

Software Architecture Implementation of an e-HUB to offer e-Services for SMEs

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Abstract. The creation of industrial networks represents a value-added strategy to foster the individual competencies of Small & Medium Enterprises (SME). These networks require the support of e-services to enable the coordination and cooperation among different companies to integrate their capabilities in the configuration of virtual organizations. This paper presents the integration of five e-services in an open technological platform named e-HUB. The technical design of its software architecture, the results of its implementation in a real project including the deployment of one e-service aimed to support e-supply chain processes in SMEs networks, are presented in this paper.

Keywords: e-HUB, e-Services, Business Process Management, Enterprise Architecture Integration, Software Architecture, Small and Medium Enterprises.

1. Introduction

The creation of value-added industrial networks that provide the basis for competitiveness, excellence, and agility in Small and Medium Enterprises (SMEs) requires the definition of new business models and supporting infrastructures to enable the coordination and cooperation among different SMEs, allowing them to share core competencies and resources during the creation of Virtual Organizations that responds to new global business opportunities [11] [4].

A key pre-requisite for the effective creation of value-added industrial networks such as Virtual Organizations (VOs) is the design and development of a transparent, easy-to-use, and affordable “plug-and-play” ICT-infrastructure playing the intermediary role as the enabler of interoperation among organizations [3]. Therefore, the implementation of collaborative network is facilitated by the existence of an ICT-infrastructure that allows different distributed/heterogeneous applications/actors to communicate with others transparently and seamlessly [12]. In this sense, PyME CREATIVA project intends to cover part of this gap based on the vision of an open and easy-to-access technological platform, known as “e-HUB” (Integrated e-Services Center for Virtual Business).

PyME CREATIVA is a project funded by the Program of Multilateral Investment Fund of the Interamerican Development Bank within ICT4BUS Program [7], aiming to produce a low cost infrastructure for value-added networks of SMEs through the construction of an e-HUB platform for the creation of industrial networks.

The main objective of the e-HUB is the creation of a business environment composed of value-added industrial networks collaborating around a particular technology and making use of a common architecture to deliver independent elements of value (e-services). The e-HUB intends to reduce critical troublesome that traditionally limits SMEs competitiveness, thus allowing the exploitation of new business opportunities [11]. SMEs can execute trading processes, purchase orders, supply chain management, request for quotations, and other types of e-businesses with others SME into the HUB [9]. The following e-services are being developed and integrated within the e-HUB architecture platform [11]:

- *e-Brokerage*. Integrates technologies to support the development of virtual businesses and the exploitation of business opportunities through VO creation.
- *e-Supply*. Implements technologies for the integration of manufacturing execution process, order processing tracking, and client/supplier relationship management.
- *e-Marketing*. Integrates different technologies for intelligent and customizable portals development, and customer relationship management.
- *e-Productivity*. Incorporates technologies for the diagnostic and monitoring of SME development.
- *e-Engineering*. A collaboration engineering environment that integrates design technologies for integrated product development.

The technological innovation in the e-HUB concept is achieved through three variants [11]:

- e-HUB development with Internet-based services, allowing SMEs access to a wide range of value added e-services.
- e-Services implementation methodology, to demonstrate its impact and benefit for the SMEs through an integrated process to achieve competitiveness.
- Creation and demonstration of the new SME business model based on value added industrial networks that enable the creation of virtual organizations.

The following sections will describe the architecture and technologies being used in PyME CREATIVA project to implement the e-HUB based on a selection of open source technologies and e-business models, necessities to produce a low cost infrastructure.

2. e-HUB Software Architecture Analysis & Design

Different steps were applied to build the e-HUB infrastructure defined by a set of e-services in PyME CREATIVA project. The first step was the definition of an e-business model focused in the creation of value-added industrial networks. Secondly, the design of the e-HUB architecture reaching the requirements of service oriented economy of the future industrial networks. Thirdly, the e-services design for supporting the operation of those networks. And finally, the combination of open

source technologies with the aim of having low costs in implementing the e-HUB architecture.

