IMPROVEMENT OF NETWORK LIFETIME USING MOBILE SENSOR RELOCATION

Priyanka G | Keerthana S
[1](CSE, P. A. College of Engineering and Technology, Coimbatore, India , priyanka1593g@gmail.com)
[2](CSE, P. A. College of Engineering and Technology, Coimbatore, India, keerthanasindu10@gmail.com)

***Abstract*—** The big challenge in wireless sensor network is maximizing network lifetime. The Minimization of Energy consumption is important to improve the network lifetime. Sensor nodes nearer to sink consume more energy than other nodes in the network. The nodes nearer to sink drains fast and causes death of the network. The Mobile Sensor Relocation concept is introduced to improve the network lifetime. In Mobile Sensor Relocation, the sensor nodes in high consumption position are relocated with lower consumption position based on energy threshold using Distributed Consumption Rate Algorithm. The energy threshold is calculated using adaptive energy threshold algorithm. so we can use this approach to extend network lifetime by reducing rotation overhead and energy consumption.

Keywords—Wireless Sensor Networks, Mobile node Relocation, Duty Cycling, Network Lifetime

1. INTRODUCTION

The Wireless Sensor Networks (WSNs) are used to collect data about the environment. It consists of energy constrained and low-cost sensors to monitor the physical environment. Sensors are used to collect information about the object and transmit the collected information to the base station and from there the user can access the data. A node in a sensor network is equipped with a typical radio transceiver, a small microcontroller and an energy source known as battery. A sensor node can operate in one of the three roles such as data collector, cluster head and data relay. The transducer module passes the sampled data directly to the communication module for transmission in a data collector node. A cluster-head node gathers the sensed data from the cluster members and performs data processing to aggregate multiple signals into one signal. The relay node receives the data from the nearby nodes and transmits the data to other nodes or to the base station.

The design of each system component can be optimized to minimize energy consumption. Energy consumption occurs in three aspects such as sensing, communication and data processing. Algorithmic modifications can often result in significant energy savings. The highly localized and distributed solutions for different levels of communication protocols are required because the communication of data consumes much more energy than sensing and data processing.

The approaches to improve the network lifetime in previous works are controlled mobility and duty cycling. The controlled mobility approach is the robotic mobility that consists of data mule, mobile relay and mobile base station. The data mules are the specialized sensor nodes that move around the network to gather the data. The mobile relay approach [8,9] relocates the sensors to different position to reduce communication distance between the sensors. The mobile base station approach [1,2] makes the sink node to move around the network to collect data. The duty cycling approach alternatively turns on and off the power to reduce energy consumption.

The concept of mobile node relocation[12] has been exploited to improve the efficiency of WSN. It involves relocating the mobile sensors to suitable position without changing the topology of the network. The node rotation concept satisfies the main requirements of improving the network life time such as the location of nodes is unchangeable and some nodes must have extra capabilities to perform complex motion planning. The node relocation concept is exhibited by means of huddling behavior of penguins which exchange their positions into and outside of huddle to withstand cold weather. The contributions in this paper are (1) The Adaptive Energy Threshold algorithm is presented.(2) The Distributed Consumption Rate Algorithm is used (3) The mobile node relocation is presented.

2. RELATED WORK

Many approaches have been proposed to improve the network lifetime. They are classified into main groups: duty cycling, data reduction, controlled mobility and mobile node rotation. In duty cycling approach, the nodes alternatively turn on and off according to their state. The nodes are in off condition when they are in idle state. The data reduction approach involves the nodes in reducing the amount of data generated and the energy consumed by the radio component. The controlled mobility is also called as robotic mobility which involves mobility without human support. The mobile node rotation involves swapping the position of nodes to suitable location.

The minimum-energy path-preserving topology-control algorithm [6] describes the condition necessary and sufficient for a graph to have minimum-energy property. This characterization constructs a topology control algorithm named small minimum-energy communication network (SMECN). A node tries to find the minimum power such that transmitting ensures that no minimum power is transmitted directly to node outside the range in the SMECN algorithm. The subnetwork constructed by SMECN contains no 2-redundant edges broadcasting at a same power setting are able to reach all nodes in a circular region around the broadcaster.

