International Journal of Combined Research & Development (IJCRD)
eISSN: 2321-225X;pISSN:2321-2241 Volume: 4; Issue: 10; October -2015

An Energy Efficient Approach in Data-Intensive Wireless Sensor Networks

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Abstract**— Sensor nodes generally lack hardware support, they are resource limited devices, and a key challenge faced by data-intensive wireless sensor network is to transmit all the data generated within the application life time to the sink. Considering the fact that the sensor nodes have limited power supplies, the low cost disposable mobile relays are used to reduce the energy consumption of data-intensive wireless sensor network. In this project tree is formed to transfer data within the application life time to the base station. This approach is going to differ from the previous work generally in two main aspects. First, it does not require complex motion planning of mobile relay nodes, so it can be implemented on a number of low-cost mobile sensor platforms. Second, we integrate the energy consumption due to both mobility and data transmissions into a standard optimization framework. The proposed approach consists of three stages of algorithm, first to be considered is static tree construction, second is node insertion phase and third is tree optimization phase. Simulation results show that specified algorithms significantly perform in better way compare to corresponding previous methods.**

Keywords**— Wireless sensor networks, energy optimization, mobile nodes, wireless routing.**

I. Introduction

A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as 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 surveillances; today such networks are used in many industrial process monitoring and control machine health monitoring, and so on.

Each sensor node senses environmental conditions such as temperature, pressure and light, and it sends the sensed data to a sink node or base station, which is long way off in general. Since the sensor node powered by limited power batteries, in order to prolong the life time of the network, low energy consumption is important for sensor nodes. In general, radio communication consumes most amount of energy, which is proportional to the data size and proportional to the square or the fourth of the power distance. Technology advance in mobile sensor platform technology, in recent years, it has been taken into attention that mobile elements are utilized to improve the WSN's performance such as coverage, connectivity, reliability and energy efficiency

Below figure is a typical example of a wireless sensor networks. It consists of a proxy server , gateways ,sink nodes many sensor nodes deployed in application areas. User will collect data from sink through internet. Sink is a point of contact to user. Sink will collect sensed from all the sensor nodes by using some intermediate is nodes. Critical part is to collect the sensed data as early possible because generally sensor nodes have limited battery backup and also they are resource limited devices. Wireless sensor network usefully in many applications, military areas earth monitoring application.

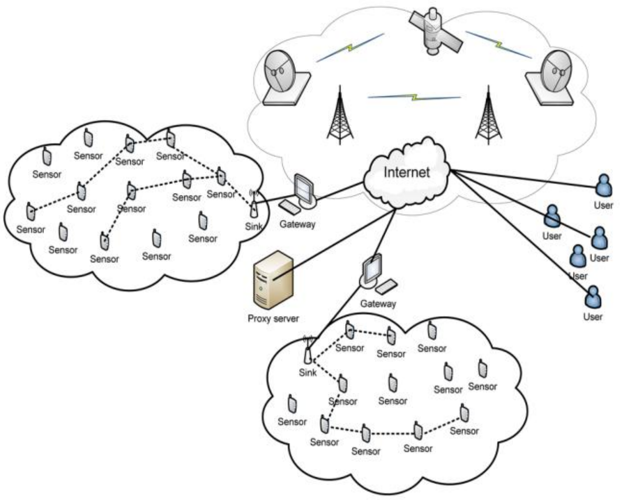

Figure 1.1 Wireless Sensor Network

WSNs have been deployed in variety of data intensive applications including micro-climate and habitant monitoring, precision agriculture, and audio/video surveillance moderate-size WSN can gather up to 1Gb/year from a biological habitat. Due to the limited storage capacity of sensor nodes, most data must be transmitted to the base station for archiving and analysis. However, sensor nodes must operate on limited power supplies such as batteries or small solar panels.

Therefore, a key challenge faced by data-intensive WSNs is to minimize the energy consumption of sensor nodes so that all the data generated within the lifetime of the application can be transmitted to the base station.