Different approaches have been identified in order to design the e-HUB architecture, such as: customized corporate portals, enterprise applications integration, SOA, workflows, and business process management. These approaches try to fulfill non functional requirements such as: high level of scalability, robustness, and integration, including easy maintenance and adaptation with external systems.

The first approach is the need to have customized corporate portals; an implementation of a customized corporate portal for each enterprise that contracts the e-services offers a unified access point to its clients and suppliers besides marketing services through configurable contents. The second approach is the technologies for application integration that access remote applications and integrate different services into composite applications through service oriented architectures (SOA) such as web services. Another quite important approach is the Workflow concept and Business Process Management (BPM) in order to maintain diverse activities within the enterprises business logic or inter-enterprises business (B2B) logic. These technological approaches used in the development of the e-HUB architecture are defined and explained in the e-HUB implementation section.

Furthermore, e-services design was approached as an overarching service-centric concept based on Internet customer service and online account management services with the aim of providing an integrated solution for customized functionalities that are delivered through the Internet. The fundamental objective of e-services in PyME CREATIVA project is to have a collection of network resident software applications accessible via standardized Web protocols (HTTP, HTTPS), whose functionality can be easily discovered and integrated into applications or composed to form more complex systems. At a fundamental level, the e-services were considered as an emerging confluence of three distinct technologies: (a) process description formalisms, including automata and workflow; (b) data management (including transforms, mediation, transactions), and (c) distributed computing middleware [6] to create business modules that represent basic independent e-business service processes or functions such as authentication, authorization, advertisement, negotiation, and process integration.

Finally, the combination of these open source technologies outcomes into an innovative e-HUB software architecture that could be considered as the new generation of business process oriented architecture.

3. e-HUB Software Architecture Implementation

As stated before, different approaches supported the implementation of the e-HUB architecture: customized corporate portals, EAI, SOA, workflows and BPM. Below a brief description of each one is presented.

Corporate Portals. Portals allow users easy access to information by integrating heterogeneous applications or data sources in a consistent way under a friendly Web environment [2] [5]. Portal pages may have different sets of portlets creating content for different users. A portlet is a Java technology based on a Web component,

managed by a portlet container that processes the requests and generates dynamic content. Portlets are used by portals as pluggable user interface components that provide a presentation layer to information systems [1].

EAI & SOA. Enterprise Architecture Integration (EAI) is the key technical enabler for managing business processes. One approach to solve the integration issues is the Service Oriented Application Integration (SOAI) that allows enterprises to share common application services as well as information. Enterprises accomplish this sharing either by defining application services that they can integrate, or by providing the infrastructure for such application service sharing. Application services can be shared either by hosting them on a central server or by accessing their inter-application through distributed objects or Web services [10].

Workflow & BPM. Workflow is the automation of processes, totally or partially, during which documents, information or tasks are passed from one participant to another for a specific action that will be accomplished according to a set of procedural rules [13]. Moreover, as the e-services are becoming the focus in BPM; Workflow technology is facing the challenge to support e-services in a proper way [14]. BPM has proved to be valuable in the definition of effective business processes as workflows for everything from a single department to an entire enterprise and its associated value networks.

After the technological approaches were identified the implementation of PyME CREATIVA e-HUB was done, next paragraphs will detail this implementation.

3.1 PyME CREATIVA e-HUB Model: Architecture & Technological Platform

The intention behind the software architecture implementation in PyME CREATIVA project is to have a portal platform accessible through standard Web protocols (HTTP, WSDL) running e-services in a robust platform (J2EE). To access the e-services, SMEs must be able to integrate to this e-HUB by deploying their own Web portal (a sub-portal for each SME) that serves as a single access point to all their e-services.

Fig. 1 shows the e-HUB architecture, a technological implementation of a robust platform that involves many components and technologies. This platform includes a set of components to deploy a number of e-services and sub-portals for each SME. At top of the architecture are the clients or consumers, these can be Web browsers, mobile devices with Web browser capabilities, accessing with HTTP standard protocol or even 3rd party applications through Web services technologies.

