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An Improved Energy Efficient Threshold Based Routing For Wireless Sensor Networks

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Abstract: Wireless Sensor Networks (WSNs) are being used extensively for monitoring and surveillance in several fields like military area, agricultural fields, forests, nuclear reactors etc. A Wireless Sensor Network generally consists of a large number of small and low-cost sensor nodes powered by small non-rechargeable batteries and equipped with various sensing devices. It is expected that it will be suddenly active to gather the required data for sometimes when something is detected, and then remaining largely inactive for long periods of time. So, efficient power saving schemes and corresponding algorithms must be developed and designed in order to provide reasonable energy consumption and to improve the network lifetime for WSNs. The cluster-based technique is one of the good approaches to reduce energy consumption in wireless sensor networks. The lifetime of wireless sensor networks is extended by using the uniform cluster location and balancing the network loading among the clusters. In this research work, various energy efficient schemes apply in WSNs have been studied. The clustering based approach has been studied and a modified protocol has been implemented which is based on selection probability. The sensor only transmits when the threshold level is achieved for this selection potential. It selects a node as a cluster head if its residual energy is more than system average energy and have less energy consumption rate in the previous round. The goals of this scheme are, increase stability period of the network, and minimize loss of sensed data.

Keywords: Wireless Sensor Networks, Energy Efficiency, Network Lifetime, Stability.

I. INTRODUCTION

Traditional wireless networks are to be used as a replacement for their wired counterparts. They provide network infrastructure for communicating any devices. In recent years a new type of wireless network emerged very rapidly with a different goal. It provides an effective way for sensing the parameters, processing and communicating data over wired or aired medium. This new type of wireless network is termed as Wireless Sensor Network (WSN). Before proceeding to the objective a brief discussion on WSN is given [1] [2]. Wireless sensor network is special categories of Ad Hoc wireless network that are used to provide wireless communication infrastructure among the sensor deployed in a specific application domain. Wireless Sensor Networks (WSNs) have been widely considered as one of the most important technologies for the recent years. Enabled by recent advances in microelectronic mechanical systems (MEMS) and wireless communication technologies, tiny, cheap, and smart sensors deployed in a physical area and networked through wireless links and the Internet provide unprecedented opportunities for a variety of civilian and military applications, for example, environmental monitoring, battlefield surveillance, and industry process control. It distinguished from traditional wireless communication networks, for example, cellular systems and mobile ad hoc networks (MANET). WSNs have unique characteristics, like the denser level of node deployment, the higher unreliability of sensor nodes, energy, computation, and storage constraint, which present many new challenges in the development and application of WSNs. WSN use meshes networking protocols. The mesh networking connectivity finds any possible communication path to the destination or sinks by hopping data from node to node. These tiny sensor nodes consist of sensing, data processing, and communicating components. The main characteristics of these sensor nodes are its infrastructure-less and self-organizing capability. The sensor nodes are to be deploying randomly and they can perform their task in an unattended manner. Another vital feature of the sensor network is the cooperation between sensor nodes. Sensor nodes contain onboard processors. Instead of sending raw data sensor nodes to transmit partially processed data by carrying out computation locally [2].

Sensor networks are generally used to monitor physical parameter like temperature, humidity, pressure, mechanical stress level, vehicular movement etc. Different types of sensors such as seismic, thermal, infrared, acoustic are used for monitoring them.

Sensor Networks can be used for continuous monitoring or event detection of parameters to be measured. It has widespread application areas which include [1].

- Disaster Management
- Military Application
- Environment Monitoring
- Health Care

In spite of all its advantages, there are some limitations that influence the performance of WSN. The prominent among such factors are Energy Constraint, Hardware Constraints, Fault tolerance, Scalability etc. Many researchers are currently trying to overcome such limitations and they become successful in rising above these limitations to some extent.

II. LITERATURE REVIEW

A Wireless Sensor Network consists of a large number of low-power low-cost energy constrained sensors responsible for monitoring and reporting a physical phenomenon to the BS node where the end user/observer can access the data [1] shown in Figure 1. Due to small size, low cost and inhospitable working places sensor nodes contain small energy sources and also it is not possible to recharge them [4]. So energy is the main constraint in WSN operation as well as it has limited storage and processing capabilities.

