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Universal Data Collection in Wireless Sensor Networks for Mobile Users

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Abstract: *With the rapid proliferation of mobile devices such as PDAs, cell phones to collect and deliver sensor data are considered as a promising application in the ubiquitous computing environment. In such application scenarios, the human factor is becoming increasingly significant. In this paper, we study the universal data collection in wireless sensor networks which provides the mobile users to get the network wide data from anywhere and anytime along their movements. We propose a different and an effective protocol for mobile users to collect the data through the sensor network. The routing structure of data collection tree is updated regularly with the movement of mobile users. Here, we update the existing routing structure through limited modification while the routing performance is bounded and controlled with regard to the optimal value. The proposed protocol is easy to follow up. We conduct wide simulation to show on large scale of our protocol. With the addition of mobile users, our protocol leads to efficient execution in the routing performance and returns the continuous appropriate data during the movement of mobile user.*

Keywords: *Universal Data Collection, Wireless Sensor Networks, Mobile Users and Protocol.*

1. INTRODUCTION

A wireless sensor network is a wireless network, comprising large number of spatially distributed and autonomous sensor nodes to sense the physical targets. Each node is generally equipped with micro controller, memory, radio transceiver, battery and a set of transducers. These sensor nodes after deployed form a short-range wireless communication sensor network. In recent years, wireless sensor networks are being deployed to a great degree and utilized for the monitoring of environment to build a sustainable society. WSNs are exciting with limitless potential for wide range of application domains including surveillance, localization, information enquiry, and transmission [1], [2], [3], etc. With the rapid proliferation of handheld devices, universal data collection is a method for mobile users to instantly collect the data from the wide sensor network through nearby sensors by using their handheld devices like mobile phones, PDAs, etc. This alleviates the deployment of sensor network in a scalable manner meanwhile providing people an eased way of collecting sensor data.

Mobile users can plump for collecting the data from various sensing applications like health care monitoring, industrial monitoring, security, transportation, environmental monitoring, etc. For illustration, Mobile sensing application such as the (PEIR) Personal Environment Impact Report uses the geographical data from cell phones or mobile phones to estimate the environment impact and exposure [4]. Mobile phones can gather different form of sensing data by communicating with sensors in their surroundings. For example, in the GreenOrbs project [5], forest rangers use their handheld devices to collect scientific data, such as concentration of carbon dioxide, temperature, humidity, and so on. These forest rangers also patrol around the Tianmu Mountain to detect any incidents such as fire indication, vegetation damage, etc., occurring in the forest.

2. LITERATURE SURVEY

As a primitive operation, the data collection in wireless sensor network has been studied to a large extent. A typical data collection protocol provides for the construction and maintenance of one or more data collection routing tree.

The CTP (Collection Tree Protocol) is a link and loop detection based data collection protocol. It implements set of schemes for highly dynamic link topology to route the packets from sensor nodes to one or more sink nodes. To accomplish reliability, robustness, efficiency, and hardware independence in CTP, a standard implementation has been offered by [7] and evaluated by [8], [6]. It comprises three main subcomponents: the link estimator, the route engine, and the forward engine. [8] Further showed that the link dynamics and transient loops are the crucial reasons cause only 2–68% of delivery ratio.

ICTP is an energy-aware routing protocol. Challen et al. [9] presented an IDEA (Integrated Distributed Energy Awareness) which is a sensor network service enabling

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effective network-wide data collection framework. Using IDEA, they were able to integrate energy awareness into CTP, the routing protocol ICTP.

Information potential is a routing structure proposed by H. Lin et al. [10]. They aim to achieve global objectives through local greedy decisions at each node in the sensor network which is based only on data available in the node's surrounding. The most existing works did research on how to plan the moving trajectory for the mobile user or sink to attain an efficient collection of data so that it compensate the time cost of data collection transitions. Tan et al. [11] exploits reactive mobility to improve the target detection and performance. Mobile sensors and static sensors get together and move reactively in [11]. We infer that above work just controlled the movement of mobile sinks for collecting the data, unlike from the mobile users with independent, unpredictable, and uncontrollable movement in our work.