II. RELATED WORK

Several different approaches have been proposed to significantly reduce the energy cost of WSNs by using the mobility of nodes. A robotic unit may move around the network and collect data from static nodes through one-hop or multi-hop transmissions [4]. The mobile node may serve as the base station or a "data mule" that transports data between static nodes and the base station. Mobile nodes may also be used as relays that forward data from source nodes to the base station. Several movement strategies for mobile relays have been studied in [5]. Although the effectiveness of mobility in energy conservation is demonstrated by previous studies, the following key issues have not been collectively addressed. First, the movement cost of mobile nodes is not accounted for in the total network energy consumption. Instead, mobile nodes are often assumed to have replenishable energy supplies which is not always feasible due to the constraints of the physical environment. Second, complex motion planning of mobile nodes is often assumed in existing solutions which introduces significant design complexity and manufacturing costs. In [6], mobile nodes need to repeatedly compute optimal motion paths and change their location, their orientation and/or speed of movement. Such capabilities are usually not supported by existing low-cost mobile sensor platforms. For instance, Robomote [7] nodes are designed using 8-bit CPUs and small batteries that only last for about 25 minutes in full motion.

III. PROBLEM DEFINITION

Energy Consumption Models

Nodes consume energy during communication, computation, and movement, but communication and mobility energy consumption are the major cause of battery drainage. Radios consume considerable energy even in an idle listening state, but the idle listening time of radios can be significantly reduced by a number of sleep scheduling protocols [8]. In this work, we focus on reducing the *total* energy consumption due to transmissions and mobility. Such a holistic objective of energy conservation is motivated by the fact that mobile relays act the same as static forwarding nodes after movement. For mobility, we consider wheeled sensor nodes with differential drives such as Khepera, Robomote and FIRA. This type of node usually has two wheels, each controlled by independent engines. We adopt the distance proportional energy consumption model which is appropriate for this kind of node. The energy EM(d) consumed by moving a distance d is modeled as:

$$EM(d) = kd$$

The value of the parameter *k* depends on the speed of the node. In general, there is an optimal speed at which k is lowest.

An Illustrative Example

We now describe the main idea of our approach using a simple example. Suppose we have three nodes s1, s2, s3 located at positions x1, x2, x3, respectively (Fig. 1), such that s2 is a mobile relay node.

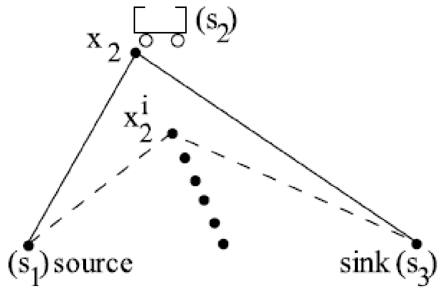

Figure 1: Simple example with three nodes

The objective is to minimize the total energy consumption due to both movement and transmissions. Data storage node s1 needs to transmit a data chunk to sink s3 through relay node s2. One solution is to have s1 transmit the data from x1 to node s2 at position x2 and node s2 relays it to sink s3 at position x3; that is, node s2 does not move. Another solution, which takes advantage of s2's mobility, is to move s2 to the midpoint of the segment x1x3, which is suggested in [13]. This will reduce the transmission energy by reducing the distances separating the nodes. However, moving relay node s2 also consumes energy. We assume the following parameters for the energy models: k = 2, a = 0.6 × 10−7, b = 4 × 10−10.

IV. PROPOSED SYSTEM

In this project low-cost disposable mobile relays to reduce the total energy consumption of data-intensive Wireless Sensor Networks. Differ from robotic unit, mobile base station or data mules, the mobile relays do not transport data; instead, they move to different locations and then remain stationary to forward data from the source or sensor node to the base station. Thus, the communication delay can be significantly reduced compared to using mobile base and data mules. Each mobile node performs a single relocation unlike other approaches which require repeated relocations. The specified approach is motivated by the current state of mobile sensor platform technology. On the other hand, numerous low-cost mobile sensor prototypes such as Robomote, Khepera, FIRA are now available. Their manufacturing cost is comparable to that of typical static sensor platforms. As a result, they can be massively deployed in a network and used in disposable manner. The approach takes advantage of this capability by assuming that we have a large number of mobile relay nodes.

