more energy efficient than the well-known routing protocol LEECH and HEED

Index Terms – Clustering, Wireless Sensor Networks, Energy efficiency, cluster head.

I. INTRODUCTION

In wireless sensor network (WSN), main source for the network node is a battery. Limited use of battery by sensor node is a crucial task and that can be improved by innovating in routing protocol. Many researchers did the work and innovate various routing protocols like LEACH (Low energy adaptive clustering hierarchy), TEEN (Threshold sensitive Energy Efficient sensor Network protocol) and HEED (hybrid energy efficient distributed) etc. These protocols used the clustering method to improve energy effectiveness but they have their own assumptions. By optimum use of limited energy of sensor node, elongate the life time of network and avoid the early exhaustion of sensor node battery. Clustering algorithms reduce the energy consumption due to collisions, over hearing and idle listening compared to the non-clustering algorithms. When clusters are created, each node is allotted a time slot to send the data to CH, A node does not need to awake all the time, it uses TDMA techniques to avoid the collisions.

Clustering protocols can be classified into two type's static and dynamic method. In the static method, clusters are permanently formed i.e. the shape of the clusters are fixed during network operation. Therefore, a more amount of energy is consumed due to the message collisions, as some CHs may be located very close to each other. In dynamic clustering methods, the shape of the clusters is not fixed during the network life cycle. The role and responsibility of the CH rotates among all network nodes to achieve load balancing. The exchange of responsibility of CH is performed periodically in each predefined round. Load balancing is achieved by periodic re-clustering but it over loads the system. More amount of energy is consumed by CHs during a round. Consequently, round based policy (RBP) is good for periodic monitoring and it is not suitable for query based events. So, there is a need for more energy efficient clustering algorithm which removes the unnecessary re-clustering task. To balance the energy consumed by CH, RBP used to schedule the clustering task by dividing the time in fix length round.

By rotating the responsibility of CH among the sensor nodes and periodic re-clustering the load of the network node is balanced. But during the cluster formation overhead is created due to message exchange. Therefore, to obtain the competent energy consumption model which increases network life time and improves load balancing, we have proposed a new optimized round policy (ORP) protocol which addresses this issue. After each round many clustering protocols used the residual energy of each node but in our ORP it checks the residual energy of CH rather than the cluster member. Ultimately, our goal is to improve the energy efficiency of network by reducing the unnecessary re-clustering operation. The remaining part of this paper is organized as per following section 1 the introduction. Section 2 provides related work. The ORP methodology is explained in section 3. Section 4 explains the simulation parameter and last result and future work explained in section 5 and 6.

II. LITERATURE REVIEW

In wireless sensor network, clustering energy efficient approach is adopted to reduce the energy consumption and increase the network lifetime. In this section we consider the traditional clustering algorithms.

In [1], LEACH is the first routing protocol in WSN which is based on the clustering method. CHs are selected randomly rather than on the basis of residual energy of sensor node. In a cluster the nodes are not evenly distributed, so cluster members are unequal in every cluster. In LEACH CH have more responsibility than the cluster member. However energy requirement of CH is more, this leads to the exhaust of energy of CH and network lifetime is decreases. CH is responsible for data aggregation and fusion; and rotates its role and responsibility to the other node to balance energy consumption.

$$T(n) = \begin{cases} \frac{P}{1-P*(r \bmod (\frac{1}{p})} & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases}$$

Where, P denotes is the percentage of sensor node to become CH among all sensors node in the network. r denotes current round and G is the set of nodes that do not participate in CH selection in previous 1/p rounds.

In [2], TEEN is the reactive routing protocol that sends the data to base station only when event of interest occurs. . The node association and CHs selection approach of TEEN are similar to the LEACH. In this protocol CH is elected and broadcast the attribute Hard Threshold and Soft Threshold. It conserves the energy since sensor node senses data continuously but transmits only when it is above Hard Threshold. Soft Threshold further reduces transmission by using the step size. No transmission from nodes to CH occurs if sensed value is below Hard Threshold, so that CH will not be aware of death of sensor node. This protocol decreases the network throughput.

In [3], [4], SEP (Stable Election Protocol) is a clustering protocol which divides the sensor node into two types normal type and advance type. Nodes with α time more energy than normal node called advance node. The fraction m of total node n nodes is provided with an additional energy factor α. Probability of normal and advance nodes to become CH are $P_{normal} = \frac{P_{optim}}{1+m.\alpha}$ and $P_{advance} = \frac{P_{optim.}(1+\alpha)}{1+m.\alpha}$ respectively. Where P_{optim} the probability of each node to become CH. SEP is uses CH selection randomly like LEACH. A Node sends data to CH and CH sends to BS. By increasing m and $P_{advance}$ throughput and stability can be improved.

