INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN: 2278 – 0211 (Online) / 2278-7631 (Print)

Rapid Spanning Tree And Cluster Head Routing In Wsn's Using A Hybrid Routing Protocol

Y.Chalapathi Rao
Research scholar,ANU College of Engg&Tech
Guntur, Andhra Pradesh, India.

Dr.Ch.Santhi Rani
Professor in ECE Department,SVH Engineering College
Machilipatnam, AP, India.

P.Lavany
Assistant professor in ECE Dept,Dr.Paul Raj Engineering College
Bhadrachalam, AP, India.

Abstract:

Many routing, power management, and data dissemination protocols have been specifically designed for WSNs where energy awareness is an essential design issue. The focus, however, has been given to the routing protocols which might differ depending on the application and network architecture. Wireless Sensor Networks (WSNs) consist of small nodes with sensing, computation, and wireless communication capabilities. In this paper, Rapid Spanning Tree and Cluster Head Routing using we present a survey of the state-of-the-art routing technique and a novel energy efficient hybrid routing protocol. We first outline the design challenges for routing protocols in WSNs followed by a comprehensive survey of different routing techniques. Overall, the routing techniques are classified into four categories based on the underlying network structure: Data centric, hierarchical, location based and Quality of Service (QoS) based. Further, ManyToOne - A hybrid protocol based on Rapid Spanning Tree (RST) and Cluster Head Routing (CHR) uses clustering, which includes partitioning stage and choosing stage, namely, partitions the multi-hop network and then chooses cluster-heads; cluster-head is responsible for receiving, sending and maintaining information in its cluster. Then all cluster-heads will construct a Rapid spanning tree to prolong network lifetime, save energy and shorten path. RST provides faster spanning tree convergence after a topology change, thereby minimizing the energy consumed.

Keywords: *wireless sensor networks (WSNs);Rapid Spanning Tree; clustering; energy efficient*

Introduction

This Recent advances in highly integrated digital electronics have led to the development of micro sensors. Such sensors are generally equipped with data processing and communication capabilities. The sensing circuitry measures ambient condition related to the environment surrounding the sensor and transforms them into an electric signal. Processing such a signal reveals some properties about objects located and/or events happening in the vicinity of the sensor. The sensor sends such collected data, usually via radio transmitter, to a command centre (sink) either directly or through a data concentration centre (a gateway). The decrease in the size and cost of sensors, resulting from such technological advances, has fuelled interest in the possible use of large set of disposable unattended sensors. Such interest has motivated intensive research in the past few years addressing the potential collaboration among sensors in data gathering, processing, coordination, management of the sensing activity, data flow to the sink. A natural architecture for such collaborative distributed sensors is a network with wireless links that can be formed among the sensors in an ad hoc manner.Networking unattended sensor nodes are expected to have significant impact on the efficiency of many military and civil applications such as combat field surveillance, security and disaster management. These systems process data gathered from multiple sensors to monitor events in an area of interest. For example, in a disaster management setup, a large number of sensors can be dropped by a helicopter. Networking these sensors can assist rescue operations by locating survivors, identifying risky areas and making the rescue crew more aware of the overall situation. Such application of sensor networks not only can increase the efficiency of rescue operations but also ensure the safety of the rescue crew. On the military side, applications of sensor networks are numerous. For example, the use of networked set of sensors can limit the need for personnel involvement in the usually dangerous reconnaissance missions. In addition, sensor networks can enable a more civic use of landmines by making them remotely controllable and target-specific in order to prevent harming civilians and animals. Security applications of sensor networks include intrusion detection and criminal hunting. However, sensor nodes are constrained in energy supply and bandwidth. Such constraints combined with a typical deployment of large number of sensor nodes have posed many challenges to the design and management of sensor networks. These challenges necessitate energy-awareness at all layers of networking protocol stack. At the network layer, the main aim is to find ways for energy- efficient route setup and reliable relaying of data from the sensor nodes to the sink so that the lifetime of the network is maximized.Routing in sensor networks is very challenging due to several characteristics that distinguish them from contemporary communication and wireless ad-hoc networks. First of all, it is not possible to build a global addressing scheme for the deployment of sheer number of sensor nodes. Therefore, classical IP-based protocols cannot be applied to sensor networks. Secondly, in contrary to typical communication networks almost all applications of sensor networks require the flow of sensed data from multiple regions (sources) to a particular sink. Thirdly, generated data traffic has significant redundancy in it since multiple sensors may generate same data within the vicinity of a phenomenon. Such redundancy needs to be exploited by the routing protocols to improve energy and bandwidth utilization. Finally, sensor nodes are tightly constrained in terms of transmission power, on-board energy, processing capacity and storage and thus require careful resource management. Due to such differences, many new algorithms have been proposed for the problem of routing data in sensor networks. These routing mechanisms have considered the characteristics of sensor nodes along with the application and architecture requirements.

