Power Saving Scheme (PSS) in Clusters of Heterogeneous Wireless Sensor Networks

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Abstract— In this paper, we proposed a Power Saving Scheme (PSS) multi-hop sensor network using partition clusters. It avoids collision and idle listening time of sensor nodes for better overall network life time. The basic sensor nodes are simple and have limited power supplies, whereas the cluster head nodes are much more powerful and have many more power supplies, which organize sensors around them into clusters. Such two-layered heterogeneous sensor networks have better scalability and lower overall cost than homogeneous sensor networks. It is proposed that using polling to collect data from sensors to the cluster head since polling can prolong network life by avoiding collisions and reducing the idle listening time of sensors .The proposal focus on finding energy-efficient and collision-free polling schedules in a multi-hop cluster. To reduce energy consumption in idle listening, a schedule is optimal if it uses the minimum time. It also considers dividing a cluster into sectors and using multiple non overlapping frequency channels to further reduce the idle listening time of sensor. We conducted simulations on the NS-2 simulator and the results show that our polling scheme can reduce the active time of sensors by a significant amount while sustaining 100 percent throughput.

Key Words—Wireless sensor networks, Clusters, Polling, Multi hop Polling, Scheduling.

1 INTRODUCTION

A wireless sensor network (WSN) is a wireless network consisting of spatially distributed autonomous devices using sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants, at different locations. The development of wireless sensor networks was originally motivated by military applications such as battlefield surveillance. However, wireless sensor networks are now used in many industrial and civilian application areas, including industrial process monitoring and control, machine health monitoring, environment and habitat monitoring, healthcare applications, home automation, and traffic control.

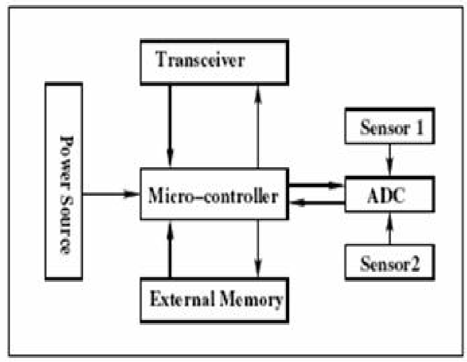

Fig.1: Architecture of sensor node

The applications for WSNs are many and varied, but typically involve some kind of monitoring, tracking, and controlling. Specific applications for WSNs include habitat monitoring, object tracking, nuclear reactor control, fire detection, and traffic monitoring. In a typical application, a WSN is scattered in a region where it is meant to collect data through its sensor nodes. A number of WSN deployments have been done in the past in the context of environmental monitoring. A sensor node, also known as a 'mote', is a node in a wireless sensor network that is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network.

The main components of a sensor node as seen from the figure are microcontroller, transceiver, external memory, power source and one or more sensors. Microcontroller performs tasks, processes data and controls the functionality of other components in the sensor node. Other alternatives that can be used as a controller are: General purpose desktop, Microprocessor, Digital signal processors, Field Programmable Gate Array and Application-specific integrated circuit. Microcontrollers are most suitable choice for sensor node. Each of the four choices has their own advantages and disadvantages. Microcontrollers are the best choices for embedded systems. The figure 1 shows the architecture of sensor node.

In general purpose microprocessor the power consumption is more than the microcontroller, therefore it is not a suitable choice for sensor node From an energy perspective, the most relevant kinds of memory are on-chip memory of a microcontroller and FLASH memory off-chip RAM is rarely if ever used. Flash memories are used due to its cost and storage capacity. Memory requirements are very much application dependent. Two categories of memory based on the purpose of storage a) User memory used for storing application related or personal data. b) Program memory used for programming the device. This memory also contains identification data of the device if any. Power consumption in the sensor node is for the Sensing, Communication and Data Processing. More energy is required for data communication in sensors.

Energy expenditure is less for sensing and data processing. The energy cost of transmitting 1 Kb a distance of 100 m is approximately the same as that for the executing 3 million instructions by 100 million instructions per second/W processor. Power is stored either in Batteries or Capacitors. Batteries are the main source of power supply for sensor nodes. Namely two types of batteries used are chargeable and non-rechargeable. They are also classified according to electrochemical is the material used for electrode such as NiCd (nickel-cadmium), NiZn (nickel-zinc), Nimh (nickel metal hydride), and Lithium-Ion. Current sensors are developed which are able to renew their energy from solar, thermo generator, or vibration energy.

