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Design and Implementation of a Framework for Process Management in Service Oriented Virtual Organizations Using Service Zones

By

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In the name of God,

the compassionate, the merciful

ABSTRACT

Virtual Organizations (VO)—a network of independent organizations collaborating to address specific business opportunities—have become popular in today's technology driven business environment. Due to their autonomous and interdependent nature, management of collaboration among such organizations is a challenging task. Although many solutions have been proposed over the past two decades to support inter-organizational interactions, VOs still face several challenges due to their dynamic and temporal nature that cannot be addressed by traditional solutions such as ebXML, RosettaNet and EDI. In this research, we present a framework for process management in service oriented virtual organizations and a distributed architecture for a flexible infrastructure that supports collaborative business process execution, monitoring and management. The framework contains 6 layers with multiple components within each layer. In designing the components of the framework, standard reference architecture such as the Open-EDI reference model and the S3 service oriented architecture, as well as best practices such as ITIL V3 and PMBOK are used. The infrastructure supports the common topologies of inter-organizational collaboration (e.g. peer-to-peer, star, linear), and responds well to changes due to its loosely coupled components. The proposed infrastructure is based on federating multiple SOA infrastructures with the Enterprise Service Bus (ESB) as its core. It is implemented using IBM WebSphere ™ products. We demonstrate that VOs built with our framework and implementation architecture facilitate flexibility, rapid process integration and dynamic evolution.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Acronyms and Definitions:

Table 1: Acronyms and Their Definitions

BPM (Business Process Management)	BPM includes methods, techniques, and tools to support the design, enactment, management, and analysis of operational business processes. It can be considered as an extension of classical Workflow Management (WFM) systems and approaches. A business process management system (BPMS) is a generic software system that is driven by explicit process designs to enact and manage operational business processes (Aalst et al. 2003).
BRE (Business Rule Engine)	A business rule engine is a software component responsible to store and execute unified business rules within the IT environment of an organization.
CNO (Collaborative Networks Organization)	A collaborative network (CN) is a network consisting of a variety of entities (e.g. organizations and people) that are largely autonomous, geographically distributed, and heterogeneous in terms of their operating environment, culture, social capital and goals, but that collaborate to better achieve common or compatible goals, thus jointly generating value, and whose interactions are supported by computer network. Although not all, most forms of collaborative networks imply some kind of organization over the activities of their constituents, identifying roles for the participants, and some governance rules. Therefore, these can be called manifestations of collaborative networked organizations (CNOs) (Luis M. Camarinha-Matos et al. 2009)
ESB (Enterprise Service Bus)	An Enterprise Service Bus is a software component that facilitates web service transaction and enforces policies and quality measures within a SOA infrastructure. It can also act as integration middleware for information systems.

SFM (Service Federation Management)	The Service Federation Management is an add-on software component added to IBM Service Registry and facilitates federation of multiple IBM SOA infrastructures.
SOA (Service Oriented Architecture)	SOA is an architecture for building business applications as a set of loosely coupled black box components orchestrated to deliver a well-defined level of service by linking together business processes" (Hurwitz et al. 2009)
SOA Infrastructure	SOA Infrastructure is a set of software solutions which facilitate web service choreography, orchestration and execution. A SOA infrastructure does not only allow web services to be reused and composed but facilitates dynamic agile changes in business processes. Therefore it is said that BPM and SOA together will facilitate the next phase of business process evolution from merely "automated" to "managed flexibility" (Jasmine 2005)
UDDI	A registry with the support of Universal Description, Discovery and Integration standards.
VO (Virtual Organization)	A dynamic, temporal consortium of autonomous legally independent organizations which corporate with each other to attend a business opportunity or cope with a specific need, where partners share risks, costs and benefits, and whose operation is achieved by a coordinating sharing of skills, resources and competencies (Marcus V. Drissen-Silva & Ricardo José Rabelo 2008; Karvonen et al. 2005),
VO Management	VO management denotes the organization, allocation and coordination of resources and their activities, as well as their inter-organizational dependencies to achieve the objectives within the required time; cost and quality frame (Karvonen et al. 2005).

VO Creation	VO creation process is the responsible for discovering the possibility of having a truly dynamic VO in response to a collaboration opportunity. This process consists of characterizing a collaboration opportunity, rough VO planning, partner search and selection, partner negotiation, detailed VO planning and contracting (Luis M. Camarinha-Matos et al. 2005).
VO Initiation	VO initiation is the first phase of the VO operation lifecycle. At the time VO initiation starts the VO creation is almost over and negotiations are in their final stage. VO initiation focuses on topology selection, activity scheduling, task assignment, budget allocation, KPI identification and Risk identification (Negretto et al. 2008). VO Formation is sometimes used as a substitute to VO Initiation in the literature.
WSRR	Stands for IBM WebSphere Service Registry and Repository product. It is an essential product of the IBM SOA Infrastructure, that stores organizational services and provides discovery and search catalogs of these services.
WESB	Stands for IBM WebSphere Enterprise Service Bus product and its IBMs ESB product.
WAS	Stands for IBM WebSphere Application Server product. This product is IBMs web application server and most IBM SOA Infrastructure components are hosted on this application server.

Part 1
Introduction

CHAPTER ONE: INTRODUCTION

Participation in inter organizational collaboration is inevitable in today's business environments, especially when organizations need to achieve a differentiated competitive advantage (Luis M. Camarinha-Matos et al. 2009). This is even more essential if the organization is a small or medium size enterprise (SME). Companies are increasingly restructuring their process models and software infrastructures to facilitate dynamic and flexible environments to engage in more complex value exchanges, partnership, and business ecosystems (L. M. Camarinha-Matos et al. 2008). This has resulted in an increasing rate of Collaborative Networked Organizations (CNO) and Virtual Organizations (VO) - a special subsection of CNOs which focuses on a temporary gathering of multiple organizations to address a specific business opportunity - creation. These types of collaborative organization's interactions are often supported by computer networks and software. Due to virtual organizations characteristics which will be discussed further in Chapter Two: , VO initiation and management could be challenging and special software functionalities are required to facilitate this purpose (Luis M. Camarinha-Matos et al. 2009).

Data interchange and software interaction between different organizations has evolved a lot in the past decades. Many interaction frameworks have been developed, especially for B2B interactions. In their early stages, these frameworks were focused on data interchange but as they evolved over time, the focus changed to handling business processes between networks of organizations. EDI, RosettaNet, ebXML and SOA (Service Oriented Architecture) based solutions are some of the examples of such interaction frameworks (Jurgen Dorn et al. 2007).

Traditionally, for VO creation, an intermediary entity assessed the potential, formed the policies, provided the infrastructure and ensured virtual presence of all partners. This static formation of a virtual organization cannot address the continuously growing demand to locate products, services and business partners regardless of their physical location and affiliation to an intermediary entity. As a result, the business partners are acting as fragmented islands and the potential added value is not realized completely (Svirskas et al. 2008).

This research aims to facilitate virtual organizations initiation and management with a distributed approach. It handles software interactions in a distributed environment based on a service oriented infrastructure. Its main benefit is that it can be used by any organization to form virtual workflows based on their current software infrastructures as long as they follow a service oriented approach.

1 Research Motivation

Before the Internet was around Business to Business (B2B) commerce was known for trading and procurement processes. As computer systems became more popular, organizations started to facilitate their B2B interactions with computer networks and systems. In 2009, more than $12 trillion were spent on B2B financial interactions in the US among which only 30% were computer aided collaborations. The fact that only 30% of the B2B interactions are conducted over the Internet shows that there is a great potential for appropriate solutions and standards to drive the 70% of the market to use B2B e-commerce for their inter-organizational interactions and collaborations. Figure 1 shows the statistics on B2B E-Commerce and different categories of computer aided collaborations share in the United States of America. It also predicts the future growth of these technologies up to 2013 (Laudon & Traver 2009).

As the business climate changes, organizations need to take a step forward and start sharing values with each other. They are strongly dependent on their collaboration towards realization of a joint goal. In today's inter-organizational relationships, the focus is on the flow of value between organizations in contrast to the traditional exchange of goods and products. Businesses need to collaborate with each other to provide value added services to their customers as they are in the globalization era for which strategic partnership is considered a competitive advantage. Organizations need to engage in partnerships to survive because, in the next ten years every organization will have to participate in some sort of CNO (Luis M. Camarinha-Matos et al. 2009).

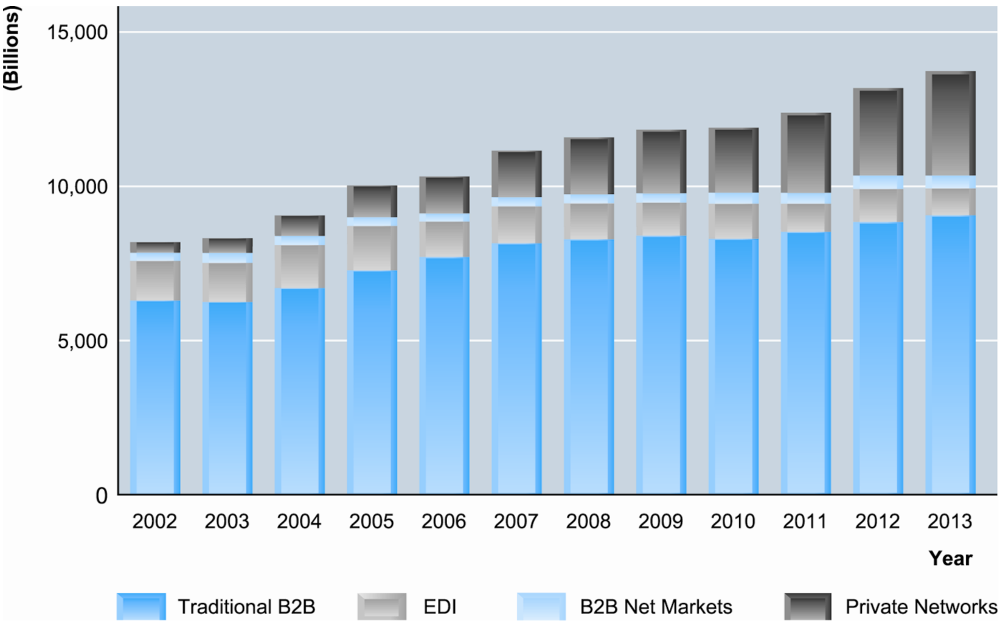

Figure 1: Statistics on B2B E-Commerce Market Share in US (Laudon & Traver 2009, p.776)

As the organization's nature of collaboration is changing towards joint value creation, their infrastructure and solution requirements are changing as well. Inter-organizational collaborations need a more process centered approach in contrast to traditional marketplaces and interaction frameworks which focus on the exchange of documents, information and goods. Process centric approaches capture the flow of business information and facilitate communication between business partners to reach a certain business goal. Use of business process models allows businesses to capture the business information that is required in each step of a collaborative business process. This eliminates redundancy in information transmission, which in turn lowers the risk of semantic differences between exchanged business information. In addition, business processes are subject to standardization efforts in future, which will allow a cost-effective implementation of commercial off-the-shelf software supporting these standardized processes (Jurgen Dorn et al. 2007) .

These requirements in collaborative environments demand faster and more efficient response to shifting market requirements, regulations and customer needs. Tight competition is forcing businesses to provide more and more services to their customers to keep them satisfied. To accomplish this, enterprises need to have a palette of atomic or composite services that can be easily and dynamically assembled into business processes (Fiammante 2010). Due to SOAs (Service Oriented Architecture) loose coupling, policy driven, composeable service architecture; it is surely one the most appropriate implementation approaches for such dynamic business processes (Holley & Ali Arsanjani 2010). A combination of a SOA and Business Process Management (BPM) approach, with the appropriate management focus, will facilitate a faster path to IT and business alignment (Fiammante 2010). According to DATAMONITOR (Datamonitor 2006), planned usage rates of SOA infrastructures were extremely high in 2006. 93% of wireless technology companies project some use of SOA, 92% of retail firms likewise, and financial (89%), manufacturing (76%) and government usage rates projected to be 89%, 76% and 75%, respectively. The estimated value on business support systems middleware market was $870 million in 2008. According to Gartner (Pettey 2008) SOA and SOA-infrastructure is being widely used in Europe. Almost 70% of the Europeans were using SOA in 2007. North American is following up by 55% and Asia with 25%. Gartner also emphasizes that SOA adoption has started falling in 2008 due to lack of SOA expertise and less viable business cases. Japanese government is promoting use of SOA to boost the number of small- and medium-sized enterprises that conduct direct B2B e-commerce (Datamonitor 2007). SOAs dynamic and reusability nature, its alliance with BPM standards and its platform independency along with its adoption rates are motivations for proposing SOA-based inter-organizational process management solutions.

2 Definition of the Research Problem

A virtual organization's existence is based on the idea to share competitive advantage and build up value added products or services to address dynamic business needs and therefore the VO is highly dependent on its partner collaboration and resource sharing. VOs interactions and collaboration is usually facilitated with computer networks and technologies. The main contribution is to provide an easy to deploy infrastructure for business process management for such collaborative networked organizations.

Over the past decades, a lot of solutions have been provided to handle inter-organizational collaborations. Virtual organizations specifically are complicated cases because; the participants have a strong dependency on each other for their service offering while they are totally autonomous in their day to day activities and operations. A paradox can be sensed, participants gather around to share their competencies and provide added value in their collaboration while at the same time they want privacy policies to guarantee their competitive advantage and need to protect how they have gained there advantage (Marcus Vinicius Drissen-Silva & Ricardo José Rabelo 2009). So any computer aided solution provided for VOs interactions should realize both dimensions. ***(1) It should be able to enforce policies in organizations service offering and sharing, to protect their competitiveness; and (2) it should be able to share and integrate different services from partners to form VO processes.*** The main focus of this study would be on providing a software infrastructure that facilitates both dimensions. As well as the mentioned dimensions of the solution the following capabilities are needed for VOs (Gehre et al. 2007):

1. Support of VO organizational structuring, including dynamic reorganization during VO lifetime, as partners can leave and join at any time;
2. Provide generic description, addressing and accessing of VO resources (data and services), including directory services;
3. Enable business process integration;
4. Be extensible in order to react to changes, extensions and new business opportunities.
5. support the organizational polymorphism that is typical for VOs;
6. ensure privacy of information;
7. provide services that keep the information about the collaborative VO network up to date;
8. ensure reasonable response times and scalability to ensure end user acceptance; use or provide for compatibility with industry standards

according to the above requirements, it is concluded that virtual organizations need a dynamic infrastructure that facilitates partner collaboration and provides the ability to build up collaborative business processes while perusing organizational privacy and protecting its competitive advantage. By analyzing the requirement of the desired solution we narrowed our choices to service oriented solutions which facilitate loosely coupled business service composition. In conclusion, the research problem is described in one sentence as “Designing a service oriented software infrastructure which facilitates distributed business process execution by integrating different partners processes while providing a manageable abstraction layer for every partner to enforce meditation, policy and security mechanism that facilitate organizations autonomy”. Table 2 summarizes how we framed our research problem:

Table 2: Framing Research Problem

Steps	***Description***
Observation	❖ Collaborative network organizations (CNO) are increasing and by 2020 almost every organization participate in some sort of CNO (Luis M. Camarinha-Matos et al. 2009) ❖ Virtual Organization success depend on collaboration of dependent partner organizations
Thesis	VO process management is challenging because partners are completely autonomous but at the same time inter-dependent on each other in the virtual organization
Enthymeme	An easy to deploy infrastructure that can facilitate process integration between multiple organizations is needed. The infrastructure should guarantee partner authority on its processes and ensure partners privacy.
Problem Statement	Designing an abstraction service layer for every organization that provides manageable privacy and security mechanism for sharing business processes between organizations and facilitates an infrastructure for collaborative business process execution.
Objectives	Facilitating creation of global virtual organizations faster and easier through web services.

Research Questions	1. How to design an easy to deploy infrastructure for collaborative process execution? 2. How to implement collaborative business processes from current organizations information systems? 3. How to preserve organization's privacy and competitive advantage while providing access to adequate information for partner organizations?

3 Research Methodology

3.1 Design Science Research in Information Technology and Information Systems

The Design Science Research (DSR) in the information Technology (IT) industry focuses on designing and implementing IT artifacts that improve performance of business organizations or create new opportunity for businesses. Research in Information Systems (IS) usually focuses on either why to deploy a technology or what technology to adopt. Each of these questions represent a critical class of IS research questions. To address the second class of these questions a design task is required with the aim to shape artifacts and events to create a more desirable future (March & Storey 2008). This class of research is called Design Science Research in Information Systems which consists of building and evaluating IT artifacts that extend the boundaries of known applications of IT while addressing an important problem and are not amenable to computational approaches (Hevner et al. 2004; March & Storey 2008). Researchers in DSR build and evaluate IT artifacts that enable (1) the description of desired information processing capabilities and their relationship to present and desired situations, and (2) the development of actions that facilitate implementation of information processing capabilities that move organizations toward desired situations. Therefore, DSR is considered problem focused and its either an initial research in a new problem area that focuses on constructing sufficient actions toward the ultimate goals and often involves prototype artifacts demonstrating feasibility of addressing the problem; or subsequent research, that aims at improving effectiveness and efficiency of attaining goals or demonstrating the necessity of certain actions (March & Storey 2008).

A typical DSR research will have five steps in its lifecycle. The first step is the awareness of the problem, which is usually achieved by a new development or a reference in the discipline. The output of this step is an initial research proposal. The second step is suggestion of a solution with the output of a tentative design based on the information acquired in the first step. The third step focuses on developing the solution and has an IT artifact as its output. The fourth step is to evaluate the resulted artifact against the initial problem and the implicit and explicit criteria extracted through the first and second step. The output of this phase is performance measures. Finally the fifth step is conclusion with the output of overall research results. The flow of knowledge in DSR is from the development, evaluation and conclusion steps to the awareness step and the research follows an iterative pattern (Takeda et al. 1990).

A DSR research has many different outputs in different abstraction levels. We discuss five type of outputs for DSR projects, (1) Constructs, known as conceptual vocabulary of a domain; (2) Models, known as set of propositions or statements expressing relationships between constructs; (3) Methods, defined as set of steps used to perform a task, (4) Instantiations, recognized as operationalization of constructs, models and methods, and finally (5) Better Theories, artifact construction as analogous to experimental natural science, coupled with reflection and abstraction. These outputs are categorized in three abstraction level known as (1) Artifact as situated implementation which consists of instantiations, methods and constructs; (2) Knowledge as operational principles which consists of models, methods, constructs and better theories; and (3) emergent theory about embedded phenomena which consists of constructs, better theories and models (Purao 2002).

3.2 Research Method and Steps

In this research, we follow the DSR research methodology. We discover the main characteristics of the required artifacts and their relationships from the literature. The main aspects that we focus on in this research, is the dependency between partners involved in a VO and their autonomy in terms of how their run their businesses. It is important to be able to identify a solution that could provide black box reusable components to the VO and guarantee privacy on how organizations perform their tasks. On the other hand we know that SOA is an accepted IT approach which defines organizational services as black box components and handles business processes by composing different reusable services. In this research, we intend to determine how existing SOA solutions are used to address VO collaborative process execution and management. The solution is evaluated by instantiating a prototype and implementing it using the proposed solution. The criteria by which we have evaluated our prototype are presented in Table 3. It starts from a main construct in our research which is “Inter-Organizational Process Management” and defines three lower level operational concepts to describe its criteria.

