In-network Query for Wireless Sensor Networks

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Abstract

Recently, in-network aggregate query processing techniques have problems such as high energy consumption in sensor nodes, low accuracy of query processing results, and long query processing time. In order to solve these problems and to enhance the efficiency of aggregate query processing in wireless sensor networks, this paper proposes In-network Query Method(IQM). IQM divides a query region into several cells according to the distribution of sensor nodes and builds a Quad-tree, and then processes aggregate queries in parallel for each cell region according to routing.

Keywords: *Wireless Sensor Networks, In-network Query, Aggregate Query.*

1. Introduction

Recently, the aggregate query process, which is to obtain aggregate results from data collected by sensors, is recognized as an important research area[1,2,3]. Aggregate queries execute functions such as MAX, MIN, SUM, AVG, COUNT, MEDIAN, and HISTOGRAM on the entire wireless sensor network or a specific region of the network.

Representative techniques of aggregate query processing in network include TAG(Tiny AGgregation) and IWQE(Itinerary-based Window Query Execution) that focus on routing algorithm. TAG is an aggregate query processing technique using hierarchical routing[4] and

IWQE is an aggregate query processing technique using itinerary routing[5]. Although TAG and IWQE propose routing algorithm for efficient aggregate query processing, they have problems such as high energy consumption by the sensor nodes, low accuracy of query processing results, and long query processing time.

In order to solve these problems in existing aggregate query processing techniques and to enhance the efficiency of aggregate query processing in wireless sensor networks, this study proposed aggregate query processing technique IQM(In-network Query Method). IQM collects information on sensor nodes within a query region, divides the query region into multiple cells according to the distribution of sensor nodes, builds a quad-tree using the cells, and processes an aggregate query in parallel according to itinerary routing for the cell coverage of the quad-tree nodes. Because IQM processes an aggregate query in parallel, the sensor nodes consume less energy and query processing time is short even if the query region is wide or the number of sensor nodes is large.

2. Related Works

2.1 TAG

TAG is a technique of aggregate query processing in network that uses hierarchical routing for aggregate query processing[4]. That is, TAG establishes hierarchical routing for the entire wireless sensor network in order to process aggregate queries in the network. Figure 1 shows the hierarchical routing structure of TAG.

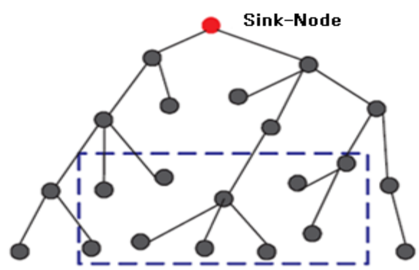

Figure 1. Hierarchical Routing Structure of TAG

As in Figure 1, TAG establishes hierarchical routing by defining parent-child relations among all the sensor nodes. A child sensor node in the query region sends sensed data to its parent sensor node, which sends intermediate aggregate query results to its parent sensor node. At last, the sink node returns the final results of aggregate query processing to the server.

2.2 IWQE

IWQE is a technique of aggregate query processing in network that uses itinerary routing for aggregate query processing [5]. IWQE processes aggregate queries by establishing temporary routing for the region of interest when a user query is given instead of establishing routing for the entire region of wireless sensor network. Figure 2 shows the itinerary routing structure of IWQE.

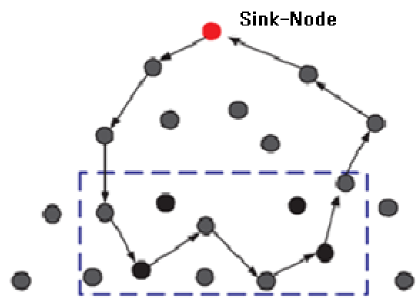

Figure 2. Itinerary Routing Structure of IWQE

As in Figure 2, IWQE processes an aggregate query for data sensed by sensor nodes within the query region using itinerary routing, and the sink node returns the final result of the query to the server.

3. IQM (In-network Query Method)

IQM establishes hierarchical routing and collects sensor node information in order to reduce energy consumption by sensor nodes and query processing time. Then, using collected sensor node information, it divides the query region into a number of cells according to the distribution of sensor nodes, builds a quad-tree with the cells, and processes an aggregate query in parallel on the cell coverage of the quad-tree through the itinerary routing. Figure 3 shows the hierarchical routing structure and an example of MBR structure for collecting sensor node information.

