Report on Design of Distributed Energy Efficient and Reliable Routing Protocol for Wireless Sensor Networks

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***Abstract*—** A WSN (wireless sensor network) is a collection of nodes organized into a cooperative network, which are small energy constrained devices The efficient use of energy source in a sensor node is most desirable criteria for prolong the life time of wireless sensor network. So designing efficient routing for reducing energy consumption is the important factor. The energy consumed in cluster head (CH) selection phase of a random cluster based wireless sensor network (WSN) has been assumed as an insignificant factor in the previous research works. In this paper, the consumption of energy during the transmission of data from sensor nodes to the sink has been calculated. Routing protocols in WSNs along with the most energy efficient protocol named LEACH (low energy adaptive clustering hierarchy) and STR protocol (shortest tree routing protocol) along with its advantages and disadvantages are discussed here. In this paper we improved the energy consumption of the node to get the parameters result such as energy, delay, throughput, jitter and Packet delivery ratio (pdr).

***Index Terms*—** *Wireless sensor network, hierarchical routing, cluster based routing protocol, LEACH, Shortest path routing*.

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I. INTRODUCTION

A wireless sensor network is a collection of nodes organized into a cooperative network. Each node consists of processing capability (one or more microcontrollers, CPUs or DSP chips), may contain multiple types of memory (program, data and flash memories), have a RF transceiver (usually with a single omnidirectional antenna), have a power source (e.g., batteries and solar cells), and accommodate various sensors and actuators. The nodes communicate wirelessly and often self-organize after being deployed in an ad hoc fashion. Systems of 1000s or even 10,000 nodes are anticipated. Such systems can revolutionize the way we live and work. Wireless sensor networks are comprised of large numbers of low-cost, low-power and multifunctional sensor nodes. Thus, it is predicted that wireless sensor networks will become conventional in our daily life.

A wireless sensor network (WSN) is typically composed of a large number of low-cost sensor nodes, which work collectively to carry out some real-time sensing and monitoring tasks within a specific area. The main constituent of a WSN are multiple number of sensor nodes and at least one sink node. The number of sensor nodes depends upon the application's requirement.

Energy efficiency is one of the most important factors in WSNs. Hierarchical (clustering) techniques can aid in reducing useful energy consumption. LEACH is a classical clustering hierarchical protocol, which incorporates randomized rotation of the high-energy cluster head position among the sensors to avoid draining the energy of any one sensor in the network. In this way, the energy load of being a cluster head is evenly distributed among the nodes. The subsequent LEACH-optimized protocols in literatures mostly improve the capability of cluster head distribution, so that the energy consumption of the whole network is reduced and the system lifetime is prolonged. However, all these hierarchical protocols only consider the algorithm of cluster formation and give little consideration on aggregated data transmission. Since the aggregated data is important, the reliability of transmission should be guaranteed.

The proposed model is on LEACH and STR protocol and also compared with only STR protocol and no protocol to get the parameters result such as energy, delay, throughput, jitter and pdr. LEACH is used for the cluster head formation and STR protocol is used for finding the shortest tree routing nodes with minimum score of the node and transmits the data by dividing into two way and then data aggregation is done in the next cluster head near to the neighbour to destination node. In this way we can minimise the energy consumption of the node.

The remainder of this paper is organized as follows: Section 2 presents the related works .Section 3 describes the proposed protocol in details. In section 4 we make analysis and simulation, comparing with the previous multipath routing protocols. Finally, section 5 draws conclusions and shows the future works.

II. RELATED WORK

Routing Protocol for Wireless Sensor Network

Recent advances in wireless sensor networks have lead to many new protocols specifically designed for sensor networks where energy awareness is an essential consideration. But approaches like Direct Communication and Minimum Transmission Energy do not guarantee balanced energy distribution among the sensor nodes. In Direct Communication Protocol each sensor node transmits information directly to the base station, regardless of distance. On the other hand, in case of Minimum Transmission Energy routing protocol data is transmitted through intermediate nodes. we classified most important energy efficient routing techniques based on various clustering attributes like cluster formation and data gathering process.