Table 3: Measurement criteria

Construct	*Operational Concept*	*Properties*	*Criteria*	*Indicants*	*Scale*
Inter-Organizational Process Management	Degree of partners privacy in information sharing	Authentication & Authorization	Mechanisms Available	features available	Number of features available
		Information access	Control over information access	Level of control	Process / Task / Rules / Record / Field
		Security	Security Mechanism	certified security mechanism available	Number of certified security mechanism available
		Log	How well does the system log information access	Level of details available	Process / Task / Rules / Record / Field
				Reporting Mechanism	Alarming/ Tracking/ Reporting
	Effort needed for Process Integration between organizations	single sign on (SSO)	Existence	Level of SSO existence	Within Organization/ Between Organizations
			Effort needed to setup	How long will take to setup	Number of hours it takes
		Integration of software components	Efforts needed to integration of software components	Programming needed	Average Number of line of codes (LOC)
					Level of expertise needed
		Collaborative Process	Efforts needed to build a collaborative	Programming needed	Average Number of line of codes (LOC)

			process		Level of expertise needed
				Configuration needed	Number of hours it takes
					Level of expertise needed
			Efforts Needed to Change a process	Programming needed	Average Number of line of codes (LOC)
					Level of expertise needed
				Configuration needed	Number of hours it takes
					Level of expertise needed
	Degree of distribution of authority	Topology	Support of multiple topologies	Number of topologies it supports	Linear / Star costumer centered / Star partner centered/ peer-to-peer
		Performance Measurement	Access to Performance Measurement Data	Level of KPIs visible to partners	Collaborative process/ partner process / Partner Task

Figure 2 shows our research methodology and steps. We used an iterative approach in designing our solution. The iteration is because of the knowledge acquired during the further steps of the research that affect the designing stages as discussed in the DSR methodology. Step 1 in Figure 2 depicts the awareness stage of the DSR methodology.

Steps 2 and 3 are the suggestion stage and steps 4 and 5 represent the development stage of the DSR methodology.

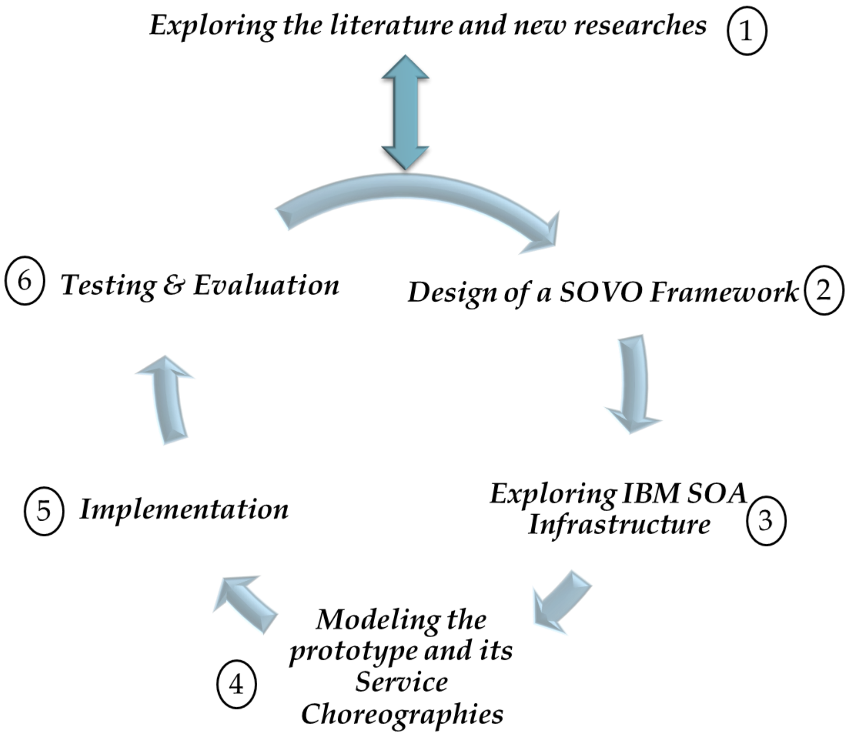

Figure 2: Research Methodology

Detail activities of each step of the above methodology are presented in Table 4. Note that these activities are showing the overall tasks of each step but they were not necessary conducted in all iterations of the research.

Table 4: Research phases and detail activities

Phase	Project Phase	Activities
1	***Literature Review***	➢ Virtual Organization ➢ Virtual Organization Process Management ➢ VO process management ICT requirements ➢ Service Oriented Architecture ➢ SOA Infrastructure and its main elements

		➢ Enterprise Service Bus and SOA integration Patterns
2	***Design of a Service Oriented Solution for Virtual Organization Management***	➢ Designing a framework for service oriented Process Management in virtual organizations ➢ Designing the main architecture of the solution ➢ Designing the different modules of the proposed solution ➢ Providing detailed specification of the modules ➢ Design of Infrastructure Components
3	***Exploring IBM SOA Infrastructure***	➢ Install IBM Web sphere ESB, BPM, UDDI Registry and iLog Business Rule ➢ Integrating IBM BPM with the ESB ➢ Explore IBM ESB federation capabilities ➢ Design the proposed solution based on IBM tools
4	***Modeling the prototype and its Service Choreographies***	➢ Selecting a prototype Virtual Organization ➢ Modeling prototype VO choreographies (using BPMN) ➢ Modeling prototype VOs business processes (using BPMN) ➢ Modeling information flow ➢ Designing prototype VOs services and service orchestrations
5	***Implementation***	➢ Partner Organizations Infrastructure setup ➢ Actual partner zone implementation ➢ Designing & implementing BPELs for the prototype VO ➢ Running different components of the infrastructure
6	***Testing & Validation***	➢ Design test case to test prototype VO service choreographies ➢ Design test case to test prototype VO business processes

		➢ Design test scenario to measure efforts needed for collaborative processes implementation ➢ Design test scenario to measure the infrastructures agility & dynamicity towards change
8	***Summarizing and writing the thesis***	

4 Contribution of the Thesis

As collaborative networked organizations and inter-organizational relationships are gaining more attention, we intend to contribute to virtual organizations initiation and facilitate collaboration between organizations. Specifically, we introduce two contributions: (a) development of a formal service choreography extraction method; and (b) design and implementation of service zone interaction model. In this research, due to VOs temporal and dynamic nature, we do not model VOs as ordinary organizations with long term strategic goals and objectives. Instead, we exploit value networks to model VO value exchange and production. Consequently, we provide a method for extracting service choreographies from value networks to align higher level value production to lower level business processes. This facilitates easier collaborative process negotiation, synchronization and implementation. Based on the choreography extraction method, we design a framework for collaborative service oriented business process design and management. The framework is generated from known best practices and reference frameworks, and it is customized for virtual organizations. We also introduce a service zone interaction model that facilitates sharing organizational resources and services while preserving the organizations privacy and competitive advantage by a gateway integration pattern. To realize goals and benefits of the proposed zone interaction pattern, we design a distributed service oriented software infrastructure that facilitates distributed business process execution by integrating different partners' service zones which allows meditation, policy enforcement and security mechanism that facilitate organizational autonomy. The software infrastructure is implemented by IBM SOA infrastructure and BPM products, and is evaluated by implementing VO collaborative processes and tasks as a prototype. Our implementation will also provide an evaluation and feedback on IBM SOA solutions federation capabilities.

5 Structure of the Thesis

The rest of this thesis is structured as follows: at the second part we conduct a research on the previously published related works. In chapter two, we discuss collaborative networked organizations and virtual organizations. In chapter three, we introduce some reference designing frameworks that we used in designing our framework and infrastructure. Chapter four discusses service oriented architecture and the building blocks of our proposed infrastructure. At part three of the thesis, we focus on our contribution in the research. Chapter five discusses the proposed process management framework. In chapter six, we introduce a service zone model and the distributed infrastructure for business process management. Chapter seven focuses on a VO prototype designed and implemented using our framework and infrastructure. Finally in chapter eight we conclude the thesis and present some future works.

Part 2
Related works

CHAPTER TWO: VIRTUAL ORGANIZATIONS

1 Collaborative Networked Organizations

During the past decade changes in manufacturing and service industries and their market is forcing them to make changes in their business strategies and management procedures. Enterprises of 2020 need to develop competencies in a very turbulent and competitive climate, therefor they need new business models, business strategies, governance principles, processes and technological capabilities (Ermilova & Hamideh Afsarmanesh 2006; Luis M. Camarinha-Matos et al. 2009). Organizations need to address six grand challenges to fulfill the gap between where they are and where they need to be in 2020 (Luis M. Camarinha-Matos et al. 2009; Committee on Visionary Manufacturing Challenges, Commission on Engineering and Technical Systems, National Research Council 1998),:

1. Achieve concurrency in (all) operations.
2. Integrate human and technical resources to enhance workforce performance and satisfaction.
3. ‘‘Instantaneously” transform information gathered from a vast array of diverse sources into useful knowledge for making effective decisions.
4. Reduce production waste and product environmental impact to ‘‘near zero”.
5. Reconfigure manufacturing enterprises rapidly in response to changing needs and opportunities.
6. Develop innovative manufacturing processes and products with a focus on decreasing dimensional scale.

The above challenges show that companies need to address more dynamic changes in different layers of their operations, thus requiring adaptation of new business models, strategies, processes and technologies. These requirements are more challenging for small and medium size enterprises which typically have limited resources, skills and infrastructure. This will result in more and more collaboration between businesses to address the limitations by sharing their resources and values. On the other hand the ability to form temporary and goal-driven associations brings the dynamicity in adjusting to business needs. Therefore dynamic inter-organizational models and processes will be an inevitable requirement for these organizations in the next few years.

Organizations have shared their resources and skills by cooperating and outsourcing some of their components and services. At the early stages these corporations were relatively stable, static and had classic associations like supply chains with well-defined roles and responsibilities. But as businesses faced more complicated and dynamic markets they needed new form of collaboration over a network of entities. The nature of the collaborations in these new initiatives is more knowledge driven in contrast with the traditional data driven networks (Luis M. Camarinha-Matos et al. 2009). A collaborative network (CN) is “a network consisting of a variety of entities (e.g. organizations, people, and even machines) that are largely autonomous, geographically distributed, and heterogeneous in terms of their operating environment, culture, social capital and goals, but collaborate to better achieve common or compatible goals, and whose interactions are supported by computer networks” (Luis M. Camarinha-Matos & Hamideh Afsarmanesh 2005). If an effort to formalize the activities and interactions of such collaborative networks, usually an individual association is formed which is called Collaborative Networked Organization (CNO). These organizations usually need some sort of distributed business process management, integration, and coordination throughout their lifecycle (Luis M. Camarinha-Matos et al. 2009).

1.1 Classification of Collaborative Networked Organizations

As defined in previous sections collaborative networks focus on communication and exchange of information, knowledge and services for a mutual benefit. A simple example would be sharing information between multiple partners on different experiences using a specific tool such as emails. The entities involved in a CN can have different dependency to each other based on the CNs nature of collaboration. In order to form a CN it is not necessary to have any common goal or structure influencing the form and timing of individual contributions, and therefore there is no common generation of value. Camarinha-Matos and his colleagues have defined an interaction maturity model for CNOs which is presented in Figure 3. Each of these terms may have common aspects; however they do not comply with a single concept. The higher the maturity of the collaboration between partners, the more they rely on each other in their business models and therefore the integration effort and business process alignment increases in those collaborations (Luis M. Camarinha-Matos et al. 2009).

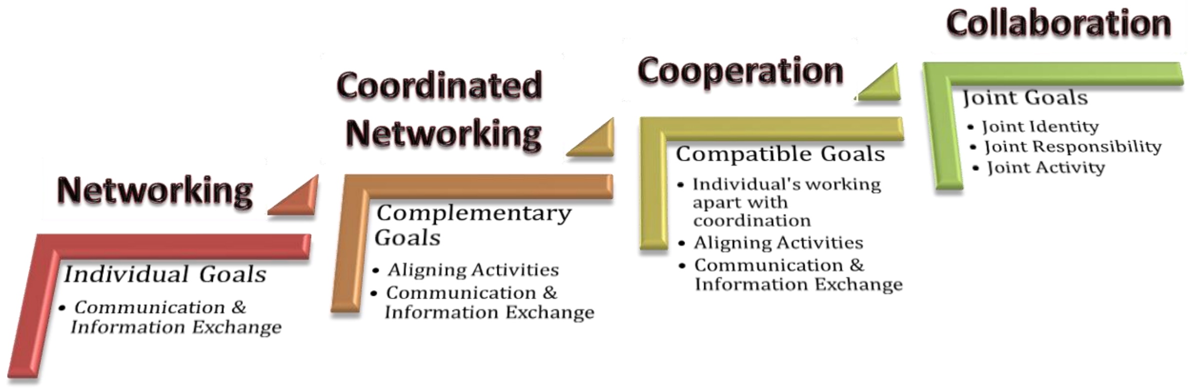

Figure 3: Different Levels of Collaboration in Networked Organizations (Luis M. Camarinha-Matos et al. 2009, p.48)

Coordination which is “the act of working harmoniously in a concerted way” (Luis M. Camarinha-Matos et al. 2009) is one of the basic building blocks of collaboration. ***Coordinated networking*** consists of not only communication and information exchange but involves aligning or even altering activities so that more efficient results are achieved. An example would be sharing of information between autonomous entities while in the process they align the timestamp of the information shared to maximize the impact. In these cases, usually each entity has its own goal and uses its own resources to produce benefits from the collaborative network. ***Cooperation*** -involves not only communication, information exchange, and adjustments of activities, but also resource sharing for achieving compatible goals. In cooperative networks, some of the non-intensive workload is usually divided between participants. In this case, the aggregated value is the result of individual components shared by each partner in a quasi-independent manner. A traditional supply chain relationship with predefined roles and responsibility that produces a value chain is an example of such a network. Participants’ goals and benefits are compatible in the sense that they will produce a value chain that leads to a product or service. ***Collaboration*** in CNOs, which is the most mature kind, demands processes “in which entities share information, resources and responsibilities to jointly plan, implement, and evaluate a program of activities to achieve a common goal and therefore jointly generate value” (Luis M. Camarinha-Matos et al. 2009). An example of such networks is in concurrent engineering where a group of experts jointly develop a new knowledge or product. Based on these levels of collaboration and other characteristics of CNOs Camarinha-Matos et al (Luis M. Camarinha-Matos et al. 2009) have presented a classification of CNOs which is presented in Figure 4.

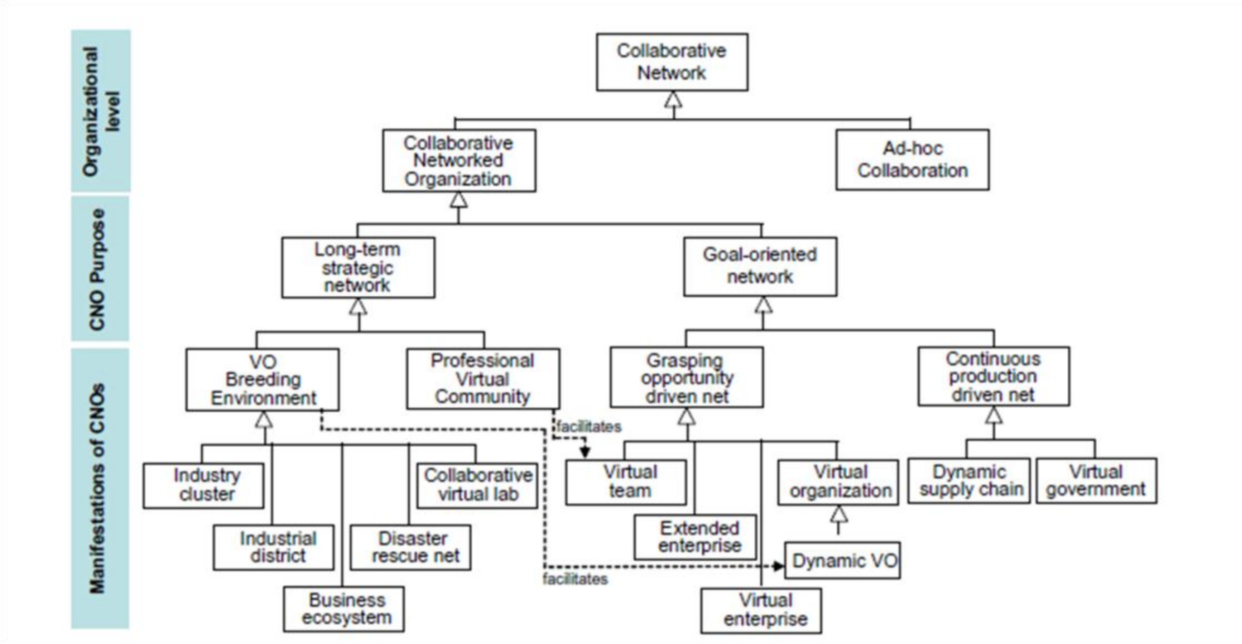

Figure 4: A Classification on CNOs (Luis M. Camarinha-Matos et al. 2009, p.49)

1.2 Definition of Virtual Organization

CNOs have different kinds and classification which was demonstrated in Figure 4. The partners involved in different collaborative networks have different dependency to each other and have different maturity level in their interactions and collaborations. In this research we have focused on goal oriented and opportunity based organizations named Virtual Organizations (VO) (see Figure 4). While there are several definitions for Virtual Organizations, there is no definition that draws an exact line for VOs. We have defined Virtual Organization, a dynamic, temporal consortium of autonomous legally independent organizations which collaborate with each other to attend a business opportunity or cope with a specific need, where partners share risks, costs and benefits, and whose operation is achieved by coordinated sharing of skills, resources and competencies and whose interactions are supported by computer networks (Marcus V. Drissen-Silva & Ricardo José Rabelo 2008; Karvonen et al. 2005).

As it can be realized from the definition, virtual organizations are one of the most mature CNOs and fall into the collaboration stage of the maturity model provided (Figure 3). VO processes are created in a collaborative environment through which a group of entities enhance the capabilities of each other. It implies sharing risks, resources, responsibilities, losses and rewards. Collaboration in virtual organizations involves mutual engagement of autonomous partners to solve a problem that benefits every partner in the organization and requires mutual trust between participants. Determination of partner contribution in the VO value creation process is much more difficult compared to other levels of collaboration in networked organizations (Luis M. Camarinha-Matos et al. 2009).

2 Virtual Organization Life Cycle

Typical organizations spend only a negligible fraction of their lifetime on initiating their organization and the operation phase constitutes their entire livelihood. If they are successful organizations they will never face a dissolution stage. Unlike typical organizations, for a wide variety of collaborative networked organizations, the creation and dissolution phases are complex stages and take up considerable attention and effort. Studies have shown that every CNO experiences four stages in its lifecycle, 1) Creation, 2) Operation, 3) Evolution, and 4) Dissolution/Metamorphosis. Figure 5 shows the mentioned stages in a diagram. Different types of CNOs need to spend more time on different stages of the lifecycle. For example a grasping opportunity based CNO such as a VO will typically dissolve after accomplishing its goal whereas more long term alliances such as Virtual Breeding Environments (VBE) are likely to dissolve but face extreme changes in their lifecycle which is considered a metamorphosis (Luis M. Camarinha-Matos & Hamideh Afsarmanesh 2007a).