In [5], HEED mitigates the problems of LEACH, TEEN and SEP protocols. HEED is a multi-hop clustering algorithm for wireless sensor networks, which focus on efficient clustering by proper selection of CH based on the physical distance between nodes and its residual energy. This protocol reduces overhead and efficiently balances the clusters. The problem of HEED is that it performs repeated iterations and complex algorithm. In [6], DEEC (distributed energy efficient clustering) algorithm assigns various energy levels to sensor nodes as an initial energy. Cluster-heads are elected by a probability based on the ratio between the residual energy of each node and the average energy of the network. The nodes with high initial and residual energy will have more chances to be the CHs than the low-energy nodes. It does not require any global knowledge of energy at every round of election. Unlike SEP and LEACH, DEEC can perform well in multi-level heterogeneous wireless sensor networks. But it suffers from the quick energy depletion problem for the CH nodes.

In [7], [8], [9], [10] select as the CHs without knowledge of node energy and using probabilistic function to select CHs, resulting in low overhead and network lifetime. In contrast some algorithm [11], [12], [13] select CHs based on residual node energy. Some algorithm requires partial knowledge of network condition and some require global knowledge of environment condition [15], [16]. To achieve load balancing, the shape of cluster is not fixed throughout the network life cycle and CH rotates its role and responsibility among the network nodes and it done periodically. In Round based policy the CH consumes more energy during the round and it used for continuous data monitoring model and is not good for query driven model. To mitigate problem our proposed model avoids unnecessary re-clustering and improve the energy efficiency.

III. ORP METHODOLOGY

To increase the network lifetime clustering is good solution as we discussed in previous section. The selection of CH depends on the residual energy of all nodes. However unnecessary re-clustering is done to choose the CH using round based policy which causes the communication overhead and reduces the energy efficiency. In proposed protocol, selection of CH depends not only on residual energy of node but also on density and distance from base station. This additional parameter improves the reliability, load balancing among the sensor network. In homogenous cluster network the workload of CH is divided among the network nodes to mitigate the problem of node swift energy exhaustion. To overcome energy depletion by optimum clustering approaches, with the aim of load balancing, the network life cycle is divided into fixed time period, called rounds. As shown in Fig. 1.

The length of Optimum round is integer multiple of rounds that depends on node condition. At the beginning of ORP re clustering is done and in next successive round no need of re clustering until the residual energy, distance from BS and density of any CH is less than Eth. The length of ORP is long when all nodes have high energy, as node energy is decreases length of ORP is also decreases that affects the load balancing of network and re clustering is done in shorter period of time.

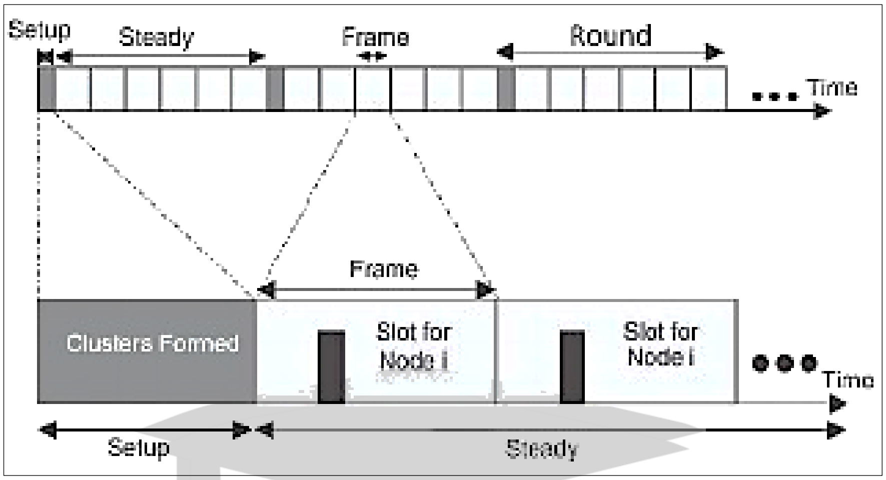

Figure 1: Time line of round [14]

After CH selection stage each CM sends message to respective CH to join message as CM joins along with current residual energy. The average of CMs residual energy can be computed by respective CH.
Threshold energy Eth for each CH can be determined by,

Ethr = RF * PCM

Where PCM average of CMs residual energy and RF is re clustering factor and it depends on the application requirement,
$0 \leq RF \leq 1$.
After cluster formation the CH checks it's all three parameters as mentioned above if these are less than Ethr than CH broadcast, the re-clustering task schedule message to their nearby CHs and then they forward broadcast for entire network. Upon receiving the message CH informs its CMs to hold the setup phase in coming round. Re-clustering is performed under special event, rather than fixed time interval. Worst condition happens only when length of ORP is equal to length of round, then ORP is treated as RBP. The set up phase is split into four stages: 1) CH selection; 2) CM joins; 3) CH schedules; and 4) route discovery stage and in each stage energy is consumed. In CH selection stage, CH is selected at the starting of setup phase. In CM Join stage every sensor node send a CM join message to its respective CH. After that each CH send schedule message to its respective CMs in CH schedule stage. Last stage route discovery occurs in worst condition. Performance evaluations parameter of proposed protocol improves the energy efficiency by comparing parameters like Network lifetime, Energy consumption and Throughput

