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SCHEDULING TRANSFERABLE OBJECTS FOR QUERY PROCESSING IN WSN

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Abstract

Mobile elements are used to reduce and balance the energy consumption in wireless sensor networks. Data collection latency is increased with reference to the low travel speed of mobile elements. Mobile elements are scheduled with their traverse pattern for data collection from sensors. Combine-Skip-Substitute (CSS) scheme is used to identify solutions for lower bound. A progressive optimization scheme is used to reduce the data collection latency under sensor networks. Multi Rate CSS (MR-CSS) scheme is used to reduce the data collection latency. Traveling Salesman Problem with Neighborhoods (TSPN) is used with mobile elements to reduce the tour size and delay. Skip-and-Substitute Algorithm and Combination Algorithm are used to schedule the data collection process. Data collection schedule process is enhanced with traversal scheme of Mobile Elements. The scheduling scheme is tuned for multi radio environment. Multiple node data transmission supported by the system. Transmission coverage of sensor node is integrated with the ME data capture process. Cluster head based data collection mechanism is integrated with the system. Java, Java in Simulation Times (JiST) and Oracle softwares are used for the system development process.

Index Terms - Multi Rate CSS(MR-CSS), Mobile Element,Data Collection.

1.Introduction

Sensors are hardware devices that produce measurable response to a change in a physical condition like temperature and pressure. Sensors sense the physical data of the area to be examined. As wireless sensor nodes are micro-electronic sensor device. Sensor device are with a limited power source of less than 0.5 Ah and 1.2 V. Sensors are divided into three categories.

- Passive, Omni Directional Sensors: Passive sensors sense the data without actually manipulating the environment by active probing. They are self-powered i.e energy is needed only to amplify their analog signal.

  There is no notion of "direction" involved in these measurements.

- Passive, narrow-beam sensors: These sensors are passive but they have well-defined notion of direction of measurement.

  Typical example is „camera‟ .

- Active Sensors: These type of sensors actively analysis the environment.

A wireless sensor network (WSN) is a wireless network consisting of spatially distributed autonomous devices using sensors to cooperatively monitor physical or environmental condition. The development of wireless sensor networks was originally motivated by military applications such as battlefield investigation. However, wireless sensor networks are now used in many resident application areas, including environment and healthcare applications, home automation, and traffic control. A sensor network normally organizes a wireless ad-hoc network, that each sensor supports a multi-hop routing algorithm.

The applications for WSNs are many and some of them are monitoring, tracking, and controlling. Specific applications for WSNs include environment monitoring, object tracking, nuclear reactor control, fire detection, and traffic monitoring. In a typical application, a WSN is spread in a region where it is meant to collect data through its sensor nodes.

Several standards are currently development for wireless sensor networks. ZigBee is a mesh-networking standard used for sensing, medical data collection, consumer device. Zigbee is developed by a large consortium of industry players. Wireless HART is specifically designed for Industrial applications like Process Monitoring and Control. Wireless HART was added to the overall HART protocol suite as part of the HART 7 Specification, which was approved by the HART Communication Foundation in June 2007. ZigBee, Wireless HART, 6lowpan/ISA100 all are based on the same underlying radio standard: IEEE 802.15.4 - 2006.

The main aim is to reduce cost and tiny sensor nodes. Now the sensor nodes are mainly prototypes. Reduction and low cost are understood to follow from recent and future progress in the fields of MEMS and NEMS. Some of the existing sensor nodes are specified under. Some of the nodes are still in developing stage. Energy is the rarest resource of WSN nodes, and it also determines the lifetimes of WSNs. WSNs are meant to be organized in large numbers in various environments. Some of the issues are lifetime maximization, robustness and fault tolerance and self-configuration. Some of the "hot" topics in WSN software research are security, mobility and middleware is the design of middle-level between the software and the hardware.

2. Related Work

Recently, many research efforts have appeared in the literature to explore various devices with different mobility in sensor networks to collect data from sensor nodes. Shah et al. show an early work on this topic, where a three-tier network architecture was proposed. The mobile entities, referred to as data mobile ubiquitous LAN extensions (MULEs), lie in the middle tier on top of the stationary sensor nodes, move around in the network to collect data from sensor nodes, and ultimately upload the data to the sink. The term Data MULEs was widely used in the literature since then. Mobile data observer, called SenCar, was used as a mobile base station in the network. It also showed that the design of the traveling tour is critical for SenCar to accomplish data collection jobs successfully.

