Improving Supply Chain Operations performance by using a collaborative platform based on a Service Oriented Architecture

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Abstract. Every new technology promises to solve a lot of problems inside companies and to achieve unforeseen performance improvements. Nowadays, Service-Oriented Architectures begin to be promoted as new balsam where companies may realize their visions and put all their new strategies in practice. Initially focused on intra-organizational integration efforts, they begin to be used when supporting inter-organizational business processes engineering in networked organizations. Although these kinds of initiatives in most of cases are lead by major companies, the INPREX project (Spanish acronym for Interoperability in Extended Processes), here presented falls out this category. By contrast, this is an undergoing initiative leaded by a Small and Medium Enterprise (SME) and founded by a local government in Spain. In this work, we introduce the IDIERE Platform which has been designed for supporting three major requirements of networked enterprises: openness, flexibility and dynamism when deploying and executing distributed business processes

1 Motivation

Collaborative Networks (CN) are enabling new ways of conducting business transactions and functional alignment between their members [7]. As organizational form, they tie together two or more companies that had understood the benefits of conducting win-win partnerships coming from such collaborative environments (([2], [6]).

When adopting this emerging approach, extended functionality needs to be designed and deployed to reach such levels of interaction. Collaborative, Extended or Distributed Business Process are terms used to name a set of activities that, in such context, need to be carried out in order to accomplish some commonly agreed business goal.

New technologies, mainly those related to the Internet are enabling the deployment of global business processes and facilitating, at the same time, the interoperability of the information systems in which they are supported [8].

The INPREX Project is an undergoing initiative founded by the Ministry of Education and Science of the Spanish Government. One of the main objectives is the de-

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ployment of a platform (called IDIERE) that, taking advantage of web services and their orchestration, enables the engineering, deployment, execution and monitoring of distributed business processes in a network of companies surrounding one SME stamping firm in the automotive sector, located in Valencia, Spain.

In this work, we are going to present the architecture and main components of the platform and how it has been used to improve the coordination and information visibility in a distributed business process inside a network of companies surrounding a stamping firm in the automotive sector.

The paper is structured as follows: Section 2 depicts how the service-oriented architectures support Distributed Business Process Management. Then, in Section 3, the IDIERE Platform is presented, that is, its architecture and the software components that implement the architecture. In Section 4, how it has been applied for improving a Production Planning Business Process and, finally, in Section 5, we state some conclusions that we are gaining when developing this project.

2 Distributed Business Processes Management and Service-Oriented Architectures (SOA)

2.1 Introduction

Relaying on emergent Internet technologies, Service-Oriented Architectures (SOA) [3] are allowing to conceive the Internet not merely as a communication channel but also as support of more complex activities tied, for instance, to purchasing, personnel recruiting or customer service support.

Business process management's requirements and the Internet are moving towards a third stage of evolution [9] where the applications that support business processes are conceived as a single user graphic interface (based on web browsers) but whose functionality is composed of computational capabilities on the client side combined with a set of invocations to third-party provided services ([1]).

The main changes provided by SOA are:

- The capability of narrowing down the gap existing between the modelling and the operational phases of the business process engineering, by means of intermediate languages like Business Process Execution Language (BPEL) to link the business process modelling world and the web-services world. BPEL is explicitly designed to work with Web services and provide coordination and integration of business services into higher-level business processes.
- The emerging web-services technologies (mainly XML, SOAP, WSDL, UDDI and BPEL4WS) supporting the service-oriented architecture are wide-spread and well-accepted by service-oriented tools.
- Web Services allow a loose decoupling between process's functionality and executors [4] so they provide a higher dynamicity

When these concepts are applied to collaborative networks (CN) they gain additional advantages related to information sharing policies and visibility. SOA-based applications orchestrate and compose invocations of computational capabilities by means of service interfaces. This mechanism allows companies to keep as independent as they want by only providing the information that could improve the global performance of the CN.

Based on those principles, has been proposed [4] that web services interfaces are able of encapsulating activities, or sub-processes, of a business process definition, and then, support composition and execution of their instances.

2.2 Web Services extended

The term Web Service is used by various groups to describe widely differing concepts. From a technological perspective, they have been defined as [11].

> *A Web service is a software system identified by a URI [uniform resource identifier], whose public interfaces and bindings are defined and described using XML. Its definition can be discovered by other software systems. These systems may then interact with the Web service in a manner prescribed by its definition, using XML based messages conveyed by Internet protocols.*

By contrast, in a more business-related context, web services are also considered as pieces of business functionality that companies provide (offer, rent or sell) to third parties by using Internet-related technologies.

Despite the technological complexity that may be related to this technology, most companies can be able of start providing services in a short period of time. This has caused that service offering rate had increased quickly but without much order.

