International Journal of Science and Modern Engineering (IJISME)
ISSN: 2319-6386, Volume-1 Issue-5, April 2013

A Protocol to Increase the Lifetime for Wireless Sensor Network

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*Abstract***—** ***The applications of the sensor network require consistent coverage of the region in which they are deployed over the course of the network lifetime. The sensor networks may be deployed randomly, node distribution and data redundancy may be lower than others. The sensors in the sparsest regions should not be more considered for increasing the network lifetime. The densely deployed sensor regions should be considered more to route the traffic of other nodes in the network. Here by we introduce the protocol.Here by we introduce the protocol called DAPR which is used for sensor selection and route discovery with the goal of minimizing the use of sensors in sparsely covered areas.***

I. INTRODUCTION

As wireless sensor networks continue to attract attention for use in numerous commercial and military applications,there have been many efforts to improve their energy efficiency so that they can operate for very long periods with no manual maintenance. Because of the limited energy supplies of typical microsensors, however, achieving long network lifetimes has been a very challenging task. A great deal of research has focused on power reduction in several areas, such as hardware,operating system, and low-level protocol design, in order to increase network lifetime.

However, further stepsmust be taken in order to balance, as well as reduce, energy consumption so that sensor networks will be able to realize their maximum potential lifetime. As the cost of manufacturing sensor nodes continues to decrease and large-scale networks consisting of thousands of sensors become realizable, the redundancy that exists among the data generated by the sensors can be exploited.

Recent work in this area has focused on techniques such as dynamic sensor selection, in-network aggregation, and distributed source coding that reduce the amount of data generated by the network but ensure that the cumulative data from the sensor network at any given time meets the sensor network's application quality of service (QoS) requirements. In this work, we focus on networks in which data flow is reduced by dynamically selecting only a subset of the sensors in the network to generate data at a given time. The generated data are routed back to a single base station within the sensor network, where it may be processed locally or sent to an end user via a dedicated communication channel.Depending on the nature of deployment, it may be the case that certain sensors are more important than others in a sensing role due to non-uniformities in sensor deployment, sensing capabilities, and initial energy resources.

II. BASIC DAPR OPERATION

We have designed a simple distributed protocol called DAPR (Distributed Activation with Predetermined Routes) that integrates the services of sensor selection and route discovery. Most architectures proposed for use in coverage-preserving wireless sensor network applications use a modular approach where sensor selection and routing are performed independently.

To use an integrated approach and the integration is rather loose, as the sensor selection algorithm considers the effect of the potential routers, but the routers are not chosen with any consideration of the sensor selection algorithm. In the proposed DAPR protocol, route discovery and sensor selection are performed separately, but decisions made in each process are influenced by the other. The premises for the design of DAPR are twofold

That sensors critical to the sensing applications as data generators should be avoided as routers and that the selection of a sensor for active sensing affects its potential routers as well as the sensor itself. To ensure that sensors with the highest route costs are given the highest priority to deactivate, each node backs off before broadcasting its deactivation beacon, with backoff delays set according to a decreasing function of the route costs.

1. IMPLEMENTATION ISSUES

The calculation of our proposed coverage-aware routing costs assumes that nodes have location information of neighboring nodes with redundant coverage regions.This information can be exchanged between neighbors after being obtained through GPS or any number of proposed location estimation algorithms in the current literature.Since DAPR was designed for networks of static sensor nodes, location updates must be performed only a single time at the beginning of network operation, or very infrequently in the worst case.

2. COVERAGE AWARE ROUTING COSTS

The coverage-aware routing costs also depend on information about the residual energy of neighboring nodes. This information can be conveyed within the Query messages that are forwarded. Before forwarding these messages, which each node should do once per query, a node simply fills in a field in the packet header.

3. RESIDUAL ENERGY

A node must know its own routing cost before forwarding a Query message, it must calculate this value from information obtained during the previous query. As long as the query length is not so long that nodes may use a significant portion of their initial energy during a single.The residual energy information should not be too stale to calculate near-optimal routes.

Manuscript received April 12, 2013.

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Alternatively, two packets could be sent during the Route Discovery Phase the first containing only residual energy information and the second containing route cost information.

