Applied Mathematics & Information Sciences
An International Journal

Development of Logistic Management Information System Based on Web Service Architecture and RFID Technology

Shang-Liang Chen[1], *Yun-Yao Chen*[1] *and Chiang Hsu*[2]

[1]Institute of Manufacturing Information and Systems, National Cheng Kung University, Tainan City, Taiwan, R.O.C.
[2]Department of Business Administration, Chang Jung Christian University, Tainan City, Taiwan, R.O.C.

Received: 15 Aug. 2012, Revised: 28 Nov. 2012, Accepted: 2 Jan. 2013
Published online: 1 May 2013

Abstract: Traditional logistic systems in industries are normally built for different business processes of different companies. Industry always budgets high maintenance costs for his own management systems. Therefore, a RFID information system for logistic management based on Web Service architecture is proposed in this research. Web Service structure can enhance the flexibility according to its service-oriented architecture (SOA), which can be used for designing all types of systems. The developed system Integrates RFID technology, Google maps, GPS/GIS, IP camera and information pushing technologies. A case study, to deploy the developed system into a company, is designed for testing the systems performance, named as RFID Management Information System (RMIS). The main advantages of this developed system are: 1. Enhance traditional logistic systems in industries by adapting Web Service architecture. 2. Integrating information and communication technologies with proposed system architecture based on Web Services and SOA protocols. 3. By deploying RMIS into a company, the benefit of the system can be verified and the maintenance costs can be lower down.

Keywords: Logistic Management Information System, Web Service, SOAP, RFID.

1 Introduction

Radio Frequency Identification (RFID) technology is primary used to track and trace objects in modern logistic enterprises. They also need to exchange their data and information more effectively and quickly in order to become more competitive in global markets. Although RFID tags are generally associated with many beneficial properties compared with barcodes, many constrains, such as high unit cost, security issues, appropriate decision support tools, are urgently to be solved.[1] From the published results of Moore, Service Oriented Architecture (SOA) is a promising computing paradigm for software in a heterogeneous open environment and has received some research supports from other researchers (1999).[2,3] SOA provides software systems abilities to build and evolved online by dynamically discovering and binding to open services, which are accessible through standard protocols. For example, all the information is exchanged through XML data type. However, current illustrated models and structures usually focus on the theory of Web Service model construction, lacking the design of whole system and implementation for real environment. In other words, these researches are heard to apply to real IT systems for logistic industries. In this paper, a logistic management information system, with design models, design patterns and a case study scenario, based on Web Service architecture and RFID technology is proposed for designing and implementing a RMIS. Taking advantages of 3G network, Wi-Fi, Google Maps, mobile devices, PDA, Tablet PC and information pushing service, functions as in-time information delivery, logistic in-time tracking are also provided in RMIS. Data exchanging and information delivering can be more effective and faster in logistic scenarios.

The remainder of this paper is structured as follows. In Section 2, we discuss some past related works and references about Web Services adapted for constructing supply chain management systems. In Section 3, we illustrate the system design models and design patterns

* Corresponding author e-mail: yewyewchen@gmail.com, slchen@mail.ncku.edu.tw

Table 1 RFID technology used for logistic systems.

Researcher	Literatures
Jaselskis *et al.*	RFID technology can provide owners and constructors with RFID information for enhancing the operation of industries.[7]
Yagi *et al.*	RFID technology can be used for building architecture with concepts of "parts and packets unified architecture". Products information can be handled through its own RFID tags.[8]
Ergen *et al.*	RFID technology can be designed as mobile infrastructure for locating components.[9]
Wang *et al.*	The research integrate promising technologies, including RFID scanning and data entry mechanisms, Persona Digital Assistance (PDA) and develops a web-based system called RFID-QIM to improve the acquisition of quality inspection data in material test labs.[10]
Chow *et al.*	Researchers proposed a system, which is suitable for usage in a warehouse operation environment, enhances the effectiveness in formulating resource usage package and managing resource operation.[11]
Zhao *et al.*	In this research, the researcher proposed architecture to support different readers. A novel SOA-based architecture for large-scale deployment and integration of RFID devices at the edge of network was proposed.[12]
Kwok *et al.*	This paper explores the feasibility and practicality of shifting the focus of product identification from traditional human readable or kiosk-based solutions.[13]