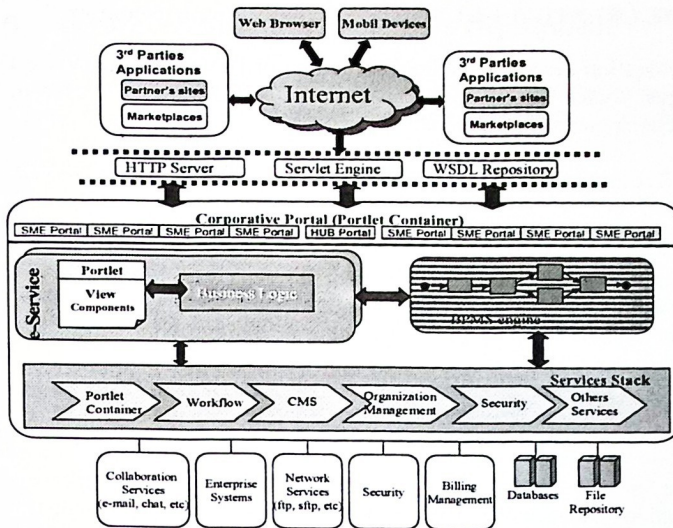


Fig. 1. e-HUB Architecture (e-Services Platform)

The main component within the platform is a corporate portal with a portlet container (Java Specification Request-168) in order to achieve hot-deployment behavior of e-services; each e-service is a portlet-application containing several view components like Java Server Pages (JSPs) or static HTML content. An e-service implementation could be defined as a composite component from a combination of user interfaces (views) and portlets (controllers) that interact with the services stack (model) explained later.

Another component is the business process system engine integrated to the platform to manage many workflows like quotation requests, work orders, purchase orders, among others; it interacts with other components through its Application Programming Interface (API) and the services stack. The component that serves as broker of the entire platform is a services stack containing the definition and implementation of applications, database connections (JDBC pools), content management system (CMS), security (LDAP, certificates), organization management (roles, users, permissions), and others. Below this platform is sited the technological physical infrastructure that supports the services stack consisting in collaboration services (SMTP, POP3), file repository, network services (FTP, SFTP), security (Kerberos, SSL), and database management systems (PostgreSQL).

At infrastructure level, security concerns are supported by J2EE technologies such as JAAS (Java Authentication and Authorization Service) combined with physical certificates through Kerberos and SSL configurations. In the business level, the security model is based on roles and access levels defined within portal platform and all user accesses are filtered for each page request. The combination of both security levels provides the e-HUB architecture with a strong robustness of information protection and isolation.

3.2 PyME CREATIVA e-HUB Model: Technical Implementation

This sub-section describes the implementation of PyME CREATIVA e-HUB model using open source technologies and open source software tools used to implement these technologies as listed in Table 1.

Table 1. Technologies and Open Source Software Tools used to implement the e-HUB

Technology	Free Software
J2EE Web Container	Apache Tomcat
Portal Platform	eXo Platform
Web Services	Apache Axis
Business Processes	jBPM
MVC framework	Apache Struts
Database Management	PostgreSQL

Portal Platform. The portal platform is eXo Platform, an open source portal technology that includes a portlet container and a services stack by providing several components like content management, LDAP and database integration, security, organization management, XML processing, and BPM implementation. Its main features are [14]: (a) Services Container that provides the inversion of control pattern design to allow services dependencies resolutions; (b) Content Management System (CMS) that provides a hierarchical organization of binary objects that can be stored in different databases or file systems with a small amount of code; (c) Portlet Container that is an open source implementation of the portlet API specification (JSR 168). This module manages the life cycle and lazy instantiation of portlet components, and the portal platform implements; and (d) User Management based on roles, groups and memberships by allowing to have access control of portlets and portals.

e-Services. In general, an e-service is an integrated solution for customize services that are delivered through the Internet, enabling their dynamic discovery, composition and delivery [8]. For its implementation, each e-service is composed by a set of components using the eXo portal platform core API and components.