On the other hand due to low manufacturing cost, existing mobile sensor platforms are typically powered by batteries and have the capability of limited mobility. Consistent with this constraint, the approach only requires one-shot relocation to designated positions after deployment. Compared with this approach, existing mobility approaches typically assume a small number of powerful mobile nodes, which does not exploit the availability of many low-cost mobile nodes.

V.IMPLEMENTATION

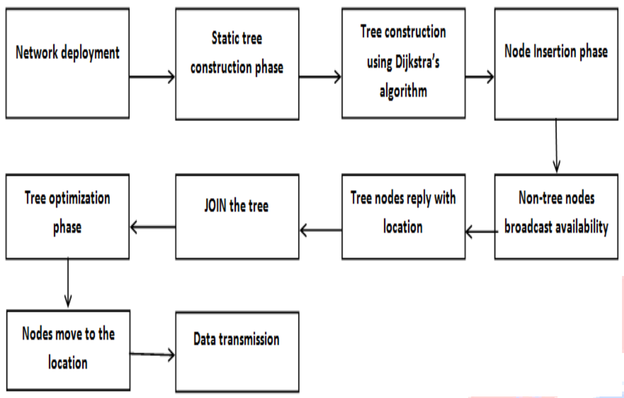

Figure 2: Proposed System block diagram

A. Modules:

- WSN creation and routing
- Mobile Relay nodes
- Tree Construction
- Performance analysis

B. Modules Description

- WSN creation and routing

In this module, a Wireless Sensor Network is created. The sensor nodes and Sink in configured and randomly deployed in the network area. The sensor nodes are equipped with energy resource. The sensor nodes are connected with wireless link. The sensor nodes would transmit the data to the Base station nodes. The sensor nodes need to consume the energy to send, receive the data. The communication is enabled in the network between sensor node and base station or sink.

- Mobile Relay nodes

In this module, the mobile relay nodes are used to transport data from sensor nodes to sink. Mobile Relay used in tree construction process. Depending upon on the data size mobile relay node will move and remain stationary to forward the data from sensor nodes to sink. Mobile relay nodes do not always active. Instead they goes to sleeping modes untill the noticeable variation in the data rate from the source nodes and request from sink nodes. When sink is requested it will send phenom packets signal to all sensor nodes and Mobile ralay nodes. When they receive phenom packets mobile relay nodes comes under alive state and ready to transmit the data to sink nodes.

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- Tree Construction

In this module, using dijkstra algorithm, routing tree is constructed. Network nodes outside the tree broadcast their availability (as HELLO packets message) to tree nodes within their communication range and wait for responses for a period of time. The tree nodes respond to the sender by giving it its location information and its parent's location information. The algorithm used in this project is explained in next section. Then the sender nodes calculate the reduction in cost and join with the tree. In Tree optimization phase, the nodes move to their transmission positions, send messages to their neighbors saying they are in position, and finally perform the transmission. The algorithm used in this project is explained in next section.

- Performance analysis

In this module, the performance of proposed method is analyzed. Based on the analyzed results graphs plotted using X-graphs. Throughput, delay, energy consumption are the basic parameters considered here and X-graphs are plotted for these parameters.

The delay graph shows comparison graph of existing and proposed system. The graph shows the delay is going to be less in the proposed system compared to the existing system. Energy graph shows energy consumption comparison graph of existing system and proposed system. It shows the energy consumption is less in the proposed system compared to existing system. This is the throughput comparison graph of existing system and proposed system. It shows the throughput is high in proposed system with compared the throughput value in the existing system.

Finally, the results obtained from this module is compared with third module results and comparison X-graphs are plotted. Form the comparison result, final RESULT is concluded.

