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ENERGY EFFICIENT BACKBONE SCHEDULING ON MOBILE SENSORS

Ms. R. Priya,
Assistant professor,
Mahendra College of Engineering,
Salem, Tamilnadu, India

Ms. S. Meera,
Assistant professor,
Mahendra College of Engineering,
Salem, Tamilnadu, India

Abstract*— In this paper we have devised an energy saving scheme for the mobile sensors in wireless sensor network. Here we use a proposed technique called Backbone scheduling (BS) for power conservation in mobile sensors. Motion less design is a common design because long term motion will consume a lot of energy. Power conservation in mobile sensors can be achieved based on the BS, in this traffic is only forwarded by Backbone sensor nodes, and the rest of the sensor nodes turn off their radios to save energy. Mobile sensors are duty-cycled and have the same working cycle. We define T continuous cycles as a round, where T >1, T is a tunable parameter. At the beginning of each round, a Backbone is selected to work in duty-cycling.

***Keywords*— Sensor Network, Mobile sensors, Backbone scheduling**

I. INTRODUCTION

A wireless sensor network (WSN) consists of a large number of sensor nodes which are deployed over an area to perform local computations based on information gathered from the surroundings. Each node in the network is equipped with a battery, but it is almost very difficult to change or recharge batteries.

A sensor node is composed of typically four units. Sensing unit- sense the desired data from the interested region, the memory unit - store the data until it is sent for further use, computation unit- computes the data, and the power unit provides the power supply for entire process. Efficient use of energy in the wireless sensor network is one of the most challenging tasks for the user of the sensor networks. Usually sensor devices are small and inexpensive so they can be produced and deployed in large numbers, but their resources of energy, memory, computational speed and bandwidth has several constraints. Therefore, it is important to design sensor networks aiming to maximize their life expectancy. Energy of a sensor node is consumed for sensing coverage area of that node, to send data from one node to another node or to a receive data from other nodes.

Mobile sensor node deployment and power management are important issues in the wireless sensor network system. Motion less is a common design because long time motion will consume lot of energy. Different perspective mobile sensor node is useful to deploy sensor nodes based on the requirement, which make the system more flexible. The goal is the formation of an energy efficient node topology for a longer system life [8].

With the rapid progress of embedded system and the significant evolution of wireless technologies, computation surrounded us can realize a vision of ``ambient Intelligence´´. It means many different devices will gather and process information from many different sources to control physical process and to interact with human users. From this perspective, wireless sensor network (WSN) has been developed as a new wireless network technology. Due to combining the advantages of embedded system technology and wireless technology, WSNs can be widely used in numerous applications. However, current WSN protocols are very limited in supporting mobility applications. The main challenge is mobility causes network changing instantly. WSN protocols should be re-designed or extended to handle this challenge.

Several reasons can lead sensor nodes to be mobile. After deployment, existing sensor nodes can fail due to hardware error or power exhausted. New sensor nodes can join the network to replace failed ones. This kind of movement is defined as weak mobility. If sensor nodes physically move, the mobility would be defined as strong mobility [1]. In WSNs, more and more applications need to deal with this kind of strong mobility.

II. RELATED WORK

The aim of our proposed work is to balance energy consumption and prolong the network lifetime by scheduling dynamically a mobile nodes to go for a sleep in each round. Infinite power supply will be there in one sink in the network which is always active. Mobile sensor nodes are placed in the field, for this type of typical sensor nodes battery is the most consuming energy consumption part. Scheduling of radio is the considerable factor. The former refers to case where each node independently chooses random sleep and wake up times (Fig.1). The latter refers to the case where all nodes go to sleep and wake up together in a synchronized fashion.

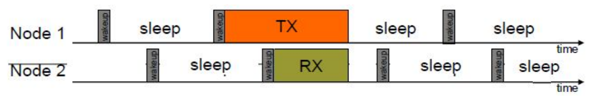

Fig 1: Random sleep and listen time

Sleep scheduling ensures that coverage rotates such that each point in the environment is sensed within some finite interval of time.

The time span from when the sensor node starts working and when its energy is depleted is the lifetime of a sensor. The lifetime is counted in rounds because of the rotation after each round. To conserve energy by separating all the working nodes by a minimum distance and check the status of neighboring nodes whether it is working. Each node broadcast a message after sleeping for a random period. A node will enter the on-duty mode only if it receives no replies from the neighboring working nodes. Otherwise it will continue in the off-duty mode.

