A service-oriented travel portal and engineering platform

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1. Introduction

A service-oriented travel portal will be proposed to implement a classic business model with SOA paradigm. It provides tourists with composite travel packages through dynamic composition among travel-related services from distributed service providers across business domains. Considering that a travel portal is a typical service-oriented platform to support resource sharing and business coordination, the authors decided to develop a framework and a dedicated development environment for service-oriented travel portals, and it could be customized for the service-oriented systems of other industries using a similar framework and approaches to those presented in this paper.

2. Background and related work

In our previous work we proposed a multi-model driven collaborative platform for service-oriented software engineering, and for
generic e-Business systems (Li et al., 2008). This platform is being developed to have three basic modeling views, i.e., business view, process view, and service view. The platform is a collaborative development environment for engineers and consultants from IT vendors or businesses such as business consultants, technical consultants and solution designers. The platform allows them to use customized views to model their requirements according to their expertise and languages. The platform supports rapid service-oriented e-business analysis, planning, process reengineering and application integration. Various stakeholders can use special views designated for their roles to collaborate on a service-oriented e-business system over geographically distributed sites. In another work, we designed a service-oriented digital city framework and customized the platform for features and requirements of digital cities (Zhu, Li, Shi, Xu, & Shen, 2009). The initiative for digital city framework is from a project funded by municipal government. The project had been accomplished and the research on its development platform was hard to get down into the implementation.

Since 2006, authors took part in another project for travel portal. With fast-emerging tourism resources, infrastructure and services, tourism is becoming a critical economic activity for China. During the past few years China has put many measures in place to develop travel resources and marketplaces. Tourism has contributed to a large amount of income to the ten cities such as Zhourshan, Mianyang, Huangshan, Hangzhou, Beijing, Suzhou, Guilin, and Kunming. Encouraged by past successes, the China central government, provincial governments and municipal governments have initiated many programs to develop new tourism models and infrastructure that meet the needs of modern tourism industry (China Industry Research, 2009).

Service-oriented architecture (SOA) is becoming a leading paradigm for system engineering and applications integration (W3C, 2010). There are thousands of Web-based travel sites and online ticketing systems. Two of the most popular systems in China are ctrip.com (Xiecheng Computer Technology Ltd. Corporation, 2010) and tickets.com (Shanghai Zhanglei Information Service Consulting Ltd. Corporation, 2009). However, most of these systems only cater for ticketing agents and the ticketing systems, and they do not provide the services such as tourist spots tickets, tour guides and other services beyond travel and hotel reservation. In addition, there is no trustable cooperative platform for service providers. Thus, development of an SOA based portal was required to streamline travel-related services from various modeling and design points of view. Further, intelligent route planning services (Niaraki & Kim, 2009) and service discovery and management services (Leea & Park, 2009) should be employed to make the Web systems to provide better user experiences. We designed a collaborative travel service portal with multi-level authentication for the project (Li, Xie, Zhu, Dong, & Chao, 2009). The work presented in this paper is a part of these initiatives.

Service-oriented software engineering methods, development tools, delivery platforms and performance monitoring tools are required to model, design and develop complex Web services applications. A majority of software engineering methods applied to SOA applications are based on object-oriented paradigm. It is necessary to develop tools and techniques in order to address this issue in SOA applications. For example, Yu-Liang Chia and Hsun-Ming Lee proposed a formal modeling platform for composing Web services (Chia & Lee, 2008). The mentioned SOEP is suitable for service-oriented system but not for object-oriented system design. Service-oriented engineering platforms overlook programming issues and support business and process design to incorporate SOA features of loose coupling, semantic description discovery and cross-platform composition. The proposed platform describes both business and design concepts and elements in a well-defined structured and processable format. To implement a service-oriented system the developers need to capture business requirements and incorporate them into IT systems. The proposed platform has been designed on WSDL (Farrell & Lause, 2009), BPMN (OMG, 2009) and WS-BPEL (OASIS, 2007). As a result, the proposed platform can accurately represent business logics, the context and function of the services, service operations at abstract level, interface design and expressions of service design.

3. Service-oriented travel portal

3.1. Motivation

A service-oriented travel portal is being developed by authors for Shanghai World-Expo and Yangtze River Delta in China. A travel alliance has been set up to share resources and infrastructure across the delta to contribute towards the success of the portal. In the portal the tourism resources, services and information are a kind of public goods and distributed in different cities and domains that needs to be composed and delivered to travelers according to their requirements. The portal combines resources and services of bus companies, hotels, rail companies and sightseeing vendors to provide travel packages to clients. The proposed portal could be viewed as an online ticketing window as compared to their current offline ticketing offices.

