SERVICE-ORIENTED WORKFLOW: CONCEPTS, ARCHITECTURE AND KEY TECHNOLOGIES

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ABSTRACT

The advent of Grid and SOA (Service-Oriented Architecture) technologies has brought new opportunities and challenges into the area of workflow. Service-Oriented Workflow (SOWF), which integrates web service and workflow technology, has become a mainstream for flexible integration among heterogeneous systems. In this paper, firstly the definition of the service is proposed with a three-dimensional model and based on a detailed analysis of the characteristics of SOWF, the architecture of SOWF including the user interface layer, the operation logic layer, and the persistent storage layer is presented. As key technologies, process modeling, process execution, workflow implementation technologies, transaction management and performance evaluation are discussed respectively. Finally, an application demonstration of SOWF is given to prove the advantages of applying service-oriented technology in the field of workflow.

KEYWORDS
Service, Service-Oriented Workflow, System Architecture, Process Modeling

1. INTRODUCTION

Web services technology has become a new wave for Internet-based business applications (W3C, 2002). It has brought to the world a loosely coupled environment that enables flexible integration among heterogeneous systems. Under such circumstances, service and workflow are close related: workflow can be constituted with service, and workflow itself can be encapsulated into service as well. Thus it appears a new tendency that combines web service and workflow technology together. Because of the loosely coupled, autonomous and dynamic nature of service, the operation mechanism of workflow meets some new characteristics and difficulties.

Many researchers have carried out their studies in this area. For example, Zhou et al (2004) regarded every activity in workflow as service, automatically executed by the agent. Xiao et al (2004) proposed a conceptual model of Web services workflow. Zhao and Liu (2006) studied the modeling and implementation of organization-centered workflows in the Web service environment. IBM developed a workflow management system "intelliFlow" on the basis of SOA for business process management. HP Laboratories proposed a service composition model and realized a prototype system (Casati and Shan, 2001). Grid workflow has also become a hotspot (Oinn et al, 2004).

As a result, a new workflow paradigm, Service-Oriented Workflow (SOWF), comes up into being. However, most above research merely concerns a specific part of service-oriented workflow, lacking the research on integral architecture and implementation technologies. Consequently, it is hard to unify existing research to a common foundation. Moreover, few of them proposed an explicit definition of service-oriented workflow, thus the understanding of which is confused.

In order to address these issues, we analyze the characteristics of SOWF and give out the concepts of service and service-oriented workflow. Then the architecture of SOWF is proposed, based on which the key technologies are discussed and summarized in detail.
The rest of the paper is organized as follows. With a definition of service in Section 2, we present the characteristics of SOWF in Section 3. The architecture and five key technologies of SOWF are described in Section 4 and 5. Section 6 introduces an application demonstration of SOWF. Finally, conclusions are given in Section 7.

2. DEFINITION OF SERVICE

A new field called Service Science has become the focus in recent years, but there still lacks a uniform definition of service. In this paper, a service is defined as an IT-enabled or IT-innovated functionality involving certain business process or activity, which is offered by a provider. A three-dimensional service model is proposed as shown in Figure-1, which describes service from three views.

![Figure 1 –Three-dimensional service model](image)

**Construction**
- **Description**
  - Configuration
  - Inputs/outputs
  - Constraints
- **QoS & Measurements**
- **Inputs/outputs**
- **Constraints**
- **QoS & Measurements**
- **Lifecycle**
  - **Design**
  - **Deploy**
  - **Execute**
  - **Maintain**
  - **Genericity**
    - **Generic**
    - **Partial**
    - **Particular**

3. WORKFLOW IN SERVICE-ORIENTED ENVIRONMENT

Service-oriented workflow (SOWF) is the business process partly or totally executed by the computers automatically in service-oriented environments, partial or entire activities in the business process are completed by services in Network. In other words, SOWF is a composition of web services for the purpose of special tasks.

4. ARCHITECTURE OF SOWF

![Diagram of SOWF architecture](image)
5. KEY TECHNOLOGIES FOR SOWF

5.1. PROCESS MODELING
Different from traditional process modeling, service-oriented workflow model includes normal tasks and service nodes, so the main issue of process modeling is the mapping from business processes to service resources and the composition of service resources.

5.1.1. Service Process Modeling Method

Existing process modeling methods comprise two types: formal method based on Petri-net and process algebra, informal method based on business process description language. Table-1 lists several typical methods.