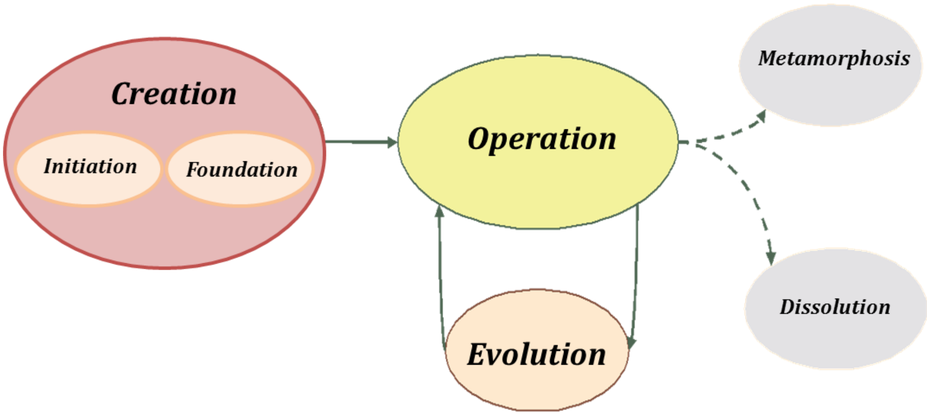

Figure 5: CNO Life Cycle Stages (Luis M. Camarinha-Matos & Hamideh Afsarmanesh 2007a, p.539)

Virtual organizations have the mentioned four stages in their lifecycle with a difference that they do not face metamorphosis but always face a dissolution stage. We will discuss these four stages generally in this section and references will be provided for detail study.

2.1 Virtual Organization Creation:

VO creation is the phase in which the collaboration opportunity is discovered, formalized and the appropriate partner candidates are selected. Finding the appropriate partners and fulfilling the necessary requirements for an effective collaboration is challenging due to lack of information (organization profiles and capabilities), lack of common collaboration infrastructure and lack of preparedness towards joint process development. Furthermore, partner selection is not simply an optimization problem of matching appropriate business processes many other factors which are of a subjective nature such as personal preferences and mutual trust must be considered. Four approaches for VO creation are discussed by Camarinha-Matos and Afsarmanesh: 1) manual or assisted VO creation which is mostly based on competency matching, 2) multi agent based VO creation which is based on market oriented negotiation mechanisms, 3) service federation VO creation which focuses on matching the appropriate services published by service providers with specific SLA (Service Level Agreement) and finally; 4) e-contracting which focuses on finding suitable cooperation agreements between partners (Luis M. Camarinha-Matos & Hamideh Afsarmanesh 2007b).

ECOLEAD (European Collaborative Networked Organizations Leadership Initiative) is a European project with the objective to create strong foundations and mechanisms needed to establish the most advanced collaborative and network-based industry society in Europe. According to ECOLEAD, VO creation stage consists of three main phases: Preparatory Planning, Consortia Formation and VO Launching. Figure 6 shows these processes and their activities. Note that based on different VO costumers and situations this activities sequence and deepness of analysis could be altered. Figure 7 Shows a two phase VO creation process which basically follows the same activities but in a different sequence and deepness (Luis M. Camarinha-Matos & Hamideh Afsarmanesh 2007b; Luis M. Camarinha-Matos et al. 2005),

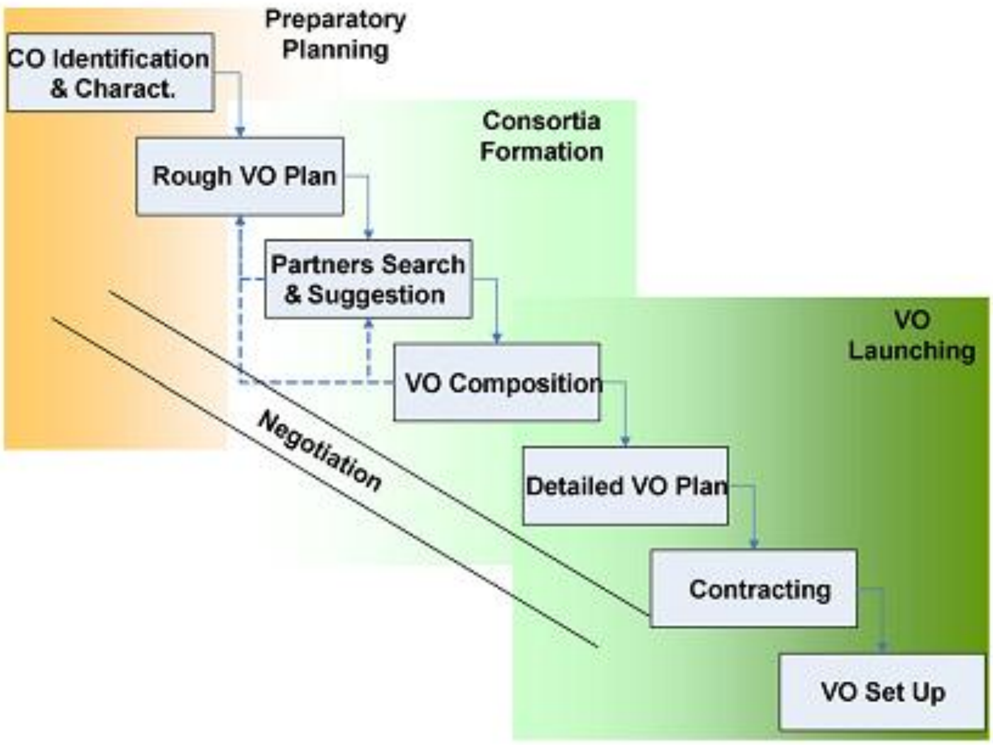

Figure 6: VO Creation Process (Luis M. Camarinha-Matos & Hamideh Afsarmanesh 2007b, p.129)

In preparatory planning, a collaborative opportunity is identified. The opportunity is identified based on identification of a competency requirement which organizations are either not able to address on their own or could address the requirement with a much higher performance in a collaborative environment. After the collaborative opportunity is identified, its characteristics are analyzed and different strategies to fulfill the opportunity are proposed. Later on, feasibility study on different strategies is performed and a rough plan for the VO is presented (Luis M. Camarinha-Matos et al. 2005).

The first step of the consortia formation is to search and suggest appropriate business partners. In this step, different technical, economical, reliability and preference elements must be considered. Different studies on how to assess partners and come up with a suggestion has been done which basically use one of the four approaches discussed earlier. The negotiation activity is an iterative process that aligns different partner capabilities which will finally result in an agreement. It is a complementary module to partner search and selection which might require multiple iteration of partner identification. Finalizing the negotiations will result in a structure for the VO formation where responsibilities and tasks are assigned to different business partners. This activity is called VO composition. The VO launching phase consists of a detailed VO planning which focuses on the refinement of the VO plan and its governance principles. It involves collaborative business process modeling, VO topology selection, assignment of roles and responsibilities, definition of sharing principles and operational policies. As the final step before a VO can be effectively launched partners need to sign contracts to regulate VO collaboration and benefit sharing (Luis M. Camarinha-Matos & Hamideh Afsarmanesh 2007b).

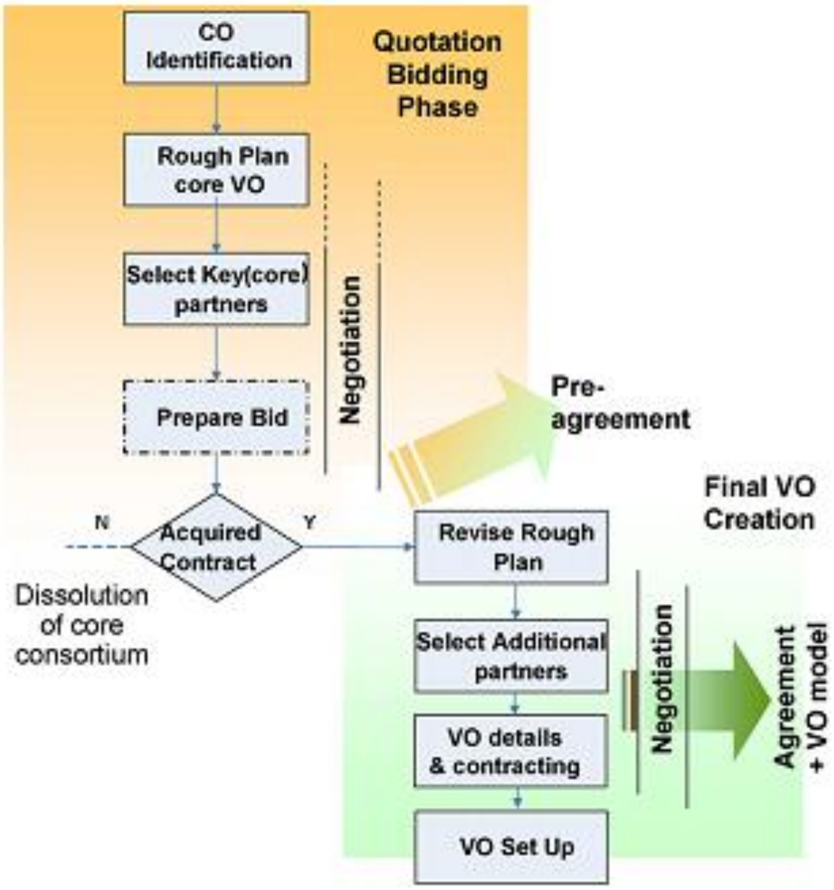

Figure 7: Two-Phase VO Creation Process (Luis M. Camarinha-Matos & Hamideh Afsarmanesh 2007b, p.131)

2.2 Virtual Organization Operation

After the virtual organization is launched, the operations of its day to day activities start. These activities are distributed throughout business partner services, according to the VO detailed plan provided in the creation phase. The VO operation management is responsible for reliable execution of the VO collaborative business processes and realization of VO value creation. At the same time that the VO process execution is triggered, it is required to start VO performance monitoring. Performance monitoring is especially important in virtual organizations due to partner's autonomy in their processes and their dependency on each other in the virtual organization. VO performance management focuses on providing visualization, monitoring and alerting functionalities from different source of information throughout partner processes. The visualization is responsible for observing and monitoring VO state and its real time view of ongoing processes. The monitoring functionality focuses on detecting exceptional conditions that may require VO evolution. The alerting functionality focuses on notifying different parties involved on VO current situation and evolution needs (Romero & Molina 2009). Usually with virtual organization risk calculation and tracking is challenging but the alerting and monitoring functionalities will help the VO to manage risk and trigger appropriate response strategies. Finally another important functionality of this stage is communication between business partners. VO partners need frequent communication with each other in all stages of the lifecycle but in the operation phase the communication falls into a more formal format (Negretto et al. 2008).

2.3 Virtual Organization Evolution

Virtual organizations are extremely dynamic and temporal in their nature. They are dependent on specific business opportunities thus changes in the market rapidly affect these kinds of organizations. Therefore VO success depends on predicting and adapting to these changes continuously. The VO evolution phase with its feedback from the operation phase is responsible for VO adaptation and change management. It consists of activities such as what-if analysis, providing alternate solutions, partner substitution, reassignment of tasks and responsibilities; reallocation of budget and even in some cases trigger of a new VO through the VO creation process (Negretto et al. 2008). The key in the evolution stage is to have the right information which should come from the market and the operation performance monitoring activity. If this is realized the VO would be able to proactively monitor the situation, thus prevent failure and make the most benefit out of the collaborative opportunity (Romero & Molina 2009).

2.4 Virtual Organization Dissolution

VO is a temporary organization. Consequently it will naturally face a stage where its purpose is no longer valid and it no longer provides a value added service or product.

This duration may vary depending on a VO's business climate; it could be a few days or a few years. At the closing stage, partners typically don't know whether there will be similar tasks to perform in the near future or not. The dissolution phase is responsible to break up the concrete collaboration. It consists of releasing shared resources and infrastructure setups. Partners break up the collaborative business processes that were built and dissolve the configuration they had made. The challenge is how to manage and inherit important assets that are created through VO lifecycle such as customer base, knowledge and lessons learned from the collaboration. The question is how to divide the tacit jointly created value between partners. This is usually referred to as VO inheritance in the literature and faces its own difficulties (Jansson et al. 2008). VO inheritance "is the practice of storing and passing on the experience and other non-proprietary assets created through the collaboration" (Jansson et al. 2008). VO inheritance management which is the most important part of the dissolution stage "takes care of gathering, storing, refining, integrating and reusing the experience and other non-proprietary assets created through collaboration in distinct VOs" (Jansson et al. 2008).

3 Virtual Organization Management

As collaborative gathering of autonomous partners is gaining more and more attention in today's business environment the need to have management solutions and best practices has raised. Collaborative networks are known to facilitate competitiveness, world-excellence and agility in turbulent market conditions (L. Camarinha-Matos & Hamideh Afsarmanesh 2004). A key point in achieving these goals is an effective management. As VOs respond to temporal specific business opportunities, their management has its own challenges and traditional management approaches and mechanisms need adoption to the specific needs and nature of virtual organizations (Karvonen et al. 2005). In this section we will define VO management, discuss its challenges, approaches and topologies.

Jansson and his colleagues (Jansson et al. 2008) have defined two elements for managing virtual organizations. The first element, VO governance, consists of principles, structures and processes and the relationship between these elements that support an efficient achievement of VO goals and values. VO governance principles should indicate relationship between all stakeholders, specify the proper flow of information between partners, ensure appropriate review issues and performance monitoring, and finally guarantee a coordinated approval of VO activities. The second element is managing the VO which relates to the operative coordination of the common activities. This element executes VO activities and processes based on the agreed governance principles and rules. In case of VOs that face a dynamic environment, both the structures (governance) and operations (management) need to be adopted by every case's individual aspect.

In this research, when we refer to VO management, we are considering both the governance and management elements. Thus VO management is defined as "The organization, allocation and coordination of resources and their activities, as well as their inter-organizational dependencies to achieve the objectives within the required time, cost and quality frame" (Karvonen et al. 2005). As VOs aggregate several autonomous partners, and operate in a highly dynamic and temporal environment, their management is multidisciplinary and complex, and critical for the success of the virtual organization (Karvonen et al. 2005).

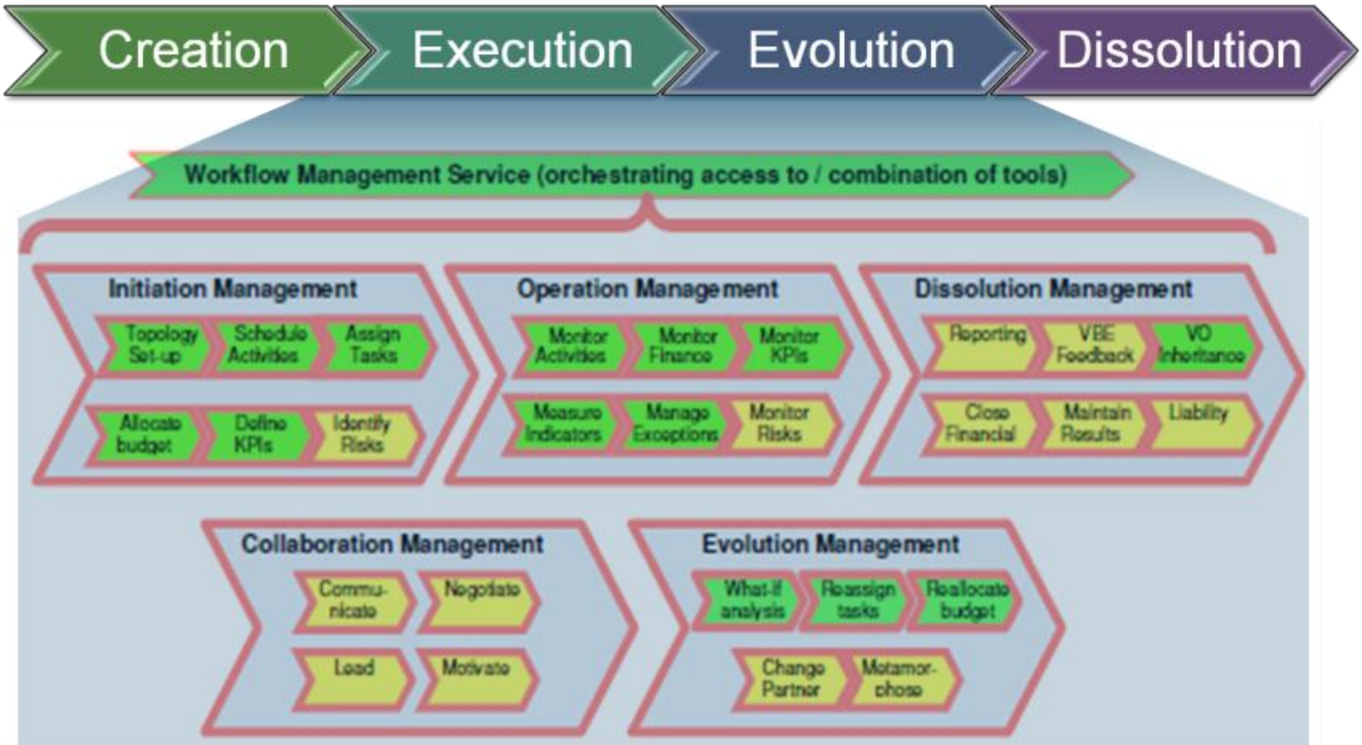

Figure 8: VO Management and its Services (Negretto et al. 2008, p.259)

VO Management starts in the creation phase of VO lifecycle and ends on the first steps of VO dissolution as depicted in Figure 8. The initiation management step of VO management services focuses on the VO launching activities described in section 2.1. VO management covers all activities of the execution phase, such as business process integration, synchronization, execution and monitoring (Negretto et al. 2008). The evolution phase is responsible for value proposition throughout the VO lifecycle. Therefore the most important task of VO evolution management is to facilitate identification of a problem and its severity, reasoning about involved partners and components; and application of right procedures for the ultimate final resolution. An important factor is that the VO evolution not only needs to be able to react and trigger actions towards problem solving but it needs to be distributed, agile and dynamic (Marcus V. Drissen-Silva & Ricardo José Rabelo 2008). VO management also needs to make sure that partners are communicating throughout the VO execution and evolution phases. This collaboration plays an important role due to VO's decentralized topology and decision making. The dissolution phase focuses on reporting partner's assets and dissolving the common resources shared (Negretto et al. 2008). Figure 8 depicts detail services needed for VO management every stage of the way. These services have been identified as part of the ECOLEAD project.

3.1 VO Management Challenges

VO management faces challenges that come from its nature such as temporality, distributed operation between different business partners, independent but interdependent partners with their specific aim, behavior and culture; need of adoption to fast changing environment which may cause restructuring in management configuration or even approach. Unlike traditional organizations, VO manager has little or no power over independent partners and must handle VO operations through creating trust and collaborative atmosphere, considering risk and relying on incomplete information (Karvonen et al. 2005) (Jansson et al. 2008). The inter-organizational supervision and control relies on the ability to synchronize and orchestrate partner business processes to perform collaborative distributed business processes. This is all handled in a very dynamic environment that needs to be proactive towards business changes and needs (Negretto et al. 2008). Decision making in virtual organizations should be transparent regarding information sharing and governance aspects, and it should be unique due to its dynamic nature. The solution for a given VO may not necessarily be valid for another (Marcus Vinicius Drissen-Silva & Ricardo José Rabelo 2009). Finally, in order to support dynamic and agile management within the VO climate, real-time actions and efficient performance management with reliable real-time indicators are required (Karvonen et al. 2005). In addition to this dynamicity, risk calculation and management in virtual organization is challenging due to multiple partners and their individual goals, differences in their organizational strategies, and different roles and position they occupy in the collaborative network. These will result in transfer of risks between organizations throughout VO lifecycle which will even make risk management more difficult (Karvonen et al. 2004). Table 5 summarizes some of the differences between traditional management model and VO management models.