C. Algorithm Used

In this project three algorithms are used. First algorithm is the Static tree constructor. Second algorithm is about node insertion and third about tree optimization. All three algorithms presented in Distributed manner.

a) Distributed Algorithms

The tree construction phase to use a fully distributed routing algorithm. We pick greedy geographic routing since it does not require global knowledge of the network although any algorithm with such property can be used.

After a routing tree is constructed, the tree restructuring phase begins. Network nodes outside the tree broadcast their availability as Node_in_range message to tree nodes within their communication range and wait for responses for a period of time Tw. Tree nodes enter a listening phase Tu. During that period, tree nodes receive messages of different types (Node_in_range, Offer…) Each tree node that receives one or more Node_in_range message responds to the sender by giving it its location information and its parent s location information. It also sends the tree node with the second largest reduction a Potential_Offer message.

If Vi's best potential offer exceeds its best offer by a certain threshold B and Vt has not already waited R rounds, Vt waits rather than accepting its best offer in the hopes that its best potential offer will become an actual offer in another round. By waiting, it sends everyone a Reject_Offer, restarts the listening phase, and records that it has waited another round.

A non tree node p that receives an Accept_Offer message moves to the corresponding local optimal location and joins the tree. It becomes a tree node and enters the listening phase. On the other hand, if p does not receive an Accept_ Offer, p repeats the process by broadcasting its availability again and resetting Tw.

Giving tree nodes the ability to wait before accepting an offer increases the chances of using mobile relay nodes to their full potential. For example, consider a scenario where several tree links but all closest to one specific link. They will all send offers to the same tree node while the rest of the tree nodes in their proximity will receive modest offers from more distant mobile nodes. If the tree nodes cannot wait, they will be forced to accept a modest offer and the mobile nodes will either remain unused or they will help more distant tree nodes where their impact is reduced since they use up more energy to get to their new location.

The centralized tree optimization algorithm can be transformed into a distributed algorithm in a natural way. The key observation is that computing each uj for node si only depends on the current position of si's neighbors in the tree (children and parent), nodes that si normally communicates with for data transfers. Thus, si can perform this computation. The distributed implementation proceeds as follows. First, there is a setup process where the sender s1 sends a discover message that ends with the receiver sn; the two purposes of this message are one to assign a label of odd or even to each node si and two for each node si to learn the current positions of its neighbors. A node si sends its current position to node sj when acknowledging receipt of the discover message. Second, there is a distributed process by which the nodes compute their transmission positions. We make each iteration of the basic algorithm a "round", though there does not need to be explicit synchronization. In odd rounds, each odd node computes its locally optimal position and transmits this new position to its neighbors. In even rounds, each even node does the same. A node begins its next round when it receives updated positions from all its neighbors. The final step is to have the nodes move to their computed transmission positions, send messages to their neighbours saying they are in position, and finally perform the transmission. To ensure the second process does not take too long, we limit the number of rounds to 8; that is, each node computes an updated position four times. Simulation results show that this is enough to obtain costs close to optimal.

```
Procedure TREERUN
  ⊳ Phase I: Run routing algorithm to discover parent and children
      (parent, children) ← DISTRIBUTEDROUTING;
  ⊳ Phase II: Start tree restructuring phase
  offers ← ∅; potentialoffers ← ∅; wait ← 0;
  repeat
      ⊳ Listen to incoming offers or changes in structure
      repeat
          RECEIVE(sender, type, data);
        if type = MOBILE IN RANGE then
              SEND(sender, META DATA, info);
        else if type = OFFER then
              offers.add(data);
        else if type = POTENTIAL_OFFER  then
             potentialloffers.add(data);
         else if type = UPDATE_STRUCTURE  then
             children.add(data.newchild);
            children.remove(data.oldchild);
        end if
      until timeout
      ⊳ Process offers and pick best
      if offers !=∅ then
        bestOffer ← offers.dequeue();
        bestPotentialOffer ← potentialoffers.dequeue();
        if bestPotentialOffer > bestOffer*B and wait < R
        then
            SEND(bestOffer.sender, REJECT_OFFER);
           wait++;
          else
            SEND(bestOffer.sender, ACCEPT_OFFER);
              parent ← bestOffer.sender;
          end if
       end if
       while offers !=∅ do
          offer ← candidates.dequeue();
            SEND(offer.sender, REJECT_OFFER);
        end while
   until timeout
  ⊳ Phase III: Iterate moving to optimal local positions
  converged ← false;
  while not converged do
       (u, converged) ← LOCALPOS(o, parent, children);
```

```
    ⊳ Exchange location info with parent and children
     SEND(parent, NEW LOCATION, u);
    for all child ∈ children do
          SEND(child, NEW LOCATION, u);
     end for
     RECEIVE(parent, NEW LOCATION, parent.u);
     for all child ∈ children do
             RECEIVE(child, NEW LOCATION, child.u);
   end for
  end while
end procedure
```

