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# An Efficient Approach for Data Transmission in RFID Middleware

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## 1. Introduction

RFID projects have been deployed in many enterprises profoundly. From the perspective of architecture, a RFID application system includes three parts: hardware, software and middleware. The hardware consists of RFID readers, tags and antennas. Software refers to the enterprise management information system which has been operated for a long time. Middleware is the most time-consuming part. How to import data from RFID reader to management information system? Who is responsible for this task? Whether or not adopt off-the-shelf RFID components? All the above issues should be carefully considered.

RFID middleware is system software that collects a large volume of raw data from heterogeneous RFID devices, filters them and summarizes them into meaningful information, delivers this information to applications and makes them interoperate with legacy systems. The implementation of RFID middleware in enterprises can provide flexible configuration. Parameters of related components can be set. And then only the required information is imported to the system. When extra RFID readers are added to the system, there is no need to develop program again. The RFID middleware will take care of all these changes.

However, the performance of RFID middleware is not satisfactory. In particular, when Web Service is used to bridge the difference of diversified platforms, the efficiency of data transmission is decreased. A Web Service is a software system identified by a URI, whose public interfaces and bindings are defined and described using XML. Web Services allow access to software components through standard web technologies, regardless of platforms, implementation languages, etc. This technology has impacted RFID-based applications in a profound way. For the mobile client system, Web Services enable the integration of various applications in a distributed environment from the resource-limited terminals. Though its performance optimization poses challenges for researchers.

Several methods and strategies have been proposed to improve it. In our paper, we design a Context-Store and apply it to the exchange process of SOAP messages between mobile terminal and server. A SOAP message which includes three sections: SOAP Envelop, SOAP Header and SOAP Body, are separated into 2 groups, one is the static part, and the other is the dynamic part. The main idea of our approach is to store the static part while only transmit the dynamic part through network. Then on the receiver side, we can assemble and obtain the whole message.

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Under the experiment of a mobile client server system, RFID data is transmitted between the J2ME platform on PDA and the Microsoft Windows Server 2003 operating system on server. SOAP messages in different lengths are tested. Compared with the general method and compressing method, our Context-Store approach has the least average response time. It is efficient. Finally, the prototype system, which is implemented and applied to production lines in a manufactory, is described in details. Processing data collected from RFID tags attached to the product on production line is packed into SOAP messages and sent to application server by Wireless LAN. After confirmation, the PDA client can access application server to update processing data continuously.

2. Background

Radio Frequency Identification (RFID) is a kind of Auto-Recognition technology that allows RFID reader to read data from RFID tags via radio signals from a distance and without line of sight. With significant technology advantages over bar code identification systems, RFID has been gradually adopted and deployed in a wide range of applications, such as access control, item tracking, highway tolls, production line auto-management, supply chain management and so on. A typical RFID system consists of tags (transponders), readers, antennas embedded both in tags and readers.

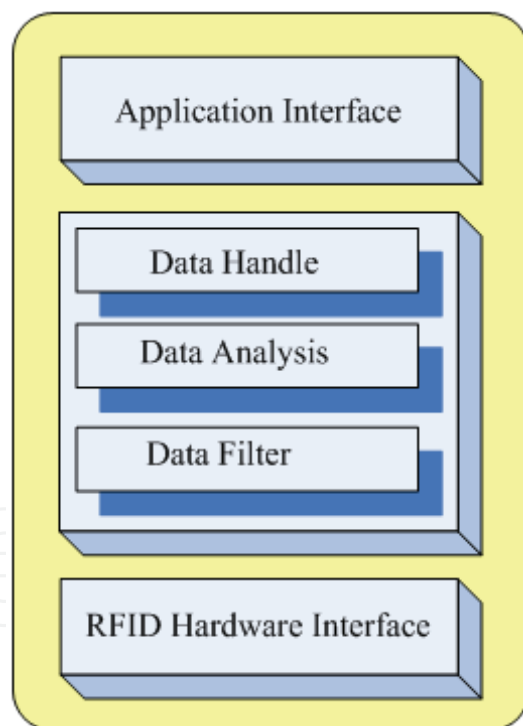


Fig. 1. Typical structure of RFID middleware

RFID middleware is system software that collects a large volume of raw data from heterogeneous RFID devices, filters them and summarizes them into meaningful information, delivers this information to applications and makes them interoperate with legacy systems (Taesu Cheong & Youngil Kim, 2005). Therefore the basic functions of RFID middleware are supporting the independency of the multi-protocol of heterogeneous readers and playing the role of a broker for data exchange.