Although web services are not distributed objects [10], applying object oriented computing principles may help when engineering software applications based on SOA. Looking for such order, some attempts in the right way have been carried out [5] where an extension of web service’s concept has been proposed in order to create an upper-level entity which provides a unique access point for a set of web services belonging to the same domain.

2.3 Supporting distributed business processes

Distributed business process can be conceived as a set of activities which are assigned to different members of a CN in order to be accomplished to achieve a common goal. When modelling this kind of processes, is not always possible to keep the same abstraction level for each activity/role. In fact, depends on how much detail can be gathered. More, initial steps in process modelling always begin with a more or less clear picture but without so much detail.

In the scope of this work, these two interrelated concepts will be introduced:

> “***Definition 1:*** *an Execution Unit is a work package that may be composed of a single activity, a sub-process or a whole process and that could be assigned to some executors which have the proper knowledge and capacity to accomplish the task for the global process”*

From the information flows management perspective, the execution unit can be seen as a computational function (*ws)* which maps some Data Inputs into Data Outputs through some internal logic not accessible by others (in a black box way).

This led us to the concept of service and service provider. If each execution unit is wrapped under some interface that can be located and consumed by third parties, it is possible to consider it as a ***service*** that may be provided by some ***service provider***.

Then, service providers or **executors** can be defined as follows:

> ***Definition 2:*** *executors are those service providers (organizations or their resources) that are capable of accomplish some execution unit for the global process by providing and consuming third-parties services.*

And relaying on SOA principles, it could be convenient to add:

> *"...by means of web services interfaces and a supporting data model."*

We consider **executors** as some extension of the object web service concept. They represent a conceptual unit that will be used as functional/computational building block when assigning some execution unit for accomplishment. They have the following structure (See Figure 1):

- Data Model layer: this data model is specific for the business domain within which executor works and it's devoted to provide the interoperability foundations from the information flows perspective.
- Internal Logic layer: the data model represents the external interface to be exposed in terms of information. If some additional computation is needed or existing system must be integrated, the internal logic layer is the mechanism to be used.
- WS Layer: the internal logic may use several mechanisms to feed up the data layer, even web services. Despite this, this layer is devoted to provide a set of web services that will be offered to external applications. This layer is also dependable of the executor's interaction scenario.

There is no one single definition for executors. Instead of this, like when defining classes in Object Oriented Programming, it could be better to define as many types as needed.

Then, it's possible to consider as executor to all organizational resources that may provide some services to a global process by means of their WS interfaces. In this sense, whole organizations, organizational units, systems, machines or devices (which can be used for human interaction) being able of run web services instances may fall under this definition.

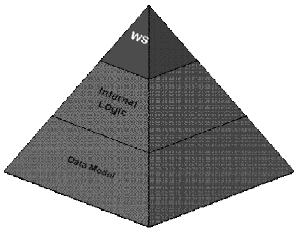

Fig. 1. Executor's Architecture

In order to completely define the execution model, we must create the execution units (**eu**) which represents the atomic building blocks used to compose inter-organizational business processes. Each **eu** represents a complete piece of work that will be assigned to executors in order to be accomplished.

The proposed Execution Model is based on execution units' assignment and monitoring to different executors. This facilitates a loose coupling of execution units and the corresponding executor, enabling either early or late binding (at process runtime) between them (See Fig. 2).

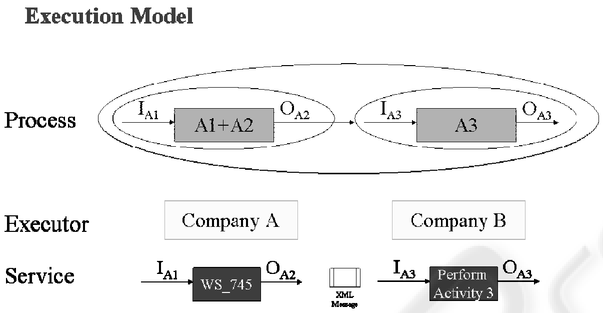

Fig. 2. The Execution Model assigns EU to executors and maps business representations with process interfaces at runtime

3 The IDIERE Platform

The IDIERE Platform relays on SOA capabilities in order to automate business process execution and monitoring. The platform provides a set of components allowing users to be involved in several business process instances of execution.

The principle is straightforward: it works as any business process system does but, at the same time, it provides different levels of automation when needed. Such levels of automation are supported by corresponding web services interfaces.

IDIERE Platform is the information system that supports distributed business process management capabilities by providing a set of components that allows creating and maintaining a centralised set of repositories of processes, executors and exchanged messages in each process's instance.

