Deployment of Multiple Mobile Sinks in Wireless Sensor Networks
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Background
Wireless Sensor Networks (WSNs) have emerged as a research dominant area over the past decade. They have been widely applied in various areas including the battlefield, environment surveillance, health monitoring, precise agriculture, underwater exploration, forest fire detection, etc. The strong demand for WSNs has been spurred by numerous applications that require in-situ, unattended, high-precision, and real-time observation over the monitored region. WSNs consist of hundreds to thousands of battery-powered tiny sensors that are endowed with a multitude of sensing modalities. Although there have been significant progress in sensor fabrics including processing design and computing, advances of battery technology still lag behind, making energy resource the fundamental constraint in WSNs. To maximize the network lifetime, energy conservation in such networks thus is of paramount importance.

It is an accepted assumption in traditional WSNs that there is only a single, static sink for data collection. However, this single static sink paradigm suffers serious limitations on network uniform, which result in poor network scalability and robustness, unbalanced energy consumption, and large data delivery delay. The single static sink based WSNs thus fail to meet ever increasing diverse application demands.

Multiple-Sink Placement
Place the optimal number of sinks in a WSN to prolong the network lifetime under the constraints:

- upper bound \( h \) on the number of hops from each sensor to its nearest sink
- pre-defined possible sink location space

A heuristic HOMP is proposed to solve the problem of multiple sinks placement in two steps:

- find the optimal number of sinks and their locations such that each sensor can reach a sink with no more than \( h \) hops
- construct a load-balanced forest, in which each sink is the root of a routing tree with the depth being no more than \( h \)

Benefits:
- improve network performance including the network lifetime prolongation, network scalability improvement, and average data delivery delay reduction
- enhance the network robustness substantially to guarantee the data collection regardless of network connectivity

Objective
This project challenges the traditional paradigm of WSNs by introducing multiple mobile sinks into the network and exploring their placement as well as mobility jointly. We aim to develop algorithms to determine the optimal number of sinks according to application demands. In addition, approaches of trajectory finding and sojourn time scheduling for a single mobile sink are also provided.

Single Sink Mobility
Explore the mobility of mobile sink in a WSN to prolong the network lifetime subject to the following constraints:

- the total travel distance of the mobile sink should be bounded
- the moving distance of the mobile sink from its current location to its next location is restricted
- the mobile sink sojourns at least a certain amount of time at each of its sojourn locations

Benefits:
- balance the energy consumption among the WSN and prolong the network lifetime significantly
- reduce the possibility of data loss by avoiding staying at a certain sojourn location for a long time
- enhance the network scalability and robustness

Future Work
Develop efficient, distributed algorithms to determine the optimal number of sinks deployed in the network as well as their trajectories. Coordinate the movements of multiple mobile sinks to balance the traffic throughout the network.

Conclusion
Introducing the concept of multiple mobile sinks into WSNs opens up the opportunities to dramatically improve the network performance by better balancing energy consumption, significantly prolonging network lifetime, and greatly shortening data delivery latency. It also enables sensor networks viable in many practical applications where a network backhaul will often only be available at certain times (e.g. weak 3G link) or the location of a network gateway must frequently change based on environmental constraints. By changing the traditional paradigm of sensor networks, we believe this significantly increases the opportunities for large-scale, embedded sensing for many applications in the future.