The multiple controlled mobile elements for data collection in sensor networks [3] describes load balancing algorithm. It is used to balance the number of sensor nodes serviced by mobile element. The multiple mobile elements are used for the purpose of data collection. A controlled mobile element is a promising approach to collect data from the sensor nodes. The sensor nodes and mobile elements may not be uniformly placed necessitating the use of load balancing to serve the sensor nodes.

Exploiting mobility for energy efficient data collection in wireless sensor networks [4] describes the three-tiered design MULE architecture. The key idea used is to exploit the mobile nodes in the environment and uses them as forwarding agents. This approach minimizes the communication responsibility of the resource-constrained sensors to extend the lifetime of the network. The energy savings of up to two orders of magnitude can be achieved with MULEs as compared to the traditional ad-hoc network approach.

The rendezvous planning in mobility-assisted wireless sensor networks [5] approach is used for utilizing Mobile Elements (ME) to collect sensor data under temporal constraints. The Rendezvous-based Data Collection (RDC) protocol provides reliable data transfers from the network to MEs. The results reveal significant reduction in network energy consumption and efficient scaling with network density, ME speed, and the number of different deadlines. RDC is robust to significant variance of ME speed.

The method restricted shortest-path based topology control algorithm (RLSP) in wireless multihop networks [7] describes an energy-efficient topology control algorithm. The algorithm first tries to preserve the minimum-energy paths. A two-hop path is used instead of single link during the need of large transmission power to cover some of the logical neighbours. Simulation results reveal that RLSP can effectively decrease the transmission power and reduce the energy consumption during transmission. This improves the network lifetime.

Maximizing data gathering capacity of wireless sensor networks using mobile relays [10] describes a new problem called max-data mobile relay configuration (MMRC). It is introduced for maximizing the data gathering capacity of hybrid wireless sensor networks consisting of both mobile and static nodes. We consider both the energy consumed during the transmission process as well as the energy consumed by mechanical locomotion. The simulations reveal that protocols quickly converge on a final solution with little messaging overhead.

A reliable clustering algorithm based on LEACH protocol in wireless mobile sensor networks [11] describes energy based clustering approach. The energy load among all the nodes is reduced and an improved algorithm called distributed-low energy adaptive clustering hierarchy (LEACH-D) based on LEACH was proposed. The algorithm combines the ideas of adjusting the threshold function about the nodes and a multi-hop communication mechanism among the cluster heads to achieve advancement in system lifetime. Simulation results reveal that the new strategy of cluster-heads election can improve the network's lifetime effectively.

3. MOBILE NODE RELOCATION

The mobile node relocation concept relocates the high consumption position with low consumption position. The node that is closer to sink is the high consumption position that consumes more energy than nodes in other position. The node relocation takes place when energy of the node in high consumption position falls below the threshold energy value. The threshold is calculated based on adaptive energy threshold algorithm. This algorithm calculates the energy based on number of packets transmitted and energy required for each packet. The node relocation is based on Distributed Consumption Rate Algorithm.

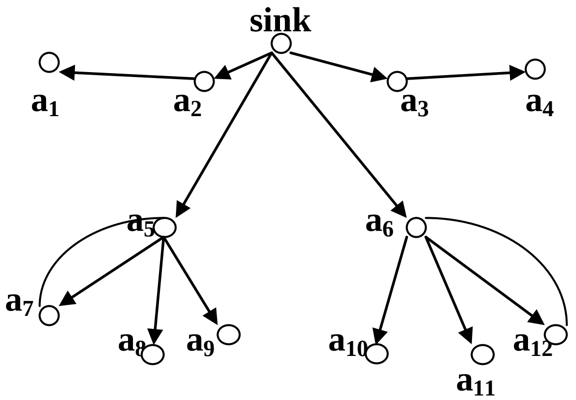

Fig. 1 Node rotation

The Fig 1 shows the routing tree consisting of single stationary sink and number of moveable sensor nodes namely a_1 to a_8. The sensor nodes a_2, a_3, a_5 and a_6 require more energy than other sensors. The sensor nodes a_7 to a_{12} that are located at low consumption position are swapped to positions a_5 and a_6 respectively. The amount of energy required at a high consumption location is shared by low consumption location sensors. This increases the network lifetime.

