ISSN:0975-9646

An Improvement for HEER Protocol in Wireless Sensor Network

Sakshi Sharma , Malti Rani

Department of Computer Science, Punjab Technical University, Kapurthala, India
Punjab Institute of Technology(PIT), Punjab Technical University, Kapurthala, India

***Abstract*— with the progression of computer networks, a wireless sensor network emerges as new technology that promises a wide range of applications. A wireless sensor network consists of large number of small sensors with low cost, low power and limited energy deployed in a region of interest. It consists of numerous sensors that send sensed data to base station and sensors are embedded with microprocessors, radio transceivers. To prolong stability and network lifetime, HEER- Hybrid Energy Efficient Reactive Protocol was proposed, in this cluster head selection is based on residual energy of node and average energy of network. HEER performs best for time critical applications and reduces the number of transmission by using threshold. In HEER, load balancing is done with the help of high energy and low energy nodes and also better intra-clustering is performed. The simulation results focuses on better performance of traditional HEER and provide more uniform energy consumption when compared with LEACH protocol.**

***Keywords*— wireless sensor network, cluster-head, Networks, Data Aggregation**

I. INTRODUCTION

A wireless sensor network (WSN) consists of large number of low cost, low-power multi-functional sensor nodes that are deployed in a region of interest and having sensing, communication, data processing and computation capabilities. These sensor nodes are small in size but are equipped with sensors, embedded microprocessors. The basic components of a node are a sensor unit, an ADC (Analogue to Digital Converter), a CPU (Central processing unit), a communication unit and a power unit. Sensor nodes are MEMS- micro-electro-mechanical systems that make a calculable response to a change in some physical condition like temperature and pressure. Sensor sense or measure the physical data of the area to be monitored. Sensor nodes are of very small size, use extremely low energy, are operated in high volumetric densities, and can be independent and adaptive to the environment [1] [2] [3].

Since a sensor node has limited sensing, computation capacities and communication performance, a large number of sensor devices are distributed over an area of interest for collecting information such as temperature, humidity, motion detection, etc. These nodes can communicate with each other for sending information either directly or through intermediate nodes and thus form a network, so each node in a sensor network acts as a router inside the network. In direct communication routing protocols i.e. single hop, each sensor node communicates directly with a control centre called Base Station or sink and sends gathered information. The base station or sink is fixed and located far away from the sensors. Sink(s) can communicate with the end user either directly or through some existing wired network. Meanwhile, Sink(s) also serves as a gateway to outside network i.e. Internet [4] [5].

In typical WSNs, sensor nodes are usually resource-constrained and battery-limited. In order to save energy and resources, data must be aggregated to avoid unnecessary amounts of traffic in the network. Data aggregation is one of the main techniques to conserve energy in wireless sensor network. The aim of data aggregation is to eliminate redundant data transmission and to enhance the lifetime of energy in wireless sensor network. In wireless sensor network, Data Aggregation is an effective technique to conserve energy. At intermediate nodes of wireless sensor network redundant data can be aggregated, reducing communications costs. Data aggregation can be performed at cluster heads to reduce the amount of data transmitted to sink and improve energy efficiency of network. Various types of data aggregation techniques in WSN are: Cluster based approach, Tree based approach and Hybrid based approach. Clustering in WSN is considered as an effective energy saving routing method. Inter cluster communication technique in drawing immense research interest in WSN applications. So it is necessary to select the best links to construct an inter-cluster communication path for reliable data transmission [6] [7].

In WSN, important issue for sensor node is to conserve energy as they have limited power. Many routing protocols have been proposed to improve energy. In this research paper, HEER is designed to prolong network lifetime and outperforms LEACH performance.

II. RELATED WORK

Many WSN applications use data aggregation to aggregate the data generated by sensor nodes for improving energy consumption. In [8] introduced the first conventional hierarchical clustering algorithm for WSN – LEACH. LEACH is low energy adaptive clustering hierarchy protocol and is self-adaptive. LEACH is most popular protocols in WSN and outperforms previous clustering algorithms. In LEACH, clusters are formed based on received signal strength and use rotating cluster nodes. This saves energy consumption but has many drawbacks as CH is selected randomly and is not uniformly distributed.

In [9], proposed DEEC protocol- distributed energy efficient clustering protocol. DEEC is proactive protocol and clustering protocol for two, multilevel network. In this CH selection is based on residual energy of nodes and average energy of network. The nodes with high initial and residual energy have probability to become cluster head.