VI. RESULT ANALYSIS

We use NS2 as our simulating tool. We assigned a network consisting of 40 nodes from node 0 to node 39.Initially, each node find its neighbor node by transmitting HELLO Messages. The HELLO Messages is transmitted periodically for every HELLO period second. The default transmitting range for HELLO Message is 250m. After finding its one hop and two hop neighborhoods, a node start transmitting its packet .The source node sends constant bit rate traffic to destination node. The traffic sources are carried by transport layer protocols User Datagram protocol (UDP) or Transmission control protocol (TCP). At the end of simulation, the trace file is created and the NAM is running (since it is invoked from within the procedure finish{}).Trace file gives the details of packet flow during the simulation.NAM trace is records simulation detail in a text file, and uses the text file the play back the simulation using animation.

Here we are assigning 40 nodes from node 0 to node 39 and they are apart from each other.

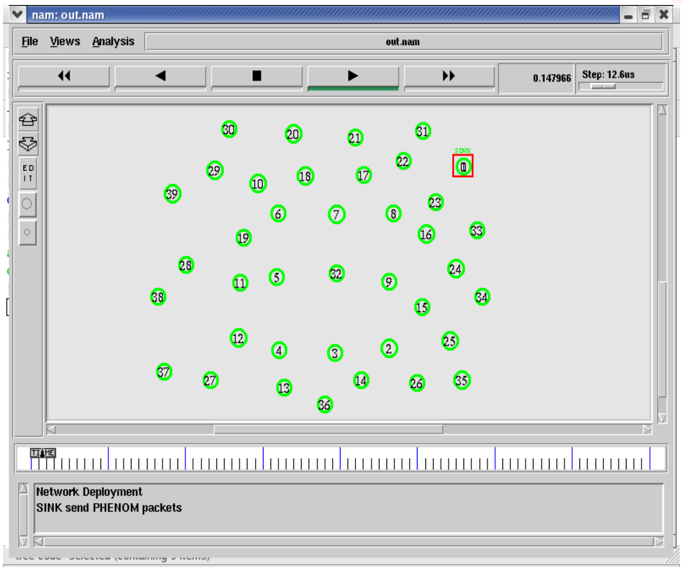

Figure 3: Node Initialization

All the nodes find its neighbor node by sending HELLO Message. They transmit HELLO Messages periodically for every hello period second. A node is deleted from its neighbor list if no hello message is received from that neighbor in three consecutive hello periods