A typical RFID middleware has such abstract structure as shown in Fig. 1. The Hardware Interface directly communicates with RFID readers and other terminal devices. The middle layer is responsible for data management and data transmission, such as filtering data, analyzing data and handle data. The Application Interface provides friendly access interface for upper layer applications including various enterprise and its partners. For instance, we can invoke Web Services in this Interface to accomplish broader applications. A number of works on RFID middleware has been published (Christian Floerkemeier & Matthias Lampe, 2005; Young-Il Kim et al., 2006).

A Web Service is a software system identified by a URI(Universal Resource Identifier), whose public interfaces and bindings are defined and described using XML (World Wide Web Consortium, 2008). Web Services allow access to software components through standard Web technologies, regardless of platforms, implementation languages, etc. This technology has impacted RFID-based applications in a profound way. Especially for the mobile client system, Web Services enable the integration of diversifying applications in a distributed environment from the resource-limited terminals. It transmits business data on Web by virtue of HTTP (Hypertext Transfer Protocol, a universal protocol used on Web) and SOAP (Simple Object Access Protocol). The transmission process is illustrated in Fig.2. The client creates a SOAP message embedded in a HTTP POST (a request method used in HTTP) request according to the WSDL (Web Services Description Language), and then sends to server through network. The Web Service request processor on the server will deal with this message. It parses the SOAP message, invokes corresponding Web Services, and then creates response message. The server sends back this SOAP response message to client by HTTP.

SOAP (World Wide Web Consortium, 2007) is a lightweight and simple protocol which is based on XML. It is designed to transmit structured and solidified information, and can be used together with many protocols and formats on the Internet, such as HTTP, SMTP (Simple Message Transfer Protocol) and MIME protocol (Multipurpose Internet Mail Extension) etc.

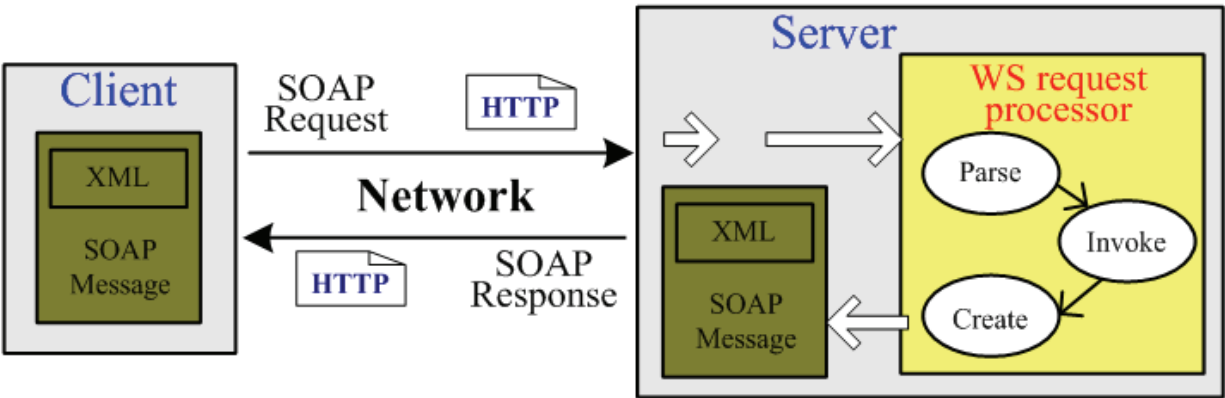


Fig. 2. Data transmission process with Web Services

For the application of Web Services-based RFID either within an enterprise or between different enterprises, several meaningful attempts have been done. Generally, when the technique of Web Services is applied to RFID system within an enterprise, the main purpose is to deal with the information in enterprise network, and make advantage of the processing capability of RFID middleware system. Clemens Kerer et al (Clemens Kerer et al., 2004) design a so-called “Presence Manager Service” to manage the list of people attending the conference. This application tries to combine Web Services with RFID devices and send the