In this paper, we propose a novel energy-efficient routing protocol based on Rapid spanning tree and Cluster head routing for wireless sensor network to prolong network lifetime, minimize the energy consumed during tree convergence & topology change and shorten path while emphasizing energy conservation at the same time. Clustering includes partitioning stage and choosing stage, namely, partitions the multi-hop network and then chooses cluster heads; cluster-head is responsible for receiving, sending and maintaining information in its cluster. Then all cluster-heads will construct a spanning tree using RST protocol to prolong network lifetime, save energy and shorten path. We aim to show the modeling techniques for WSNs using dominating set and rapid spanning tree concepts and we describe our approaches based on dominating set and rapid spanning tree for clustering and backbone formation for WSNs. It is a promising approach and deserves more future research.

Challenges In Wireless Sensor Networking

As in embedded arena challenges are profound in wireless sensor networks. We broadly classify the challenges in sensor networks under the following category.

Network Dynamics

There are three main components in a sensor network. These are the sensor nodes, sink and monitored events. Aside from the very few setups that utilize mobile sensors, most of the network architectures assume that sensor nodes are stationary. On the other hand, supporting the mobility of sinks or cluster-heads (gateways) is sometimes deemed necessary. Routing messages from or to moving nodes is more challenging since route stability becomes an important optimization factor, in addition to energy, bandwidth etc. The sensed event can be either dynamic or static depending on the application. For instance, in a target detection/tracking application, the event (phenomenon) is dynamic whereas forest monitoring for early fire prevention is an example of static events. Monitoring static events allows the network to work in a reactive mode, simply generating traffic when reporting. Dynamic events in most applications require periodic reporting and consequently generate significant traffic to be routed to the sink.

Node Deployment

Another consideration is the topological deployment of nodes. This is application dependent and affects the performance of the routing protocol. The deployment is either deterministic or self-organizing. In deterministic situations, the sensors are manually placed and data is routed through predetermined paths. However in self-organizing systems, the sensor nodes are scattered randomly creating an infrastructure in an ad hoc manner In that infrastructure, the position of the sink or the cluster-head is also crucial in terms of energy efficiency and performance. When the distribution of nodes is not uniform, optimal clustering becomes a pressing issue to enable energy efficient network operation.

Energy Considerations

During the creation of an infrastructure, the process of setting up the routes is greatly influenced by energy considerations. Since the transmission power of a wireless radio is proportional to distance squared or even higher order in the presence of obstacles, multi-hop routing will consume less energy than direct communication. However, multi-hop routing introduces significant overhead for topology management and medium access control. Direct routing would perform well enough if all the nodes were very close to the sink. Most of the time sensors are scattered randomly over an area of interest and multi-hop routing becomes unavoidable. The routing protocol is highly influenced by the data delivery model, especially with regard to the minimization of energy consumption and route stability. For instance, it has been concluded in that for a habitat monitoring application where data is continuously transmitted to the sink, a hierarchical routing protocol is the most efficient alternative. This is due to the fact that such an application generates significant redundant data that can be aggregated on route to the sink, thus reducing traffic and saving energy.