Observing the importance of the tour selection for MEs, a lot of efforts were put into its optimal design [6]. The mobility strategy following the periphery of the network coverage is found to be optimal in terms of balancing the communication loads among sensor nodes. However, the optimal tour selection regarding to minimizing the data collection latency is still an open problem with different approaches attempted. The tour selection problem was formulated as the mini energy rendezvous planning problem (MERP). Two rendezvous planning algorithms were proposed, focusing on the scenarios where the mobile sink can move freely and only along a fixed track, respectively. This work was further investigated in [10], which jointly optimizes data routing paths and the tour of the mobile sink through Steiner minimum tree (SMT)-based approaches. These two research efforts, especially the second one, are among the most cited papers in this field. However, they did not fully explore the possibility to further optimize the tour by utilizing the wireless communication range between the sensor nodes and the mobile sink.

The tour selection problem with the consideration of the wireless communication range can be modeled as a TSPN, a generalization of the

NP-complete traveling salesman problem (TSP). Furthermore, it has been proven that TSPN in its general form is APX-hard (i.e., approximation hard) and cannot be approximated within a factor of 1.000374 unless P = NP. The lower bound of the possible approximation factors was further pushed to (2 - ε).

On the other hand, approximation algorithms do exist for certain cases of TSPN. For example, a constant-factor approximation algorithm was proposed by Elbassion etal, where the neighborhoods are discrete objects of comparable diameters. Furthermore, PTAS for the TSPN with continuous disjoint neighborhoods was presented. Although promising, these results do not apply to our problem due to the reason explained below.

The tour selection problem in our focus corresponds to another category of TSPN, where the neighborhoods are intersecting continuous disks of the same size. The performance of the existing approximation algorithms for this type of TSPN has only been characterized theoretically in terms of approximation factors, which are often quite large. Specifically, the best result so far in the literature, where an approximation factor of 11.15 is achieved. In our scenarios, knowing such a loose bound is obviously of little practical value.

Noticing the difficulty in designing approximation algorithms, most existing work adopted heuristic approaches to obtain the traveling tour. The authors started with an optimal TSP tour, based on which they reduced the search space of the problem, and adopted three evolutionary algorithms to obtain the tour. The case where multiple MEs exist in the network was considered. The problem of tour selection for MEs was formulated as the label-covering problem in [6] and a heuristic algorithm using dynamic programming was presented there to solve the problem, which was shown through simulation to be able to achieve better results.

They all assumed that as long as the tour intersects with the communication disks of all sensor nodes, all the data collection jobs can be accomplished. This assumption is acceptable when dealing with applications such as temperature monitoring, where the sensory data size is small. However, due to the communication data-rate constraint and the travel speed of the ME, the resultant tour may not always be sufficient to accomplish all the data collection jobs, especially when the data volume to be collected is large, e.g., in audio/video sensor networks. Taking the communication time into account, Bhadauria et al. tackled the tour selection problem based on a two-ring communication model [4], which was formulated as a two-ring tour (TRT) problem. Constant approximation factor algorithms, which jointly consider the travel time and the communication time, were proposed. However, the approximation factor of the proposed algorithm was based on that of the TSPN subroutine adopted, which is relatively large when the neighborhoods are intersecting continuous disks, as we have discussed above.

In this paper, we start with the same assumption but relax it eventually. For TSPN with intersecting continuous disk neighborhoods, the possible intersection and the continuity of neighborhoods make it very difficult to obtain good approximation results, but on the other hand, they also provides several opportunities to optimize the data collection tour. Utilizing the fact that these communication disks may intersect with each other, and any location in the intersected area can serve as the data collection site to carry out all these associated data collection jobs, our CSS scheme combines several data collection jobs together when possible and further skips and substitutes some collection sites, which greatly shortens the tour. We then extend it to the case, where the realistic data-rate constraints exist, and present the MR-CSS scheme to answer the question that when and where, from which sensor node and at what data rate, should the ME carry out the data collection? [5], [3].