A.LEACH

W. R. Heinzelman, A. P. Chandrakasan and H. Balakrishnan proposed Low Energy Adaptive Clustering Hierarchy (LEACH)

protocol in 2000. It is one of the most popular hierarchical routing algorithms for sensor networks. This protocol incorporates the formation of clusters and cluster heads (CHs) for the respective clusters in which all the other sensor nodes send the data to the cluster head (CH). The received data is then aggregated and is sent to the base-station (BS) periodically by the cluster head which reduces the amount of data that is to be transmitted to the basestation. The role of the cluster head (CH) is rotated among the other sensor nodes in the cluster so as to evenly distribute the power load between the sensor nodes in a particular cluster. A TDMA/CDMA MAC is used for avoiding the collisions among the clusters and within the clusters.

Working Principle: The LEACH protocol functions in two different phases. The setup phase and the steady state phase . The formation of clusters and selection of the cluster heads is done during the setup phase and the aggregated data is transmitted to the base-station during the steady state phase which is of greater duration than the setup phase. During the setup phase, a random number r, between 0 and 1, is selected by the sensor nodes. If this random number is less than a threshold value T(n), that sensor node is selected as the cluster head. The threshold value T(n) is calculated as follows :

$$T(n) = p / [1-p(r \bmod(1/p))] \text{ if } n \epsilon G$$

Where, p is the predetermined number of sensor nodes, r is the random number and G is the set of nodes that are involved in the CH selection that have not been selected as cluster heads in the last (1/p) round. After the selection, the cluster heads sends an advertisement to all the other sensor nodes in the network. The formation of clusters is based upon the signal strength of this advertisement. After the cluster formation, a TDMA schedule is created assigning time slots to the sensor nodes for data transmission. After the cluster formation and the selection of the cluster heads, the network goes into steady state phase where the aggregated data from the sensor nodes is sent to the base-station by the cluster heads. The network again goes back into the setup phase after a predetermined time period to select a new set of cluster heads as to rotate the role of the cluster heads among the nodes of a cluster.

The network lifetime is increased as the load of power dissipation is evenly distributed among the nodes in the cluster. Also the amount of data to be transmitted is less which in turn reduces the latency of the network. The LEACH protocol is not suitable for networks deployed in large areas. Also the predetermined cluster heads may not be uniformly distributed. The path taken by the aggregated data to reach the base station is not optimal.

B.PEGASIS

The Power-Efficient Gathering in Sensor Information Systems (PEGASIS) proposed in is an improvement over the LEACH protocol. It is a near optimal chain-based protocol. The idea of cluster formation and cluster head is discarded in PEGASIS. Instead of multiple nodes, a single node in the chain communicates with the base-station. The sensor nodes in this protocol only communicate with a single node closest to them and communication with the base-station is done in rounds so that the power dissipation in communicating with the base-station is distributed evenly among all the nodes.

Working Principle: PEGASIS assumes that all the sensor nodes maintain a database of the location of all the other nodes in the network. Each node determines the distance of its neighboring nodes using the signal strength and adjusts the signal strength only to communicate with the closest node. In PEGASIS, the sensor nodes closest to each other are in the chain and they form a path to transmit the aggregated data to the base-station. The chain is constructed using Greedy algorithms. Each sensor node sends the sensed data to its closest node in the chain. The data is aggregated at each node in the chain and finally only the aggregated data is sent to the base-station. The lifetime of each node is increased as they only have to communicate with their closest node which, as a result increases the network lifetime. Delay is caused in data transmission from the distant node in the chain. There is significant overhead as the nodes need the know-how about the other node location and the path for transmitting data.To overcome the problem of delay occurrence in transmitting the aggregated data to the base-station (BS) an extension to PEGASIS, called Hierarchical-

PEGASIS was introduced in which the transmission of the data was allowed only by the spatially separated sensor nodes. This ensured parallel data transmission and reduced the delay.