Data Aggregation/Fusion

Since sensor nodes might generate significant redundant data, similar packets from multiple nodes can be aggregated so that the number of transmissions would be reduced. Data aggregation is the combination of data from different sources by using functions such as suppression (eliminating duplicates), min, max and average. Some of these functions can be performed either partially or fully in each sensor node, by allowing sensor nodes to conduct in-network data reduction. Recognizing that computation would be less energy consuming than communication, substantial energy savings can be obtained through data aggregation. This technique has been used to achieve energy efficiency and traffic optimization in a number of routing protocols. In some network architectures, all aggregation functions are assigned to more powerful and specialized nodes. Data aggregation is also feasible through signal processing techniques. In that case, it is referred as data fusion where a node is capable of producing a more accurate signal by reducing the noise and using some techniques such as beams forming to combine the signals.

Routing Protocols In Wireless Sensor Networks

Having looked at the challenges in the wireless sensor networks it's time to dive in to the routing protocols. Since it's difficult for a single protocol to solve all the above challenges the routing protocols were designed with specific goals. We classify the routing protocols based on their goals.

Data Centric Routing Protocols

In many applications of sensor networks, it is not feasible to assign global identifiers to each node due to the sheer number of nodes deployed. Such lack of global identification along with random deployment of sensor nodes makes it hard to select a specific set of sensor nodes to be queried. Therefore, data is usually transmitted from every sensor node within the deployment region with significant redundancy. Since this is very inefficient in terms of energy consumption, routing protocols that will be able to select a set of sensor nodes and utilize data aggregation during the relaying of data have been considered. This consideration has led to data centric routing, which is different from traditional address-based routing where routes are created between addressable nodes managed in the network layer of the communication stack. E.g.: Directed Diffusion.

Hierarchical Protocols

Similar to other communication networks, scalability is one of the major design attributes of sensor networks. A single-tier network can cause the gateway to overload with the increase in sensors density. Such overload might cause latency in communication and inadequate tracking of events. In addition, the single-gateway architecture is not scalable for a larger set of sensors covering a wider area of interest since the sensors are typically not capable of long-haul communication. To allow the system to cope with additional load and to be able to cover a large area of interest without degrading the service, networking clustering has been pursued in some routing approaches. 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. E.g.: Low-Energy Adaptive Clustering Hierarchy (LEACH), Two Tier Data Dissemination.

Location Based Routing Protocols

Most of the routing protocols for sensor networks require location information for sensor nodes. In most cases location information is needed in order to calculate the distance between two particular nodes so that energy consumption can be estimated. Since, there is no addressing scheme for sensor networks like IP addresses and they are spatially deployed on a region, location information can be utilized in routing data in an energy efficient way. For instance, if the region to be sensed is known, using the location of sensors, the query can be diffused only to that particular region which will eliminate the number of transmission significantly. Some of the protocols discussed here are designed primarily for mobile ad hoc networks and consider the mobility of nodes during the design. However, they are also well applicable to sensor networks where there is less or no mobility. E.g.: Geographic and Energy Aware Routing (GEAR).

Network Flow And Qos-Aware Protocols

Although most of the routing protocols proposed for sensor networks fit our classification, some pursue somewhat different approach such as network flow and QoS. In some approaches, route setup is modeled and solved as a network flow problem. QoS-aware protocols consider end-to-end delay requirements while setting up the paths in the sensor network. E.g.: Sequential Assignment Routing (SAR), Energy-Aware QoS Routing Protocol.

Rapid Spanning Tree And Cluster Head Routing

System model

Consider a multi-hop WSN consisting of M clusters arranged as shown n Fig.1.Cluster i has n_i sensing nodes and a cluster head which is used for management and relaying. (where i =1, 2... M). The distance between the sink and the 1st cluster is d_1 and between the j^{th} cluster and the i^{th} cluster is d_{ij}. A cluster-head not only collects data from the sensing nodes of its cluster but also relays collected data from other cluster head. This many-to-one data routing paradigm leads to nonuniform traffic distribution in different clusters of the WSN. The cluster-heads closer to the sink transfer more traffic than those located at farther region.

