유비쿼터스 컴퓨팅 환경을 위한 MDR 기반의 새로운 RFID 시스템 구조

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A New MDR-based RFID System Architecture for Ubiquitous Computing Environment

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Abstract

유비쿼터스 컴퓨팅은 무수히 많은 센서들이 관련 데이터 처리 시스템들과 또는 센서들 간의 정보 공유를 통해 서비스를 제공하면서 특정한 장치나 위치에 구애받지 않고 사용자들이 서비스를 이용할 수 있도록 해 준다. 이 논문에서는 유비쿼터스 환경하에서 현재 가장 활발하게 활용되고 있는 RFID(Radio Frequency IDentification) 시스템이 지니는 문제점을 정의하고 이를 극복할 수 있는 새로운 RFID 시스템 구조를 제안한다. 현재의 RFID 시스템은 특정 분야에만 한정하여 단순히 미리 주어진 태그의 식별자를 통해 대상을 식별하는 응용만으로 그 활용성이 제한되어 있다. 이 논문에서는 이러한 제한된 현재의 RFID 시스템의 문제점을 해결하고 유비쿼터스 환경에 적합한 활용성을 극대화할 수 있는 MDR(Metadata registry) 기반의 RFID 시스템 구조를 제안한다. 제안된 시스템은 특정 응용 분야에 종속되지 않고 다양한 분야와의 원활한 연계성을 제공한다. 또한 새로운 정보의 의미를 동적으로 처리할 수 있기 때문에 보다 넓은 응용 범위를 제공한다.

Key Words: Radio frequency identification, Ubiquitous computing, Metadata registry, Pervasive computing, Semantic consistency

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1. Introduction

Ubiquitous computing is recognized as a new computing paradigm. We can acquire and use various data from many sensors under ubiquitous computing environment. Although we can now use data from sensors under the current computing environment, its application is very narrow and in a specific boundary such a given and restricted sensor field.

To realize the complete ubiquitous computing environment, many issues should be resolved. They includes issues such as energy management, protocol to gather data, data processing, independency on applications, and so on. Especially, the independency of sensor use on applications should be supported to maximize the usability of sensors [1].

There are many kinds of ubiquitous computing applications and RFID (Radio Frequency IDentification) system is one of representative applications. The RFID system enables contactless and wireless information access of objects (RFID tags) using radio frequency. Also it is now widely used in actual application domains [2]. Until now, many research has been done to make more improved RFID system but there are still limitations as below:

- Data dependency on a specific boundary /sensor field
- Static semantic management
- Semantic inconsistency between sensor fields/application domains

The goal of this paper is to define a new RFID system architecture to resolve the aforementioned issues. To do this, the new RFID system architecture is based on MDR (Metadata registry), which is the international standard developed to enhance the interoper -ability of data [4,5,12].

The MDR has many advantages such as dynamic metadata management, consistent semantic maintenance method, and so on. Hence the concept and reference models of The MDR has been applying to various other application fields such bibliographic field, environmental data management, e-Commerce, component management, scientific field, and so on [6,7,8,9,10,11].

The MDR provides many advantages and is one of the most well-known methods to share and exchange data. In this paper, we use key properties of the MDR as follows:

- Dynamic metadata management
- Consistent metadata handling policy and model
- Detailed and standardized registration processes
- Semantic consistency maintenance

The proposed new RFID system architecture accepting the above properties and extending the previous RFID system architecture has several good points such as semantic independency on data processing servers, easy and consistent data sharing and exchanging between data processing servers, dynamic metadata management, high usability of RFID tag information, progressive integration and standardization of data used in various RFID applications, and so on.

This paper is organized as follows: Section 2 introduces the related technologies which are the most important concepts, the general RFID system architecture and the MDR in this paper. Section 3 describes the proposed RFID system architecture and section 4 concludes this paper.

2. Related Work

This section introduces a current and general RFID system architecture. The metadata registry definition and its semantic consistency concept are described.

2.1 Generic RFID system architecture

RFID stands for Radio Frequency IDentification and RFID system enables contactless and wireless access of objects by radio frequency. RFID systems consist of main three elements, RF (radio frequency) tags (RFID tags, transponders), RF tag readers (RFID readers, transceivers), and DPSs(data processing servers) [2,3].

