AN EFFICIENT DATA COLLECTION MODEL USING PHANTOM PARTITIONING TO RECONNECT TRAFFIC PARTITIONED NODE IN WIRELESS SENSOR NETWORK STRUCTURE
Biju Paul\textsuperscript{a}, E Gopinathan\textsuperscript{b}
\textsuperscript{a}Research Scholar, Computer Science Engineering, Vels University, Chennai-600043
\textsuperscript{b}Dean, School of Engineering, Vels University, Chennai-60004

Abstract

Although traffic partitioned node on wireless sensor network has been under way for many years and many energy optimization model have been investigated, it is still unclear whether integer linear programming problem is consistently effective on overlapping time over multiple mobile elements. With the objective of measuring the energy consumption on partitioning multi-hop wireless communications, a Traffic Reconnect Set-up Partitioning (TRSP) method is proposed in this paper. TRSP finds the affected location on varying range of mobile elements and reconstruct the network structure accordingly. A framework for traffic reconnect set-up partitioning based on inter partition gaps using the phantom partitioning concept is designed that identifies the network partitioning for most practical conditions using the NS2 simulator. With this, the TRSP with phantom partitioning balances the constraints with double cut method. The double cut based partitioning leads to safe route path by minimizing the energy consumption of sensor nodes in sensor network structure. The reestablishment of connectivity using the TRSP method provides improved data collection using the centroid mean point collection. The centroid mean point collection works with reconnect partition free sensor network system for varying range of mobile elements by achieving higher performance rate. The most affected location (i.e.,) partitioned nodes is identified and connectivity is reestablished during data aggregation. Simulation results demonstrate that the proposed TRSP method achieves better performance than the state-of-the-art methods in terms of energy consumption, data collection efficiency, and bandwidth rate.

© 2015 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
Peer-review under responsibility of the Organizing Committee of ICECCS 2015

Keywords: Wireless Sensor network; Centroid Mean Point Collection; Traffic Reconnect Set-up Partitioning; Phantom Partitioning; Mobile Elements.
1. Introduction

Efficient data collection has become significant in wireless network operation since the partitioning on multi-hop wireless communications and volume of energy consumption by sensor nodes may lead to extensive requirements on energy consumption during data collection in wireless structure network. A promising approach has been developed recently to decrease the energy required for communication in connecting the partitioned nodes.

A Maximum Amount Shortest Path (MASP) method is suggested in\(^1\) which uses linear programming problem to increase the network throughput. MASP also acts as an efficient data collection scheme. However the method is not proved to be effective in connecting the partitioned node while considering the overlapping time. Combine-Skip-Substitute (CSS) scheme suggested in\(^2\) reduces the data collection latency in wireless sensor network system by using travelling salesman problem. But CSS scheme does not focus on extending the partition work over multiple mobile elements. The two most important and contrasting goals to be satisfied in wireless sensor network are to enhance the efficiency of energy and the rate of throughput. The problem gets further complicated whenever there arise a situation to satisfy different types of quality of service (QoS) metrics related to wireless sensor networks. The packet assignment\(^3\) not only improves the robustness of the scheme but also is proved to be efficient in terms of energy using revised optimization formulation of elements. However the method does not address to the transmission rate and the computational complexity. Quantize and Estimate Compress and Estimate (QECE)\(^4\) is designed to minimize the rate of distortion for optimal number of sensor nodes. However, estimation of random fields remained unaddressed. Steiner-Tree-Based Critical Grid Covering Algorithm (STBCGCA)\(^5\) was developed for critical monitoring areas rather than static or common areas. STBCGCA is proved to be efficient by increasing the transmission rate at the rate of low cost.