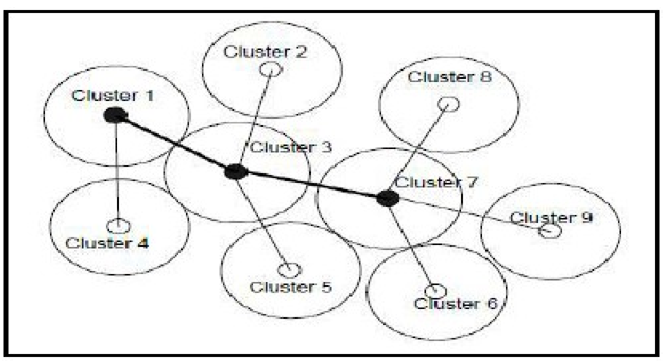

Figure 1: Clustered WSN using Rapid Spanning Tree

Sensors and cluster-heads are assumed to be stationary or limited moving inside clusters. Sensorsreceive commands from and send data to its cluster-head, which does preprocessing for the data and forward them to other cluster heads. A cluster-head is located within the communication range of all the sensors of its cluster and can communicate with its neighbor cluster-heads. Since a cluster-head forwards traffic to

other cluster-heads with longer distance as compared to its sensing nodes, in some applications it is more powerful than the sensing nodes in terms of energy, bandwidth and memory, while others select cluster–heads from the deployed sensors. When a cluster-head is under failure due to insufficient power, another cluster-head will be selected among the sensors (assume a sensor can adjust its transmission power to a larger value once it is selected as a cluster-head.). The cluster-based architecture raises many interesting issues such as cluster formation, cluster-head selection and cluster maintenances, which are beyond the scope of this work. Here, we only focus on modeling the traffic behavior along with the multi-hop cluster-heads by Rapid spanning tree.

The system model consists of five parts:

<u>Constructing cluster-head</u>

Dynamic construction of a cluster head according to the remainder energy.

<u>Constructing Spanning Tree</u>

Construction of spanning tree using RST to achieve maximum lifetime and minimize the tree convergence time.

<u>Sensing</u>

Sensors around the target area are responsible for probing the target/event and send the collected data to their cluster-head..

<u>Data Forwarding</u>

Collected data are transmitted through among the cluster-heads by Rapid spanning tree until to the sink.

<u>Sink</u>

Sink performs system-level data analysis and process for overall situation awareness.

Energy Computation

For a simplified power model of radio communication, the energy consumed per second are the key challenges in unlocking the potential of transmission is

$$E_t(i) = (e_t + e_d\, r^n)\, B \qquad (1)$$

Where e_t is the energy/bit consumed by the transmitter electronics and e_d accounts for energy dissipated in the transmit op-amp (including op-amp inefficiencies). Both e_t and

e_d are properties of the transceiver used by the nodes, r is the transmission range used. The parameter n is the power index for the channel path loss of the antenna. This factor depends on the RF environment and is generally between 2 and 4. B is the bit rate of the radio and is a fixed Topology management provides the distributed parameter. On the receiving side, a fixed amount of power is required to capture the incoming radio signal.

$$E_r(j) = e_r B \qquad (2)$$

e_r is the energy/bit consumed by the receiver electronics used by the node. Energy consumed by one-hop communication in a finite one dimensional network from the i^{th} cluster-head to the j^{th} cluster-head across a distance d_{ij} is,

$$E_t(i,j) = (e_t + e_d\, d_{ij}^{\ n})BA_i \qquad (3)$$

The j^{th} cluster-head as the receiver, the power consumed by this communication is then simply

$$E_r(j,i) = e_r B\ A_i \qquad (4)$$

By combining Eq. (1) to Eq. (4) with the cluster-based WSN model in Fig. 1, we know the energy consumed at the cluster head is much larger than that at individual sensing node.

The reason is as follows:

The cluster-head needs to relay all the traffic of the cluster

For each data unit, the cluster-head needs to transmit longer distance due to transmission between clusters, while the sensing nodes just transmit data inside the cluster.

Dominating Sets For RST-CH Routing

Nodes in WSN can be represented in form of a graph (G). Every vertex in G is either in S or adjacent to a vertex in S. Dominating sets can be classified into three main classes, Connected Dominating Sets (CDS), Weakly Connected Dominating Sets (WCDS) and Independent Dominating Sets(IDS) as described below and also shown in Fig.2.