Table 5: Comparison Between Traditional Organizations and VO Management (Marcus V. Drissen-Silva & Ricardo José Rabelo 2008)

	Traditional Organizations	***CNO/VO***
Decision Scope	Intra-Organizational	Inter-Organizational
Decision	Typically Centralized	Preferably decentralized
Information Sharing Among Partners	No or Eventual	Yes
Decision Transparency	No or Low	Yes
Quality Decision Evaluation	No or Low	Yes
Decision Process Rigidity	Inflexible / Workflow	Flexible / Ad-hoc
Information Integration Between Partners	Low / Medium	High / Very High
Trust Among Partners	Implicit	Explicit
Decision Objective	Best Local Result	Feasible Global Result
Mutual Help Level Between Partners	Cooperation	Collaboration

Karvonen and his colleagues (Karvonen et al. 2004) have classified the mentioned challenges in VO management into five major categories; (1) Distribution, dependencies and coordination, (2) VO Performance management, (3) Knowledge and information sharing, (4) VO risk management and (5) VO change management in different phases of the lifecycle. In conclusion, any solution intended to address VO management should consider the above requirements and challenges. The solution should be configurable and adoptable in different situations.

3.2 VO Management Approaches

Managing the planning, execution and control of organizations coming together to address a new business opportunity or market segment needs is not new and industries have been struggling with it for some time. Drissen-Silva and Rabelo have categorized prior research in this are into four categories and named them VO management approaches (Marcus V. Drissen-Silva & Ricardo José Rabelo 2008). In this section we are going to discuss these approaches and some of their benefits and constrains.

- ***Managing Virtual Organization as a Project:***

  Projects as they are performed in today's industries have several similarities to VOs and due to a great deal of experience in developing best practices and management frameworks for them, project management is considered as one of the basis of VO management. One of the approaches used to manage VOs is to treat them as project which will result in use of Project Management Body of Knowledge (PMBOK (Project Management Institute. 2008)) principles. PMBOK defines a project as "a temporary effort to create a unique product or service". A VO then fits in PMBOKs definition of a project. PMBOKs principles on integration management, risk management, work break down structure (WBS), resource sharing and change management provide a good ground work for VO management (Karvonen et al. 2005). Although there are many similarities between projects and VOs, when carefully considered, PMBOK lacks some functionalities in dealing with VOs due to multiple organization involvement, a complicated long preparation process for VO creation, having no central authority in decision making, and the collaborative nature which requires continuous negotiation (Karvonen et al. 2004). As stated by Drissen-silva and Rabelo in (Marcus Vinicius Drissen-Silva & Ricardo José Rabelo 2009), it is dangerous to leave decision making in a VO to a central authority (in PMBOK the project manager) as the ultimate goal is to reach a feasible and realistic solution not a theoretical plan and in order to do so, partner negotiation and involvement is crucial.

- ***Managing Virtual Organization with Project Management Reference Models:***

  In this category of practices toward VO management, project management principle and frameworks are considered as reference models for VO management. A great deal of case by case customization is needed but it overcomes many of the disadvantages of the previous approach. In the end the problem with these models is that they are designed for projects and usually disregard the collaborative and decentralized decision making notion of virtual organizations. Studies in this category have been done on PMBOK, Capability Maturity Model Integration (CMMI) which has been mostly used in software development, Agile Project Management (APM) and Engineering Change Management (ECM) (Marcus V. Drissen-Silva & Ricardo José Rabelo 2008).

- ***Managing Virtual Organization with Decision Protocols:***

  This approach focuses on defining and employing a set of decision protocols to manage every virtual organization. These protocols and mechanisms can be adopted for every virtual organization’s specific needs. This approach normally consists of reporting and alerting systems, automated rescheduling and reconfiguration aided by simulation capabilities for a VO. However they leave it to the VO manager to implement the necessary corrections, follow up information sharing and discussion among partners. The downside is that it usually lacks the guidelines and supporting methodologies for management and effective collaboration activities (Marcus V. Drissen-Silva & Ricardo José Rabelo 2008).

- ***Managing Virtual Organization with Collaborative Discussion Forum:***

  Finally, the fourth approach is based on collaborative discussions between different VO partners. The logic behind it is that everything should be collaborated between different business partners and every one should be involved in every step of the way. This approach relies highly on computer network to facilitate VO collaboration. The downside is that in terms of computer support for discussions over the network, groupware tools only cope with a partial part of the problem. The matter is not only to facilitate partners talking to each other, but rather to globally coordinate their discussions, integrate information for further auditing, provide transparency to the whole communication and decision making process, and regulate partners involvement and information access (Marcus V. Drissen-Silva & Ricardo José Rabelo 2008).

We believe that none of the above approaches on their own are going to satisfy and address VO management requirements. A successful solution for VO management should use a combination of the mentioned approaches to address every aspect of VO characteristics. Therefore in this research we refer to project management and service management best practices as reference models that support VO management activities and recommend a combination of decision protocols and information sharing to support partner collaborations.

4 Virtual Organization Topologies

Different approaches are considered when classifying virtual organizations. These different classification approaches are highly dependent on the collaborative characteristics of virtual organizations. A common classification method for virtual organizations is based on their collaboration topologies. Due to VOs dynamic nature these topologies could vary in different stages of VOs lifecycle (Karvonen et al. 2005). In this section we describe four topologies for opportunity discovery and later on expand them to VO contracting and planning. At the second phase we discuss three main topologies for VO management and operation.

Collaborative opportunities that result in creation of virtual organizations fall into one of the four main collaboration modalities: (1) Collaborative business processes model, (2) Project model, (3) Problem solving model, and (4) Ad-hoc model. A collaborative business process is defined as a set of heterogeneous activities distributed through cross-organizational sub-processes. A collaborative project model is a combination of multiple projects coordinated with work break down structures. A collaborative problem solving model focuses on establishing a roadmap for multiple organizations to analyze a desired scenario and the ways to attain that from a current situation. This achievement is realized by the collaboration of multiple organizations. The ad-hoc collaboration model is used when big cooperation's need to collaborate with each other to address an external request. These models are used in a similar manner to handle contracting between virtual organizations. Partners may form an explicit consortium in which the client selects and regulates the partners involved and follows a star topology managed by consumer itself. An internal consortium follows a star topology but one of the VO partners regulates the communication and handles the contract with the costumer. The third model would be a sub-contracting solution which follows a supply chain topology. The final pattern which follows the peer-to-peer topology is a partnership in which all partners are responsible for a legal contract, and interact with the costumer directly. In this case, sometimes a legal entity is formed using the partnership agreement (Luis M. Camarinha-Matos et al. 2005)**.**

VO management and operation are categorized in three different topologies: the supply chain topology in which partners' collaboration follows a linear pattern where each partner communicates to its upper and lower neighbors; the star topology, also called hub and spoke, which has a main contractor acting as the central partner, and the interactions between different partners is arranged predominantly star-like between the central partner and other organizations; and finally, the peer-to-peer topology where the partners interact with each other with no hierarchy or central control. The VOs processes are divided into operational processes and management processes. The operational topology describes the physical and informational flows needed for the production of a product or service while the management topology describes the information and control flows of VO guidance process. The VO might follow one of the topologies in its operation and another one in its management. Figure 9 depicts these topologies (Karvonen et al. 2005).

Figure 9: VO Interaction and Management Topologies

CHAPTER THREE: REFERENCE FRAMEWORKS

1 Project Management Body of Knowledge (PMBOK)

As indicated in previous chapter one of the reference frameworks usually used in VO management is PMBOK. The similarities between projects and VOs - both in their lifecycle stages and temporary goal oriented nature- have attracted VO management solutions to use PMBOK as a reference model. Therefore in this research PMBOK is used to frame our proposed framework's scope.

Project management has gained a great level of acceptance over the past few years. This indicates that application of knowledge, processes, skills, tools, and techniques have significant impact on project successes. Project Management Body of Knowledge (PMBOK) – a recognized framework for project management - was first introduced by Project Management Institute in 1987 as an attempt to document and standardize generally accepted project management practices (IEEE Computer Society 2011).

Based on PMBOK Guide (IEEE Computer Society 2011) a "project is a temporary endeavor undertaken to create a unique product, service, or result". The temporary nature of a project requires a project to have a definite beginning and an end. The end is touched when certain goals and objective of the project is been met or the project is terminated. Project management "is the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements. Project management is accomplished through the appropriate application and integration of the logically grouped project management processes comprising of five Process Groups". These process groups are initiating, planning, executing, monitoring and controlling, and closing. Project management comprises of identifying requirements, addressing the various needs, concerns, and expectations of the stakeholders, and also balancing the competing project constraints. These project concerns are usually known as: scope, quality, schedule, budget, resources, and risk. In recent edition PMBOK has introduced nine knowledge areas which are presented as follows (IEEE Computer Society 2011):

- **Project Integration Management:** It consists of the processes and activities that are required to identify, define, combine, unify, and coordinate the various processes and activities within the five Project Management Process Groups.
- **Project Scope Management:** This knowledge area focuses on ensuring that the project contains all the work required, and only the work required, to complete the project successfully. Project scope management is mainly responsible for defining and controlling what is and is not included in the project.
- **Project Time Management:** It includes the processes required to accomplish timely completion of the project.
- **Project Cost Management:** Project Cost Management consists of cost estimation, budgeting, and controlling the budget so the project would be completed within the planned boundaries.
- **Project Quality Management:** This knowledge area focuses on the processes and activities that are accountable for quality policies, objectives, and responsibilities so that the project quality criteria are met.
- **Project Human Resource Management:** Project Human Resource Management includes the processes that organize, manage, and lead the project team.

- **Project Communications Management:** It consists of processes that ensure timely and appropriate generation, collection, distribution, storage, retrieval, and ultimate disposition of project information.
- **Project Risk Management:** Project Risk Management focuses on conducting risk management planning, identification, analysis, response planning, and monitoring and control within the project lifecycle.
- **Project Procurement Management:** It is a set of processes required to purchase or acquire products, services and etc. from outside the project.

Figure 10 is showing detailed steps and tasks in project management across the nine knowledge areas presented.

Knowledge Areas	Project Management Process Groups				
	Initiating Process Group	Planning Process Group	Executing Process Group	Monitoring & Controlling Process Group	Closing Process Group
4. Project Integration Management	4.1 Develop Project Charter	4.2 Develop Project Management Plan	4.3 Direct and Manage Project Execution	4.4 Monitor and Control Project Work 4.5 Perform Integrated Change Control	4.6 Close Project or Phase
5. Project Scope Management		5.1 Collect Requirements 5.2 Define Scope 5.3 Create WBS		5.4 Verify Scope 5.5 Control Scope	
6. Project Time Management		6.1 Define Activities 6.2 Sequence Activities 6.3 Estimate Activity Resources 6.4 Estimate Activity Durations 6.5 Develop Schedule		6.6 Control Schedule	
7. Project Cost Management		7.1 Estimate Costs 7.2 Determine Budget		7.3 Control Costs	
8. Project Quality Management		8.1 Plan Quality	8.2 Perform Quality Assurance	8.3 Perform Quality Control	
9. Project Human Resource Management		9.1 Develop Human Resource Plan	9.2 Acquire Project Team 9.3 Develop Project Team 9.4 Manage Project Team		
10. Project Communications Management	10.1 Identify Stakeholders	10.2 Plan Communications	10.3 Distribute Information 10.4 Manage Stakeholder Expectations	10.5 Report Performance	
11. Project Risk Management		11.1 Plan Risk Management 11.2 Identify Risks 11.3 Perform Qualitative Risk Analysis 11.4 Perform Quantitative Risk Analysis 11.5 Plan Risk Responses		11.6 Monitor and Control Risks	
12. Project Procurement Management		12.1 Plan Procurements	12.2 Conduct Procurements	12.3 Administer Procurements	12.4 Close Procurements

Figure 10**: Project Management Knowledge Areas (IEEE Computer Society 2011, p.43)**

2 ITIL V3 Framework

Information Technology Infrastructure Library (ITIL) provides a framework for service management and service life-cycle. The third version of the framework is one of the most adopted set of guidance for IT service management worldwide. It is considered as non-proprietary best practice that can facilitate IT service management in different businesses and organizational environments (Kneller 2010). As information technology has evolved over the years, the technology focus has moved from mainframe-centric infrastructure and centralized IT organizations to distributed computing and geographically dispersed resources. Although this has many benefits especially in optimizing resources, reducing costs and providing organizations more flexibility, but at the same time it has made technology delivery, management and support more difficult. The UKs Office of Government Commerce recognized the opportunity to utilize consistent practices for all aspects of a service lifecycle to drive organizational effectiveness and efficiency. This resulted in the ITIL framework as a governance methodology that has been successful in driving consistency, efficiency and excellence into the business of managing IT services. From a business perspective, the adoption of ITIL practices by IT service providers – whether in-house providers or external suppliers – ensures many benefits, including (Long 2008):

- IT services which align better with business priorities and objectives, meaning that the business achieves more in terms of its strategic objectives
- Known and manageable IT costs, ensuring the business better plans its finances
- Increased business productivity, efficiency and effectiveness, because IT services are more reliable and work better for the business users
- Financial savings from improved resource management and reduced rework
- More effective change management, enabling the business to keep pace with change and drive business change to its advantage
- Improved user and customer satisfaction with IT
- Improved end-customer perception and brand image.

ITIL V3 provides a life-cycle for service management. Figure 11 shows the lifecycle stages.

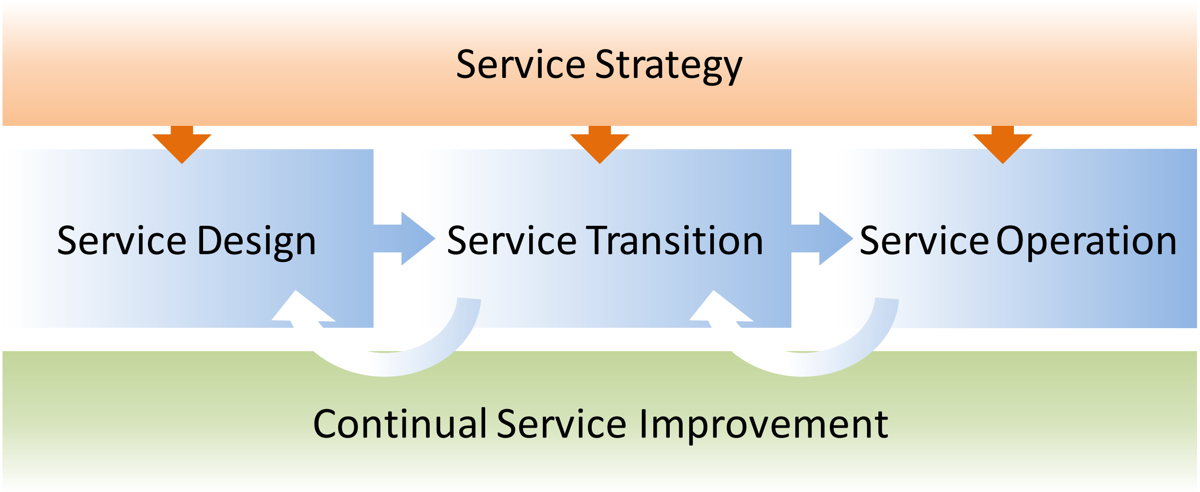

Figure 11: ITIL lifecycle for Service Management

Service Strategy defines high-level strategies for providing services. First it identity's the market for every proposed service. This will result in the identification of service offerings as well as the strategic assets that will constitute these services. The envisioned services are then charted into the Service Design stage. ***Service Design*** is a stage in which a new or modified service is developed which includes defining service requirements, designing the service solution, evaluating alternate suppliers of the service, and integrating service assets into a service. ***Service Transition*** focuses on transition planning and support. This process plans all the activities that must take place to put the service into production. This may involve the creation of a number of RFCs that will carry out all necessary changes (Change Management) and deployments (Release and Deployment Management). The ***Service Operation*** stage is responsible for a reliable service execution. During its execution, a service is carefully monitored to determine service levels as well as to look for operational faults. Operational faults may be detected as events from service monitoring. Those events may be resolved within Event Management or may be escalated to Incident Management to be resolved by Service Desk personnel.

In either case, the event is recorded as an incident and the service is restored as quickly as possible via either a workaround or some other resolution. The ***Continual Service Improvement*** module collects data and feedback from users, customers, stakeholders, and other sources to enhance services through their lifecycle. This involves the use of a 7-step improvement process that collects data, analyzes the data, provides recommendations, and implements those recommendations. The ***Service Level Management (SLM)*** module of ITIL is a set of processes responsible for negotiating customer requirements, forming Service Level Agreements (SLA), and ensuring the quality of service delivery. This process will be triggered in “Service Design” stage and the outcomes will be used through the following stages. SLM is also responsible for ensuring that Service Management Processes, Operational Level Agreements (OLAs), and underpinning Contracts, are appropriate for the agreed service level targets. SLA is developed between service providers and customers to describe the service, document service level targets, and specify the responsibilities of each party. This agreement is made after the customer’s requirements are stated in Service Level Requirement (SLR) (Long 2008).

3 A Reference model for Collaborative Networks (ARCON)

Camarinha-Matos and Afsarmanesh have presented a “A Reference model for COllaborative Networks” (ARCON) which identifies different dimension of CNO modeling. It provides two perspectives in CNO modeling, the endogenous elements and exogenous interactions (Luis M. Camarinha-Matos & Hamideh Afsarmanesh 2007a).

The endogenous elements focus on providing an abstract representation of the CNO from inside, namely the identification of a set of characteristic properties that can together capture the elements constituting CNOs. The endogenous elements are divided to four dimensions (Luis M. Camarinha-Matos & Hamideh Afsarmanesh 2007a):

- ***Structural dimension.*** This perspective addresses the structure or composition of the CNO in terms of its constituting elements (participants and their relationships) as well as the roles performed by those elements and other characteristics of the network nodes such as the location, time, etc.
- ***Componential dimension.*** This dimension focuses on the individual tangible/intangible elements in the CNO's network, e.g. the resource composition such as human elements, software and hardware resources, information and knowledge. Not all these elements are "physical" in a strict sense but rather represent the "things" of which the network is built of. Furthermore, the componential dimension also consists of ontology and the description of the information/ knowledge repositories that pertain to the CNO.
- ***Functional dimension.*** This perspective addresses the "base operations" available at the network and the execution of time-sequenced flows of operations (processes and procedures) related to the "operational phase" of the CNO's life cycle.
- ***Behavioral dimension.*** This dimension addresses the principles, policies, and governance rules that drive or constrain the behavior of the CNO and its members over time. Included here are elements such as principles of collaboration and rules of conduct, contracts, conflict resolution policies, etc.

The exogenous interaction perspective aims to reach an abstract representation of the CNO from the outside perspective. Its focus is on the characteristics that the CNO reveals in its interaction with its logical surrounding environment. The exogenous interactions are divided to four dimensions (Luis M. Camarinha-Matos & Hamideh Afsarmanesh 2007a):

- ❖ ***Market dimension.*** This dimension covers both the issues related to the interactions with "customers" (or potential beneficiaries) and "competitors". The customers' facet involves elements such as the transactions and established commitments (contracts), marketing and branding, etc. On the competitors' side issues such as market positioning, market strategy, policies, etc. can be considered.
- ❖ ***Support dimension.*** Under this dimension the issues related to support services provided by third party institutions are to be considered. Examples include certification services, insurance services, training, external coaching, etc.
- ❖ ***Societal dimension.*** This dimension captures the issues related to the interactions between the CNO and the society in general. Although this perspective can have a very broad scope, the idea is to model the impacts the CNO has or potentially can have on the society (e.g. impact on employment, economic sustainability of a given region, potential for attraction of new investments) as well as the constraints and facilitating elements (e.g. legal issues, public body decisions, education level) the society provides to the CNO development.
- ❖ ***Constituency dimension.*** This perspective focuses on the interactions with the universe of potential new members of the CNO, i.e. the interactions with those organizations that are not part of the CNO but that the CNO might be interested in attracting. Therefore, general issues like sustainability of the network, attraction factors, what builds/provides a

sense of community, or specific aspects such as rules of adhesion and specific "marketing" policies for members, are considered here.