C. TEEN

Threshold-sensitive Energy Efficient sensor Network (TEEN) is a hierarchy based routing protocols proposed in, for time-critical applications. The region is sensed continuously by the sensor nodes but the sensed data is transmitted less frequently. The cluster heads (CHs) broadcasts a hard threshold, which is the threshold value of the sensed data and a soft threshold, which is a small change in the hard threshold value of the sensed data to all the other sensor nodes in a cluster. The soft threshold instigates the sensor node to switch on its transmitter and transmit the data.

Working Principle: In TEEN, a hard threshold value and a soft threshold value is sent to all the other sensor nodes by their respective cluster heads (CHs). The sensor nodes begin to transmit data by switching on their transmitters when they sense a change in the soft threshold value. Transmission of data occurs only when the sensed data is in the range of interest of the user.

Adv/Disadv: TEEN protocol reduces the number of transmissions by only transmitting the data only when the sensed data is of interest to the user. The major disadvantage of the TEEN protocol is that, if the threshold values are not received, the sensor nodes will not communicate and the user will not receive any data either.

D. APTEEN

Def: Adaptive Periodic Threshold-sensitive Energy Efficient sensor Network (APTEEN), is a hybrid protocol which was proposed in, is also for time critical applications. In APTEEN, according to the user needs and the application type, the threshold values used in TEEN are changed at some specific time intervals.

Working Principle: In APTEEN, few parameters such as the

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3676 - 3681

Attributes (A), Hard Threshold (HT), Soft threshold (ST), Schedule and Count Time (CT) are sent to the other sensor nodes in the cluster by the respective cluster heads (CHs). When the sensed data value is greater than the HT, the data is transmitted only when there is a change in that value. Each sensor node in the cluster is given a time slot using a modified TDMA schedule for transmission. When a sensor node does not transmit data for a time period equal to the CT, it is forced to sense again and retransmit the data.

APTEEN is flexible, as the power consumption is controlled by the user by changing the count time (CT) and the threshold values. The implementation of the threshold values and the count time (CT) is complex. Also the overhead increases.

III.Proposed Protocol

A.Introduction

The proposed model is on LEACH and STR protocol and also compared with only STR protocol and no protocol to get the parameters result such as energy, delay, throughput, jitter and pdr. LEACH is used for the cluster head formation and STR protocol is used for finding the shortest tree routing nodes with minimum score of the node and transmits the data by dividing into two way and then data aggregation is done in the next cluster head near to the neighbour to destination node. In this way we can minimise the energy consumption of the node.

B.Cluster Formation

LEACH is one of the first hierarchical routing protocols for WSNs. The idea proposed in LEACH has inspired many other hierarchical routing protocols. Clustering is the method by which sensor nodes in a network organize themselves into hierarchical structures. By doing this, sensor nodes can use the scarce network resources such as radio resource, battery power more efficiently. Within a particular cluster, data aggregation and fusion are performed at cluster- head to reduce the amount of data transmitting to the base station. Cluster formation is usually based on remaining energy of sensor nodes and sensor's proximity to cluster-head. Non cluster-head nodes choose their cluster-head right after deployment and transmit data to the cluster-head. The role of cluster-head is to forward these data and its own data to the base station after performing data aggregation and fusion.

C.LEACH (Low-Energy Adaptive Clustering Hierarchy)

Low Energy Adaptive Clustering Hierarchy (LEACH) proposed by Wendi B. Heinzelman, et al. is the first hierarchical, self-organizing, adaptive cluster-based routing protocol for wireless sensor networks which partitions the nodes into clusters, in each cluster a dedicated node with extra privileges called Cluster Head (CH) is responsible for creating and manipulating a TDMA (Time division multiple access) schedule and sending aggregated data from nodes to the BS where these data is needed using CDMA (Code division multiple access). Remaining nodes are cluster members.In Adaptive clustering, cluster heads change as nodes move in order to keep the network fully connected.