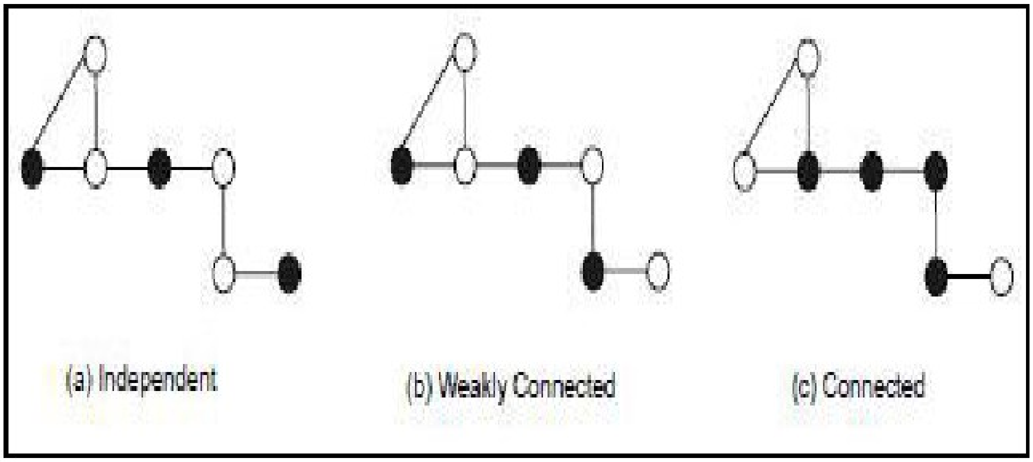

Figure 2: Classification of Dominating sets

Independent Dominating Sets

IDS is a dominating set S of a graph G in which there is no adjacent vertices. Fig.1.a shows a sample independent dominating set where black nodes show cluster heads.

Weakly Connected Dominating Sets

A weakly induced sub graph Sw is a subset S of a graph G that contains the vertices of S their neighbors and all edges of the original graph G with at least one endpoint in S. A subset S is a weakly-connected dominating set, if S is dominating and Sw is connected. Black nodes in Fig.1.b show a WCDS example.

Connected Dominating Set

A connected dominating set (CDS) is a subset S of a graph G such that S forms a dominating set and S is connected. Fig.1.c shows a sample CDS.

A graph G is connected if there is a path between any distinct V. A graph Gs = (Gs, Es) is a spanning sub graph of G= (V, E) if Vs = V. A spanning tree of a graph is an undirected connected acyclic spanning sub graph. Intuitively, a spanning tree for a graph is a sub graph that has the minimum number of edges for maintaining connectivity. This minimizes the number of dummy clusters in the network. Although IDS are suitable for constructing optimum sized dominating sets, they have some deficiencies such as lack of direct communication between cluster heads.

Clustering and Rapid Spanning Tree

In this analysis, we consider the wireless networks where all nodes in the network are homogenous and energy constrained, and each node can vary its transmission range to directly communicate with any node in the network. In this environment, instead of using a flat configuration, adopting the clustering approach can statistically multiplex many connections into a few paths so that the overall interferences can be reduced with well-controlled access.

Clustering Cluster Head

The process of constructing cluster-head is comprised of two phases, as illustrated below:

a. Initial phase

First, partitions the multi-hop network and then chooses cluster-heads with the following stages

Partitioning stage Nodes in WSN partitions into clusters according to some distributed clustering algorithm.

Choosing stage Every node within a cluster sends its remaining energy, to the cluster-head to which it belongs. The cluster-head, upon receiving the power information choose the node with the maximum power as the new cluster-head and broadcasts the decision to its member. From now on, the cluster-head become a normal member, which listens to the messages from the new head just like the other members.

b. Re-clustering phase

When the energy of a cluster-head is lower than threshold, a cluster-head switches its role back to a node with the most residual power within the cluster. Since the power information is maintained by the cluster-head, this can be done easily with broadcasting message.

