ISSN 2350 - 0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 1, Issue 3, October 2014

Energy Efficient Hierarchical Routing Protocol in Wireless Sensor Network

Kinjal Patel, Sanjay Tiwari, Pradeep Jha

Associate Professor, Department of Computer Science, S.V College, Kadi, Gujarat, India

Associate Professor, Department of Computer Science Engineering, Arya College, Jaipur, Rajasthan, India

Associate Professor, Department of Computer Science Engineering, Arya College, Jaipur, Rajasthan, India

ABSTRACT: Hierarchical routing protocols are critical for the wireless sensor networks (WSN) to maximize its lifetime, but the existing protocols are prone to lead nodes in clusters to die early due to ignoring the state of neighbors in the cluster head decision. A WSN is a specialized wireless network made up of a large number of sensors and at least one base station. The foremost difference between the WSN and the traditional wireless networks is that sensors are extremely sensitive to energy consumption. Energy saving is the crucial issue in designing the wireless sensor networks [1]. This research presents a survey of energy efficient routing protocols in sensor network by categorizing into a main classification as architecture based routing. Architecture based routing is further classified into two main areas: flat or location based routing protocol, and hierarchical based routing protocols. Flat based routing is more suitable when a huge number of sensor nodes are deployed, and location based routing is employed when nodes are aware of their location. Since the radio transmission and reception consumes a lot of energy, one of the important issues in wireless sensor network is the inherent limited battery power within network sensor nodes. Most often the battery of sensor nodes cannot be charged or changed during transmission. This is the reason why routing techniques in wireless sensor network focus mainly on the accomplishment of power conservation. In order to maximize the lifetime of sensor nodes, it is preferable to distribute the energy dissipated throughout the wireless sensor network. So it is essential to design effective and energy aware protocols in order to enhance the network lifetime. A WSN can have network structure based or protocol operation based routing protocol .In this paper, a review on network structure based routing protocol in WSN is carried out. Energy consumption and network life time has been considered as the major issues. Wireless sensor network consisting of various tiny wireless sensor nodes that are equipped with transmission devices that require some amount of energy to transmit the data to other node(s). Most of the recent researches have shown various algorithms mainly designed to minimize energy consumption in sensor networks. Using simulation a basic idea is also given in this paper that shows how hierarchical routing mechanism is better than non hierarchical mechanism. The model developed is simulated in MATLAB. The results are obtained in terms of three metrics, lifetime of the network, and number of clusters and energy consumption of clusters heads. From the results of simulation, it is observed that the performance of EEHCRP is better in terms of energy consumption of CH, number of clusters and lifetime of network compared with LEACH.

KEYWORDS: Wireless sensor network, Hierarchical routing protocol, LEACH problem, Protocol architecture.

I. INTRODUCTION

A Wireless Sensor Networks (WSN) consist of large number of sensor nodes and is a set of hundreds or thousands of micro sensor nodes that have capabilities of sensing, establishing wireless communication between each other and doing computational and processing operations. These node are directly interacting with their environment by sensing the physical parameter such as temperature, humidity etc. All the sensor node send or receive data to/from a fixed wired station called base station.

The base station usually server as a gateway to some other network. WSN have a comprehensive range of application in this field including Environmental application, Military Application, Home Application etc. It can be use to process and forwarding the information while lower energy node can be use to do the sensing the target, Clustering is an efficient way to reduce energy consumption & fusion in order to reduce the number of transmitted message to the BS

ISSN 2350 - 0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 1, Issue 3, October 2014

[1]. Sensor networks have a wide variety of applications and systems with vastly varying requirements and characteristics. The sensor networks can be used in,

1. Military environment
2. Disaster management
3. Habitat monitoring
4. Medical and health care
5. Industrial fields, home
6. Networks, detecting chemical, Biological, radiological, nuclear, and explosive material etc.

Deployment of a sensor network in these applications can be in random fashion (e.g. dropped from an airplane) or can be planted manually (e.g., fire alarm sensors in a facility). For example, in a disaster management application, a large number of sensors can be dropped from a helicopter. Networking these sensors can assist rescue operations by locating survivors, identifying risky areas, and making the rescue team more aware of the overall situation in the disaster area.

II. WIRELESS SENSOR NETWORK

Wireless sensor network consisting of various tiny wireless sensor nodes that are equipped with transmission devices that require some amount of energy to transmit the data to other node(s).