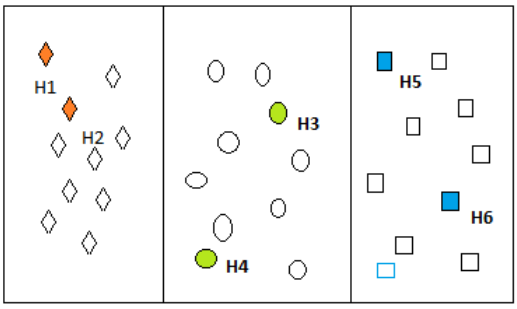

Fig. Multiple Cluster-head in small region.

Key Features of LEACH (Low-Energy Adaptive Clustering Hierarchy)

- Localized coordination and control for cluster set up and operation.
- Local compression to reduce global communication
- Randomized rotation of the cluster heads and the corresponding clusters.
- Random Death of nodes : there is no one section of the environment that is not being "sensed" as nodes die, as occurs in the other protocols.

D.STR protocol (Shortest tree routing protocol)

By formation of cluster head, with highest energy node using LEACH protocol then we uses STR protocol. The STR protocol is used for finding the shortest tree routing nodes with minimum score of the node and transmits the data by dividing into two way and then data aggregation is done in the next cluster head near to the neighbour to destination node. In this way we can minimise the energy consumption of the node.

E. Principle of Proposed Protocol

We proposed the model of LEACH and STR protocol and also compared with only STR protocol and no protocol to get the parameters result such as energy, delay, throughput, jitter and pdr. LEACH is used for the cluster head formation with highest energy node and STR protocol is used for finding the shortest tree routing node with minimum score of the node and transmits the data by dividing into two way and then data aggregation is done in the next cluster head near to the neighbour to destination node. In this way we can minimise the energy consumption of the node.

Consider the above sensor network in which shows the multiple cluster head in small region (fig.). Here we define the no of nodes (nn), which is 30 nodes and cluster head (CH_n) in the network with three group of cluster heads consisting of each cluster heads has 10 sensor nodes including two cluster heads. These cluster heads are formed by LEACH protocol with selecting highest energy of the sensor node into hierarchical structures and lebel it as (CH_n) and (CH_{n+1}) such that $E(CH_n) > E(CH_{n+1})$.This work done by the LEACH protocol.

Then the STR protocol is used after creation of cluster head. We have to find the score of the nodes. This way we will find two shortest tree routing nodes which has minimum score of the nodes and communication will start between the nodes i.e from source to destination. The data will be transmitted by the two shortest path by dividing the data into two ways and then that

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data aggregates to the next cluster head near to the neighbour of destination node. In this way we can minimise the energy consumption of the node. Also we get result of the parameter energy, delay, throughput, jitter and pdr which shown the next chapter.

Now the number of nodes is 30 in the sensor network by making group of 10 node there is formation of cluster. Each cluster has two cluster heads which has maximum energy node. Then we will find two shortest tree routing nodes which has minimum score of the nodes and communication will start between the nodes i.e from source to destination. The data will be transmitted by the two shortest path by dividing the data into two ways and then that data aggregates to the next cluster head near to the neighbour of destination node. In this way we can minimise the energy consumption of the node. While running this model we can run it in three way as:

1) STR protocol+ Cluster head (LEACH)
2) Only STR protocol
3) Normal network (no protocol used)

In STR protocol+ Cluster head (LEACH), communication is done between source and destination with the help of two cluster heads. And also use STR protocol for shortest path so that data is divided into two ways and then that data aggregates to the next cluster head near to the neighbour of destination node. In this way we can minimise the energy consumption of the node.

In Only STR protocol, communication is done between source and destination without the help of two cluster heads. And then STR protocol is used for finding shortest tree routing node considering minimum score of the node we will transmit the data from source to destination.