In [10], proposed TEEN is threshold-sensitive energy efficient network protocol and is a reactive protocol. The cluster formation and cluster head selection is same as of LEACH. In TEEN, two values are introduced: Hard threshold and soft threshold. Hard threshold is value beyond which a sensor turns its transmitter on to report sensed data to its cluster head and Soft threshold indicated a small change in value of sensed attribute. Thus, threshold values are used to increase network lifetime.

III. MOTIVATION

A number of routing protocols have been proposed in WSN and most of them are based on clustering. However, not much attention has been given to time critical applications. Most of routing protocols are for proactive network as DEEC protocol. But TEEN is reactive protocol and guarantees that unstable region will be short in homogenous environment. In TEEN after the death of first node, all the remaining nodes die within small number of rounds as a consequence equal remaining energy distributed. In the presence of high energy nodes TEEN results in large unstable region because all high energy are equipped with same energy hence the process of cluster selection process become unstable. So, HEER was proposed to give better result for time critical applications by using threshold value and distributing load among high energy nodes, low energy nodes.

IV. PROTOCOLS IN WIRELESS SENSOR NETWORK

A. Leach

LEACH is one of the popular hierarchical routing approaches for sensor networks and mostly all clustering algorithms are derived from LEACH algorithm. LEACH is based on an aggregation (or fusion) technique that aggregates or combines the original data into a smaller size of data that carry only meaningful information of sensors. LEACH divides a network into several clusters of sensors and forms cluster based on received signal strength and uses cluster head nodes as routers to base-station. In order to balance the energy consumption of each node, nodes are selected as cluster head nodes. This algorithm gives every node a chance to become a cluster head. The normal nodes join the corresponding cluster head nodes and deliver their data directly to cluster head nodes. The Cluster head nodes receive data and send it to base station. LEACH is divided into rounds, each of which is composed in two phases- Set-up phase and Steady phase. Specifically, a sensor decides to become a cluster head based on desired percentage p of cluster head, the current round and set of sensors that have not become cluster heads in last 1/p rounds.

However LEACH is an elegant solution for energy efficiency but has some deficiencies: some very big cluster or very small cluster may exist in network, unreasonable cluster head selection despite all nodes having different energy; cluster member nodes deplete energy after cluster head was dead. Thus, LEACH doesn't take account of residual energy to address this, a novel technique- HEER was proposed [10].

B. Teen

TEEN is hierarchical and first reactive protocol. In this protocol, sensors are grouped into clusters with their cluster head and report their sensed data to cluster head. This is same as LEACH protocol but at every cluster change time it transmits two values i.e. hard threshold (HT) and soft threshold (ST). Each cluster head broadcast a value called hard threshold for sensed attribute and another value is broadcasted called soft threshold which indicated a small change in value of sensed attribute. HT and ST both reduce no of transmissions thus increasing energy efficiency. The sensors in TEEN use TDMA or CDMA to avoid collisions in a cluster. However, TEEN is not suitable for sensing applications which require sensors to report their data on a regular basis.

C. Heer

A protocol designed for characteristics of reactive homogenous WSNs, HEER- Hybrid Energy Efficient Reactive Protocol. To prolong network lifetime and stability by reducing energy consumption, HEER was proposed. In HEER, cluster head selection is based on ratio of residual energy of node and average energy of network. HEER uses the initial and residual energies of node to become cluster head- CH. HEER performs better for time critical applications and also reduces the no of transmissions with the help of threshold values- Hard threshold, soft threshold to conserve more energy. The CV- current value on which first transmission occurs is stored in an internal variable called sensed value- SV. When this condition becomes true: CV $\geqslant$ HT then it reduces no of transmissions and further transmissions are reduced when CV-SV$\geqslant$ST.

