Design and implementation of a global logistic tracking system based on SaaS cloud computing infrastructure

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Abstract: In this paper, we propose a Software-as-a-Service (SaaS) infrastructure for industry logistics, which is normally constructed with the technology of SOA. We then propose a logistic cloud and design with service pools in it and discuss with some related works and references discussions. In the last section, we implement a SaaS-based global logistic tracking system (SGLTS) structure by abstract the web services in service pools in the Logistic Cloud designed in our research with explanations. Finally, we describe a typical system design and scenario in a normal logistic environment with design patterns of it. Logistic transportations in industries can equipped with different devices such as PCs, tablet PCs, laptops, personal digital assistants with Wireless LAN, 3G network and GPS facilities can be able to install the system with different platforms and can access the web services in the Logistic Cloud that we proposed in our research. Prototype systems that we implement in this paper can have better interoperability and reusability than former systems.

Keywords: Service Oriented Architecture, Cloud Computing, Web Service, Global Logistic Tracking System, Logistic Cloud, SaaS

1. Introduction

Modern logistic enterprises need to exchange their data and information more effectively and quickly in order to become more competitive in global markets. According to Moore and Lopes1999, Service Oriented Architecture is a promising computing paradigm for software in a heterogeneous open environment and has received some research support(Tsai, 2005). In service oriented architecture, software systems are built and evolved online by
dynamically discovering and binding to the open services, which are accessible through standard protocols. On the other hand, Wireless communication and network services have substantially changing the landscape of logistic systems. Researches have been proposed to show the importance on integration of logistic built with RFID, GPS, GIS, Zigbee, Web Service technologies and the Internet (Benaissa & Benabdellhafid, 2007; Zhang et al., 2008; He et al., 2009; Kim et al., 2009). However, these researches are usually lack the whole architecture of SOA interacts with web services and their detail management solutions. In our research, we design and implement a SOA-based global logistic tracking system with models and interfaces for enterprises to exchange their data and information more effectively and quickly in order to become more competitive in global markets.

The remainder of this paper is structured as follows. In Section 2, we discuss some related works and references throughout SaaS and SOA-based logistic systems. In Section 3, we discuss the design and implementation of SGLTS with an infrastructure of logistic cloud and logistic service pool. We than discuss the architecture with an overview description of the components and architecture with design patterns. In section 4, we summarize our works and sum up the conclusions and future works of this research.

2. Related Works

2.1. SaaS and Service-Oriented Architecture

SaaS cloud computing infrastructure refers to encapsulate some certain applications into services by adopting SOA interfaces. For example, some companies provide CRM (Client Relationship Management), HRM (Human Resource Management), SCM (Supply Chain Management), ERP (Enterprise Resource Planning) services for industry management systems. However, these services are seldom applied to industry logistic supported by Langley Jr. (1985). Some industries even lag behind the other industries on communication and information technologies (Hertz & Alfredsson, 2003). Current logistic systems in industry are usually designed case by case, lacking the ability to reuse. With SOA technology, departments and companies can componentized their own information and services through abstraction and combination in an unprecedented way (Deng & Xu, 2009). Using SaaS infrastructure can lower the cost of development and lower the cost of maintenance (Cao & Zhou, 2009) for information systems in industries.

In the proposed SGLTS system, we implement the system by design and
implement several service pools such as Active Push Service Pool (APSP), Logistics Manage Service Pool (LMSP), User Manage Service Pool (UMSP) and GIS Manage Service Pool (GMSP). According to the research of Curbera (2002), the interface of web services are defined and described using XML (Extensible Markup Language) and is identified by a URI (Uniform Resource Identifier, provided in About XML(2011). A URI is a compact sequence of characters that identifies an abstract or physical resource, provided in Uniform Resource Identifier (URI): Generic Syntax (2005). Web services can be interoperable with agreement on following standards as XML, SOAP, WSDL, and UDDI. UDDI (Universal Description, Discovery, and Integration) is a standard for web services to register and publish services available to users discussed in UDDI.ORG(UDDI.ORG 2001). WSDL (Web Services Description Language), 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 clarified by Christensen et al.(2011). SOA defines a base communication protocol for users to exchange XML data. The GLTS SOA model of Web service-aware TPC and PC in our system interact with the Web Service provider and the Web Service Register is shown as Fig. 1, which can have numerous advantages according to the research of YIN et al.2002 is describe as below:

(1) It enables handset manufacturers to rapidly deploy Internet solutions build on open standards.

(2) It makes applications more dynamic as they can invoke different services or service implementations based on the user’s context.

(3) It facilities the interoperability and integrate with enterprise applications and applications running on other wireless devices.

