2012 2nd International Conference on Information and Network Technology (ICINT 2012)
IPCSIT vol. 27 (2012) © (2012) IACSIT Press, Singapore

An Approach for Prolonging the Life Time of Wireless Sensor Network

Rohit Kr Batwada, Meenakshi Tripathi, M.S.Gaur, Vijay Laxmi

Malaviya National Institute of Technology, Jaipur (Raj.)-India
{batwadarohit, indian.meenakshi, gaurms,vlgaur}@gmail.com

Abstract. Wireless sensor networks consists of thousands of tiny, low cost, low power and multifunctional sensor nodes where each sensor node has very low battery life. So to increase the network lifetime the routing algorithm must be energy efficient. LEACH uses distributed cluster formation & randomized rotation of the cluster head to minimize the network energy consumption. In this paper we proposed an algorithm which is modified version of LEACH and uses the remaining energy of a node while selecting the cluster head to increase the network lifetime. The resulting algorithm is then simulated on ns-2 under Linux operating system. We observed the significant improvement in the lifetime of the overall network.

Keywords: Wireless Sensor network, routing algorithm, LEACH, reliable, network lifetime.

1. Introduction

Wireless sensor networks consists of thousands of tiny, low cost, low power and multifunctional sensor nodes, each of which can sense various ambient conditions such as temperature, pressure, humidity, sound, lighting etc. and can communicate with each other through wireless medium. Sensor nodes are usually scattered in a region. Each sensor node has the capability to sense the data, compute some result and then communicate the result to the sink ([1], [2], [3]). Data are routed back to the end user by a multihop infrastructure less architecture through the sink. The sink may communicate to the task manager node via internet or satellite. The applications of sensor networks are quite numerous. Military applications, Environmental applications, natural habitat monitoring of birds [4], Biological applications: to monitor the glucose level, to detect the cancer, organ monitor, general health monitor etc.

Routing in sensor network is very challenging, since they are power constrained, a sensor node which is having 2 AA batteries can last upto three years. To Increase the lifetime of the network various strategies have been proposed and one of them is clustering where each cluster is being formed by combination of sensor nodes. Our clustering algorithm is an improvement of LEACH, where while selecting the cluster head after every round we consider their residual energy so that we can distribute the equal energy consumption to all the nodes. The paper is organized as follows: section 2 describes the various routing issues of the sensor networks, taxonomy of routing protocols is given in section 3, section 4 is about the LEACH protocol, simulation results are presented in section 5 followed by conclusions in section 6.

.

2. Routing Issues In Sensor Networks

Routing in sensor network is very challenging due to their specific characteristics. *First*, sensor networks are power constrained. Sensor nodes have small energy reserves. All communications even passive listening have a significant impact on those reserves. So to maximize the lifetime of the network, it is critical to maximize the usefulness of every bit transmitted or received. *Second*, these networks are expected to be highly dynamic in nature. Over time sensors may fail or new sensors may be added. Sensors are likely to experience change in their position, reachability, available energy, and even task details. These changes make static configuration unacceptable, the network must automatically adapt to changes in environment and requirements. *Third,* sensor networks must be self-configuring. Because of their deployment in large numbers or in places which are out of reach of a human being, the manual handling of the sensor nodes is not practical. *Fourth,* lack of global addressing scheme. Because of their dense nature it is very difficult to employ any global addressing scheme of wired networks. So traditional IP based protocols may not be applied to wireless sensor networks. An address-free architecture is proposed [5] for these networks, where nodes or data are described by attributes rather than addresses. *Fifth,* 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. *Sixth,* the number of nodes deployed in the sensing area may be in the order of hundreds, thousands, or more and routing schemes must be scalable enough to respond to events. *Seventh*, Sensor networks are application-specific. In some application (e.g. some military applications), the data should be delivered within a certain period of time from the moment it is sensed, while in other application (e.g. home security systems) the information should be sent only when an intruder is detected. Finally, Sensor networks can be deployed in hostile territory, where they can be subject to communication surveillance and node capture and compromise by adversaries. So routing algorithm must need to be designed in such a way that these problems can be avoided.

3. Taxonmy Of Routing Protocols In Sensor Netwroks

In broadways routing protocols [6] for sensor network can be divided into two categories *flat routing* and *hierarchical routing* depending on the network structure. In flat routing protocol each node plays the same role in the network, no hierarchy is there. Sensor networks are power constrained so multihop routing is used to send the data from various nodes to the sink. While in hierarchical routing protocols some sensor nodes are assigned special functionalities than other nodes in the network. This is achieved by cluster formation. A cluster consists of a set of geographically proximal sensor nodes; one of the nodes serves as a cluster head and all the other nodes are known as child of that cluster head. The cluster heads can be organized into further hierarchical levels. We worked upon LEACH one of the most common hierarchical routing protocols for the sensor networks.