Though several techniques have been developed to increase efficiency and throughput, the tradeoff between energy and throughput remains a broad area of interest. Redundant radix Based Number (RBN)\(^6\) was designed for energy and throughput improvement by applying Frequency Shift Key and Amplitude Shift Key respectively. However, optimality of energy saving was not achieved. To provide solution to this, selective message forwarding policies was introduced in\(^7\) to not only reduce the energy but also to increase the lifetime of the sensor nodes in wireless sensor network. The method was proved to be efficient in terms of energy and increased network lifetime for arbitrary network topology.

A trade-off can be seen in most of the wireless sensor networks due to the two most important factors, namely, network lifetime and the coverage of nodes. In order to obtain the optimal coverage, many sensor nodes in the network have to be active for a given period of time. At the same time, to increase the factor of scalability many nodes have to be in the sleep mode for longer duration of time. An integration model was introduced in\(^8\) called as the centralized heuristic and distributed parallel optimization protocol (POP) for improving the detection rate at a lesser amount of time. However, this integration model was not possible to be applied at critical scenarios. A distributed and scalable mechanism was introduced\(^9\) to address critical applications and to minimize the collision occurring at critical stages using conflict-free time slot allocation mechanism. However, the method suffered from location awareness. A randomization mechanism was selected in\(^10\) to address the problem related to non-convex optimization problem and included solutions for optimality condition.

Our contributions are in three folds. First, we designed a phantom partitioning method to find the affected location on varying range of mobile elements and reconstruct the network structure based on inter partition gaps. Second, the method achieves high data collection efficiency by applying centroid mean point collection method based on Euclidean distance. Finally, to minimize the energy consumption during re-establishment of connectivity, double cut based partitioning is applied to movable sensor nodes in wireless network structure.

The paper is organized as follows: Section 2 provides related research with respect to data collection in wireless sensor networks. In Section 3 the detailed explanation of Traffic Reconnect Set-up Partitioning (TRSP) method is described with the help of a neat framework using algorithmic description. Section 4 includes the experimental setup
required to design TRSP. Section 5 discusses in detail about the experimental settings provided for TRSP. Finally, Section 6 concludes the work.

2. Related Works

One of the most fundamental operations performed in wireless sensor networks for data collection is CONVERGECAST based on the conventional tree based routing. In certain applications involving delay tolerant and critical missions, provisioning of optimal guarantee time and enhancing the data collection rate is of high significance. In\textsuperscript{11}, multi frequency scheduling was considered to address the above said problems for several interference and channel modes. Joint frequency time slot assignment and scheduling was considered for improving the transmission power and improving the data collection efficiency. However, only static data were considered and variable amount of data remained unaddressed. Reliable Minimum Energy Cost and Routing (RMECR) were designed in\textsuperscript{12} to address energy minimization problem in wireless ad hoc networks.

One of the extensive measures of data collection in Wireless Sensor Networks (WSNs) is the implementation with respect to its network capacity. Several research works were concentrated on the unpractical model of data collection called as the deterministic network model. In order to improve and enhance the network capacity, a probabilistic network model was designed in\textsuperscript{13}. However, security issues remained unaddressed. In\textsuperscript{14}, a data collection protocol was designed that provides mechanisms for security in addition of supporting time based queries in WSNs. The method also includes provisioning of data confidentiality and data integrity by applying data co-commitment scheme.

One of the main areas considered for real time application includes physical monitoring of devices or sensor nodes in WSNs where database-oriented methods are shown to be of significant and used in an extensive manner. The Pocket Driven Trajectories (PDT) algorithm in\textsuperscript{15} used the local information regarding the selected nodes and accordingly applied a minimum Steiner tree for data collection resulting in energy savings. However, the latency incurred during data collection remained unaddressed.

An elaborate relationship between two aspects namely, security and data aggregation in wireless sensor networks were addressed by constructing the Merkle hash tree in\textsuperscript{16}. However, multilevel layer protocols were remained unaddressed. A stochastic model\textsuperscript{17} applying random field theory was designed in Wireless Sensor that used space-time behavior that reduced the mean delay for varying regions under observation. Based on the aforementioned techniques and methods, an efficient traffic reconnect set-up partitioning method on wireless sensor network structure is designed to improve the data collection efficiency and reducing the energy consumption during re-establishment of connectivity.

