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GA-BASED OPTIMAL POSITIONING OF MOBILE SINK IN WIRELESS SENSOR NETWORK

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ABSTRACT

A primary challenge faced by Wireless sensor networks is to transmit large chunks of data by sustaining the limited energy available. We propose to reduce the energy consumption of data-intensive WSNs using cheap mobile relays. Our proposal differs from previous work in that we integrate the energy consumption due to both mobility and wireless transmissions into an optimization framework. This framework consists of three main aspects. The first procedure computes an optimal routing tree with an assumption that no nodes can move. The second procedure involves adding mobile nodes using genetic algorithm (GA).The third procedure improves the network by optimizing the routing tree. This algorithm links up to an optimal position for each node, given that the topology of routing tree does not change. Our simulation results prove that our proposal significantly surpasses the existing solutions.

Keywords: wireless sensor network, mobile sensors, energy optimization, routing, genetic.

1. INTRODUCTION

Wireless Sensor Network (WSN) is a technology with a variety of applications such as environment and patient monitoring, military applications such as surveillance, security [1]. For WSNs, many protocols have to be specifically designed that have to be efficient, resource friendly where energy awareness is an important design issue. In wireless sensor networks, there are unique challenges with regards to unit power consumption, overall size. In WSNs and MANETs, energy is an insufficient resource. But WSNs have other requirements such as network lifetime, and recharging a WSN node's battery is much less an option compared to MANETs. Thus, the impact of energy considerations on the complete architecture is deep in WSNs than in MANETs. In a WSN, this problem exists if the sensor nodes are mobile in the given application. Deploying the mobility of nodes increases the energy consumption of these nodes. Several works have been made on the fact that mobile nodes improve the energy of the network. However, the algorithms used to prove the above are not optimal [2]. So our paper deals with determining an optimal position of mobile nodes by employing an evolutionary algorithm named Genetic Algorithm (GA).We propose a heuristic GA algorithm that helps in determining the optimal position and in turn reduces the energy consumption.

2. RELATED WORKS

Based on the application that is required, sensor nodes have to be spread over an area that is geographically wide, resulting in a sparse network. The distribution of sensors can be homogeneous or heterogeneous. For example, Sensors at the intersection point of cities are an example of a homogeneous distribution while habitat monitoring sensors are scattered in a heterogeneous manner. [3] Energy is one of the most crucial resources in sensor networks because of the process of recharging the batteries of devices in remote environments. Generally, the nodes closer to the sink are more prone to use up the energy because it is these nodes that transfer data coming from farther nodes. [4] Sensors do not use any data directly however they transmit it to the sink. On the other hand, sinks transmit the data to the end users through gateways. Sensors are spread over a wide area so recharging them is a cause of concern. Also the network has to be partitioned in case some sensor nodes fail causing exhaustion of energy. Therefore, the networks have to be designed in such a way that it consumes energy evenly. The most apt routing protocol for the above issue is TTDD (Two Tier Data Dissemination). TTDD is said to cover-up for draining the energy because almost all the nodes are involved in data transmission. The network, sparse or dense, in which the sensors are connected and deployed, plays a prominent role. There are several methods to ensure that a proper connection is established in sparse networks like deploying the required sensors to form dense sensor nodes in a connected network. The approach that involves base station yields high communication power that is needed by the sensors in addition to the cost of fixing newer stations. Also, the cost of deployment of low cost nodes to form a dense and completely-connected network may not be effective. However employing dense sensors does not graduate the performance of the network and is not suitable when we use mobile sensor nodes. The key solution to making this possible is the use of data MULEs (Mobile Ubiquitous LAN Extensions). For example, in the scenario of environment monitoring, humidity can perform this role. MULEs are capable of wireless communication through short range and can transfer the data from nearby sensors or the access points they encounter that occurs as a result of the MULE's motion. Thus MULEs can gather data from sensors when they are present within a reachable range, buffer the data and drop the data to connected access points when present in that particular range [5]. The basic advantage of using mules is their huge potential of saving power that arises at the sensors because of close range communication. However the disadvantage in using

