frequency and orientation of local ridge in this dissertation. A fast implementation of Gabor filter is also employed for the symmetry of Gabor filter. The experimental results show that the proposed method is effective and the computation cost is reduced. The images enhanced by the proposed method have clear distinction between ridges and valleys in all area of the image and are ready to be processed by feature extraction module.

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An Improved Multi-query Optimization Algorithm in Wireless Sensor Networks

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Abstract

Wireless sensor networks (WSNs) is a data-centric network, the traditional query algorithm becomes difficult in dealing with the query efficiency and energy consumption. How to reduce the energy consumption of sensor

nodes in wireless sensor networks is a big challenge for the researchers. In this paper we propose an improved multi-query optimization algorithm. The base station analyses and rewrites the queries submitted by users for the previous period, so that queries data can be shared between multiple queries, thus reducing the number of queries distributed to the network, thereby reducing the amount of data transmission. The simulation results show that the improved multi query optimization can reduce the number of queries in the network, and consequently reduce energy consumption of the network.
Keywords: WIRELESS SENSOR NETWORK, QUERY REWRITING, MULTI-QUERY OPTIMIZATION

1. Introduction

Wireless sensor networks is a self-organizing network system composed of a large number of sensor nodes. This kind of network system is constructed without prior infrastructure, and it has the advantages of wide coverage, rapid deployment, invulnerability. So it is widely used in military battlefield, environment monitoring, transportation, medical diagnostics and other fields[1,2].

Wireless sensor network may contain thousands of perception node which are scattered randomly in the sensing environment region. The sensor nodes are battery-powered, but the power is very limited, and the application of sensor nodes need a long life cycle. Therefore, energy efficiency is the most basic requirement of wireless sensor networks.

In wireless sensor networks, data transmission among the sensor nodes consumes more energy than data calculation. Reducing network data transmission can effectively cut down the energy consumption of sensor networks. Therefore, the design of query optimization algorithm should minimize the transmission of data from the source node to the base station, thereby reducing node energy consumption. Existing query optimization studies focus on single query optimization [3-5], but in practical application, the user may submit multiple query request to the network, and these queries need to be processed at the same time, which will certainly increase the data acquisition rate and data transmission in wireless sensor networks. The amount of transmitted data within the network continues to increase, while the bandwidth of the network is limited, if the multi query processing doesn't be optimized, it is bound to increase the transport burden and cause concurrency conflicts among nodes, resulting in delays, loss of information, reduction of network data transmission quality and longevity. Therefore, it is highly needed to find a more efficient way to optimize the query.

The remainder of this work is structured as follows. Section 2 reviews some related works. We introduce the improved multi query optimization in Section 3. Experimental results are reported in Section 4 with rigorous analysis. Finally, the concluding remarks are provided in the last Section .

2. Related works

Wireless sensor network is a data-centric network, with a data processing system of extraction, storage and management of sensor network data. The core of the system is to optimize and process sensor network queries. In this section, we give a brief review on recent works related to our method.

The current researches mainly focus on single query optimization. For multi queries, we need to use the network processing technology and sharing mechanism to optimize queries.

Some references [6-9], focus on the issues of sensor network data processing and energy conserving. These methods reduce the amount of data transmission nodes, but with the expansion of network size, the system delay and calculation amount also increase.

Some researchers put forward a multi-equivalence based query optimization algorithm and adaptive routing mechanisms[10], but the algorithm has an unsatisfactory scalability; data fusion is insufficient for the nodes are only routed within the equivalence class based on the degree of integration. Li Ximing proposed an Association Degree based Multiple Queries Optimization algorithm(ADMQO) in WSNs[11]. In ADMQO, node chooses parent node by association degrees with its candidate parent nodes. As a result, nodes covered by the same set of queries are clustered to a group, so their values can be shared among multiple queries, and aggregate queries values can be efficiently merged in networks.

These techniques can reduce the amount of transmission load in WSNs, thus extending the lifetime of wireless sensor networks and achieving energy efficiency. In addition, some works try to maximize the performance of the multi-query optimization algorithm. Nevertheless, the multi-query optimization algorithm still remain unclear thus requiring further explorations.

In this paper we improved the multi-query optimization algorithm and proposed a new algorithm based on query and rewrite. The base station analyses and rewrites the queries submitted by users for the previous period, so that queries data can be shared between multiple queries, thus reducing the number of queries distributed to the network, thereby reducing the amount of data transmission. Details are narrated in the following section.