There are three main characters shown in the web service model (Figure 1), describing as follows:

(1) Service Provider: A Service Provider uses WSDL to describe the function, input, output interface in a service object.

(2) Service Requester: a Service Requester request for the connection from service provider by the information published by service register.

(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.
2.2. Logistic System Based on SaaS

Z. Jing et al. proposed a logistic system based on SOA and proposed a solution named Logistics Resource Sharing Grid (LRSG), which is an advanced solution for the bottleneck of network logistics. The paper proposed a service-oriented architecture based LRSG is suggested, which validates the resource sharing and business collaboration in the LRSG. The model (Zhang et al., 2002) is composed of 5 models and the model is shown as figure 2 and described as follows:

(1) LRSG Infrastructure layer:

This layer abstracts different information infrastructures into a uniform logical entity by using OGSA Grid foundation framework and Grid middleware and masks differences brought by heterogeneous platforms.

(2) LRSG Resource layer:

This Layer refines and optimizes the Grid Infrastructure layer. The paper developed four customized grid services, namely Task Management Service (TMS), Resource Management Service (RMS), Business Collaboration Management Service (BCMS), and Security Management (SM).

(3) LRSG Service layer:

This layer is the core layer of LRSG, it can access and manipulate different kinds of logistics resources in the basic layer through standard OGSI Grid service interface.

(4) LRSG Application layer:

This layer includes three modules namely Task Decomposing Service (TDS), Task Scheduler Service (TSS), and Computer Supported Collaborative Business
According to this structure, we can refer that the independent environment of LRSG has benefits for SOA-based applications deployment. The proposed system of LRSG is based on GT (Globus Toolkit), which is usually used in grid environments, providing services a platform to exchange. It may lake the efficiency of development due to the services in GT usually needs to implement separately for different grid nodes. Although the SOA-based models of the research seem to be complete, the implementation results of the systems need to be satisfied.

L. Zhang et al. (2006) describes a general design for the integration of distributed logistics information system based on service-oriented architecture (SOA) and enterprise service bus (ESB). An ESB gives a tool and an infrastructure facilitating implementation of the SOA structure. The author proposed a SOA model for the system in the research (Figure 3). In this model, all the services are stored in services warehouse for reuse purpose. Although the proposed model in the paper can briefly describe the idea of logistics information system, the model is not complete satisfied the whole structure of SOA infrastructure.
3. Design and Implementation of SGLTS

3.1. Architecture of Logistic Cloud

This study is based on the principle of SOA, which exchange by the data type of XML. We implement the SGLTS system with a private cloud computing architecture based on 4 layers, shown as figure 5 named as Logistic Cloud. The architecture is constructed with 4 layers as Resource Pool Layer (RPL), Middleware Layer (ML) and SOA Architecture layer (SAL) and is described as below:

(1) Physical Resource Layer:
The structure of PRL is responsible for data storage and software/hardware infrastructure; include computer, database, network equipment, storage, software etc. We setup physical resource environment with five individual servers for five service pools. Figure 4 shows the hardware used to implement Logistic Cloud.

Fig. 3: SOA model for logistics information system.

Fig. 4: The hardware used to implement Logistic Cloud.
(2) Resource Pool Layer:

RPL integrated by some existed type sources and web services into service pools such as Active Push Service Pool (APSP), Logistics Manage Service Pool (LMSP), Container Manage Service Pool (CMSP), User Manage Service Pool (UMSP), and GIS Manage Service Pool (GMSP) for enterprises and clients to access through SOA standard protocol. Services can be abstract by system developers with different platforms when designing applications. Services in service pools are describe in table 1.

<table>
<thead>
<tr>
<th>No.</th>
<th>Service pool</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>APSP</td>
<td>APSP provides pushing service and pushing content management service for enterprise systems a common interface to use functions such as SMS push and Email push.</td>
</tr>
<tr>
<td>2</td>
<td>LMSP</td>
<td>LMSP provides logistic pallet inventory service and logistic pallet monitoring service for logistic departments in enterprises to access logistic data and to inventory pallets with common protocol and data type, which may enhance their ability to exchange data.</td>
</tr>
<tr>
<td>3</td>
<td>CMSP</td>
<td>CMSP provides Zigbee container monitoring service and container manage service for enterprise to centralize manage the container information in common protocols. Container security can be enhanced by access the services in CMSP to control the monitoring Zigbee devices deployed on the container.</td>
</tr>
<tr>
<td>4</td>
<td>UMSP</td>
<td>UMSP provides enterprise a common manage platform to enhance the manage ability of user and staff management. Use information can be exchanged between different departments more precisely and efficiently due to common interfaces.</td>
</tr>
<tr>
<td>5</td>
<td>GMSP</td>
<td>GMSP integrate the existing Google Maps API as services such as Google Maps positioning service and GIS information manage service. This service pool provides transportation with devices to access certain service to automatically report its location. Enterprises can real-time track the pallets and cargo by access the services in GMSP to enhance the transport progress.</td>
</tr>
</tbody>
</table>

(3) Middleware Layer:

ML is responsible for handling tasks such as User Management (UM), Task Management (TM), Resource Management (RM), and Security Management (SM). User Management is an indispensable task to implement the business model in cloud computing, including user management, user environment deploying, user data exchange and management, and user log; Task Management is responsible for execute and manage applications request by users, including call service task, execute service task, service lifecycle management, service deploy and management.

