Mobile Element Trajectory Control Scheme to Reduce Sensed Data Collection Delay against Obstacles

V.Shrinithi

PG student, Department of Computer Science & Engineering,
Vivekanandha College of Engineering for Women, Tiruchengode, Tamil Nadu, India

R.Rohini

Assistant Professor, Department of Computer Science & Engineering,
Vivekanandha College of Engineering for Women, Tiruchengode, Tamil Nadu, India

Abstract - Mobile elements usage created a new dimension to reduce and balance energy consumption in wireless sensor networks (WSN). At the same point, due to the inherent and slower movement of mobile elements makes the data collection latency to become higher. Scheduling of Mobile elements need to address traverse pattern through the sensing field, time of data collection from respective sensor. The proposed work presented Mobile Element Trajectory Control scheme to reduce the sensed data collection delay against obstacles. It will partition the deployment area with fixed cell decomposition and the beacon trajectory is divided into global and local trajectory. Approximate trajectory is obtained by greedy strategy. Mobile element trajectory control scheme decreases the delay cost, maintain better accuracy with beacon-based localization method and consider both local and global trajectories of the mobile element.

Keywords - Wireless Sensor Network, Mobile Elements, Depth-First-Search, Greedy strategy

I. INTRODUCTION

Wireless Sensor Network (WSN) is network of small devices, called sensor nodes, that are embedded in the real world for observations related to an application and are connected by a wireless network. Protocol designers for WSNs place a high emphasis on energy conservation, since the nodes run on limited battery power. Data generated by the nodes is typically transmitted to the sink over a multi hop wireless network. In such a network, a node might spend most of its power relaying other nodes' packets, depleting its battery. Over time, as nodes die out, the network tends to get disconnected, leading to loss of coverage and connectivity.

Data collection from the nodes deployed in a sensing field is one of the most important tasks of wireless sensor networks. Typically, data collection relies on wireless communications between sensor nodes and the sink node. Another approach to the data collection in sensor network is Mobile Elements. MEs can act as the mechanical carrier which move around in the sensing fields, collecting the data from the sensors and transmitting them to the base station.

One way to solve this problem is to mobile element trajectory model. Mobile elements usage created a new dimension to reduce and balance energy consumption in wireless sensor networks (WSN). Data collection latency becomes higher due to relatively slow movement of mobile elements. Scheduling of mobile elements need to address traverse pattern through the sensing field, time of data collection from respective sensor. Formulated as traveling salesman problem with neighborhoods (TSPN) approximation and heuristic algorithms appeared in literature.
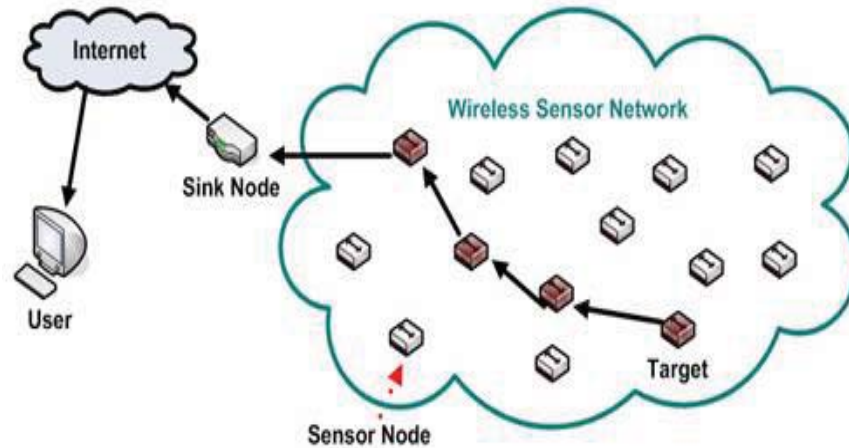
Figure 1.1 Wireless Sensor Network

To decrease the delay cost and maintain better accuracy with beacon-based localization methods, Mobile beacon assisted localization algorithms are used. This method uses a mobile beacon to traverse the network. The existing trajectory planning method progressive approach to reduce data collection latency in wireless sensor network with mobile elements often suppose the network deployment area is obstacle-free, but there are many obstacles in real world, such as trees, rocks, holes. Therefore, this paper focuses on the planning of obstacle avoidance trajectory for mobile beacon.