3. Traffic Re connect Set-up Partitioning

In this section, we discuss in detail about the design of traffic reconnect set-up partitioning method on wireless sensor network to improve the data collection and minimize the energy consumption during the reestablishment of connectivity. The main objective of the proposed work is to reconnect the network structure which gets partitioned for larger set of mobile elements. With the aid of reconnected network structure, the TRSP method performs effective data collection process with minimal energy consumption. The traffic network structure with mobile sensor node locates the correct position (i.e.,) exact position of partitioned nodes and performs the re-establishment activity. The partitioning of the sensor network structure is depicted with the aid of Figure 1.

As illustrated in figure1, the partitioned nodes are clearly represented with the help of diagrammatic representation. The intermediate gaps between the partitioned nodes are identified using the phantom partitioning. Phantom partitioning in TRSP method denotes the spectral based damaged and partitioned nodes are identified in the sensor network structure. The traffic network structure identifies the route path connectivity using the double cut. The goal of the double cut in TRSP method is to divide or cut the network structure into two parts (i.e.,) bisects
and then balances the partitioned constrains with minimal energy consumption. The bisected path also creates safer route between the nodes in sensor network structure using TRSP method.

The re-established network structure now performs effective data collection using centroid mean point collection method. This method works with solved network traffic problem in TRSP method. The partitioned nodes are now added into the most appropriate group in the re-connected network structure. The data collection is carried out using the centroid mean computation value. The re-connected network structure for data collection carried out using the centroid mean point collection method is represented in the form of diagram shown in Figure 2.

![Diagram of Re-connected Network Structure](image)

**Fig. 2.** Re-connected Network Structure in TRSP for data collection.

The centroid mean point in TRSP method is evaluated using the Euclidean distance. The centroid based data collection divides the structure into 'n' zones and exact centroid of each zone is taken as a collection point. The centroid mean value performs high rate data collection with minimal energy consumption. The framework of Traffic Reconnect Set-up Partitioning (TRSP) is illustrated in Figure 3.

![Diagram of TRSP Method](image)

**Fig. 3.** Framework of TRSP Method.
phantom partitioning now uses the double cut in TRSP method to balance the constraints. The balanced constraints remove the partitioned node and reconnect the set-up in sensor network. The reconnected network structure uses the centroid mean point collection method to improve the data collection rate.

![Architecture Diagram of TRSP method.](image)

**3.1 Centroid Mean Point Collection method**

![Design of centroid mean point collection.](image)
Finally, the re-established network structure without any traffic performs data collection based on the evaluation of centroid mean point. Figure 4 describes the centroid mean point collection method. In order to evaluate the centroid mean point collection on all ‘n’ zones in sensor network structure using TRSP method, the partitioned nodes are placed inside the appropriate group to perform effective data collection. The Euclidean distance on the rectangular shape distance is computed.

4. Experimental Evaluation

Traffic Reconnect Set-up Partitioning (TRSP) method in wireless sensor network performance is tested on NS2. The movement of all nodes is generated over a size of 900m x 900m sensor field. NS2 simulation takes 100 sensor nodes for experimental purpose. The sensor nodes use the DSR routing protocol to perform the experiment on randomly moving objects. The sensor mobile nodes move at the random speed of 30 m/s with an average pause of 0.01s.

Random Way Point (RWM) model is chosen to shift easily in randomly chosen locations. A randomly selected location with randomly selected velocity offers a predefined speed with the random progression being constant during the simulation period. The selected location with an arbitrarily selected speed contains a predefined amount and speed count. The RWM uses standard number of sensor nodes for data aggregation work. Traffic Reconnect Set-up Partitioning (TRSP) method is compared with the existing Maximum Amount Shortest Path (MASP) and Combine-Skip-Substitute (CSS) scheme on the factors such as energy consumption, data collection efficiency, time taken to reestablish the connectivity, bandwidth rate.