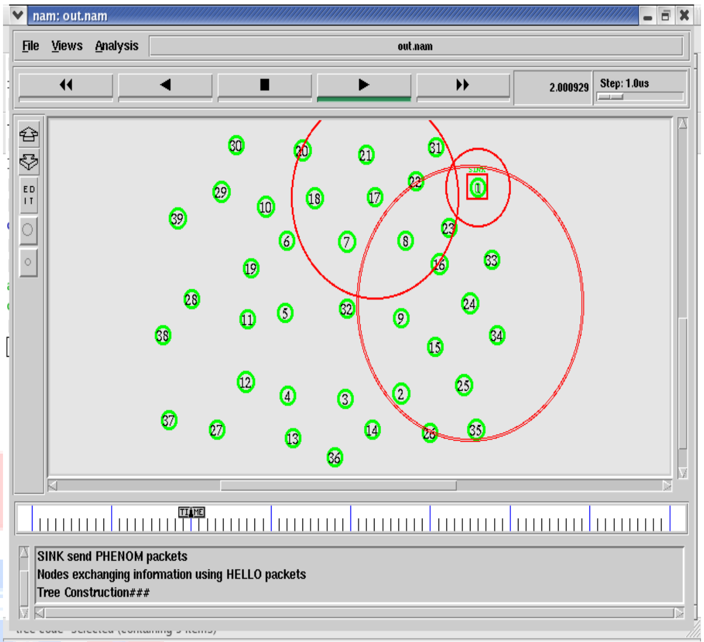

Figure 4: Tree Construction

The above window shows the important stage of the operation i.e. the tree construction stage. Nodes within communication range using hello packets sends request to neighbour nodes to construct tree. Once tree is constructed then node insertion phase begins.

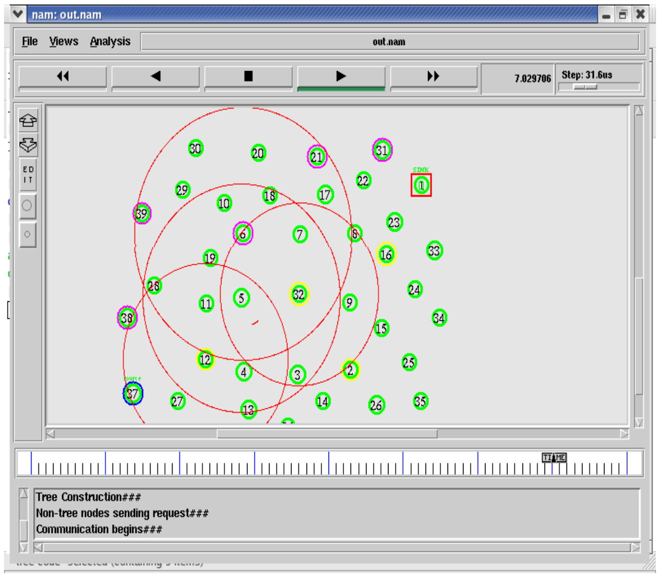

Figure 5: Communication Phase

The above window shows the communication part of the operation, where the specific data packets are getting transmitted from source to corresponding sink node.

a. *XGRAPH FOR THROUGHPUT*

The graph in Figure 7 shows the throughput comparison for existing system and proposed system. The throughput is high for proposed system compared to existing system.

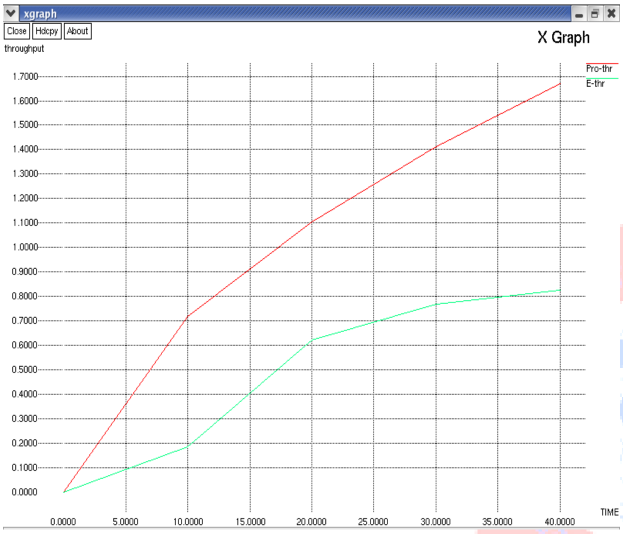

Figure 6: Xgraph for Throughput

b. *XGRAPH FOR ENERGY CONSUMPTION*

The graph in Figure 7 shows the energy consumption parameter comparison for proposed system and existing system. The energy consumption is less in the case of proposed system compared to existing system