With tourists’ demand for personalized and diversified services, travel service providers need to build a powerful platform for information services and information interchange to provide integrated one-stop tourism products. There has been some progress on cooperative travel portal for distributed resources and service sharing, for example, the ticketing system of Shanghai tourism hub is now not only a travel hub of Shanghai’s ticketing, but also as a tourism hub in the Yangtze River Delta and provides ticketing services to other parts of the Delta. However, with many tourism hubs for Yangtze River Delta, there are many heterogeneous problems with geographic distribution, service systems, data protocols and standards.

3.2. Technical architecture of the portal

The proposed travel portal is to apply service-oriented architecture and Web services to the planning, design, implementation and integration of a travel portal, and to make the portal flexible and responsive to meet dynamic service composition and evolvements. Service-oriented architecture aims to increase the travel portal’s manageability through the design of large granular services to be constructed from smaller ones, to split up a complex problem into smaller problems to be solved independently, and to improve openness and flexibility. With the SOA paradigm, it is easy to add new services, upgrade, replace or remove existing services without affecting the others.

As can be seen from Fig. 1, further, the portal is designed to be a Internet-based distribution center and provided services for resource sharing, route scheduling and service management across industries, businesses and locations. From the geographic side, the portal is a joint travel e-marketplace for providers and tourists across counties, provinces and cities. This unified e-marketplace is helpful to reduce barriers between economic entities and provide a one-stop travel service for tourists.

The developed portal provides a number of options for the consumers to choose for their desired trips. The services the portal provides include flights, hotels, train/ship/coach ticket booking. It also offers travel packages and some highly recommended packages for the consumers. The consumers are allowed to choose and compose their own packages in the system. So, the system needs to be able to optimize their selections in order to propose...
the best deals for them. This involved a large of numbers of companies and their existing software systems which are often developed in different hardware platforms, programming languages and located at different sites. The workflows among these vendor software systems are very different. In addition, the terms they used are inconsistent. To enable these systems to work together seamlessly presents a great challenge.

A number of tasks (such as defining their programming interfaces, using coherent terms via ontology, and finding the missing steps in the processes, etc.) had to be carried out, before the proposed platform could be introduced. Some of the above issues still appear during the modeling process. Therefore, the proposed platform is used as a mediator to identify and alleviate their differences. In general, the portal applies service-oriented and model driven approaches to design large granular services constructed from smaller ones, and to splits up a complex problem into smaller problems to be solved independently to improve interoperability and flexibility. The Web services were used to wrap the existing systems to provide coherent interfaces for collaborations. Since, the number of loosely coupled Web services available in the repository is not trivial, the consumers may change service providers regularly based on specified criteria such as price, reliability, security, credit, or a weighted performance utilities of these elements. In other words, the required services can be identified at runtime and can be composed dynamically with inclusion of appropriate processes. A service search engine is critical for the loosely coupled service-oriented applications to select emerging Web services regularly and automatically across the Internet.

### 3.3. Functional requirements of the portal

The portal is a Web-based online ticketing system. It is a middleware that integrates travel Web services to provide travel packages to consumers. The portal performs dynamic service composition among buses, hotels and scenery tickets to prepare travel packages and travel route scheduling. It also provides an information management system for service providers to manage their resources, services and income.

The portal is for multi-level users, including distribution centers of different cities. Each center is covered by multi-level user roles. The business process includes functions such as setting tourism route, design ticket category, presetting transportation schedules, accommodation and sightseeing resources, auditing cost, booking ticket, managing club members, cross-center service proxy and so on. The portal also meets the needs of the member entities of the alliance of independent operation management at the same time supports the cross-system and cross-organization business activities including a variety of business models of cooperation and settlement management. In particular it needs to establish efficient mechanisms for rights control supporting the complex organizational structure of users' rights and flexible roles. The portal should include the following functions:

1. **System management**: It includes system parameters settings to set all kinds of value that affect system's running, organization management to set the affiliation of all the tourism
entities registered in the system, role management to map the system operating rights to the registered organization and user management.

(2) **Service product management**: It includes tourism circuitry configuration, ticket category design, cross-center circuitry sharing management.

(3) **Service resource management**: It includes vehicle management involving bus, ship, railway and airline scenery spot management, hotel room management, tour guide management, and related public information management.