IV. SIMULATION ENVIRONMENT

Routing protocols are simulated using NS2 simulator and evaluate the performance for Sensor node placed randomly in area of 100 * 100, with varying node from 30 to 180. The Simulation parameters are listed in table 1. To claim the network life time enhancement, we evaluate LEACH, HEED and ORP with four performance matrix.

TABLE 1: SIMULATION PARAMETER

Parameter	Values
Monitor Region	(100, 100)
Node number	30 – 180
Routing protocol	LEACH, HEED and ORP
MAC	IEEE 820.11
Propagation model	Two- Ray Ground

Packet length	512 kbps
Data rate	1Mbps
Simulation time	30 Sec
Initial energy of each node	20.1 Jules
Transmission energy	0.660 J/bit
Reception energy	0.395 J/bit

V. RESULTS

We executed each protocol at different node values. A lower value of energy dissipation and higher number of alive node indicate more efficient protocol. This is because of the task of re-clustering is performed more effectively than the LEACH and HEED. The proposed routing protocol performs the re-clustering on the basis of three parameters as we discussed earlier.

Figure 2 and 3 shows the energy consumption and network life with increasing the number of nodes, as nodes increase the energy consumption decreases, because more number of nodes are in sleep or idle mode and less nodes are involved in data transmission. Average energy consumption and network lifetime performance shows the significantly increases the energy efficiency using ORP.

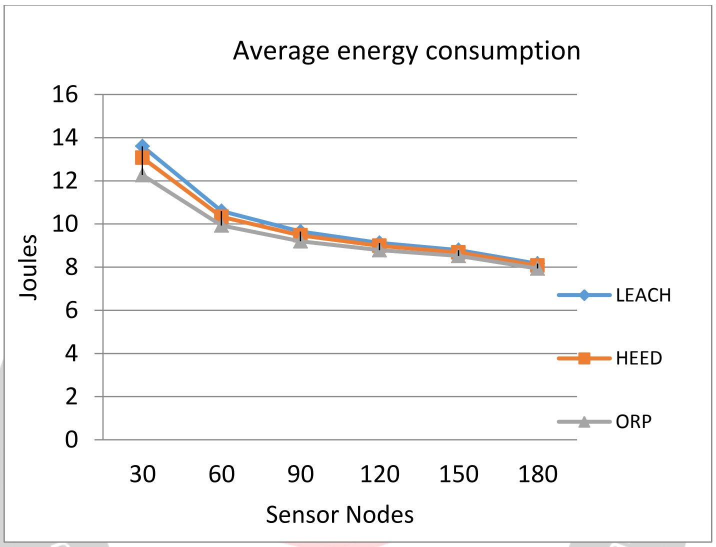

Fig. 2: Average energy consumption

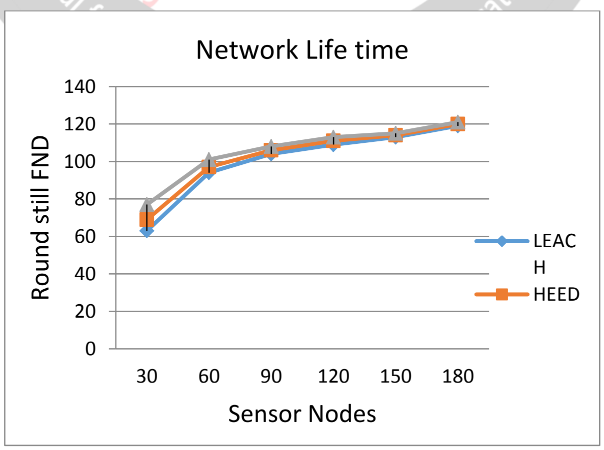

Fig.3: Network Lifetime

The objective of this paper is to propose the optimum design routing protocol which consumed less energy and good quality of Service (QoS). In Figure 4 simulated result for throughput shows the improved QoS as compared with well-known protocol HEED and LEACH because routing is perform on the basis of distance from BS and number of neighbor to transmit the data towards the sink node.

