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Optimizing Base Station Mobile Sink by Energy Balanced Clustering for Wireless Sensor Network

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Abstract: Clustering plays an effective role in utilization and saving of senor energy. Where nodes are grouped into clusters and one node, called the cluster head is responsible for collecting data from other nodes, aggregates them and sends them to the BS. In multi-hop communication, the cluster head farthest away from the BS routes its data over several hops until they reach the BS. A network portioning problem arises when the nodes that are very close to the BS burdened with heavy relay traffic load and therefore die much faster than others. In this project we introduced a new unequal size clustering protocol that balances the energy consumption among all clusters, where each cluster will have an mobile sink has been used to collect data from CH, clusters head send data to mobile sink that are will have few number of nodes to be able to save energy to the ones that are far from the BS, that have large number of nodes. This path and energy balanced algorithm helps to balance energy and prolong the life time of node.

Key word: Wireless sensor networks, base station, unequal clustering, network lifetime, simulation

INTRODUCTION

The Wireless sensor networks consists of spatially distributed autonomous sensor to monitor physical or environmental conditions such a temperature, sound, pressure etc. and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications such as industrial process monitoring and control, machine health monitoring and so on (Abbasi and Younis, 2007).

The WSN is built of “nodes” from a few to several hundreds or even thousands where each node is connected to one (or sometimes several) sensors. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting. A sensor node might vary in size from that of a shoebox down to the size of a grain of dust, although functioning “motes” of genuine microscopic dimensions have yet to be created. The cost of sensor nodes is similarly variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. The propagation technique between the hops of the network can be routing or floodin (Chen *et al*., 2004).

Mobile sink: A wireless Sensor Network (WSN) consists of sensor nodes capable of collecting information from the environment and communicating with each other via wireless transceivers. The collected data will be delivered to one or more sinks, generally via multi-hop communication. The sensor nodes are typically expected to operate with batteries and are often deployed to not-easily-accessible or hostile environment, sometimes in large quantities. It can be difficult or impossible to replace the batteries of the sensor nodes. On the other hand, the sink is typically rich in energy. Since the sensor energy is the most precious resource in the WSN, efficient utilization of the energy to prolong the network lifetime has been the focus of much of the research on the WSN. Although, the lifetime of the WSN can be defined in many ways, we adopt the definition that it is the time until the first node exhausts its energy which is a widely used. Much work has been done during recent years to increase the lifetime of the WSN. Among them, in spite of the difficulties in realization, taking advantage of the mobility

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in the WSN has attracted much interest from researchers. We can take the mobile sink as an example of mobility in the WSN. The communications in the WSN has the many-to-one property in that data from a large number of sensor nodes tend to be concentrated into a few sinks. Since multi-hop routing is generally needed for distant sensor nodes from the sinks to save energy, the nodes near a sink can be burdened with relaying a large amount of traffic from other nodes. This phenomenon is sometimes called the "crowded center effect or the "energy hole problem". It results in energy depletion at the nodes near the sink too soon, leading to the separation of the sink from the rest of nodes that still have plenty of energy. However, by moving the sink in the sensor field, one can avoid or mitigate the energy hole problem and expect an increased network lifetime (Arboleda and Nasser, 2006).

This study proposes a framework to maximize the lifetime of the WSN by taking advantage of the mobile sink. Compared with other mobile-sink proposals, the main novelty is that we consider the case where the underlying applications tolerate delayed information delivery to the sink. In our proposal, within a prescribed delay tolerance level, each node does not need to send the data immediately as they become available. Instead, the node can store the data temporarily and transmit them when the mobile sink is at the stop most favorable for achieving the longest network lifetime. To find the best solution within the proposed framework, we formulate optimization problems that maximize the lifetime of the WSN subject to the delay bound constraints, node energy constraints and flow conservation constraints. Another one of our contributions is that we compare our proposal with several other lifetime-maximization proposals and quantify the performance differences among them. Our computational experiments have shown that our proposal increases the lifetime significantly when compared to not only the stationary sink model but also more traditional mobile sink models. We also show that the delay tolerance level does not affect the maximum lifetime of the WSN.It integrates the following energy-saving techniques, multipath routing, a mobile sink, delayed data delivery and active region control, into a single optimization problem. Such sophistication comes at a cost. Whether the proposal should be adopted in practice will depend on the tradeoff between the lifetime gain and the actual system cost. Even if the decision is not to adopt it due to a high cost or high complexity, the framework in the study is still useful because it can supply the practitioners with a performance benchmark how much lifetime improve (Baker and Ephremides, 1981).