The number of sleeping nodes can be increased by the quality of service as K-coverage and K –connectivity [2]. To maintain K coverage, a node only checks whether the intersection points inside its sensing area are K-covered. Sensor network topologies maintain a certain data delivery ratio while allowing redundant sensors to stay asleep in order to conserve energy.

Light traffic network is assumed in the network. In this model the congestion and loss of packets are less. As the nodes are static failure of the route occurs in rare cases. Thus, energy efficiency becomes a critical issue in WSNs. the residual energy of the entire sensor nodes are small. The narrow confidential intervals indicate that the energy consumption is balanced. We can see that nodes in the network of imbalanced energy distribution have larger means and confidential intervals. The existing performs worse in networks with imbalanced energy distribution, which is inevitable. Among the functional components of a sensor node, the radio consumes a major portion of the energy.

Fig. 2 can help to illustrate the following concepts:

*Connected Dominating Set(CDS),*C is a dominating set of G which induces a sub connected graph of G.A CDS in Fig. 2 is {c,d,e,g}.
Minimum Connected Dominating Set(MCDS) is the CDS with minimum cardinality. Finding MCDS is NP-Hard. In Fig. 2 {c,g} is MCDS.
Messages can be routed from the source to a neighbor in the dominating set, along the CDS to the dominating set closest to the destination node, and then finally to the destination. This is termed dominant based routing or spine based routing [3].

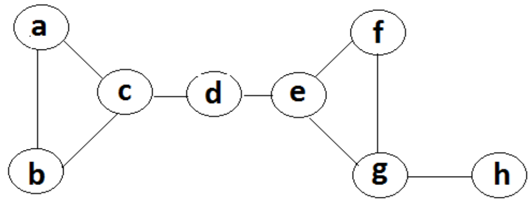

Fig 2: Representation of wireless network with eight nodes as a graph

The communication range of a node in a wireless network is typically modeled as a disk centered at the node with radius equal to the transmission range of the radio. Consequently, when transmission range is fixed for all nodes, the network has the property of a unit-disk graph (UDG)[4], where an edge exists if and only if two nodes have inter-nodal distance less than or equal to 1 unit (the fixed communication range). Many of the CDS algorithms use the properties of UDG's to prove their performance bounds [4].

An important problem in wireless ad hoc and sensor networks is to select a few nodes to form a virtual backbone that supports routing and other tasks such as area monitoring. Previous work in this area has focused on selecting a small virtual backbone for high efficiency. The construction of a k-connected k-dominating set (k-CDS) as a backbone to balance efficiency and fault tolerance has been devised. Four localized k-CDS construction protocols are proposed. The first protocol randomly selects virtual backbone nodes with a given probability pk, where pk depends on the value of k and network condition, such as network size and node density.

The second one maintains a fixed backbone node degree of Bk, where Bk also depends on the network condition. The third protocol is a deterministic approach. It extends Wu and Dai's coverage condition, which is originally designed for 1-CDS construction, to ensure the formation of a k-CDS [5]. Fig. 3 is referred from [5].The last protocol is a hybrid of probabilistic and deterministic approaches. It provides a generic frame work that can convert many existing CDS algorithms into k- CDS algorithms. Complicated algorithm and high computation cost. Sensor coverage consideration is not considered in this system. An optimal wake up scheduling algorithm for determining the wake-up frequency of the nodes in a sensor network [7]. This algorithm minimizes the energy consumption of the nodes and bounds the maximum delay on the routes from the nodes to the gateway. This study revealed that the algorithm reduces the total energy consumption by 60-70% compared to energy consumption under equal assignment. When this algorithm is used along with an energy aware routing algorithm, the

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network lifetime was shown to increase by 40%-80%.

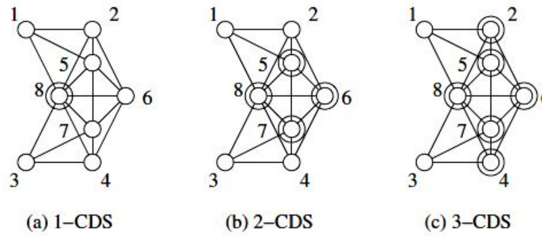

Fig 3 : K-connected k-dominating sets

A novel algorithm that enables fine-grained sleep scheduling, an intuitive idea is to construct multiple disjointed CDSs and let them work alternatively Prior work on data gathering techniques for sensor network has explored various avenues to reduce the cost of acquiring data from a sensor network. These include energy- efficient routing protocols, aggregation techniques and data store abstractions .These schemes did not adopt duty cycling but focused on reducing the energy cost of communication, and the gains achieved were limited because application aware duty cycling can explicitly transition nodes to an inactive state and achieve greater energy savings.