<table>
<thead>
<tr>
<th>Category</th>
<th>Language</th>
<th>Description</th>
<th>Proposed year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Informal method</td>
<td>GSFL</td>
<td>An effort to examine technologies that address workflow for Web services and leverage this technology for Grid services. It contains both an XML schema definition for the specification of workflow in Grid environments and a reference implementation of the Workflow engine for use in the Open Grid Services Infrastructure (OGSI). (Laszewski, 2002)</td>
<td>2002</td>
</tr>
<tr>
<td>Formal method</td>
<td>Petri-net</td>
<td>The Web Service process model built by Petri-net represents service processes with graphics mode vividly, convenient for various persons to participant in constructing business processes. All the analysis methods of Petri-net could be used to validate the correctness and analyze the performance of web service process model.</td>
<td>1968</td>
</tr>
<tr>
<td></td>
<td>Process algebra</td>
<td>Normally uses Pi-calculus as formalization representation, describes complicated process model by composing simple structured process control modules, and verifies the correctness of models.</td>
<td>Late 1970s - early 1980s</td>
</tr>
</tbody>
</table>

Totally speaking, BPEL4WS has become the standard of Web Service supported by OASIS (Organization for the Advancement of Structured Information Standards). It is considered as the most mature and complete business process modeling language.

5.1.2. Service Matching and Composition

In SOWF, process is constituted with services or mapped to a service. Service matching is the basis of process modeling, while service composition is the basis of workflow execution. As far as service matching, there are normally two implementation methods: the method based on UDDI keyword mapping and the method based on artificial intelligence technology. The former one strictly follows the UDDI rules and well supports the discovery of services described by WSDL, but shows the deficiency of low flexibility, lack of measurement of mapping degree and weak support on semantic operation. Consequently, most
5.2.1 Workflow Engine

5.2.2 Process Interaction

5.2.3 Dynamic Resource Scheduling
5.3. WORKFLOW IMPLEMENTATION TECHNOLOGIES

5.3.1 Workflow Based On Web Service

5.3.2 Workflow Based On Grid Service

5.3.3 Workflow Based On Agent

5.4 TRANSACTION MANAGEMENT
5.5 PERFORMANCE EVALUATION

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6 APPLICATION OF SOWF

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Taking an online shopping process for example, Figure 3 illustrates the scenario of a business process in service-oriented environments. When the customer wants to buy something, he submits the order with his customer information, such as user ID and password. Then, the system checks whether the customer exists or not, if yes, continue to check whether the inventory of selected goods is enough, if not, give an error report to the customer and remind him to register again. When the inventory is lacking, the system notifies the customer and recommends him to purchase other related goods. While if the inventory is enough, inform the customer to select pay mode according to his preference, such as bank transfer, remit, pay on delivery and e-Pay. After receiving the money, the company delivers the goods in the way that the customer prefers. If the customer is satisfied with the goods, he accepts it. However, if he is not satisfied, the goods is returned to the company.

In this process, some activities need to communicate with the customer, and some activities work as services, requiring agents in Enterprise service bus to perform corresponding functions. For the activity “check customer”, the agent queries the CRM system of this company, which provides query service and other services. Similarly, for the activity “check inventory”, the agent queries the ERP system. The functions of CRM and ERP systems are encapsulated into inner-enterprise services which could be invoked by other systems. For payment service, there are mainly four kinds of services, bank transfer, remit, pay on delivery and e-Pay. Suppose the customer selects e-Pay to pay the cost online, then he decides the delivery mode including home-delivery, mail, express and EMS (Express Mail Service). The payment service and delivery service are all inter-enterprise services that are open to users out of the domain of their providers. Each kind of service may have hundreds of providers, so the agents also need to choose the most suitable service with best performance and lowest cost.

In traditional situations, ERP and CRM system may be invoked from different portals and cannot be integrated seamlessly. The payment and delivery activities also need to be completed by searching service providers artificially. For example, if the customer selects the home-delivery mode, the seller has to ask various logistic companies for the cost, time and security of home-delivery service, then to decide which logistic company will perform this service according to the customer's requirements. However, through encapsulating inner-enterprise services including legacy systems like CRM, ERP, SCM and PDM systems, and through developing inter-enterprise services covering physical resources, information resources and service resources distributed in the world wide, the issues of information integration, process integration and application integration are resolved.
7 CONCLUSIONS

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