with detail descriptions. System architecture is also proposed with an overview description of the components. In section 4, a sample scenario of case study is discussed with the comparison of the process of before and after importing RMIS. In section 5, we summarize our works and sum up the conclusions and future works of this research.

2 Related Works

2.1 RFID technology in industry management systems

RFID tags can be used for coordinating data with its ability to be attached on different surface of object and can be sensed in-time by using active or passive RFID readers. RFID technologies have been widely used in many industries such as construction, education, manufacturing, healthcare and airline industries.[4] Not only active/passive RFID, modern technologies such as information pushing, Tablet PC, Wi-Fi, 3G network, mobile devices, smart phone, Google maps and service oriented architecture has become a new aspect of research for constructing applications. However, they are seldom applied to logistic industries even if the IT department of the company is mature since IT technology-integrated systems are not commonly used in manufacturing today.[5] Currently, information systems, such as manufacturing and logistic company, are usually designed case-by-case, lacking the ability for the system to reuse and rebuilt. Companies can componentize their own information and services through software componentized in an unprecedented way through SOA.[6]

According to characters definitions of RFID middleware from Forrester Research Institution (2004), it plays the role of communication between RFID readers and RFID applications, which include four functions listed as below:

1.Reader Coordination:
End users can use RFID middleware for loading, monitoring, deploying and sending commands to the reader. For example, users can turn off the readers when RFID reading interrupted by unknown reasons or errors. Some middleware manufacturers even provide hot-plugging functions for users to operate dynamically.

2.Data filtering and aggregation:
When tag reading errors occur, the responsibility of RFID middleware is to fix the errors by implementing correction algorithms in RFID middleware. When dealing with big amount of data, RFID middleware must provide buffer to filter and aggregate data.

3.Data routing and integrating:
Some companies are already having their own Supply chain management(SCM), Enterprise resource planning(ERP) and Customer relationship management(CRM) systems (full name). Those companies hope that RFID middleware can be equipped with data routing and integration functions, which can enhance the efficiency of using RFID.

4.Process Management:
Middleware must be capable of data monitoring and data activating. In other words, the middleware should notify the manager when the storage of product or goods is not enough.

Researchers have shown the importance on integrating logistic system with RFID, GPS, GIS, Zigbee, Web Service technologies and the Internet. Many researches showed that systems combined with RFID technology can improve the information collection, sharing and exchanging in a supply chain. They are listed in Table 1.

2.2 Web Service and SOA for logistic systems

Web Service has become a significant trend in service based architectures and an interoperable solution across

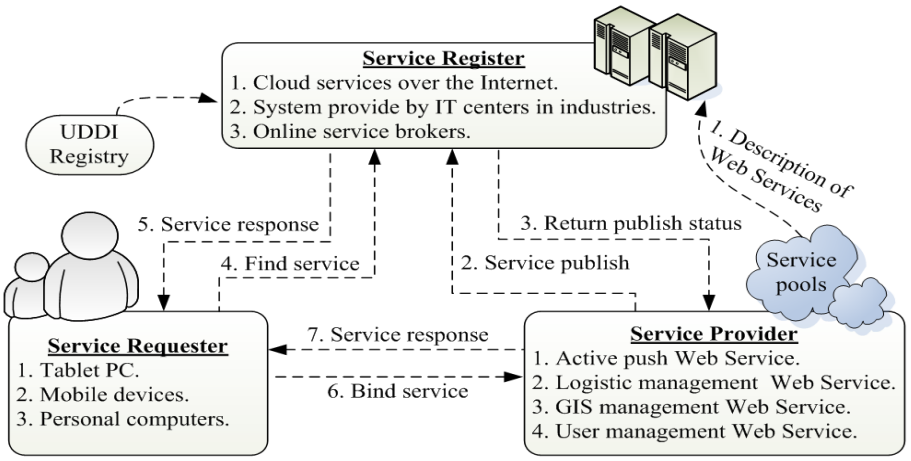


Fig. 1 Web Service model of this research.