A. Adaptive Energy Threshold Algorithm

The adaptive energy threshold algorithm is used to determine the threshold value for energy level of node. It is also used to determine which node to move next. It is used as an input to Distributed Consumption Rate Algorithm for performing node rotation according to energy level. The steps used in calculating threshold are:

STEP 1: Get the data of source node in bytes (D).

STEP 2: Calculate the number of packets (P) required for sending data (D).

STEP 3: Get the energy required for single packet.

STEP 4: The total energy is calculated as D x P.

STEP 5: Set this energy as threshold energy (ρ).

STEP 6: Then broadcast the threshold energy information to all nodes in the network.

B. Distributed Consumption Rate Algorithm

This algorithm relocates the node according to energy level and location of the node. The relocation takes place when the energy falls below the threshold. It requires less information from the controller and also requires only local information. The global information is not necessary. It does not require any coordination between sensor nodes. The steps involved in Distributed Consumption Rate Algorithm are:

STEP 1: The controller collects only local information and energy from the sensor nodes.

STEP 2: Each node then calculates the energy drop level.

STEP 3: Then compare energy drop level with threshold value (p) calculated from adaptive energy threshold algorithm.

STEP 4: If energy drop level falls below the threshold value, then node swapping occurs by finding suitable swap candidate.

STEP 5: If energy drop level is greater than or equal to threshold value, then it remains in its own position.

The main advantage of this scheme is rotation of high energy consumption node with low energy consumption node. This improves network lifetime by reducing the rotation overhead. As the energy required for swapping is more than energy required for transmission, the swapping of nodes can be controlled through Adaptive Energy Threshold Algorithm.

4. RESULTS AND DISCUSSION

Finally we calculate network lifetime and energy consumption.

A. Simulation

OMNeT++ simulator is used. OMNeT++ is an object-oriented modular discrete event network simulation framework. OMNeT++ is not a simulator of itself, but also provides infrastructure and tools for writing simulations. The main ingredients of the infrastructure are component architecture for simulation models. Models are assembled from reusable components and it is called as modules. The well-written modules can be combined in various ways like LEGO blocks. Modules can also be connected with each other through gates and combined to form compound modules. Modules communication is made through message passing where messages carry arbitrary data structures. Modules pass messages along predefined paths through gates and connections. Modules at the lowest level of the module hierarchy are called simple modules and they are used to encapsulate model behavior.

Simple modules are programmed in C++ and OMNeT++ simulations are made to run under different user interfaces. Graphical and animating user interfaces are highly useful for demonstration and debugging purposes. The command-line user interfaces are best for batch execution. The simulator as well as user interfaces and tools are highly portable. They are tested on the most common operating systems such as Linux, Mac OS/X and Windows and also they can be compiled out of the box or after trivial modifications on most Unix-like operating systems. OMNeT++ supports parallel distributed simulation and use several mechanisms for communicating between partitions of a parallel distributed simulation. The parallel simulation algorithm can easily be extended or new ones can be installed. OMNeT++ is non-profitable and free only for academic purposes. It is not for commercial purposes.

OMNeT++ provides efficient tools for the user to describe the structure of the actual system.

Some of the main features are the following:

1. It consists of hierarchically nested modules.

2. Modules are the instances of module types.

3. Modules make communication using messages through channels.

4. Flexible module parameters are available.

5. It consists of Topology description language.

5. SIMULATION ENVIRONMENT AND RESULTS

The simulation is written in C++ to evaluate the performance. In this simulation, the rotation of node according to energy is shown. Here 25 nodes are deployed. Each node has minimum coverage of 35m. The network area is set as 100 x 100m area. Each node transfers the data it obtained from the sensor to one of nodes in the upper layer. The algorithm presented here works with general communication model where the nodes have different communication range. In our proposed scheme, we consider hierarchical routing where routing tree is constructed such that each node forward its data in hierarchical manner to the nearer node in the topology. Due to the reduction of rotation overhead, the lifetime of network is improved.