Figure 12 presents the ARCON modeling framework. At the bottom the endogenous elements (Structural, Componential, Functional and Behavioral) and the exogenous interaction (Market Support, Societal and Constituency) dimensions are presented. On the left side the CNO lifecycle with the sequence of Creation, Operation, Execution and Dissolution are presented from bottom to top. The third dimension of the model focuses on three levels of modeling the General Representation, Specific Modeling and Implementation Modeling.

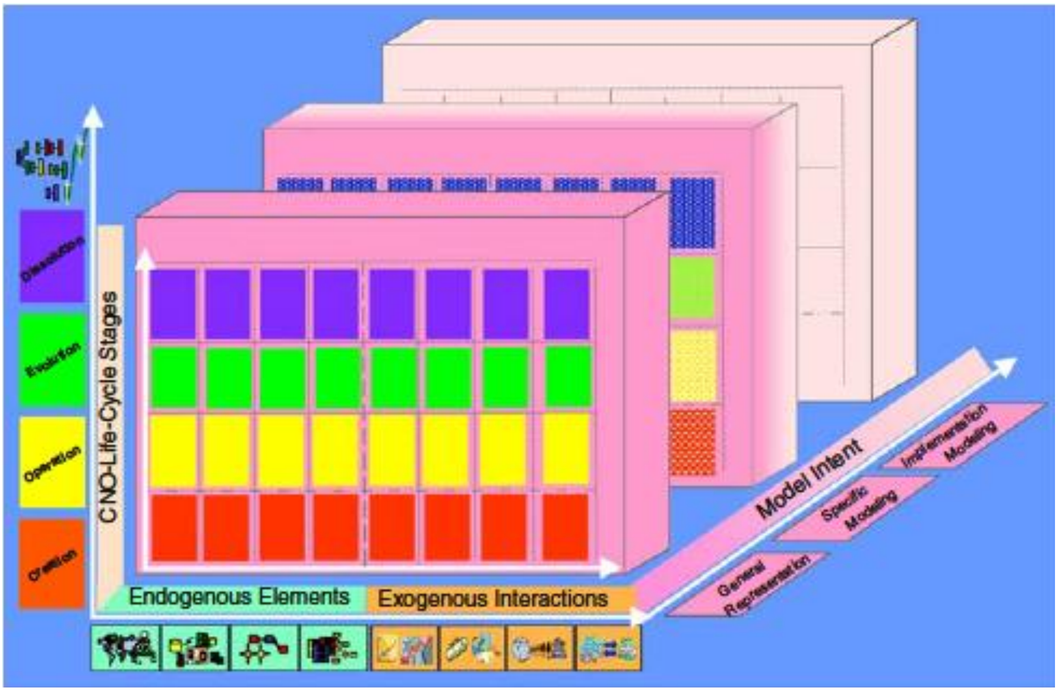

Figure 12: ARCON Framework (Luis M. Camarinha-Matos & Hamideh Afsarmanesh 2007a, p.541)

4 EDI B2B Reference Architecture

In this section a layered architecture for B2B e-commerce is proposed. This architecture is based on the Open-EDI reference model - standardized by the International Organization of Standardization (ISO) (ISO 2004) – which groups B2B process definition and management into two abstract views. This layered architecture is shown in Figure 13.

The business operational view (BOV) addresses the semantics of electronic business, hence the semantics of business collaborations and related business information exchanges. Specifications going into the BOV capture business knowledge in a technology independent way. The functional service view (FSV) addresses the technologies and the implementation aspects to support business collaborations specified in terms of BOV related specifications. In other words, technologies on a lower level implement higher level methodologies. Since the BOV describes a business in a technology independent way, different FSV implementations (i.e., deployments for different platforms) may be available (Jurgen Dorn et al. 2007).

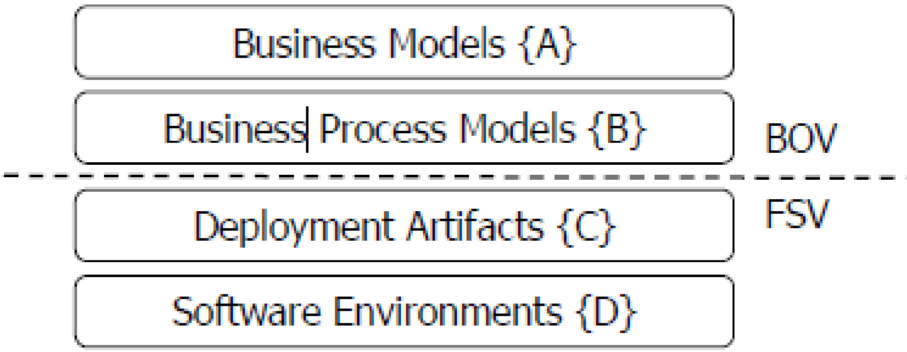

Figure 13: Layered Architecture for B2B E-Commerce (ISO 2004)

The BOV itself is split up into two sublevels. The FSV comprises specifications for deployment artifacts as well as software environments. These layers will be discussed in the upcoming sections.

4.1 Business Models

Fast moving markets in which business fell and rise by the minute and a lot of value chain deconstruction and reconstruction happens in every day to day business activities, stakeholders need to form business networks in a more flexible and agile way and on a plug & play basis (Mohamed et al. 2010). These circumstances demand business models to be expressed formally so that they can be processed in a machine-readable way. This helps organizations to adapt easily to requirement changes and allows them to analyze themselves with tools that are capable of simulating different business scenarios to facilitate the selection of the most sustainable one. This requirement has derived different approaches to design business models. Two of the most promising and mature business model approaches that are used for B2B modeling are the e3-value and the Business Model Ontology (BMO) (Jurgen Dorn et al. 2007).

4.2 Business Process Model

Business process is defined as a flow of related activities that together create a customer value. A business process model is an abstract description of the flow of one or more business processes. This layer of the architecture aims to provide a description flow of information, product, documents, activities and money between the business partners in order to fulfill a collaboration agreement. In this section a few different approaches used for business process modeling are discussed. Some of which are dedicated to B2B collaborations and some are general solutions. (Jurgen Dorn et al. 2007).

Pure UML approaches:

Although UML was initially introduced as a modeling language for object oriented software systems, its flexibility and extensibility have attracted business modelers and analysts. In order to describe the behavior of a B2B business process, the suggestion is to comprise activity diagrams for modeling collaborative processes as a flow of transactions in which a transaction is denoted as an activity and implies a message exchange between two business partners. For specifying interactions between participants on a lower level, one might also utilize sequence diagrams. Constrains of using UML are that 1) it does not include requirements elicitation in early development stages. 2) The scope does not consider the reuse of artifacts. 3) Up until now it’s not widely accepted by the industry to use it and it mainly is discussed in academic environments.(Jurgen Dorn et al. 2007)

UN/CEFACT's Modeling Methodology (UMM)

UMM is again a UML-based standardized methodology developed by UN/CEFACT and well accepted in the field of B2B modeling. In its early stages, RosettaNet community contributed experiences from its application in the IT, telecommunication, and semiconductor industry to the development of the UMM which later became part of the ebXML standard for B2B E-Commerce. UMM consists of three views - the business domain view, the business requirements view and the business transaction view. In the business domain view, the business analyst gathers existing domain knowledge from stakeholders. The business requirements view elicits requirements of desired and to-be designed business collaborations. The business transaction view describes business collaborations and business transactions. Although UMM was specifically defined for B2B interactions and the reuse of the artifacts was considered but still it has its shortcomings. Currently, there is a lack of tool support by software vendors and it needs further training for business process designers to use it due its complexity and specialty. This mainly results from the fact that the methodology provides means to capture complex collaborations with clearly defined business transaction semantics (Jurgen Dorn et al. 2007).

Business Process Modeling Notation (BPMN)

BPMN – an OMG specification (Object Management Group) - provides a small, but clearly defined notation for modeling business processes. The simple notation enhances the understandability of BPMN diagrams among different groups of users. Since BPMN is defined from scratch as a business process modeling notation, it has a definite business centric approach. BPMN defines Business Process Diagrams (BPD) to capture a business process. A BPD describes the flow of a process using flowchart techniques. The modeled process might be either internal to a company (private process) or collaborative if executed between two or more participants (public process). Furthermore, BPMN allows modeling the interface that a private process exposes to its outside world. The interface of such a process defines what message exchanges are required in order to interact with it (Emig et al. 2006).

An advantage of BPMN in comparison with previous methods is that unlike those other modeling notation that are unfamiliar to most business analysts, BPMN is well-formed and easily understood by business analysts and managers. In addition BPMN defines a direct mapping to BPEL, which is also part of its specification. The closely defined relationship between BPMN and BPEL should narrow the gap between business process models and process implementations. Unfortunately BPMN only defines a notation for capturing business processes but in order to capture the complexity of a B2B process a supporting methodology guiding the business analyst from the requirements of the business domain to the formal business collaboration specification is needed (Jurgen Dorn et al. 2007).

4.3 Deployment Artifact

The third layer of the architecture focuses on implementing B2B business processes. B2B business process is composed of partner interactions and their underlying internal business processes and functions. An important challenge in B2B E-commerce is handling these partner interactions. Interaction is defined as consisting of *interoperation* and *integration* with both internal and external enterprise application. Handling these interactions between business partners is not as easy as it sounds because B2B interactions are composed of autonomous, heterogeneous, and distributed underlying components within each business partner's domain. Each one of the partners uses its own technology and software solutions to handle day to day business activities. Interactions in B2B E-commerce have unique challenges because of issues such as scalability, volatility (dynamism), autonomy, heterogeneity, and legacy systems. B2B E-commerce requires the integration and interoperation of both applications and data at a higher level for connecting (i) front-end with back-end systems, (ii) proprietary/legacy data sources, applications, processes, and workflows to the Web, and (iii) trading partners' systems (Medjahed et al. 2003).

<u>Architecture of a B2B interaction framework</u>

"B2B applications refer to the use of computerized systems (e.g., Web servers, networking services, and databases) for conducting business (e.g., exchanging documents, selling products) among different partners" (Medjahed et al. 2003). The building blocks of B2B applications are provided through a B2B interaction framework shown in figure 2. These include modules for: (1) defining and managing internal and external business processes, (2) integrating those processes, and (3) supporting interactions with back-end application systems such as ERPs (Enterprise Resource Planning) (Medjahed et al. 2003).

As you can see in the architecture presented in Figure 14, different business partners handle their process management and internal workflows differently and they depend on different software solutions. For example an organization might use SAP as its ERP system while its business partner is using People soft. In order to have effective business process management in an organization an integrated layer for business process management is needed which in Figure 14 is named internal system. The final layer in every organization is the external interaction gateway which is responsible for B2B business process management and handles organizations interaction (processing messages sent by trading partners' systems and trigger the appropriate in house process and finally communicating the appropriate response to the partner) which in the proposed architecture was the called deployment artifacts. Interactions between partners' external business processes may be carried out based on a specific B2B standard (e.g., EDI, RossettaNet, ebXML, Web services, etc) or bilateral agreements. Interactions in B2B applications occur in three layers: communication, content and business process layers. The business process layer defines mapping of previously modeled business processes to the interaction standard messages and functions (Medjahed et al. 2003).

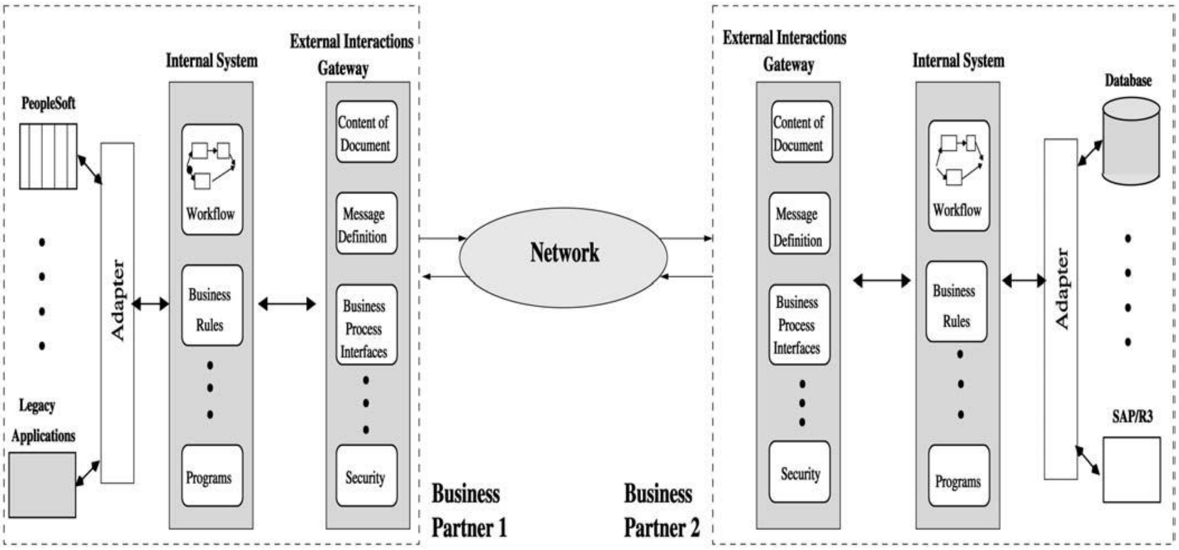

Figure 14: B2B Interaction Framework Architecture (Medjahed et al. 2003, p.60)

The content layer provides languages and models to describe and organize information in such a way that it can be understood and used. Content interactions require that the involved systems understand the semantics of content and types of business documents. Finally the communication layer focuses on messaging and message exchange standards and protocols (Medjahed et al. 2003).

4.4 Software Environment

The technical implementation and integration of the standards mentioned for the deployment artifacts are in this layer. Different technologies can be used to develop such applications and software's such as J2EE and .NET.

CHAPTER FOUR: SERVICE ORIENTED ARCHITECTURE

It has been more than a decade since the introduction of Service Oriented Architecture (SOA). Different benefits and constraints are associated with SOA but the majority of IT professionals and scholars agree on flexibility as a key benefit of SOA. Some even believe that SOA is more than just a flexible new technology but an IT paradigm that facilitates agility and reusability in organizations (Holley & Ali Arsanjani 2010). SOA is defined as " An architecture for building business applications as a set of loosely coupled black-box components orchestrated to deliver well defined services by linking together business processes" (Hurwitz et al. 2009).

Holley and Arsanjani have described different aspects of SOA in different organizational levels. They believe that, from a manager's point of view, SOA "is a journey that promises to reduce lifetime cost of the application portfolio, maximize Return on Investment (ROI) in both application and technology resources, and reduce lead times in delivering solutions to the business". From a business executive's point of view "SOA is a set of services that can be exposed to their customers, partners and different parts of the organization". From an information systems architect's point of view, "SOA is a means to create dynamic, highly configurable and collaborative applications built for change which reduces IT complexity and rigidity" (Holley & Ali Arsanjani 2010).

In today's market, enterprises have to respond faster and more efficient to shifting market requirements, regulations and customer needs. Tight competition is forcing businesses to provide more and more services to their customers to keep them satisfied. To accomplish this, enterprises need to have a palette of atomic or composite services that can be easily and dynamically assembled into business processes (Fiammante 2010). Due to SOAs loose coupling, policy driven, composable service architecture; it is surely one the most appropriate implementation approaches for such dynamic business processes (Holley & Ali Arsanjani 2010). A combination of a SOA and Business Process Management (BPM) approach, with the appropriate management focus, will facilitate a faster path to IT and business alignment. Although SOA BPM approach has known to be successful, failure stories have been reported in this area which was mostly caused by a sole web service orientation towards SOA implementation (Fiammante 2010). SOA principles and best practices need to be used to design services in three different layers, and to compose services on those three layers to realize dynamic BPM. The first layer is collaborative services, which include high level business processes defined between enterprises. The second layer is public services which are processes inside an enterprise composed of different business components and orchestrated properly. Finally the third layer, private services, which are internal business activities within a business component (Fiammante 2010).

1 S3 Reference Architecture

SOAs main contribution is to provide decoupled reusable functionality to organizations and govern the quality of services (QoS) by declarative specification and standards such as WS-Policy. SOA is an extensible architectural framework that reduces cost, increases revenue and enables rapid application delivery and integration throughout the organization. The challenging downside to SOA is that it’s significantly difficult to create an SOA solution. A great deal of SOA’s flexibility relies on a well-defined interconnected architecture and transformation capabilities. Therefore the architect must figure out how to organize a solution that fulfills the mentioned requirements. In addition, the SOA solution designer faces a challenge on how to design for reusability and which tools and components to use (A. Arsanjani et al. 2007).

Arsanjani and his colleagues (A. Arsanjani et al. 2007) have designed layered reference architecture for SOA solutions which is presented in Figure 15. The nine layers are relatively independent, which lets the organization choose the degree of consumer provider integration. An SOA solution might exclude a business process layer, for example, and have the consumer and service layers interact directly. Services are, of course, part of both consumer and provider views. The lower layers (services, service components, and operational systems) are provider concerns, while the upper layers (services, business processes, and consumers) are consumer concerns.