Literature review: Rapid advances in Wireless Sensor Networks (WSNs) have enabled densely deployment of nodes. WSNs are an emerging technology that consists of large number of low cost, low power sensor nodes; a sensor node, an electronic device that is capable of detecting environmental conditions. Those sensor nodes can be deployed randomly to perform many applications such as monitoring physical events, for example environmental monitoring, battlefield surveillance, disaster relief, target tracking, etc. and they work together to form a wireless network.

A typical node of a WSN is equipped with four components a sensor that performs the sensing of required events in a specific field, a radio transceiver that performs radio transmission and reception, a microcontroller: which is used for data processing and a battery that is a power unit providing energy for operation.

The limited energy given to each node, supplied from non-rechargeable batteries with no form of recharging after deployment is one of the most crucial problems in WSN. Many routing protocols have been proposed for WSNs. Most of the hierarchical algorithms proposed for WSNs concentrate mainly on maximizing the lifetime of the network by trying to minimize the energy consumption (Ephremides *et al*., 1987).

Researchers agreed that clustering of nodes in wireless sensor networks is an effective program of energy conservation. Clustering is defined as the grouping of similar objects or the process of finding a natural association among some specific objects or data. In WSN it is used to minimize the number of nodes that take part in long distance data transmission to a BS, what leads to lowering of total energy consumption of the station 6 .

Clustering reduces the amount of transmitted data by grouping similar nodes together and electing one node as a cluster head, where aggregation of data is to avoid redundancy and communication load caused by multiple adjacent nodes, then sending the aggregated data to the next cluster head or to the BS where it is processed, stored and retrieved (Min *et al*., 2001).

In any clustering organization intra-cluster communication as well as inter-cluster communication can be single hop or multi-hop. However, the hot spot and network partitioning arises when using multi-hop routing in inter-cluster communications. Because the cluster heads close to the BS, are burdened with heavy relayed traffic that will make them die faster than other cluster heads, resulting in loss of coverage of sensing. To effectively prolong the life time of network sensors, the network should be designed carefully to be energy efficient. Many of the previous clustering algorithms organize the network into equal size clusters; however, the problems of unbalanced energy consumption exist. We proposed an unequal size clustering algorithm that results in more uniform energy dissipation among cluster heads and prolongs the life time of the whole network (Gupta and Younis, 2003).

We assume a WSNs model similar to those used in with the following properties: All sensor nodes uniformly deployed over the sensing field. All nodes are stationary and energy constrained. The nodes have power control capabilities to vary their transmitted power. The nodes can be either cluster heads or ordinary nodes. Data fusion is used to reduce the total data message sent. A fixed BS is located inside or outside of the sensor network fields. For the simulations described in this study we assume that the BS is located outside of the network in order to show the effect of our protocol better.

Proposed system: During last few years many unequal clustering algorithms have been proposed for wireless sensor networks as an efficient way for balancing the energy consumption and prolonging the lifetime of the networks. Clustering provides an effective way to prolong the lifetime of wireless sensor networks. One of the major issues of a clustering protocol is selecting an optimal group of sensor nodes as the cluster heads to divide the network. Another is the mode of inter-cluster communication. In this study, an Energy-balanced Unequal Clustering (EBUC) protocol is proposed and evaluated using simulation. EBUC partitions all nodes into clusters of unequal size in which the clusters closer to the base station have smaller size. The cluster heads of these clusters can preserve some more energy for the inter-cluster relay traffic and the 'hot-spots' problem can be avoided. For inter-cluster communication, EBUC adopts an energy-aware multihop routing to reduce the energy consumption of the cluster heads. Simulation results demonstrate that the protocol can efficiently decrease the dead speed of the nodes and prolong the network lifetime. Wireless Sensor Networks (WSNs) has attracted more and more researchers and engineer's attention recently, owing to its wide use in many applications such as earthquake and climate forecasting, target tracking and surveillance, outer space exploring and precision agriculture. However, energy source of the sensor nodes in WSNs is usually powered by battery which is undesirable even impossible to be recharged or replaced. Therefore, improving energy efficiency and maximizing the network lifetime by decreasing energy consumption of the individual nodes and balancing energy consumption of all nodes are the major challenges in the research of the routing protocols in WSNs. Clustering algorithms divide all nodes of the network into some clusters, select cluster heads to be responsible for collecting and fusing intra-cluster data and sending the fused data to the Base Station (BS) via one-hop or multihop. This approach has the advantages of reducing energy dissipation.