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MULEs is the increased latency that occurs when the sensors have to wait for a MULE to be approached before the transfer can occur. However for many applications that involves collection of data, increased latency is sustainable but when it comes to energy optimization it is essential that we take into account the movement cost of nodes. MULEs move independent of each other and do not exchange any data among themselves when they intersect. Data mules are similar to a particular form of mobile base station. They collect data from the sensors and transport it to the sink. Here, the data mule visits all the available sources, combines together the data, transports data over some possible distance, and then relay it to the base station through the network. The goal is to find a movement path that minimizes both communication and energy consumption due to mobility. Similar to mobile base stations, data mules produce large delays since sensors have to wait for a mule to progress before starting their transmission. The concept of reducing the energy consumption of nodes in a wireless sensor network is not effective when the network consists of only static sensor nodes. So considering the movement and transmission cost of nodes, mobile nodes serve a better purpose. This in turn helps to minimize the consumption of energy [6].

Mobile sensors can physically carry large chunks of data to reduce energy consumption in wireless transmission. Networks with mobile nodes are generally smaller; they are more versatile than static nodes as they can be used in any scenario and cope up with any topological changes. Even in predominant static sensor networks, there is a possibility to have a few mobile nodes. However Mobility of nodes in WSNs adds a significant challenge. The challenge faced by such mobile sensor networks is routing to mobile sink .In typical WSN scenarios, sensor nodes outline their measurements to the sink using multi-hop communication. Also, several routing protocols are available that make use of neighborhood information to route packets to the sink. This ensures a reliable and efficient communication in the case of one to multi hop scenarios. The GRAB (Gradient Broadcast) protocol is based on the above idea. However this route discovery method encounters large overheads. The Ad-Hoc on Demand Vector routing protocol overcomes the overhead incurred by maintaining a routing table for each destination which in turn minimizes the energy consumed. The sink transmits the data along a shortest path, considering the energy along each of these paths. [7] The energy consumption of network nodes can be reduced by adopting sink mobility which in turn helps to avoid energy holes in the network. However a side effect caused by using the GRAB protocol that employs mobile sink is, loss in the packet rate. Routing to the mobile sink must follow the periphery of the network. Thus the lifetime of the networks strongly depends on the energy of the sensors nodes around the sink that relay all messages on the last hop [8]. [9] However, when we use multiple path hops, additional energy is consumed which is not desirable in terms of efficiency. For the purpose of extending the network lifetime and efficient energy consumption, we employ mobile sink.) In a sensor network with a mobile sink, the data must be routed from the static sensor sources to the moving entity. The routing protocols handle mobility in WSN by updating the routes at a high cost is it using proactive or reactive routing protocols. The ZigBee standard is widely used to study the mobility in sensor nodes [10]. Mobility of sensors and sink node may result in regaining the data faster using a reinforcement learning algorithm for mobile sensor nodes called Hybrid Learning Enforced Time Domain Routing (HLETDR). Each node learns the pattern in which the mobile sink moves and visualizes it as a probability distribution function. Also, energy can be conserved by minimizing the distance taken by the packets to reach the sink node [11].

3. PROPOSED SYSTEM

The proposed algorithm consists of a data aggregation tree construction algorithm for given positions of all sensor nodes and a GA-based algorithm to decide the best positions of mobile sensor nodes. The proposed model has the following steps.