Some studies focus on mobile users or sinks without any assumption of fixed trajectory. Kusy et al. [12] presented an algorithm to predict the future position of the mobile sinks from the data traffic. They computed and maintained the mobility graph of the mobile sinks to improve the routing reliability in data collection process. Similarly, Lee et al. [13] introduced a routing strategy that exploits the movement pattern of the mobile sinks. The above works mainly focus on predicting the movement of mobile users to better the routing efficiency.

In this paper, we solve the problem of universal data collection process for mobile users in wireless sensor network by locally modifying the previously constructed data collection tree with the users' movement in the network.

3. CONVENTIONAL DATA COLLECTION

Conventional data collection is usually based on the static settings or says prediction method. An optimal data collection tree (i.e., routing structure) is constructed and fixed in a static sensor network; so that the network wide-data is delivered efficiently to the static sink. However, the data collection tree constructed at one point is not enough for mobile users to access the network- wide universal data along their walks. This led to the requirement of construction and modification of the data collection tree from time to time according to movement of mobile users.

The construction of data collection tree is a time and energy consuming process. Directly acquiring the conventional data collection paradigm leads to a plenty of independent data collection trees at different positions of the mobile users. Here, the communication overhead is large and it contains a non- negligible time delay, and the data delivery is not guaranteed to the mobile user.

4. UNIVERSAL DATA COLLECTION

The proposed universal data collection protocol utilizes the spatial correlation to carefully maintain and update the data collection tree with the movement of mobile users. We make the following assumptions:

- The mobile user is equipped with handheld device that must be compatible to communicate with sensor nodes.
- We assign one of the sensor node as virtual sink within the communication range of mobile users. First the network wide-data is delivered to virtual sink and then sent to the mobile user via a direct communication.
- We used network hop distance as a metric for the routing path quality.

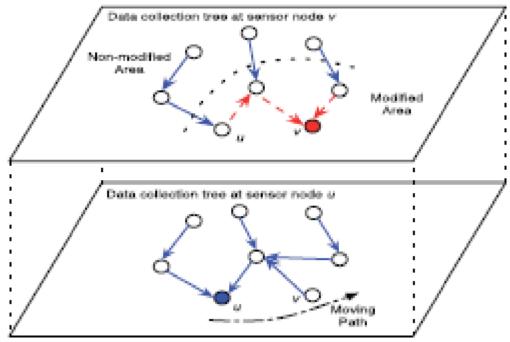

Figure 1: Spatial correlation between T_u and T_v

Figure 1 shows the illustration of Spatial Correlation to introduce our protocol. Suppose for the first time, the mobile user collects the data at sensor node u. A routing structure indicated as T_u will be constructed by using the existing data collection tree protocols like CTP, ICTP, or Information potential. Based on this, the mobile user collects the data as shown by the bottom scenario in the Figure 1.

After accessing data at node u, the mobile user continues to walk in the network. Now mobile user accesses the sensor network for the second time at node v. Meanwhile, a new data collection tree must be constructed at this new data collection position. Thus, T_v can be built as shown by top scenario in Figure 1. Here, independent routing trees needs to be built up at different positions. Through our study, we find that it is unnecessarily needed.

From Figure 1, we can discover that T_u and T_v are not completely independent, i.e., they share a few number of common edges. We say that there exists a spatial correlation between them. Thus, we can construct T_v by locally updating T_u. This results in light-weighted data collection routing tree in terms of both communication costs and time efficiency. The delay between routing tree formation is very short as we need to update only a local area. Finally, the mobile user is able to collect continuous data streams within the wireless sensor network.

5. SIMULATION RESULTS

We use NS-2 simulator to implement our universal data collection protocol for mobile users. In our simulation, there are 41 nodes being deployed among which one is designated as mobile user i.e., universal data collection node. The simulated traffic is Constant Bit Rate (CBR). Table 1. summarizes our simulation parameters.