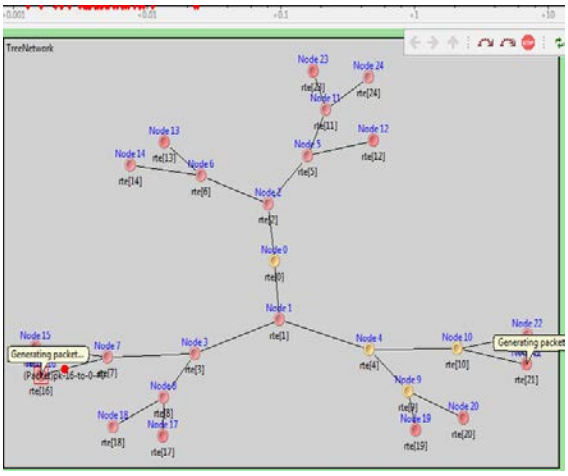

Fig.2 Node Formation with Packet Transmission

The Fig. 2 shows the deployment of nodes in the network region. The 25 nodes are arranged in tree based topology. The generating nodes are blue in color and transmitting nodes are yellow in color. The sink node is green in color. The red box represents packet transmission. The packets are transmitted from the source node to the sink node in multihop fashion. The nodes that involve in forwarding packets sees whether any more packets to be transmitted to same node. The routing takes place by using shortest path algorithm.

Fig. 3 shows the relocation of node based on threshold energy. In this topology node 1, node 3, node 4, node 5 and node 6 are in high consumption position. According to adaptive energy threshold algorithm, when the energy of these node go below the threshold energy the node relocation takes place. The number of packets transmitted is 10 and energy required for each packet is 5 J. The threshold is calculated as 50. The node rotation takes place using the concept of Distributed Consumption Rate Algorithm. The node 3 swaps with node 6, node 4 swaps with node 9, node1 swaps with node 19, node 2 swaps with node 6 and node 5 swaps with node 11.

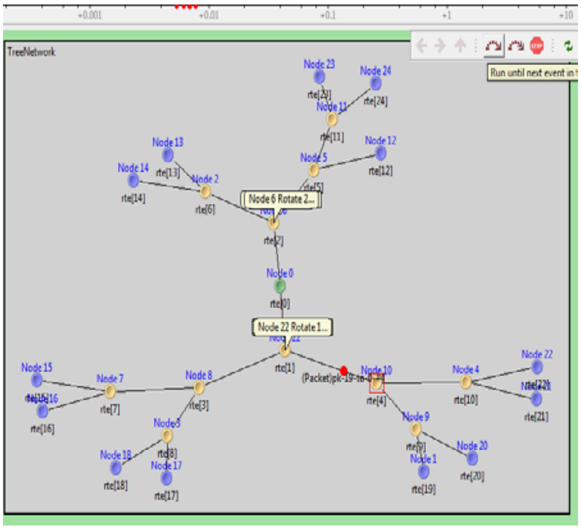

Fig. 3. Mobile Node Relocation.

Fig 4 represents the Energy File. The energy file is generated during the compilation of the .cc file. The energy file shows that during the decrease of energy below the threshold value the node relocation.

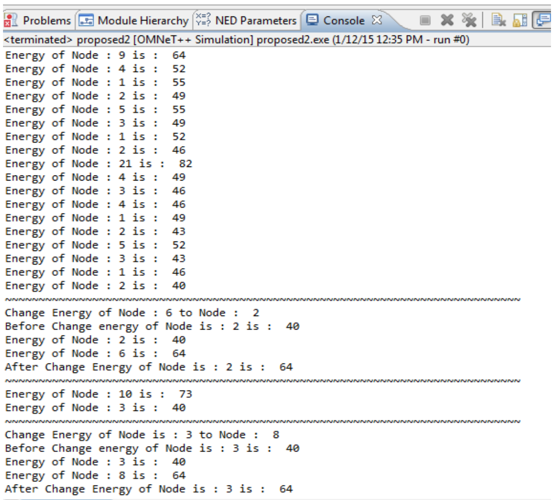

Fig. 4 Energy File

The Experimental results show that the node relocation extend the network lifetime by relocating the node to suitable position. This maintains the energy level of battery to maximum time limit.