As in Figure 3 the sensor node closest to the center of the query region is searched for, and the node is used as R-node (root node) of hierarchical routing to be established. Starting from R-node, a sensor node with child nodes defines MBR (minimum boundary rectangle) that includes itself and its child sensor nodes, collects information on the sensor nodes within the MBR, and sends the data to its parent sensor node.

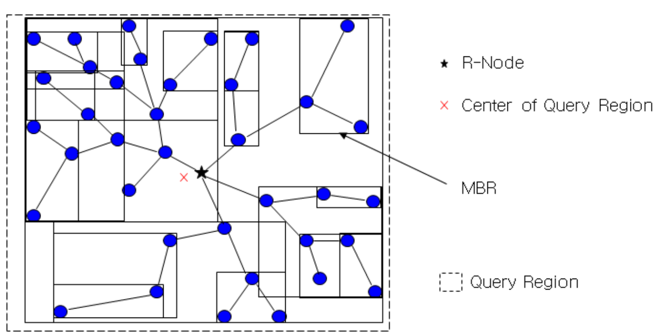

Figure 3. Hierarchical Routing Structure and Example of MBR Structure

Figure 4 shows the recursive process transmitting the result of aggregate query processing to the representative sensor node of the parent node cell.

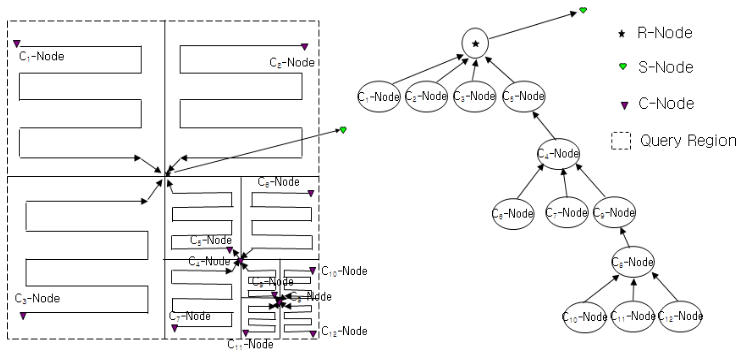

Figure 4. Transfer Process of Query Processing Results

As in Figure 4, the results of aggregate query processing in C10-node, C11-node and C12-node are transmitted to C8-node, and the result of aggregate query processing in C8-node is transmitted to C9-node. In addition, the results of aggregate query processing in C6-node, C7-node, and C9-node are sent to C4-node, and the result of aggregate query processing in C4-node is sent to C5-node. Lastly, the results of aggregate query processing in C1-node, C2-node, C3-node, and C5-node are transmitted to R-node, and the result of aggregate query processing in R-node is returned to S-node, the sensor node that started the query.

IQM uses itinerary routing in order to process aggregate queries in quad-tree cells. Figure 5 shows an example of routing process in quad-tree cells.

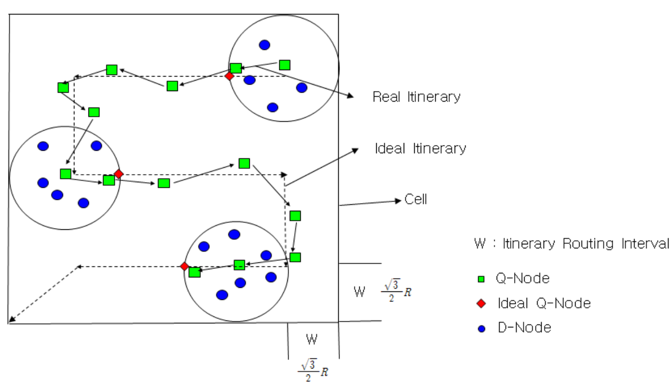

Figure 5. Example of Routing Process in Quad-tree Cells

As in Figure 5, Q-node, which is the query transmission sensor node within each cell, collects data from D-nodes, which are data transmission sensor nodes within the $\frac{\sqrt{3}}{2}R$ communication range, through the ideal itinerary routing, processes an aggregate query, and sends the result to the next Q-node. At that time, the actual routing path of Q-nodes is the real itinerary routing and each itinerary routing interval W is set as using sensor nodes' communication range R.

4. Conclusions

This study proposed IQM, a parallel aggregate query processing technique for more efficient aggregate query processing in wireless sensor networks. In order to reduce the energy consumption of sensor nodes and query processing time, IQM builds a query region into a quad-tree and processes an aggregate query in parallel through the itinerary routing over the cell coverage of quad-tree nodes.

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