International Journal of Advance Research in Science and Engineering
Vol. No.5, Special Issue No. (01), February 2016
www.ijarse.com
IJARSE
ISSN 2319 - 8354

A STUDY OF HYBRID ENERGY EFFICIENT DISTRIBUTED (HEED) PROTOCOLS FORHETEROGENEOUS WIRELESS SENSOR NETWORKS

Ms.Vandana Dubey[1], Mohd. Waes Siddiqui[2]

[1]Assistant Professor, [2]Department of CSE, Amity University, Lucknow (India)

ABSTRACT

Now a days the main area of research in wireless sensor network is to prolong the network life and energy efficiency. Here in this study paper, we have studied Heterogeneous - Hybrid Energy Efficient Distributed (H-HEED) Protocols for Wireless sensor Network has been planned to prolong the network lifetime. We have also discussed the heterogeneity in terms of node energy in wireless sensor networks. This study focuses on the essential techniques employed in H-HEED for Wireless sensor networks.

Keywords: Heterogeneity, Network Lifetime, Wireless Sensor Network.

I. INTRODUCTION

Due to the big selection of applications of Wireless sensor Networks (WSN) in the past few years become a hot research area now a days[1]. One of the most important drawbacks of WSN is that sensor nodes battery powered and deployed in tough environment so it is not easy to recharge or replace the batteries all the time the node fails or dead. WSN are used in various applications like health care, industrial control units, military and environment monitoring. Routing protocols are developed networks such as VANET, MANET etc. can not apply directly in WSN because of energy constrains of nodes. It is verified that sensor nodes need a lot of energy to transmit data rather than sensing thus routing protocol developed for WSN should be efficient so that the network lifetime can be prolonged. in this paper, a study of various cluster routing protocols has been done indicating their advantages and disadvantages[2].

Due to recent technological progress and availability of low cost sensors created wireless sensor networks. Sensors are little devices that sense physical quantities and convert them in to electrical signals. A WSN consists of many sensor nodes that can sense data and communicate among them or to the sink (external base station). Figure 1 [3], shows the structural view of a sensor network. It mainly consists of 4 components:

A. Sensor Unit

B. Communication Unit

C. Power Unit

D. Central Processing Unit (CPU)

All are assigned with different tasks. The sensor unit consists of sensor and an Analog to Digital Converter (ADC). The sensor unit sense the data and returns the sensed analog data to ADC which is been converted into digital data and informs the CPU what data is been sensed. Communication unit receives the sensed data and transmit the data to rest of the sensors in the network. CPU controls the power, process, compute next hop to the sink, etc. Power unit's main task is to supply power to sensor unit, processing unit and communication unit. Each node may consist of two optional components namely Location finding system and Mobilizer.

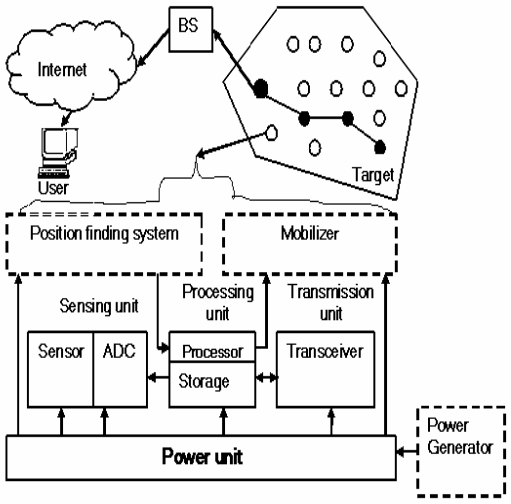

Figure 1[3]: Structural view of sensor network

Routing protocols for WSNs can be classified mainly into two categories depending on the Network Structure [4]:

1.1 Flat Routing Protocol

1.2 Clustering/Hierarchical Routing Protocol

1.1 Flat routing: Flat Routing Protocol is effective only to small-scale networks and not suitable for large-scale networks.