data collected from RFID reader to organizer of the conference. It is a unique application of which functions are not complex and the data involved is in a small scale. So it is not appropriate to apply this method to large scale systems, such as supply chains in logistics. When Web Services is used to assist the information exchange between different enterprises, its characteristic of supporting real-time data share and mutual interchange of B to B is revealed. Both the information on RFID tags and the processing status are provided to users. Niranjana and Aura Ganz (Niranjana & Aura Ganz, 2004) propose a framework for a multimedia information transmission system in which diverse wireless networks and devices communicate. The client components which include lap-top, PDAs, are connected to smart objects through Web Services in dynamic environment. Each network provides its own resources to other networks by Web Services. B S Prabhu et al (B S Prabhu et al., 2006) introduce a framework for RFID middle ware. The task of this middle ware is to serve the information exchange between enterprises. Each enterprise communicates with others through Web Services across the boundaries.

Though these Web Services-based performance improvement poses challenges for researchers. There are some achievements both from industrial and academic institutes. V Prabakar et al. focused on the manageability of Web services in RFID application (V Prabakar et al., 2006; Han Chen et al., 2005). K.Devaram and D.Andresen suggested to cache SOAP messages in client side to enhance the performance (K Devaram & D Andresen, 2003) Seshasayee B and Noah Mendelsohn et al encoded the SOAP message by binary codes (Noah Mendelsohn et al., 2004; Seshasayee B et al., 2004). Mike Nikitas compressed SOAP messages (Mike Nikitas, 2003). However the above methods cause some negative effects. The binary encoding loses the advantage of readability of the XML-based SOAP messages. The compressing method produces extra compressing and decompressing time costs and loses the access transparency.

In this paper, we design and realize a Context-Store approach to improve the Web Services performance in RFID middleware. Both the experiments and the application example show its efficiency. The remainder of this paper is organized as follows. Section 3 presents our framework. Section 4 describes the realization of our approach in detail. Section 5 shows the experiments. Section 6 outlines the application in manufactory. Section 7 draws conclusions and suggests future research.

### 3. Framework design

According to the research work (Julio Fernandez et al., 2005; Toyotaro Suzumura et al., 2005), the major factor affects the performance of Web Services is the cost of SOAP message transmission. So the purpose of our approach is to reduce the message length transmitted in network. The main idea is to store the static part while only transmit the dynamic part through network. Then on the receiver side, we can assemble and obtain the whole message. SOAP message (World Wide Web Consortium, 2007) is a sort of XML document. It comprises 3 sections: SOAP Envelop, SOAP Header and SOAP Body. In the following discussion, we divide it into 2 parts, the static part which contains the SOAP Envelop, fixed SOAP Header (accessing Web Services not for the first time) and Tag information such as "<? xml version='1.0' encoding='utf-8'?>", and the dynamic part which contains SOAP Body and dynamic SOAP Header (accessing Web Services for the first time).

The framework of the system is shown in Fig. 3. This framework includes mobile terminals which are capable of collecting data from RFID tags, Context-Store, Web Services server and transmission channels such as network and so on. The mobile terminal sends requests by SOAP messages. The Web Services server responses. Context-Store is a kind of file storage