Business Processes Implementation. The BPM engine integrated to eXo platform is JBoss' jBPM a flexible and extensible workflow management system. The first step was to identify the occurrence of the business process and how it helps to achieve its main goals. Once this step is performed, it is necessary to model the business process using a formal notation (e.g. UML activity diagram). Once the business process is modeled, the next step is to transform the process model into a process definition in XML language. jBPM uses a process definition language (jPdl) for process description and deployment. Each activity, decision, fork or join from the activity diagram is transformed into XML elements with its attributes.

Web Services. The integration of SMEs systems is a common need in the implementation of an e-HUB. A good example is when a legacy application or an ERP system must create a report of work orders, so it needs to check their status and tracking them. A Web service interface could achieve this kind of integration; and an open source software to develop Web services is Apache Axis, which is an implementation of the Simple Object Access Protocol (SOAP), based on XML to allow applications communicate through Internet protocols like HTTP.

4. e-HUB Software Architecture: e-Services Deployment

The e-HUB implementation comprises also the details involved in each e-service; the purpose of each e-service results in different features and needs. The e-brokerage service was selected to describe the implementation details, because its business process definition is a good example to show the mapping of e-services implementation in the e-HUB. The purpose of e-Brokerage analysis is to show the tracking of negotiation business process, starting from the business process analysis and ending in the e-service implementation.

The e-Brokerage service objective is to underpin business development through SMEs collaboration for the creation of virtual organizations (VO) by identifying the competencies needed to participate in a particular business opportunity. Therefore, collaboration between SMEs, especially those participating in a VO require the rapid establishment of such relation supported by a high level of scalability, robustness, internal/external integration and ease of maintenance ICT-infrastructure.

SMEs negotiation process is the starting point to define the roles and functionalities to be implemented by the e-Brokerage service. Even though the e-Brokerage service was defined using a more complex process model than the one presented in Fig. 2, this diagram can be used to show some points related to the e-Brokerage service design. Fig. 2 shows a business process diagram represented in Business Process Management Notation (BPMN), where every activity in this diagram ended with a corresponding use case in the e-service design and the swim lanes ended also as actors of a UML use case diagrams. Having such a mapping ensures that at least some part of the process requirements are reflected in the e-service design. Each one of the use cases functionalities can be exposed as Web Services allowing a process level integration with external systems.

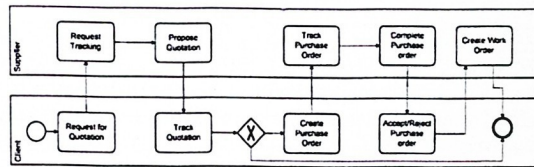


Fig. 2. e-Brokerage Simplified Process Diagram

In the e-Brokerage service context there are basically three user's types, first is the anonymous user who has not been registered in any portal and is not a member of any SME belonging to the e-HUB but is looking for a product or service in the e-HUB. The second user type is the one who belongs to an SME registered in the e-HUB and who is trying or is participating in a business transaction as a client. Finally there is a third user type; an SME registered in the e-HUB and who is acting in a business transaction as a provider. It is important to remark the fact that a user can only be a client or provider in the context of a single business transaction, but the same user can take both roles in a global context.

The functions that a user can perform are related to the role in the business transaction and also to the subscription in the e-HUB. The use case diagram presented

in Fig. 3 shows the functions that the e-service allows to the users given their user type. For example, a client can perform several actions related to the access point he gets: (1) the enterprise portal he belongs to, (2) the enterprise portal he is client of, or (3) the e-HUB's main portal. A provider can only use his own portal to get to the e-negotiation service. An anonymous user is restricted to the posting of information requests through the public section of any HUBs' enterprise portal.