(4) **Operation management**: It is concerned with transportation plan to schedule vehicle according to the tourism circuitry, vehicle transportation monitoring, hotel room schedule and ticket paper management.

(5) **Business operations**: It includes online/offline ticket sales management, ticket reclaim data upload, ticket refund, tourist satisfaction queries and promotion activity management.

(6) **Statistical inquiries**: This functionality is concerned with the ticket sales daily report, vehicle transportation daily report, tourism circuitry daily report, hotel room occupation daily report, scenery spot person-time daily report and user satisfaction daily report.

(7) **Financial settlement**: It includes financial settlement processing and organization account balancing.

(8) **Member management**: It is related to member credit management and member history travel track.

### 3.4. Travel alliance and service providers

We put forward a concept of cross-regional travel alliances to make the portal to accommodate more quality services to meet today’s modern travel market. The alliance includes not only the tourism hubs, but also transportation companies, hotels and scenic spots. The members of the coalition may decide to join in or leave according to the need of resource-sharing. The cooperation and interaction between members is completely specific to tourism business opportunity and resources need. This feature makes it appropriate to have a neutral third party to manage and operate the travel portal of the coalition in order to support dynamic collaboration. The organizational structure of the dynamic travel alliance is shown in Fig. 2. It includes various roles such as chief administrator of coalition, administrator of distribution center, vehicle ticketing administrator, ticketing dispatcher, hotel administrator and scenery ticket checkers.

### 3.5. Service discovery with travel ontology

This work will develop a discovery service to precisely find suitable travel services to compose travel packages according to user requirements. A travel ontology and package composition rules make a big difference in improving the matchmaking precision. The discovery service has a service meta engine to invoke distributed service search engines to accomplish Web services search task. A travel Web service ontology provides semantic Web service

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Fig. 2. The organization of the travel portal.
description to be a prerequisite for service matchmaking, which is usually linked to several existing general ontologies, e.g., WordNet (WorNet, 2010) to get basic service knowledge. Semantic Web service matchmaking engine is the key to combine and process the search results to find the best-fit Web services. Matching algorithms are developed for the semantic Web service matchmaking engine to process outputs from UDDI (Luc, Andrew, Claus, & Tony, 2004), ebXML (The OASIS ebXML Joint Committee For OASIS, 2010), and SAWSDL (Farrell & Lausen, 2009) discovery services.

The discovery service will make difference in that the discovery service (i) uses a matrix of description elements for search precision (ii) uses semantic dictionary to make its engine intelligent and capable of self-learning, (iii) uses meta-search techniques to utilize multiple Web services registration sites. The matchmaking engine is able to process Web services descriptions in UDDI, ebXML or SAWSDL. In this work, SAWSDL based Web service modeling and searching is being developed. By introducing SAWSDL into the service view, semantic description for the functions of Web services have been achieved, and Web services matchmaking accuracy has been improved. The matchmaking approach will be proposed to assume that service providers use SAWSDL, and both of the requester and the provider will supply the semantic description. The service view makes a match for their semantic descriptions for Web services and selects the proper Web services for requester. The service view contains two components. One is semantic definition of the Web service, including service name, operation, input and output parameters with the semantic annotations in the files of XML schema and the addresses of WSDL files for matching.

4. Service-oriented engineering platform for travel portals

4.1. A service-oriented engineering platform

A secure, reliable and efficient framework is required for rapid development of service-oriented travel portal. The framework should provide a generic system model and common infrastructure for development and runtime environments. Currently the popular frameworks supporting Web services are J2EE and .NET. Based on these two basic frameworks, some major application vendors, such as SAP and Oracle have provided SOA business platforms (Fricke, 2004; SAP, 2004).

A devoted service-oriented engineering platform is prerequisite for service-oriented travel portals to be accepted and put into practice efficiently. A multi-model driven collaborative platform is being developed and customized based on the proposed travel portal based on authors’ previous work (Li et al., 2008). The platform is designed for service-oriented software engineering and will have three basic modeling views, i.e., business view, process view, and service view, to model and design a travel portal (see Fig. 3). A travel ‘business’ is supposed to be composed of a single or a set of travel-related services. The business view is to model the travel processes from high to bottom levels independent of computing systems and their locations. The consultants with business background can model travel-related service interactions and processes. The process modeller translates the processes into BPEL-based models, and engineers with technical background improve the processes in the process view. Engineers and consultants can find and define travel services and add them in the subject businesses and processes in the service view.