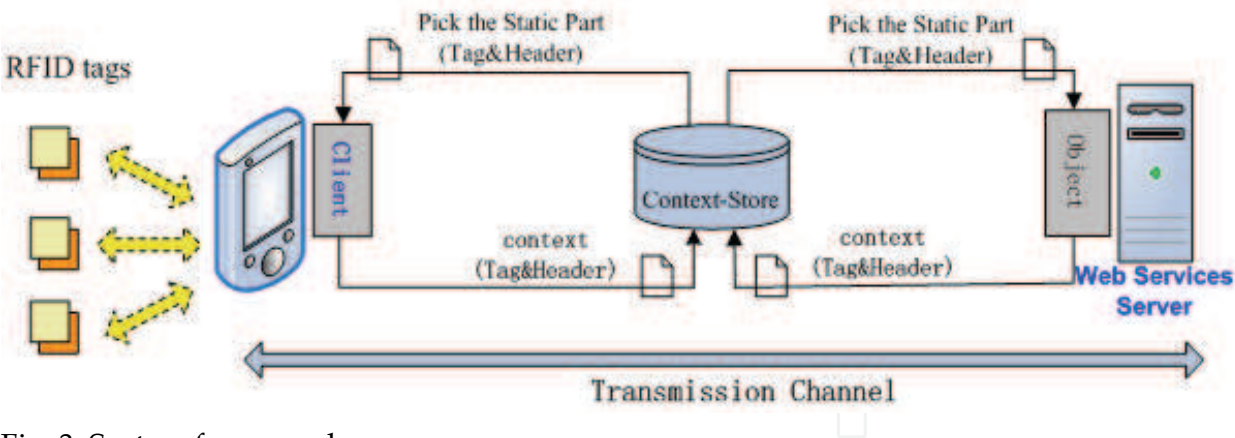


Fig. 3. System framework

structure, which can be accessed by client and server. It stores the context information such as SOAP Envelop, fixed SOAP Header and tag information. To choose a suitable structure as Context-Store is up to the specific application environment. For example, considering the limited resources on mobile terminal, we adopt a simple text file structure. The static part of SOAP message stores in Context-Store, while the dynamic part is transmitted through network. Then after assemble, we can obtain the whole message from the mobile client side or the Web Services server side.

4. Approach description

4.1 Context-Store construction

The main idea of our approach is to reduce the lengths of SOAP messages transmitted through network to enhance the performance of Web Services.

```
<?xml version="1.0" encoding="utf-8"?>
<soap:Envelope
xmlns:soap="http://schemas.xmlsoap.org/soap/envelope/"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:xsd="http://www.w3.org/2001/XMLSchema">
  <soap:Header><MyHeader
xmlns="http://www.xaut.edu.cn"><ID>00</ID></MyHeader>
  </soap:Header>
```

Fig. 4. A Context-Store template

- The mobile terminal communicates with the Context-Store in the following steps:
- Step 1. Create a context with ID;
  - Step 2. Store a specific context matched to the ID;
  - Step 3. Pick the context from Context-Store;
- The server communicates with the Context-Store in the following steps:
- Step 1. Store the context information which access the Web Services for the first time;
  - Step 2. Pick the context from Context-Store;
- We construct a template for the Context-Store in Fig. 4 to initiate communication process between mobile client and server in which we set the ID as “00”. Because of the fast speed of assess ordinary text file, in our realization, we construct TXT files as Context-Store to store

context information in both mobile client and server side. They are symmetrically nominated as Client\_Context\_Store and Server\_Context\_Store respectively.

4.2 SOAP expansion on mobile client

On the mobile terminal client side, we expand the communication process by the following algorithm, and it is illustrated in Fig. 5.