The RF tag is the data carrier and typically has a role as identifier of objects to be identified. RFID systems can be classified into two types and one is the passive RFID system and the other is the active RFID system. In the passive RFID system, the RF tag is called the passive RF tag and its communication is small or medium. In contrast, active RF tags have larger communication rages than an passive tag. RFID readers read data from and write to RF tags. Finally, the DPS receives data from RFID readers, and processes and uses data for achieving given goals. Figure 1 shows a basic RFID system architecture [2,13].

2.2 Metadata registry and semantic consistency

MDR is the most important core component of ISO/IEC11179, which is the international standard and has been developed to provides improved interoperability of data. A MDR is a set of data elements and a data element consists of properties describing data. Also there are many components and a MDR is built using the components including data elements. Figure 2 shows the high-level metamodel for the key regions /components [4].

A conceptual domain is a set of value meanings, which may either be enumerated or expressed via a description. A data element concept presents a concept that can be represented in the form of a data element, described independently of any particular representation. A value domain provides representation, but has no implication as to what data element concepts the values are associated nor what the values mean. A data element is a basic

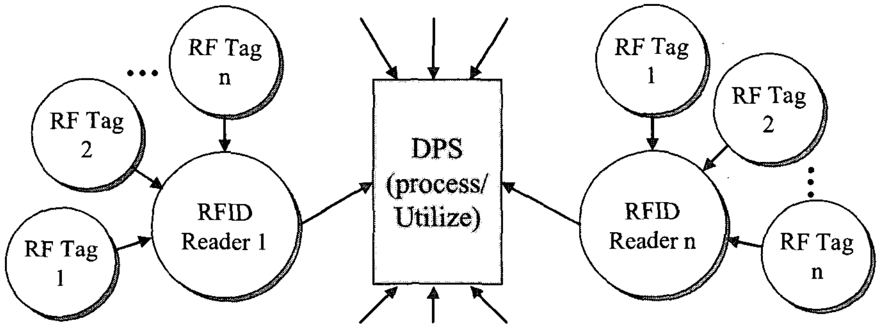

Figure 1. Basic RFID System Architecture and Key Elements.

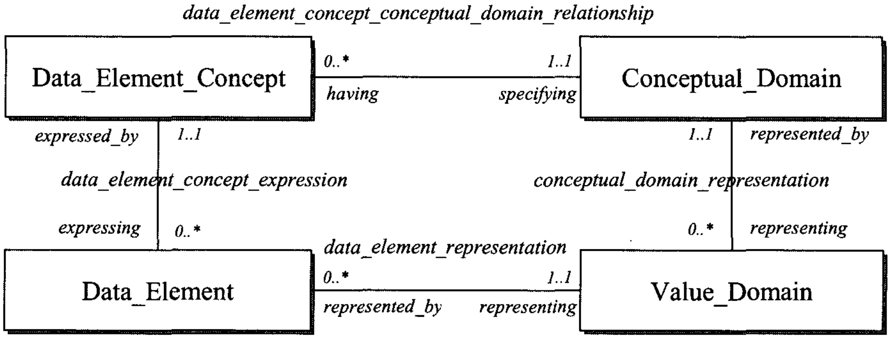

Figure 2. High-level metamodel for the key components of MDR.

unit of data of interest to an organization. Data elements includes many attributes to describe the definition, identification, representation, and permissible values of data.

3. MDR-based RFID System Architecture

3.1 Limitations of Existing RFID Systems

Recently, many research is doing to make improved RFID systems but they have still limitations as follows [14,15,16]:

- *Data dependency on a specific boundary/sensor field*
  In current RFID systems, data of tags can be used in only corresponding domain. However, the data should be accessed and utilized by various readers or DPSs to maximize its application.
- *Static semantic management*
  Tags are located on objects and generally include only identification information to identify the objects. Recently, enhanced tags, which can include and carry much information such as historical data of objects have been studying and developing. Therefore, management policy of semantics of various data in tags is required. Especially, semantics can be created, updated, and deleted. However, current RFID system architectures do not consider the issue.
- *Semantic inconsistency between sensor fields/application domains*
  To improve application of the RFID system, data of tags in all fields can shared and exchanged. To do this, semantic consistency should be maintained. However, existing RFID systems do not be supported this issue.

3.2 New RFID System Architecture

This section shows the overview of the proposed new RFID system architecture to resolve the aforementioned issues of the previous RFID systems. Figure 3 illustrate the key concept and relation of the technologies used to design the proposed RFID system architecture.