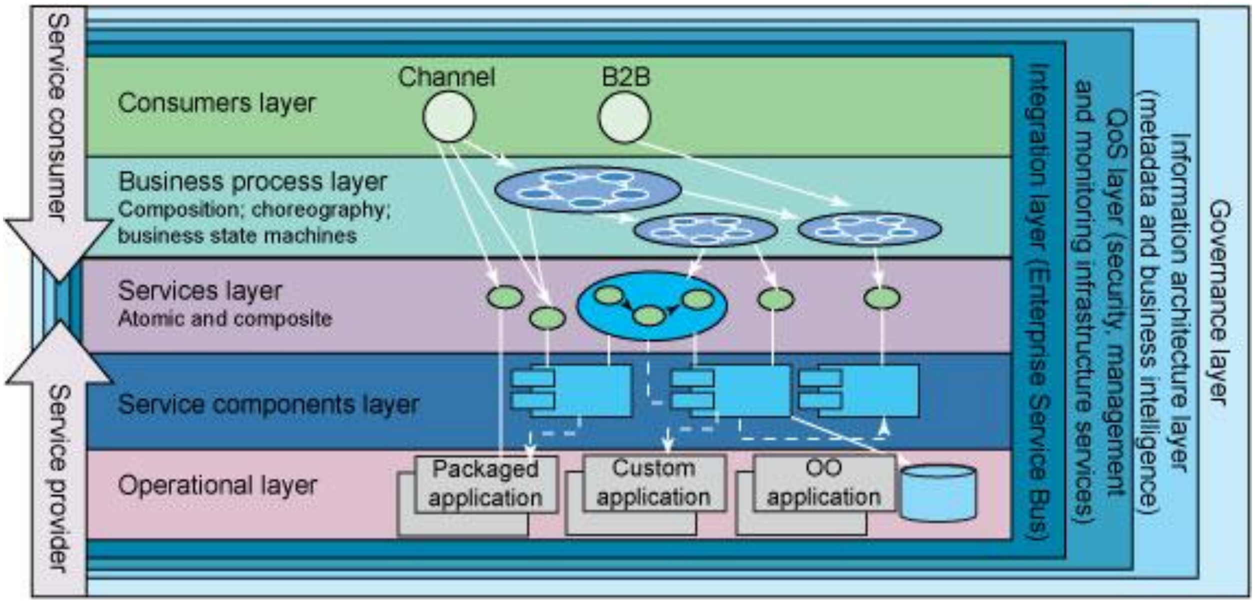

Figure 15: IBM SOA Reference Architecture (A. Arsanjani et al. 2007, p.12)

The ***operation layer*** contains low level application assets in IT operating environment. It provides support for business activities by custom, semicustom or off-the-shelf applications. This layer is responsible for reusing different existing non SOA solutions and software systems. The ***service component layer*** contains software components, each of which is the realization of a service or operation on a service. Aside from the actual service functionality offered, a service component reflects the QoS requirements for a service as well. The ***services layer*** consists of all the services defined within the SOA environment that the higher level applications depend on. In this layer the definition of service is “an abstract specification of one or more business-aligned IT functions (operations)” (A. Arsanjani et al. 2007). The specification contains sufficient detail in order to invoke a business functions exposed by a service provider. The services in this layer should ideally be platform independent and represent reusable functionalities. In the ***business process layer***, a composition of the lower level services, mostly services level, called an orchestration are produced to support organizational business processes. In a non SOA world these processes are supported by custom application. As the descriptions and the architecture image imply, the business process layer is a central coordinator for linking higher level business needs and IT-Level solution components through its collaboration with the six layers of the architecture. This layer manages interactions of consumers with underlying IT components by communicating consumer inputs to the appropriate services and providing responses to different role players such as the user, decision makers and system administrator through Web portals or B2B interactions. The ***consumer layer*** handles interaction with the user or with other programs in the SOA ecosystem. The ***integration layer*** is responsible for integrating the primarily layers 2 through 4, making it a crucial layer to an SOA solution. Its integration capabilities facilitate an organization to mediate, route, and transport service requests from the service requester to the correct service provider. It grantees reliable messaging and supports implementation of security mechanisms such WS-Security. The ***QoS layer*** focuses on service quality and is inherited from SOA characteristics that exacerbate existing QoS concerns in computer systems such as increased virtualization, loose coupling, widespread use of XML, the composition of federated services, heterogeneous computing infrastructures, decentralized service-level agreements, the need to aggregate IT QoS metrics to produce business metrics, and so on. These characteristics create complications for QoS that clearly require attention in any SOA solution. The ***information architecture layer*** is responsible to align data and information architecture with organization's strategic strategies and knowledge management plans. In addition, this layer is responsible for organizational business intelligence solutions, data marts and warehouses. It includes stored metadata content of applications and handles messaging and information flow between different services. Finally the ***governance and policies layer*** covers aspects of managing the business operations' life cycle. The layer provides guidance for managing service-level agreements, including capacity, performance, security, and monitoring strategies (A. Arsanjani et al. 2007).

2 SOA Infrastructure

SOA promises to deliver integrated business processes across an organization's lines of business and information systems. This is not achieved unless a flexible architecture is provided to model and manage services spanning information, applications and people to coordinate the challenges inherent to enterprise level integration. In addition to the afore-mentioned responsibilities for the architecture it must also use a component-based flexible integration approach. This approach creates solution frameworks that enable agile and adaptable integration of IT solutions through a more simplified loosely-coupled approach. The framework is accompanied by an SOA-based integration foundation which facilitates technology co-existence through support of standards-based design, development, and implementation (Simmons 2005). Different names have been given to this kind of application support in the industry and academia such as SOA foundation, SOA application, SOA suite or SOA Infrastructure. These solutions have three main characteristics: support of standard-based interoperability (WS-Standards), dynamic composition via service discovery, and dynamic governance and orchestration (Tsai et al. 2006).

In this research we have provided a layered architecture for SOA infrastructure components which is presented in Figure 16. This architecture has been designed based on information extracted from vendor solutions such as IBM SOA Foundation (Web-Sphere), Oracle SOA suite 11g (Jellema & Dikmans 2010), Sonic ESB (Sonic Software Corp et al. 2005) and scholarly articles (Linthicum 2009, p.6; A. Arsanjani et al. 2007; Simmons 2005; Tsai et al. 2006; Buckow et al. 2011),.

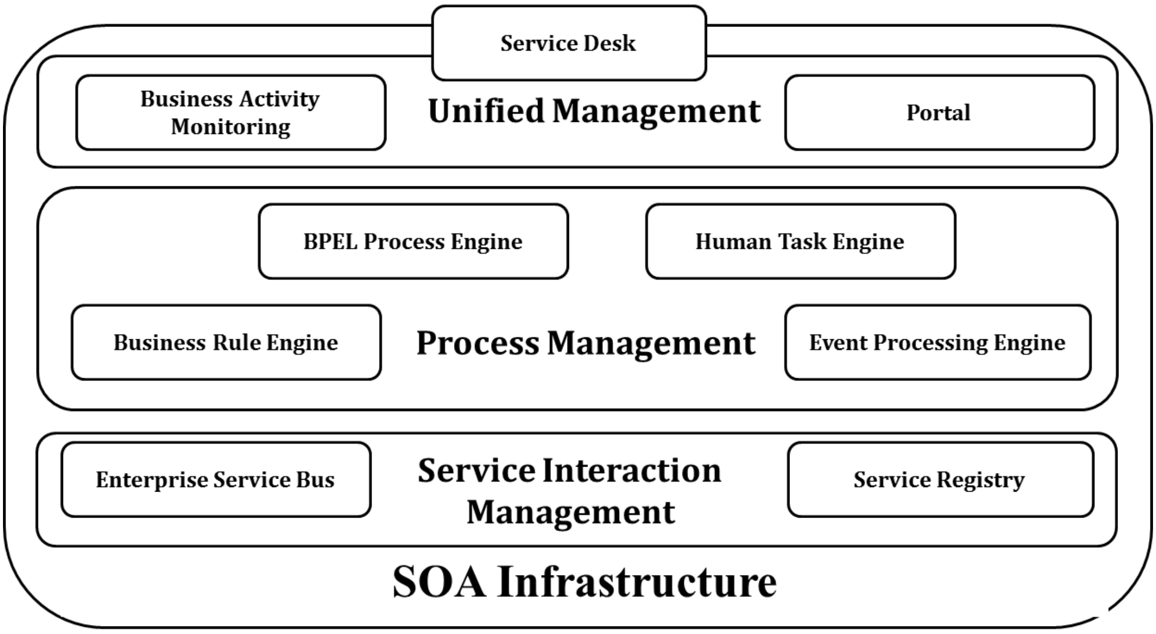

Figure 16: Layered Architecture for SOA Infrastructure Components

The first layer of the architecture named service interaction management includes ESB and the service registry. The service registry is where organizational services are published and discovered. The service registry needs to at least support UDDI standards but nowadays it usually includes more advanced standards as well. Service versioning and dynamic binding of services is facilitated by this component. ESB as the heart of an SOA infrastructure enables service interaction, large scale implementation of SOA principles, and heterogeneous component integration (Schmidt et al. 2005; Keen & (Firme) 2004).

In addition to providing basic infrastructure for service interactions, the ESB provides a set of common patterns for construction of on demand applications and facilitates realization of distinct services (Keen & (Firme) 2004). The second layer – called Process Management – is responsible for executing and managing business processes and consists of a BPEL process engine that executes and composes services, a business rule engine that facilitates the enforcement of business rules throughout the service execution lifecycle, an Event Processing Engine which triggers, tracks and monitors various events in the organizations and is essential for an event-driven architecture in the service execution environment, and finally the human task engine that facilitates human interactions within business processes. The highest level of the architecture – called unified management – consists of a Business Activity Monitoring (BAM) module that monitors the infrastructure and performance of its services to facilitate SLA management; a portal which facilitate a single, customizable point of information access; and a service desk module − which is at the edge of the infrastructure and can be considered as a part of a bigger help desk solution of the owner organization − is a necessary component to support user interaction with the infrastructure. Most of the features and benefits of the proposed framework is realized by employing a suitable ESB.

Part 3
Proposed SOVO Framework and Infrastructure

CHAPTER FIVE: THE PROPOSED FRAMEWORK FOR BUSINESS PROCESS MANAGEMENT IN SERVICE ORIENTED VIRTUAL ORGANIZATIONS

Virtual organizations operate in a very dynamic environment. The collaborative, dynamic and temporal nature of VOs has forced the adoption of computer systems and networks to facilitate partner collaboration. Shared infrastructure and interoperable information sharing structure is a crucial component of computer-aided networked organizations (Karvonen et al. 2005). VOs' operation phase consists of a set of collaborative business processes, which need to use, synchronize and integrate current partner resources and processes to perform collaborative business aligned duties (Marcus V. Drissen-Silva & Ricardo José Rabelo 2008). SOAs reusable, loosely coupled, policy driven, composeable service architecture is one of the best ways to implement and manage dynamic business processes (Holley & Ali Arsanjani 2010). As indicated in (Fiammante 2010; Pettey 2008) most failure stories of SOA BPM implementation are due to the lack of business alignment of the IT projects. Therefore, an important factor in designing service oriented BPM implementations is the alignment of organizational goals and business processes to the lower level software implementation as services. On the other hand, VOs are considered temporal organizations that we model by their value offering instead of long term business goals and strategies. As such, in this research we provide a method and a framework for designing collaborative business processes based on value networks. Our proposed method for service choreography extraction from value networks facilitates the alignment of lower level process and service implementations to the higher level value offerings. This method is accompanied by a framework for ***Service Oriented Virtual Organization (SOVO) Business Process Management***, which is based on known reference frameworks and best practices customized for VOs, to ensure an effective service oriented process design and implementation. The layering of the framework is based on the Open-EDI reference model (ISO 2004) and the S3 Service Oriented Reference Architecture (A. Arsanjani et al. 2007). Detailed descriptions of the components of the framework are derived from best practices of ITIL V3 (OGC 2007) and PMBOK (Project Management Institute. 2008). Figure 17, shows the framework and its components in six layers that are discussed further this chapter. The main boxes represent the layers and the small inner boxes indicate components of each layer.

This framework is based on a distributed service oriented infrastructure which facilitates different topologies of VO management, while keeping the actual organizations and their services and processes completely autonomous. The framework assumes that in every VO a two layer business process is defined. The higher layer would be collaborative business processes which are VOs processes orchestrated and composed from partner processes acting as the lower level. The infrastructure facilitates this layering, by using ***service zones*** as an abstraction layer for the organizational services. The service zone allows organizations to share their business processes as services under specific rules and policies defined by the VO business processes and service choreographies. The zone model enable's VO to manage and orchestrate its services as if it is the actual owner, while providing the business partners with complete control and autonomy to manage or change their services within the boundary of the collaborative policies and zone specifications. The detail specification of service zones is discussed in Chapter Six: .

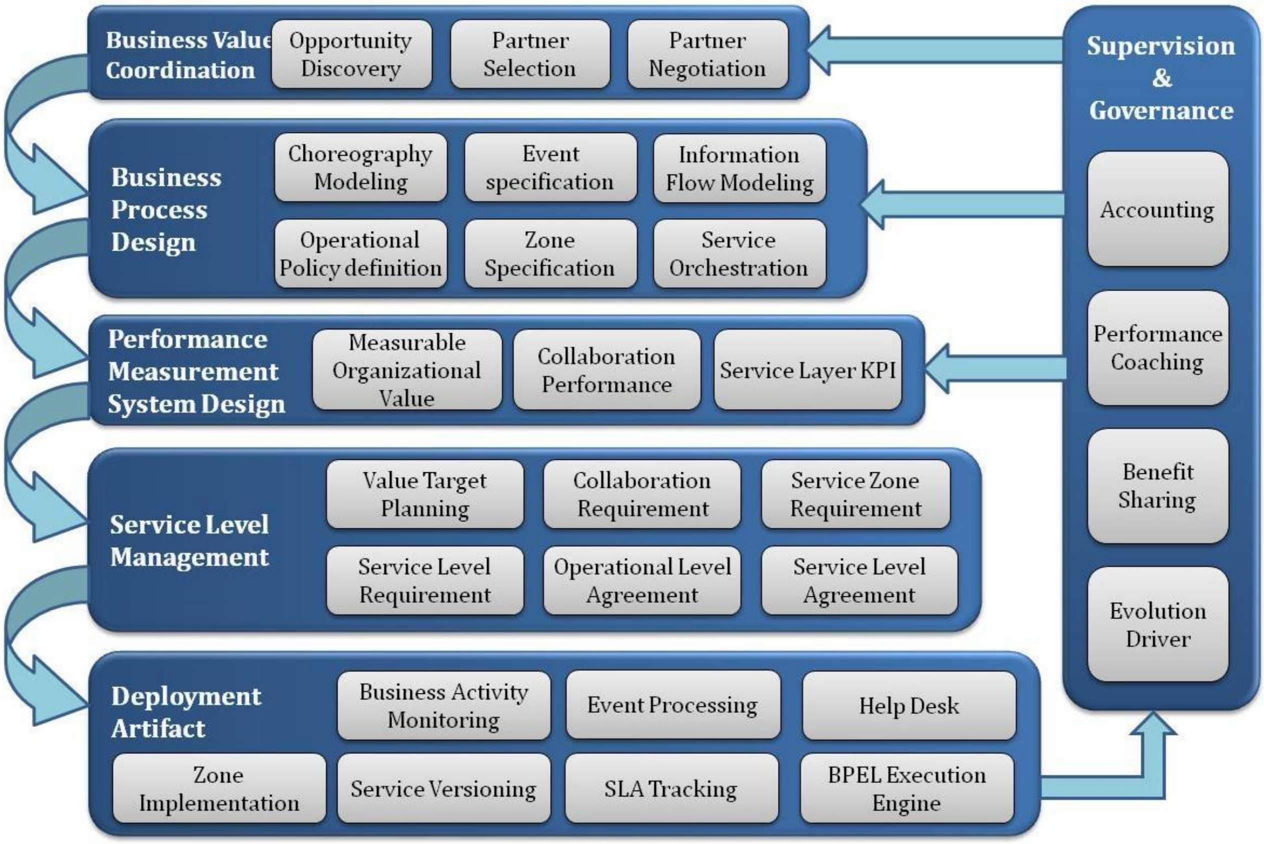

Figure 17: The SOVO Process Management Framework

1 Business Value Coordination

This layer focuses on the business values and motivations of VO formation. It illustrates the business opportunity and the values that the VO consortium will gain. The opportunity discovery results in a set of business values provided by partner collaboration and a general business model for the VO. After the business model is defined, partner discovery and selection is performed. In an ideal service oriented environment this is done by agent based semantic oriented service matching using the service registry (with the Universal Description, Discovery and Integration standard or more advanced protocols). Further discussion on VO partner search and VO creation phase can be found in (Luis M. Camarinha-Matos & Hamideh Afsarmanesh 2007b) and (Luis M. Camarinha-Matos et al. 2005). Partner negotiation and contracting − which is based on value constellation (network of enterprises that jointly creates and distributes objects of economic value) modeled by e3-Value (Huemer et al. 2008; Pijpers et al. 2009) is the most important part of this layer− finalizes this phase. As part of the value constellation, each partners offering and competencies is identified, and their contribution in VO value creation is elaborated and modeled. The resulted output of this phase is the network of collaborative value creation named “Value Network”.

1.1 Value Network

There are different ways to model and design collaboration between organizations. Traditionally when organizations gather together to produce value added services, they started by engineering their processes using function or process oriented models. However these methods usually have shortcomings to align with the overall value co-production of the virtual organizations (Zhongjie Wang et al. 2010). Therefore in this research we have used value networks to model business value creation and tracking and it’s the starting point for business process design and engineering. Business Value Networks “are ways in which organizations interact and share values forming complex chains including multiple providers and administrators to derive increased business value” (Ul Haq & Schikuta 2010). This helps the VO in the identification of service participants and their value expectations and value exchange relations. In (Zhongjie Wang et al. 2010), the authors have presented five topologies for value networks, (1) direct-to-consumer pattern, (2) outsourcing chain pattern, (3) mash-up and aggregation pattern, (4) crowdsourcing pattern, and (5) Third-Party Payment Pattern which are shown in Figure 18. Note that this topology is for the value network and it should not necessarily look similar to VO management and interaction topologies.

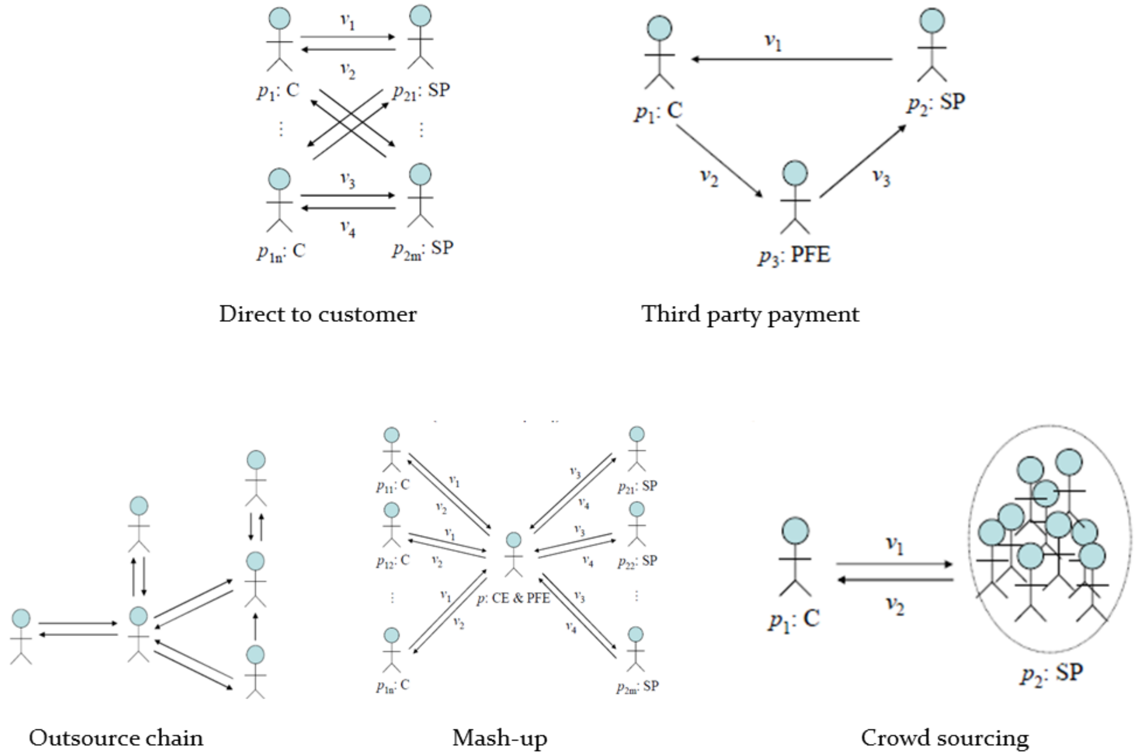

Figure 18: Value Network Topologies (Zhongjie Wang et al. 2010, p.496, 497)

e3-Value is an ontology defined for modeling value networks which is further discussed in (Kort & J. Gordijn 2008). We have used the e3Value notation for modeling value networks. A glossary of e3Value notations and a sample value networks is depicted in Figure 19.