Depending upon whether the routing protocol is exploiting the location information of sensor nodes in calculating the routes or not the protocols can be *location aware* or *location less* protocols. *Flooding-based* protocols rely primarily on flooding for route discovery. Many protocols couple query routing with data routing, i.e. source nodes transmit their observed data readings directly in response to queries from sink nodes. Such protocols can be classified as *query-driven* protocols. On the other hand, *data-driven* protocols assume that there is a separate query propagation phase by which some sensor nodes realize that their data should be sent to a sink. This phase is generally also responsible for setting up routes. Source nodes transmit their readings along these routes either periodically or whenever they observe some interesting events during the subsequent data transfer phase *Multipath routing* protocols attempt to construct several completely or partially disjoint paths from the source to the sink. This increases the resilience of the network to node failures. Some routing protocols try to achieve QoS requirement along with the routing function, these are known as *QoS routing* protocols.

4. Leach (Low Energy Adaptive Cluster Hierarchy)

Heinzelman et al [7] introduced LEACH, a hierarchical clustering algorithm for sensor networks. The operation of LEACH is divided into two rounds, having a cluster set-up phase and a steady-state phase to be a cluster-head; each node selects a random number x between 0 and 1. if the number is less than threshold T(n), the node becomes cluster-head for current round. The threshold is set as formula (1)

$$T(n) = 0 \qquad \forall n \notin G$$
$$T(n) = \frac{P}{1 - P\left(r \bmod \frac{1}{P}\right)} \qquad \forall n \in G \tag{1}$$

Where, P is the cluster-head probability, r is the number of the current round and G is the set of nodes that have not been cluster-heads in the last 1/P rounds. So after 1/P-1 rounds, T(n)=1 for all nodes that have not been a cluster-head. Proposed threshold $T(n)_{New}$ is given by formula (2) which directly correlates to the energy of the nodes. The improved threshold can make each node act as a cluster head in more balance, thus utilizing energy in the network effectively and prolonging survival time of the network to a certain extent.

$$T(n)_{New} = \frac{P}{1 - P\left(r \bmod \frac{1}{P}\right)} \frac{E_{n\_current}}{E_{n\_max}} \quad (2)$$

Now every cluster-head sends a TDMA schedule to all the nodes of its own cluster so that they can send the data to respective cluster-head within that schedule. Data transmission happens in two steps, in first step data are transmitted to cluster head nodes in their assigned TDMA slot and in second step the data aggregation take place from cluster head to sink. The frame time for this purpose is defined as follows:

FrameTime = (CAT+S) X Ts (3)

CAT - It is the number of time slots for data aggregation and transmission from cluster head to Base station.

S - Number of nodes during a particular round in TDMA schedule of clusters.

Ts - Time required for sensor node to transmit data frame to their corresponding cluster head.

The sensor nodes are adaptable and move to sleep mode after sending the information in their assigned TDMA slot and cluster head is always in wake up mode. The numbers of frame during a round of T duration are given by formula 4:

F = T / (CAT + S)* Ts (4)

According to this equation the clusters with small node degree(s) will transmit more data frames as compare to the clusters with large node degree(s). Cluster head having less node degree have to perform more task so they consume more energy and will die early as compared to the cluster head with more number of nodes. To solve the problem of unequal energy consumption by different clusters, a load balancing technique is also being proposed in which frame rate is adaptive to the number of nodes in a cluster. The expected number of nodes in each cluster S(E) is defined as:

S(E) = N/P

Where N is the number of nodes in the network and P is the desired percentage of cluster head for the network.When S<S (E) the frame time can be modified by formula 5:

FrameTime = (CAT+S (E)) x Ts (5)

Using this equation the number of data frames transmitted by the sensor nodes in clusters with small node degree is reduced. So the task of data aggregation and transmission to cluster head has been reduced. The energy saving and hence the network lifetime is increased. As well as the cluster head goes into sleep mode during time interval (S (E)-S) time slots after transmission of aggregated data frames to the base station so again we are conserving more energy. We simulated the scenario using ns-2 and compared the performance on the basis of network lifetime, energy and data transmission.

5. Simulation Parameters

We considered 100 sensor nodes which are spread uniformly over a square area of 100×100 unit area. Data packet size is set to 500 bytes and packet header size is 25 bytes. Desired number of cluster heads during a round is 5. Cluster head change time is 20 sec. Channel bandwidth is set to 1mbps. Simulation time for every simulation was 30 minutes. We ran the simulation for the BSD (Base Station Distance) 25, 50 and

75. We calculated the network lifetime, data gathered and network energy consumption at different number of node death.

When we compared our scheme with the LEACH, as shown in the Figure 1 our scheme shows the improvement by 5.12%, 2.37% and 1.37% in terms of energy consumption for first node death, half node death and last node death.