5. Performance Analysis on TRSP method

It is shown that the factors of the model structure can be easily designed and adjusted to provide maximum bandwidth while minimizing the energy consumption and improving the data collection efficiency.

5.1 Scenario 1: Measure of energy consumption

A comparative analysis for energy consumption with respect to movable sensor nodes was performed with the existing MASP and CSS. The increasing energy consumption for increasing number of movable sensor nodes in
the range of 10 to 70 are considered for experimental purpose in wireless sensor network. The simulation results are shown in Fig. 5. As shown in figure, while considering higher number of movable sensor nodes, the energy consumption level also increases, though improvement is achieved using the proposed TSRB method.

5.2 Scenario 2: Measure of data collection efficiency

The second evaluation metric considered for evaluating the effectiveness of TRSP method is data collection efficiency with respect to the number of movable sensor nodes. An elaborate comparison is made with the existing two state-of-the-art works. The data collection using TRSP method is the measure of using centroid mean collection for ‘n’ zones, with each zone representing the collection point.

![Data Collection Efficiency Graph](image)

Fig. 6. Measure of data collection efficiency conducted for a specific simulation run.

Figure 6 illustrates the comparative measure of data collection efficiency using the proposed TRSP and the state-of-the-art works MASP [1] and CSS [2]. It is assumed that N is set to 15 and 90 as minimum and maximum number of sensor nodes respectively. It is arranged in a rectangular area of 900m x 900m sensor field and each simulation has been run for 20 m/s with an average pause of 0.02s of simulation time. An increased variance in the potential specifies larger space with more significant results, to further increase the data collection efficiency which also improves the network performance. From the figure, we find that TRSP deviates from MASP by more than 34 percent while performing data collection. This is because the TRSP method performs the partition over multiple mobile elements using centroid mean point collection method that closely match higher rate of data collection at different time periods.

5.3 Scenario 3: Measure of time taken to re-establish connectivity

In Figure 7, we provide a bisection of vector points for identifying network partitioning for most practical conditions using NS2 simulator. As can be seen from the figure, there appears a slight variation in the selection of vector points for several partitioned nodes. More importantly larger variations in the variability of the vector points also exist within each partitioned nodes that lies outside the range of network. The results thus suggest that further time savings could be achieved by increasing the size of vector points available for communication.

We have thus proved that the time taken to re-establish the connectivity is drastically reduced compared to the state-of-the-art works. This is because the reconnected network set-up with traffic free mobile element structure using double cut provides mechanism for effective connectivity between sensor nodes by improving the time taken to reestablish the connectivity by 47 – 68 % and 75 – 88 % as compared to MASP¹ and CSS² respectively.
6. Conclusion.

In this work, we address the problem of data collection effectively in wireless sensor network structure and propose a Traffic Reconnect Set-up Partitioning (TRSP) method to achieve minimization of energy consumption during re-establishment of connectivity. We show how movable sensor nodes can be used in a ubiquitous fashion to significantly minimize the transmission energy across different movable sensor nodes in the system and improving the data collection efficiency. We also analyze how this reduction in energy consumption during re-establishment of connectivity converts into data collection efficiency and obtain optimality for these contentious objectives. Three novel methods have been introduced called as phantom partitioning for varying range of mobile elements in wireless sensor network structure for identifying the exact positioning of partitioned nodes, that utilize the double cut for effective energy consumption resulting in effective data collection using centroid mean point collection method for movable sensor nodes. Simulated results show that the proposed TRSP method provides higher level of data collection efficiency and also it minimizes the energy consumption when compared to the state-of-art works.

References

5. Wei-Chieh Ke, Bing-Hong Liu, and Ming-Jer Tsai,” Efficient Algorithm for Constructing Minimum Size Wireless Sensor Networks to Fully Cover Critical Square Grids”. IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS, VOL. 10, NO. 4, APRIL 2011