An Energy Efficient Sink Repositioning Technique for Data Gathering In Wireless Sensor Networks

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***Abstract* - We have considered the problem of using static sink for data gathering purpose in an energy constrained multi hop wireless sensor networks. Sensing and relaying the collected data to the sink node using multi hop communication in an energy efficient manner is of prime importance. Optimizing sensor networks involves addressing a wide range of issues steaming from limited energy reserves, computation power, communication capabilities and self managing sensor nodes. In this paper we have investigated the problem of using static sink in case of the sensor networks which results in uneven energy expenditure and also the uneven sensing coverage over different parts of the network. We have used the concept of repositioning of the sink for enhancing the performance of the network in terms of energy which will also help in extending the lifetime of the network. For this we have used the repositioning algorithm which has been simulated in the NS-2.32 environment. Our simulation results show that repositioning the sink achieves significant energy savings as compared to the static sink approach which helps in improving the life of the entire network.**

***Keywords* – Wireless Sensor Networks, ECR, Energy Efficiency, Sink Repositioning**

I. INTRODUCTION

Wireless Sensor Networks realize an all pervasive distributed network to create an intelligent environment and are responsible for sensing as well as for the first stages of the processing. Sensor networks are highly distributed networks of small, lightweight wireless nodes deployed in large numbers to monitor the environment or system by the measurement of physical parameters such as temperature, pressure or relative humidity. Each node of the sensor network consists of three subsystems: the sensor subsystem which senses the environment, the processing subsystem which performs the local computations on the sensed data and the communication subsystem which is responsible for the message exchange with neighboring sensor nodes. While individual sensors have limited sensing region, processing power and energy, networking a larger number of sensors gives rise to a robust, reliable and accurate sensor network covering a wider region. Generally the wireless sensor networks consist of a data acquisition network and a data distribution network monitored and controlled by a management centre. For un-metered sensor nodes the power supply is a crucial component. There are essentially two aspects. Firstly storing the energy and providing power in the required form and secondly attempting to replenish the consumed energy by scavenging it from some external power source over time. Sensor nodes have a very stringent energy constraint. Batteries have small capacity and recharging by energy scavenging is complicated and volatile. Hence the energy consumption of sensor node must be tightly controlled.

Wireless sensor networks have numerous applications in variety of disciplines both military and civilian. The possible applications of sensor networks are wide ranging from intelligent building and sensor controlled chemical plants to habitant monitoring .The ability to remotely measure ambient conditions and track dynamic targets/events can be invaluable, especially in harsh environments where human intervention is risky or infeasible.[1]The direction of research in sensor networks is towards overcoming the challenges of scalability, reliability, robustness and power efficiency so that a variety of applications can be implemented in highly constrained scenarios. The importance of sensor networks is highlighted by the number of recent funding initiatives including military, agriculture and security programs.

II.PROBLEM IDENTIFICATION

Sensors are usually battery operated and have a limited transmission range and on board processing capacity like memory, processing, energy and power. Such constraints have motivated lots of research on effective management strategies of WSN's that trade off resources ,data fidelity, latency and coverage so that the network can stay functional for the longest duration. The interest in optimizing the transmission energy tends to increase the levels of packet relaying and thus makes queuing delay an issue especially for real time traffic.

One of the most important issues to be aware of when handling wireless sensors is the energy consumption. Sensor batteries are usually impossible or impractical to replace or recharge therefore energy must be spared so as to perform for longer possible period. Energy is consumed by several tasks but the prominent energy consumer is the communication module.[2]

Energy consumption depends upon the communication distance. Communication distance can be reduced in many ways and one such method is to use Multi hop transmission. Most of the energy aware routing approaches for unattended wireless sensor networks pursue multi hop paths in order to minimize the total transmission power. Since almost in all the sensor networks data are routed towards a single sink, hops close to that sink becomes heavily involved in packet forwarding and thus their batteries get depleted rather quickly. The nodes around the sink would deplete their energy faster, leading to what is called an energy hole around the sink. If this happens then the sensors around the sink stops from functioning, the sink becomes isolated from the rest of the network and no more data can be transmitted to the sink .As a result, the network lifetime ends soon and much energy of the nodes would be wasted. Experimental results have shown that when the network lifetime is over up to 90% of the total initial energy of the nodes is left unused if the nodes are normally distributed in the network [3]

Multi-hop relaying is the main reason for the energy hole problem where some sensors have to relay a lot of traffic for the other sensors. Thus multi hop relaying results in unbalanced energy expenditure over different parts of the fields.

