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A web service enabled framework for RFID applications of medicine logistics

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ABSTRACT

RFID can give a unique digital identifier to real physical object, and bridges the physical world with the virtual digital world. Based on the analysis on our experience of RFID applications, some common key issues and requirements of RFID application are presented. A lightweight framework based on Web Service to support ubiquitous RFID application of medicine logistics is designed and implemented. This lightweight framework provides the integration of RFID technology and other holistic applications. Virtual object is used to map the real physical world object and the virtual digital object. Experiment result is given and some future research directions are discussed.

Key words: RFID, Application Framework, Virtual Object, Medicine Logistics

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INTRODUCTION

Radio Frequency Identification (RFID）is a contactless and automatic identification technology for objects, and can enable IT systems to identify object with frequency radio to acquire related data. RFID tags can be embodied into various kinds of objects and assign a unique digital id to the embodied objects so that objects can be classified, tracked and traced. RFID technology bridges the gap between the physics and the virtual world and is currently used and will be widely used in many fields, such as logistical and supply chain management, transportation management, security, military, anti- counterfeiting, as well as hospital, medicine and health caring. It is generally recognized that the pervasiveness of RFID technology in the next few years will become a realistic situation.

However, there is a need to develop a software framework for RFID applications. Although different kinds of RFID application may have different requirements for the software, there are some common requirements in practice and RFID applications may shows some common features. Such a framework can enhance the development of RFID applications.

In this paper, based on the analysis of the common requirements for different RFID applications, a Web Service enabled lightweight framework is designed and implemented for various RFID applications. The Web Service technology is chosen due to the following reasons: the service description and discovery framework for Web Services can be used to describe and locate virtual tag objects. Besides, Web Services are built on open standards such as Simple Object Access Protocol (SOAP), making them universally applicable, invoked via HTTP through the Internet and our Web Service enabled framework can easily communicate with other services on the Internet.

The structure of this paper is as follows. In section II, some common issues of RFID applications are analyzed, and some requirements of the application framework are discussed. Section III presents the design of the framework. Section IV discusses implementation and experiment experiences of the framework in a typical RFID application and some analysis about the performance of the framework and Web Service technology is given. Section 5 presents some of other related research works. And finally, in section VI, we conclude and give some future research

directions.

COMMON ISSUES FOR RFID APPLICATION

Based on some practical experiences, we have identified some common issues concerning the RFID applications and came up with some general design concepts, which form a part of the requirements for the RFID application framework. In the following, we will introduce these general issues first, and then analysis some of the general requirements for the RFID application framework.

1. Common Issues for the RFID Application

There are quite a lot of common issues for various RFID applications in real situation. Some of the important common issues are:

(1) Linkage of the physical and virtual world. The most important issue of the RFID technology is that through the unique ID provided by a RFID tag, a link between the tagged physical objects in the real world and virtual object in the digital world of the application is formed, which enables the rapid reactions of software applications to the physical world objects. The link is built and destroyed through sending an event notification message to the application when a tagged object enters or leaves a spcace. To do so, the RFID system has to support at least two basic events, enter(X) and leave(X), for the entering and leaving of a physical region for object identified as X. Besides, there should be a mechanism in the system for an application to express its interest in a subset of tags.

It should be noted that application system and tag detection system may run on different systems and platforms, but they need to communicate with each other through networks. And the required input message of the application and the actual notification message sent out by the tag detection system may be mismatch. For example, application systems are typically only interested in the changes of the detection tags, and want to receive tag enter/leave event notification messages, but the tag detection system usually can only detect tags which are present in its detection range. Although this mismatch can be solved by introducing a software component which can convert the result of the detection system to the event notification message the application systems need, but since the detection result is often imperfect due to that tag collisions and event flicking may occur frequently, the rapid alternating leave and enter events may be generated for a tag that is actually present in the detection region all the time. The task for such a software component is nontrivial, and the ability to process these spurious enter/leave events is required.

(2) Virtual Object Mapping. Neither the physical object nor the RFID tag can implement some complex operations due to limited computation and communication resources they posses. A virtual object which represents the tagged object is need for adopting this role in the system. Applications should interact directly with the virtual object instead of the tagged object. The RFID tag is used as a bridge between the physical object and the virtual object in the information system.

(3) Time and Location Management. The notions of time and location of an event are the most important concerns for RFID applications. Every event in the system should have time and locations stamps.
The time stamps of event originated from different readers should be comparable even if some of the reader may be offline during the event generation. Application can use the timestamps from different readers to detect the movements of the tagged objects.