A. ROUTING

Routing (or routing) is the process of selecting paths in a network along which to send network traffic [2]. The goal of sensor network routing protocol is to disseminate data from sensor nodes to the sink node in energy-awareness manner, hence, maximize the lifetime of the sensor networks.

B. ROUTING PROTOCOL CLASSIFICATION

There are different routing protocols already reported for WSN applications but mostly they are for static networks. All major protocols may be categorized into following four categories:
Data Centric Protocols, Hierarchical Protocols, Location Based Protocols and Network Flow and QoS Aware Protocols. Few representative works of these categories are given below.

No.	Category	Representative Protocols
1	Data Centric Protocols	Flooding and Gossiping, SPIN, Directed Diffusion, Rumor Routing, Gradient Based Routing, Energy-Aware Routing, CADR, COUGAR, ACQUIRE.
2	Hierarchical Protocols	LEACH, PEGASIS, HPEGASIS, TEEN and APTEEN
3	Location Based Protocols	MECN, SMECN, GAF, GEAR
4	Network Flow and QoS Aware Protocol	Maximum Lifetime Energy Routing, Maximum Lifetime, Data Gathering, Minimum Cost Forwarding, SAR and SPEED

Table I: Classification of Energy-efficient Routing Protocol

C. ROUTING PROTOCOL CLASSIFICATION

Routing in sensor network is very challenging due to several characteristics that distinguish them from contemporary communication and wireless ad-hoc networks.

1. Classical IP-based protocols cannot be applied to sensor networks.
2. All applications of sensor networks require the flow of sensed data from multiple regions (sources) to a

ISSN 2350 - 0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 1, Issue 3, October 2014

particular sink.

3. Generated data traffic has significant redundancy; such redundancy needs to be exploited by the routing protocols to improve energy and bandwidth utilization.

III. HIERARCHICAL ROUTING PROTOCOL

A. INTRODUCTION

There are the following important Hierarchical routing protocols.

1. LEACH
2. PEGASIS
3. TEEN
4. APTEEN

The main aim of hierarchical routing is to efficiently maintain the energy consumption of sensor nodes by involving them in multi-hop communication within a particular cluster and by performing data aggregation and fusion in order to decrease the number of transmitted messages to the sink. Cluster formation is typically based on the energy reserve of sensors and sensors proximity to the cluster head. LEACH is one of the first hierarchical routing approaches for sensors networks.

B. LEACH

Low-Energy Adaptive Clustering Hierarchy (LEACH) protocol for sensor networks is proposed by W. R. Heinzelmanetal which minimizes energy dissipation in sensor networks, it is based on a simple clustering mechanism by which energy can be con- served since cluster heads are selected for data transmission instead of other nodes. The operation of LEACH is broken up into rounds, where each round begins with a set-up phase, when the clusters are organized, followed by a steady-state phase, when data transfers to the base station occur. In order to minimize overhead, the steady-state phase is long compared to the set-up phase.

Set-up phase: During this phase, each node decides whether or not to become a cluster head (CH) for the current round. This decision is based on choosing a random number between 0 and 1.

Once the cluster head is chosen, it will use the CSMA MAC protocol to advertise its status. Remaining nodes will take the decision about their cluster head for current round based on the received signal strength of the advertisement message.

Before steady-state phase starts, certain parameters are considered, such as the net- work topology and the relative costs of computation versus the communication. A Time Division Multiple Access (TDMA) schedule is applied to all the members of the cluster group to send messages to the CH, and then to the cluster head towards the base station. As soon as a cluster head is selected for a region, steady-state phase starts. Figure 1.3 shows the flowchart of this phase.

Steady-state phase: Once the clusters are created and the TDMA schedule is fixed, data transmission can begin. Assuming nodes always have data to send, they send it during their allocated transmission time to the cluster head. This transmission uses a minimal amount of energy (chosen based on the received strength of the cluster- head advertisement). The radio of each non-cluster-head node can be turned off until the nodes allocated transmission time, thus minimizing energy dissipation in these nodes. The cluster-head node must keep its receiver on to receive all the data from the nodes in the cluster. When all the data has been received, the cluster head node performs signal processing functions to generate the composite single signal.

For example, if the data are audio or seismic signals, the cluster-head node can beam form the individual signals to generate a composite signal. This composite signal is sent to the base station. Since the base station is far away, this is a high-energy transmission. F Code Division Multiple Access (CDMA) is utilized between clusters to eliminate the interference from neighboring clusters.