To overcome this problem some proposals tried to solve the problem by placing more sensor nodes around the sink. However this may result in an unbalanced sensing coverage over different parts of the fields. [4][5].

Energy optimization in sensor networks must prolong the life of a single node as well as of the entire network.

III. REPOSISTIONING METHODOLOGY

Both the problem of Multihop relaying and multiple sinks can be avoided by sink repositioning technique which involves making use of the mobile sink which has the capability to move inside the monitored region and collect the data from the sensors it passes by.

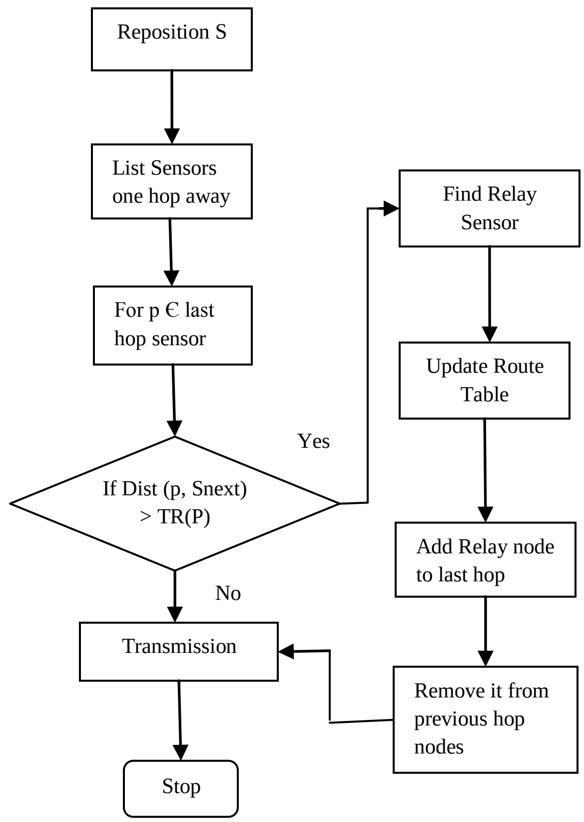
Repositioning the sink during the regular network operation is very difficult. The basic issues are when the sink should move, where it should be moved and how the data traffic would be handled during its movement. [11]

For this we have used a sink repositioning technique and it has been considered for an unconstrained traffic. Once an undesirable situation exists, the sink will decide to relocate. Then it will check for those sensor nodes that are just one hop away from it and for those hops which are relaying high traffic. Then the optimal location for the sink is calculated. In order to test for the impact of repositioning the total power transmission of the sensors for the previous and next sink positions is evaluated and compared. Then the gain in terms of power transmission is checked and if it is more than a particular threshold value then only the sink will be moved to a next position otherwise it remains at the previous location and if further the overhead is justified then only the sink will finally move to the next position.

