

## Efficient Data Management in RFID Applications

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### ABSTRACT

Logistics is in the limelight as one of a variety of RFID applications. The RFID technology is actively being applied to improve the competitiveness power of companies through the synthetic management of products and information. The RFID system generates large volume of stream data. It has problems which occur waste of storage and long processing time when storing large data and processing queries. Recently, many studies have been done to solve the problems which are generated in RFID system. In this thesis, we propose an efficient data management scheme for path queries and containment queries which are occurred frequently. The proposed data management scheme considers a change of the containment of products during a transport and supports a path of changed products by representing a path of various containments. Also, the compression utilizing the structure of supply chain reduces the stored data volumes. In order to show the superiority of our approach, we compare it with the existing schemes. As a result, our experimental results show that our scheme outperforms the existing scheme in terms of storage efficiency and query processing time.

**Keywords:** SCM(supply chain management), RFID, stream data.

### 1. INTRODUCTION

RFID(Radio Frequency Identification) is a technology which automatically senses information of tag attached to products. It have been attracted in many applications because of features which is able to read a number of tags at a time, recognize moving products fast and store data at the tag. Logistic is the most attractive field among the many RFID applications. RFID technology is being positively applied to improve competitiveness of company by promptly controlling supply chain against the market's change. Commercial traffic, demand of logistic service and importance of off-line logistic have been constantly increased. So, necessity of RFID technology is being improved.

The RFID system generates large volume of data which can be seen as a stream[5]. The data generated by RFID

applications is stored at a database through the antenna. Venture Development Corporation, a research firm, predicts that when tags are used at the item level, Walmart will generate around 7 terabytes of data every day.

The RFID system generates large volume of stream data. It has problems which occur waste of storage and long processing time when storing large data and processing queries. Recently, many studies have been done to solve the problems which are generated in RFID system. Wang has proposed a database structure considering various entities and relations of entities. To use a variety of relation tables can reduce response time for a query but there was an amount of storage by data duplication. Gonzalez has proposed a new database structure[2]. It is efficient to utilize a storage and process a path query by reducing the large amount of redundancy in the raw data, grouping the products and applying a path compression scheme. However, the proposed data management scheme has a reconstruction problem and doesn't consider a containment query. Lin has proposed database structures which are

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considered for containment and path queries. It is able to process path and containment queries by using various containment tables[3]. However, it doesn't consider a path for dynamic containment relation change during a transport.

In this paper, we propose an efficient data management scheme for path queries and containment queries which are occurred frequently in supply chain management. The proposed data management scheme considers a change of the containment of products during a transport and supports a path of changed products by representing a path of various containments. Also, we can reduce a data size by compressing path information of each product.

2. RELATED WORK

Wang has proposed a DRER(Dynamic Relationship ER Model) considering RFID data features[1]. RFID system has common basic features. In RFID system, relations of static entities which are reader, tag and location can be changed dynamically with time attributes. DRER consists of state tables for static entities and dynamic tables for dynamic relations. Dynamic relation tables are classified into static-based dynamic relation and event-based dynamic relation according to duration of relation. Fig. 1 shows a DRER.

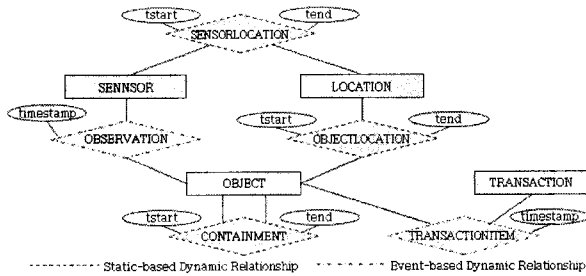


Fig. 1. DRER

Gonzalez has proposed a database structure considering a compression for data which are generated from an RFID application[2]. RFID-Cuboid, proposed a database structure, is efficient to utilize a storage and process a path query by reducing the large amount of redundancy in the raw data, grouping the products and applying a path compression scheme. Fig. 2 shows a database structure of RFID-Cuboid.