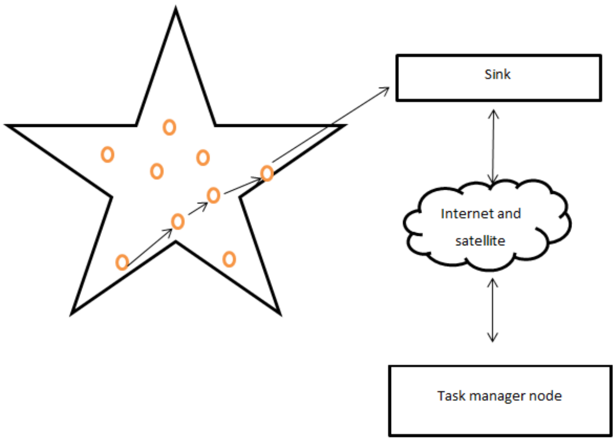

Figure 1: Wireless Sensor Network

Sensor nodes are small, cheaper, low-power, distributed devices, which are capable of local processing and wireless communication [2]. Each sensor node is capable of only a limited amount of processing. But when coordinated with the information from a large no. of other nodes, they have the ability to measure a given physical environment in great detail. A sensor node combines the abilities to compute, communicate and sense. The aim is to fit all mentioned features in a single chip solution. Here a simple structure of sensor node is given in Figure 2. A sensor node is having a battery attached to it which is the main power supply of a sensor node. So for a sensor node power is one of the main constraints as it can't be regenerated.

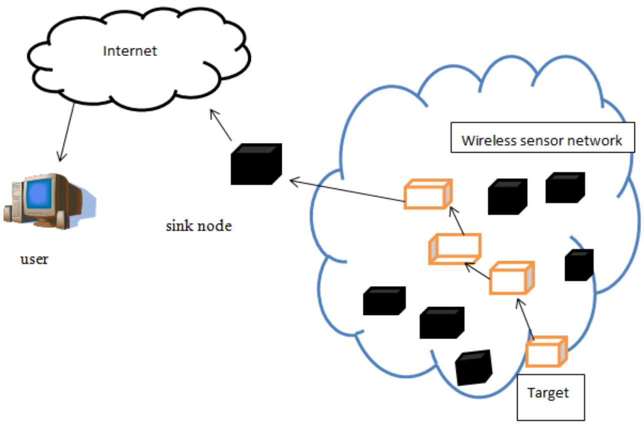

Figure 2: Structure of Wireless Sensor Nodes

Recent advances in WSNs have to 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 [7] 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. As a result, the nodes furthest from the Base are the ones to die first [8]. On the other hand, in the case of Minimum Transmission Energy routing protocol data is transmitted through intermediate nodes. Thus each node acts as a router for other nodes' data in addition to sensing the environment. Nodes closest to the Base are the first to die in MTE routing. So far, the cluster-based technique is one of the approaches which successfully increases the lifetime and stability of whole sensor networks.

Table 1: Classification of Routing Protocols

Categories	**Representative protocols**
Data Centric Protocols	Flooding And Gossiping, SPIN, Direct Diffusion, Rumor Routing, Gradient-Based Routing, Energy-Aware Routing, CADR COUGAR & ACQUIRE
Hierarchical Protocols	LEACH, PEGASIS, TEEN, APTEEN
Location Based Protocols	MECN&SMECN, GAF & GEAR
Network Flow &Qos Aware Protocols	Maximum Lifetime Energy Routing, Maximum Lifetime Data Gathering, Maximum Cost Forwarding, SAR &SPEED

III.PROPOSED WORK

In order to save the total energy cost of the sensor networks and prolong its lifetime, we propose a distance-based clustering protocol. The basic idea of the protocol is as follows:
Firstly some assumptions are addressed in our work:

- All nodes can send data to Base Station (BS).
- The BS has the information about the location of each node. It's assumed that the cluster heads and nodes have the knowledge of its location.
- Data compression is done by the Cluster Head.
- In the first round, each node has a probability p of becoming the cluster head.
- All nodes are of the same specification.
- All nodes in the network are having the same energy at the starting point and having maximum energy.
- The energy of transmission depends on the distance (source to destination) and data size.
- Nodes are uniformly distributed in the network in a random manner.