In normal network no protocol is used that means the communication is done directly between source to destination. From the fig.6.1 working of the proposed protocol is as below

- In the cluster1, H1 and H2 are the two cluster heads having E(H1)>E(H2). In the cluster2, H3 and H4 are the two cluster heads having E(H3)>E(H4). In the cluster3, H5 and H6 are the two cluster heads having E(H5)>E(H6).
- If Data transmission done between first two cluster. Cluster head will find shortest path by using STR protocol.Then, data from the source will go to the H1 then, H1 will find such two nodes which having minimum score. And minimum score will find by ratio of minimum distance from H1 and high energy of the node.
- Suppose that node are S1 and S2.Then H1 will send the 50% data to S1 to H3 and other 50% data will send to S2 to H3. In this way data will aggregated to the cluster head H3 and then transmitted to the destination.

IV. Simulation

The performance of LEACH and STR protocol is being evaluated by analysis comparing with only STR protocol and normal network. For analysation we used NS2 and tested our protocols. For performance evaluations following parameters are taken into account: Energy, Network Throughput, Delay, Jitter, Pdr.

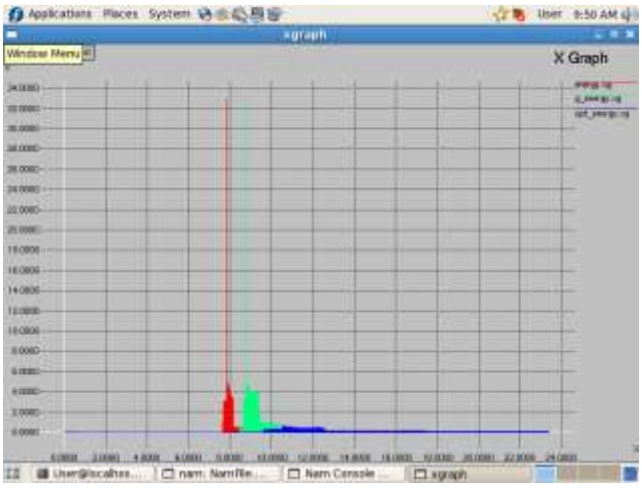

Fig.1 Comparison between energy for Normal protocol, Only STR Protocol and STR Protocol +Cluster Head (LEACH)

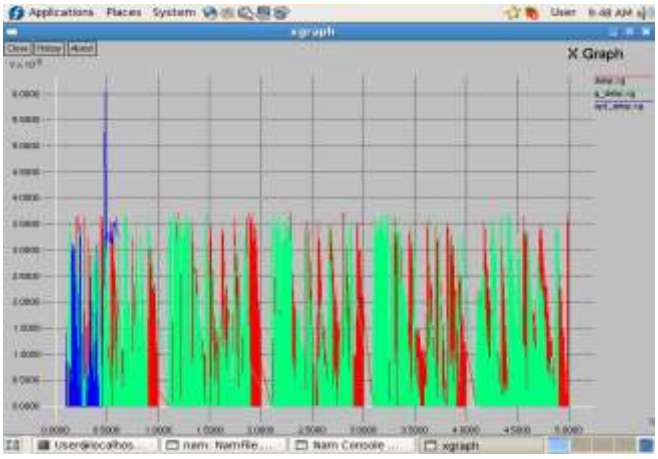

Fig.2 Comparison between dealy for Normal protocol, Only STR Protocol and STR Protocol +Cluster Head (LEACH)

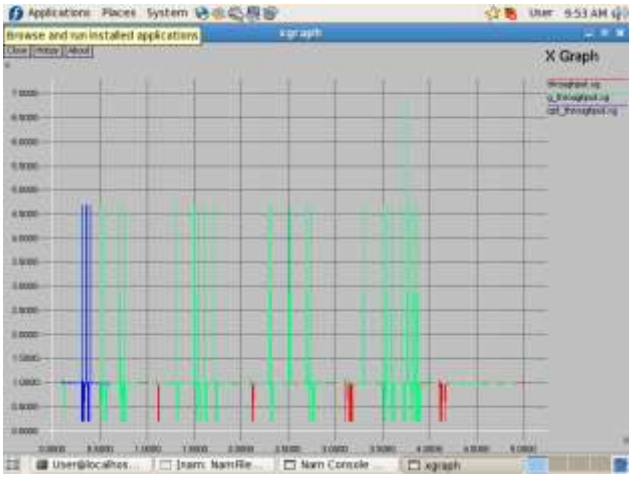

Fig.3 Comparison between throughput for Normal protocol, Only STR Protocol and STR Protocol +Cluster Head (LEACH)

