Research Journal of Applied Sciences 11 (12): 1522-1525, 2016
ISSN: 1815-932X

Performance Analysis of Cluster-Based Routing Protocols in Wireless Sensor Network

C. Jothikumar and Revathi Venkataraman
Department of Computer Science and Engineering, SRM University, Chennai, India

Abstract: Of all cutting-edge technologies, one of the pioneering technology is a wireless sensor network. This technology was used in military, environmental monitoring and many. This technology was developed for real-time application in industries. When the application moves to real-time monitoring, the sensor needs to be active throughout the operation. Energy consumption is an important issue in developing the network for a real-time environment and the sensor nodes are also miniature in nature energy efficient routing is the leading task for the sensor network. The goal is to maximize the lifespan of the wireless sensor network by minimizing the consumption of energy. In this study we analyze the cluster based routing protocol such as LEACH, BCDCP, SHPER and GSTEB and the comparison of each other.

Key words: Wireless sensor network, cluster routing, cluster head, base station, energy efficiency, network lifetime

INTRODUCTION

Wireless sensor networks is a self-organized wireless sensor system. The surviving nodes must automatically perform a variety of setup and configuration steps, including the establishment of communication with neighbor sensor nodes and the intention of their sensing responsibilities (Akyildiz *et al*., 2002; Bandyopadhyay and Coyle, 2003). Each sensor node performs sensing, processing and communicating the data and power supply are limited. So designing of network structure and routing protocol is the most important study in WSN. A Cluster-based routing protocol is well-known techniques that enable the operation of WSNs to be highly energy-efficient. Sharing of data through cluster reduces the transmission distance that further minimizes the transmitted energy. Figure 1 shows the clustering, fusion and transmission process.

Using the clustered approach we reduce the amount of data transfer within the network (Akkaya and Younis, 2005; Karaki and Kamal, 2004; Mhatre and Rosenberg, 2004). Thus, energy saving is achieved. On the other hand, load balancing is an essential consideration aiming at prolonging the network lifetime in WSN, since the distance between each node and based station are different, direct transmission leads to unbalanced energy consumption. Even distribution of sensor nodes among the cluster is usually considered for cluster construction where the cluster head performs the task of data processing and intra-cluster management.

Literature review: The most important task of wireless sensor network is to periodically collect information and

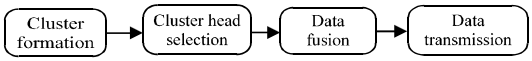

Fig. 1: Clustering, fusion and transmission process

transmit the information to the base station. When a base station located far away from the target area, the sensor nodes dies quickly due to limited energy. The LEACH is a first hierarchical routing protocol using cluster-based approach. It is more energy efficient algorithms for WSNs that was proposed to reduce energy consumption. A cluster consists of single cluster head and any number of cluster members which only communicate with their Custer Head (CH). Cluster-based routing is the best task that performs data aggregation and in-network processing at the CH.The two phases include a setup phase and a steady state phase. The setup phase includes CH selection and cluster formation. LEACH forms a cluster by using a distributed algorithm where node makes autonomous decisions without any centralized control. Therefore, LEACH rotates the CHs responsibility among sensor nodes to evenly distribute the energy load. In steady state phase, the sensor node communicates only with the CH and is allowed to transmit data only during its allocated slots indicated the schedule received from the CH. It is the responsibility of the CH for forwarding fused data to the Base Station (BS).

MATERIALS AND METHODS

Network and radio model: In this model, radio dissipates E_{elec} = 50 nJ/bit to run the transmitter or receiver circuitry and the energy dissipation of the radio caused by

Corresponding Author: C. Jothikumar, Department of Computer Science and Engineering, SRM University, Chennai, India

running the transmit amplifier equals $\varepsilon_{amp} = 100$ pJ/bit/m^2. An r^2 path loss due to free space propagation model is used. The energy consumption of transmitting an n-bit packet to a distance (d) and receiving that packet is given as for transmitting:

$$E_{Tx}(n, d) = E_{elec} \times n + \varepsilon_{amp} \times n \times d^2$$

For receiving:

$$E_{Rx}(n) = E_{elec} \times n$$

Due to this reason the protocol should try to find out not only the near optimal path, but also reduces the number of transmitting and receive operations for each other.

RESULTS AND DISCUSSION

Protocol analysis

Low Energy Adaptive Clustering Hierarchy (LEACH): The LEACH is acluster based routing protocol for sensor network application (Heinzelman *et al*., 2000, 2002). The LEACH includes cluster construction phase and data transmission phase.

In cluster construction phase: In this phase, the clusters are organized and the CHs are selected. The CHs receive the data from the nodes which were in its radio communication range. The CH fuses, compress and forward the data to the BS. The CH was chosen based on using random probability distribution. Only nodes that have not been CHs recently are candidates for the CH role. This rotation of CHs leads to a balanced energy consumption to all the nodes and hence to a longer lifetime of the network.