3.1 The IDIERE Architectural View

The IDIERE Platform, is based on a traditional client-server architecture that is deployed over the Internet. Inside the platform it's possible to identify:

- *The IDIERE Server*: it supports two major phases: process engineering and execution. It allows defining collaborative business processes structure, storing them in a common repository, registering executors, assigning execution method and executors to individual activities or sub processes, monitoring delegated activities, deploying a set of indicators for performance measurement.

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– *Client-side*: in terms of users, there would be a set of nodes which may be connected to the platform in order to notify each assignment's status. Each node represents the instantiation of one executor for each process instance. Correspondingly, each deployed thin client, will act as Task Manager for the system (in the traditional workflow sense) but having some extended functionality.

Initially, we have defined three different kinds of users that will access the platform that is, users that will interact with the platform in order to: manage processes, accept or reject assignments, or status reporting. The types of user identified are:

˜ *Organization*: this user initially will act as any company that provides some service to a process. By means of its Task Manager, it will provide a service interface that may be located and accessed by the server some eu accomplishment. When Workers users are present, work items can be delegated.

˜ *Workers* are nodes belonging to an Organization. A Worker is a Task Manager also but with a simplified functionality in terms of capabilities for delegating tasks or accepting offers, for instance. Organization is able of adding their workers by registering them into the system. Once this process has been completed, tasks can be delegated to these nodes to be internally processed.

˜ *Individual*: finally, it represents individuals not belonging to any organization but, once registered, may conduct transactions inside the platform.

3.2 The IDIERE Software Architecture

Major components of the platform are shown next (software modules, applications and databases) and how they are interrelated.

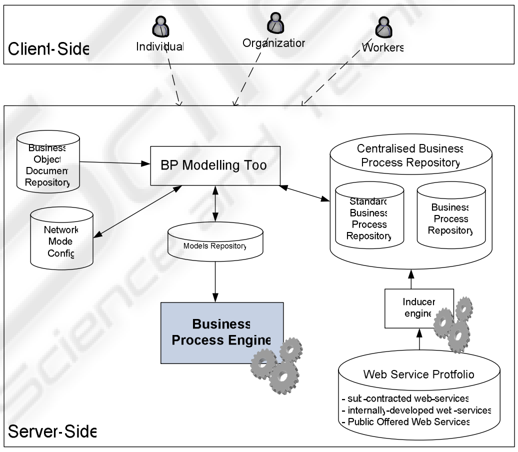
Client-Side
Individual
Organizatior
Workers
Business Object Documen Repository
BP Modelling Too
Centralised Business Process Repository
Standard Business Process Repository
Business Process Repository
Network Mode Config
Models Repository
Business Process Engine
Inducer engine
Web Service Protfolio
- sub-contracted web-services
- internally-developed web-services
- Public Offered Web Services
Server-Side

Fig. 3. The IDIERE Architectural View and its Major Components

On the server-side, the architecture is mainly composed of:

- A *Business Process Modelling Tool*: it's devoted to model business processes in a graphical way. Definitions are stored in three repositories:

˜ A *Centralised Business Process Repository* (CBPR) which will store business process definitions. This repository can consider processes appearing in reference mod-

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  els as SCOR, or in standard documents as the ISO series; business processes defined by a user as a template and finally business processes induced from web-services by an inducer tool.

  - A repository with all the business object documents that will give support to he definition of information and control flows.
  - The *Network model configuration module* is devoted to configure all those topics related to the network deployment. That is, the organization model, executors' permissions or additional parameters.

- The *Business Process Engine* is responsible of executing and monitoring process' instances. Consequently, it considers the enterprise models released by the business process modelling tool and it is able to execute and monitor them. By assigning each execution unit to the corresponding executor.
- *Web Services Portfolio* within which all active web services definitions that may be used to compose a business process will be registered. There will be three kind of services: sub-contracted with third parties (outside of the CN), internally deployed (owned by the core members) and additionally those services that the CN will able to provide to third parties to be consumed.
- The *inducer engine* is capable of inducing business process templates from existing web-services definitions.

4 Case Study: an SME stamping firm in the automotive sector

4.1 Business scenario

The IDIERE Platform has been deployed inside a network of companies surrounding an SME (which is a 1st-tier Supplier, and high level sub-assembly supplier, for one Original Equipment Manufacturer (*OEM*) in the automotive sector. The company is responsible for its own logistics and independently chooses its own suppliers (*2nd-tiers*), the components of its products, etc.

The network, as it is now, has a relatively low degree of synchronization and collaboration. Generally, although the production plans of the company that is directly connected with the demand are those who launch the supply chain's production, certain information that needs to be drawn upstream is held up and sequentially the cycles of planning and production decrease, and therefore the delivery time of the final item is significantly affected.