platforms. Wireless communication and network services have substantially changed the landscape of communications. The associate facilities of logistic industry have been developing rapidly in recent years due to the advocacy of the demand of automation. Therefore, information technologies used in logistic industry has increased substantially. However, most applications are often based on different OS (Operating System) due to the preference of users and the brands of operating systems. The goal of this paper is to combine RFID, 3G network and other promising technologies with SOAP-based (Simple Object Access Protocol) Web Services designed for various OS platforms.

According to the research of Curbera (2002),[14] the interface of Web Services is defined and described using XML (Extensible Markup Language), and identified by a URI (Uniform Resource Identifier).[15] A Uniform Resource Identifier (URI) is a compact sequence of characters that identifies an abstract or physical resource.[16] Web Services can be interoperable with agreement on following standards, such as XML, SOAP, WSDL, and UDDI. UDDI (Universal Description, Discovery, and Integration) is a standard for Web Services to be registered and published.[17] WSDL (Web Services Description Language),[18] which is an XML format for describing network services as a set of endpoints operating on messages containing either document-oriented or procedure-oriented information. SOA defines a communication protocol for users to exchange XML data. A Web Service-aware model can have numerous advantages for mobile devices.[19] The listed advantages can be applied to mobile applications in our proposed logistic scenario.

3 System Implementation

3.1 System architecture

A conceptual model of a Web Service architecture based logistic information system is shown in Fig. 1. The diagram consists of service requester, service register and service provider. There are three main characters in the Web Service model, described as follows:

1.Service provider:
Service Provider uses WSDL to describe the functions and input/output interface in a service object. In this research, four main Web Services are provided, including active push Web Service, logistic management Web Service, GIS management Web Service and user management Web Service. Four Web Services are consisted by functions that a logistic management system need.

2.Service requester:
A service requester can request the connection from service provider based on the information published by service register. For logistic management, a service requester normally represents the devices used for implementing the Web Services. For example, tablet PC (TPC) is used as a mobile device, which can be equipped for transportations.

3.Service register:
Service register provides a place for service provider to post their services and provides a place for service requester to find the services they need. We set up an environment with server farms to publish our designed Web Services with a common interface for service requesters to find services they need and rebuild for applications for logistic management.

In this research, we addressed four main Web Services for constructing our own logistic and apply to