Step 1: Constructing a routing tree with static nodes
Step 2: Apply genetic algorithm to a set of mobile nodes
Step 3: Apply localization technique to determine the optimal position.
Step 4: Reconstruction of tree

The above mentioned steps have been integrated into an algorithm as given below:

procedure Djikstra's_algo
Begin
For a and b in the tree,
path(a, b, m) ⟵ set of links connecting a and b
For each 'm'
cost(path) sum of |m|
P and Q ⟵ empty set
If q ∈ Q
such that (s, sinknode) ⟵ minimum,

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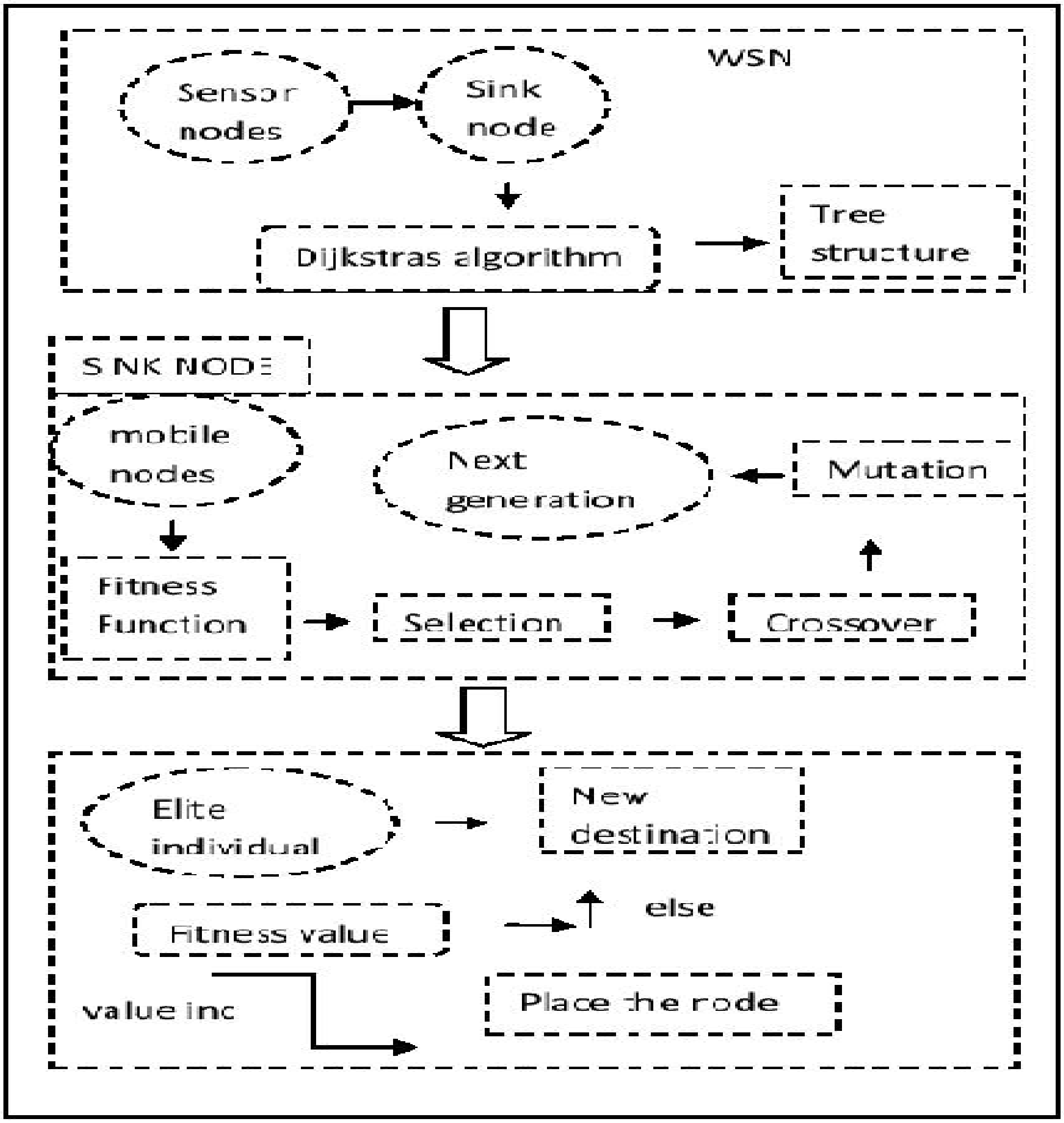