Constructing Rapid spanning tree By using IDS, one can guarantee that there are no adjacent cluster heads in the entire graph. This minimizes the number of dummy clusters in the network. Although IDS are suitable for constructing optimum sized dominating sets, they have some deficiencies such as lack of direct communication between cluster heads. In order to obtain the connectivity between cluster heads, WCDSs can be used to construct clusters. CDSs have many advantages in network applications such as ease of broadcasting and constructing virtual backbones, however, when we try to obtain a connected dominating set, we may have undesirable number of cluster heads. So in constructing connected dominating sets, our primary problem is the minimum connected dominating set decision problem. Dominating Set Based Algorithm finds a minimal connected dominating set in a WSN.

Rapid Spanning Tree Construction The key idea in RSTP is to prune (looping) links in order to reduce the network topology to that of a tree. The resulting tree "spans" (i.e. connects) all nodes, but eliminates loops. The steps in order to best accomplish this process are:

Cluster head will send messages to each other that convey their identity and link "cost".

Elect a single cluster head, among all the cluster heads in the WSN to be a "root".

Let all other cluster heads calculate the direction and cost of the shortest path back to the root using messages received from cluster heads closer to the root. Each cluster head must have only one "best" way to forward frames to the root.If two cluster heads servicing the same messages with each other, the one with the lowest cost to the root will service the cluster. The cluster head will discard all frames received from that cluster, thus opening the link and blocking a traffic loop.

Rapid Spanning Tree based Modeling Merging Clustering Algorithm (MCA) finds clusters in a WSN [3] by merging the clusters to form higher level clusters as mentioned in Gallagher, Humblet, and Spira's algorithm. However, we focus on the clustering operation by rapid spanning tree. This reduces the message complexity. The second contribution is to use upper and lower bound heuristics for clustering operation which results balanced number of nodes in the cluster formed. We assume that each node has distinct node_id. Moreover, each node knows its cluster_leader_id, cluster_id and cluster_level. Cluster_level is identified by the number of the nodes in a cluster. Leader node is the node with maximum cluster_id. Cluster_leader_id is identified by the node_id of the leader node in a cluster.Cluster_leader_id is equal to the cluster_id. The local algorithm consists of sending messages over adjoining links, waiting for incoming messages and processing messages. The main idea of Backbone Formation Algorithm is to maintain directed ring architecture by constructing a spanning tree between cluster heads and classifying cluster heads into BACKBONE or LEAF nodes, periodically. To maintain these structures, each cluster head broadcasts a Leader_Info message by flooding. In this phase, cluster member nodes are acting as routers to transmit Leader_Info messages. Algorithm has two modes of operation; a hop-based backbone formation scheme and a position-based backbone formation scheme. In hop-based backbone formation scheme, minimum numbers of hops between cluster heads are taken into consideration in the Rapid spanning tree construction. Minimum hop counts can be obtained during the flooding scheme. For highly mobile scenarios, an agreement between cluster heads must be maintained to guarantee the consistent hop information. In position based backbone formation scheme, positions of Cluster heads are used to construct the spanning tree. If each node knows its velocity and the direction of velocity, this information can be appended with a timestamp to the Leader_Info message to construct a better spanning tree. But in this mode, nodes must be equipped with a position tracker like a GPS receiver. A balanced clustered WSN with its cluster heads and Rapid spanning tree is shown in Fig.1. BACKBONE cluster heads are filled with black and LEAF cluster heads are filled with white.

Simulation Results

The simulation is carried out using 10 to 200 nodes, with randomly deployed in 100m x 100m square area. The protocol stack is adjusted to IEEE 802.11 standards. We use Ad hoc On Demand Distance Vector (AODV) routing algorithm for earlier simulations. Later we implemented our cluster-based hybrid routing protocol and simulation results for the hybrid protocol based on Rapid Spanning Tree and Cluster Head Routing is shown in Figure 3.

Figure 3, shows the comparison of the network convergence time between Spanning Tree - Cluster Head Routing (CHR-STP) and Rapid Spanning Tree - Cluster Head Routing (CHR-RSTP). The network convergence time of CHR-RSTP was in terms of milliseconds (ms) where as the convergence time for same number of nodes was in terms of seconds. The least spanning tree algorithm passively waited for the network to converge before it turned a port into the forwarding state. The achievement of faster convergence was a due to rapid transition of port / channel states based on the Proposal-agreement algorithm in the Rapid Spanning Tree Protocol.