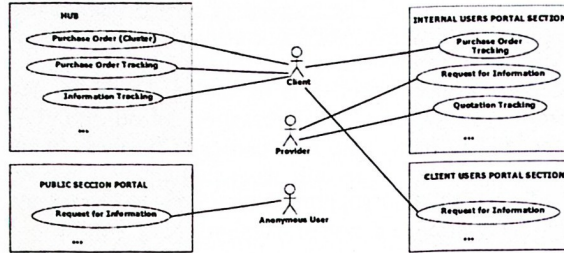


Fig. 3. e-Brokerage Service Use Cases

The BPM engine integrated to eXo is JBoss' jBPM. The language used by jBPM is jBPM Process definition language (jPdl); a jPdl process definition is an XML file containing process information. JBoss jBPM maintains the state, logs, and performs all automated actions of the process instances. The jPdl file that serves as input to the jBPM engine provides all the required information required by the engine. An example of these input file can be seen in the following XML snippet.

```
<process-definition name="RFQ-process-cluster">
  <swimlane name="client"> <delegation
class="org.jbpm.delegation.assignment.ActorAssignmentHa
ndler">client</delegation> </swimlane>
  <swimlane name="supplier"> <delegation
class="org.jbpm.delegation.assignment.ActorAssignmentHa
ndler">supplier</delegation> </swimlane>
  <start-state name="generate_request"
swimlane="client"> <transition to="evaluate_request">
    <action> <delegation
class="org.jbpm.ehub.RequestForQuotationActionHandler">
</action> </transition> </start-state>
    <state name="evaluate_request"> <assignment
swimlane="supplier"/> <transition name="accept"
to="make_quotation"/> <transition name="cancel"
to="end"/> </state>
    <state name="make quotation"> <assignment
swimlane="supplier"/> <transition
to="evaluate quotation"> <action> <delegation
class="org.jbpm.ehub.GenerateQuotationActionHandler"/><
/action> </transition> </state>
    <state name="evaluate quotation"> <assignment
swimlane="client"/> <transition name="accept"
```



```

to="generate_purchase_order"/> <transition
name="negotiate" to="make_quotation"/> <transition
name="cancel" to="end"/> </state>
  <state name="generate_purchase_order">
    <assignment swimlane="client"/> <transition to="end">
    <action> <delegation
class="org.jbpm.ehub.POGenerationActionHandler"/></acti
on> </transition> </state> <!-- END-STATE --> <end-
state name="end"/> </process-definition>

```

Once the engine has been started a process instantiate a process activity resulting in the execution of an action class. These action classes have to be coded to achieve the functionality of each business process activity. Inside these action handlers it is possible to implement any action in order to achieve the process goal, such as send mail, change a database or call a Web service.

An actor (e.g. a client or supplier), can perform an action associated to an activity when a process arrives to this activity. In this way, all variables and business process tokens can be read into the action class and execute its code.

The user types detected were mapped to eXo Platform roles, eXo memberships are used to assign roles to new users, and finally the configuration of navigation and pages available were defined in the eXo Platform configuration files. This configuration was defined according to the eXo platform features before the deployment of each enterprise portal.

5. CONCLUSIONS & FURTHER RESEARCH

ICT-infrastructures are very important enablers for effective implementation and operation of collaborative networks as a new business model for SMEs competitiveness. PyME CREATIVA project conscious of SMEs limited resources has designed and implemented a new ICT-infrastructure (the e-HUB) supported by a scalable, robust and quite complete IT architecture able to satisfy SMEs technological requirements (low cost, easy access and operational infrastructure) for the developing of businesses opportunities over the Internet.

This paper presented the e-services HUB software architectural approaches to allow SMEs share their competences towards the creation of virtual organizations, supporting its architecture in three main IT approaches: corporate portals, enterprise application integration, and business process management.

The software components implemented for the PyME CREATIVA e-services HUB were constructed by integrating open source information technologies: a portal platform (eXo platform), portlet container (JSR-168), BPM engine (JBoss' jBPM), user interfaces components (Java Server Pages) and Web services (Apache) for Enterprise Application Integration. By developing this software implementation, the e-HUB architecture can be accessible through a Software-as-a-Service (Saas) supply model in order to deliver on-demand services based on actual and potential customers.

The PyME CREATIVA implementation is now under deployment to a large group of SMEs, personalizing their individual portals and enabling collaboration inside the marketplace defined by the e-HUB of engineering services. Future implementation of

the new e-HUB version will consider the deployment of a Content Management System, new e-services such as e-Quality based on quality models and the integration of a usability layer in the platform in order to develop new Web 2.0 business models.

6. ACKNOWLEDGEMENT

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