LEACH achieves over a factor of 7 reduction in energy dissipation compared to direct communication and a factor of 4-8 compared to the minimum transmission energy outing protocol. The nodes die randomly and dynamic clustering increases life time of the system. LEACH is completely distributed and requires no global knowledge of network.

ISSN 2350 - 0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 1, Issue 3, October 2014

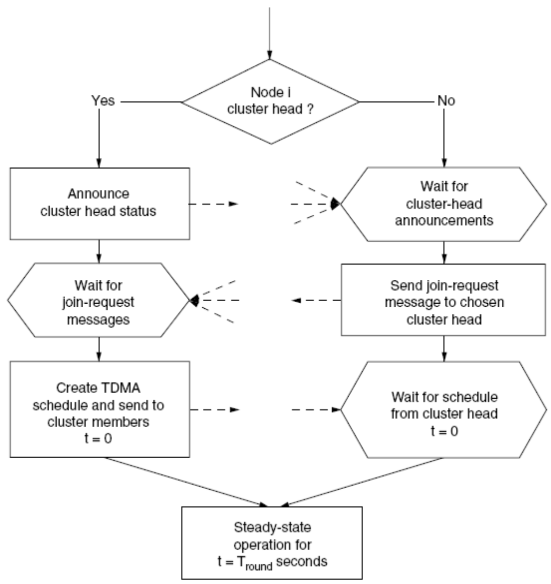


Fig 1: Flow chart of the set-up phase of the LEACH protocol

C. PEGASIS

PEGASIS which stands for Power-Efficient Gathering in Sensor Information Systems [8] is a data-gathering and near-optimal chain-based algorithm that establishes the concept that energy conservation can result from no des not directly forming clusters. This algorithm decreases the energy consumption by creation of a chain structure comprised of all nodes and continually data aggregation across the chain. The algorithm presents the idea that if nodes form a chain from source to sink, only one node in any given transmission time-frame will be transmitting to the base station. Data-fusion occurs at every node in the sensor network allowing for all relevant information to permeate across the network.

PEGASIS avoids cluster formation and uses only one node in a chain to transmit to the BS instead of using multiple nodes. In order to increase network life time, nodes need only to communicate with their closest neighbors and they take turns in communicating with the BS. When the round of all nodes communicating with the base-station ends, a new round will start and so on.

D. TEEN

Threshold sensitive Energy Efficient sensor Network protocol (TEEN) [4], is a hybrid of hierarchical clustering and data-centric protocols designed for time-critical applications. It is a responsive protocol to sudden changes of so me of the attributes observed in the WSN (e.g., temperature). The algorithm first goes through cluster formation. The CHs then broadcast two thresholds to the nodes in their clusters. Those are hard and soft thresholds for the sensed attribute: Hard Threshold (HT): This is a threshold value for the sensed attribute. It is the absolute value of the attribute beyond which, the node sensing this value must switch on its transmitter and report to its cluster head. Soft Threshold (ST): This is a small change in the value of the sensed attribute which triggers the node to switch on its transmitter and transmit. It stimulates the node to switch on its transmitter and report the sensed data. A node will report data only when the sensed value is beyond the HT or the change in the value is greater than the ST. However , TEEN cannot be applied for sensor networks where periodic sensor readings should be delivered to the Sink, since the values of the attributes may not reach the threshold at all. Moreover, we have some wasted time-slots in TEEN protocol and there is always a possibility that the sink may not be able to distinguish dead nodes from alive ones. Another limitation of the protocol is that the message propagation is accomplished by CHs only. If CHs are not in each other's transmission radius, the messages will be lost.

ISSN 2350 - 0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 1, Issue 3, October 2014