The rest of the paper is organized as follows. Section 2 summarizes related work. Section 3 investigates the performance of cluster operations. Section 4 gives the simulation results. Finally, Section 5 concludes the paper.

2. Related Work

Adopting hierarchies in sensor networks has been considered in many works in the literature; see, for example, [4], [14], [24], [28], [35]. However, these works typically consider a homogeneous sensor network, where all nodes are identical, and focus on protocols for cluster forming and cluster head selection. In this paper, we consider a heterogeneous sensor network, where nodes are different, and mainly focus on the operations inside a cluster. We consider a heterogeneous sensor network because it has the advantages mentioned in the previous section, whereas a homogeneous network, although it can be more robust in case of node failure, may have a higher cost since every sensor can potentially be elected as the cluster head and, thus, more transmitting and storage capabilities are needed in every sensor. Also, note that cluster head selection is not needed in a heterogeneous network since there are nodes specifically designed as cluster head nodes.

Heterogeneous sensor networks have been considered in [12], [21], [22], [23]; however, these works typically assume that sensors use contention-based MAC protocols for media access, whereas we use polling to improve energy efficiency. Recognizing the need to reduce the idle listening time to prolong battery life, Ye et al. [9] introduced a new contention-based MAC layer protocol called SMAC in which sensors can enter the sleep mode periodically to save energy. However, as will be seen in the simulations section of this paper, in SMAC, the energy spent in idle listening is still quite significant as compared to the polling scheme we propose.

Polling in wireless networks have long been studied and used, for example, the 802.11 PCF and the Bluetooth network. These networks are one-hop networks, that is, the master node can reach the slave nodes with one hop and vice versa. Polling in one-hop networks is simple, where the master polls one slave at a time and the slave immediately reply in the next time slot. One-hop networks can also use Time Division Multiplexing (TDMA), where each node is given a unique time slot for data transmission. In this paper, we consider multihop networks in which sensors have to relay packets for other sensors due to the low transmission power of sensors.

Existing scheme uses heterogeneous sensor network, in which basic sensors are simple and perform the sensing task and second is cluster head, which are more powerful and focus on communications and computations. Cluster head organizes the basic sensors around it into a cluster. Sensors only send their data to the cluster head and the cluster head carries out the long-range inter cluster communications. The message sent by a cluster head can be received directly by all sensors in the cluster as considered in [1], [5].

Message sent by a sensor have to be relayed by other sensors, to travel multiple hops, to reach the cluster head. Transmission ranges of the basic sensors are short due to their limited power supply. Transmission range of the cluster head can be much longer since it has a far richer or even replaceable power supply. Cluster heads communicate with each other by organizing themselves into wireless network consisting of only the cluster head nodes which is the second layer of the sensor network. Existing work on wireless ad hoc networks is applied to the second-layer network. Drawbacks of Existing system are i) Active time is longer in a larger cluster than in a smaller cluster. ii) More power consumption. iii) Inter-cluster interference. The proposed systems are

Cluster Partitioning

Two-layered heterogeneous sensor networks are partition into clusters and the cluster head controls all sensors in a cluster. An energy efficient design within a cluster will improve the lifetime of a cluster as considered in [4],[3]. Deploy polling mode to collect data from sensors instead of letting sensors send data randomly for less energy consumption. It provides collision-free polling in a multi-hop cluster and it reduces energy consumption in idle listening [6], by presenting an optimal schedule.

Sector Partitioning

Active time is longer in a larger cluster than in a smaller cluster. This leads us further to consider partitioning a cluster into smaller sector and letting each sectors wake up and do data transmission in turn to reduce the active time of sensors. Note that, since sectors can be considered as small clusters, their routing and polling mechanisms are same as for the clusters[2].Advantages of Proposed system are i) Avoids collision and minimizes idle listening time ii)

Further increases the life-time of the sensor network.

3. CLUSTER OPERATIONS

In this section, we describe how the sensor network is organized and operated. Throughout this paper, we will use *S* to denote a sensor and *t* to denote a cluster head. We will assume that no node can send and receive at the same time and one node can send or receive at most one packet at a time. The figure 2 shows the two layered sensor network.