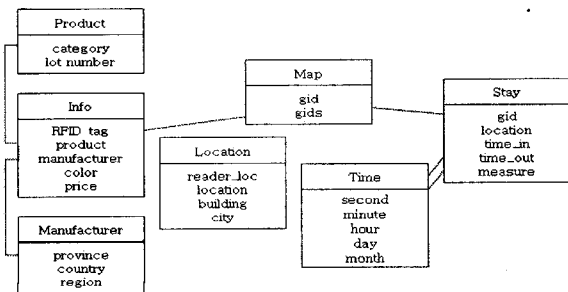


Fig. 2. RFID-Cuboid

Lin has proposed Multi-table approach considering a containment and path[3]. Fig. 3 shows a Multi-table approach.

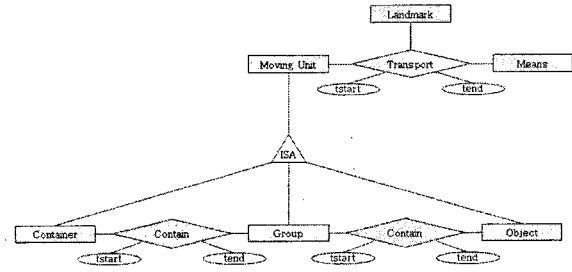


Fig. 3. Multi-table approach

3. PROPOSED DATA MANAGEMENT SCHEME

In this paper, we propose an efficient data management scheme for containment query and path query. The proposed data architecture is classified into the two parts. One of them is a part of containment the other is a part of path. Fig. 4 shows the proposed database structure.

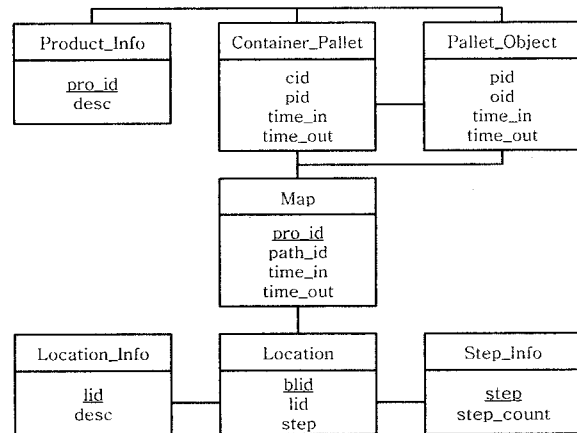


Fig. 4. The proposed database structure

3.1 Containment Structure

Containment tables are the structure which considers a hierarchical containment of products. Product is contained in pallet and pallet is contained in container. Fig. 5 shows containment tables. Pallet\_Object table indicates a relation between product and pallet. Container\_Pallet table indicates a relation between pallet and container. Product\_Info table indicates information about the product, pallet and container.

table	Description
Pallet_Object	store the relations between product and pallet
Container_Pallet	store the relations between pallet and container
Product_Info	store the information of product, pallet and container

Fig. 5. Containment tables

**3.2 Path Structure**

We propose an efficient data management scheme for processing a path query about the products which confirms a various hierarchical containment. In the proposed data management scheme, bit ID is allocated to each location based on a supply chain's structure. And then, allocated bit IDs are combined to make the path information. To make the path information, we utilized a supply chain's structure only. Thus, the proposed data management scheme can express a path of products dynamically. Fig. 6 shows path tables

table	description
Location	store information about the location
Location_Info	store specific information about location
Map	store information about the path
Step	store information about the supply chain

Fig. 6. Path tables

In the proposed data management scheme, the path information is generated as follows. First of all, we allocate bit IDs to each location of supply chain to generate the path information. Allocated bit ID is generated using architecture of supply chain. Bit IDs are decided according to the number of location which organizes a supply chain. And the third step and the fourth step consist with four and ten locations and each location use two and three bits. The path of product transported along the supply chain is expressed by combining bit IDs of location. Fig. 7 shows bit ID allocated to each location and generated path information