Figure-1. Architecture diagram.

add a link (q, sinknode) to P
remove q from Q.
For q'∈ Q
q'' in P such that
|(q, q″)2 +cost(path(q′,sinknode, P)) ⟵ smallest
add link (q', q″) to P
remove q' from Q
Until Q becomes empty
end
procedure optimization_algo
Begin
For nodes in list,
evaluate fitnessf(i) ⟵ sqrt(distance)/energy of each node
perform crossover, mutation
obtain the fittest node
for each new destination
calculate the fitness again
compare with the other nodes in the list
obtain the energy value
until energy increases
end

4. SIMULATION

We have performed simulations using an NS-2 simulator. A network simulator is most suitable for wireless networks. The NS2 simulator has various functionalities not available in NS-1. It allows for Scalable Reliable Multicast and provides high end support for mobile hosts. It allows for implementation of Link Layer, MAC and since our project is based on mobile host, we implement using Network Simulator 2. We carried out simulations on an initial topology consisting of a set of nodes placed uniformly at random within a 500 m by 500 m area. We use these initial topologies to generate two

ARPN Journal of Engineering and Applied Sciences

subsequent sets of complete topologies with established sources and sink. We perform the simulation based on the above mentioned algorithm and the results are as follows. To obtain the fit node, we have performed genetic algorithm by going through the operations such as selection, crossover and mutation. This process continues for some random number of generations. The next level of optimization by placing the fit node at random destinations and analyzing their values after displacing their positions are also one. This comparison shows that the position we placed the mobile node is optimal. Table-1 depicts the value of mobile nodes as they go through 6 generations of the genetic algorithm. For resulting topology, we created separate input instances by varying the data chunk size where the data chunk size for an input instance is the common amount of data to be transferred from each source to the sink. Figure-2 and Figure-3 shows the network life and transmission delay analysis of proposed approach with and without mobile sink. Mobile sink improved the performance than static sink.

Table-1. Iteration of node population.

Nodes	Present Generation	Generation 1	Generation 2	Generation 3	Generation4	Generation5	Generation6
17	2.770415	1.385208	0.692604	0.230868	0.038478	0.023087	0.001283
18	5.035961	1.678654	0.503596	0.419663	0.069944	0.020983	0.003497
19	4.018519	1.004630	0.502315	0.334877	0.033488	0.011163	0.001395
20	2.359831	1.179915	0.589958	0.098326	0.098326	0.003933	0.001639
21	9.605254	4.802627	2.401314	0.320175	0.100055	0.026681	0.002668
22	10.545184	2.109037	1.757531	0.878765	0.146461	0.087877	0.007323
23	7.844801	3.922400	0.784480	0.653733	0.081717	0.032687	0.002179
24	8.755713	1.751143	4.377856	0.292857	0.121607	0.072964	0.012161
25	7.625018	1.906255	3.812509	0.635418	0.317709	0.031771	0.005295
26	6.800801	1.360160	0.680080	0.377822	0.056673	0.011335	0.003149

VALUE OF FIT NODE = 0.001283
OPTIMAL POSITIONING OF NODES
AFTER MAKING RANDOM DESTINATIONS
RANDOM DESTINATIONS1
value of 17 at random destination = 0.000655
RANDOM DESTINATIONS2
value of 17 at random destination = 0.001964
ENERGY VALUE OF FITNODE IS HEIGHER AT VALUE 0.000655
At the new destination 34.000000 314.000000
COMPARISION WITH OTHER NODE
value of 24 at the above destination = 0.005500