The rest of this paper is organized as follows: The work related to exploring mobility for data collection in wireless sensor networks is reviewed in Section 2. In Section 3, we define the scope of our problem and highlight our approach. Experimental evaluation in section 4, Conclusion in section 5. Further discussion is offered in Section 6.

II. RELATED WORK

Wireless sensor networks, such as Data collection, object tracking, environment monitoring, health perception and ship navigation, the location information is significantly essential and indispensable as it offers insights into deriving the meaningful sensor data. One approach to the data collection in sensor network is Mobile Elements. Mobile Element can act as the mechanical carrier which moves around in the sensing field, collecting the data from sensor, transmitting them to the base station. The usage of Mobile elements resulted in a newer mode in order to minimize and provide a energy consumption in wireless sensor networks (WSN). At the same point, due to the inherent and slower movement of mobile elements makes the data collection latency to become higher.

The scheduling of mobile elements need to address the traverse pattern and also the time of data collection from respective sensor nodes. Many research works have been conducted on the approximation and usage of heuristic algorithms has been applied with the help of traveling salesman problem using neighborhoods. The range-based methods require the unknown nodes measure the distance to virtual beacons, and estimate their locations with tri-lateration or multi-lateration. The range-free method estimates the unknown nodes with area or borderline measurement technology. The area measurement determines the area where unknown nodes located, and uses the centroid or weighted centroid as the location estimation.

In RSSI (Received Signal Strength Indicator) where the sensor nodes receiving beacon packets infer proximity constraints to the mobile beacon and use them to construct and maintain position estimates. The range-free method estimates the unknown nodes with area or borderline measurement technology. The area measurement determines the area where unknown nodes located, and uses the centroid or weighted centroid as the location estimation. ADO (Arrival and Departure Overlap) that determines the arrival and departure area using a mobile beacon and estimates unknown nodes' locations with centroid. A localization scheme using the conjecture of perpendicular bisector of a chord, which selects three virtual beacons to generate two perpendicular bisectors of chord and estimate locations. Clearly, by utilizing the wireless communication range, collecting data while traveling leads to a better data collection efficiency.

III. DISCUSSIONS

The use of data mules in collecting data introduces the trade-off between energy consumption and data delivery latency. Our objective is to optimize this trade-off, so that energy consumption is minimized under some latency constraint or vice versa. Protocol designers have tried to optimize the multi-hop forwarding in both energy and latency through sophisticated MAC protocols. Data mule, or its combination with multi-hop forwarding, is a relatively nascent area. In this paper, we focus on the data collection approach, in which each node uses only direct communication with the data mule and no multi-hop forwarding. Energy consumption related to communication is already minimized in this case, since each node only sends its own data and does not forward other data. Naturally, our objective is to minimize the data collection latency by minimizing the travel time of the data collection.

The number of papers that we have reviewed for wireless sensor network in data collection techniques has different strong and weak points about data collection delay and energy consumption. All the data collection algorithms have to comply with a few basic requirements. The thing that are needed as follows

A. Data Collection

Data collection is the fundamental functions of WSN. In Data Collection, the sensed data is collected at all or some of the sensor node and forwarded to the central Base Station (BS) for further processing.

B. Energy

The energy is an important parameter in are source limited network such as the WSN as the lifetime of battery is very much limited.

C. Sink

Sink is the destination of the information. It collect the data sensed by the sensor node either directly or indirectly. It connect the sensor network to the user via the internet or other networks and it is responsible for signaling and traffic handling.

D. Latency

Latency is defined as the transport delay in receiving the data from the actual time in the real time network. Latency refers to the "Time Delay" measured in milliseconds, between the initial input and output. Latency requirements depends on the applications.