In this figure, tags (objects) can be accessed and used by various DPSs, which are in different fields, applications, domains. DPS-1 receives data tags from RF readers. DPS-1 interpret semantics of the received

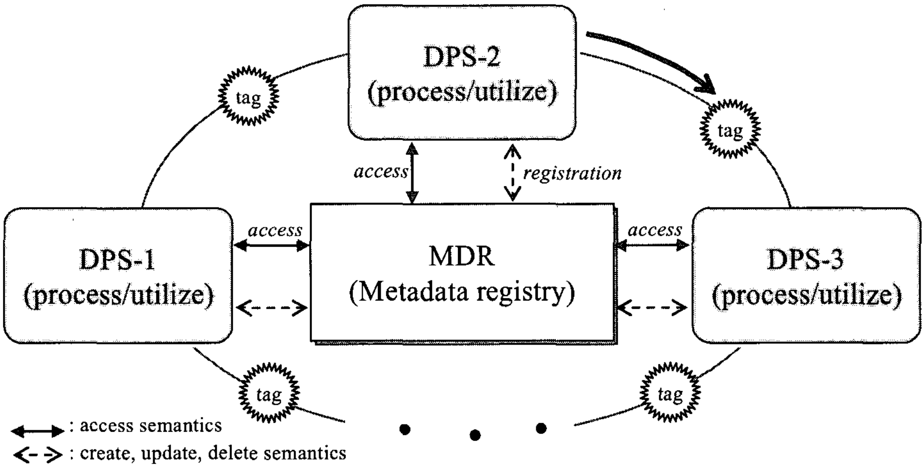

Figure 3. Conceptual model of the proposed RFID system architecture.

data before utilization. More details, metadata such as definition and description of the received data obtained by MDR.

When tag data is created, all data are defined according to the specification in MDR. If there is no proper data format, we can submit suggestions, candidate format. After conformation, the others including the original submitter can use the new data (standardized data).

3.3 Interpretation of Semantics

Every DPS accesses and retrieves the MDR to interpret semantics of obtained data. Figure 4 shows the interpretation process. A RFID reader accesses a RF tag to get data related with the object including an object ID. Once the RFID reader read data of the object, it sends data to a DPS. The DPS should interpret semantics of obtained data before utilizing data. Under current RFID system environment, this operation does not be required, because exiting RFID systems only use pre-defined data in their own closed environment.

This paper consider a new RFID system environment. In other words, a RF tag includes various information as well as the ID for an object. Also, the RF tag can be

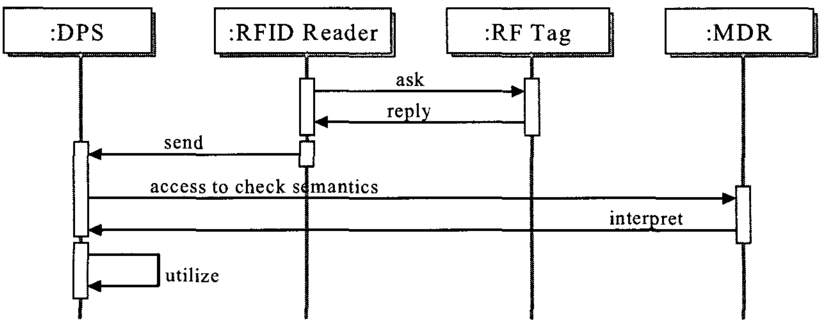

Figure 4. Interpretation process.

used by many RFID readers and DPSs in different fields. Therefore, semantic interpretation process should be accomplished to inter-exchange and share data in various RF tags.

3.4 Dynamic Semantic Management Process

The proposed system has key processes for dynamic semantic management. One is the creation process that new semantics are submitted, checked, and registered. The other is the process to write data into RF tags maintaining semantic consistency using the MDR.

Figure 5 shows the writing process. Actually, data volume at the sensor field level is less than traditional database level. Thus, we can easily realize and use the interoperability concept and method of ISO/IEC 11179. To write information into a RF tag, we first define a data set. We access the MDR to find proper semantics before defining finally the data set. The MDR provides appropriate semantics pre-registered. In fact, the semantics includes various information such as name, definition, description, data type, max length, and so on.