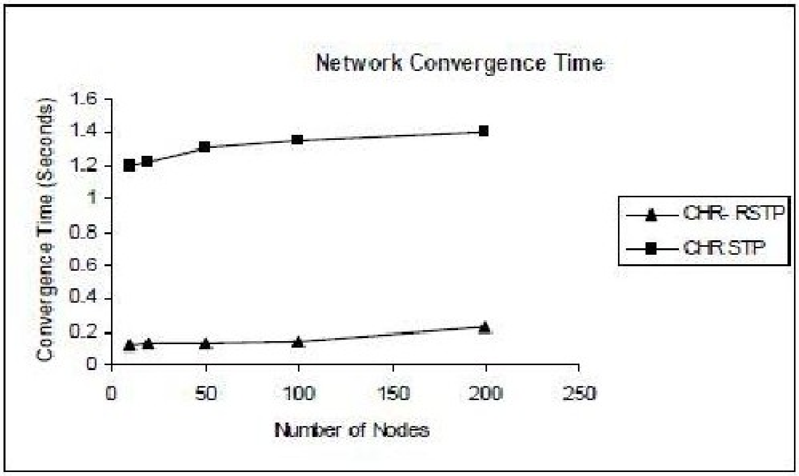

Figure 3. Network Convergence Time

When the energy level of the cluster head goes below the threshold level, the reelection of cluster head begin and hence change in topology of the spanned tree, which results in reconstruction of the spanning tree. Even during this time convergence time of CHR-RSTP was very less when compared to CHR-STP and hence all the nodes in the network are converged in shorter duration. Thereby minimizing initial data collection delay in the network and data loss due to change in topology of the network.

Conclusions

In this paper, we propose a novel energy-efficient hybrid routing protocol based on rapid spanning tree and cluster head routing for wireless sensor network to prolong network lifetime, Minimal convergence time in case of topology change and shorten path while emphasizing energy conservation at the same time. Clustering includes partitioning stage and choosing stage, namely, partitions the multi-hop network and then chooses cluster-heads; cluster-head is responsible for receiving, sending and maintaining information in its cluster. Then all cluster-heads will construct a Rapid spanning tree to prolong network lifetime, save energy and shorten path. Simulation results show that the convergence time has further improved by using hybrid protocol based on rapid spanning tree and clustering head routing.

Reference

1. Jamil I and Imad M, Cluster based routing in wireless sensor networks: Issues and Challenges, SPECTS, 2004
2. Wei-Tsung Su , Ko-Ming Chang, Yau-Kuo, eHIP: An energy efficient hybrid intrusion prohibition system for cluster-based WSN's, Computer Networks 51 (2007) .
3. Kayhan Erciyes, Orhan Dagdeviren, Deniz Cokuslu, Modeling and Simulation of Wireless Sensor and Mobile Ad hoc Networks, International Conference on Modeling and Simulation 2006.
4. Kayhan Erciyes , Orhan Dagdeviren , Deniz Cokuslu , Deniz Ozsoyeller, Graph Theoretic Clustering Algorithms in MANETs and WSNs, Appl. Comput. Math. 6 (2007).
5. M. Ilyas, I. Mahgoub, Handbook of Sensor Networks:Compact Wireless and Wired Sensing Systems, CRC Press,New York, 2005.
6. Ming Zhang,Yanhong Lu, Chenglong Gong, Energy-Efficient Routing Protocol based on Clustering and Least Spanning Tree in WSN's, International Conference on Computer Science and Software Engineering, 2008.
7. Karthickraja N P , Dr.V.Sumathy, Deepak Pandian, Routing Protocols in WSN's, Embeddd System Conference, Bangalore 2008.
8. S. Gandham, M. Dawande and R. Prakash, "Link scheduling in sensor networks: distributed edge coloring revisited," *IEEE INFOCOM*, March 2005.
9. Ma Chaw Mon Thein, Thandar Thein "An Energy Efficient Cluster- Head Selection for WSN's" 2010 International Conference on Intelligent Systems, Modelling and Simulation.