Researchers have also developed policies that use transmission power regulation to provide energy savings. These policies require complicated MAC and routing protocols [4]. Since our aim is to build a system which is simple to implement, we try to avoid the use of such complex protocols .Sleep scheduling and duty cycling have been proposed in the past, and the main goal is to preserve some level of connectivity and coverage among nodes that are active. Whereas prior work has demonstrated the value of exploiting low-power sleep states in sensor nodes, we have developed a decentralized scheme for sleep scheduling that is configurable in terms of the active neighborhood size for any node.

Besides reducing the number of active nodes, there are other network topology control techniques, which also intend to increase power efficiency and extend network lifetime [6] produces a minimum-energy communication sub network by adjusting transmission power. The sub network is computed distributed at each node using local neighbor location information or directional information[16].

Recently, the dominating-set-based routing problem has been intensively studied in the context of ad hoc networks. A dominating set is defined as a subset of the vertices of a graph if every vertex not in the subset is adjacent to at least one vertex in the subset [7] The main advantage of connected dominating-set-based routing is to restrict routing and Searching to a sub-graph induced from the dominating set, therefore reducing the overall energy consumption. Wu and Li [7] proposed a simple and efficient distributed algorithm for the formation of connected dominating set, which marks a dominating node by determining if two of its neighbors are not directly connected.[7] They also introduce two rules to optimize the size of dominating set based on node ID.

S-MAC introduced the idea of duty cycling and scheduled sleeping into the MAC protocol [4]. Sensor nodes follow a periodic active/sleep cycle, and the sensor nodes that are close to each other synchronize their active cycles together to reduce transmission delays. Synchronous scheduling is more complicated, but offers lower communication delay. The problem in sleep scheduling is the minimum end-end delay is in general NP-hard. Optimal scheduling can be found in polynomial time for tree and ring networks [7]. The energy delay trade off in tree networks and wake up patterns use homogeneous scheduling, which does not consider redundancy in the network.

Sleeping conditions are chosen based on the working conditions of the sensor nodes [3]; if the distance between the nearby sensor is less than the average distance between the sensors and the user or base station energy efficiency can be maximized [3].

The algorithmic aspect of CDP based approach and multi parented method is identical [6]. It reduces the communication delay instead of increase the network lifetime. The solution is based on linear programming and has no distributed implementation.

III. PROPOSED METHODOLOGY

We proposed a novel energy saving scheme BS that enhances the basic schemes used in mobile sensor networks. We identify the mobile node which gives redundant coverage in a round and put them into sleep to conserve energy without affecting network coverage and connectivity.

3.1 Backbone Construction

In this paper, we devised a Backbone scheduling (BS), which dynamically turns off the radio of the mobile sensor nodes to save energy. BS lets a fraction of some of the mobile sensor nodes in the network in a WSN turn on their radio to forward messages, the rest of the sensor nodes turn off their radio to save energy. Communication quality of WSNs having redundancy doesn't get affected by using this technique. Backbone scheduling (BS), a novel algorithm that enables fine grained sleep scheduling for mobile sensors.

We define a *virtual node* that corresponds to a sensor node as a node that contains e *energy*. Nodes with more energy will

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cause "isolated" virtual nodes. In this way, the CDS construction algorithm is forced to pick virtual nodes with more energy Fig.4 represents the construction of the Backbones.CDS is a widely used abstract of the Backbones. The MCDS problem is NP hard for both general graph and UDG [18].We uses these algorithms extensively in BS.

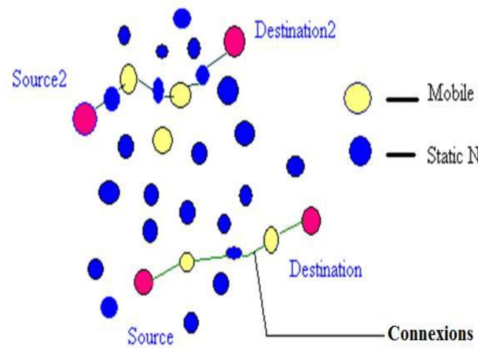

Fig 4 : Backbone Construction

We studied the problem of sleep scheduling power nodes in a hierarchical network to improve the overall efficiency and network lifetime. In our scheme almost all the node die at same time, increasing the active lifetime of the network. Our scheme achieves complete use of wireless sensor network and it causes balanced energy dissipation.

