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A Path Selection Strategy For Energy Efficient Mobile Sink In Wireless Sensor Networks

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Abstract: *Mobile sink reduces the energy consumption of nodes and prevents the formation of energy holes in wireless sensor networks(WSNs).These benefits are dependent on the path taken by the mobile sink, especially in delay-sensitive applications, as all sensed data must be collected within a given time constraint. So,a hybrid moving pattern is formed in which a mobile-sink node only visits rendezvous points (RPs), as opposed to all nodes. Sensor nodes that are not RPs forward their sensed data via multihopping to the nearest RP. The fundamental problem is computing a tour that visits all these RPs within a given delay bound. Identifying the optimal tour, however, is an NP-hard problem. To solve this problem, a heuristic called weighted rendezvous planning(WRP) is proposed, where each sensor node is assigned a weight corresponding to its hop distance from the tour and the number of data packets that it forwards to the closest RP. WRP is validated via extensive computer simulation, and our results demonstrate that WRP enables a mobile sink to retrieve all sensed data within a given deadline while conserving the energy expenditure of sensor nodes.WRP reduces energy consumption by 22% and increases network lifetime by 44%, as compared with existing algorithms.*

I. INTRODUCTION

In recent times, wireless sensor networks have drawn a lot of attention due to their broad application potentials. Sensor nodes in the network are characterized by severely constrained energy resources and communicational capabilities. Sensor networks aggravate the security and privacy problems because they make large volumes of information easily available through remote access. Hence, adversaries need not be physically present to maintain surveillance. Due to limited capabilities of sensor nodes which are storage, power and processing, providing security and privacy against these attacks are challenging issues to sensor networks. These security and privacy issues have led to breaches of applications in Wireless Sensor Networks in corporate organizations and homes among others. Wireless sensor networks are potentially one of the most important technologies of this century. Recent advancement in wireless communications and electronics has enabled the development of low-cost, low-power, multifunctional miniature devices for use in remote sensing applications. The combination of these factors has improved the viability of utilizing a sensor network consisting of a large number of intelligent sensors, enabling the collection, processing analysis and dissemination of valuable information gathered in a variety of environments. They have wide-ranging applications, some of which include military environment monitoring, griculture. In addition, it is equipped with a battery, which may be difficult or impractical to replace, given the number of sensor nodes and deployed environment. These constraints have led to intensive research efforts on designing energy-efficient protocols.In WSNs with a mobile sink, one fundamental problem is to determine how the mobile sink goes about collecting sensed data. One approach is to visit each sensor node to receive sensed data directly .This is essentially the well-known traveling salesman problem (TSP) .where the goal is to find the shortest tour that visits all sensor nodes. However, with an increasing number of nodes, this problem becomes intractable and impractical as the resulting tour length is likely to violate the delay bound of applications. To this end, researchers have proposed the use of rendezvous points (RPs) to bound the tour length .This means a subset of sensor nodes are designated as RPs, and non-RP nodes simply forward their data to RPs. A tour is then computed for the set of RPs. As a result, the problem, which is called rendezvous design, becomes selecting the most suitable RPs that minimize energy consumption in multihop communications while meeting a given packet delivery bound. A secondary problem here is to select the set of RPs that result in uniform energy expenditure among sensor nodes to maximize network lifetime.

II. PROPOSED APPROACH

The factors like Limited computational power and memory size affect WSN in the sense that each node stores the data individually and sometimes more than one node store same data and transfer the data to the base station where processing of data take place. This wastes the power and the storing capacity of nodes. Therefore effective routing schemes and protocols must be developed to eliminate data redundancy and maximize the network lifetime. WRP, which is a heuristic method that finds a near-optimal traveling tour that minimizes the energy consumption of sensor nodes.