Data collection is the fundamental functions of WSN. In that, the sensed data is collected at all or some of the sensor node and forwarded to the central Base Station (BS) for further processing. In this we will outline the different phases of the data collection process and the main issues involved. The description can be easily completed, where sensor nodes are also mobile.

IV. PROPOSED WORK

In our Approach Mobile Element Trajectory control scheme to reduce sensed data collection delay against obstacles in wireless sensor network are used. Trajectory is a path moving the data follows through the space as a function of time. It will reduce the data collection delay and balance the energy consumption in wireless sensor network. The trajectory control scheme partition the deployment area with fixed cell decomposition where the beacon trajectory is divided into global and local trajectory. Using depth-first-search shortest global trajectory is approximated whereas the local trajectory is obtained by greedy strategy.

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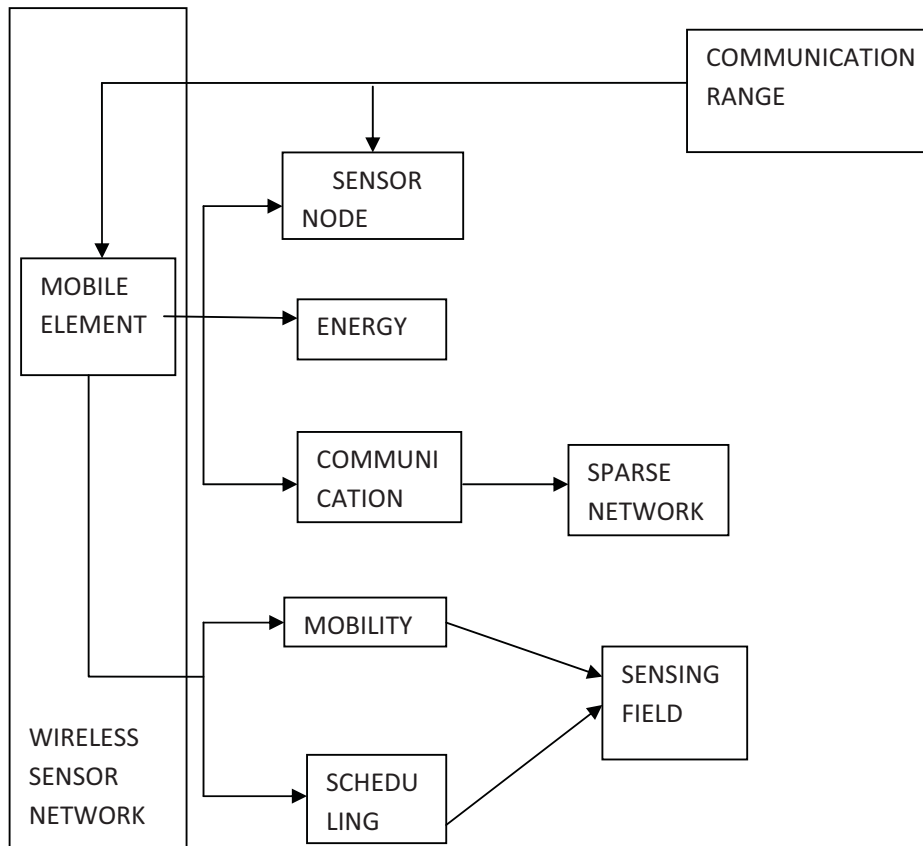
Figure 4.1   Architecture Diagram for Mobile Element Trajectory Control Scheme

Use of smaller cell size leads to longer beacon trajectory and more localizable sensor nodes. Mobile beacon assisted localization algorithms are evaluated with multiple simulation scenarios. Simulation indicates that mobile element trajectory control decreases the delay cost, maintain better accuracy with beacon-based localization method and consider both local and global trajectories of the mobile element.