6. CONCLUSION

In this paper, A Distributed Consumption Rate Algorithm scheme for maximizing the lifetime of the mobile WSN is presented. The Adaptive Energy Threshold algorithm is used to calculate the threshold energy. The nodes in higher layer aggregate the data collected from lower layer and forwards to the sink. This preserves the connectivity of the network. Then the node relocation concept was introduced to rotate the nodes according to threshold energy. So the Energy consumption can be minimized. Our simulation shows that node relocation scheme prolongs the network lifetime.

REFERENCES

[1] A. A. Somasundara, A. Ramamoorthy, and M. B. Srivastava, “Mobile element scheduling with dynamic deadlines,” IEEE Trans. Mobile Comput., vol. 6, no. 4, pp. 395–410, Apr. 2007.

[2] J. Luo and J.-P. Hubaux, “Joint mobility and routing for lifetime elongation in wireless sensor networks,” in Proc. IEEE 24th Annu. Joint Conf. IEEE Comput. Commun. Soc., 2005, pp. 1735–1746.

[3] D. Jea, A. A. Somasundara, and M. B. Srivastava, “Multiple Controlled Mobile Elements (Data Mules) For Data Collection In Sensor Networks,” in Proc. 4th IEEE Int.Conf. Distrib.Comput. Sensor Syst., 2005, pp. 244–257.

[4] S. Jain, R. Shah, W. Brunette, G. Borriello, and S. Roy, “Exploiting Mobility For Energy Efficient Data Collection In Wireless Sensor Networks,” Mobile Netw.Appl., vol. 11, no. 3, pp. 327–339, 2006.

[5] [5]G. Xing, T. Wang, Z. Xie, and W. Jia, “Rendezvous Planning In Mobility-Assisted Wireless Sensor Networks,” in Proc. 28th IEEE Int. Real-Time Syst. Symp., 2007, pp. 311–320.

[6] L. Li and J. Halpern, “A Minimum-Energy Path-Preserving Topology-Control Algorithm,” IEEE Trans. Wireless Commun., vol. 3, no. 3, pp. 910–921, May 2004.

[7] Y. Shen, Y. Cai, X. Li, and X. Xu, “The Restricted Shortest-Path Based Topology Control Algorithm In Wireless Multihop Networks,” IEEE Commun. Lett., vol. 11, no. 12, pp. 937–939, Dec. 2007.

[8] D. K. Goldenberg, J. Lin, and A. S. Morse, “Towards mobility as a network control primitive,” in Proc. 5th ACM Int. Symp. Mobile Ad Hoc Netw. Comput., 2004, pp. 163–174.

[9] C. Tang and P. K. McKinley, “Energy optimization under informed mobility,” IEEE Trans. Parallel Distrib. Syst., vol. 17, no. 9, pp. 947–962, Sep. 2006.

[10] F. El-Moukaddem, E. Torng, and G. Xing, “Maximizing Data Gathering Capacity Of Wireless Sensor Networks Using Mobile Relays,” in Proc. IEEE Mobile Adhoc Sensor Syst., 2010, pp. 312–321.

[11] Y. Liu, Z. Luo, K. Xu, and L. Chen, “A Reliable Clustering Algorithm Base On Leach Protocol In Wireless Mobile Sensor Networks,” in Proc. Int. Conf. Mech. Electr. Technol., 2010, pp. 692–696.

[12] F. El-Moukaddem, E. Torng, and G. Xing, “Maximizing network topology lifetime using mobile node rotation,” in IEEE Trans. Parallel Distrib. Syst., vol. 26, no. 7, (2015) pp. 1958–1969.