The data transmission phase: In this phase, the data send from CHs to the BS. To save energy, each cluster member uses the minimum required to transmit power to reach the CH and turn off the wireless radio. On the other side, the CH must be awake all the time to receive sensor data from its cluster member and communicate the data to the BS. The advantage of LEACH protocol performs better than flat based routing protocols, regarding energy dissipation and system lifetime of the network by employing a clustering approach. However, LEACH uses single-hop routing where each node can transmit directly from the CH to the BS.

Base-Station Controlled Dynamic Clustering Protocol (BCDCP): In BCDCPthe protocol sets up clusters based on the idea of balancing the energy level (Muruganathan *et al*., 2005). To achieve this, the BS, before constructing the routing path, receives information about the current energy level of all the nodes in the network. Based on this response, the BS first computes the average energy level of all the nodes. Then the BS chooses a set of nodes whose energy levels are above the average (threshold limit) and declare that nodes are the CH for the next round. Each clusteris allocated with equal no of members to avoid the overhead of CH. TheCHs was placed uniformly throughout the sensor region and utilize a CH-to-CH communication to transfer the data to the BS. Also, in the BCDCP the base station is considered to be a high-energy node with a large amount of energy supply.

Scaling Hierarchical Power Efficient Routing (SHPER): In SHPER the protocol mainly aims at power conservation. The routing protocol should be scalable so that it does not degrade as the network size increases (Kandris *et al*., 2009). These nodes are randomly distributed within a delimited area of interest. The BS has located away from the sensor field. Both the BS and the set of the sensor nodes are fixed. So the base station can transmit with a high enough power to all the network nodes, due to its unlimited power supply. The nodes form the cluster and each cluster has individual CH. The CH located close to the BS is marked as an upper-level CH. The CHs located far away from the BS is called lower-level CH that communicates the data through upper-level CH to send data to BS. This protocol performs the CH selection in a non-randomized way by taking into account the residual energy of the nodes and the power dissipation among the nodes is more even.

General Self-Organized Tree-Based Energy-Balanced Routing Protocol (GSTEB): The GSTEB Protocol is to achieve a longer lifetime of the network. The BS nominates a root node based on residual energy and broadcast its ID and its coordinates to all sensor nodes. GSTEB can change the tree structure that depends on dynamic root construction with short delay (Han *et al*., 2014). Simultaneously each node selects its parents based on itself and its neighbor's information like energy level of each node. Every node can share the message with their adjacent nodes during its time slots. Root Construction mechanism: BS assigns a root node and broadcast its root ID and root coordinates to all sensor nodes. By employing root node network gains less energy consumption and load balancing. Data fusion takes place in root node and the fused data addressed from root node to the BS. So, only one node will communicate with the base station (which results in less energy consumption). Each node selects its parents by considering its energy level and its neighbor's Energy Level (EL). Only the nodes with the largest EL of all its neighbors and itself can act as a relay node that communicates with the root

Table 1: Analysis and comparison

Algorithm	Advantage	Disadvantage	Route metric	Scalability	Load balancing
LEACH	Low energy, evenly sharing the load, collision avoidance by TDMA	It is not applicable for large regions and the dynamic clustering brings extra overhead	Best route	Medium	Medium
BCDCP	The network consuming less energy	Performance gain decreases as the sensor field area becomes smaller	Shortest path	Low	Good
SHPER	Energy balance of the network	It does not support mobility	Best route	Good	Good
GSTEB	Minimizing the total energy consumption and balancing workload	It needs a BS to compute topography which leads to energy consumption	Best route	Low	Good

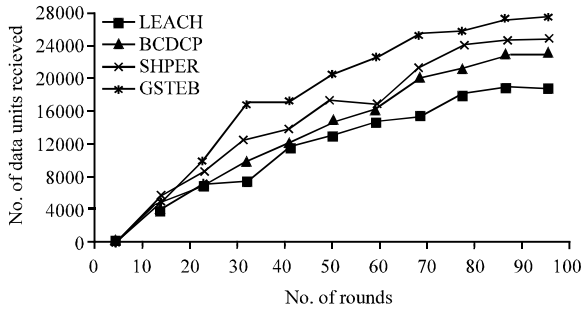

Fig. 2: Number of messages recieved over a number of rounds

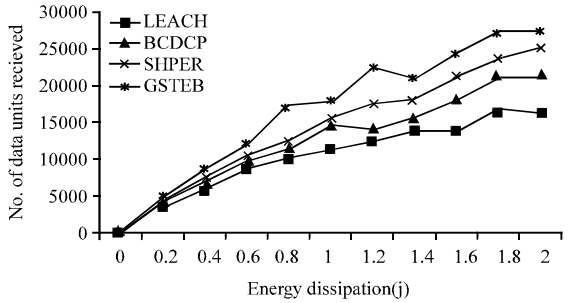

Fig. 3: Number of the messages received over energy dissipation

node. In self-organized data gathering/transmission at the end of tree construction, all the sensor nodes have some data to transmit to BS.