3. Our methods

In this paper, we use the data model of TinyDB system [12] and SQL query language for more systematic analysis of inquiries, and then propose solutions.

3.1. Problem formulation

In TinyDB system, all sensor data is seen as a single, virtual table, wherein each sensor attribute occupy one column. The system inserts the data tuples into the table within a specified time interval. The time interval between samples is also the sampling period. In Table 1, the first column is the sensor node ID, the following three columns are sensor nodes attributes.

Table 1. sensors table

node id	temperature	light	humidity
1	25	220	120
2	37	234	217

Since the sensors table includes only the node ID and sensor nodes readings, and the data is automatically updated in the table when new data is generated. Therefore, we defined the format of sensors table as the following (as shown in Fig 1):

$$sensors\_schema = (nodeid, A_1, A_2, \ldots, A_S) \quad (1)$$

Wherein, node id is a node's ID, and it's the keyword in sensors table. $A_1, A_2, \ldots, A_S$ are attributes of the sensor nodes, such as temperature, humidity, brightness and so on. $Q = \{q_1, q_2, \ldots, q_n\}$ is used to denote the network query. In this article, we only take into account the selection and projection query, because both operations are most frequently used in sensor networks. We use the following formula to represent a selection - projection query q (as shown in Fig 2):

$$q = \prod_l (\sigma_c(sensors)) \quad (2)$$

If a query $q_1, q_2, \ldots q_n$ is already existed, then another query q_{new} is submitted to the base station, we aims to use the existing query to rewrite q_{new}. If it can be rewritten, the data base can be used to answer a query without distributing a new query to the network, which reduces the number of network queries, and thereby reduce the network energy consumption and extend the network lifetime.

QueryRewriting Algorithm( )

{

initialize $Q_{a_i} = \varnothing$;

if $C(q) \wedge C(q_{new}) = true$ then

$q \to Q_{a_i}$;

else if $SP(q)$ have the common divisor with $SP(q_{new})$ then

$q \to Q'_{a_i}$;

end if

while $a_i \in P(p_{new}) \cup S(p_{new})$ do

$Q'_{a_i} = \{q \mid (q \in Q_{a_i}) \wedge a_i \in P(q)\}$;

while $Q'_{a_i} (1 \le i \le n), Q''_{a_i} (1 \le i \le n)$ do

$C(q_{new}, a_i) \to \vee_{q \in Q'_{a_i}} C(q)$;

while $a_i \in P(q_{new})$ do

$d_{a_i} = \bigcup_{q \in Q'_{a_i} \text{ or } q \in Q''_{a_i}} \prod_{nodeid, a_i} (\sigma_{C(q_{new}, a_i)}(q))$

while $a_i \in S(q_{new}) - P(q_{new})$ do

$d_{a_i} = \bigcup_{q \in Q'_{a_i} \text{ or } q \in Q''_{a_i}} \prod_{nodeid} (\sigma_{C(q_{new}, a_i)}(q))$

return $q'_{new} = d_{a_1} \bowtie d_{a_2} \bowtie \ldots \bowtie d_{a_n}$;

}

Figure 1. an improved multi query optimization algorithm

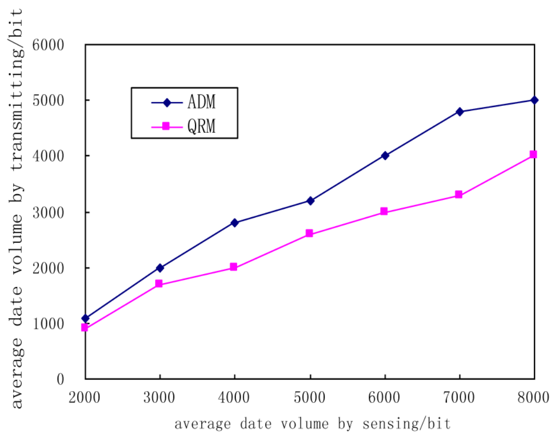

Figure 2

3.2. Multiple query optimization algorithm based on query rewrite

From the analysis above, we know that there is a query overlap among multiple queries. If the multiple queries are distributed to the network without any treatment, query redundancy will emerge, thereby increasing the energy consumption of the network. In order to achieve shared multiple query data, we propose a multiple query optimization algorithm based on query rewrite. The main idea of the multiple query optimization is the query rewrite. Query rewrite can realize shared query results between multiple queries, thus reduce the number of queries distributed to the network, and cut down network consumption.

