OMSI-Tree: Power-Awareness Query Processing over Sensor Networks by Removing Overlapping Regions*

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Abstract. Sensor networks have played an important role in our daily life. The most common applications are light and humidity monitoring, environment and habitat monitoring. Window queries over the sensor networks become popular. However, due to the limited power supply, ordinary query methods can not be applied on sensor networks. Queries over sensor networks should be power-aware to guarantee the maximum power savings. In this paper, we concentrate on minimal power consumption by avoiding the expensive communication. A lot of work have been done to reduce the participated nodes, but none of them have considered the overlapping minimum bounded rectangle (MBR) of sensors which make them impossible to reach the optimization solution. The OMSI-tree and OMR algorithm proposed by us can efficiently solve this problem by executing a given query only on the sensors involved. Experiments show that there is an obvious improvement compared with TinyDB and other spatial index, adopting the proposed schema and algorithm.

1 Introduction

Sensor Networks was awarded as one of the 21 most important technologies for the 21st century by Business Week [1]. A sensor network is a computer network that consists of many small, inexpensive and spatially distributed devices using sensors to monitor and detect status in different locations.

While the sensor node processing and monitor capabilities are improving, crucial problems in the application of the sensor networks still remain, power consumption and communication become one of the most urgent problems. All the sensor nodes are equipped with limited power supply. It is almost impossible to recharge or replace these batteries. Once a sensor node is power off, it should be abandoned. In addition, the expense of communication is emphasized to be relatively high. The energy

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consumption of executing 3 million instructions, using a 100(MIPS)/W processor, is approximately the same as that of transmitting 1Kb data over 100m [2] [3].

Due to the energy scarcity, the centralized index for spatial query is no longer feasible. Many researches have been done to extend the life span of sensor networks by reducing the energy cost during querying [4]. The most common solutions are increasing data processing on single sensor node and limiting the involved sensor nodes.

Madden and Franklin introduced Fjord architecture [6] for multiple queries management over sensors. This architecture focused on maintaining high query throughput with limited sensor resource demands and showed that in sensor environments, communication costs, and power consumption are important issues. Cougar approach [7] discussed the in-network query processing over sensor networks. A central administration that is aware of the location of all the sensor nodes. TiNA schema [11] extends the life of the sensor network by up to 300% by using temporal coherency tolerances to reduce the communication of individual nodes. Soheili et.al, in [8] proposed a distributed spatial index over the sensor networks for processing spatial queries. The research group of TinyDB [4] at UC Berkeley has made a lot of contribution on sensor mote and Tiny OS design. They propose ACQP and prove it is energy-efficiently. A distributed index called Semantic Routing Trees (SRT) is designed to efficiently manage relevant sensor nodes participate in a given query over some constant attribute. FDSI-tree [12] introduced by Eo et.al provided a power-aware range queries based on MBRs which is much the same as our proposed schema. Queries are efficiently limited in relevant sensor nodes to guarantee the maximum power savings. However, the author did not consider the possibility of overlapping MBRs.

In this paper, we propose the design of Overlapping MBR Spatial Index Tree (OMSI-Tree) which efficiently restrains the spatial query to the essential sensors. If the monitoring area MBR of sensor nodes overlaps with each other, their parent node will decide whether both of the sensor nodes are essential to this query. Thus, the query message will only be disseminated to the involved sensor nodes. Although the extra computation of MBR overlapping increases the parameter storage and data processing, the whole performance of the sensor networks improved and energy consumption decreased as we have emphasized before, the communication is much more expensive than processing. The notions of node selection and MBR overlapping are derived from the traditional R-Tree [5] structure. With the strong capability of handling spatial attributes efficiently, R-tree like structure becomes the base for almost all the MBR and spatial index algorithms.

The remainder of this paper is organized as follows: in section 2, we propose a schema called OMSI-tree and OMR algorithm to ensure the minimum energy consumption while querying over sensor networks. In section 3, we make a comparison for our schema and algorithm with previous schemas. The conclusion and future work are given in section 4.

2 OMSI-Tree

In this section, we propose the Overlapping MBR Spatial Index Tree (OMSI-Tree) used for queries in distributed fashion. In addition, Overlapping MBR Remove (OMR) algorithm is introduced.