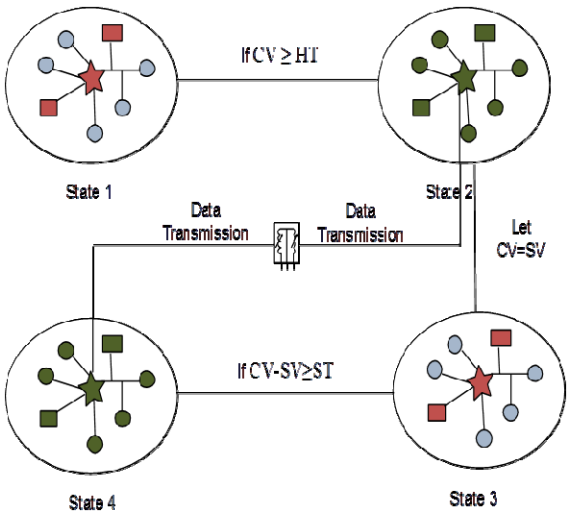

Fig.1 States of HEER

Fig. 1 shows states of cluster, nodes select CH itself on basis of its low energy (initial) and high energy (residual). In state (1) cluster formation is done the nodes will sense environment continuously until the parameter CV reaches HT value. When CV reaches HT value, the nodes will turn on its transmitter as nodes become green and data is sent to CH as in state (2). Cluster head aggregates the data and

transmit to base station; in state (3) nodes will again start sensing its environment in same cluster period until this condition become true CV-SV ⩾ ST as in state (4) and nodes will become green to transmit data [10].

HEER performs best for time critical applications and is more efficient than TEEN and DEEC. HEER reduces the energy consumption by first distributing load to all high nodes and then on to low energy nodes. Also HEER provides better intra-cluster communication. In HEER, concept of normal, advance nodes is used to distribute load as in DEEC and Hard threshold, soft threshold concept is used as in TEEN. So HEER represent hybrid reactive approach. Thus, it also increases network lifetime and stability period with better intra-clustering scheme.

V. SIMULATION RESULTS

In this, simulation of LEACH environment is done and field has dimensions of 100 x 100 square units. Simulation is done using MATLAB tool. The number of nodes in the field is n=100. Also assume that base station is in the centre of sensing nodes. The parameters used in simulations are listed in Table I.

In Fig. 2 and Fig. 3 result is computed via graphs. Firstly in Fig. 2 graph is plotted between alive nodes and no of rounds, all nodes dead at 300th round and initial energy becomes zero. Secondly, in Fig. 3 graph is plotted between packets to CH and no of rounds but the performance is not good as packets are dropped when there is no cluster head formation.

TABLE I
PARAMETERS USED IN LEACH SIMULATION

Parameter	**Value**
n- no of nodes	100
p- probability	0.05
Initial Energy, E_0	0.5 J
Transmitting and Receiving Energy	5nJ/bit
Amplification energy minimum	10pJ/bit/ m^2
Amplification energy maximum	0.013pJ/bit/ m^4

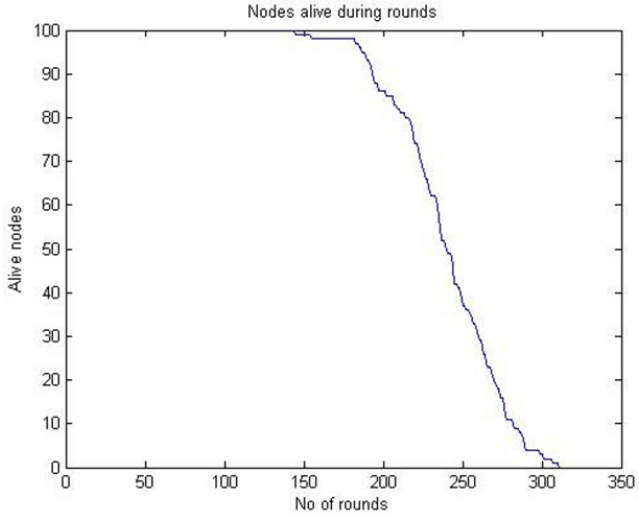

Fig.2 Graph- Alive nodes vs no of rounds to nodes dead during rounds

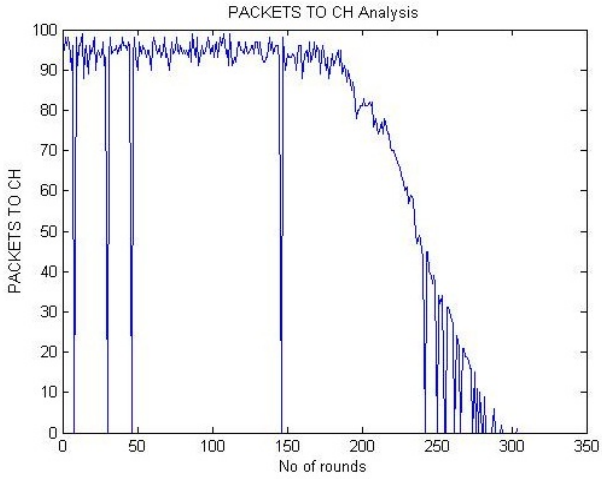

Fig.3 Graph- PACKETS TO CH Analysis in LEACH

In LEACH, nodes consume their energy quickly and efficiency of energy decreases because nodes with low energy elected as cluster head nodes. Moreover, all nodes have same probability to become cluster head so all nodes die very quickly.