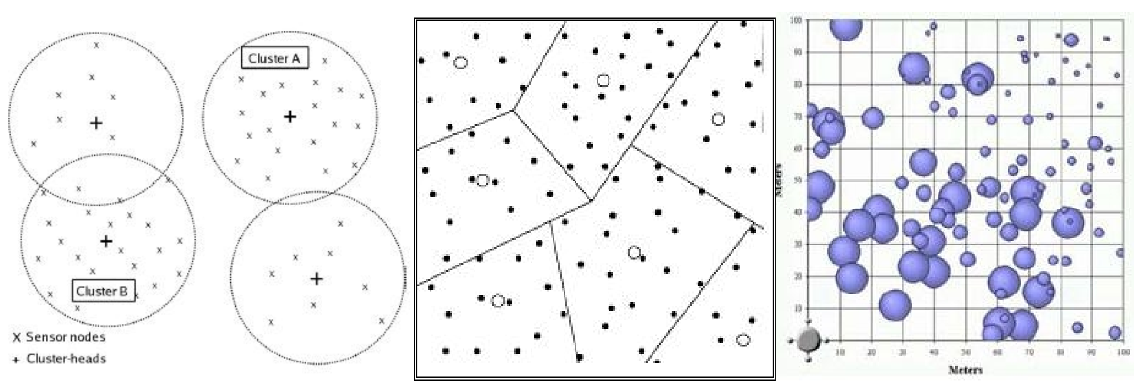
E. APTEEN

The Adaptive Threshold sensitive Energy Efficient sensor Network protocol (APTEEN) [5] is an extension to TEEN and aims at both capturing periodic data collections and reacting to time critical events. The architecture is same as in TEEN. When the base station forms the cluster s, the cluster heads broadcast he attributes, the threshold values, and the transmission schedule to all nodes. Cluster heads also perform data aggregation in order to save energy. APTEEN supports three different query types: historical, to analyze past data values; one-time, to take a snapshot view of the network; and persistent to monitor an event for a period of time.

IV. LEACH PROBLEM

I t performs single hop routing. Each node transmit information directly to cluster head and also cluster head directly transmit information to base station. Therefore, it is not applicable to networks deployed in large regions.

1. It performs dynamic clustering. The idea of dynamic clustering brings extra overhead, e.g. head changes, advertisements etc., which may diminish the gain in energy consumption.
2. LEACH assumes a homogeneous distribution of sensor nodes [4] in the given area. This scenario is not very realistic. Let us consider a scenario in which most of the sensor nodes are grouped together around one or two cluster-heads. As being shown in figure 3.1, cluster-heads A and B have more nodes close to them than the other cluster-heads. LEACH cluster formation algorithm will end up by assigning more cluster member nodes to both A and B. This could make cluster head nodes A and B quickly running out of energy.
3. LEACH [2] assumes that all nodes can transmit with enough power to reach the BS if needed and that each node has computational power to support different MAC protocols.
4. It also assumes that nodes always have data to send and nodes located close to each other have correlated data. It is not obvious how the number of predetermined Cluster Heads is going to be uniformly distributed throughout the network. Therefore, there is a possibility that the elected CHs will be concentrated in one part of the network. Hence, some nodes will not have any CHs in their vicinity.



(a) (b) (c)

Fig. 2. LEACH Problem (a) Sensor Network (b) Non uniform clusters in LEACH (c) Random distribution

V. OPTIMIZE PROTOCOL ARCHITECTURE

A. New Technique / scheme

Assign random time interval to the nodes. Nodes which have shortest time interval will win the competition and become the cluster heads. Tries to obtain constant no. of cluster heads in given area.

When the number of the counter has reached specified value, nodes no longer continue competition for cluster heads.

When the number of cluster members is less than specified threshold, the very small cluster will be merged with the neighboring clusters.

ISSN 2350 - 0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 1, Issue 3, October 2014

Algorithm Objective:

1. It selects constant no. of cluster Head (CHs).
2. It focuses on setting up well-distribution of cluster.

B. ROUTING PROTOCOL ARCHITECTURE

In Time Dependant-LEACH, competition for cluster-heads (CHs) no longer depends on a random number as in LEACH, and a random time interval instead. Nodes which have the shortest time interval will win the competition and become cluster heads.

In order to obtain a constant number of cluster-heads, set a counter which shows optimum no. of cluster heads(K_{op}). When the number of the counter has reached specified value, nodes no longer continue competition for cluster-heads.

For example, the nodes need to elect four CHs. Every node in the network produces a random timer at the beginning of a round. When the timer expires, and if the number which node has received of CHs' advertisement messages (C H ADV) is less than four, the node broadcast a CHs advertisement message to announce its CH status by using a non-persistent carrier-sense multiple access (CSMA) MAC proto- col. Else, it can't become a Cluster-head.

Once CHs are elected, the following processes are completely similar to LEACH. This algorithm is still a_distributed algorithm, that is, nodes make autonomous decisions without any centralized control.