Essentially, the two-ring communication model used in [4] is a special case of the multirate model we adopted in the MR-CSS scheme, where only two different data rates are considered in [4]. The main difference is that the ME works in a collect-while-travel way in the MR-CSS scheme, while in [4] it carries out the data collection in a stop-and-collect manner. Clearly, by utilizing the wireless communication range, collecting data while traveling leads to better data collection efficiency.

3. Data Collection Using Mobile Elements

Data collection from the nodes arranged in a sensing field is one of the most important works of wireless sensor networks [1]. Typically, data collection relies on wireless communications between sensor nodes and the sink node, which may suffer from the following problems.1) In wireless communications long-range ones, may consume the limited on-board energy supply of sensor nodes excessively due to super linear path loss exponents [9]. 2) In shorter range, multihop wireless communications are adopted, due to the data combination toward the sink, nodes around the sink still have to consume much more energy than others due to heavier volumes of traffic transferred by them and it leads to reduce the overall network lifetime.

Another approach to data collection in sensor networks uses the regularly available, controlled mobility of certain nodes [7], [8], referred to as mobile elements (MEs). Introducing mobility to the problem increases the dimension of the solution space to improve the network performance, and the achievable solutions are always no worse than those obtained in a subspace with a reduced dimension [2]. However, data collection with MEs in sensor networks. Due to the lower speed of MEs, data collection may suffer a much higher latency than multihop forwarding when the latter is feasible at a higher energy cost for sensor nodes [10]. Large data collection latency not only damages the timeliness of the data, but also may result in the buffer overflow of sensor nodes.

4. Problem Statement

Mobile elements are used to reduce and balance the energy consumption in wireless sensor networks. Data collection latency is increased with reference to the low travel speed of mobile elements. Mobile elements are scheduled with their traverse pattern for data collection from sensors. Combine-Skip-Substitute (CSS) scheme is used to identify solutions for lower bound.

A progressive optimization scheme is used to reduce the data collection latency under sensor networks. Multi Rate CSS (MR-CSS) scheme is used to reduce the data collection latency. Traveling Salesman Problem with Neighborhoods (TSPN) is used with mobile elements to reduce the tour size and delay. Skip-and-Substitute Algorithm and Combination Algorithm are used to schedule the data collection process. The following drawbacks are identified in the existing system. Single radio transceiver based network, concurrent communication is not managed, and mobile element movement pattern is not considered abd Coverage optimization is not performed.

5. Cluster Head Based Data Collection

Data collect through mobile element (ME) under Wireless Sensor Networks. It supports multi-

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radio based mobile element communication. In proposed system, data collection schedule process is enhanced with traversal scheme of mobile elements

.The scheduling scheme is tuned for multi radio environment. Multiple node data transmission supported by the system. Transmission coverage of sensor node is integrated with the ME data capture process. Cluster head based data collection mechanism is integrated with the system. Using query processing we can request the data and retrieve the data in sensor networks.

Through the construction of existing problems as a special case of the traveling salesman problem with neighborhoods (TSPN), where the neighborhoods are possibly intersecting continuous disks, and due to its NP-hardness, several approximation and heuristic algorithms have appeared in the literature. However, so far the best approximation algorithms only have theoretical value due to their large approximation factors, and we have shown that our progressive optimization-based CSS scheme can obtain results that are quite close to the lower bound of the optimal solution. Second, our work takes the advantage and reality of modern multirate wireless communications into account .MEs are able to communicate with further-away sensor nodes at a lower data rate and potentially reduce their tour length. However, due to a lower data rate, MEs have to communicate with a certain node for a longer time. To prove the correctness of the proposed algorithms, analyze their perform and show their efficiency using through extensive simulation.

The mobile element based data collection system is improved for cluster based environment. Cluster heads are assigned to manage sensor node in the same coverage.

Data collection communications are carried out with different radio frequency levels. The system is dividing into five major modules. They are network analysis, cluster construction, scheduling with single radio, scheduling with multi radio and data collection process.