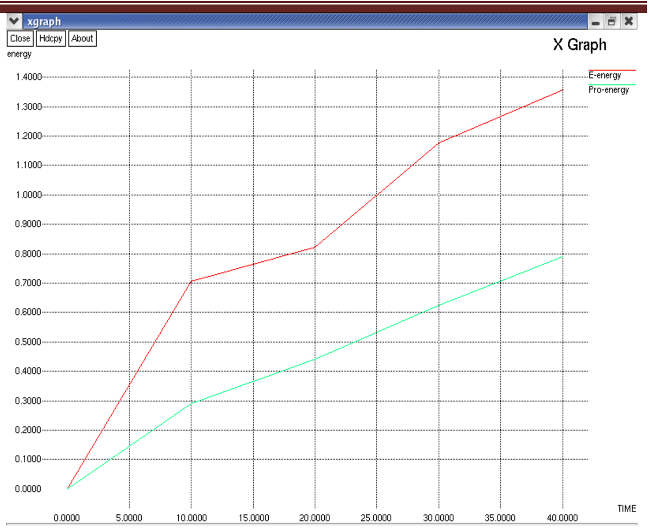

Figure 7: Xgraph for Energy Consumption

c. *XGRAPH FOR DELAY*

The graph in Figure 8 shows the delay comparison for proposed system and existing system. The delay is less in the case of proposed system compared to existing system.

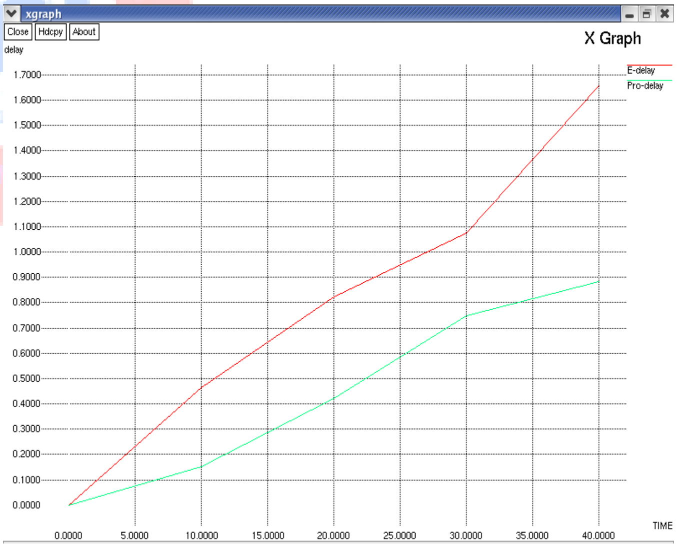

Figure 8: Delay Graph

VII. CONCLUSIONS

It is a known fact that sensor nodes have issues like limited battery. Considering the permanent batteries won't support for long duration of time and sensor nodes also have issue like recharging the battery energy. In this approach mobile relay nodes are used and also algorithm used to minimize the energy consumption in wireless sensor network. The algorithm consists of three phases: Static tree construction phase, Node insertion phase and finally tree optimization phase are used to reduce the energy consumption in WSNs during data transfer from sensor nodes to sink. Simulation results show that the algorithms significantly outperform when compared to the previous methods. Energy consumption is minimized because mobile relay nodes are used and also delay is reduced to great extent during data transmission operation.

In a complex and large building or area, multiple heterogeneous sensor networks can be deployed with a single gateway (GW). Hence, an energy efficient delivery mechanism from sinks to the GW is required and relay points (RPs) are placed between sinks and the GW for providing the network connectivity between them. The optimal placement of RPs becomes an important performance determining factor, so we have proposed a mechanism to deploy RPs in a grid pattern and to use the tree-based relaying network whose root is the GW. In the tree-based relaying net work, RPs perform only the simple forwarding function, so the cost of the RP can be significantly reduced and the lifetime of the RP can be increased.

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