Main objective of mobile element trajectory control scheme to reduce sensed data collection delay against obstacles are follows:

- Mobile Element Obstacles in Sensor Networks
- complete Trajectory Control
- Path Plan for Obstacle Avoidance
- Metrics for Evaluation

A. Mobile Element Obstacles in Sensor Networks

The Mobile Element (ME) Obstacle in sensor network includes cell decomposition and Deployment area of sensor network in configuration space. Cell decomposition partition a given region into disjoint sets. Each element of disjoint sets after decomposition is called cell. The cell decomposition method classified as exact and approximate.

Partitioning the given region into disjoint sets is called cell. Exact cell decomposition is to decompose the configuration space into a collection of non-overlapping cells to the union of all the empty cells exactly equal configuration space. Approximate cell decomposition is to construct a collection of non-overlapping cells to the union of all the empty cells approximately covers configuration space. If all cells have equal size, it is fixed cell decomposition. Otherwise it is referred to as approximate cell decomposition.

B. Complete Trajectory Control

Deployment area is modeled by connectivity graph after cell decomposition and Global trajectory-planning present the shortest path traversing all vertices of connectivity graph. Greedy method make path containing less backtrack. After visiting a vertex next it will goes to next vertex to visit one with most adjacent and non-visited vertices and the Vertex with minimal degree is the vertex to visit firstly and degree of vertices adjacent to current visiting vertex is decreased by 1. If current visiting vertex has no non-visited neighbors the algorithm backtracks to its parent vertex. Otherwise selects non-visited neighbor with minimal degree to visit .

In greedy method every time slot, it send each message from current node to its parent without creating interference with any high priority message. Greedy method takes into consideration the path containing less backtrack.

C. Path Plan for Obstacle Avoidance

The Localization is one of the most important technologies in wireless sensor network, and mobile beacon assisted localization is a promising localization method. The mobile beacon trajectory planning is a basic and important problem in these methods. In mobile element beacon trajectory, unknown nodes in empty cells are localized in one-hop range. Unknown nodes in configuration space are useless nodes (cannot provide useful information). others are useful nodes with decrease of cell size. The number of empty cells and localizable unknown nodes increase rapidly. So, Trajectory is short to save energy of ME against obstacles.

D. Metrics for Evaluation

The performance metrics to be evaluated in "Mobile Element Trajectory Control Scheme (METCS) to Reduce Sensed Data Collection Delay against Obstacles" comprises of Trajectory control rate, ME obstacle density, Ratio of global to local trajectory, Latency for sensed data collection and Obstacle delay in path plan.

 Measure of Latency

Table 4.1 illustrates the latency for sensed data collection and comparison analysis is made with the existing CSS scheme and measures the effectiveness of Mobile Element Trajectory Control Scheme.Latency is a measure of percentage of time delay experienced in wireless sensor networks which purely depends on the system and the time being measured. From the figure it is evident that the latency is lesser in the proposed Mobile Element Trajectory Control Scheme when compared to the existing CSS scheme. The variance achieved is 10-15% lesser than the existing CSS scheme.

The simulation experiments are conducted to evaluate the efficiency of the proposed work "Mobile Element Trajectory Control Scheme (METCS) to Reduce Sensed Data Collection Delay against Obstacles". The performance of METCS is compared with the Combine Skip Substitute scheme.