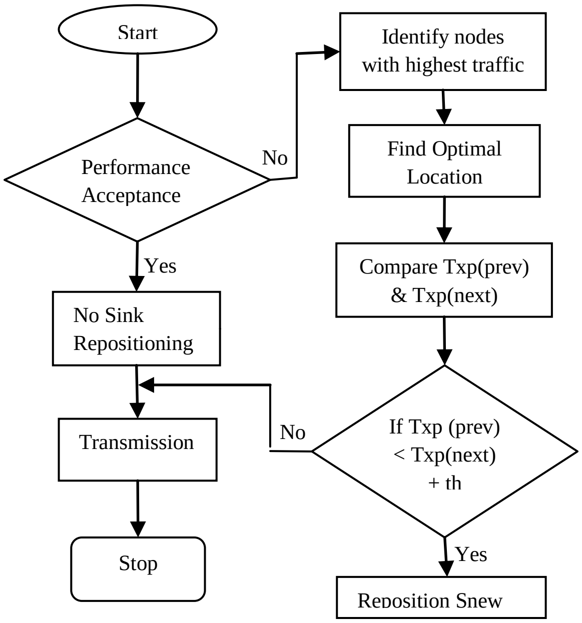
When the sink starts to move towards its next location at each step the algorithm will check the list of sensor nodes that are one hop away from the sink in order to check for their connectivity with the sink. If the sink is reachable then the last hop sensor nodes will adjusts its transmission power so that the sink can receive the messages properly until reaching the next intermediate position. On the other hand if the sink goes out of the transmission range of these sensor nodes then it will look for a sensor node that can be used to relay the data further. Such selected sensor node should be such that it should be reachable to both the sink and the last hop sensors and should have ample amount of energy. If multiple node alternatives are available then the one having the higher energy is picked. After this the sink will update the routing table and inform the other sensors and then move ahead to the next location.

IV. ALGORITHM

The proposed steps for sink repositioning algorithm for enhancing the energy consumption metric in WSN as follows:-



V. SYSTEM MODEL AND PARAMETERS



In the experiments, we have considered the network consisting of varying number of sensor nodes (3–200) that are randomly placed in a 600 x 600 m^2 area. The gateway's initial position is determined randomly within the region boundaries. A free space propagation channel model is assumed with the capacity set to 2 Mbps. Each node is assumed to have an initial energy of 2 J. A node is considered non-functional if its energy gets completely depleted. The maximum transmission (power) range for a sensor node is assumed to be 50 m. A time division multiple access (TDMA) based MAC protocol is employed. The gateway manages slot assignment based on the network topology. The gateway informs each node about the slots in which it should listen to other node's transmission and the slots that the node can use for its own transmission. This eliminates the possible interferences during transmission and reception. In addition, the gateway broadcasts the routing table to all sensors prior to starting or resuming data transmission. Each data packet is time-stamped when it is generated to allow the calculation of the average delay per packet. In addition, each packet has an energy field that is updated during the packet transmission in order to calculate the average energy per packet and to track the remaining energy at each node.[11]

VI. SIMULATION RESULTS

After compiling our code in ns-2.34 we get a nam file which should be opened in nam console to see the visualization of our wireless sensor network (wsn). Below given are the screenshots of nam console.