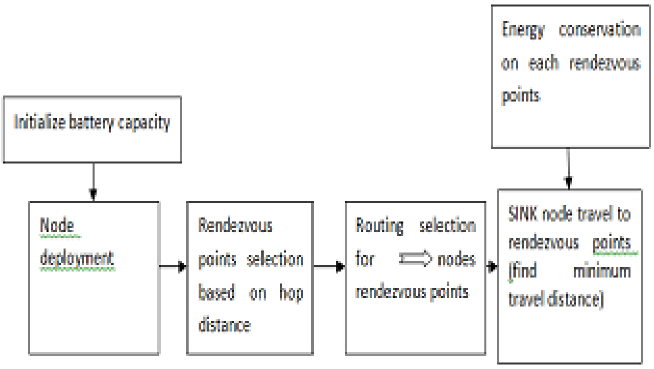


Fig.1 Operational flow of weighted rendenzvous planning

Deploying the nodes is done with initializing the battery capacity. After this rendezvous points are selected and routed according to weighted rendezvous planning. Mobile sink travels in the shortest path and collects the data from rendezvous points and forwards to the base station. nodes that have a high degree. This is critical as sensor nodes in dense parts of a WSN generate the highest number of packets. Hence, giving priority to sensor nodes in these parts during tour computation will help to reduce congestion points, and in turn, reduces energy consumption and improves WSN lifetime. In addition, it helps to mitigate the energy-hole problem.

III. ALGORITHM ANALYSIS

a) Different types of algorithm

In contrast to cluster-based (CB) rendezvous design for variable tracks (RD-VT) and rendezvous planning utility-based greedy (RP-UG) algorithms, WRP is guaranteed to find a tour if the latter exists. We demonstrate via computer simulation the properties and effectiveness of WRP against the CB RD-VT and RP-UG algorithms [31]. Our results show that WRP achieves 14% more energy savings and 22% better distribution of energy consumption between sensor nodes than the said algorithms.

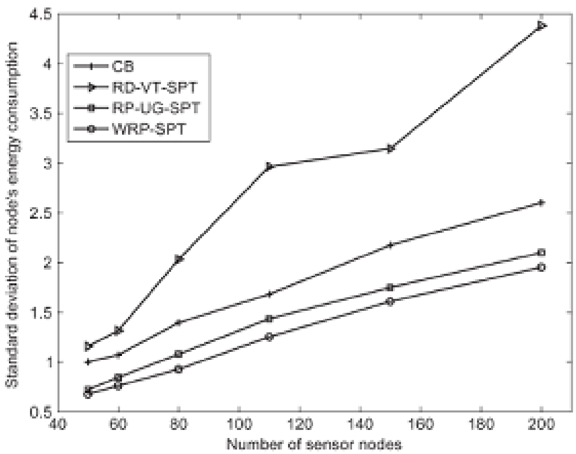


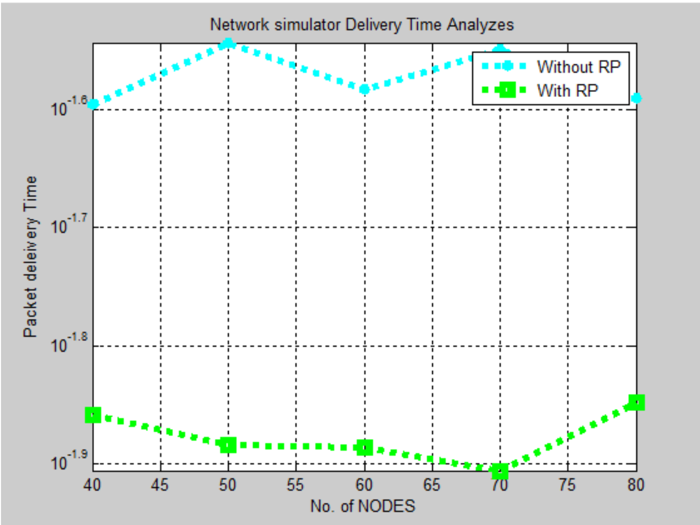
Fig 2. Standard deviation of sensor nodes' energy consumption for WRP, CB, RD-VT, and RP-UG models.