Here, TDMA and FHSS are applied. DATA-PKT moves from the parent node to root node based on the time slot. To avoid interference between the child nodes FHSS was popularized (Fig. 1). Once the tree construction is established, the BS computes the energy level of all the nodes. This information helps to calculate the topology for the next round. The advantage is to minimize the total energy consumption and to balance the workload. The disadvantage is it need a BS to generate topography which leads to increase the energy waste and longer delay. Table 1 Gives the analysis and comparison of LEACH, BCDCP, SHPER and GSTEB routing protocol.

The comparison of hierarchical (or) cluster based routing scheme is presented. The protocol is LEACH,

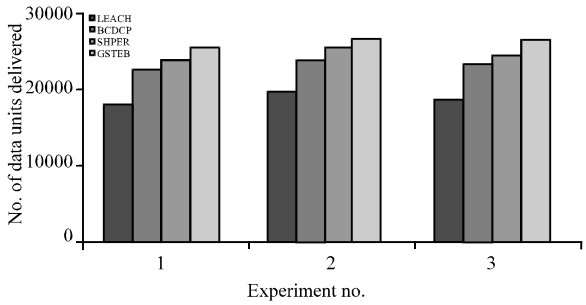

Fig. 4: Comparison on message reception

BCDCP, SHPER and GSTEB are absorbed with the parameter like scalability, route metric and load balancing. The focus is to improve the scalability and load balancing to create a new routing protocol.

We analyze the number of the data message received by the sink for the four routing protocols. Figure 2 shows the total number of the data message received by the base station over the number of rounds. The graph explains the performance of protocolsregardingdelivering the data message to the sink. Figure 3 shows the average energy dissipation of four protocols. The performance analysis of the protocols shows average energy consumption in delivering the data message to the sink. Figure 4 compares LEACH, BCDCP, SHPER and GSTEB algorithm regarding the number of message reception by the sink in the three conducted experiments.

In the proposed system, the clusters have been formed using a cluster splitting algorithm. The CH was selected using neighbor information. Each node shares their energy and distance of the node to other neighbors. The cost of the link and the quality of the link need to be analyzed to forward the data to the sink. The system employs dynamic coordinator and hence using a greedy algorithm to address the data to base station. Thus the protocol reduces the transmitted energy and minimizes the power consumption in the network.

CONCLUSION

On the analysis of the LEACH, BCDCP, SHPER and GSTEB routing algorithm the merits and demerits of the protocols are identified based on some of the characteristics such as load balancing, scalability and

route metrics. With this comparison, the main issue identified was the reduced lifetime of the network by consuming more energy due to uneven load balancing. An approach is suggested to have an advanced model to intensify the lifespan of the network. These protocols focus on increasing the network lifetime. The complexity of the protocols needs to be analyzed. We need to have more models to balance the energy of the node in the network. The compression and data aggregation technique is used to balance the energy of the node in the network is one of the future research areas to be explored. This increase, node lifetime and indirectly reduces the energy consumption.

REFERENCES

Akkaya, K. and M. Younis, 2005. A survey on routing protocols for wireless sensor networks. Ad Hoc Networks, 3: 325-349.

Akyildiz, I.F., W. Su, Y. Sankarasubramaniam and E. Cayirci, 2002. Wireless sensor networks: A survey. Comput. Networks, 38: 393-422.

Al-Karaki, J.N. and A.E. Kamal, 2004. Routing techniques in wireless sensor networks: A survey. IEEE Wireless Commun., 11: 6-28.

Bandyopadhyay, S. and E.J. Coyle, 2003. An energy efficient hierarchical clustering algorithm for wireless sensor networks. Proceedings of the 22nd Annual Joint Conference of the Computer and Communications, Volume 3, March 30-April 3, 2003, San Franciso, CA., USA., pp: 1713-1723.

Han, Z., J. Wu, J. Zhang, L . Liu and K. Tian, 2014. A general self-organized tree-based energy-balance routing protocol for wireless sensor network. IEEE. Transac. Nucl. Sci., 61: 732-740.

Heinzelman, W.B., A.P. Chandrakasan and H. Balakrishnan, 2002. An application-specific protocol architecture for wireless microsensor networks. IEEE Trans. Wireless Commun., 1: 660-670.

Heinzelman, W.R., A. Chandrakasan and H. Balakrishnan, 2000. Energy-efficient communication protocol for wireless microsensor networks. Proceedings of the 33rd Annual Hawaii International Conference on System Sciences, January 7, 2000, IEEE, Cambridge, Massachusetts, ISBN:0-7695-0493-0, pp: 1-10.

Kandris, D., P. Tsioumas, A. Tzes, G. Nikolakopoulos and D.D. Vergados, 2009. Power conservation through energy efficient routing in wireless sensor networks. Sensors, 9: 7320-7342.

Mhatre, V. and C. Rosenberg, 2004. Design guidelines for wireless sensor networks: Communication, clustering and aggregation. Ad Hoc Networks, 2: 45-63.

Muruganathan, S.D., D.C.F. Ma, R.I. Bhasin and A. Fapojuwo, 2005. A centralized energy-efficient routing protocol for wireless sensor networks. IEEE Commun. Maga., 43: S8-S13.