Deployment

In heterogeneous sensor networks, the basic sensors can be deployed randomly as in homogeneous sensor networks. The cluster heads, on the other hand, should be more carefully deployed to make sure all basic sensors are covered, that is, each sensor can hear from at least one cluster head. However, since the number of cluster heads is small, their best locations can be found within a reasonable amount of time and they can even increase their transmission power to cover remote sensors.

The problem of sending packets from sensors to a single sink node with energy constraints has been studied. However, the difference between our work and those is profound. First, assume that data should be gathered by a data-forwarding tree, that a tree is not the best structure for data gathering applications. The best structure can be found by running a network flow algorithm, which is what we will adopt in our work. Second, in essence, focus on traffic routing, whereas we consider both traffic routing and media access control. The various modules involved in this process are as follows, i)Multi-hop heterogeneous sensor networks ii)Partitioning sensor network into clusters iii)Deploying polling scheme in clusters iv) Performance metrics

Multi-hop heterogeneous sensor network

In a heterogeneous sensor network, where nodes are mainly focus on the operations inside a cluster. Cluster head selection is not needed in a heterogeneous network since there are nodes specifically designed as cluster head nodes. Heterogeneous sensor networks recognize the need to reduce the idle listening time to prolong battery life. In heterogeneous sensor networks, the basic sensors can be deployed randomly.

The figure 3 shows the formation of clusters.The cluster heads are more carefully deployed to make sure all basic sensors are covered, that is, each sensor can hear from at least one cluster head. Number of cluster heads is small, Best locations are found within a reasonable amount of time and increase their transmission power to cover remote sensors.

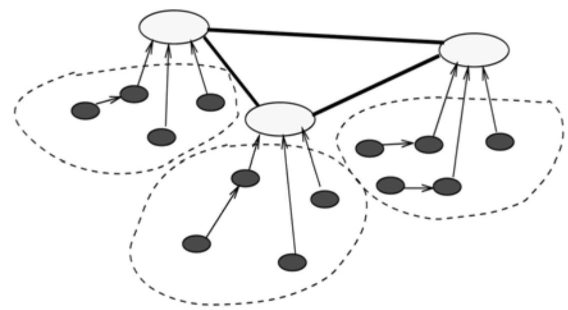

Figure 2 Two layered sensor network

Partitioning sensor network into clusters

Initially, the sensor network should be partitioned into clusters. In a heterogeneous network of cluster partition cluster head know which sensors are in its cluster and letting the sensors know to which cluster they belong. Operation within a cluster is more essential for cluster partition. Assume that cluster heads and sensors know their locations. First, based on the IDs given to them, the cluster heads will broadcast a message containing their location information in turn, the cluster head with the lowest ID first. This is done within a reasonable amount of time since the number of cluster head nodes is relatively small. Each sensor will then make a list of cluster heads it has heard from, whose messages have been correctly received by the sensor, according to the received signal strength (largest signal strength first). After this, each sensor will know to which cluster it may belong and will choose the cluster head at the top of the list as its preferred cluster head. Then, in turn, the cluster head starts the “discovering process,” in a way much like a Breadth-First Search.

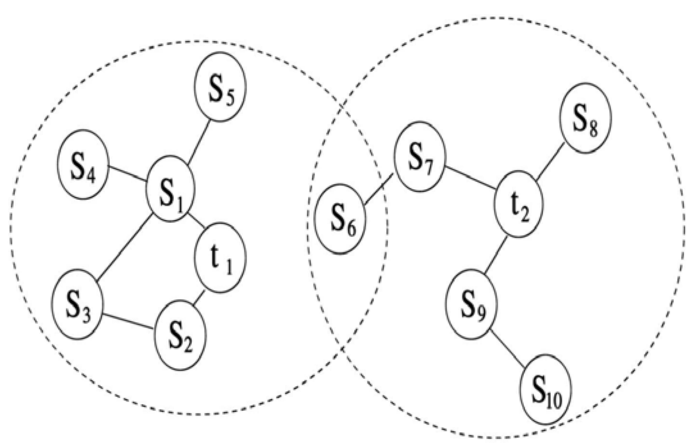

Figure 3 Formation of clusters

Deploying polling scheme in clusters

Polling scheme in heterogeneous sensor networks for such applications is to reduce power consumption. In polling packet sending is completely controlled by a central controller, which, is the cluster head.The cluster head sends out polling messages to poll sensors and only the polled sensors can send packets. Since the cluster head has full control of the cluster, energy wasting can be minimized as the cluster head can ensure that no collision and overhearing will occur and no control packets needed from the sensors. The cluster head find a good polling schedule to collect data as fast as possible to reduce idle listening and prolong the lives of sensors.