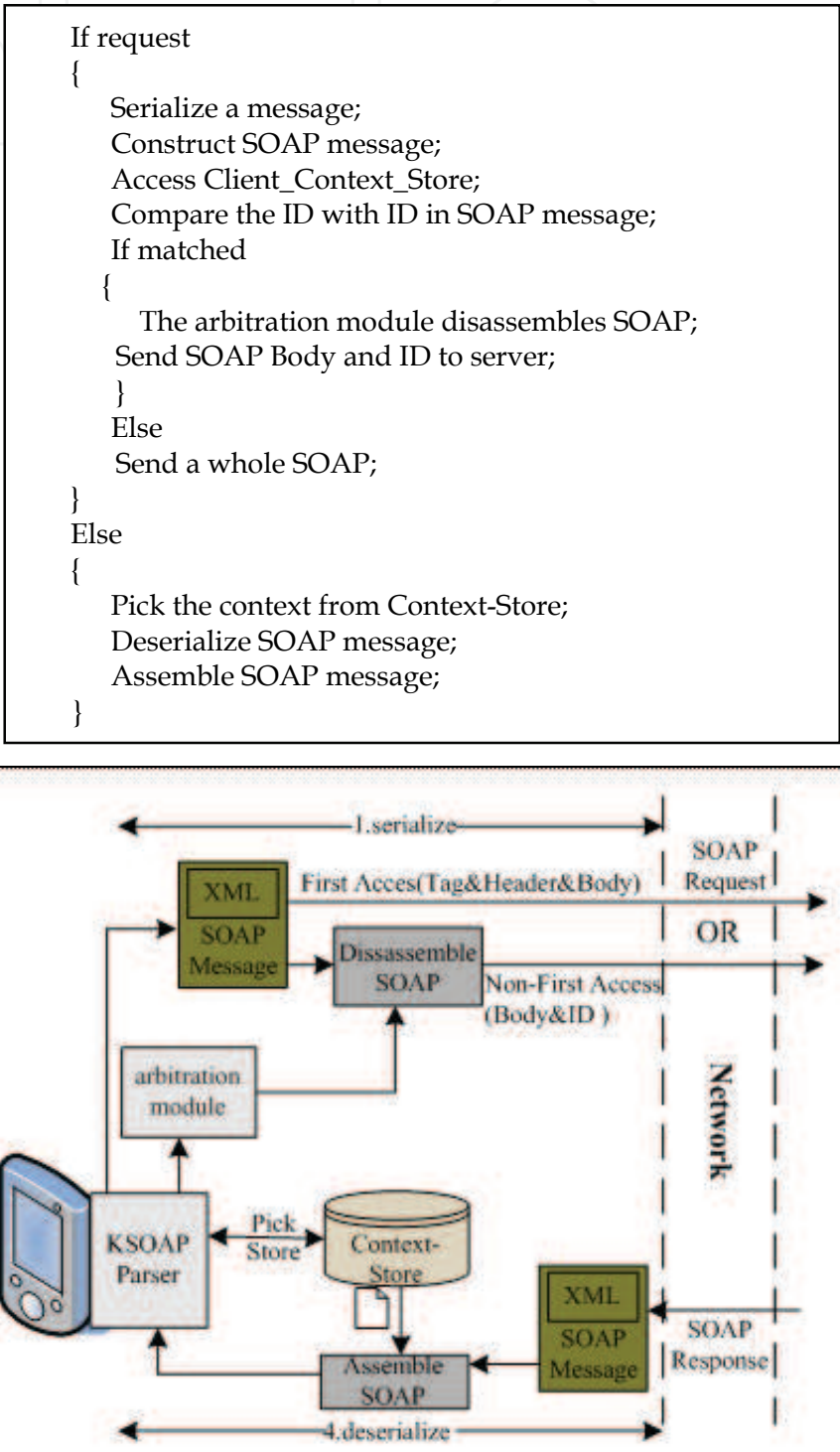


Fig. 5. Algorithm on mobile client

4.3 SOAP expansion on Web Services server

On the Web Services server side, we expand the communication process by the following algorithm, and it is illustrated in Fig. 6.