The algorithm first constructs a Steiner minimum tree (SMT) rooted at the sink node. RD-VT then starts from the sink's position and traverses the SMT in preorder until the shortest distance between visited nodes is equal to the required packet delivery time. Since, in an SMT, a Steiner point may be a physical position and does not correspond to the position of a sensor node, RD-VT replaces these virtual RPs with the closest sensor nodes. A major limitation of RD-VT is that traversing the SMT in preorder leads to the selection of RPs that in turn results in long data forwarding paths to sensor nodes located in different parts of the SMT. As a result, RD-VT causes nodes to have an unbalanced data forwarding load and energy consumption.

To construct the ME's traveling path, RP-CP first sorts all edges according to their weight. It then selects the edges with the highest weight until the length of the selected edges becomes equal or less than the required packet delivery time. The problem with RP-CP is that the traveling path of the ME is restricted to routing tree edges. This also means that the ME will visit the sensor nodes on the selected edges twice. In the propose an improvement to RP-CP, which is called the RP-UG algorithm. Initially, a geometric tree, which is rooted at the fixed sink node, is constructed, and all edges on the tree are split into multiple short intervals, which are denoted as Lo. All points that join two edges with length Lo are considered RP candidates. RP-UG starts from the sink's position and, in each step, adds the RP that minimizes the distance of sensor nodes from selected RPs and also results in the shortest traveling tour between RPs. RP-UG uses a TSP solver to calculate the tour length. To finalize the tour, RP-UG replaces virtual RPs with the closest sensor nodes and marks them as RPs. RP-UG does not balance the energy consumption rate of sensor nodes, which has a significant impact on network lifetime. Specifically, the network lifetime is determined by the sensor node with the highest energy consumption rate, e.g., n, assuming all nodes have the same initial energy level. In this regard, RP-UG does not aim to minimize the energy consumption rate of node n. In addition, when using RP-UG with a small Lo value, the number of RPs increases significantly, and the complexity of RP-UG grows exponentially. The algorithm uses a TSP solver N times in each iteration, where N is the number of RPs. Hence, RP-UG has a running time complexity of O(N2 × O(TSP)). A CB algorithm is proposed in [32], in which a binary search procedure is used to select RPs. Fig. 3 shows how CB works in a network with ten nodes where the maximum allowed tour length is 90 m. In the first iteration, using binary search on arange from 0 to 10, CB selects five random cluster heads. In this case, we have nodes 2, 3, 4, 5, and 7. Other nodes then establish a path to their closest cluster head in terms of hop count. After the clusters are determined, CB starts from the sink node's position and selects one node from each cluster as an RP, which is the closest node to the set of selected RPs.

