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Design of Compressed Data Transmission for Mobile IoT Devices

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Abstract

With the recent development of small computing devices, IoT sensor network can be widely deployed and is now readily available with sensing, calculation and communication functions at low cost. For applications such as sensor monitoring systems that access large volumes of data in a read-intensive manner, the column-based compressed database has become a proper model because of its superior read performance.

In this paper, we introduce a compressed sensor database and IoT service technologies. We also propose a new sensor-aware dynamic transmission scheme and its data management structure for a IoT sensor-based database system. The proposed dynamic transmission management skills minimizes battery waste and communication failures of unstable sensor nodes.

Keywords: *Sensor network, Sensor database, Data management, Column compression*[1]

1. Introduction

The widespread deployment of sensors is transforming the physical world into a computing platform. Sensor data is the output of a device that detects and responds to some type of input from the physical environment.

Sensor database is in integral component of the increasing reality of the Internet of Things (IoT) environment. Much of the data transmitted is sensor data. Recently, various sensor database systems, including TinyDB and Cougar, have been developed for the ubiquitous environment [1].

Applications monitor the physical world by querying sensor data. Typically, these applications involve a combination of stored data (a list of sensors and their related attributes, such as their location) and sensor data. We call sensor database the combination of stored data and sensor data [2][3].

2. Background

2.1 WSN

The sensor node has a small battery with limited power, and it has insufficient computational processing power. Therefore, if the storage of the sensor node is exhausted, or if the battery is not replaced after it is exhausted, the sensor node is disabled. Moreover, if sufficient number

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of sensor nodes do not operate normally, the sensor network will not perform requested query operations.

In particular, mobile sensor nodes such as drones may be disconnected frequently. In other words, mobile sensor nodes may be disconnected from the connected wireless network due to battery failure or cell-to-cell movements. In addition, some users intentionally turn the mobile device on and off to save battery power.

Due to the nature of these mobile sensor nodes, network partitioning occurs more frequently in IoT data environments than in conventional data environments. Network partitioning causes serious data availability problems that hold the required data to be separated. This paper discusses both these mobile and fixed sensor nodes, and assumes that the sensor nodes have limited communication channels and small batteries.

2.2 Sensor Databases

Sensor data consists of measured data such as temperature, humidity and light, as well as data stored in the sensor node itself. These sensor data are often used for data analysis after being collected, and the most workload of the sensor network is caused by read-only search queries.

The sensor data network is a shared-nothing platform since the sensor nodes are independent. Within these distributed platforms, sensor nodes can be easily added and search queries can be performed in parallel by the sensor nodes [4].

Recent column-based storage model [4][5][6] is more advantageous than general storage models for storing sensor data. A column-based data storage store data in the order of columns and not in the order of rows(records) as in general data storages. Especially, it is more I/O efficient for read-only queries, such as sensor queries, because it only accesses the columns (or attributes) required for the queries. To store data of computing devices, a wide variety of memory can be used. Sensor nodes use flash memory owing to the low price, compactness, portability, and stability[3].

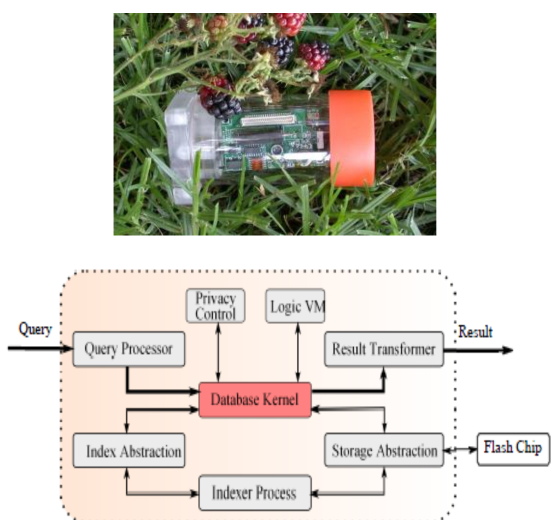

Figure1. Architecture of Sensor Database for Tiny Sensor Node

2.3 Reducing Energy in Sensor Network

Some researches have been started to reduce power in the general computing environment before the sensor network developed. Techniques such as hardware power control and database query re-balancing have been proposed to save energy on data center servers. In a typical computing environment, the CPU uses up to 60% of the whole energy at peak times, so it is important to efficiently schedule data queries to reduce power.

However, the battery energy available in the sensor network is very limited. In particular, the amount of battery consumption required for wireless communication increases significantly as transmission begins and continues to consume the battery powerFigure 2. Therefore, the key issue to be solved is how to reduce transmission energy. For example, sensor query control study uses a node-cut strategy that dynamically generates filtering records with less computational overhead when collecting query results. This technique can reduce data comparison and calculation overhead by dynamically modifying the delivery path of sensor queries [7].