MATERIALS AND METHODS

Low energy adaptive clustering hierarchy: As we all know that all the networks have a certain lifetime during which nodes have limited energy by using that, the nodes gather, process and transmit information. This means that all aspects of the node, from the sensor module to the hardware and protocols, must be designed to be extremely energy-efficient. Decreasing energy usage by a factor of two can double system lifetime, resulting in a large increase in the overall usefulness of the system. In addition, to reduce energy dissipation, protocols should be robust to node failures, fault-tolerant and scalable in order to maximize system lifetime. LEACH is the first network protocol that uses hierarchical routing for wireless sensor networks to increase the life time of network. All the nodes in a network organize themselves into local clusters with one node acting as the cluster- head. All non-cluster-head nodes transmit their data to the cluster-head while the cluster-head node receive data from all the cluster members, perform signal processing functions on the data (e.g., data aggregation) and transmit data to the remote base station. Therefore, being a cluster-head node is much more energy-intensive than being a non-cluster-head node. Thus, when a cluster-head node dies all the nodes that belong to the cluster lose communication ability. LEACH incorporates randomized rotation of the high-energy cluster-head position such that it rotates among the sensors in order to avoid draining the battery of any one sensor in the network. In this way, the energy load associated with being a cluster-head is evenly distributed among the nodes. Since the cluster-head node knows all the cluster members, it can create a TDMA schedule that tells each node exactly when to transmit its data. In addition,using a TDMA schedule for data transfer prevents intra-cluster collisions. The operation of LEACH is divided into rounds. Each round begins with a set-up phase when the clusters are organized, followed by a steady-state phase where several frames of data are transferred from the nodes to the cluster-head and onto the base station (Lin and Gerla, 1997).

In LEACH, nodes take autonomous decisions to form clusters by using a distributed algorithm wit out any centralized control. Here no long-distance communication with the base station is required and distributed cluster formation can be done without knowing the exact location of any of the nodes in the network. In addition, no global communication is needed to set up the clusters. The cluster formation algorithm should be designed such that nodes are cluster-heads approximately the same number of time assuming all the nodes start with the same amount of energy. Finally, the cluster-head nodes should be spread throughout the network as this will minimize the distance the non-cluster-head nodes need to send their data. A sensor node chooses a random number, r between 0 and 1.

Let a threshold value be T(n) : T(n) = p/1-p ×(r mod p-1)

If this random number is less than a threshold value, T(n), the node becomes a cluster-head for the current round. The threshold value is calculated based on the above given equation that incorporates the desired percentage to become a cluster-head, the current round and the set of nodes that have not been selected as a cluster-head in the last (1/P) rounds, p is cluster head probability. After the nodes have elected themselves to be cluster-heads, it broadcasts an Advertisement message (ADV). This message is a small message containing the node's ID and a header that distinguishes this message as an announcement message. Each non-cluster-head node determines to which cluster it belongs by choosing the cluster-head that requires the minimum communication energy, based on the received signal strength of the advertisement from each cluster-head. After each node has decided to which cluster it belongs, it must inform the cluster-head node that it will be a member of the cluster. Each node transmits a join-request message (Join- REQ) back to the chosen cluster-head. The cluster-heads in LEACH act as local control centers to co-ordinate the data transmissions in their cluster. The cluster-head node sets up a TDMA schedule and transmits this schedule to the nodes in the cluster. This ensures that there are no collisions among data messages and also allows the radio components of each non cluster-head node to be turned off at all times except during their transmit time, thus minimizing the energy dissipated.