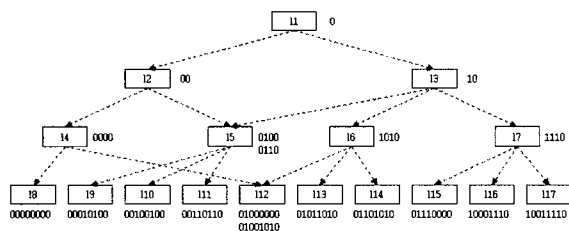


Fig. 7. Generation of path information

**3.3 Query processing**

In RFID system, it is frequently generated that products with an attached tag are carried by group and regrouped during the transportation. So, Importance of containment query and path query processing is increased. Queries for RFID data are classified variously. Ban classified into four query type.

[a<sup>+</sup>, a<sup>-</sup>] indicate the range of value projected on axis.

**Type 1:** FIND query: Q = (tid, [t<sup>+</sup>, t<sup>-</sup>]), returns the location(s) of tag tid at [t<sup>+</sup>, t<sup>-</sup>].

**Type 2:** LOOK query: Q = ([x<sup>+</sup>, x<sup>-</sup>], [y<sup>+</sup>, y<sup>-</sup>], [t<sup>+</sup>, t<sup>-</sup>]), returns the set of tags in specific location [x<sup>+</sup>, x<sup>-</sup>], [y<sup>+</sup>, y<sup>-</sup>] at [t<sup>+</sup>, t<sup>-</sup>].

**Type 3:** HISTORY query: Q = (tid), returns all location(s) of tag tid.

**Type 4:** WITH query: Q = (tid, [t<sup>+</sup>, t<sup>-</sup>]), returns identifiers of tags located in the same place with tag tid at [t<sup>+</sup>, t<sup>-</sup>].

The HISTORY query is a query whose time range is a whole time axis. And a WITH query is on a par with a LOOK query after processing a FIND query.

Lin has classified to containment query and path query according to information queried. The containment query searches for a specific object in the upper categories or the low categories of the containment. This is similar to WITH query but hierarchical containment is a difference. The path query retrieves path information of product or group and also has time and location conditions. FIND, LOOK, HISTORY queries can be classified into the path query.

In this paper, queries are classified into containment query and path query as defined by Lin. Containment query and path query frequently generated at supply chain. Therefore, we propose a data management scheme and a query processing scheme to process a containment query and a path query efficiently.

**[Example of path query]**

\* What is the location history of a container c2?

Select M.path\_id From Map M Where M.pro\_id = 'c2'

\* What products were transported from l1 to l3 via l6 and l12?

Select M.pro\_id From Map M Where M.path\_id = "created path\_id"

**[Example of containment query]**

\* What products are in container c1 from t1 to t2?

Select PO.oid From ContainerPallet CP, PalletObject PO Where CP.cid = 'c1' and CP.pid = PO.pid and CP.time\_in >= 't1' and CP.time\_out <= 't2'

\* What products are transported with product o1 from t1 to t2?

Select PO.oid From PalletObject PO Where PO.pid = (Select PO.pid From PalletObject PO Where PO.oid = 'o1' and PO.time\_in >= 't1' and PO.time\_out <= 't2')

**4. PERFORMANCE EVALUATION**

In this section, we perform a simulation to improve the superiority of the proposed data management scheme. All experiments were implemented using J2SE 1.5 and Mysql 5.0. We used a Pentium 4(R) processor system with 2GB of RAM. The system ran Microsoft Windows XP Professional. Experiments were performed about data size and query processing time. We analyzed data size according to the number of products and paths. Also, we analyzed query processing time according to the number of product about containment query and path query.