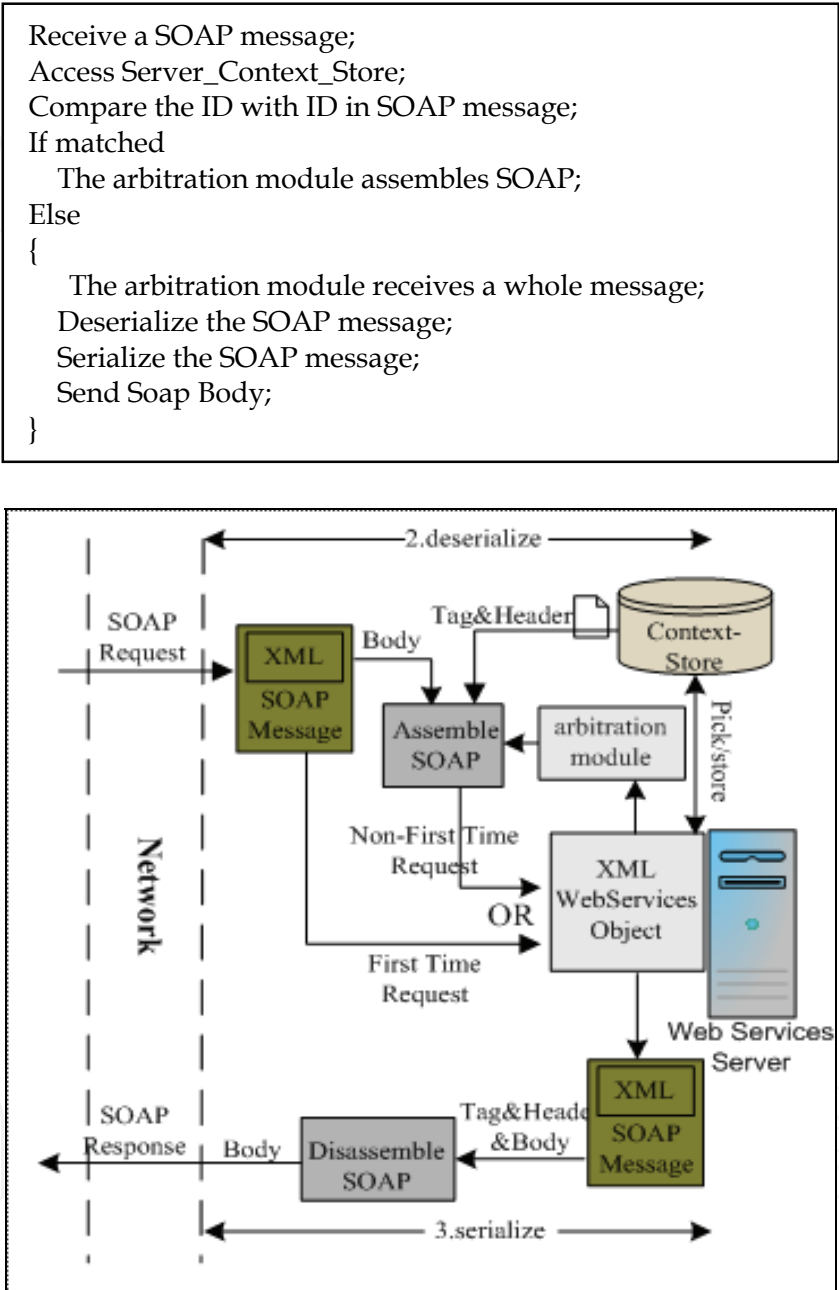


Fig. 6. Algorithm on Web Services server

5. Experiments

We construct the following environment to test our approach. The mobile client side adopts PDA, which installs J2ME and the Wireless Toolkit 2.5.2 development tool. The server side installs the Intel Pentium 4 CPU, 3.0GHz, 768MByte RAM, Bandwidth 100Mbps, and Microsoft Server 2003 operating system, and Dot Net SOAP Engine expansion system, IIS



6.0. Under such configuration, the result of our experiment is shown in Fig.7. The result in an Internet mobile computing environment is indicated in Fig.8.