An unequal clustering communication : The hierarchical clustering in WSN can greatly contribute to overall system scalability, lifetime and energy efficiency. Hierarchical routing is an efficient way to lower energy consumption within a cluster, performing data aggregation and fusion in order decrease the number of transmitted messages to the BS. On the contrary, a single-tier network can cause the gateway to overload with the increase in sensors density. Such overload might cause latency in communication and inadequate tracking of events. In addition, the single-tier architecture is not scalable for a larger set of sensors covering a wider area of interest because the sensors are typically not capable of long-haul communication. Hierarchical clustering is particularly useful for applications. Context implies the need for load balancing and efficienties our reutilization. Applications requiring efficient data aggregation (e.g., computing the maximum detected radiation around a large area) are also natural candidates for clustering. Routing protocols can also employ clustering. In clustering was also proposed as a useful tool for efficiently pinpointing object locations.

In addition to supporting network scalability and decreasing energy consumption through data aggregation, clustering has numerous other secondary advantages and corresponding objectives. It can localize the route setup within the cluster and thus reduce the size of the routing table stored at the individual node. It can also conserve communication bandwidth because it limits the scope of inter cluster interactions to CHs and avoids redundant exchange of messages among sensor nodes. Moreover, clustering can stabilize the network topology at the level of sensors and thus cuts on topology maintenance overhead. Sensors would care only for connecting with their CHs and would not be affected by changes at the level of inter-CH tier. The CH can also implement optimized management strategies to further enhance the network operation and prolong the battery life of the individual sensors and the network lifetime. A CH can schedule activities in the cluster so that nodes can switch to the low-power sleep mode and reduce the rate of energy consumption. Furthermore, sensors can be engaged in a round-robin order and the time for their transmission and reception can be determined so that the sensors reties are avoided, redundancy in coverage can be limited and medium access collision is prevented Table 1.

Clustering is the task of dividing objects into groups called clusters, those objects has to be similar in a way or

Table 1: Input cluster data

Cell id	No of nodes	Cluster energy
0	12	99.736092
1	13	99.736702
2	16	99.736092
3	17	99.736519
4	19	99.736092
5	21	99.735795
6	23	99.736092
7	26	99.736092
8	28	99.736214
9	33	99.736519
10	38	99.736519
11	40	99.736519

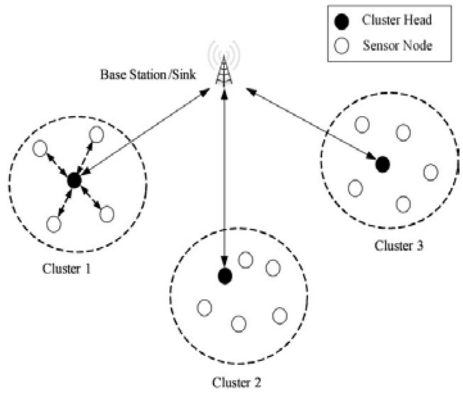

Fig. 1: Cluster based wireless sensor network

another. In WSN, clustering techniques are applied to solve the challenges encountered in WSN as a result of constrained energy supplies, communication range and bandwidth capabilities. In large scale WSN, clustering is an effective technique for the purpose of improving the utilization of limited energy and prolonging the network lifetime. Communication within one cluster as well as communication between different clusters can take place as combination of single hop and multi- hop as illustrated Fig. 1. In single hop communications, each sensor node can directly reaches the BS. While in multi-hop communications, nodes are forced to route their data over several hops until the data reaches the BS; due to the transmission range limitations. However, the single hop transmission from the CHs to the BS is not scalable because of limitation of the maximum transmission range. However, both models face the unavoidable of unbalanced energy consumption among different sensor nodes, leading to hotspot and network partitions problems. Clustering algorithms differ with respect to the metrics they use for cluster control such as energy, lifetime calculations, hops, distance from the cluster head and also the type of controls such as centralized or distributed.