III. MATHEMATICAL CALCULATION

In general, let A(si) represent the sensor si's coverage area. In order to provide coverage of the entire region that is being monitored, it is possible to activate the sensors in many combinations, each combination constituting a cover set.
A cover set ci is defined as any set in which the constraint given in below equation is satisfied.

$$\bigcup_{j:s_j \in c_i} A(s_i) \supseteq \underline{\mathbf{A}}$$

We refer to the set of Nc cover sets as where for each cover set. It should be noted that our problem formalization does not preclude the use of non-disjoint cover sets. The sensor network is periodically queried by a single data sink, and data from the sensors in the current cover set are routed back to this data sink. In this work, we consider the general scenario where the data sink's location does not remain constant over the course of the entire network lifetime. In general, we assume that there are Nsink data sink locations.The total number of nodes in the network (sensors and data sinks) over the course of the network lifetime is Nt = Ns + Nsink we are limited by several constraints, including constraints ensuring the conservation of data flow (i.e., that the sum of a node's incoming data and its generated data must equal its outgoing data), expressed as

$$\sum_{j=1}^{N_t} f_{ijm} = \sum_{j=1}^{N_s} f_{jim} + \sum_{k:s_i \in c_k} R \cdot t_{km}$$
$$\forall i \in \{1, \ldots, N_s\}, \quad m \in \{1 \ldots N_{sink}\}$$

Furthermore, we are limited by energy consumption constraints that limit the total amount of time any sensor can route and actively sense data by that node's initial energy. we propose distributed methods for the sensor modes region todetermining the cover sets to use as the network operates over time.

$$\sum_{m=1}^{N_{sink}} \sum_{k:s_i \in c_k} p^{sense} \cdot t_{km} + \sum_{m=1}^{N_{sink}} \sum_{j=1}^{N_t} f_{ijm} e_{ij}^{tx} +$$
$$\sum_{m=1}^{N_{sink}} \sum_{j=1}^{N_s} f_{jim} e_{ji}^{rx} \leq e_i^{init} \quad \forall i \in \{1, \ldots, N_s\}$$

Over the course of the network lifetime, queries may arrive from a number of locations within the network, either from multiple data sinks within the network or from a single mobile sink roaming throughout the network. The fraction of queries Q that will propagate from each data sink location impose additional constraints given as

$$\sum_{k=1}^{N_c} t_{km} = q_m \sum_{k=1}^{N_c} \sum_{m'=1}^{N_{sink}} t_{km'} \quad \forall m \in \{1, \ldots, N_{sink}\}$$

The network lifetime L is the combined operating time of all individual cover sets.

$$L = \sum_{k=1}^{N_c} \sum_{m=1}^{N_{sink}} t_{km}$$

IV. POWER CONSUMPTION

Under ideal conditions (e.g., very high density), power consumption is minimized by sending packets over distances, where

$$d^* = \sqrt[\alpha]{\frac{2E_{elec}}{(\alpha - 1)\varepsilon}}$$

We suspect that the reason for this is that this cost does not consider the utility of a node as a router, but rather as a sensor only. Nodes that should be kept alive for routing purposes may be used too liberally, causing them to die and forcing other sensors in the region to use suboptimal routes for the remainder of the network lifetime. The uniform and clustered deployment scenarios since a node's importance as a sensor and as a router are both tied to its location.

V. PARAMETER SELECTION

A. *PARAMETER MODEL*

we analyze the performance of our proposed coverage-aware routing costs as alternatives to traditional energy-aware routing, where C(si) = Cea(si),and minimum power routing, where C(si) = 1, using the DAPR protocol.

Parameter	Value
Packet Size	20 $bytes$
Packet Rate	1 $packet/sec$
α	2
E_{elec}	50 nJ/bit
ε	100 $pJ/bit/m^2$
Query Length	24 hr
Initial Node Energy	1000 J
Sensing Range (Uniform, Clustered)	25 m
Deployment Radius (Uniform, Clustered)	100 m
Surveillance Radius (Uniform, Clustered)	90 m
Room Width (Video)	70 m
Room Height (Video)	30 m
Sensor Spacing (Video)	10 m
Sensor Field of View (Video)	30 degrees

B. *ROUTING PROTOCOL*

The field of ad hoc routing has been explored extensively.Initially, protocol design focused on efficiently finding shortest path routes in the presence of node mobility.Later research addressed the need for energy-based metrics to be used in energy-efficient ad hoc routing protocols. Singh et al. proposed several routing costs based on the residual energy of individual nodes.Chang et al. proposed a routing cost that was a combination of residual energy, normalized residual energy,and required transmission energy and found an optimal combination of these parameters

C. *COVERAGE AWARE ROUTING*

We build on this work by developing a routing cost for use specifically in wireless sensor networks, where the property of node redundancy is important. Our proposed coverage-aware routing cost is based not only on a sensor node's residual energy, but also the residual energy of redundant neighboring sensors, in order to ensure that the most critical sensors are avoided and live long enough to maintain high fidelity over long periods of time.