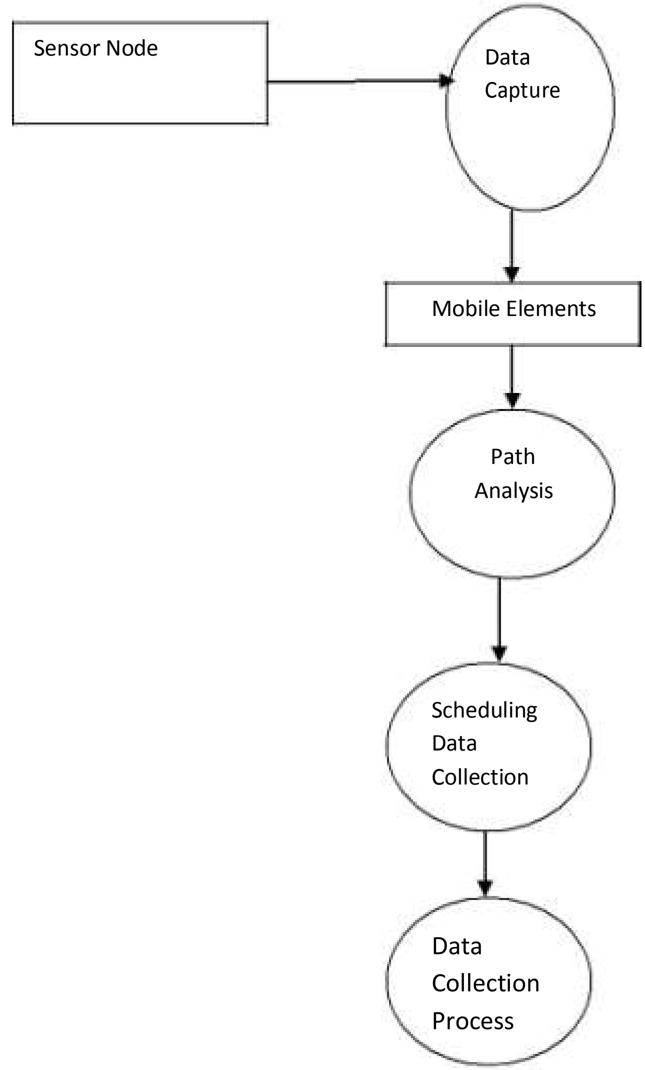

Figure 5.1. Cluster Head Based Data Collection

Data capture in the sensor node through the mobile elements. Next process is the path analysis to form the cluster head based construction. Then schedule the data which are collect from sensor networks. Data collection process Managed whenever needed the information about the data we can get the data by requesting.

6. Movement Plane Transferable Objects

6.1. Multirate Communication Model

It is known that wireless signals suffer from path loss, fading, shadowing, interference, and other impairments. The communication performance is determined by the received SNR, defined as p_r/p_n, where pr is the received signal strength and p_n is the power of the background noise. Denote α as the path-loss exponent, whose value is normally in the range between 2 and 6, then the received signal strength can be calculated based on the Friis freespace model, which is of the superliner relationship $p_r \sim (d^{-\alpha})$ to the communication range d. The fact that the SNR deceases as the communication range increases is also verified through experiment measurements.

Based on this observation, we consider the multiple data rates widely available in modern wireless communication technologies for this data-rate constrained case, and adopt the multirate communication model: Sensor nodes can choose from m different modulation and coding schemes, resulting in m different communication ranges (d_1, d_2, . . . , d_m) and m different data rates (r_1, r_2, . . . , r_m) as illustrated. Normally, $r_i > r_{i+1}$ for $d_i < d_{i+1}$.

In principle, the movement of the ME will impact its communication with sensor nodes, due to the Doppler shift of signals, which may result in unstable channel conditions, and affect the data rate eventually. However, since the travel speed of the ME is usually low, the resultant Doppler shift will be small, and we exclude its impact in this paper. Neglecting the effect of the travel of the ME on the data rate is also reasoned through experiment measurements.

6.2. Multirate CSS Scheme

We extend the basic CSS scheme to make it fit the problem under the multirate communication model, i.e., the MR-CSS scheme, which is based on the following observation. The straightforward because the solution space is increased after the communication range is increased, and the same search scheme working in the larger space will obtain results that are no worse than those obtained when working in the smaller one.

Although longer communication ranges give more flexibility to reduce the tour length, the data transfer rate will also be reduced as the communication ranges of sensor nodes increase, and the resultant T_{css} may not always be feasible to accomplish all the data collection jobs. An intuitive view of this process, where the width of solid line represents the available data rate, i.e., the wider the line, the higher the data rate. The path length is reduced from $|A_1A_2|$ + |A2A3| to $|A_1A''_2|$) $|A''_2A_3|$ and to $|A_1A_3|$ when increasing the communication range from d_0 to d_1 and to d_2 with a decreasing data rate, respectively.