The research work done here has mainly focussed on the realistic situational aspect of the Wireless Sensor Networks. With the kind of application for which the wireless sensor nodes are employed its important for them to have a situational awareness which is directly linked to their energy consumption. If we can keep an eye on the situation and accordingly monitor and control the energy being used in the Wireless Sensor Networks, hence improving the efficiency of the network. TEEN has been closely studied in this respect which is a threshold based routing protocol as has been discussed earlier. 4.2 The proposed protocol here also monitors the behaviour of the nodes and Cluster Heads with respect to energy and distance. In this proposed algorithm, once the potential of each node is calculated, the head of cluster head (CH) or the leader node is selected on the basis of the energy level of the various nodes. The distance of all nodes from the base station or sink is then evaluated to locate the nearest and farthest nodes in the network. Based on a threshold distance level a temporary leader node is selected for each cluster. The energy and distance from the base station are then evaluated and the ratio between them is evaluated. If this ratio is above the threshold value then the cluster head is the optimal selection for this round for that cluster. The process is continued further by continuous monitoring of the values of energy of nodes and the distance from the base station.

$$\text{Selection Potential (Q)} = \frac{E}{DtoBS} \qquad (1)$$

The selection of child nodes i.e. the nodes that can potentially be cluster heads in the upcoming rounds is done subsequently using the same metrics i.e. the distance to base station and the energy of the nodes. Apart from this the distance between the all nodes under a particular cluster and cluster head is also evaluated and compared to a threshold value according to the round number. The nodes which do not satisfy the distance parameters i.e. who have the distance value less than the threshold for the current round from the cluster head it is assigned a new cluster. Thus ensuring the connectivity of all nodes in the network at a particular instant of time.

As is the case with most cluster based techniques, the algorithm starts with the formation of clusters i.e. cluster setup phase. Initially, when clusters are being created, each node decides whether or not to become a cluster-head for the current round. This decision is based on the suggested percentage of cluster heads for the network (determined a priori) and the number of times the node has been a cluster-head so far. This decision is made by the node n choosing a random number between 0 and 1. If the number is less than a threshold T(n), the node becomes a cluster-head for the current round. The threshold is set as:

$$T(n) = \begin{cases} \frac{P}{1-P*(r \bmod \frac{1}{P})} & If\ n \epsilon G \\ 0 & Otherwise \end{cases} \quad (2)$$

Where P = the desired percentage of cluster heads (e.g., P = 0.05), *r* = the current round, and G is the set of nodes that have not been cluster-heads in the last *1/P* rounds. Using this threshold, each node will be a cluster-head at some point within *1/P* rounds. During round 0 (*r* = 0), each node has a probability *P* of becoming a cluster-head. The nodes that are cluster-heads in round 0 cannot be cluster-heads for the next *1/P* rounds. Thus the probability that the remaining nodes are cluster-heads must be increased since there are fewer nodes that are eligible to become cluster-heads.
After *1/P* -1 rounds, T=1 for any nodes that have not yet been cluster-heads, and after *1/P* rounds, all nodes are once again eligible to become cluster-heads. Future versions of this work will include an energy-based threshold to account for non-uniform energy nodes. In this case, we are assuming that all nodes begin with the same amount of energy and being a cluster-head remove approximately the same amount of energy for each node. Each node that has elected itself a cluster-head for the current round broadcasts an advertisement message to the rest of the nodes. For this “cluster-head-advertisement” phase, the cluster-heads use a CSMA MAC protocol, and all cluster-heads transmit their advertisement using the same transmit energy. The non-cluster-head nodes must keep their receivers on during this phase of set-up to hear the advertisements of all the cluster-head nodes.

IV. SIMULATION RESULTS

Simulated Environment

- Simulated an environment with varying temperature in different regions.
- The sensor network nodes are first placed randomly in a bounding area of 100x100 units.