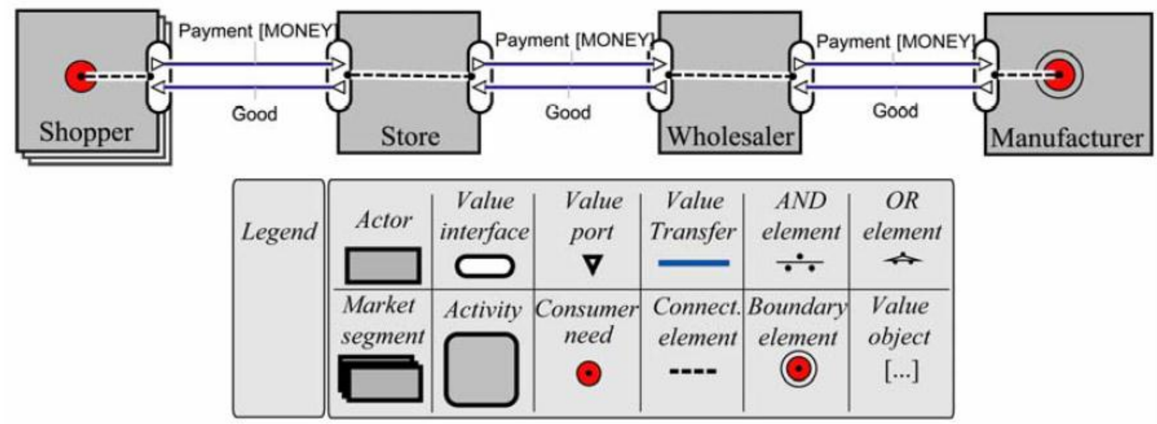

Figure 19: A Sample Value Network modeled by e3Value (Kort & J. Gordijn 2008)

2 Business Process Design

This layer focuses on business process flow and clarifies different conditions and dependencies between processes and their related conditions. It is also responsible for design and correlation of individual services to form efficient healthy business processes. The choreography modulation focuses on partner collaboration and service interactions. It specifies each party's role and activities, and the sequences of service invocation. It serves as an agreement between the participating business partners in their collaboration (Mohamed et al. 2010). This step of the business process design may even alter some of the partner negotiation. As such, some iteration between the two components might be necessary. Due to the use of Enterprise Service Buses (ESBs) and support of multiple messaging patterns in SOA infrastructure, the notion of listening and responding to events is embedded and supported which makes SOA and event driven architecture (EDA) complementary solutions (Holley & Ali Arsanjani 2010). In this module VO event specification is defined and modeled using Business Process Model and Notation (BPMN) (Allweyer 2010). The information flow is specifying data flow between different services in a process. It models what to be delivered to whom at what time. BPMN will be used to model VO processes and information flow. Policy definition in VOs has two aspects, first service policy definitions which further qualify capabilities of interaction endpoints; simply put, a policy expresses anything a service wants the world to know about it other than what messages it understands. These policies will be enforced by the ESBs and their collaboration (Schmidt et al. 2005). The second aspect is the process layer policies which indicate the collaborative process rules and policies. They are implemented using business rule engines. The zone specification is focused on how each partner of the VO organizes its gateway. It indicates what services are shared, and what main policies and security restrictions apply. These specifications are derived from the service choreography and policy definition. Finally, the service orchestration illustrates service sequences. In this layer we use BPMN to model the final process, and derive the corresponding BPEL (Business Process Execution Language) according to the partner zone specifications. In Figure 20 the notation for choreography modeling in BPMN v2 is depicted.

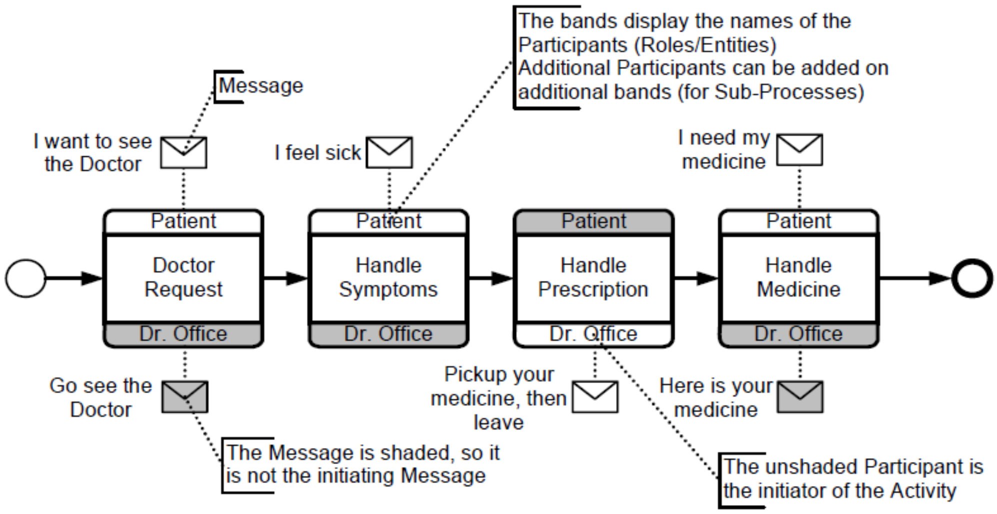

Figure 20: BPMN Choreography Modeling Notation (Allweyer 2010, p.317)

2.1 Extracting Service Choreographies from Value Networks

There have been different attempts to derive business choreographies from value networks. Among these attempts authors in (Zhongjie Wang et al. 2010) and (Wieringa & Jaap Gordijn 2005) based the service choreography description and dependencies on value inter-dependencies in the value network. In (Zhongjie Wang et al. 2010), the authors start by decoupling the value network into value chains with loose or no relation to each other. The service choreographies are then extracted from sets of values and finally they connect different sets of service choreography together. The downside in this method is when we have a peer-to-peer network where decoupling will not be an option because of inter-dependencies between values. In this research we use a similar approach based on value dependencies but we do not base are choreographies on sets of decoupled value chains. We propose the following steps for extracting Choreographies from value networks:

1. Note that information and service values in the value network need to be broken down to the smallest unit possible. For example if a finance company facilitates financial services (the value that the finance partner brings to the VO as its main contribution), we need to specify lower level services such as loan acquisition, financial transaction, plan provisioning and receipt provisioning. Now that the network contains all services we assign every value in the network an ID.
2. Now we have a set values which we can define V= $\{v_1, v_2, \dots, v_n\}$.
3. At the next step the following matrix must be formed. In the presented matrix v_i's are values of the set V. p_{ij} is 1 if v_j has a dependency on v_i in a sense that v_j cannot perform as it should unless v_i is performed otherwise p_{ij} is 0. Note that this dependency needs to be a direct dependency which means if $p_{ij} = 1$ and $p_{jk} = 1$ but there is no direct relation between v_i and v_k then $p_{ik} = 0$.

$$M = \begin{array}{c} \\ v_1 \\ v_2 \\ \vdots \\ v_n \end{array} \begin{array}{c} \begin{array}{cccc} v_1 & v_2 & \dots & v_n \end{array} \\ \begin{bmatrix} 0 & p_{12} & \cdots & p_{1n} \\ p_{21} & 0 & \cdots & p_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ p_{n1} & p_{n2} & \dots & 0 \end{bmatrix} \end{array}$$

4. For each value in V, count its successive values (SV_i)

$$SV_i = \sum_{k=1}^{n} p_{ik}$$

5. For each value in V, Calculate its depth of influence (DF_i) which is equal to the following formula (note the best way to calculate this formula is to start from the values with $SV_i = 0$) :

$$DF_i = \left\{ SV_i + \sum_{j=0}^{n} DF_j \middle| where\ p_{ij}\ in\ matrix\ M\ is\ equal\ to\ 1 \right\}$$

$$where\ DF_i\ = 0\ for\ values\ with\ SV_i = 0$$

6. Rank the values based on DF_i
7. Start modeling service choreographies from the two top values (service choreography is defined based on dependency between two or more values) and continue until no dependency is left. In Figure 21 a sample value dependency graph (resulted from a value network and matrix with 9 values) is presented. The nodes are representing values in set V. The numbers on top of each node are depicting that values depth of influence. The numbers on the edges of the graph are depicting choreography modeling steps.

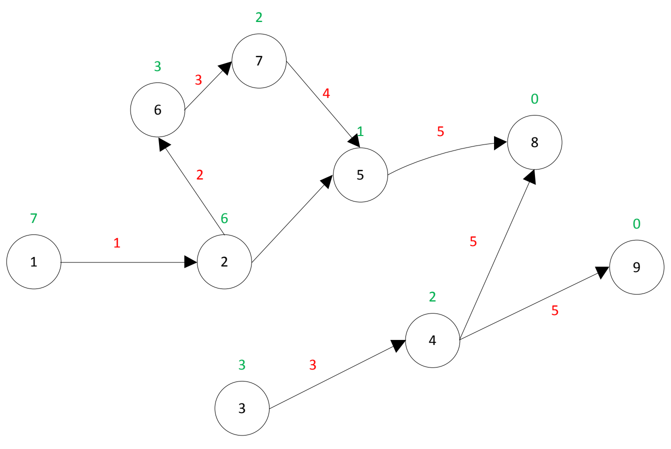

Figure 21: Sample Value Dependency Graph and Choreography Steps

3 Performance Measurement System Design

Before introducing performance management for SOVO, we need to identify the categories of Key Performance Indicators (KPIs) in collaborative environments such as VOs. The ECOLEAD project (Mulder & Meijer 2006) divides performance indicators in CNOs into three different categories: 1) the performance of fulfilling the given task and the contributing performance of the partners, 2) the performance of the partners' collaboration, and 3) the performance of the management approach. In case of a service oriented virtual organization, these layers can be interpreted as 1) Service Layer KPIs, 2) Services Collaboration Performance, and 3) Organizational Values (which all together present the value network). These performance categories can be depicted as different layers of a SOVO performance pyramid as shown in Figure 22.

The bottom-level performance indicators in a SOVO will be used to assess the performance of services provided by a specific partner in the collaborative process. These indicators are mostly domain specific and must be agreed upon by the corresponding partners. These indicators are mainly at operational level. The mid-level performance indicator is Collaboration Performance which is used to measure the effectiveness and efficiency of the independent partners' interaction. Meeting the targets in these performance indicators enables merging of their processes to accomplish a common task in a non-hierarchic way (Graser et al. 2005) . The collaboration performance layer can be considered strategic, whereas the value creation in a SOVO can be done only by smooth interaction and collaboration among SOVO partners. The top level of performance indicators in Figure 22 is employed to measure the effectiveness of management approach and the strategic level of decision making in SOVO. Considering the time restriction and limited resources available, one approach to manage SOVOs is the IT project management (Marcus V. Drissen-Silva & Ricardo José Rabelo 2008). Thus, using the language of IT project management, the criteria indicating the success of SOVO at this level could be measureable organizational values (MOVs) (Marchewka 2006). MOVs are considered the most strategic level of performance indicators as they have the strongest ties with SOVO's strategy. In fact, the temporal and dynamic nature of SOVO substitutes the long-term strategic goals and objectives with short-term organizational value creation. Balances Score Card (BSC) can be used to establish the links among these three layers. The BSC method provides a balanced approach by considering non-financial metrics (customer, internal business process and learning and growth), as well as financial ones. The change in non-financial indicators will affect the financial ones in long-term defined by mathematical relationship between the two (Kaplan & Norton 2007).

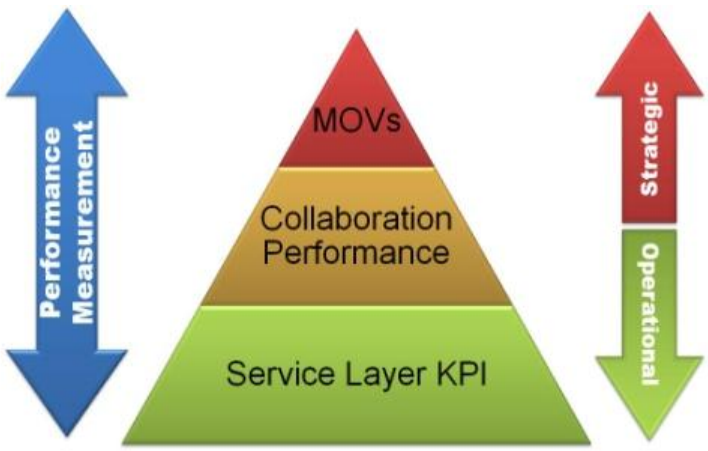

Figure 22: The SOVO Performance Indicators Pyramid

4 Service Level Management

This layer is derived from ITIL V3 service level management principles (OGC 2007). It is a set of processes that are responsible for defining and negotiating service level targets, objectives and agreements which ensure the performance of overall VO services and operations. Service level management guarantees service consistency and continual improvement which also facilitates better monitoring and quality assurance. This layer maps the previously modeled processes and performance system design to traceable services, and generates manageable service level agreements (SLAs) from them. The value target planning focuses on overall service level targets based on measurable organizational values defined in the previous sub-section. The service collaboration requirement specifies service interdependencies and their quantitative measurements derived from the collaboration performance as mentioned in the previous sub-section. These two components follow a top-down approach for definition of performance threshold, whereas, a bottom-up logic is followed for the definition of the performance indicators. The service zone describes the gateway requirements per each partner participated in the VO. It acts as an SLA for the overall policies and rules supporting specific partner's services. The service level requirement (SLR) is a set of specifications and requirements for a service, based on the business objectives. The main functionalities expected from a service are described in SLR and operational level agreements (OLA). OLA is an agreement on operational support between service provider and its users. The service layer KPI boundaries are set in this phase through the SLR and OLA, also projected in the SLA. The SLA describes the Service, documents service level targets, and specifies the responsibilities of the IT service provider and the users. The results of the negotiations and performance indicators and agreements are all projected in a single SLA document which is the main output of this process, and is used for monitoring the service.

5 Deployment Artifact and Implementation Infrastructure

This layer proposes an implementation approach to virtual organizations. It consists of a set of components and implementation principles for SOVO process deployment and monitoring. It also embeds some guidelines for continual improvement derived from ITIL, which also provides input to the final supervision and governance layer. The following components will fulfill their duty more effectively if they run on a distributed infrastructure. In an ideal solution these components will be part of a unified portal for VO management. The business activity monitoring (BAM) is a module who tracks the status of VO activities and processes. A set of dashboards and reports of the processes are building the BAM and SLA tracking modules. The KPIs mentioned in the third layer of the framework are projected in these components. The event processing module focuses on the events specified in collaborative processes and allows further analysis of these events. The service versioning module is a set of documents tracking services and how they have changed over time. The zone implementation module is providing authenticated access to service federation manager which is fully discussed in the next chapter. The BPEL execution engine - which in a distributed environment is more than one instance – is responsible for executing the orchestrated collaborative processes.

6 Supervision and Governance

This layer of the framework focuses on driving VO towards the right direction based on performance monitoring and the feedback it receives. It facilitates forecasting, planning and design of future trends of the VO which result in continual improvement and change management in the virtual organization. Performance coaching includes the efforts taken for performance appraisal, and providing appropriate feedbacks to partners in order to improve their performance based on the specified objectives and performance targets. In other words, performance coaching is the systematic effort to link the performance reviews and evaluations to the continuous training and development. The benefit sharing component aligns VO partner benefits based on the value constellation and value creation in accordance to their performance. It uses performance as the criteria for assessing rewards or sharing benefits, as well as services offered through the infrastructure. These two components are both drivers for moving the performance of partner organizations to desired level of performance. Accounting is related to the financial shared activities of the VO which is affected by the benefit sharing component of this layer (Danesh et al. 2011). This component requires further specification that is not addressed in this framework, and is left to the VO financial planners. Finally, the evolution driver is a set of processes designed to drive appropriate changes in the VO based on performance monitoring aspects (Marcus V. Drissen-Silva & Ricardo José Rabelo 2008). These changes are classified in three categories: the first one is usually within a partner's services, and only triggers performance indicators; the second category is the one that affects VO service choreographies, and is results in a higher level change in VO; and finally, the third category which involves changes in VO value creation and might even result in renegotiation between partners.

CHAPTER SIX: IMPLEMENTATION OF THE VIRTUAL INFRASTRUCTURE

In this chapter, we explain the second component of our research, the distributed SOA-based infrastructure for business process management in virtual organizations. This infrastructure has two main components, a zone interaction model and implementation architecture. The main contribution of this research in this section is the zone interaction model in which the partners share services in an abstract layer and enforce policies and security mechanism to protect their competitive advantage. We facilitate zone interactions by instantiating a virtual hub, and federating multiple partner zones which is further expanded to the distributed architecture proposed in this section. In this chapter, we start by introducing the zone interaction model. We will then explain the implementation of the virtual ESB using IBM service federation capabilities and provide detail specification of service zone and its implementation. Then, we will present the architecture of a distributed infrastructure to handle collaborative business process management based on the zone interaction model. We conclude the chapter by an analysis of the proposed infrastructure against inter-organizational process management success factors.

1 Service Zone Interaction Model

In SOA-based BPM systems, processes are defined in three different layers. The first layer is collaborative processes, which include high level business processes defined between enterprises. The second layer is public services which are processes inside an enterprise composed of different business components and orchestrated accordingly. The third layer, private services which are internal business activities within a business component. In each layer processes are built using the underlying level of services

(Fiammante 2010). The VO collaborative processes follow one of the three VO interaction topologies (Supply-chain, Star, and Peer-To-Peer).

VOs collaborative processes are highly dependent on partner organizations; therefore, VOs success is tightly connected to the performance of its partners. At the same time, VO has no central authority over its participants, and as such, cannot enforce and manage them in traditional fashions. We proposed a service zone model for partners to share their processes. The service zone acts as an abstraction layer (between the layers of collaborative process and public services) for partners and facilitates policy and security enforcement for every autonomous partner. This service zone provides a gateway for the VO to the partner's services enabling it to choreograph and manage VO collaborative processes, rules and events as if the VO is the owner of the services, while at the same time, preserves organizations' privacy and their control over services.

As shown in Figure 23, the service zone is part of every organization's ESB and service registry which together are responsible for publishing the organizational process through the service zone gateway. The service zones are then federated together to form a virtual hub that will allow service discovery and binding between participants in the VO. This virtual hub will be formed based on VO interaction topology. VO collaborative business processes can now operate on top of the virtual hub based on the configured topology. Organizations are entitled to change their services as they please. These changes will be mediated through organizations service zones so the effect on VO collaborative process would be minimal unless the changes will benefit the VO as well.