Once a DPS find suitable data set, it checks the retrieved semantics and finally define (refine) a data set. A RF writer pushes data into the RF tag according to the defined data set. After writing data, the DPS finally check and confirm the written data.

In the writing process, one exceptional situation might arise. There is no proper semantic and a DPS does not refine a part of its data set. To overcome this limitation, our new RFID system provides the dynamic semantic management method. The concept of the dynamic semantic management method is almost similar to the dynamic metadata management concept of ISO/IEC 11179 specification [4].

Figure 6 shows the overall step to create new semantics. When a DPS can't get any semantics, the DPS submits proper semantics. The MDR check its requirement, and then register the confirmed semantics after the submitter (DPS)'s confirmation. Finally, the MDR notifies the new semantics and all DPS can use them.

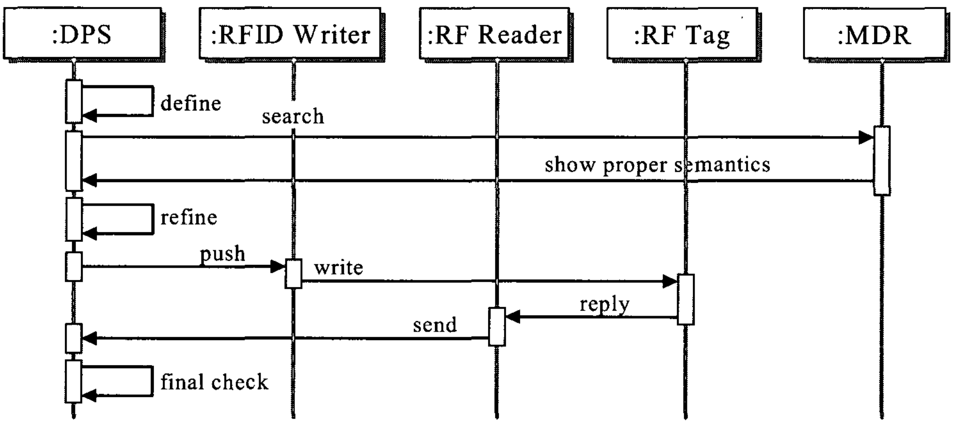

Figure 5. Writing process supporting semantic consistency

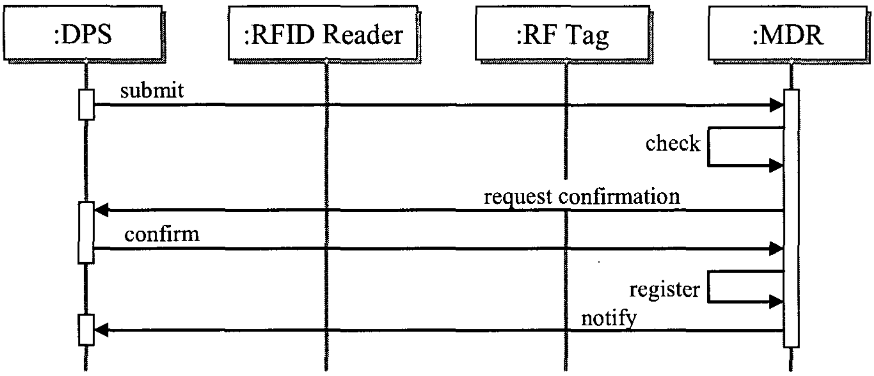

Figure 6. New semantic creation process

3.5 Evaluation

We first show the proposed model contributions with an example. Figure 7 shows the sample. In figure 7, a RF tag includes information and its information can be interpreted and used by DPSs in the same field. However, DPS-3 in another field cannot understand its meaning, type, and so on. DPS-3 accesses to MDR and gets its descriptions. Then DPS-3 stores and uses the RF tag information according to the descriptions from MDR.

This paper proposes a new RFID system architecture for ubiquitous computing environment and several constraints (requirements) are assumed as follow:

- RF tags have various data including an ID (for objects)
- RF tag data can be inserted, updated, and deleted under valid authorization.
- This paper just focus on at the middle level between database level and RF signal level.