Base station situated out of the network. Different colours are showing the different sensor nodes

- We use two metrics to analyze and compare the performance of the protocols.

Table 2: Simulation Parameters

Parameter	Value
Number of sensor nodes	100
Network size (m^2)	100*100
No of round	5000
Base station location	(50,50)
Efs (pJ/bit)	10*10^(-12)
Eamp (pJ/bit)	0.0013*10^(-12)
ETX (nJ/bit)	50*10^(-9)
ERX (nJ/bit)	50*10^(-9)

Figure 4: Alive Nodes per Round

In our simulation, the age of the network or in other words the network lifetime is indicated by the number of nodes alive after a certain number of rounds. Figure 4 shows the curve for the number of alive nodes while figure 5 gives the number of dead nodes. As is seen from both the graphs, there is a drastic change (fall in the number of alive nodes and rise in the number of dead nodes), in the curve. The number of alive nodes has fallen sharply from around 90 to approximate nodes in figure 6 and, similarly, there has been a steep rise in the number of dead nodes. This drastic change has occurred at around halftime of the total network time i.e around after 2000 rounds and can be attributed to the considerable loss of the energy at the network half time.

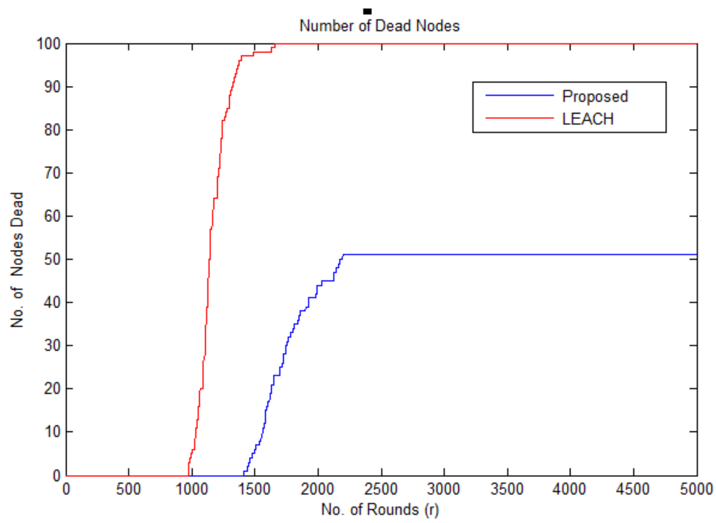

Figure 5: Dead Nodes vs Rounds

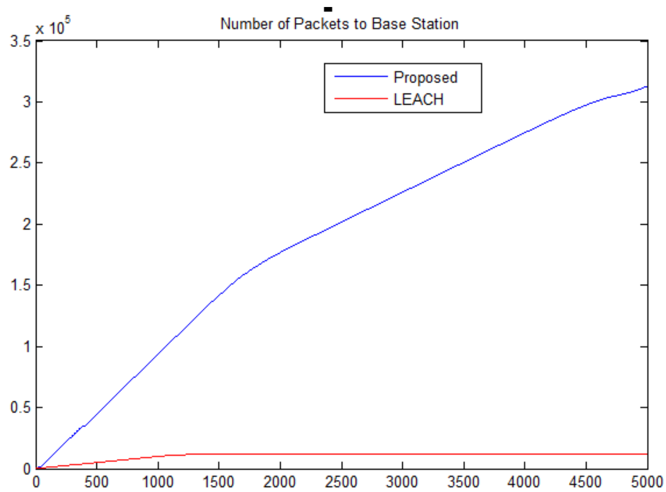

Figure 6: Throughput vs. Rounds

Figure 6 shows the graph between LEACH and proposed method for the number of packets transferred from Cluster heads to the base station.

CONCLUSION

A novel technique for improving the energy efficiency of wireless sensor network has been proposed and implemented in this paper. The simulation has been performed using MATLAB software tool and various results like number of dead nodes per, the number of alive nodes per round, throughput per round has been evaluated and plotted. The comparison of the proposed protocol with the standard LEACH protocol shows considerable improvement in performance in terms of network lifetime and stability and energy efficiency.

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