3.2 Performance Evaluation

In this section, we present the results of the network lifetime achieved by our proposed algorithms. The number of nodes in the network ranges from 10 to 100 with a step of 10. Since the area of the network is fixed, these settings vary the density of the mobile nodes. Fig.5 presents the results in networks with uniformly distributed initial energy.

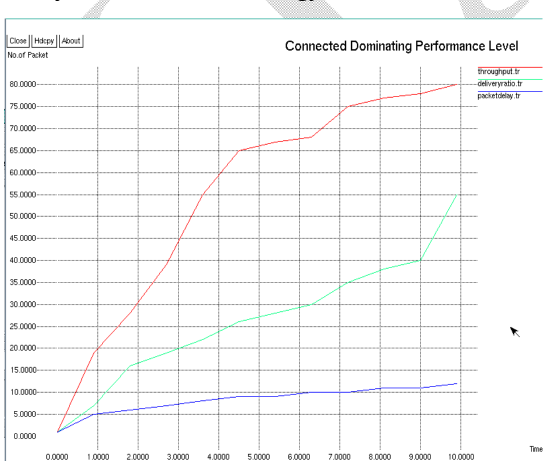

Fig 5 : Lifetime of Networks

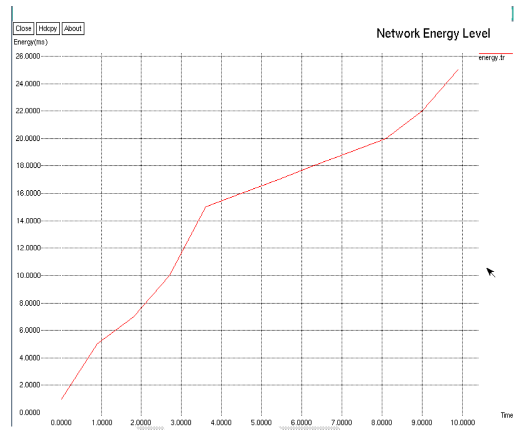

Fig 6 . Energy Balance Level

In this section, we present the results of the network lifetime achieved by our proposed algorithms. The number of nodes in the network ranges from 10 to 100 with a step of 10. Since the area of the network is fixed, these settings vary the density of the mobile nodes. Fig.5 presents the results in networks with uniformly distributed initial energy. However, our proposed schemes still achieve much longer lifetimes. The lifetime increases with network density because CDSs in denser networks are smaller and tend to be disjoint.

Fig.6 represents the energy level balance of our proposed techniques. Imbalanced energy distribution has larger means and confidential intervals. The proposed algorithms are implemented in a customized simulator. The simulator implemented the CDS construction algorithms that are used in this paper. We present the results of the network lifetime and the energy balance. Sensor modes are randomly placed in a square area. The sink is placed at the center of the area. All sensor nodes have the same transmission range. The number of sensor nodes is varied to model different network densities and scales. We assume that the sensor nodes in the backbone consume 1 unit of energy per round.

TABLE I. Network Performance Report

Static Node Performance	Mobile Node Performance
Throughput ratio=0.59 Send=516.00 Received=500.00	Throughput ratio=0.89 Send=516.00 Received=506.00
Dropped Packets=16.00	Dropped Packets=10.00
Packet Delivery Fraction=93.52	Packet Delivery Fraction=95.52
Energy Level=32	Energy Level=24

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IV. CONCLUSION

Lifetime maximization is one key element in the design of sensor-network-based surveillance applications. We proposed a protocol, Backbone scheduling (BS) and duty cycling. By taking redundancy of the WSNs BS improves the network lifetime of the network. Our proposed scheme achieves much longer lifetimes. The lifetime increases with network density because CDSs in denser networks are smaller and tend to be disjoint. BS employs the mobile sensor nodes in the sleep mode, which prolongs the network lifetime compared to the existing approaches. We will also focus on comparison of network parameters of static and mobile using BS.

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Corresponding Author: Ms. R.Priya, Mahendra College of Engineering, Salem, Tamilnadu, India.