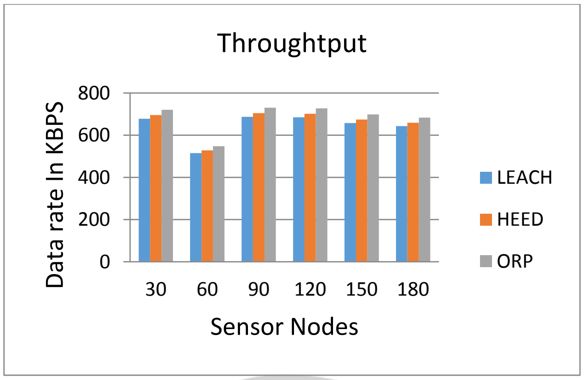

Fig. 4: Average throughput performance

VI. CONCLUSION AND FUTURE WORK

The performance of the proposed process is measured in terms of average energy consumption, network life and throughput. The experimental result of proposed protocol the improved results of average energy consumption, network life time and throughput than the state of art routing protocol when compared. By adding some more parameter to select the CH and some optimization techniques for path selection of data transmission is a future work.

REFERENCES

[1] W. R. Heinzelman, A. Chandrakasan, and H. Balakrishnan, “Energy efficient communication protocol for wireless micro sensor networks,” in Proc. 33rd Annu. Hawaii Int. Conf. Syst. Sci., 2000.

[2] A. Manjeshwar and D. P. Agrawal, “TEEN: A routing protocol for enhanced efficiency in wireless sensor networks,” in Proc. 15th IPDPS, vol. 1. p. 189, 2001.

[3] G. Smaragdakis, I. Matta, and A. Bestavros, “SEP: A stable election protocol for clustered heterogeneous wireless sensor networks,” Dept. Comput. Sci., Boston Univ., Boston, MA, USA, Tech. Rep. BUCS-TR-2004-022, 2004.

[4] A. J. Joseph and U. Hari, “Hexagonally sectored routing protocol for wireless sensor networks,” Int. J. Eng., vol. 2, no. 5, pp. 1249–1252, May 2013.

[5] O. Younis, and S. Fahmy, “HEED: a hybrid, energy-efficient, distributed clustering approach for ad hoc sensor networks,” Mobile Computing, IEEE Transactions on, vol. 3, no. 4, pp. 366-379, 2004.

[6] L. Qing, Q. Zhu, and M. Wang, “Design of a distributed energy-efficient clustering algorithm for heterogeneous wireless sensor networks,” Comput. Commun., vol. 29, no. 12, pp. 2230–2237, 2006.

[7] W. B. Heinzelman, A. P. Chandrakasan, and H. Balakrishnan, application-specific protocol architecture for wireless micro sensor networks,” Wireless Communications, IEEE Transactions on, vol. 1, no. 4, pp. 660-670, 2002.

[8] S. Bandyopadhyay, and E. J. Coyle, "An energy efficient hierarchical clustering algorithm for wireless sensor networks." pp. 1713-1723, 2003.

[9] S. H. Kang, and T. Nguyen, “Distance based thresholds for cluster head selection in wireless sensor networks, “Communications Letters, IEEE, vol. 16, no. 9, pp. 1396-1399, 2012.

[10] A. S. Malik, K. Jingming, L. iakang, and X. Huihui, "Effect of Confinement of Event Field within the Sensor Field on Network Lifetime and Energy Consumption for Cluster-Based Wireless Sensor Networks." pp. 1-6, 2009.

[11] O. Younis, and S. Fahmy, “HEED: a hybrid, energy-efficient, distributed clustering approach for ad hoc sensor networks, “Mobile Computing, IEEE Transactions on, vol. 3, no. 4, pp. 366-379, 2004.

[12] H. Taheri, P. Neamatollahi, O. M. Younis, S. Naghibzadeh, and M. H. Yaghmaee, “An energy-aware distributed clustering protocol in wireless sensor networks using fuzzy logic,” Ad Hoc Networks, vol. 10, no. 7, pp. 1469-1481, 2012.

[13] B.-C. Cheng, H.-H. Yeh, and P.-H. Hsu, "Schedulability analysis for hard network lifetime wireless sensor networks with high energy first clustering," Reliability, IEEE Transactions on, vol. 60, no. 3, pp. 675-688, 2011.

[14] PeymanNeamatollahi, Mahmoud Naghibzadeh, SaeidAbrishami, Mohammad-HosseinYaghmaee,"Distributed Clustering-Task Scheduling for Wireless Sensor Networks Using Dynamic Hyper Round Policy", IEEE TRANSACTIONS ON MOBILE COMPUTING, TMC-2016-02-0080, 2017.

[15] N. Dimokas, D. Katsaros, and Y. Manolopoulos, "Energyefficient distributed clustering in wireless sensor networks," Journal of parallel and Distributed Computing, vol. 70, no. 4, pp.371-383, 2010.

[16] D. Wei, Y. Jin, S. Vural, K. Moessner, and R. Tafazolli, "An energy-efficient clustering solution for wireless sensor networks," Wireless Communications, IEEE Transactions on, vol.10, no. 11, pp. 3973-3983, 2011.