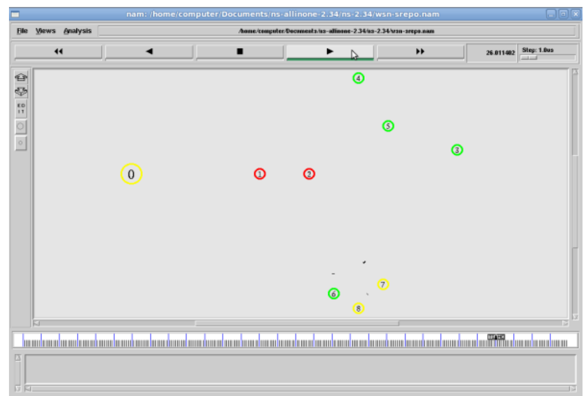


Fig.1: Output before sink repositioning

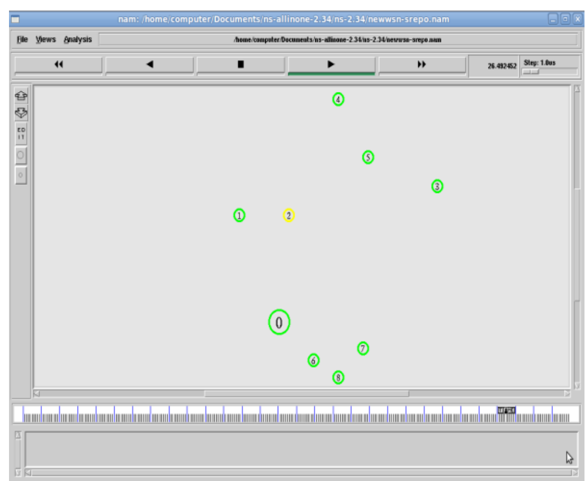


Fig. 2: Output after sink repositioning

The metrics used to capture the performance of our approach was the energy metrics. Figure below depicts the effect of relocation on energy consumption measured in terms of average energy per packet.

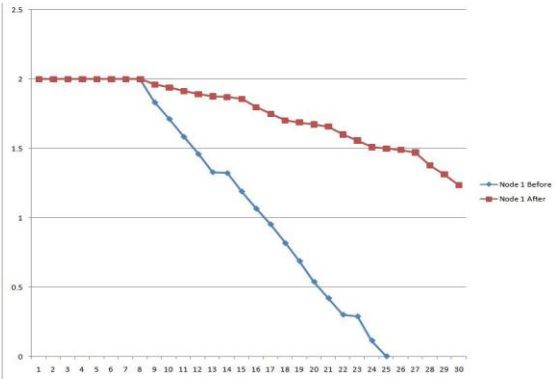


Fig. 3.1 Energy Graph of Node 1
[X-axis: No of sensors & Y-axis: Energy in Joules]

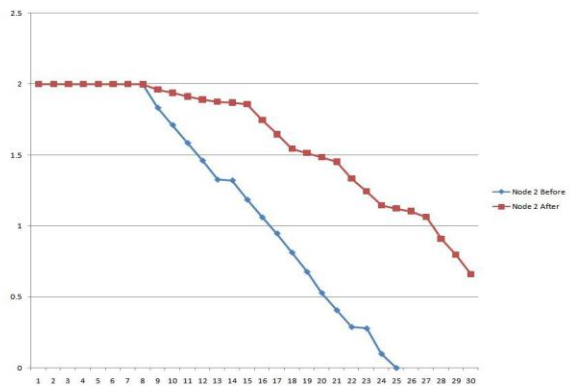


Fig .3.2: Energy Graph of Node 2
[X-axis: No of sensors & Y-axis: Energy in Joules]

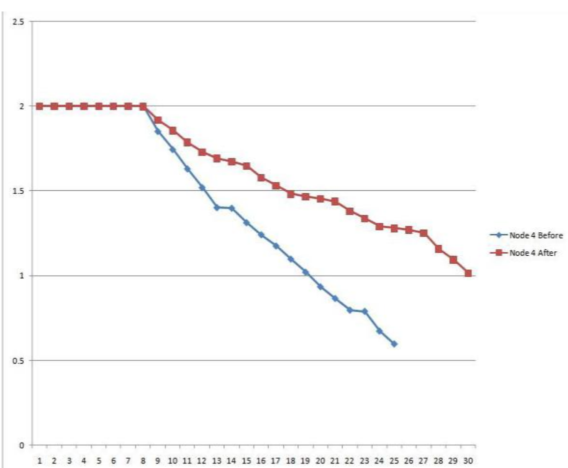


Fig. 3.3: Energy Graph of Node 3
[X-axis: No of sensors & Y-axis: Energy in Joules]

Like wise sink repositioning shows significant energy savings at each and every sensor nodes of WSN.

VII. CONCLUSION

It was observed that both the drawbacks of multi hop transmission and deployment of multiple sink in wireless sensor networks can be overcomed by making use of sink repositioning. In this paper we have investigated the performance advantage of repositioning the sink node of wireless Sensor networks. Simulation results have shown that such repositioning of the sink increases the average lifetime of the nodes by decreasing the average energy consumed per packet. It achieves significant amount of energy savings as compared to the base line approach. The work can further be extended for increasing the throughput and reducing the delay for any particular scenario of the wireless sensor network.

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