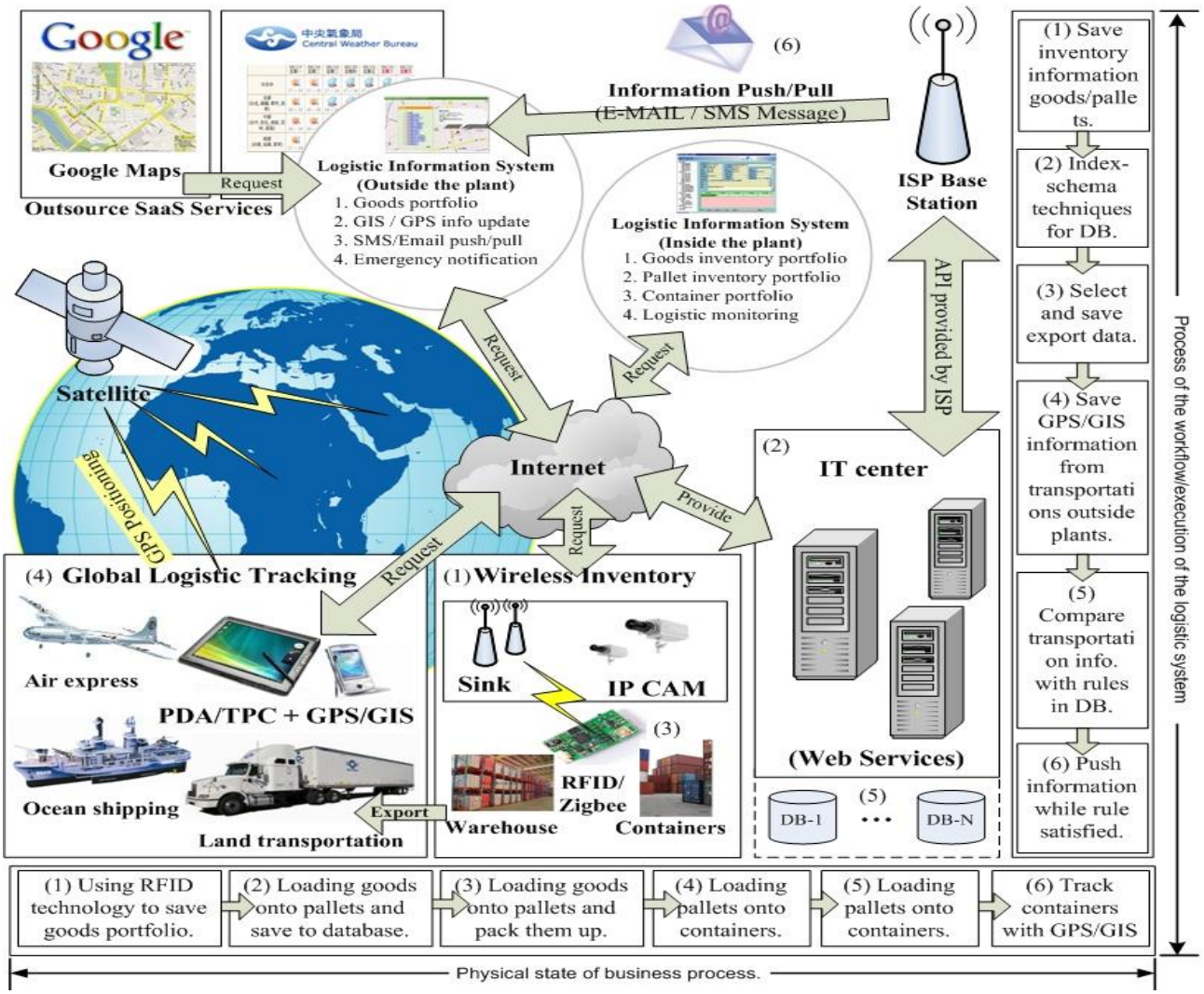


Fig. 2 Scenario of the case study for investigating the feasibility of the developed RMIS.

experimental scenario, listed in Table 2. Four Web Services include Active push Web Service (APWS), Logistic management Web Service (LMWS), GIS management Web Service (GMWS) and User management Web Service (UMWS). They are mainly addressed correspond to all the functions we need in a real logistic system environment. Meanwhile, four Web Services are building according to the concept of the Web Service model of this research.

3.2 A case study for implementing RMIS

To illustrate the applications of RMIS in a logistic industry, a RMIS prototype (Fig. 2.) is proposed, which shows the scenario of our case study for implementing RMIS. There are four main parts setup in our experimental scenario, including RFID antenna, pallet, cargo, and RFID tags. The staff packs all the cargo onto pallets and tight them into a pack. All the pallets will be tagged with RFID tags near it. While the conveyer moves, all the RFID on the pallets will be automatically scanned. Therefore, by operating RMIS and connected to the RFID reader, updating information could be easily obtained. There is a database supporting the above-mentioned resource management process and running the applications of RMIS. Otherwise, for integrating distributed web applications and systems for construction project management, we design of a logistic scenario with workflow with flow description to demonstrate the potential of RMIS to facilitate communication among construction project participants. It also shows the relationships between equipped devices and the services developed in this research.