**4.1 data size**

To evaluate data size according to the number of products, we vary the number of products. We evaluate the size of data

about various number of products(10,000, 20,000, 50,000, 100,000) in P4(1, 10, 40, 500). Fig. 8 shows data size according to the number of products. In this case we vary the degree of bulkiness of the path, e.g., the number of tags that stay and move together through the system. We define 4 levels of bulkiness P1 = (1, 2, 4, 10), P2 = (1, 2, 10, 50), P3 = (1, 4, 20, 200), P4 = (1, 10, 40, 500) and indicate the number of the location which constructs the supply chain. The number of product is constantly set at 100,000. Fig. 9 shows the data size compared with other data management scheme.

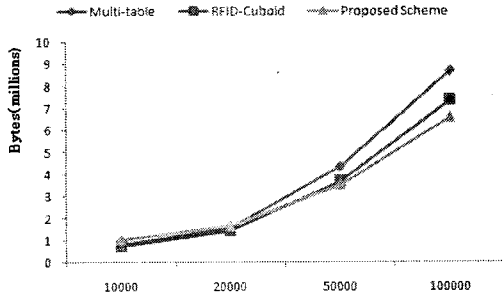


Fig. 8. Data size according to the number of products

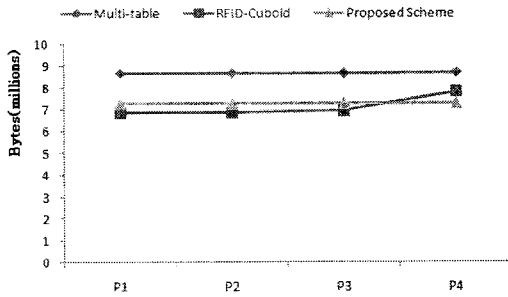


Fig. 9. Data size according to location and path

4.2 Query processing

To evaluate containment query processing time according to the number of products, we vary the number of products(10,000, 20,000, 50,000, 100,000). ) in P4(1, 10, 40, 500). Fig. 10 shows the result of containment query processing. Evaluation of containment query is performed in the same environment with path query. We vary the number of products(10,000, 20,000, 50,000, 100,000). ) in P4(1, 10, 40, 500). Fig. 11 shows the result of path query processing.

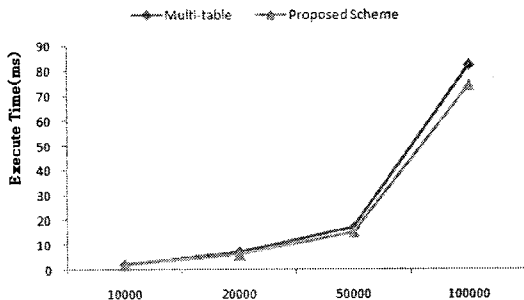


Fig. 10. Containment query processing

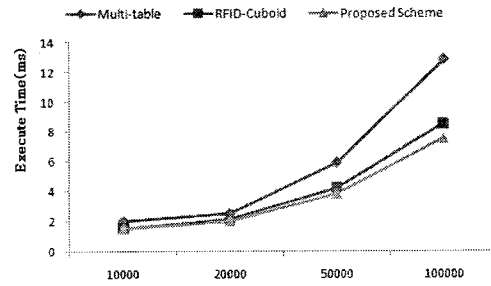


Fig. 11. Path query processing

5. CONCLUSIONS

In this paper, we have proposed an efficient data management scheme for containment queries and path queries which are occurred in supply chain management frequently.

In the proposed data management scheme, we reduce a data redundancy by utilizing various hierarchical containment tables. And we reduce the data size by compressing path information based on architecture of supply chain. Also, we efficiently manage a change of containment and a path of each changed product. The reason is that the proposed data management scheme can flexibly express a path for the containment of the changed product.

As a result, we confirm that the proposed data management scheme is more efficient than RFID-Cuboid and Multi-table approach in terms of storage space and query processing time. Our scheme improves about 10% to 23% over the existing schemes in the data size. Also the path query processing time in our scheme is saved about 11% to 40% on average. However, in containment queries, the processing time of our scheme is similar to that of Multi-table approach. In the near future, we will apply our scheme to the real applications.

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