Location stamps of tagged objects can be based on different representations, for example geographical coordinate or symbolic information about a place. If the location of a reader is known, the location for its detected objects can also be estimated.

There are two basic issues for location management. One is that a physical object can contain other physical objects. The other is that symbolic locations can form a hierarchical structure and be managed hierarchically. Correspondingly, there are two issues to be considered for location management. One refers to the dynamic containment relationships between objects, and the other refers to the evolution of symbolic location hierarchies.

Location management is a key issue almost all RFID application, for example, intelligent supply chain management, logistic management and product counterfeiting systems all need the information of tagged objects.

(4) History of the tagged object. Some applications need not only the current enter/leave event the detection system generated for tagged objects, but also the history events of the object. For example, in product counterfeiting system, the application should be able to consult the history events and data of the product to determine whether the tagged is a counterfeiter or not. Therefore, a general mechanism for logging and querying the tagged object is necessary.
(5) Context of the Events. Besides current enter/leaving event and history data, some application may also need the

current context of an occurring event for further processing. The context of events includes, for example, the earlier presence and absence of other tags. Often, applications are only interested in events within a certain context. Selection of events context can be performed at several levels, from application level to event level. But for scalability and performance of the RFID system, the selection of context should be performed close to the original source of the events. But this requires a way for application to express their interested context for events.

(6) State and Behavior of the Tagged Object. Applications usually assign state and behaviors to virtual objects. But different application may assign different states and behaviors according to the need of the application system, and moreover, a single virtual object can contribute to the behavior of more than one physical object and more than one application. Therefore, a flexible mechanism is needed for assigning state and behavior to virtual objects.

(7) Life-cycle Management. The creation, migration and destruction of all virtual objects in the system should be managed by a life-cycle management subsystem. After an object is tagged and detected by the detection system for the first time, a virtual object should be created by the life-cycle management subsystem. When a tagged object is destroyed, the corresponding virtual object should be destroyed optionally or exist forever.

When a tagged object is moved, the corresponding virtual object should also migrate to improve performance of the overall system.

2. General Requirements for the Framework

Besides these common issues of the RFID applications, there are also some common and special requirements for the RFID Framework. Below we will discuss some of the important requirements in detail.

(1) Integration with holistic systems. Quite often, before the deployment of the RFID and related technology in an organization, there have already been some management information systems, for example, ERP and SCM systems for the enterprise management, and Retail Management System in the retailers. To put the RFID technology into practice, there is a need to integrate the RFID technology and system with these holistic systems.

But such integration is difficult due to a lot of reasons. Firstly, these existing information systems did not take RFID and related technologies into consideration during their design and deployment phases. Secondly, quite often, the RFID system is not directly compatible with the existing systems, the output of RFID systems are not directly compatible with the input of these information systems. And thirdly, different information systems are often developed and deployed by different manufacturers, which adds the difficulty to integrate them together.

Even if some existing systems are compatible with some existing object coding systems, for example the retail management system can deal with the bar code system directly, but the RFID tag often contains more information than these existing object coding systems. Usually the bar code of a product can only specify the manufacture and category of the product, but the RFID tag, besides the manufacture and category information, also may contain a serial number of the product.

To integrating the RFID to holistic systems, there need adapter components which can convert the RFID data to the data that the existing systems need.

(2) Highly scalable and flexible. The RFID applications are usually highly scalable, can be deployed with quite great difference ranges, from a single computer to a large scale world-wide network. And different RFID applications make use of different kinds of background services. These require that the application framework must be work under highly scalable environment.

The RFID applications may also run on a variety of systems and platforms, from desktop computers to intelligent handhold equipments, such as PDA or Mobile Phone. Besides, the environment of the RFID applications may be heterogeneous, different components running on different platform, with different hardware, operating system and software systems. These challenges require the RFID application framework must be of flexibility, and adapt to different hardware and software platforms.

(3) Inter-organizational service sharing. Some RFID applications are deployed across many organizations in the world wide, and the success of these applications depends on the collaboration of these organizations. For example, in the typical Supply Chain Management system, the success of system depends highly on the information sharing of other enterprises in the Supply Chain.

Despite the fact that a part of the information for an organization is internet accessible, the inter-organization

integration of applications and data is still difficult. The strategies for control of the data and resource sharing among independent organizations are challenges for the design and implementation of the application framework. The following questions must be answered for the information sharing: what information can be shared? Who can use the shared information? How the shared information can be accessed?