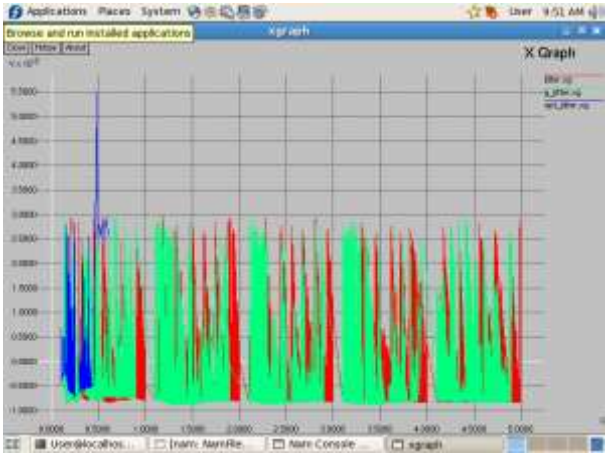

Fig.4 Comparison between jitter for Normal protocol, Only STR Protocol and STR Protocol +Cluster Head (LEACH)

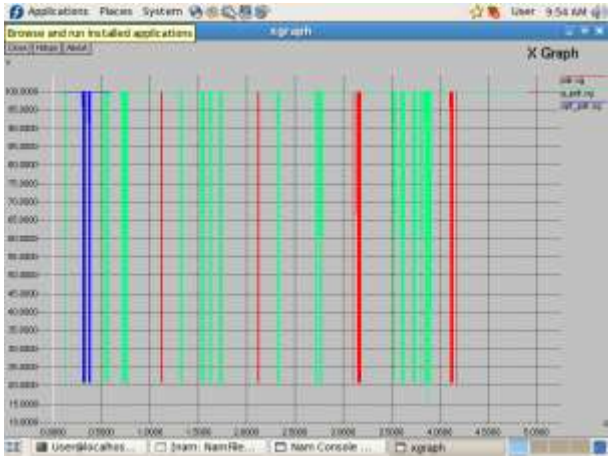

Fig.5 Comparison between pdr for Normal protocol, Only STR Protocol and STR Protocol +Cluster Head (LEACH)

In the given graphs, red color indicates normal network, green color indicates only STR protocol and blue color indicates STR protocol and cluster head. The comparison of parameter are as shown below:

Table .1 Comparison of all parameter for Normal protocol, Only STR Protocol and STR Protocol +Cluster Head (LEACH)

Sr. No.	Parameter	Energy consumption		
		Normal protocol (E_N)	Only STR Protocol (E_{STR})	STR Protocol +Cluster Head (LEACH) (E_{opt})
1	Energy	High	Medium	Low
2	Delay	High	Medium	Low
3	Throughput	Low	Medium	high
4	Jitter	High	Medium	Low
5	Pdr	Low	Medium	high

V. CONCLUSION

The main goal of this thesis was to minimize the energy consumption of the node. The proposed system consists of two main parts: clustering and shortest path routing. In this thesis we have presented a performance analysis of routing protocols for wireless network communication. These protocols have been implemented in NS-2 and are analyzed on the basis of four crucial parameters: energy , delay, throughput, jitter and pdr. After analyzing the graphs , we conclude that STR protocol and cluster head is better in comparison to only STR protocol and normal network. After applying the clustering and shortest path algorithm energy consumption of all parameters are improved.

As a future scope we can say that energy efficiency is one of the major design issues in wireless sensor networks. As most of the energy is consumed in communication than any other task so the need is to develop energy efficient routing protocols. Many of these protocols have been developed in the past few years but still improvements are required in routing protocols in terms of QoS parameters.

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