Performance Metrics

Effects of Dividing a Cluster into Sectors

Analyze lifetime of a cluster both when divided into sectors and when not divided into sectors, while sustaining 100 percent throughput, and the lifetime ratio. By dividing a cluster into sectors, the sensor lifetime will always increase. Larger clusters can be divided into more sectors, the increase in lifetime is greater for larger clusters.

Percentage of Active Time

The major goal of our polling scheme is to reduce the active time of sensors. The percentage of active time is needed to ensure that all packets are received by the cluster head, (number of sensors in a cluster ranges from 10 to 100 and the data generating rate ranges from 10 to 80 Bps.) When the number of sensors increases or when the data generating rate increases, the active time of sensors will increase to ensure packet delivery. Under a certain data generating rate, there is a maximum size of a cluster above which packets will be lost. Size of a cluster should be carefully chosen such that no packets are lost and sensors can also enjoy long sleeping time.

Sector Formation

The lifetime of a cluster, both when divided into sectors and when not divided into sectors, while sustaining 100 percent throughput and the lifetime ratio of the former over the latter. It can be seen that the ratio is always larger than 1, which means that, by dividing a cluster into sectors, the sensor lifetime will always increase. Also, because usually larger clusters can be divided into more sectors, the increase in lifetime is greater for larger clusters.

Deployment of Cluster head

In heterogeneous sensor networks, the basic sensors can be deployed randomly as in homogeneous sensor networks. The cluster heads, on the other hand, should be more carefully deployed to make sure all basic sensors are covered, that is, each sensor can hear from at least one cluster head. However, since the number of cluster heads is small, their best locations can be found within a reasonable amount of time and they can even increase their transmission power to cover remote sensors.

Delivering Message

The message sent by a cluster head can be received directly by all sensors in the cluster, whereas the message sent by a sensor may have to be relayed by other sensors, that is, to travel multiple hops, to reach the cluster head. This is because the transmission ranges of the basic sensors are short due to their limited power supply, whereas the transmission range of the cluster head can be much longer since it has a far richer or even replaceable power supply. Also, the cluster heads can communicate with each other by organizing themselves into a wireless network consisting of only the cluster head nodes, which will be referred to as the second layer of the sensor network.

Route Maintenance

The cluster head will fail to get a data packet after polling a sensor, only if all sensors in the relaying path have no packet to send. Since the number of packets in the sensors can be arbitrary, the cluster head may not be able to guarantee that it can get a packet after polling a sensor. Therefore, to optimize the operations in the first phase, it is reasonable to consider the problem of finding and a polling schedule such that the first phase can be finished in minimum time. However, it is not hard to see that this problem is still NP-hard because, clearly, in the TSRF must be the sensors in the second level and the problem reduces to finding a minimum time polling schedule in a TSRF, which has been proven to be NP-hard. We therefore propose solving the problem in two steps, that is, breaking the problem of jointly finding and the polling schedule into two sub-problems and solving them one by one, where the first sub-problem is to find and the second sub-problem is to find a polling schedule after has been given. Since the second sub-problem can be solved by the polling algorithm as follows.

Polling Algorithm:

Input : The list of polling requests.
Output: Polling schedule.

While the request list is not empty
if a packet has been received
delete the request for this packet
end if
if a packet expected to arrive has not been received
Set the request for this packet to active
end if
while TRUE
Grant an active request if it does not cause collision
Mark this request as idle.
break from the loop if no request can be granted.
end while
Wait until next time slot.
end while

4. SIMULATION RESULTS

Network simulator 2 is used as the simulation tool in this work. NS was chosen as the simulator partly because of the range of features it provides and partly because it has an open source code that can be modified and extended.

We have simulated this experiment using NS-2 simulator. The figure 4 shows the creation of Multi hop heterogeneous wireless sensor network environment. The figure 5 shows the cluster formation. The figure 6 shows the implementation of polling scheme. Mobility and routing algorithm was simulated and method shown in figure 5. The power control scheme is simulated in figure 6. The figure 7 shows the sector information. The figure 8 shows the simulation between Numbers of nodes with power consumption. Here we take 50,000 nodes. The existing system consumes 1.4500. The Proposed system consumes 0.8000. It shows that 10 % of power is saved. We have done a simulation between the numbers of nodes versus life time of sensors.