The proposed algorithm also employs cluster member threshold to avoid the very big cluster and the very small cluster existing at the same time. As shown in figure 4.1 [8] there are 6 clusters and marked them A to F and A to D are the very small cluster and E, F are the very big cluster. Very big clusters (E, F) and the very small clusters (A, B, C and D) exist at the same time the energy of the nodes in the very small cluster will be used up quickly.

The reason that the energy of node in a small cluster declines sharply is explained below: The cluster head must wait until all members of the cluster finished to collect and send data once before starting the data aggregation, and then sent the aggregated data to the BS. The small cluster has fewer members, so the time for completion of data acquisition and delivery is shorter; the result is the small cluster will send data to the base station more frequently than the big cluster(As shown in below Table I). From a simulation result[18], found that in a small cluster the average energy consumption of cluster member node were significantly higher than a big cluster. So there is need to balance the clusters. So, algorithm use cluster member threshold to balance the clusters.

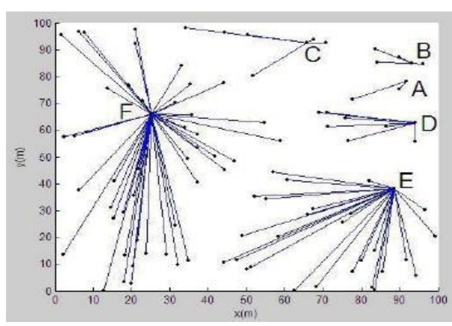


Fig. 3 The very big cluster and the very small cluster exist at the same time

VI. CONCLUSION

Sensor nodes are tightly constrained in terms of transmission power, on-board energy, processing capacity and storage and thus require careful resource management. This proposed cluster head selection technique put the constraint minimum cluster member nodes, so it tries to balance the clusters in the network. Also it obtains the optimum no. of clusters in each round, which will improve the performance of sensor network as compare to heterogeneous distribution of clusters in LEACH. Simulation results show that the proposed optimized algorithm provides the better energy efficiency and the longer network lifetime than the LEACH. There are still chances to improve techniques for the following approaches in the existing hierarchical routing protocols (Ex.

ISSN 2350 - 0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 1, Issue 3, October 2014

LEACH, PEGASIS, V-LEACH) so that energy consumption of node will be reduced and life time of sensor network will be improved.

1. Cluster Head Selection.
2. Cluster Head Communication
3. Cluster Formation.
4. Data Aggregation and fusion among the clusters.
5. Distance between Head and base station node consideration.
6. Energy level of nodes could be considered during selection of head node.

REFERENCES

[1] ZHANG Zhen-chuan, ZHANG Xin-xiu, "Research of Improved Clustering Routing Algorithm Based on Load Balance in Wireless Sensor Networks", Indian Journal of Science and Technology, Vol.3 No 2, 2007.

[2] Rajib Mall Hiren Kumar, Deva Sarma, Avijit Kar, "Energy efficient communication protocol for a mobile wireless sensor network system", pp.386-394, 2009.

[3] Eunil Park, Dongju Bae, and Hyunseung Choo, "Energy Efficient Geographic Routing for Prolonging Network Lifetime in Wireless Sensor Networks" In IEEE, International Conference of Computational Science and Its Applications. pp. 285-288, 2010.

[4] Deng Zhixiang, Qi Bensheng, "Three-layered Routing Protocol for WSN Based on LEACH Algorithm."

[5] Jaco Leuschner, Gerhard P. Hancke, "SEER: A simple energy efficient routing protocol for wireless sensor networks", In SACJ journal, No. 39, pp. 24-27, 2007.

[6] Liang Xue, Xin-Ping Guan, " A Power- and Coverage-aware Clustering Scheme for Wireless Sensor Networks", International Journal of Automation and Computing.

[7] Wendi B. Heinzelman, Anathan P. Chandraskan, Hari Blakrisshnan, "An Application Specific Protocol Architecture for Wireless Microsensor Networks", IEEE Trans. on Wireless Communications. Volume 1, Issue 4, pp. 660-670, 2002.

[8] Hendrik vom Lehn, Elias Weingartner and Klaus Wehrle. " A performance comparison of recent network simulators", http://jist.ece.cornell.edu/

[9] W. R. Heinzelman, A. Chandrakasan, H. Balakrishnan, "Energy Efficient Communication Protocol for Wireless Micro Sensor Networks", Proceedings of IEEE HICSS, 2000.

[10] Lu Tao, Zhang luqiao, "An improvement for LEACH algorithm in Wireless Sensor Network" IEEE 2010.