(4) Service Registry and Discovery. Another important issue for the RFID application framework design is the service discovery mechanism. In a typical distributed RFID system, there are a lot of services and resources distributed in different devices and organizations, applications can share these services and resource dynamically and at run time across organizations.

In order to integrate these services with application efficiently and with flexibility, service registry and discovery mechanism is needed. RFID services providers can advertise and register their services to the service registry. Client applications can look-up the service registry and try to find the services which they requires. After a required service is found, the application can bind and exchange information with the service dynamically.

The introduction of service registry and discovery mechanism broke the direct couple between the services and the client applications, services and applications can be modified and updated independently, and the overall flexibility of the system and application is improved.

WEB SERVICE ENABLED FRAMEWORK

Web Service is an appropriate technology for the development of RFID application framework and applications for some reasons. Firstly, the virtual object which acts as a bridge between the physical world and the virtual world can provide its functionality as a service, and applications used by the end-user can act as service clients, the service clients can locate and invoked the service dynamically. Secondly, Web Services provide standard mechanism for service description and service discovery, which can be used to describe the virtual objects and other services of the system and advertise them in service registry. Thirdly, Web Service can be invoked using open standards such as SOAP via HTTP, which makes that Web Service can be used by applications across organizations. Web Service can enable the information and service sharing in heterogeneous and inter-organization environment.

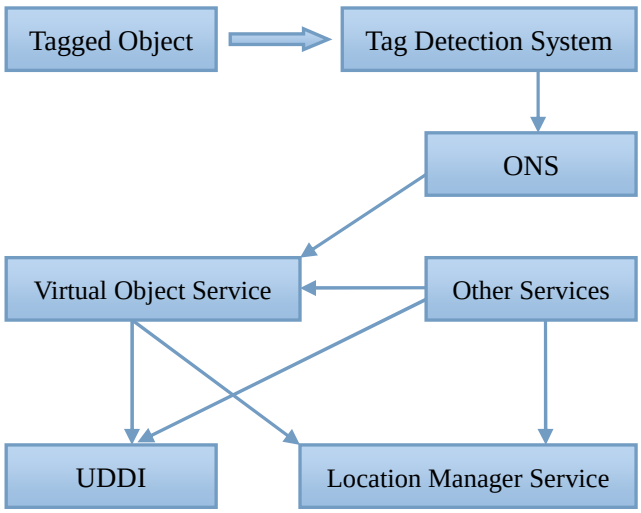

Fig.1 Components in the Framework

Figure 1 shows the main components of our framework. Tag detection system can detect tagged objects within its range. When a tag value is read, the tag detection system encode the tag value into a URL representation and lookup the ONS [1,3] (Object Naming System) using the tag value and get a URI for the Web server on which the virtual object is running as a Web Service. Then, the tag detection system set the location and time of the tagged object for the virtual object using functions the Web Service provides, the location is set using the location of reader which detects the tagged object. The virtual object uses this location information to register itself to the hierarchical location manager service. Virtual object can get neighbor virtual objects from the location manager service.

Below, we will discuss these components in detail.

(1) Tagged Object. Our framework currently support passive RFID technology but can be expended to support other

tagging technologies. Tagged object is a physical object embodied with a RFID tag, and can be observed by tag detection system. The RFID tag contains a unique identifier, which is translated into a URL coding system and is used to locate the corresponding Web Service of the corresponding virtual object through looking-up the ONS.

(2) Tag Detection System. The tag detection system is the actual bridge which connects the physical world with the virtual world. On one hand, the system can detect the tag embodied in real object, one the other hand, the system communicates with the corresponding virtual objects of the real objects and reports the location and time of the real objects to the virtual objects.

When the tag detection system observer a tagged object, it acts the following steps. Firstly, it reads the identifier of the RFID tag. Secondly, it converts the read identifier to a URL style representation using EPC (Electric Product Code) tagging standards. Thirdly, the URL representation is used to search the ONS system and get the web server in which the web service that represents the virtual object is running and the corresponding virtual object is located. And finally, the location of the reader and detected time are assigned to the virtual object through Web Service invocation.

(3) ONS. ONS is used in our framework to locate the Web Service of virtual objects. ONS, just like DNS (Domain Naming System) of the Internet, stores the access entry of virtual objects. The identifier of tagged object is converted to some URL like representations, and there exist one-to-one mappings between the URL representation of tag and the access entry of virtual objects in the ONS.