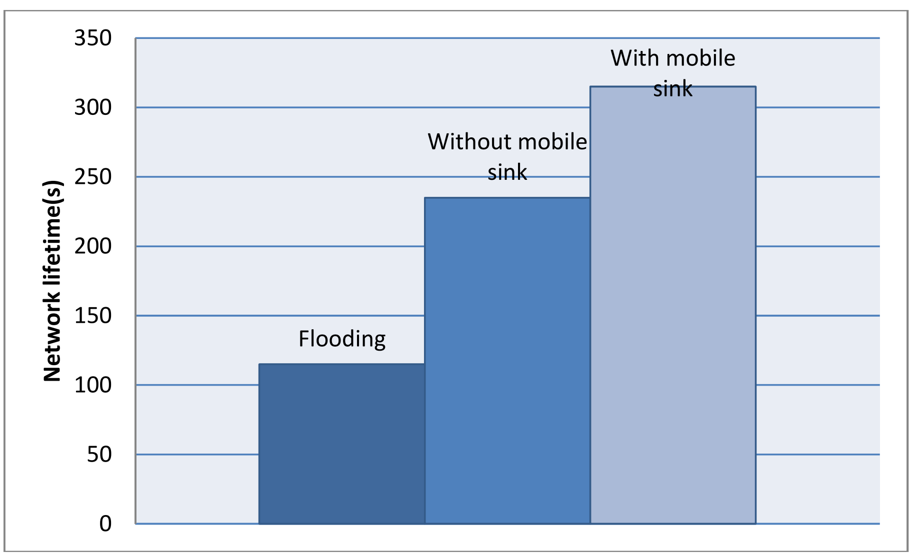

Figure-2. Comparison of network lifetime.

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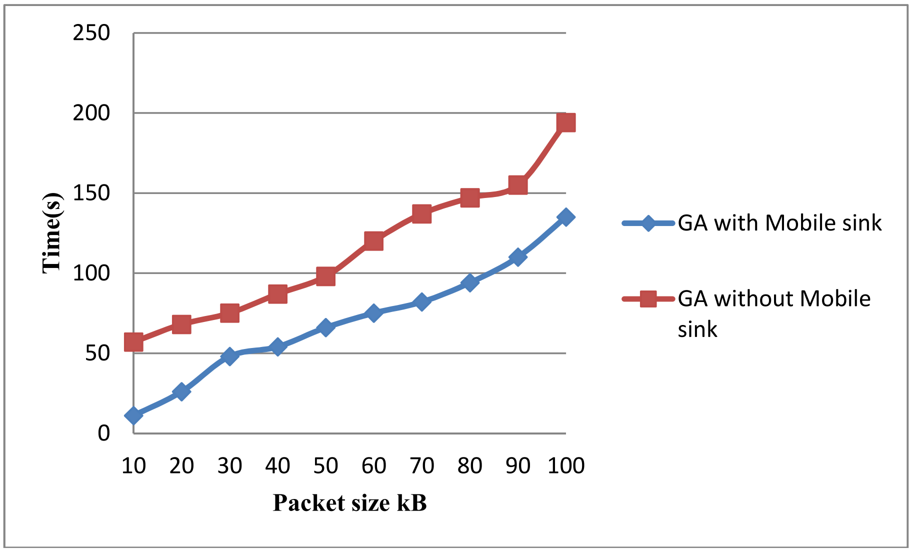

Figure-3. Comparison of data tranmission delay.

5. CONCLUSIONS

In this paper, we proposed a heuristic approach to reduce the total energy consumed by both mobility of nodes and transmissions in wireless networks. Previous works ignored the energy consumed by moving mobile nodes. The optimal position of a node that receives data from one or more neighbors and transmits it to a single sink when there is an inclusion of both sources of energy, is not the midpoint of its neighbors; instead, we place it at the position where the efficiency of mobile node improves and thus reduces the transmission cost incurred by the node. This scheme computes the fitness value of mobile nodes in the tree by using genetic algorithm. This algorithm is appropriate for a variety of data-intensive wireless sensor networks. It allows some nodes to move while other nodes do not because any improvement done locally for a given mobile relay causes a global improvement. This allows us to extend our approach by inserting the fittest nodes into the tree topology and thereby improving the efficiency of the network system. Also, we can take into account the performances of the other nodes and perform any re-construction if required.

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