(4) SOA Architecture Layer:

SAL provides the ability for our system to encapsulate our cloud computing into standard functions such as service connection, service enroll, service
searching, service visiting, service scheduling. In common develop environment, the key technology are the ML and RPL. The SAL is commonly handled by develop environments. As the clients ask for certain data in the inner part of the databases through SOA protocol in SAL, the ML will handle the service acquisition tasks and security issues.

Fig. 5: Architecture of Logistic Cloud.

3.2. A Scenario Example of SGLTS

To illustrate the SGLTS for construction industry applications, a SGLTS prototype of logistic scenario with workflow (figure 6) is proposed with flow description to demonstrate the potential of SGLTS to facilitate communication among construction project participants, and to integrate distributed web applications and systems for construction project management. The scenario demonstrates the integration of industrial applications and transportation equipped devices interact with service pools developed in our research are describe as below:

1. First, deploy UHF RFID readers with computers alone industry gates then connect the computer to the Logistic Cloud through the Internet.

2. Pallets can automatically inventory by using inventory services while exporting/importing to the industry. The inventory data saved in the databases of the Logistic Cloud by accessing data manage service.
(3) The inventoried pallets will be transported to cooperate industries. The transportation vehicles will be equipped with portable devices to return GIS information of their position. The information can be automatically updated to databases in the Logistic Cloud and servers through 3G network provided by ISP.

Decision makers can access the logistic process information with different platforms in order to make final decisions.

![Diagram of SGLTS prototype of logistic scenario with workflows.](image)

**Fig. 6:** SGLTS prototype of logistic scenario with workflows.

We selected GPS receiver module shown in Figure 7 and the device equipped with the logistic transportation shown in Figure 8 for our global logistic tracking system. We implement web services for logistic tracking, combined with Google Maps API for GIS service.

![GPS receiver module.](image)

**Fig. 7:** GPS receiver module.
Fig. 8: The description of service pools in the Logistic Cloud.

To illustrate the SGLTS for construction industry applications, two example implementation results we developed in our paper are shown in the following sections. The first example is a SGLTS sub-system scenario for pallet inventory. Second one is a SGLTS sub-system scenario for global logistic tracking, which are describe as below. We proposed two models by using the tool of UML Use Case Model to illustrate the concepts of the two implementation results.

(1) Implementation of pallet inventory sub-system:
The use case model of pallet inventory sub-system is shown in figure 9. All the departments (decision maker, manager, delivery person) in industries can access the private services through the cloud database we established. Figure 10 shows the system interface of pallet inventory sub-system.

Fig. 9: Use case model of pallet inventory sub-system.
The functions of pallet inventory sub-system are for consisted of following functions listed as below:

- Pallet Inventory
- Goods Inventory
- Pallet/goods export
- Pallet/goods export histories

(2) Implementation of global logistic tracking sub-system:

The use case model of global logistic tracking sub-system is shown as figure 11. All the departments (decision maker, manager, delivery person) in industries can access the private services through the cloud database we established. Figure 12 shows the system interface of global logistic tracking sub-system.
The functions of global logistic tracking sub-system are for consisted of following functions listed as below:
• Logistic route planning and tracking
• Pallet/goods on transportation listing
• Transportation information Email/SMS pushing
• Road/weather condition display

4. Conclusion

The biggest advantage of service-oriented architecture is to provide a strong support for enterprise applications integration. In this paper, we prototype the service oriented architecture of our research and propose the service pools for our system implementation scenarios with some related works and references. The proposed SGLTS architecture and model aimed to fulfil the requirements, which are (1) ease of installation and configuration, (2) low cost, (3) ease of connection and integration, (4) customizable access to other applications. We describe the typical design implementation scenarios and design patterns of our system which logistic transportations can equipped with different devices with different platforms such as PCs, tablet PCs, laptops, personal digital assistants with Wireless LAN, 3G network and GPS facilities to access the web services we proposed in our system. Pallets can be inventoried by abstract services in the Logistic Cloud. Cross-platform concepts can be satisfied when system engineers to develop applications based on the Logistic Cloud.

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References