IV. SOFTWARE IMPLEMENTATION RESULTS

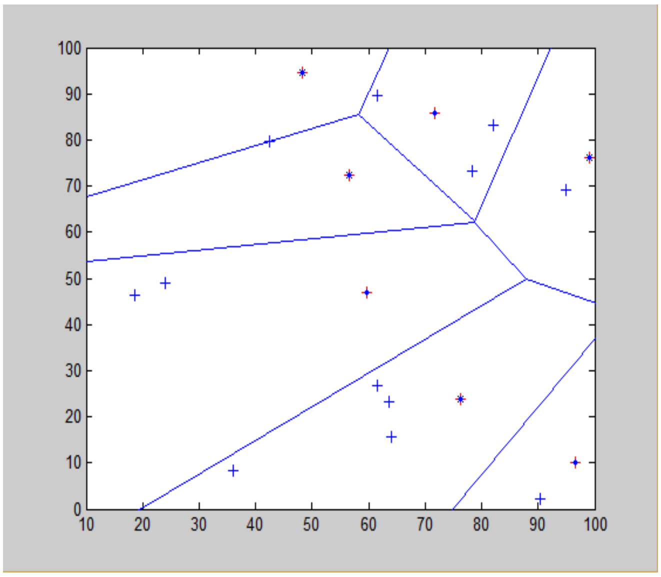
a) WRP analysis



This graph shows that when weighted rendezvous planning is used the packet delivery time decreases when compared to routing without weighted rendezvous planning. This type of efficient routing is useful for delay sensitive datas. This makes the delivery of packets faster by decreasing the delay in the routing by using weighted rendezvous planning. However, with an increasing number of nodes, this problem becomes intractable and impractical as the resulting tour length is likely to violate the delay bound of applications. To this end, researchers have proposed the use of rendezvous points (RPs) to bound the tour length. This means a subset of sensor nodes are designated as RPs, and non-RP nodes simply forward their data to RPs.

Among all the nodes the rendezvous points should be selected. Rendezvous points are selected such that they are nearer to each other. Rendezvous points should be near to each other to reduce the travelling distance of the mobile sink. Rendezvous points are selected such that the selected rendezvous point data collection becomes effective. This is done to reduce the travelling time of the data of the nodes. Sensor nodes that are not RPs forward their sensed data via multihopping to the nearest RP. The fundamental problem then becomes computing a tour that visits all these RPs within a given delay bound. Identifying the optimal tour, however, is an NP-hard problem.

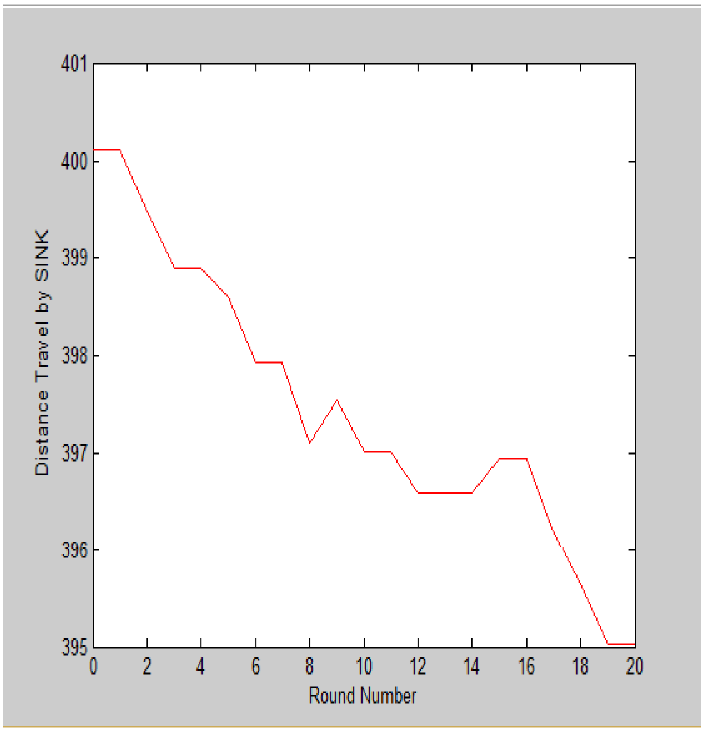
b) Random point selection



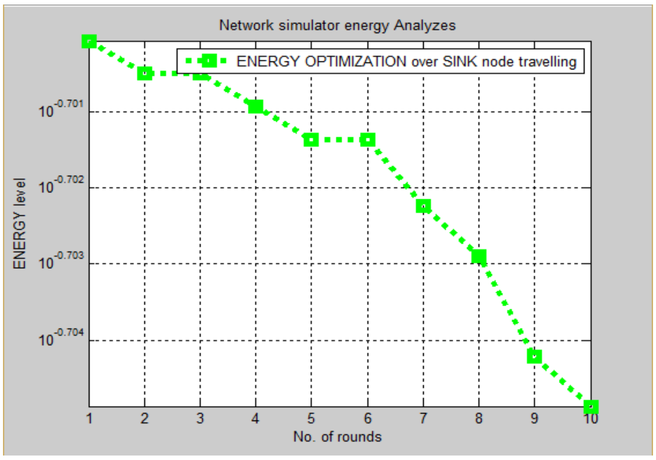
The graph shows that the distance travelled by the mobile sink reduces. The distance travelled by the mobile sink reduces by keeping the rendezvous point near to another rendezvous point. Mobile sink collects the data from the rendezvous points and forwards to the base station.