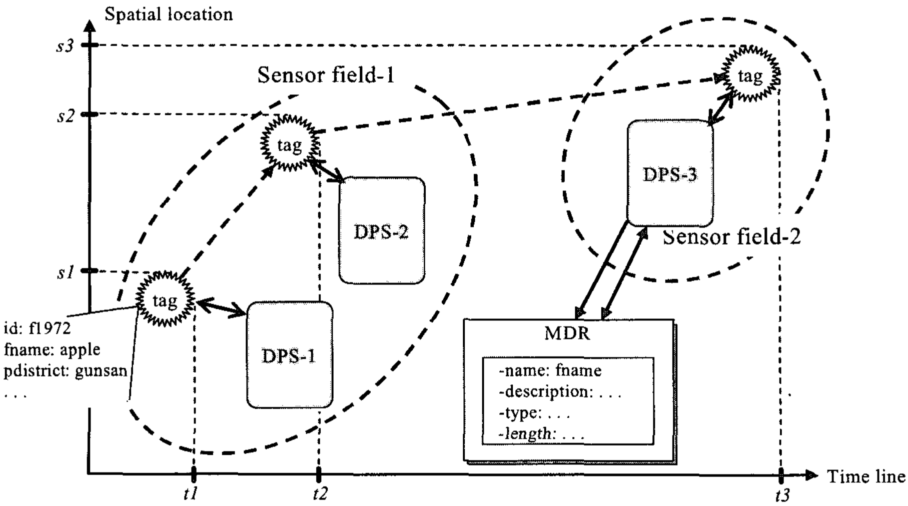

Figure 7. An example for description of contributions.

- The power issue is out of bound of this paper.
- The electric signal issue does not be considered.

With the preconditions above, the comparative evaluation is described in Table 1. One of the critical problems of existing RFID system architecture is that RF tags can be used for only their own field (boundary). This is a big limitation for emerging ubiquitous computing environment because its ideal-final goal is that all sensors can be used by every device. To achieve this goal, we must resolve several issues such as electric signalling, data semantic management, and so on.

The proposed RFID system architecture consider the data semantic management issue. Therefore, RF tags can be accessed and used by every DPS and our system provides high usability of RF tags (tag data). Also, our architecture guarantees independency of RF tags on a specific field.

ISO/IEC 11179 provides a method to dynamically manage metadata. The proposed RFID system architecture use the method and thus it can simply realize the mechanism to exchange and share data all RF tags between DPSs.

4. Conclusion

Ubiquitous computing is recognized as a new computing paradigm and many researchers has been studying on its application and realization. Although RFID system is one of the famous and well-known applications, and it has been implementing and applying to many real applications, current system architecture does not consider the emerging ubiquitous computing environment.

Existing RFID system architecture has several problems to be suitable for and apply to the ubiquitous computing environment: (1)data dependency on a specific boundary/ sensor field; (2)static semantic management; (3)semantic inconsistency between sensor fields /application domains.

To reslove the problmes, this paper proposed a new RFID system architecture. It is based on MDR (Metadata registry), which is the international standard developed to enhance the interoperability of data. The MDR has many advantages such as dynamic metadata management, consistent semantic maintenance method, and so on. Hence the concept and reference models of The MDR has been applying to various

Table 1. Comparison of the existing architecture and the proposed architecture

Comparative items	Existing RFID System	Proposed RFID System
Dynamic semantic management mechanism	N/A	Support
Usability of RF tag information	Low (Restricted)	High (Broad)
Exchange mechanism between different sensor fields	Complex	Simple
Exchanging cost of data between sensor fields	High	Low
RF tags dependency to their own field	High	Independent
Global semantic consistency	N/A	Support

other application fields such bibliographic field, environmental data manage -ment, e-Commerce, component management, scientific field, and so on.

This paper first introcuded the related technologies which are the most important concepts (current general RFID system architecture and basic MDR structure). The overall proposed RFID system architecture has been described and also its core components have been shown. Finally, key processes have been illustrated and then the comparative evaluation (qualitatively evaluation) has been described.

The proposed system architecture provides several contributions: (1)independency on a specific boundary/sensor field; (2)dynamic semantic management; (3)semantic consistency maintenance between sensor fields/ application domains.

As a further work, an access control mechanism should be defined and supported to improve the application and usability of RF tags. This issue is deeply related to security policy. In other words, we want some RF tags are used with constraints such as when, where, who, and son on. With rapid development of hardwares, if this issue is resolved, improved application and usability of RFID system will be provided.

In addition, the contributions of the proposed system should be shown definitely through simulation or prototyping with an actual example.

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