1.2 Clustering routing protocol: nodes are in cluster formations. Each cluster consists of two types of node:

1.2.1Cluster Head**:** Every cluster would have a leader, often referred to as the Cluster Head (CH). CH is just one of the sensors with richer resources. CH may be elected by the sensors in the cluster or pre-assigned by the network designer. One cluster consists of only one CH at a time.

1.2.2 Member Nodes: These are the remaining nodes in the cluster with lower resources. Once the CH fails these remaining member nodes in the cluster may get the chance to become the CH.

Mainly two types of communication are performed in clustering protocols:

1.2.3 INTRA-CLUSTER: The communication among the nodes present in the clusters.

1.2.4 INTER-CLUSTER: The communication which takes among the clusters.

The remaining of the paper is organized as follows: section 2, outlines the advantages of clustering routing protocol. Section 3, provides an overview of various Clustering routing protocols. Section 4, summarizes the Heterogeneous network model.Section 5, scope of work. Finally, section 6, concludes the paper.

II. ADVANTAGE OF CLUSTERING ROUTING PROTOCOL

Routing in WSN consist various challenging issues such as power supply, scalability, processing capability, transmission bandwidth, global address, frequent topology changes, data aggregation, data redundancy, etc. Clustering routing protocols try to overcome few of these challenges some of them are listed below:

1.1 Network Lifetime: Clustering routing protocol helps in energy-efficient routing thus the overall network lifetime is increased.

1.2 Energy Efficient: Data aggregation at CH reduces data transmission and thus saves energy. whereas inter-cluster communication helps in less energy consumption.

1.3 Fault Tolerance: In WSN nodes are deployed in harsh environment and thus nodes are usually exposed to risk of malfunction and damage. Tolerating the failure of nodes or CH is necessary in such conditions. Whenever a CH fails re-electing of CH will not be efficient rather than we can assign a backup CH. Rotating the role of CH among the nodes in the cluster is also a solution for CH failure.

1.4 Robust: WSN like wired network doesn't have any fixed topology thus addition of new node, node mobility, node failure, etc. has to be maintained by the individual cluster not by the entire network. CHs rotate among the entire sensors node to avoid single point of failure.

1.5 Load Balancing: Load balancing can be done by even distribution of nodes in the cluster and the data fusion at the cluster head before inter-cluster transmission. CH is responsible for load balancing within the cluster.

1.6 Data Processing: Data redundancy can be reduced by aggregating the packets send by various nodes in the cluster to the CH. Thus various redundant data can be removed during this process.

III. CLUSTERING PROTOCOL FOR WSN

1.1 Energy Efficient Hierarchical Clustering (Eehc)

It is a distributed, randomized clustering algorithm for WSNs. EEHC is based on two stages [5]:

1.1.1 Initial: In the initial stage, each node announces itself as a CH with probability p to the neighbouring nodes within the communication range. These announcements are done by direct communication or by forwarding. These CHs are named as the volunteer CHs. The nodes which receives the announcement and is not itself a CH becomes the member of the cluster. The node which doesn't received the announcements within a time interval t that is calculated based on the duration for a packet to reach a node becomes a forced CH.

1.1.2 Extended: Multi-level clustering is performed in this stage. CHs at the level-1 transmit aggregated data to the level-2 CHs and so on. At the top level CHs transmit the aggregated data to the base station.

1.2 Low Energy Adaptive Clustering Hierarchy (Leach)

LEACH is one of most popular clustering algorithm for WSN [6,7]. It forms the cluster based on the received signal strength and uses the CH nodes as routers to communicate with the sink. Cluster formation in LEACH is done using a distributed algorithm, where each node makes decision without any centralized control.