The platform of this paper is in fact a set of software tools which allow design and implementation of SOA applications in a consistent and effective way. The proposed platform caters for the needs of various stakeholders involved in development and deployment of complex travel portals. The platform allows to model business process graphically and it automatically generates codes from these models. The three views provide basic modeling tools to support service-oriented engineering and application developments. The proposed views are driven by three models, respectively, i.e., service meta model, process model and business model. The service model supports semantic travel service description and operations, the process model is concerned with the Business Process Execution Language for Web services (BPEL4WS) and the business model considers services, providers, adapters and their relationships for specified businesses.

The SOEP extends our previous collaborative development platform to ensure the consistency among its various views based on the usages of travel portals. It also incorporates design information in our previous proposed platform. This extended platform is associated with a rule base mechanism dedicated to maintain consistency amongst the all models. The rules form the templates to build the required elements of the service-oriented models and to facilitate design processes. The representative elements cover the related concepts of travel service types, service identities, service sequences, business objects, assembly models, and service activities, etc.

4.2. Modelling views of the platform

The business functions can be derived from organizational structures/functions or others. These functions can be realized by either the computer systems or humans. For example, a manager may be involved to make a final decision. A high level business function normally consists of a number of sub-functions and these functions form some kind of relationships through interacting with each other. The business view allows these functions to be modeled and decomposed into more detailed functional units. The outcome of this view is a business model which includes the essential business functions and the detailed descriptions to form these functions without involving the issues relating to business processes and computational implementation.

The process view explicitly defines the relationships or interactions among these business functions. These relationships include
the sequence of the business functions to be performed, the conditions of their interactions, and possible parallel execution, etc. Therefore, the required inputs of one business function which can be obtained by the outputs of other functions need to be defined explicitly. The start and the end of the whole process also required to be defined explicitly. In the modeling process, the process view starts with describing the relationships among the high level business functions, and then models the interactions among sub-level functions. In other words, more detailed processes will be specified among the basic functional units. A top-down approach is adopted to model business’s functions and processes.

The service view is a bottom up approach which starts with identifying atomic services (basic unit of services) or composite services which are available in the repository to support the basic function unit. The repository here means a collection of service repositories which could be distributed. If there is no service available, a new service needs to be created. The creation of a new service can be constructed from scratch or via composition of the existing services. Ideally, a basic business function will have a corresponding service to support, so a high level function should be realized by a collection of composite services.

However, the model mismatch between business functions and services often occurs, so the modification on the services is required to meet the requirement of the business functions. These mismatches also help the business manager and the system developer to realize the inconsistencies among some business requirements or to identify some functional requirements are not realistic. This leads to modifications of business model and process model. Another round of system modeling is required. These processes will be iterated until all business functions can be realized and their consistency can be maintained. The proposed platform is equipped with the essential tools and services, and can be used by the portal designers and developers to facilitate the portal development and maintenance in an effective and consistent way. The platform also provides a number of templates to business, process, and service views. These templates are generic models that can be instantiated to meet specific applications’ requirements. An instance of a template can be modified or includes features to minimize the efforts in modeling and reduction of incoherent processes.

The overall architecture can be seen as a model-driven architecture which is characterized by separating business logics from underlying platform technologies. The architecture provides a set of tools that allow the developers to specify a system independently of its operating platform. For instance, there are four models to support the three modeling views and their consistency translation, i.e., Web service meta-model, service-oriented process model, service-oriented business model, and domain design information model. The developers can use these views to specify the conceptual models which can be used to generate code at later stage.

4.3. Consistency between the modelling views

As presented in the previous work (Li, Zhang, Chen, & Huang, 2009) and illustrated in Fig. 4, the basic global information model which extends multi-model driven collaborative platform is composed of properties of businesses, processes and services of the systems. The system information has a mechanism to manage various system versions to ensure that they are consistent. It also includes design information which is composed of required services and business logics. Domain information can be broken down into domain template and domain services. The domain template includes a set of good business practices in the applications that can be reused to model new applications. The domain services are implemented to support the realization of the particular domain. The platform information contains a collection of customized collaborative platform which consists of different specified models (businesses, processes, and services) to support different domain applications. The platform is open to accommodate new system requirements. It produces different versions over time which requires a version management mechanism to handle them. The property values in these information models are captured by business analyzers and technical consultants in order to incorporate design information in an engineering platform. The global information model is also associated with a rule base. The rules are derived from the experiences and knowledge in the modeling and designing of service-oriented applications.