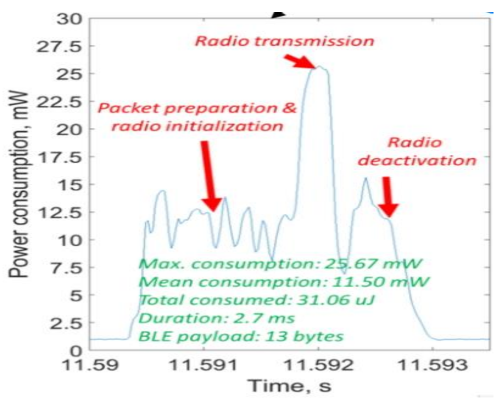

Figure 2. Power Consumed in Packet Transmission

In addition, various studies have been conducted to increase battery life by reducing energy-consuming process in the course of data transmission in the lower layer. For example, it can reduce the number of bits to be transferred from the sensor node, or it can periodically put the sensor node into sleep mode to increase the life of the battery. It also uses energy-sensitive routing on sensor network paths to reduce energy consumption. The routing protocol uses energy saver and energy balancer to minimize the total energy consumed.

In summary, general transmission techniques are suitable for stable network environments, but not for unstable sensor network environments. Therefore, special consideration for energy-efficient data communication is needed for the sensor network environment.

3. Transmission Control for IoT Sensor Networks

In the IoT environment, small sensor nodes have limitations such as frequently disconnected wireless channels, insufficient battery energy, and small storage capacity. In particular, the energy consumption for wireless communications is much greater than the energy consumption for sensing and computing, and the wireless network is slow to transmit at the rate of hundreds of kbps. In addition, the time required to measure or access data varies for each sensor mounted on the sensor node. Therefore, these sensor specific differences are considered in the sensor query design [8].

In this study, we propose stable and efficient data transmission schemes for unstable IoT sensor nodes in wireless network environments. In other words, to achieve the data transmission efficiency and stability objectives, Sensor-aware Dynamic Transmission (SaDT) control scheme is proposed. In detail, sensor-aware classification and variable compression techniques are proposed. In case of periodic transmission, the stability and performance of the sensor database are improved by reusing last sensor data.

In order to support the stable service of the sensor database, the possibility of the sensor node failures should be considered in advance. Moreover, accumulated data generated continuously from the sensors usually has the characteristic of statistical measurements such as overall average. Therefore, if a sensor node is disabled due to battery or communication failure, the result of collective functions may be inaccurate. To cope with this problem, it is necessary to reduce battery consumption and to manage wireless communications efficiently in advance.

SaDT scheme measures the service stability of each sensor node before sending data to a remote server. Based on this measurement, the proper transmission mode is determined and then the sensor data is dynamically compressed to reduce communication costs and battery power consumption.

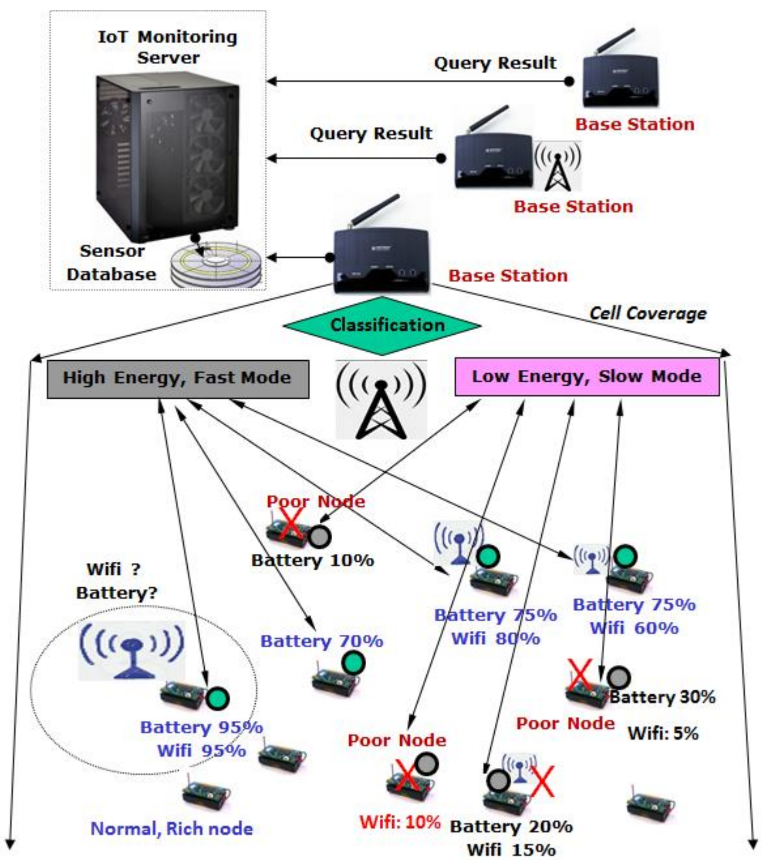

Figure 3. State Classification of Sensor Nodes

First, the state of a sensor node is classified into two categories, depending on the stability of data transmission, in order to determine appropriate transfer mode. That is, if the battery power and the wireless signal strength are good enough, the sensor node is determined to be a normal-state. Otherwise, the sensor node is determined to be a poor-state Figure 3. Each sensor node maintains its time stamp for status logging when checking the remaining battery power and the radio signal strength.

4. Conclusion

This study analyzed recent technological trends of wireless sensor networks and sensor databases. It also discussed efficient energy saving technology and low-power transmission technology to cope with sensor nodes and communication failures.

In order to improve the stability and energy efficiency of data transmission for unstable sensor node in the unstable wireless networks, a new sensor-aware dynamic transmission scheme was proposed. In detail, the classification method for transmission mode was devised and selective dynamic transmission was applied to the unstable nodes.

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