The operation of LEACH is divided into two phases namely:

1.2.1 Setup Phase: It is an advertisement phase in which nodes uses CSMA MAC protocol to advertise their status, CSMA MAC protocols main task is to prevent two advertisement messages from colliding with each other. Thus, all non-cluster head nodes must keep their receiver ON during the setup phase to receive the message. Initially a node decides to a CH with a probability p and broadcasts its decision. Each non-CH node determines its cluster by choosing the CH that can be reached using the least energy. CH is been rotated periodically among the nodes of the cluster to balance load. The rotation is performed by getting each node to choose a random number "T" between 0 and 1. A node becomes the CH for the current round if the number is less than the following threshold:

$$T(n) = \begin{cases} \dfrac{p}{\left(1 - p\left(r - \mathrm{mod}\left(\frac{1}{p}\right)\right)\right)} & ,if\ \ n \in G \\ 0 & ,otherwise \end{cases}$$

Where p is the desire percentage of the CH nodes in the sensor population, r is the current round number, and G is the set of nodes that have not been CHs in the last 1/p rounds.

1.2.2 Steady-State Phase: Once the network is divided into clusters, CH uses TDMA schedule for its sensors to send the data. Data sent by the nodes in the cluster is aggregated at the CH and compresses the aggregated data before sending it to the sink. After the compression of data is done it is been send to the sink.

Though LEACH is an energy-efficient routing protocol still it has some drawbacks described as follows:

- It is only suitable for small networks and not suitable for network deployed in large area.
- TDMA schedule wastes the bandwidth because some nodes might not have data to send.
- Large amount of energy is wasted if the CH is located away from the sink.
- If the CH fails due to some reason between the processes the whole process has to be repeated again which leads to wastage of energy.

1.3 Leach-Centralized (Leach-C)

It is a centralized clustering algorithm developed as an improvement over LEACH. In LEACH-C the nodes in the network sends their location and energy information to the base station [8, 9, and 10]. Location information may be sent using some location identifying devices imported on the sensors like GPS etc. On the basis of this information the base station forms clusters, select CH and the members of clusters. In this way the setup phase is completed. The steady-state phase is same as that of LEACH. It is costlier due to the use of location finding devices and less reliable due to single point of failure.

1.4 Thershold Sensitive Energy-Efficient Sensor Network Protocol (Teen)

TEEN is a clustering routing protocol, which groups nodes into cluster with each led by a CH [12]. Once the cluster is formed CH broadcast two types of threshold values to the nodes in the cluster namely hard threshold value and soft threshold value. The parameters in the attribute set of the node reaches its hard threshold value,

the node switches on its transmitter and sends its data if the sensed attribute is greater than the head threshold, and the current value of the sensed attribute differs from sensed value by an amount equal to or greater than the soft threshold.

The main drawback of TEEN is that if the threshold values are not reached, the node will never communicate. And not even come to know if the entire nodes are alive or dead.

1.5 Adaptive Periodic Threshold Sensitive Energy Efficient Sensor Network Protocol (Apteen)

APTEEN is an improvement over TEEN. APTEEN is a clustering routing protocol that allows its nodes to send the sensed data periodically and react to any sudden changes in the value of the sensed data by reporting it to the CHs [13]. Architecture of APTEEN is similar to that of TEEN.

APTEEN supports three types of queries namely:

1.5.1 Historic Query: To analyse past data value.

1.5.2 One Time Query: To view the whole network.

1.5.2 Persistent Query: To monitor an event for a period of time.

- APTEEN guarantees energy efficiency and larger number of sensor alive.

1.6 Hybrid Energy-Efficient Distributed Clustering (Heed)

It is a distributed clustering algorithm developed as an improvement over LEACH. The enhancement is done in the CH selection method. HEED [11], selects CH on the basis of energy as well as communication cost. In HEED, each node is mapped to exactly one cluster. It is divided into three phases:

1.6.1 Initialization Phase: Each sensor node sets the probability $C_{prob}$of becoming CH follows:

$$CH_{prob} = C_{prob} \cdot \frac{E_{residual}}{E_{max}}$$

Where $C_{prob}$is the initial percentage of CH required in the network, $E_{residual}$is the current energy of the node and E_{max} is the maximum energy of the fully charged battery.

1.6.2 Repetition Phase: This is an iterative phase in which each node repeats the same process until it find a CH to which it can transmit with least cost. If any node finds no such CH, the elects itself to be a CH and sends the announcement message to its neighbours. Initially sensor node become tentative CH, it changes its status later if it finds a lower cost CH. The sensor node becomes permanent CH if its CH_{prob} has reached 1.