RESULTS AND DISCUSSION

Ebuc protocol: The operation of our protocol is based on a centralized control mode that is implemented at the BS which is assumed to have no energy constraint. The EBUC protocol operates in rounds. Each round begins with a set-up phase when the clusters are organized and the multihop routing for inter-cluster communication is found, followed by a steady-state phase when the sensors perform periodical data gathering for predefined R times. At the end of the set-up phase, the BS broadcasts a message that contains the information about the clusters and the multihop routing. According to this message, every node confirms its role and every cluster head knows its RN. The system goes into the steady state phase gives an overview of the EBUC protocol, where the circles of unequal size represent our clusters of unequal size and the traffic among cluster heads illustrates our multihop forwarding method. In this study, an Energy-Balanced Unequal Clustering (EBUC) protocol is proposed and evaluated EBUC partitions all nodes into clusters of unequal size, in which the clusters closer to the base station have smaller size. The cluster heads of these clusters can preserve some more energy for the inter-cluster relay traffic and the 'hot-spots' problem can be avoided. For inter-cluster communication, EBUC adopts an energy-aware multihop routing to reduce the energy consumption of the cluster heads. Simulation results demonstrate that the protocol can efficiently decrease the dead speed of the nodes and prolong the network lifetime. Our energy model for the sensors is based on the first order radio model as used in Ref. In this model, the transmitter has power control abilities to dissipate minimal energy to send data to the receiver. In order to achieve an acceptable Signal-to-Noise-Ratio (SNR), the energy consumption of the transmitter Where, k is the number bit of the message and d is the distance. elecE (nJ/bit) is the energy dissipated per bit to run the transmitter or the receiver circuit and 2fs E (pJ/(bit m-)), mpE (pJ/(bitm-)) is the energy dissipated per bit to run the transmit amplifier depending on the distance between the transmitter and receiver. If the distance is less than a threshold od, the Free Space (FS) model is used; otherwise, the Multi Path (MP) model is used. The energy consumption of the receiver is given by:

$$R \times \text{elec } E\ (k) = E\ k$$

For the simulations described in this paper, we adopt the same assumption as used in. The communication energy parameters are set as:

$$E = 10\ \text{pJ} / (\text{bit} .\text{m-}\ )$$

The data fusion model used inour simulations assumes that the overall information collected by a cluster of n nodes, where each node collects k bits of data, can be compressed to k bits regardless of the number of nodes in that cluster. In our simulations, the energy cost for data aggregation is set as:

$$5\ \text{nJ} / \text{bit}\ D\ E$$

In order to cluster all nodes optimally, the BS needs to know the position and energy information of the nodes. When the nodes with random initial energy are