Table 4.1 Tabulation for Latency

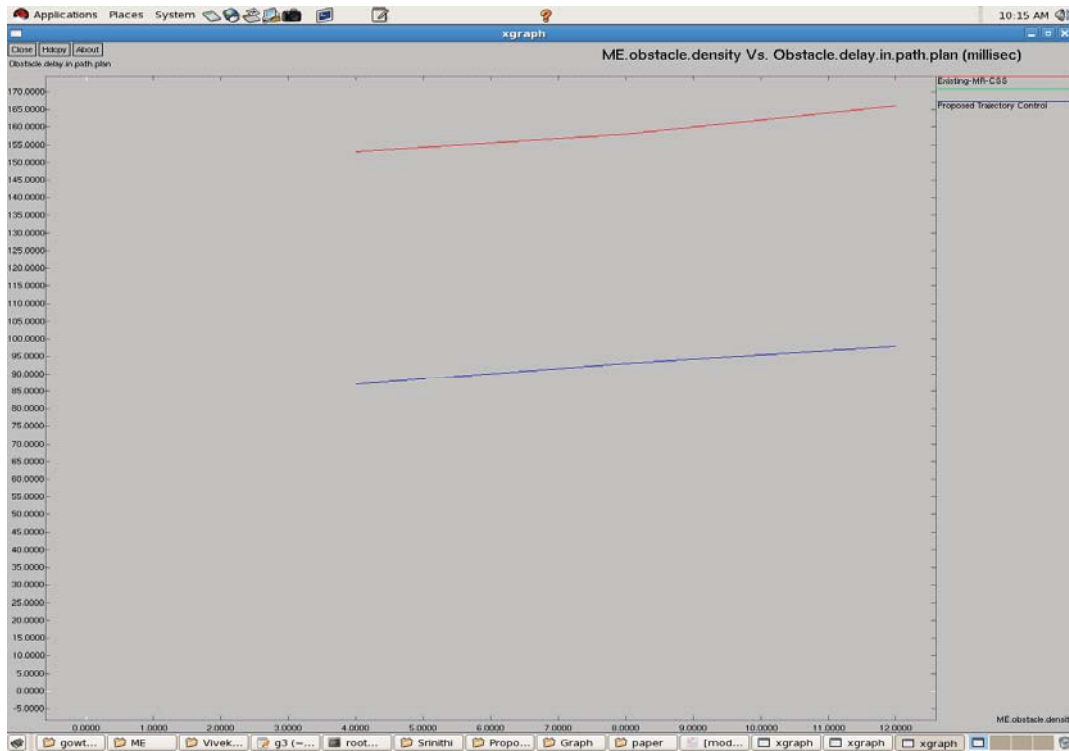| Number of Sensor Nodes	Latency (%)	
	Proposed METCS	Existing CSS
10	35	43
20	42	52
30	45	60
40	52	65
50	55	72

Figure 4.2 ME obstacle density Vs Obstacle delay
in path plan

Figure 3 shows better performance of Mobile Element Trajectory Control (METC) scheme in terms of Mobile element obstacle density than Multi-rate Combine-skip-substitute (M-CSS). Mobile Element Trajectory Control (METC) achieves 10 to 20% less Obstacle delay in path plan variation when compared to existing system.
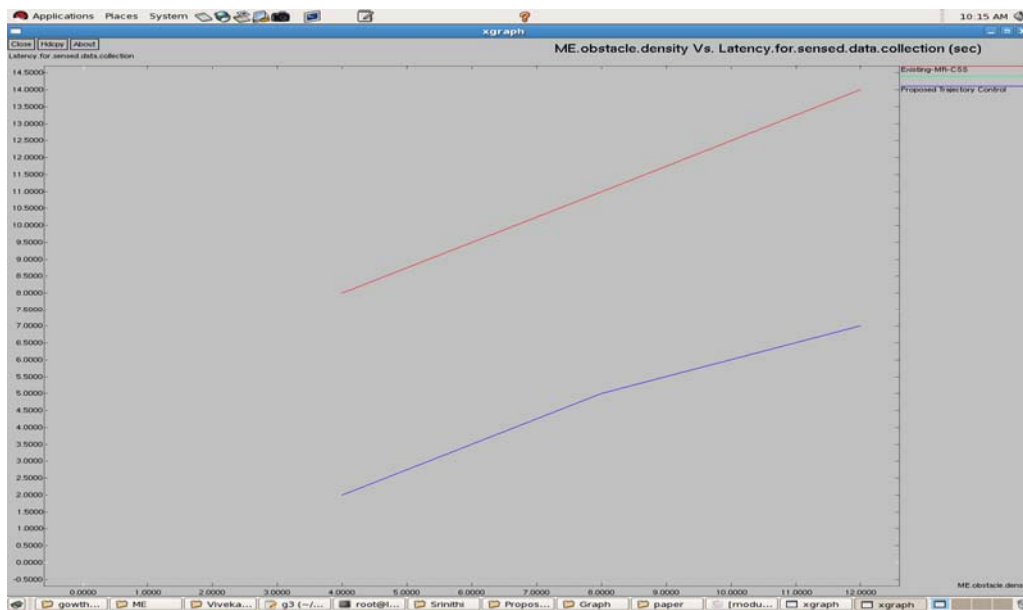