ONS from different organizations can be linked together and form a hierarchical structure. Tag detection system, when reading a tag identifier, can first lookup the local ONS, if the local ONS cannot find the entry point of the corresponding virtual object, upper-level ONS can be used according to the hierarchical structure to get the entry point.

(4) Virtual Object. Every virtual object in our framework is implemented as a Web Service running on a Web server and can be accessed and invoked through Internet. Although different kinds of virtual objects may own different interfaces, a minimal set of common functions exist for all services and must be implemented by all services. The common functions include the set and get of the location of the tagged object, get/set of the time of events, and the looking up the event history of the object.

(5) Location Manager Service. The location manager service tracks the logical location of tagged objects hierarchically. Since all virtual objects must register themselves to the location manager service, the service is able to determine the neighbors of a tagged object. Hence, a virtual object can ask the location manager service for other virtual objects nearby.

The location manager service can arrange the logic representation of location in a tree structure. The root of the location manager is the whole world. Child nodes constitute a partition of their parent node. When the virtual object registers its location, the service manager service delegates this registration to the node that covers the smallest space in which the tagged object is contained.

(6) Interface Description of the Service. Besides these components, there are also a lot of other services in the framework, such as data storage service, data filtering service. These components are also encapsulated as Web services, located in some Web servers and accessed through Internet.

The interfaces of these services, as well as the virtual object services, are described using WSDL (Web Service Description Language), and registered in a UDDI. Client application can look up the UDDI and locate the service they needed.

IMPLEMENTATION AND EXPERIMENT

The overall framework is implemented using Microsoft Visual Studio. Net and developed under Microsoft Windows. The UDDI of Windows 2013 is used for Web Service registry and discovery. WSRF.NET is used for WS-Notification. BIND is used to act as ONS. The virtual object is implemented as Web Services in the framework.

A simple test was performed on personal computers with Intel Core i5 2.4GHZ, 4G memory running Windows Server 2010 or Windows 7, and connected with 100M Ethernet network. The simple test involves finding a virtual object in the network and set both the location and time information of the virtual object. We measured the amount of time required to finish the operation. The test was run 100 times. The average time used was 516.3 ms with the deviation of 85.4ms. From this test, we can see that Web Service needs improvement to put into use in real-time

environment.

The hierarchical location management of virtual objects and other components are implemented as Web Services. The migration and history data management of tagged object are also implemented using Web Service and database.

RELATED RESEARCHES

There are already some trial systems for the RFID application. For example, the EPCgroup[1,2] and MIT auto-ID lab have proposed some standard protocols for adapting RFID technology in Supply Chain Management. Their protocols use Application Level Event, EPC IS and ONS to construct RFID applications. But the protocols they proposed are highly related to the application of RFID in supply chain, and lack the support of ubiquitous RFID applications. Also, there is such concept as virtual object in their architecture, which we think is very important for the RFID applications.

B. S. Prabhu[4] also proposed an architecture for RFID application based on Microsoft .NET. But there is no such concept as to virtual object in their architecture. Besides, their architecture tries to cover all aspects of RFID application, from data gathering and processing to application integration, which is quite different from ours.
Clemens Kerer[5] proposed an infrastructure presence aware of objects with Web Service and RFID, but their work was limited to presence aware of tagged objects.

IBM, SUN, Oracle, SAP and BEA [6,7] have also developed middleware for RFID applications, but their work focus on integrating RFID technology with their middleware system. And these RFID middleware systems cannot be used alone in lightweight RFID applications.

CONCLUSION

Based on previous experience we have gained in developing RFID applications, a set of basic issues and requirements for RFID application middleware are analyzed and suggested to support the development of a lot ubiquitous RFID applications. An application framework based on Web Service is designed and developed using Microsoft Visual Studio.NET. Experiment shows that such a lightweight framework is applicable to tag-based applications. A lightweight framework based on Web Service to support ubiquitous RFID application of medicine logistics is designed and implemented. This lightweight framework provides the integration of RFID technology and other holistic applications. Virtual object is used to map the real physical world object and the virtual digital object. Experiment result is given and some future research directions are discussed.

In the future, there are some more researches to be taken. For example, to investigate the application of Web Service enabled framework in real time environments, to support some other tagging systems and to investigate some concepts in more detail, our final goal is to develop a framework with necessary level of performance for a wide variety of ubiquitous RFID applications.

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