Table 2 Web Services addressed in our research with descriptions of functions.

No.	Web Service	Functions of Web Service
1	Active push Web Service (APWS)	APSP provides pushing service and pushing content management service for enterprise systems a common interface to use functions such as SMS pushing and Email pushing.
2	Logistic management Web Service (LMWS)	LMSP provides logistic pallet inventory service and logistic pallet monitoring service for user to access logistic data and to inventory pallets with common protocol and data type, which may enhance their ability to exchange data.
3	GIS management Web Service (GMWS)	GMSP provides monitoring service and container manage service for central manage the container information in common protocols. Container security can be enhanced by accessing the services in GMSP to control the monitoring Zigbee devices deployed on the container.
4	User management Web Service (UMWS)	UMWS can be implement for providing a manage platform to enhance the efficiency of user and staff management. User information can be exchanged more precisely and efficiently due to common interfaces between different industries or different departments in certain industry.

For implement RMIS, Windows .NET platform is selected as the environment. SQL Server 2005 is selected as the database and management tool. UHF RFID and HF RFID are selected as the tags for the products of inventory. Moreover, we adapted 3G network as outdoor tracking tool. Transportations for cargo transport are equipped with 3G network card and mobile devices. By implementing with Google Maps on the system designed for logistic transportation, the IT centers in logistic industries are able to locate and track all the transportations while moving and transporting outside the plant. This technology can enhance the safety and the real-time of information of cargos.

Fig. 3 Deployment of UHF RFID on pallets in our case study scenario.

4 Scenario of case study

First, we use RFID technology to save goods portfolio by deploying UHF and HF RFID near the gate of the plant. Second, we load goods onto pallets in order to build pallet portfolio and save them into databases. The staff will load the goods onto pallets and pack them up into packages. Fig. 3. shows the deployment of UHF RFID on pallets in our case study scenario.

Fig. 4. shows the deployment of RFID readers on conveyers in our case study scenario. Then move the pallets into containers. The pallets prepared to be export will be saved into databases. Finally the IT center in the plant can track the information of the transportation by updated to databases through 3G network provided by ISP. Decision makers can access the logistic process information with difference platforms in order to make final decisions.

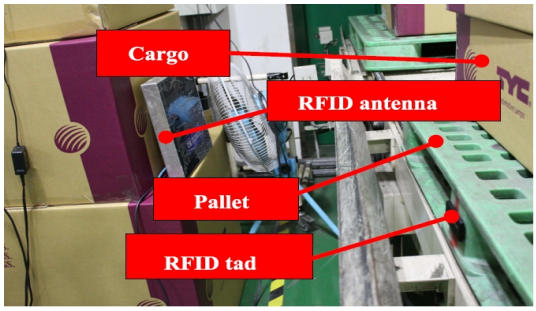


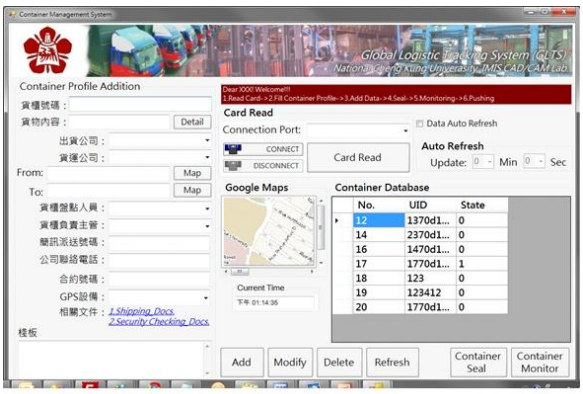
Fig. 4 Deployment of RFID readers on conveyers in our case study scenario.