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Table 1: Simulation Parameters

Parameters	Values
Network Area	1600 × 1600m
Number of Nodes	41
MAC Layer	802.11
Message Packet Size	500 bytes
Node Placement	Random way-point
IFQ Length	5 Packets
Communication Traffic	CBR
Simulation Duration	11 seconds

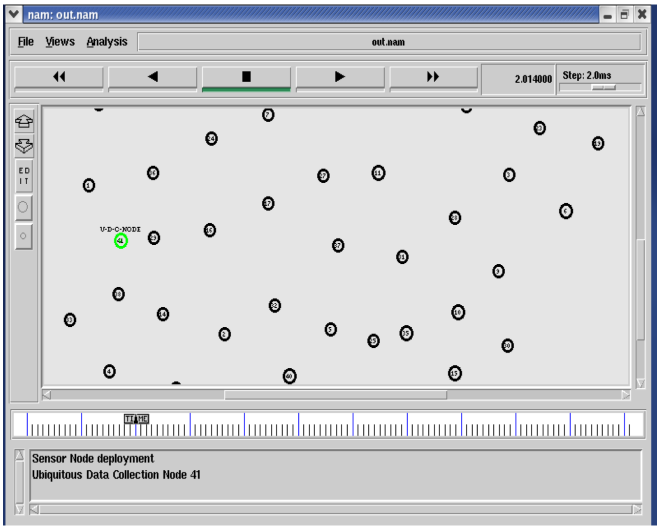

Figure 2: Wireless Sensor Node Deployment

Figure 2 shows that 41 nodes are deployed. Node 41 is designated as Universal Data Collection Node (UDC Node).

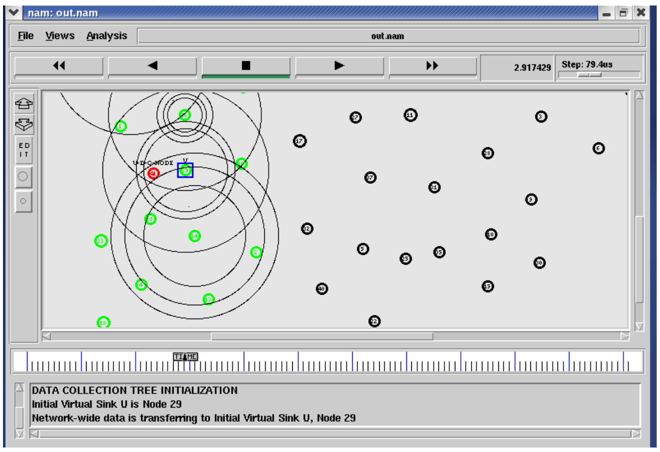

Figure 3: Universal Data Collection

Figure 3 demonstrates the universal data collection which is done by node 41from initial virtual sink node 29 denoted as node U. All the green color sensor nodes transmit the data to the virtual sink node U and later the U-D-C node collects the data from node U.

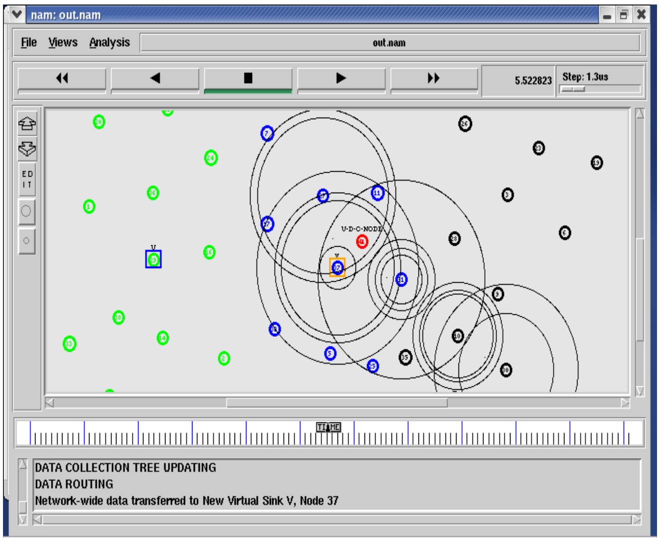

Figure 4: After Movement of UDC Node

Figure 4 indicates that a new virtual sink node 37 denoted as node V is formed after the UDC node has moved to its surrounding.

6. PERFORMANCE ANALYSIS

We set several performance metrics to evaluate the performance of proposed universal data collection protocol. The following three important performance metrics are evaluated and compared to existing system. Namely, Delay, Energy Consumption and Throughput.