The result is presented in the figure 9. Here also improvement in power saving. In this, we consider 50,000 nodes; the life time by the existing system was 8.00000. But in the present system are 9.00000. It represents 10% improvement in life time. In figure 10, the analysis between the numbers of nodes and the throughput by the nodes. We take assume that 50,000 nodes. Existing system produce 1.10000. But in the present systems produce 1.45000. Here also 20 % improvements in throughput.

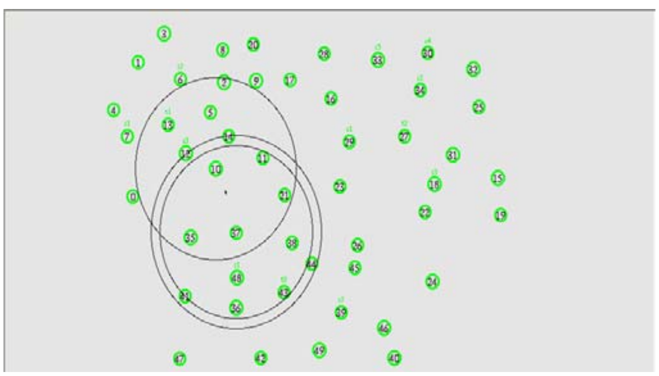

Fig4. Multi-hop heterogeneous sensor network

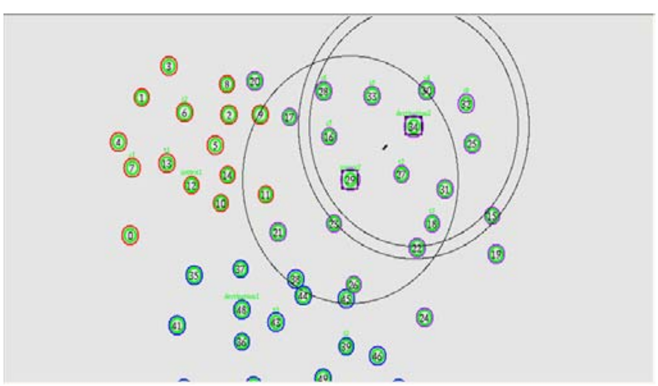

Fig5. Cluster formation

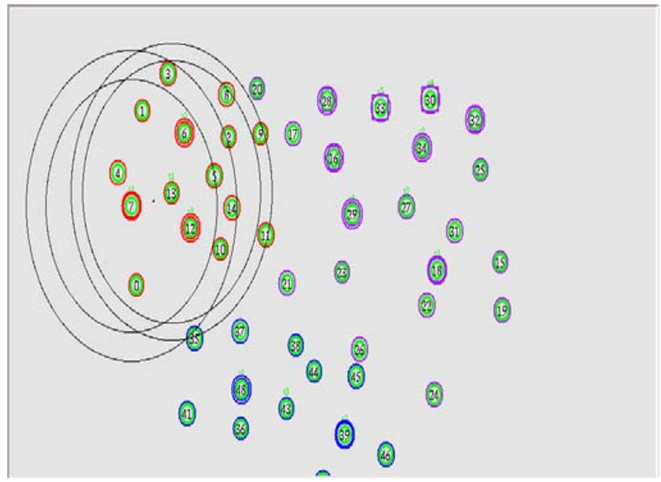

Fig6. Implementation of polling scheme

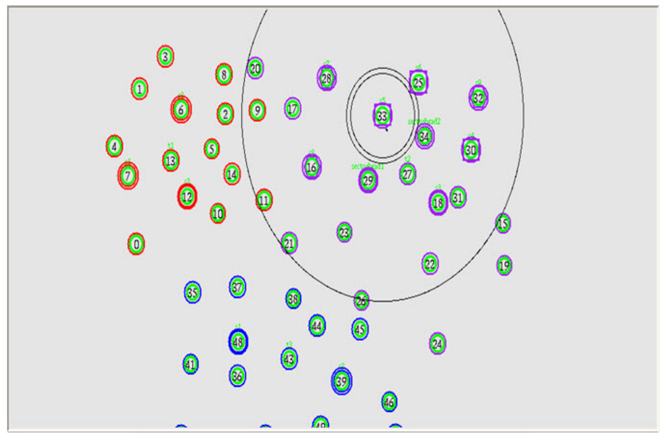

Fig7. Sector formation

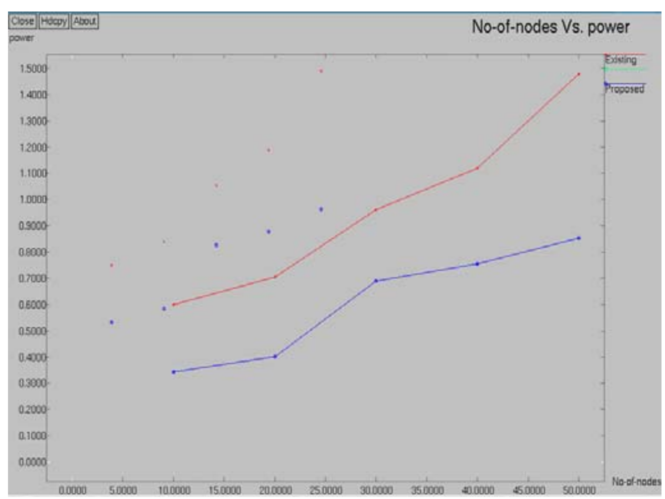

Fig.8 Comparison of No. of nodes with power

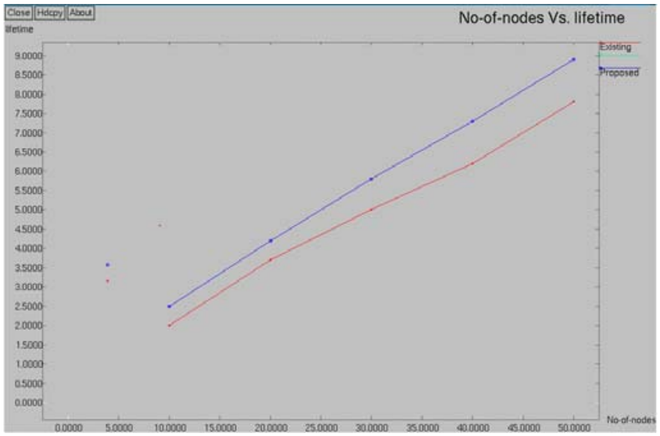

Fig9. Comparison of No. of .nodes with lifetime of sensors

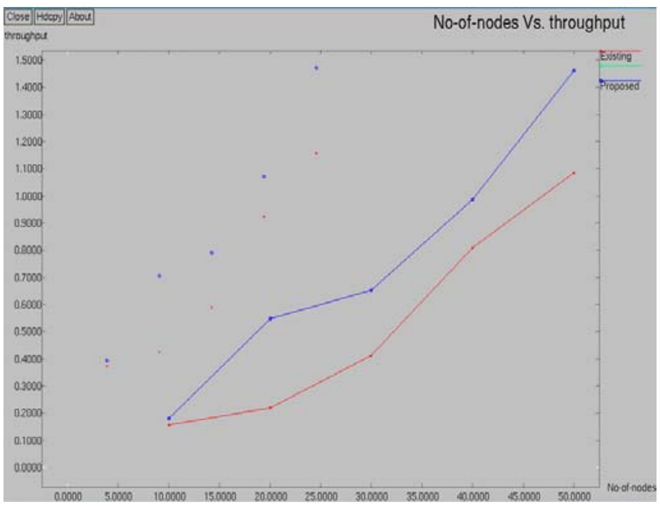

Fig10. Comparison of number of nodes with throughput

5. CONCLUSION

The network is partitioned into clusters and a powerful cluster head controls all sensors in a cluster. Further each cluster is partitioned into Sectors. The main focus is on the energy efficient design within a cluster and sector to prolong network lifetime. The proposal used polling to collect data from sensors instead of letting sensors send data randomly, so that less energy is consumed. The simulation results show that the problem of finding a contention-free polling schedule, which uses the minimum time, is complex and then gave a fast online algorithm to solve it approximately. The simulations are conducted on the NS-2 simulator and the results show that the polling scheme used achieves nearly 100 percent throughput, while reducing the active time of sensors by a significant amount. The network lifetime can be further improved by using multiple non-overlapping frequency channels. When the number of frequency channels keeps on increasing, the percentage of active time can always be reduced.

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