D. ROUTE COST

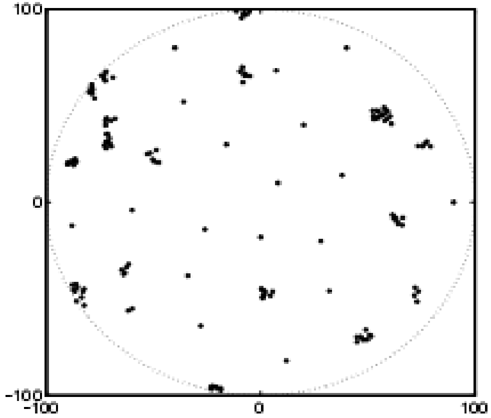
The proposed worst coverage-based cost aims to maintain 100% coverage for the maximum lifetime by finding each node's worst-covered subregion and assigning costs inversely proportional to the energy of nodes covering that region In addition to the advantages of using a coverage-aware routing cost, DAPR considers the effect that sensor selection has on potential routers by selecting sensors to actively sense and generate data based on their cumulative route costs.

Node costs inversely proportional to the energy of nodes covering that region In addition to the advantages of using a coverage-aware routing cost (1)

VI. SIMULATION AND ANALYSIS

A. METHODOLOGY

As long as the query length is not so long that nodes may use a significant portion of their initial energy during a single query, the residual energy information should not be too stale to calculate near-optimal routes. Alternatively, two packets could be sent during the Route Discovery Phase the first containing only residual energy information and the second containing route cost information.



In this section, we present simulation results measuring the performance of the proposed coverage-aware routing costs and the DAPR protocol. The simulations in this section were performed using NS2, and they focus on the routing and application layer while simplifying MAC and physical layer implications..

B. RESULTS

1) Effectiveness of the Application Cost: In order to verify the effectiveness of the application cost in DAPR, we compared versions of the protocol in which a sensor's cost was

1) constant (fewest hops),
2) the energy cost ($\frac{1}{E}$), and
3) the application cost (as presented in Equation 3).

In the first simulations, 150 sensors with equal initial energy were randomly deployed in a field with a region of the field purposely left more sparsely populated than others. The network lifetimes of DAPR with the different cost assignments are shown in Figure 3. The results show that while application cost assignment performs best, energy cost assignment also performs well. Energy cost assignment performs well because in the early stages of network operation, the sensors in the sparsely deployed areas are used most frequently, leading to an immediate drop in energy and rise in energy cost. This causes them to be avoided as routers very early. If the initial energy of the sensors is not equally distributed, the benefit from using application cost increases, as shown in Figure 4. In these simulations, the energy of some sensors in the sparsely deployed areas is initially high, giving them a low energy cost and causing other sensors to believe that they are attractive candidates as routers. Not until their battery levels decrease to the levels of the other sensors do they begin to be avoided. Meanwhile, when using the application cost, these sensors are avoided, even in the early stages of the network.

2) Effect of network density: Higher sensor density should obviously extend network lifetime when using sensor management techniques such as DAPR since more energy is distributed throughout the network. In order to observe just how much, we varied the number of sensors (randomly deployed) in the network to observe the effect on the performance of DAPR.

VII. CONCLUSIONS AND FUTURE WORK

We have proposed a distributed, integrated protocol for sen- sor management and routing to be used in large-scale wireless sensor networks. Our simulation results show that there can be a significant benefit when utilizing an application-based routing cost that considers the residual energy of neighboring sensors.

The application cost function used in the DAPR algorithm was developed through simple intuition. In future work, we would like to explore the optimality of this choice as well as alternative cost functions. Furthermore, the network model that was primarily considered in this paper was one in which sensors make a binary decision of whether to turn on or off depending on the current quality of coverage in their neighborhood. In the future, we would also like to develop sensor management algorithms for other sensor network models, especially those involving multi-mode sensors where the decision becomes much more complex. The proposed worst coverage-based cost aims to maintain 100% coverage for the maximum lifetime by finding each node's worst-covered subregion and assigning costs inversely proportional to the energy of nodes covering that region In addition to the advantages of using a coverage-aware routing cost, DAPR considers the effect that sensor selection has on potential routers by selecting sensors to actively sense and generate data based on their cumulative route costs.

Our simulation results have shown that the gains in network lifetime from using this approach become highest when sensing overlap between sensors is not as directly tied to physical proximity (e.g., the video scenario).

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