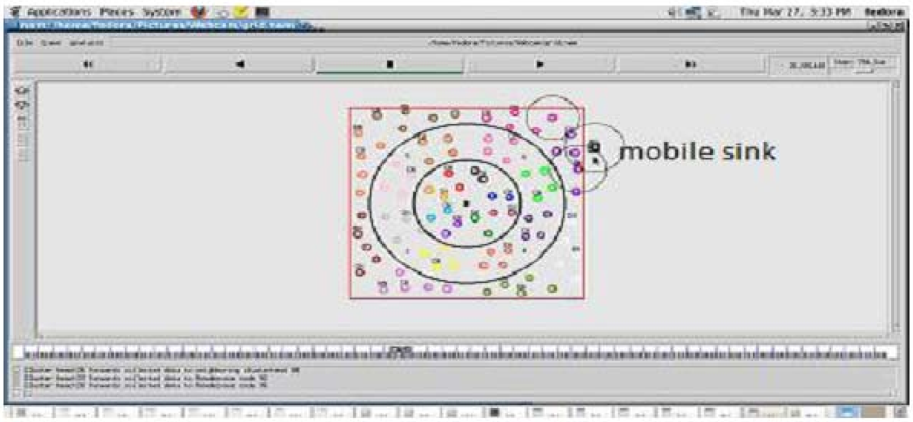

Fig. 2: Mobile sink collect data from cluster

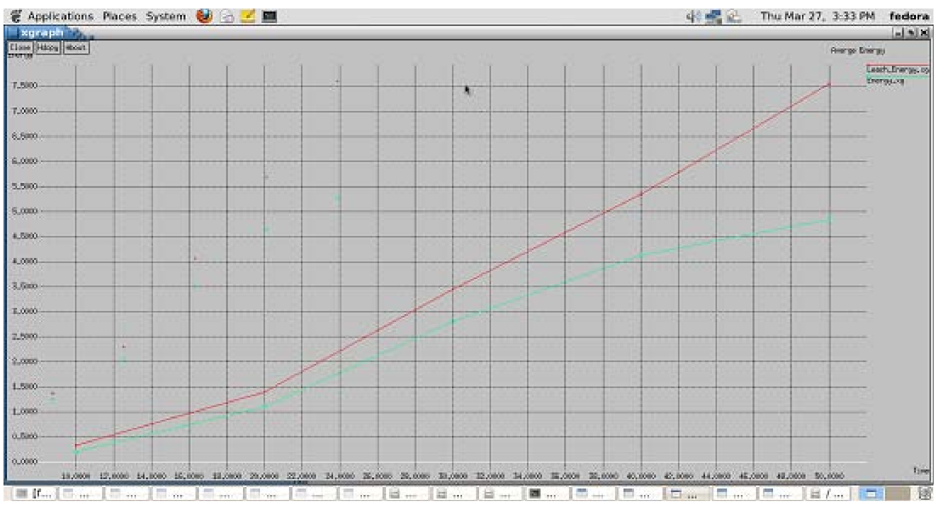

Fig. 3: Average energy consumption WSN

deployed, at the starting of the first set-up phase, all nodes send information about their initial energy status and locations to the BS. Based on this information, in the set-up phase of the following rounds, the BS can estimate the energy level of all nodes by computing the energy dissipation of nodes in last round. Therefore, all nodes don't need to send this message to the BS again (Sohrabi *et al*., 2000).

The basic idea of the clustering technique is a situation where sensor nodes are clustered and one CH is selected in each cluster that aggregates and compresses data in order to save energy and thereby to prolong the lifetime of the wsn. We proposed an energy efficient clustering algorithm that balances the energy consumption for intra and inter cluster communication. The algorithm organizes the network into unequal size clusters, where the clusters closer to the BS consist of a fewer number of nodes, to balance the energy used for the intra-cluster and inter-cluster communication .Gradient descent is based on the observation that if the cost function F(x) (energy consumption in our case) is defined and differentiable, it starts with an initial point () and generates a sequence of points according to an iterative procedure of a factor (α) as illustrated in Fig. 2-5. The cost function F(x) decreases faster if one goes in the direction of the negative gradient of F(x) at a certain point (a set of radiuses in our study case). Our goal is to determine the optimal cluster's radiuses that minimize the total power consumption among all Chs.

The wireless model essentially consists of the MobileNode at the core, with additional supporting features that allows simulations of multi-hop ad-hoc networks, wireless LANs etc. The mobilenode object is a split object. The C++ class MobileNode is derived from parent class node. A MobileNode thus is the basic node object with added functionalities of a wireless and mobile