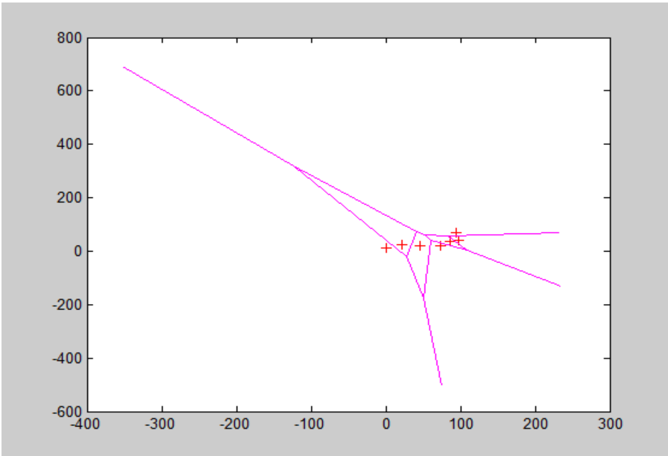
A mobile sink is used to reduce the energy consumption of nodes and to prevent the formation of energy holes in wireless sensor networks. These benefits are dependent on the path taken by the mobile sink, particularly in delay-sensitive applications, as all sensed data must be collected within a given time constraint. A mobile sink that preferentially visits these areas will prevent energy holes from forming in a WSN.A mobile sink is programmed to visit virtual RP positions and to collect data from nearby sensor nodes.

c) sink node travelling distance



d) Energy in various levels





V. ENERGY CONSERVATION VALUES

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ENERGY CONSERVATION IN ROUND
    0.1982

ENERGY CONSERVATION IN ROUND
    0.1976

ENERGY CONSERVATION IN ROUND
    0.1973

ENERGY CONSERVATION IN ROUND
    0.1971

ENERGY CONSERVATION IN ROUND
    0.1971

ENERGY CONSERVATION IN ROUND
    0.1968

ENERGY CONSERVATION IN ROUND
    0.1968

ENERGY CONSERVATION IN ROUND
    0.1963

ENERGY CONSERVATION IN ROUND
    0.1961

ENERGY CONSERVATION IN ROUND
    0.1961

ENERGY CONSERVATION IN ROUND
    0.1959

ENERGY CONSERVATION IN ROUND
    0.1956

ENERGY CONSERVATION IN ROUND
    0.1954
```

When all roundes are considered the energy in each round decreases compared to previous round. The simulation results show the energy decrease. Hence the energy is saved by using rendezvous points, mobile sink and weighted rendezvous planning.

VI. CONCULSION

In this paper, we analyzed the performance of WRP with mobile sink based data collection to base station in a WSN. The efficiency of weight age based selection of RPs for the low energy expenditure of sensor nodes and to ensuring sensed data is collected on time. In addition, visiting virtual nodes which are considered to be a RP point with minimum traveling distances through extensive search for minimum path distance along with energy conservation as benchmark for each iteration. Our simulation results proved the efficiency of weight age based RP selection for minimized delay and energy optimized sink node visits to RP points.

Our simulation results show that WRP uniformly distributes energy consumption by 39% and 44% better than CB and RD-VT, respectively.

we plan to enhance our approach to include data with different delay requirements. This means a mobile sink is required to visit some sensor nodes or parts of a WSN more frequently than others while ensuring that energy usage is minimized, and all data are collected within a given deadline. Moreover, we plan to extend WRP to the multiple mobile sinks/rovers case. This case, however, is nontrivial as it involves subproblems such as interference and coordination between rovers. Having said that, we note that WRP remains applicable if a large WSN is partitioned into smaller areas where each area is assigned a mobile sink. WRP can be thus run in each area.

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