1.6.3 Finalization Phase: In this phase nodes either picks the least cost CH or itself becomes a CH.

Though it is an improvement over LEACH still it has some disadvantages like more CH are generated than expected and it is not aware of heterogeneity.

IV. HETROGENOUS NETWORK MODEL

4.1 In 2-level H-HEED protocol: In 2-level H-HEED protocol two types of sensor nodes, i.e., the advanced nodes and normal nodes are used. Let us assume there are 'N' numbers of sensor nodes deployed in a field. *E0* is the initial energy of the normal nodes, and *m* is the fraction of the advanced nodes, which own *a* times more energy than the normal ones. Thus there are *m* * *N* advanced nodes equipped with initial energy of E_0 * (1 + a), and (1 + m) * N normal nodes equipped with initial energy of *E0*. The total initial energy of the network is given by:

$E_{total} = N * (1 - m) * E_0 + N * m * E_0 * (1 + a)$

$= N * E_0 * (1 + am)$

So, this type of networks has *am* times more energy and virtually *am*more nodes.

4.2 In 3-level H-HEED protocol: In 3-level H-HEED protocol there are three types of sensor nodes, i.e. the super nodes, advanced nodes and the normal nodes. Let *m*be the fraction of the total number of nodes *N*, and *m0* is the percentage of the total number of nodes $N * m$ which are equipped with *B* times more energy than the normal nodes, called as the super nodes, the number is $N * m * m0$. The rest $N * m * (1-m0)$ nodes are having a times more energy than the normal nodes, being called as advanced nodes and the remaining $N * (1-m)$ nodes are the normal nodes. *E0* is the initial energy of the normal nodes. The energy of the each super node is $E_0 * (1 + B)$, and the energy of each advanced node *is*

$E_0 * (1 + a)$

The total energy of the networks [14] is given by:

$$E_{total} = N * (1-m) * E_0 + N * m * (1 - m_0) * E_0 * (1 + a) + N * m * m_0 * E_0 * (1 + B)$$

$E_{total} = N * E_0 * (1 + m * (a + m_0 * B))$

So, the total energy of the network is increased by the factor of $(1 + m * (a + m_0 * B))$

4.3 In multi-level H-HEED protocol: In multi-level H-HEED protocol initial energy of sensor nodes is randomly distributed over the close set $[E_0, E_0 * (1 + a_{max})]$ where *E0* is the lower bound and a_{max}determine the value of the

Maximal energy. Initially, the node *si*is equipped with initial energy of $E_0 * (1 + a_i)$, which is *ai*times more energy than the lower bound *E0*. The total initial energy of the network is given by:

$$E_{total} = \sum_{i=1}^{N} E_0 * (1 + a_i)$$

$$= E_0 * \left(N + \sum_{i=1}^{N} a_i\right)$$

During Cluster formation phase, every node will have its own E_{max}value in case of heterogeneity while computing the cluster head probability of the sensor node.

V. SCOPE OF WORK

5.1 Problem Statement: In the current body of research done in the area of wireless sensor networks, we see that particular attention has not been given to the time criticality of the target applications. Most current protocols assume a sensor network collecting data periodically from its environment or responding to a particular query. We feel that there exists a need for networks geared towards responding immediately to changes in the sensed attributes. We also believe that sensor networks should provide the end user with the ability to control the trade-off between energy efficiency, accuracy and response times dynamically. So, in our research, we have focused on developing a communication protocol which can fulfil these requirements.

5.2 Methodology: The methodology includes the study and analysis of various current hierarchical protocols and performance evaluation.

This includes:

- Literature survey of various papers and inference drawing.
- Study of various protocols.
- Implementation of a novel algorithm for energy efficient routing protocols using HEED as base.