Now, simulation of HEER environment is done and field has dimensions of 100 x 100 square units. The number of nodes in the field is same as that of LEACH i.e. n=100. Also assume that base station is in the centre of sensing nodes. The parameters used in simulations are listed in Table II.

TABLE III
PARAMETERS USED IN HEER SIMULATION

Parameter	**Value**
n- no of nodes	100
Initial Energy, E_0	0.5 J
Transmitting and Receiving Energy	5nJ/bit
Amplification energy minimum	10pJ/bit/ m^2
Amplification energy maximum	0.013pJ/bit/ m^4
Percentage of advance nodes, m	0.3
Energy of advance nodes	$E_0(1+a)$

In Fig. 4 graph is plotted between alive nodes and no of rounds. It is shows that the stability period of HEER is much longer as it introduces HT (hard threshold) value which decreases the number of transmissions to base station which in result increases lifetime of network.

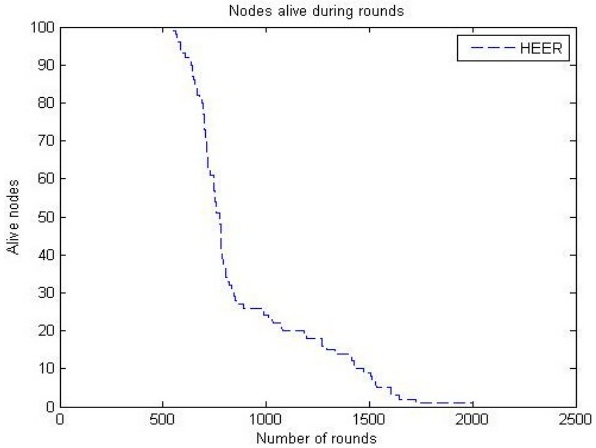

Fig.4 Graph- Alive nodes vs no of rounds to nodes dead during rounds

In Fig. 5 and Fig. 6 graph is plotted to show packet transmission rate to base station by cluster heads and packet rate to cluster heads by sensor nodes.