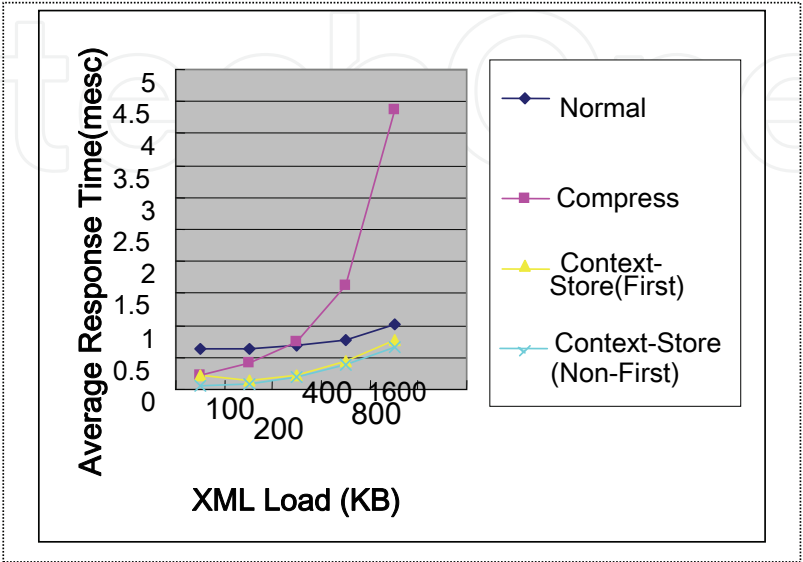


Fig. 7. Comparisons under Wireless LAN

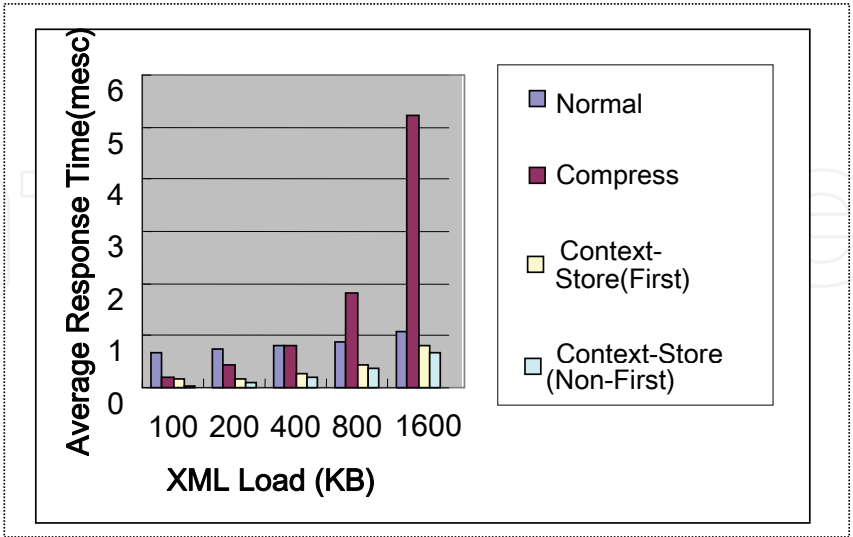


Fig. 8. Comparisons under mobile computing environment

We packed several SOAP messages in the length of 100, 200, 400, 800, 1600 Kilo Bytes with the contents of Production ID, material, tested date and so on. Under the methods of normal SOAP transmission, Compressing and our Context-Store transmission, all the average response time increases as the length of the SOAP message augments. But apparently, our Context-Store approach has the least time cost compared with the other 2 methods. For the Compressing method, due to the plenty of time consumed by CPU and the limited processing ability, the performance becomes worse even though it cost less time in data transmission. For the Context-Store approach, owing to the only dynamic part of SOAP message transmission, the average response time reduces. In other words, our approach greatly enhances the performance of SOAP message transmission efficiency.

6. Application

Based on the above design and experiments, the prototype system has been implemented and applied to production lines in a manufactory, shown in Fig. 9. In the manufactory,