5 Design and implement of RMIS

The proposed system was implemented. A case study based on a manufacturing companys logistic chain is investigated to verify the feasibility of the developed RMIS. It integrates current technologies, such as information pushing technology, UHF/HF RFID and web portal. For verifying the developed Web Services, we designed three sub-systems as below.

1.RFID logistic information sub-system (RLISS):

(a) Pallet/Good inventory functions.



(b) Pallet/Good export functions.

Fig. 5 System interface of RLISS.

System interface of RLISS is shown in Fig. 5. RLISS is mainly used for inventory of the goods and pallets in the case study. Staffs use PDA or mobile device to inventory goods and pallets for import and export the plant. The functions of RLISS include:

- Pallet inventory/good inventory functions.
- Pallet/good export functions.
- Pallet/good export histories.
- Inventory devices manage functions.
- Company/staff/device/pallet/good portfolios maintain functions.

2.Mobile tracking sub-system (MTSS):
System interface of MTSS is shown in Fig. 6. MTSS is mainly used for tracking the logistic transportations outside plants. Transportation staffs equipped with mobile devices or Tablet PC with 3G network can automatically transmit packages back to information center in plants. The monitoring functions of MTSS can also activate the pushing function while the transportation meets certain conditions such as pass-by certain city. The functions of MTSS include:

- Location uploads functions.
- Route planning functions.

(a) Location uploads functions. (b) Route planning functions.

Fig. 6 System interface of MTSS.

- Emergency feedback functions.

6 Conclusions

The biggest advantage of service-oriented architecture is to provide a strong support for integrations in enterprise applications. In this paper, we integrated SOA structure with promising information technologies for enhance the systems in logistics. The proposed RMIS architecture and model aimed to fulfill the requirements:

1.Ease of installation and configuration for real logistic environments with the integration of Web Service and SOA structure with a real environment scenario deployment in this research.

2.Ease of connection and integration. Devices or machines can easily connect to Web Services provided in our research through the Internet. Moreover, all systems are designed with information and communication technologies.

3.Customizable access to other applications. Exist systems can develop new functions by implementing all the Web Services in our research, which means systems based on our Web Services are flexible. By deploying RMIS into a company, the benefit of the system can be verified and the maintenance costs can be lower down.

Acknowledgement

This research is funded by National Science Council of the Republic of China, Taiwan under grant NSC-99-2221-E-006-176-.

References

[1] D. Sundaram, W. Zhou, S. Piramuthu, and S. Pienaar, Knowledge-based RFID enabled Web Service architecture for supply chain management, *Expert Systems with Applications*, Vol. **37**, (2010), 7937-7946.

[2] G. Lodewijks, H. M. P. Veeke, and A. M. Lopez de la Cruz, Reliability of rfid in logistic systems, *Proceedings of IEEE International conference of service operations and logistics, and informatics*, (2006), Shanghai, China.

[3] W. T. Tsai, Service-oriented system engineering: a new paradigm, *Proceeding of IEEE Service-Oriented System Engineering*, Vol. **1**, No. 3, (2005), 3-6, Beijing, China.

[4] C. John, Jr. Langley, Information-Based Decision Making in Logistics Management, International Journal of Physical Distribution & Logistics Management, Vol. **15**, (1985), 41-55.

[5] S. Hertz, M. Alfredsson, Strategic development of third party logistics providers, Industrial Marketing Management, Vol. **32**, (2003), 139-149 .

[6] Z. Hou, X. Zhou, J. Gu, Y. Wang, T. Zhao, ASAAS: Application Software as a Service for High Performance Cloud Computing, Proceedings of 12th IEEE International Conference on High Performance Computing and Communications, (2010), 156-163, Melbourne, Australia.

[7] E. J. Jaselskis and E. Tarek, Implementing radio frequency identification in the construction process, Journal of Construction Engineering and Management, Vol. **129**, No. 6, (2003), 680688.