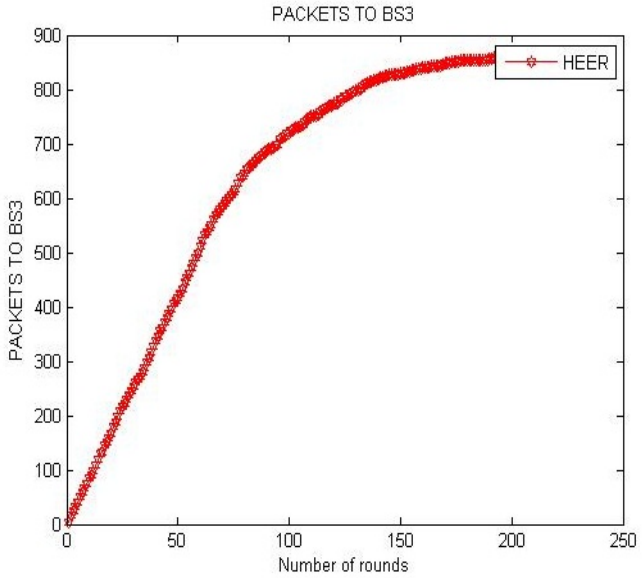

Fig.5 Graph- PACKETS TO BS Analysis in HEER

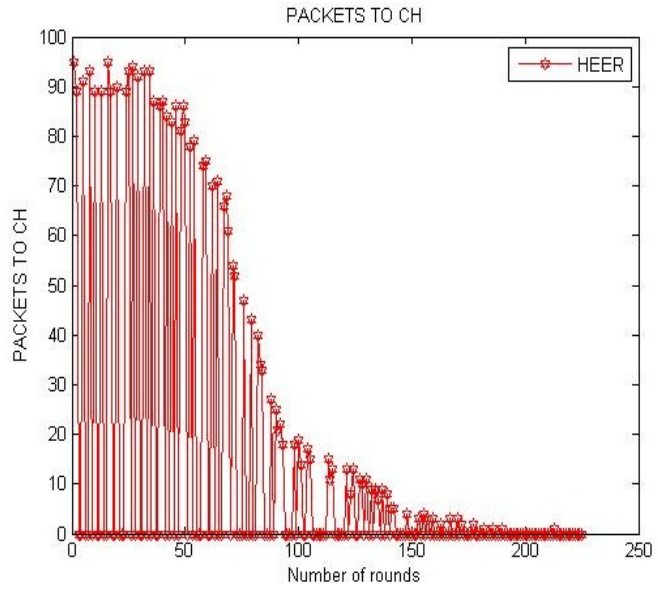

Fig.6 Graph- PACKETS TO CH Analysis in HEER

In this simulation of LEACH and HEER, it is clearly observed that network lifetime and stability period of HEER is more. Also, HEER outperforms LEACH and it is well suited for time critical applications. Moreover, HEER is also more efficient than other data aggregation protocols: TEEN, DEEC.

VI. Conclusion and Future Work

In this paper, better intra-cluster aggregation of HEER is done. HEER outperforms LEACH performance because in LEACH nodes with low energy become cluster heads which consume energy quickly. HEER minimizes load by first distributing load to all high energy nodes and increase network lifetime using intra-clustering, threshold values- Hard threshold and soft threshold.

As HEER, does not use data aggregation at the sink by individual nodes; therefore may causes flooding of the data which consequences in maximum energy consumption. By improving inter cluster aggregation that is to elect the cluster head and decide aggregation function can easily handle the problem of flooding at base station efficiently.

Acknowledgment

Foremost, I Sakshi Sharma would like to express our sincere gratitude to my Head of the Department, Mr Rajdeep Singh and my guide Mrs. Malti Rani for their continuous support, their patience, motivation, immense knowledge and their complete guidance for this research paper.

References

[1]] L. Tao, Z.Q. Xin and Z. Luqiao, *"An Improvement for LEACH Algorithm in Wireless Sensor Network"*, in Proc. of IEEE 5th Conference on Industrial Electronics and Applications, pp. 1811-1814, June 2010.

[2] J. Peng, W. Chengdong, Z. Yunzhou and C. Fei, *"A Low-Energy Adaptive Clustering Routing Protocol of Wireless Sensor Networks"*, in Proc. of IEEE International Conference on Wireless Communications, Networking and Mobile Computing (WiCOM), pp. 1-4 September 2011.

[3] F. Farazandeh, R. Abrishambaf, S. Uyal, T. Gomes and J. Cabral, *"A Hybrid Energy-Efficient Routing Protocol for Wireless Sensor Networks"*, in Proc. of IEEE, pp.18-23, 2013.

[4] D. Mantri, N. R. Prasad and R. Prasad, "*Grouping of clusters for efficient data aggregation (GCEDA) in wireless sensor network*" in Proc. of Advance Computing Conference (IACC), IEEE 3rd International, pp. 132-137, 2013.

[5] Y. Lu, D. Zhang, Y. Chen, X. Liu and P. Zong, "*Improvement of L EACH in Wireless Sensor Network Based on Balanced Energy Strategy*" IEEE Proceeding of International Conference on Information and Automation Shenyang, China, pp. 111-115, 2013.

[6] A.M. Said, A.W. Ibrahim, A. Soua and H. Afifi, "*Dynamic aggregation protocol for wireless sensor network.*" in *Proc.* of Advanced Information Networking and Applications (AINA), IEEE 27th International Conference, pp. 356-361, 2013.

[7] D. Mantri, N. R. Prasad and R. Prasad, "*BHCDA: Bandwidth efficient heterogeneity aware cluster based data aggregation for Wireless Sensor Network*" in Proc. of Advances in Computing, Communications and Informatics (ICACCI), International Conference IEEE, pp. 1064-1069, 2013.

[8] A. Yektaparast, F.H. Nabavi and A. Sarmast, *"An Improvement on LEACH Protocol (Cell-LEACH)"*, in Proc. of IEEE 14th International Conference on Advanced Communication Technology, pp. 992-996, February 2012.

[9] L. Qing, Q. Zhu and M. Wang, *"Design of a distributed energy-efficient clustering algorithm for heterogeneous wireless sensor networks"*, in Proc. Of Science Direct, pp.2230-2238, March 2006.

[10] N. Javaid, S. N. Mohammad, K. Latif, U. Qasim, Z. A. Khan and M. A. Khan, *"HEER- Hybrid Energy Efficient Reliable Protocol for Wireless Sensor Networks"*, in Proc. of IEEE, 2013.