Currently, this information flow is relatively restricted. The SME receives OEM's demand planning and makes its production plans and attendant orders to 2nd-tiers according to it. But when small- scale changes and variation in demand coming from the OEM arrive, SME's production plans and order needs change, but the sub-tiers are not informed on time and thus do not have the time they may need to change their own planning, if this is possible.

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4.2 Proposed solution

We have applied the IDIERE platform principles in order to achieve a successful reengineering of the Production Planning Process (PPP).

After conducting a BP Analysis, PPP was identified as the most critical and conflictive one. Due the company's raising trend of outsource part of their production activities, more information visibility and co-ordination of such activities was needed.

Three kinds of executors were identified and their services modeled:

1. Productive: they transform some inputs (raw material or components) into outputs (components) by performing of some activity (stamping, painting, welding or similar). Finished or semi-finished goods are packaged in specific containers.
2. Transport: this kind of executor moves containers between productive executors.
3. Warehouse: they stores finished or semi-finished goods

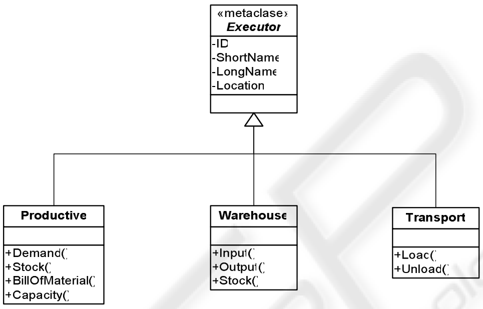

Fig. 5. Organizational resources have been modeled as executors

Once executors have been modelled, supporting services were developed for each kind of executor. Then, there is a set of services belonging to each one of them. For instance, productive executors are able of notify stocks, capacities, enact their Bill of Material, receive demand, put orders and so on.

Table 1. Supported services (non exhaustive)

Executor	ServiceName	Description
Productive	NotifyDemand()	It allows knowing which the demand for some reference is.
	NotifyStock()	It returns stock of some reference
	BillOfMaterial()	It returns those references which compose other one
	Capacity()	Notify agreed capacity about some reference based on signed contracts
Warehouse	Input()	Register receptions of material
	Output()	Register material consuptions
	Stock()	Notify availability
Transport	Load()	Load some package into the transport
	Unload()	Unload packages
	Move()	Move them between executors

After that, we modeled the production process of each reference (almost ninety) as a business process within which each activity (stamping, welding, and painting) is associated with the corresponding executor and its services.

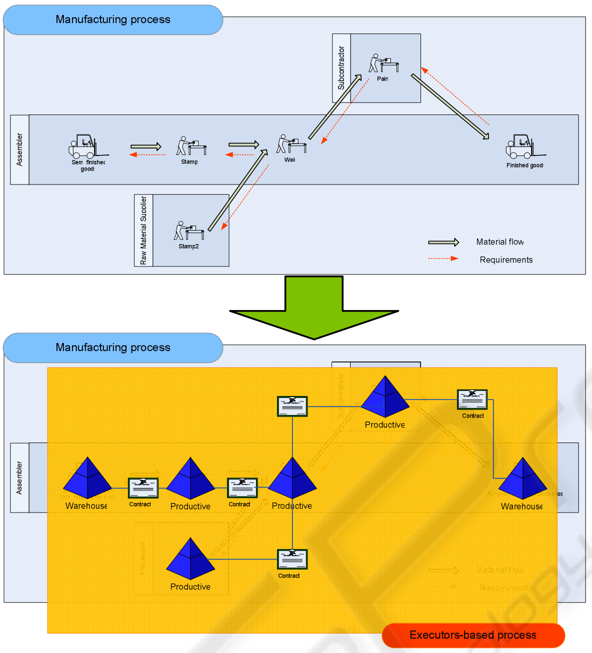

Fig. 4. Composing business processes by using executors and services

By using this set of services we provided the SME with a complementary module running in the platform: a collaborative planner who checks SME's plans feasibility after analyzing the information gathered from each executor and, complementarily, traces plan's execution.

5 Conclusions

In this work we have presented advances in the work carried out within the INPREX Project. We have introduced the IDIERE Service-Oriented Platform, and have defined the main components that implement it. The project looks for a low-cost, flexible and extensible platform that companies can use in order to design and execute inter-organizational business processes by composing a sequence of services invocations.

We strongly rely on Service Oriented Architectures as a medium for enabling Small and Medium Enterprises get involved in this kind of initiatives. By adopting standards related to the Internet (Web Services stack for Communications, current initiatives like OAGIS for content and BPMN/BPML for modelling) we have composed a framework that is open, flexible and dynamic.

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Regarding the project, it could be convenient to point out that currently there are a lot of initiatives concerning business process management by using web services composition, but real undergoing implementations being carried out by SMEs are not so usual. Currently, we are at the development stage of major components.

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