4.4. Modelling tools with the modeling views

The proposed platform provides the various views of the system. Several tools have been developed to compose these views for travel portals. Fig. 5 shows the composition of business view. The left side window consists of a collection of travel-related services in the repository for the developers to select and modify. It also contains a number of function buttons for the developers to define the relationships among these services and add new travel services. On the right hand side of the window, it demonstrates a number of services having been selected and composed to meet certain requirements. The numbers shown in the line is the sequence of executions of these services. The process starts with 1. The arrow direction indicates the information flow. In the bottom

![Fig. 4. The structure of the global information model.](image)
of the left-hand window, the table shows the properties of a particular service which include name and its associated value. The developers can use the built-in drag and drop functions to define the system specifications. The system also offers similar functionalities to support different levels and views of modeling in the conceptual stage. Once the system has been specified completely, the platform can check the consistency among these models. The pattern and Java Marshall/Unmarshall codes can be generated automatically based on the developed conceptual model. We will use travel portal as an application to examine the feasibility and functionality of the proposed platform. The travel portal provides an interesting and challenging business model for the study, as it has evolved from information systems of tour bus centers, which are getting great success around China and have become a major travel model. So, it requires more flexibilities and facilities to manage complexity.

5. Evaluation of the travel portal and its engineering platform

A service-oriented travel portal is being implemented based on a project to develop a travel portal for Shanghai World-Expo. The proposed portal architecture and modeling, and the engineering platform SOEP is considered to be development environment. The portal provides online travel packages for tourists through dynamic composite services from distributed service providers across business domains such as vendors for bus, airline, taxi, guides, scenery and hotel. According to the platform’s usage, the portal implementation starts a business model at business view, as illustrated by Fig. 6. Travel services and their providers are defined in this view. The processes and the process controllers are defined in this view. The processes and the process controllers can also be defined through double clicking a link in the business view and invoking a process controller definition dialog, as shown in Fig. 7.

Please see Fig. 5 for a defined business scenario through the above operations.

Double clicking on a link between the service providers will invoke a process modeling view. The involved services and their interactions are defined in this process view, as illustrated by Fig. 8. In the process view, double clicking on a travel service will invoke the service view to define its description such as input and output, as illustrated by Fig. 9.

So far, the engineering platform and the proposed design and development methods have been evaluated for the service-oriented travel portal. However, the platform has not been used for the real portal because the service providers have not provided travel services through Web services and the platform also need further improvement for service composition and deployment. As to the travel portal, the proposed functional modules of the travel portal have been developed, including front-end user interface and back-end management system. The travel portal is being delivered to Shanghai Tour Bus Center for beta test and then for travel services of World-Expo.

Through a service-oriented architecture, the travel portal has made several successes compared to traditional travel model and current popular travel Web site. This travel portal eliminates the bottleneck and enhances the functionality, agility and scalability. Table 1 shows the performance evaluation of this travel portal against Ctrip.com which is the most popular travel Web site in China.

Adopting SOA and using the proposed platform to develop Web-based applications brings a number of advantages such as reduction of developing time, improvement in acquainting user and system requirements due to fast prototyping, the increase of system flexibility in terms of adding and removing services, and less effort in maintenance, etc. In addition, the platform can be considered as a tool for mediating differences among stakeholders during the system development.
6. Conclusions

The subject travel portal implements a classic business model driven by SOA paradigm. It provides tourists with composite travel packages through dynamic composition among travel-related services from distributed providers across business domains. The portal is a classic collaborative infrastructure and requires a professional service-oriented engineering platform to facilitate its design.
and implementation. A secure, reliable and efficient framework is needed for rapid development of the portal. The framework should provide a generic system model and common infrastructure for development and runtime environments.

A common implementation framework and a devoted service-oriented engineering platform are prerequisite for the travel portal to be accepted and put into practice efficiently. In this paper we present a service-oriented engineering platform, which is reengineering and customized to implementing service-oriented travel portals, which have been described in previous work. The proposed platform is a set of tools that allows modeling and design of complex SOA applications from various stakeholders’ perspectives. The platform also allows using pre-existing templates in the development SOA application thus contributing to reduced application development and deployment time. The professional and devoted platform is made in this paper oriented to the implementation issues of the travel portal. Authors believe the implementation issues and methods are common for service-oriented systems and development environments. The proposed engineering platform could be customized for the service-oriented systems of other industries as well as of travel industry.

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