Figure 4.3 ME obstacle density Vs Latency for sensed
data collection

Figure 4 shows better performance of Mobile Element Trajectory Control (METC) scheme in terms of Mobile element obstacle density than Multi-rate Combine-skip-substitute (M-CSS). Mobile Element Trajectory Control (METC) achieves 15 to 20% less Latency for sensed data collection variation when compared to existing system.
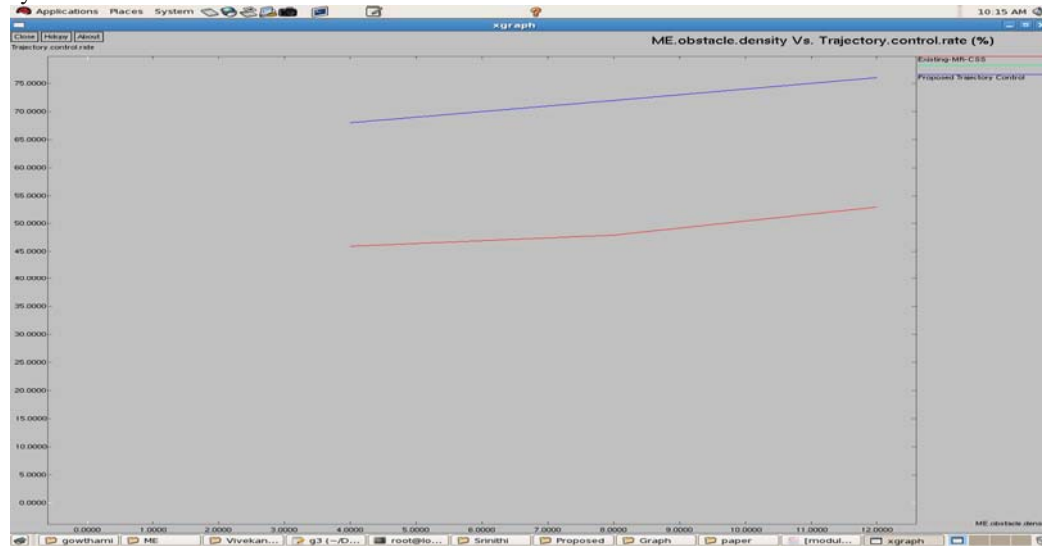

Figure 4.4 ME obstacle density Vs Trajectory control rate

Figure 5 shows better performance of Mobile Element Trajectory Control (METC) scheme in terms of Mobile element obstacle density than Multi-rate Combine-skip-substitute (M-CSS). Mobile Element Trajectory Control (METC) achieves 10 to 15% less Trajectory control rate variation when compared to existing system.

V. CONCLUSION

In this paper, we have proposed Mobile Element Trajectory Control scheme to reduce the sensed data collection delay against obstacles. The main contribution of this paper is to give a path planning method that can avoid obstacles. Using fixed cell decomposition, the sensor network deployment area are divided into many cells, and represented by a beacon trajectory in to local and global trajectory. Two algorithms comprising of depth first search, greedy strategy method are deployed and are designed to compute the approximate optimal global path among empty cells. The simulation results indicate that smaller cell size leads to more localizable sensor nodes. Multiple MEs in the network that normally are expected to have similar workload, collection latency, covering similar sizes of sensing areas and also numbers of sensor nodes. It will reduce the data collection delay and balance the energy consumption in WSN.

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