Inspired by this observation, the MR-CSS scheme starts by setting the communication range of sensor nodes to d_0, and apply the CSS scheme. The resultant tour is always feasible in this simplified problem setting. We then expand the communication ranges of sensor nodes to d_1 and apply the CSS scheme again. Repeat this until the resultant tour is no longer feasible, denoting it as T_{inf}. For the data collection jobs cannot be accomplished by T_{inf} ,we shrink the communication ranges of the corresponding sensor nodes, and apply the CSS scheme again until the tour becomes feasible again. The pseudocode of the MR-CSS scheme is shown in Algorithm 1.

Algorithm 1. The MR-CSS Scheme.

1: $T_{css} \leftarrow Ø$, $T_{inf} \leftarrow Ø$, $T_{mr} \leftarrow Ø$;
2: i ←1;
3: repeat
4: if i == m then
5: $T_{mr} \leftarrow T_{css}$;
6: go to line 18;

7: end if
8: calculate T_{css} by CSS scheme with uniform communication range d_i;
9: $i \leftarrow i + 1$;
10: until T_{css} is not feasible
11: $T_{inf} \leftarrow T_{css}$;
12: repeat
13:select sensor nodes whose data collection jobs cannot be accomplished by T_{inf};
14: shrink their communication ranges; 15:re-calculate T_{inf} with nonuniform communication ranges;
16: until T_{inf} is feasible
17: $T_{mr} \leftarrow T_{inf}$;
18: return T_{mr}.

The verification of whether a given tour is feasible or not can be carried out based on the LP formulation, in a time of O(nm). Note that we can adopt the binary search again to speed up the search for T_{inf} in lines 3-10 of Algorithm 1. Denote C_{css} as the time complexity of the CSS scheme. The computational time complexity of the MR-CSS scheme is $O(nm\log m)C_{css}$.

7. Scheduling Transferable Objects for Query Processing

The network analysis module is designed to collect sensor node and network details. Neighborhood nodes are grouped under the clustering process module. Single radio based transferable object traversal planning is performed under the single radio scheduling module. Multi radio scheduling module is used to plan the traversal of ME with multi radio. Query processing is performed under the data collection module.

7.1. Network Analysis

Sensor network and node properties are collected from the user. Sensor network is deployed with node count and transferable object details. Node name, coverage details and data capture type information are collected for each node. Node energy level and bandwidth status are separately maintained for each node.

7.2. Cluster Construction

Sensor nodes are grouped into clusters with reference to their coverage values. Sensing and coverage values are used in the clustering process. Neighborhood nodes are arranged into the same cluster environment. Cluster head is selected for each cluster with energy and bandwidth levels.

7.3. Scheduling With Single Radio

Transferable object coverage and sensor node coverage details are used for the data collection scheduling process. The Combined Skip Substitute (CSS) algorithm is used for the tour plan and data collection process. The Multirate CSS (MR-CSS) scheme assigns the data collection and transferable object movement process. Sensor node under the same coverage of transferable objects is combined in the tour plan.

7.4. Scheduling With Multi Radio

Multi radio environment is used in the transferable object and sensor nodes. Simultaneous data transmission can be performed with different frequency ranges. The data collection and tour plan are adopted for the multi radio based communication environment. The MR-CSS scheme is enhanced to perform simultaneous data communication between ME and sensor nodes.

7.5. Data Collection Process

The transferable object collects data from the sensor node during its tour operations. Cluster head handles the data collection process from the sensor nodes. All the sensor nodes data values are maintained under the cluster head. Cluster head retransmits the data to the transferable object.

8. Conclusion

Sensor node data values are collected and transferred using transferable objects. Transferable object moved across the sensor networks to reduce the data collection delay. Multi Rate Combine-Skip-Substitute (MR-CSS) model is integrated with progressive approach to manage data collection process. The scheduling scheme is enhanced to support multi radio based transferable objects. Energy consumption is minimized in the transferable object based data collection scheme. Data collection delay is reduced by the cluster based approach. Communication overhead is reduced by the system. Transferable object movement is controlled with multi radio data collection mechanism.

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