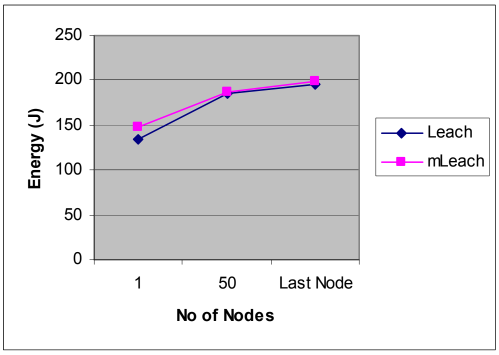

Fig. 1: Energy vs Node Death

In terms of data transmitted our scheme shows the improvement of 13.79%, 17.25 % and 20.88% for first node death, half node death and last node death which is observed from the Figure 2.

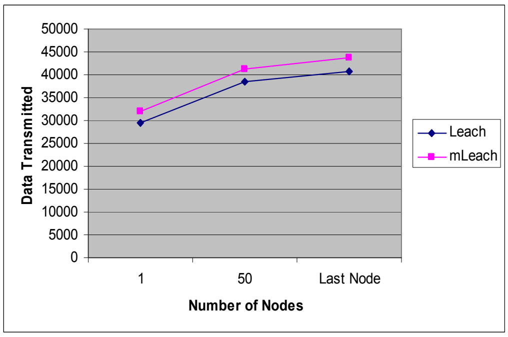

Fig. 2: Data Transmitted vs Node Death

Similarly as shown in figure 3 network lifetime has also been improved in terms of first node death, half node death and last node death.

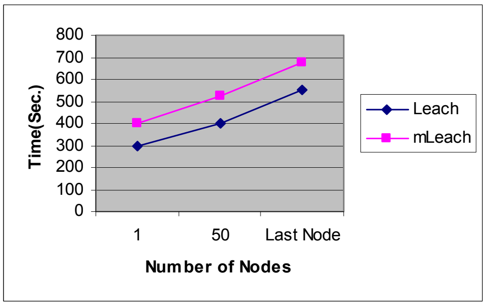

Fig. 3: Time vs Node Death

6. Conclusion

We used remaining energy and load balancing based approach for election of cluster head and through simulation we observed the significant improvement in overall network lifetime. The future work can include a concept of creating an energy bank for sensor network to reduce the energy consumption in which particular amount of energy has to be stored after each round in both routing and clustering phase to increase the network lifetime.

7. References

[1] Sayed Ahmed, Trlabs report: Current research on sensor networks. Technical report, TRLabs (Telecommunication Research Labs), Winnipeg, Manitoba, Canada, May 2004.

[2] I.F. Akyildiz, W.Su, Y.Sankarasubramaniam, and E.Cayirci. Routing techniques in wireless sensor networks: A survey. Computer Networks: The International Journal of Computer and Telecommunications Networking, 38(4):393--422, March 2002.

[3] Deepak Ganesan, Alberto Cerpa, Wei Ye, Yan Yu, Jerry Zhao, and Deborah Estrin. Networking issues in wireless sensor networks. Journal of Parallel and Distributed Computing, 64(7):799--814, 2004.

[4] Mainwaring, J. Polastre, R. Szewczyk, and J. Anderson D. Culler. Wireless sensor networks for habitat monitoring. In ACM International Workshop on Wireless Sensor Networks and Applications, Atlenta, Georgia, USA}, September 2002.

[5] J. Elson and D. Estrin. "An Address-Free Architecture for Dynamic Sensor Networks". Technical Report 00-724, Computer Science Department, USC, January 2000.

[6] Jamal, Ahmed E kamal "Routing techniques in wireless sensor networks: a survey ", IEEE Wireless Communications, Vol. 11, No. 6. (20 December 2004), pp. 6-28

[7] W. Heinzelman, A. Chandrakasan and H. Balakrishnan. Energy-Efficient Communication Protocol for Wireless Micro Sensor Networks. 33rd International Conference on System Sciences (HICSS), January 2000, pp. 8020-8029.

[8] C.P.Low, C.F.J.M.Ng, and N.H.Ang. Efficient load balanced clustering algorithms for wireless sensor networks. In Elsevier Computer communications, pages 750–759,2007.

[9] A.Chandrakasan W. Heinzelman and H.Balakrishnan. Energy-efficient communication protocol for wireless micro sensor networks. 33rd Annual V Hawaii International Conference on System Sciences (HICSS), Maui, HI, (12):3005–3014, January 2000.