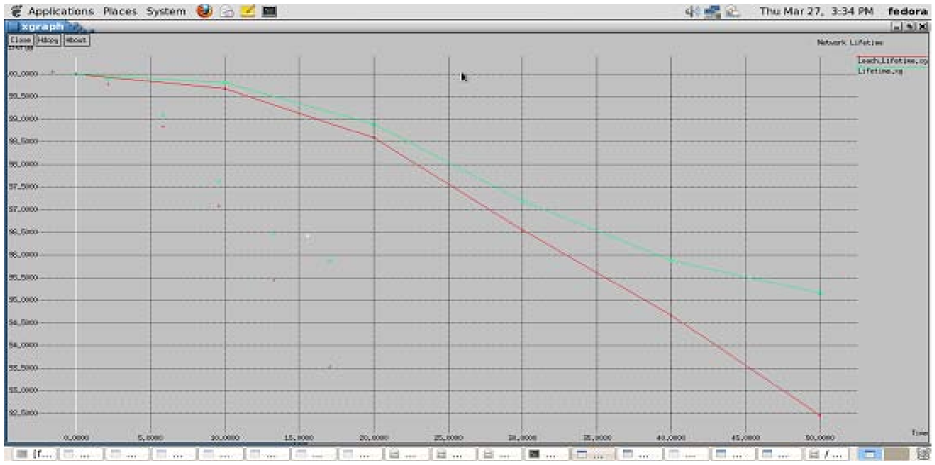

Fig. 4: Network lifetime of WSN

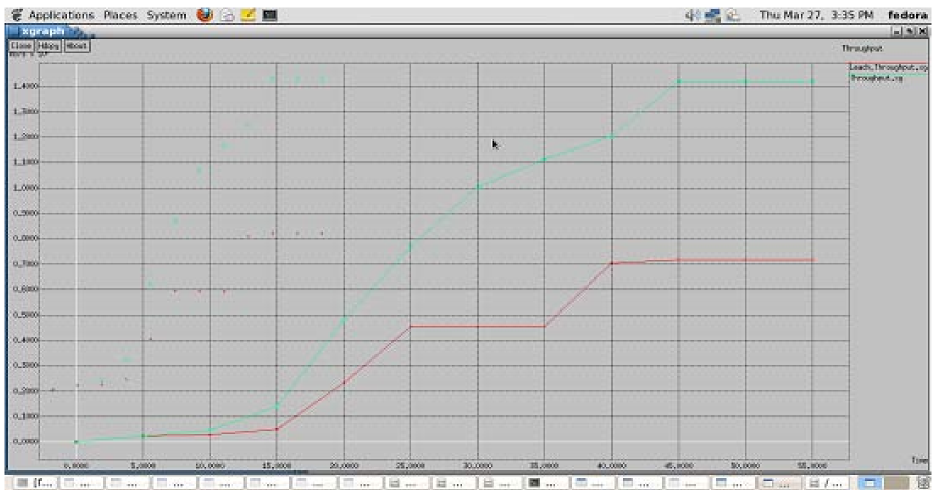

Fig. 5: Throughput power WSN

node like ability to move within a given topology, ability to receive and transmit signals to and from a wireless channel etc. A major difference between them, though is that a Mobile node is not connected by means of Links to other nodes or mobilenodes. In this section we shall describe the internals of MobileNode, its routing mechanisms, the routing protocols dsdv, aodv, tora and dsr, creation of network stack allowing channel access in MobileNode, brief description of each stack component, trace support and movement/traffic scenario generation for wireless simulations (Oyman and Ersoy, 2004).

Simulation and implementation: The mobile sink collects data from all the clusters. The data is simulated with the sample data. The data consumption and the throughput from the LEECH algorithm is compared with our unequal clustering algorithm. We can find that the throughput and the network lifetime improved compared to the leech algorithm. The sample coding of the algorithm is as follows Fig. 3.

```
set val(chan) Channel/Wireless Channel; # Channel Type
set val(prop) Propagation/TwoRay Ground; # radio-propagation model
set val(netif) Phy/WirelessPhy; # network interface type
set val(mac) Mac/802_1; # MAC type
set val(ifq) Queue/DropTail/PriQueue; # interface queue type
set val(ll) LL; # link layer type
set val(ant) Antenna/OmniAntenna; # antenna model
set val(ifqlen) 500; # max packet in ifq
set val(rp) DSDV; # routing protocol
set opt(energymodel) EnergyModel; # Initial Energy
set opt(radiomodel) RadioModel; # Transmission Model
set opt(initialenergy) 100 ; # Initial energy in Joules
```

CONCLUSION

In this study, a wireless sensor networks has been considered and an algorithm based on unequal clustering has been proposed for improvement of the network lifetime. We have analyzed a new efficient clustering approach for multi-hop routing of WSN, in order to balance energy consumption among CH nodes, in which unequal size clusters are formed based on mobile sink. This approach is compared with the leech algorithm. The improved performance is obtained in throughput and network lifetime.

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