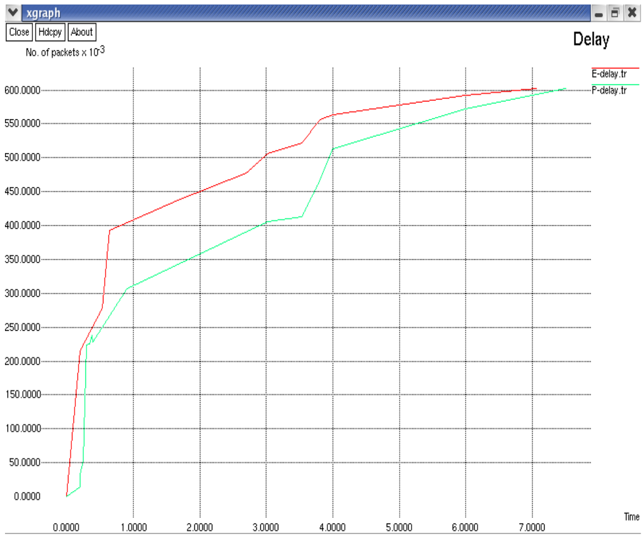

Figure 5: Delay

Figure 5 shows the delay X-graph. From the result, we can see that the proposed protocol has lower delay than the existing protocol.

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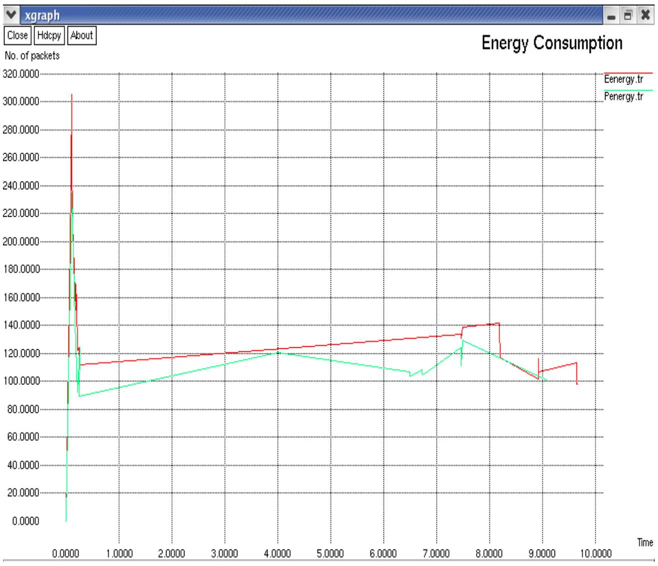

Figure 6: Energy Consumption

Figure 6 represents the comparison of energy consumption. It is clearly shown that the energy consumption in proposed protocol is lower as compared to the existing protocol.

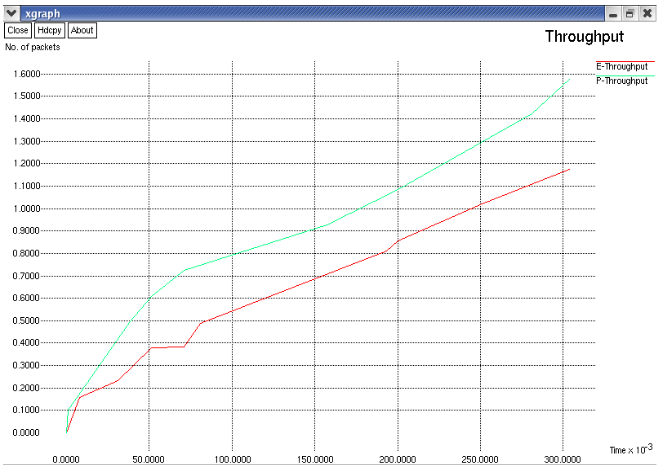

Figure 7: Throughput

Figure 7 depicts the X-graph of throughput. It shows that the proposed protocol has higher throughput than the existing protocol.

7. CONCLUSION AND FUTURE WORK

We proposed a new data collection protocol for mobile users to access the network and collect their data along their movements. The spatial correlation is adopted in our proposed protocol to efficiently construct the data collection trees according to the movement of mobile users. This helps to reduce the unnecessary packet losses and retransmissions due to disconnection with the mobile users.

Whenever the mobile user moves i.e., virtual sink is changed, the previously constructed data collection tree is updated locally and thus provides a new data collection tree instantly for the mobile users to access the continuous data streams from the sensor network. The cost of updating the data collection tree is significantly reduced, guaranteeing low delay. Simulation results demonstrated that our protocol can better the efficiency and scalability of our method.

Thus far, we have considered single mobile user. We add multiple mobile users to collect the data simultaneously from the network as our future work.

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