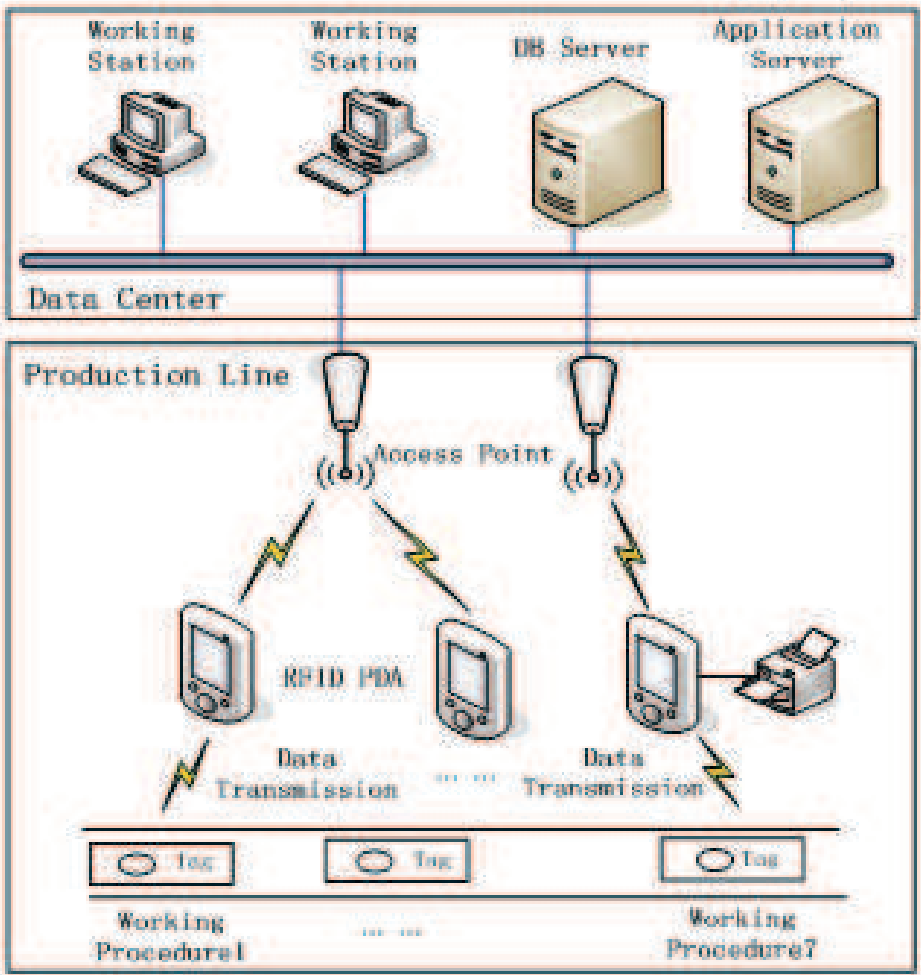


Fig. 9. Application example

considering the noisy surroundings, the limitations of temperature and humidity and the difficulty of network cabling, we choose PDA with RFID embedded communication module as readers rather than wired RFID readers. The PDA access LAN through Access Point (AP) at the frequency of 2.4GHz. While the embedded communication module exchanges data with tags at the frequency of 902 MHz which is also of free Industrial Scientific Medical (ISM) band. So there is no radio frequency interference. Other application softwares are deployed as follows: working station installs Microsoft Server 2003 operating system, Message Queue Component and Dot Net Framework 2.0. The application server installs Internet Information Services 6.0 as WEB server.

In such application scene, workers read information of products with PDA in their hands from 1.0 meters away and record important process information into tags. Meanwhile, through WLAN, By virtue of Web Services, the PDA clients access application server to update process data. With our proposed approach, the performance of data exchange is improved and the production efficiency is increased.

## 7. Conclusion

In this paper, we introduce the widely applied RFID middlewares with the technique of Web Services. More importantly, we design and realize a Context-Store approach to improve the performance of data transmission between mobile client and Web Services server. The experiments show our approach greatly reduces the average response time of SOAP messages, thus achieve its original goal. What's more, the application example of the production lines in manufactory indicates an increase of the production efficiency. However, the symmetrical Context-Store in both mobile client and Web Service server may lead to data inconsistency. Our future work will focus on exploring a more effective storage structure or seek for a way of keeping data consistency.

## 8. Acknowledgments

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The number of different applications for RFID systems is increasing each year and various research directions have been developed to improve the performance of these systems. With this book InTech continues a series of publications dedicated to the latest research results in the RFID field, supporting the further development of RFID. One of the best ways of documenting within the domain of RFID technology is to analyze and learn from those who have trodden the RFID path. This book is a very rich collection of articles written by researchers, teachers, engineers, and professionals with a strong background in the RFID area.

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