VI. CONCLUSION

In this paper, H-HEED protocol is planned for heterogeneous wireless sensor network and also used clustering routing protocol for Wireless sensor network. In this paper, we studied different levels of heterogeneity: 2-level, 3-level and multi-level in terms of the node energy. We have evaluated the performance of the planned H-HEED with HEED protocol using Matlab. It is discovered that there is important improvement within the period just in case of H-HEED protocol compared with HEED protocol as a result of the number of rounds is most with multi-level H-HEED.

REFERENCES

[1] Jamal N. Al-Karaki Ahmed E. Kamal "Routing Techniques in Wireless Sensor Networks: A Survey" Dept. of Electrical and Computer Engineering Iowa State University, Ames, Iowa 50011.

[2] Xuxun Liu, "A Survey on Clustering Routing Protocols in Wireless Sensor Networks ", Sensors 2012, pp. 1113-11153.

[3] Routing Techniques in Wireless Sensor Networks: A Survey, Jamal N. Al-Karaki Ahmed E. Kamal, Dept. of Electrical and Computer Engineering, Iowa State University, Ames, Iowa 50011.

[4] Routing Protocols for Wireless Sensor Networks: Classifications and Challenges ,Manal Abdullah, Aisha Ehsan, Quest Journals, Journal of Electronics and Communication Engineering Research Volume 2 ~ Issue 2 (2014) pp: 05-15.

[5] S. Bandyopadhyay, E. Coyle, An energy efficient hierarchical clustering algorithm for wireless sensor networks, in: Proceedings of the 22nd Annual Joint Conference of the IEEE Computer and Communications Societies (INFOCOM 2003), San Francisco, California, April 2003.

[6] W.R.Heinzelman, A.Chandrakasan, and H.Balakrishnan, "Energy efficient Communication Protocol for Wireless Micro sensor Networks", in IEEE Computer Society Proceedings of the Thirty Third Hawaii International Conference on System Sciences (HICSS '00), Washington, DC, USA, Jan. 2000, vol. 8, pp. 8020.

[7] Ashish Christian, Dr.HimanshuSoni "Lifetime Prolonging in LEACH Protocol for Wireless Sensor Networks", International Conference for Intelligent systems and signal processing (ISSP), IEEE 2013, pp 350-355.

[8] A Comprehensive Review of Cluster-Based Energy Efficient Routing Protocols in Wireless Sensor Networks, Agam Gupta, AnandNayyar, International Journal of Research in Computer and Communication Technology, Vol 3, Issue 1, January- 2014.

[9] Heinzelman W. B., Chandrakasan A. P., Balakrishnan H., "An application specific protocol architecture for wireless microsensor networks," IEEE Trans on Wireless Communications, Vol. 1, No. 4, 2002, pp. 660-670, doi: 10.1109/TWC.2002.804190.

[10] Shio Kumar Singh , M P Singh, D K Singh, "A Survey of Energy-Efficient Hierarchical Cluster-Based Routing in Wireless Sensor Networks ", Int. J. of Advanced Networking and Applications Volume: 02, Issue: 02, 2010, pp. 570-580.

[11] Younis and S. Fahmy, "HEED: A Hybrid , Energy-Efficient, Distributed Clustering Approach for Ad-hoc Sensor Networks," IEEE Transactions on Mobile Computing, vol. 3, no. 4, pp. 366–379, 2004.

[12] A Manjeshwar and D. P. Agrawal, "TEEN: A Routing Protocol for Enhanced Efficiency in Wireless Sensor Networks" in Proc. of 15th International Parallel and Distributed Processing Symposium, pp. 2009–2015.

[13] A. Manjeshwar and D. P. Agrawal, "APTEEN: A Hybrid Protocol for Efficient Routing and Comprehensive Information Retrieval in Wireless Sensor Networks", in the Proceedings of the 2nd International Workshop on Parallel and Distributed Computing Issues in Wireless Networks and Mobile computing, San Francisco CA, April 2001, pp. 2009-1015.

[14] Yingcghi Mao, Zhen Liu, Lili Zhang and Xiaofang Li. 2009. An Effective Data Gathering Scheme in Heterogeneous Energy Wireless Sensor Network. In International Conference on Computational Science and Engineering.\