When a new query q_{new} is submitted to the base station, and $P(q_{new}) \cup S(q_{new}) = \{a_1, a_2, ..., a_n\}$, then we can decompose the query namely (as shown in Fig 3):

$$q_{new} = d_{a_1} \rhd\lhd d_{a_2} \rhd\lhd ... \rhd\lhd d_{a_n} \quad (3)$$

Wherein the symbol >< is a natural connector of the database, that is q_{new} can be obtained from the natural connection of $d_{a_1}, d_{a_2}, ..., d_{a_n}$. Next, we use $Q = \{q_1, q_2, ..., q_n\}$ query to rewrite each d_{a_i} $(1 \le i \le n)$.

In practical applications, we construct a set of candidate query $Q' \subseteq Q$ to rewrite $d_{a_1}, d_{a_2}, ..., d_{a_n}$. Candidate query set Q' is the set of queries Q that can be made selected to answer queries on the query.

First, we create an empty set Q_{a_i}, then the query set Q select criteria for the query same query to move query set Q_{a_i}, the focus moves to a query q if the query Q_{a_i} will be set from the query Q.

By comparing the inquiry cycle, we get inquiries cycle query multiple candidate sets relationship $Q'_{a_1}, Q'_{a2}, ..., Q'_{a_n}$, but to get the query q_{new} period multiplied twice Enquiry candidate sets relationship queries $Q''_{a_1}, Q''_{a2}, ..., Q''_{an}$. Among them, and are defined as follows (as shown in Fig 4):

$Q'_{a_i} = \{q | (q \in Q') \wedge (a_i \in P(q))\}$ (4) Therefore, we can get the improved algorithm as shown in Figure 1.

The improved multi-query optimization algorithm refers to the analysis and rewrite of queries at the base station for the previous period submitted by users, so that queries data can be shared between multiple queries, thus reducing the number of queries distributed to the network. However, if another query is submitted to the base station during query operation, then the algorithm can be used to analyze the rewriting feasibility. If the query can be rewritten by the query in operation, it will not be distributed to the network. If it can not be rewritten, then it will be distributed to the network for data query. This multi-query optimization not only takes advantage of the query rewriting algorithm, but also responds to the data timely.

4. Experiments

In this section we use OMNET ++ simulation platform to perform simulation experiments with multi-query optimization algorithm based on query rewriting. The average amount of data transmission node in this algorithm and other algorithms are compared.

In order to calculate the amount of data transmission nodes in the network, we assume that each packet size is 34bit (with the same size of TOS_MSG in Tiny OS systems). Wherein the size of header information is 5bits, each monitoring data size is 29bits. In the experiment, we ignore the packet loss which may occur during data transfer. Routing tree structure is adopted as the network model, and the data is transmitted to the base station via multi-hop. Sensor nodes uniformly distributed in the monitoring area. Simulation parameter settings are as shown in Table 2. We compare the multiple queries optimization algorithm based on association degrees (ADM) [11] and query rewrite multiple query optimization algorithm (QRM) .

Table 2. Simulation Parameters

Parameters	Value
Simulation area size (m^2)	200×200
Number of nodes	200
Base station location	(0,0)
Radius of communication(m)	20
Initial energy (J)	2

The experiment shows the result of average amount of data collected and the data base transmission with two different algorithms (Figure 2). With the usage of query rewrite, QRM algorithm **Figure 2**. node's data transmission

achieves more data sharing between the multiple queries, thus fewer queries are distributed to network, and thereby further reducing the average amount of data transmission nodes.

Conclusions

This paper presents a multi-query optimization base on query rewrite. By analyzing and rewriting multiple queries at the base station, a shared query data is achieved, thereby reducing the number of query distributed to the sensor network and further cutting down the amount of data transmission. Simulation results show that the algorithm can sufficiently reduce the amount of data transmission in network. In future studies, we will consider the relationship between multiple queries and query periods, thus propose a better query rewrite algorithms, which will be able to further reduce the number of queries distributed to the network, and decrease the amount of data transmission in network, thereby extending the network lifetime.

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