[8] J. Yagi, E. Arai and T. Arai, Construction automation based on parts and packets unification, International Journal of Automation in Construction, Vol. **12**, No. 1, (2005), 477-490.

[9] E. Ergen , B. Akinci, and R. Sacks Tracking and locating components in a precast storage yard utilizing radio frequency identification technology and GPS, International Journal of Automation in Construction, Vol. **16**, No. 3, (2007), 354-367.

[10] L. Wang, Enhancing construction quality inspection and management using RFID technology, Automation in Construction, Vol. **17**, No. 4, (2008), 467-479.

[11] H. K.H. Chow, K. L. Choy, W.B. Lee, K.C. Lau, Design of a RFID case-based resource management system for warehouse operations, Expert Systems with Applications, Vol. **30**, No. 4, (2006), 561-576.

[12] W. Zhao, Z. Wang and T. Ku, A novel large-scale RFID integration Architecture based on SOA for supply chain logistics management, Proceedings of 2010 International Conference on Computer Application and System Modeling, (2010), 290-294, Taiyuan.

[13] S. K. Kwok, S.L Jacky, Ting, H.C Albert. Tsang, W.B. Lee, Benny C.F. and Cheung, Design and development of a mobile EPC-RFID-based self-validation system (MESS) for product authentication, Computers in Industry, Vol. **61**, No. 7, (2010), 624-635.

[14] F. Curbera,, M. Duftler , R. Khalaf, W. Nagy, N. Mukhi and S. Weerawrana, Unraveling the Web Services Web: An Introduction to SOAP, WSDL and UDDI, IEEE Internet Computing, IEEE Internet Computing Magazine, (2002), 86-93.

[15] About XML, http://www.w3.org/XML/

[16] RFC-3986, http://tools.ietf.org/html/rfc3986

[17] UDDI.ORG Version 3.0.2 specification, http://www.uddi.org/pubs/uddi_v3.htm

[18] E. Christensen, F. Curbera, G. Meredith, S. Weerawarana, Web Services Description Language (WSDL) Version 1.1, W3C Note 15, (2001).

[19] H. Yin, Q. Fu, C. Lin, Z. Tan, R. Ding, Y. Lin, Y. Li, Y. Fan, Mobile Police Information System Based on Web Services. Tsinghua Science & Technology, Vol. **11**, No. 1, (2006), 1-7.

Chen Shang-Liang received the PhD degree in Mechanical Engineering from University of Liverpool. He is currently a Professor with the Institute of Manufacturing and Information Systems at National Cheng-Kung University, Taiwan. He has published over 40 papers in international peer reviewed journals. His research interests are in the areas of information and mechatronic integration, intelligent remote Monitoring System, PC-based multi-axis controller design, automated optical inspection and CAD / CAM.

Yun-Yao Chen received the B.S. degree in Department of Computer Science and Information Engineering, National University of Tainan, Taiwan in June 2009. In July 2011, he received the M.S. degree in Institute of Manufacturing Information and Systems, National Cheng Kung University, Tainan, Taiwan. He is Certified IT Professional of Microsoft, Adobe and TQC. He received the award of 2011 International Exhibition of Inventions of Geneva, 2010 Taipei Invention Exhibition, 2009 Korea International Exhibition, 2008 INPEX International Invention Award and CSC 2008. His current research interests include Information and Mechatronics Integration Systems, Manufacturing Systems, Object-Oriented Programming, Web Service and SOA, SaaS Cloud Computing and Internet of Things.

Chiang Hsu received the PhD degree in Organizational and Managerial Psychology from University of Wyoming. He is currently a professor in Executive Master of Business Administration, Chung Jung Christian University. He has published over 10 papers and five books. His research interests are in the areas of behavioral science, organization theory and management, management psychology, consumer behavior, industrial relations.