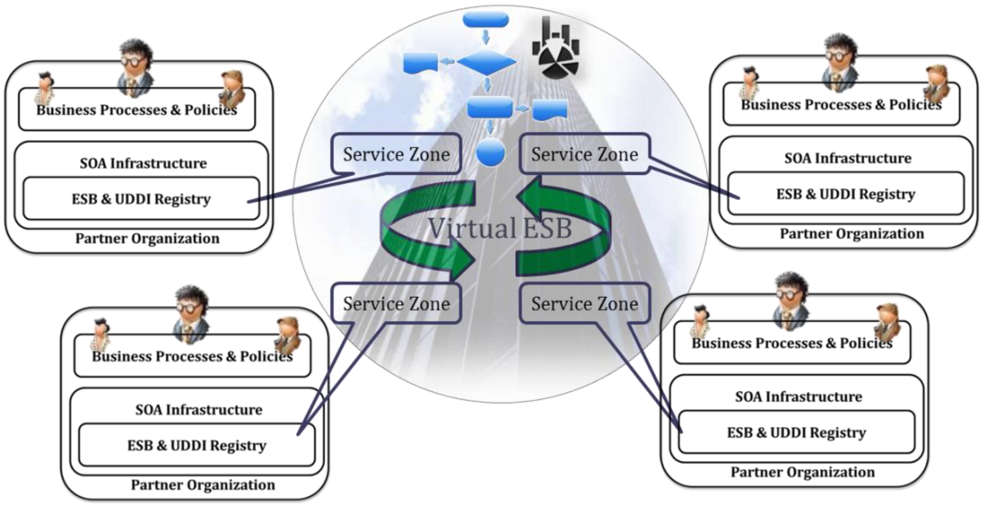

Figure 23: Virtual ESB Facilitating a Distributed SOA Infrastrcuture

2 Virtual Hub Formation and Zone Specification

In this research IBM Web Sphere products have been used to implement the virtual infrastructure. In the prototype four individual SOA infrastructures are set up and then integrated to form a virtual hub. Each partner organization has a WebSphere Service Registry and Repository V7.0 (WSRR) and a WebSphere Enterprise Service Bus V7.0 (WESB). Partner organizations publish services they want to share with the VO in their WSRR and in a specific protected business category. This will allow them to hide sensitive organizational services from their partners and federation manager.

The virtual hub is formed using IBM Service Federation Management (SFM) feature pack. This is a component added to WSRR and WESB which facilitates integration of multiple instances of these products. The organizational services mentioned earlier in WSRR are published through a gateway facilitated by the organizations' WESB to the federated repository. The WESB will provide a security proxy feature if required. Figure 24 depicts the process in which these services are shared.

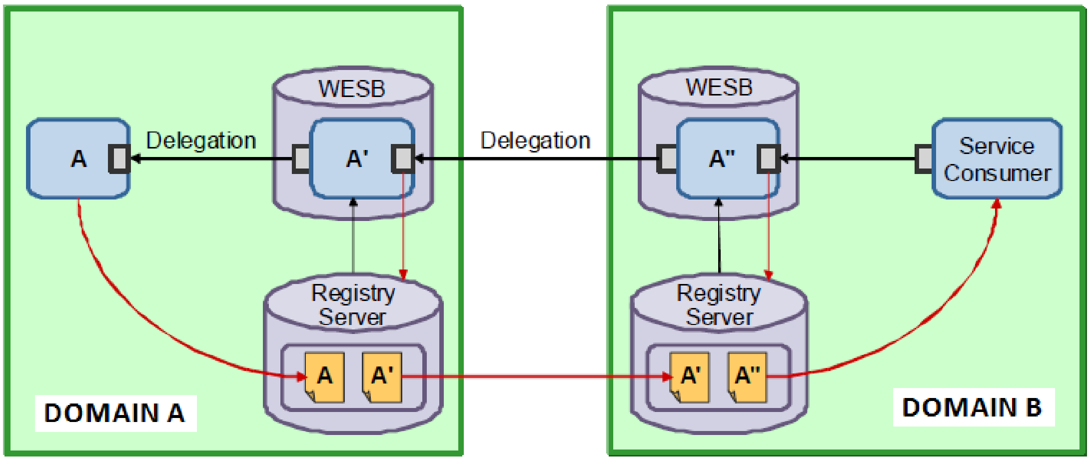

Figure 24: Federating Services with IBM (Bell 2010, p.6)

Only one of the partner organizations needs to have the SFM feature pack installed. Due to the distributed sharing of services there will be no additional overload on the SFM host except at the configuration time. The virtual hub is configured in the SFM console based on the VO interaction topology. In this case the federation is managed centrally and the partners give the VO administrator access to setup service groups and share them as they are pleased. In this case the SFM is orchestrated through a central admin panel which has access to predefined service groups within partner service zones. In this case the VO has a star management topology (note that having a star management topology does indicate a star interaction topology). However if partners involved in the VO need more privacy and are managed in a peer-to-peer topology, they require an SFM console and can configure sharing of service from the host organizations to the destination organizations is their own SFM console. In this case the federation is choreographed through multiple SFM consoles distributed between partner organization's infrastructures. A sample configured SFM is shown in Figure 25 which depicts a virtual hub with four partners that has a star topology.

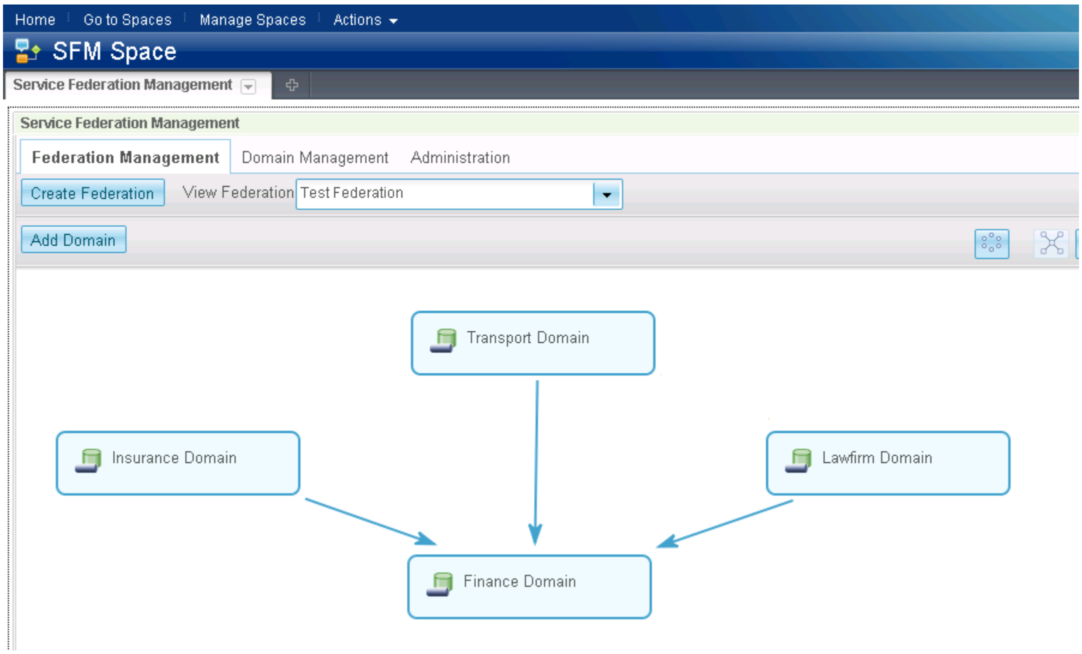

Figure 25: SFM Management Admin Console - Star Topology

As the first step in the SFM console a domain is defined and it's WESB and WSRR service categories are introduced to the SFM manger. Figure 26 is showing a screen shot of the configuration, the lower panel is showing the aliases of the WSEB and WSRR for each domain while the higher panel is depicting the user id and password for connecting to the WESB and WSRR.

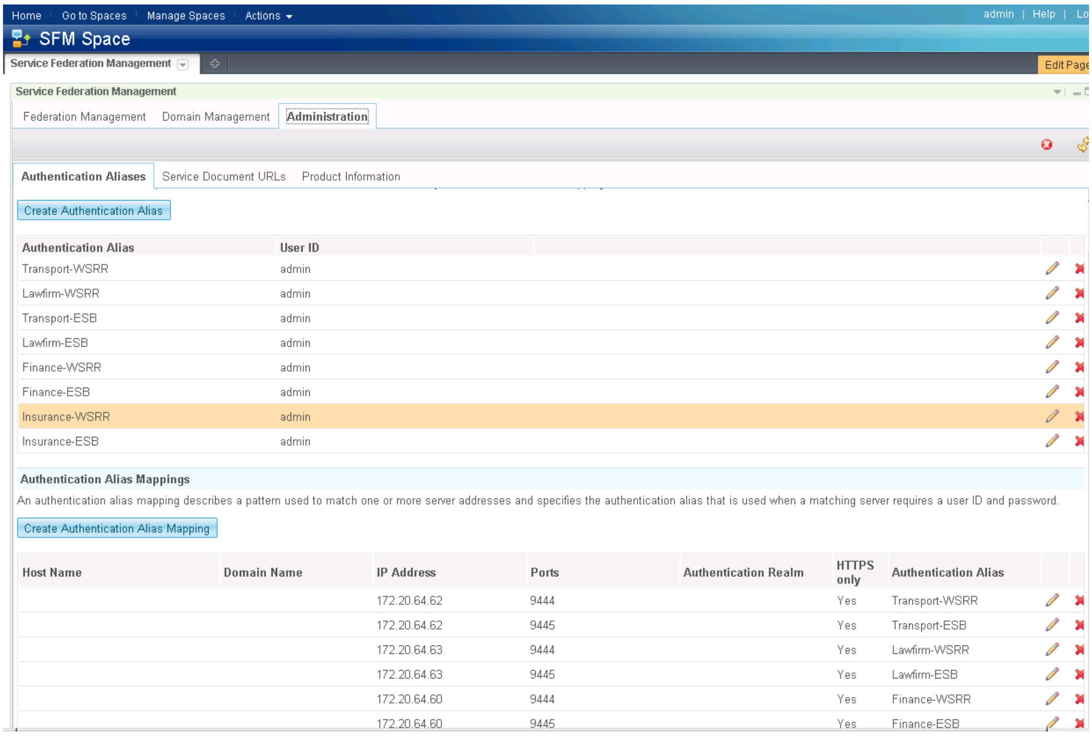

Figure 26: Domain Configuration in SFM

As the second step service groups are created in each domain that contains a set of service endpoints. Each arrow shown in Figure 25 presents a service group. This will allow the organization to choose different categories of business objects such as processes, rules, tasks and events to share in the virtual hub with a desired topology. Figure 27 is showing a sample service group in a domain. The left panel facilitates managing service groups and the right panel indicates which service endpoints to add to service groups.

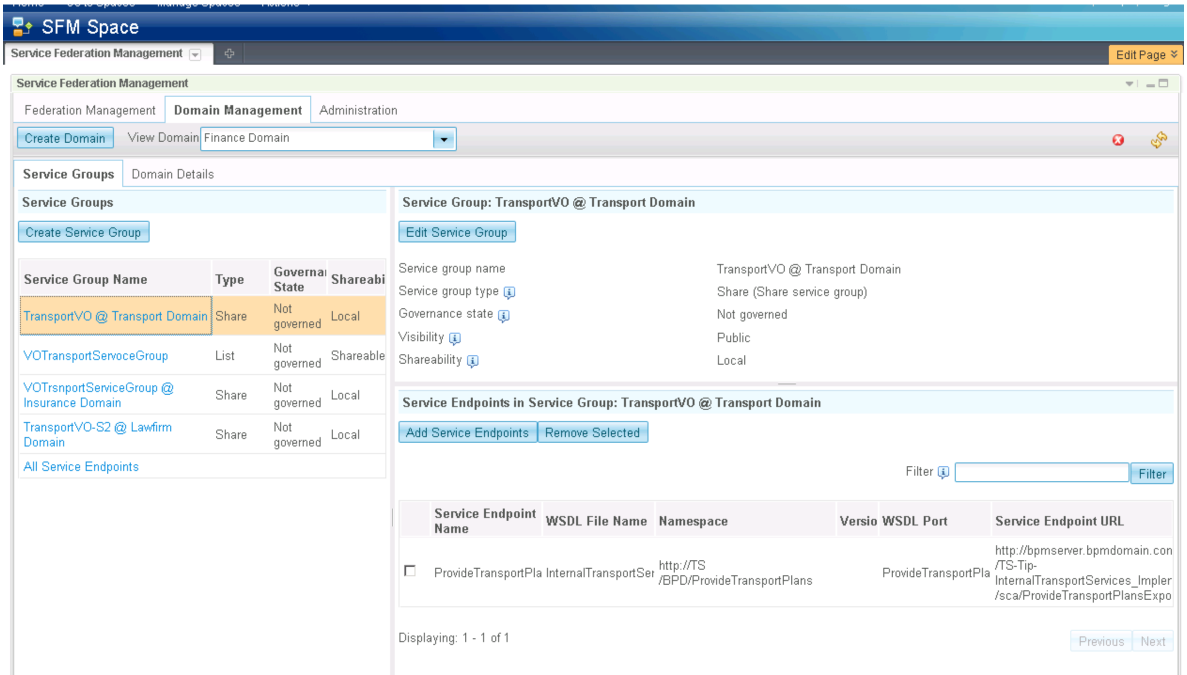

Figure 27: Service Group Configuration in SFM

To conclude, the service zone configuration consists of four major stages: The first stage is to implement a reliable synchronous callout for organizational services (at least the organizational processes). We have come up with two ways to accomplish this in our prototype. First is to use a java queue hosted on either a BPM engine or the WESB. The second way is to use a more mature messaging service such as IBM WebSphere Message Broker which facilitates better tracking and monitoring on the service operation. The Second stage is to publish the organization service in the appropriate business directory on the WSRR. The third stage consists of the domain and service group configuration on the SFM management console. Up until this stage all operation depends on each partner's administration. Although partners are autonomous in doing so, they will have to realize VO principles and needs based on the design agreed on using the framework discussed in the previous chapter. As the final stage VO admin needs to configure the virtual hub using the SFM administration console and form the appropriate VO topology which will result in population of services (A sample provided in Figure 25).

3 The Implementation Architecture

In this section the focus is on the VO virtual infrastructure and how business processes are distributed between different components and partners in the infrastructure. Figure 28 presents the overall architecture which assumes that the VO has four partners and each partner has its own SOA infrastructure. In this prototype every partner is willing to provide infrastructure services to the VO. Note that in reality this may not be the case. Each partner may or may not have a SOA infrastructure. Partners without a SOA infrastructure always have the option to get needed services from other service providers or if they are willing to sacrifice their flexibility they only need to provide web service interfaces that could be published to the VO virtual hub. Note that at least one of the partners needs to provide a SOA infrastructure and handle initial configuration. The loosely coupled components of the infrastructure make it flexible and facilitate joining and leaving VO easier.

The architecture has three main layers. The virtual hub and SFM manager which focuses on integrating SOA infrastructures of partner organizations and is considered the foundation of VO distributed business process management. This layer was fully discussed in sections 12. The BPM layer which consists of BPM engines (tagged BPM in Figure 28), business rule engines (tagged BRE in Figure 28), and event processing engines. This layer is responsible for building and executing collaborative business processes. All components above the curved line are loosely coupled components and could be distributed anywhere, added or deleted at any time during the VO lifecycle. The top layer focuses on unifying VO process management and information access. It has two major tasks, first to provide a unified portal to facilitate and regulate information access and second to provide performance monitoring and dashboard sharing for collaborative processes. The information is gathered from heterogeneous sources (mainly BPM engines) in the infrastructure and formalized in the business intelligence tool where it is shared through the VO portal to appropriate partners. The portal is not a centralized product, but distributed portlets configured to gather data from other sources and put them into VO perspective. The components of the fifth layer of process management framework (discussed in Chapter Five: 5) are implemented in this layer.

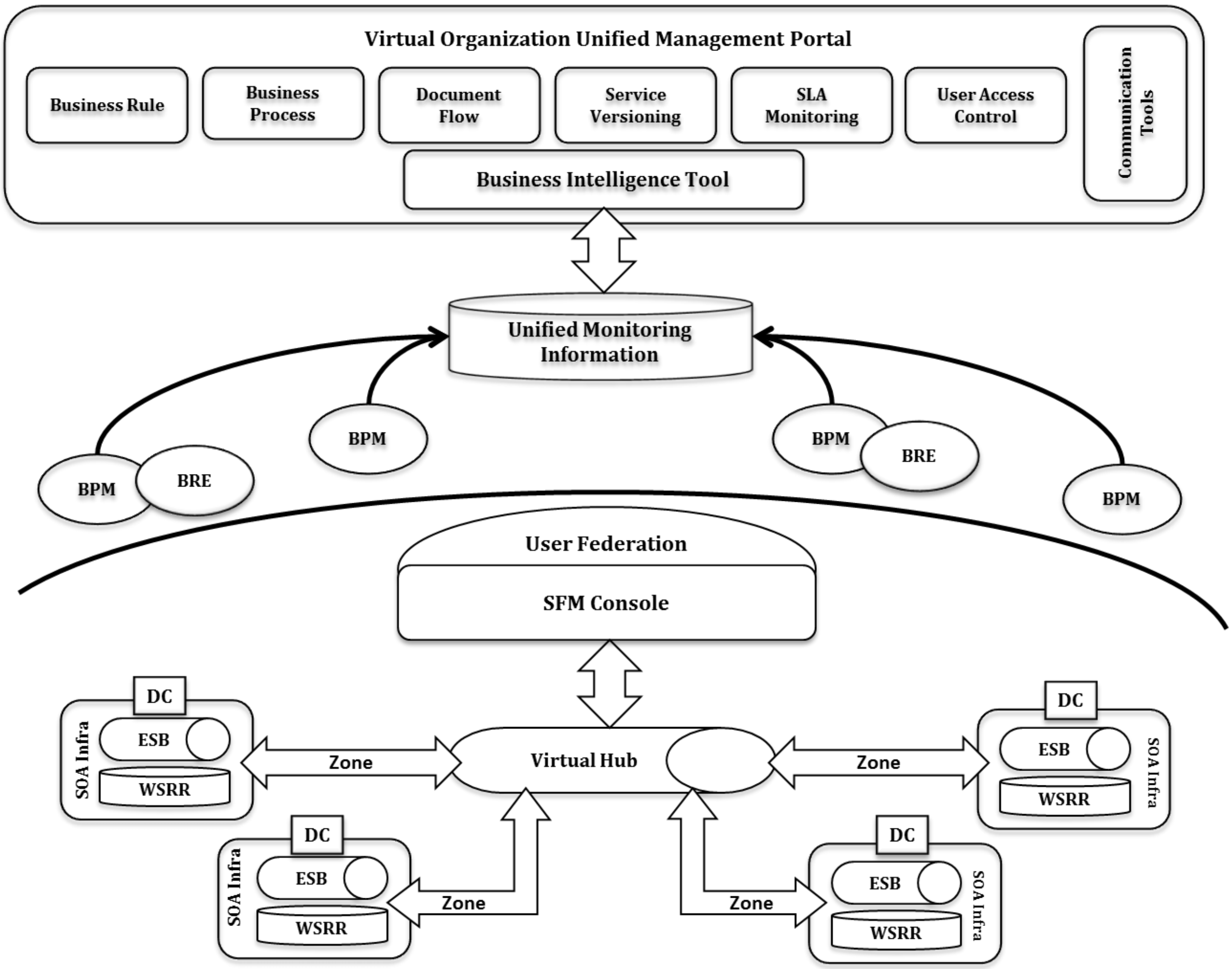

Figure 28: Proposed BPM Architecture for Virtual Organizations

4 Analysis of the proposed infrastructure

Based on inter-organizational process management requirements (Jurgen Dorn et al. 2007) and VO infrastructure requirements (Ricardo J. Rabelo et al. 2006; Marcus V. Drissen-Silva & Ricardo José Rabelo 2008; Gehre et al. 2007), we have identified three major performance criteria for collaborative business process management. We proposed full detail of these criteria's in Table 3. These criteria are (1) degree of partner's privacy in information sharing, (2) effort needed for process integration, and (3) degree of authority distribution. The first criterion is evaluated by authentication mechanisms, control over information access for every partner, security measures and interaction logging. As for the authentication mechanism, this infrastructure supports LDAP, Microsoft active directory and a customized role based WebSphere directory. The zone gateway will allow the organization to authenticate any out-coming request. The service zone is the control mechanism. So anything that the organization shares through the service zone is accessible by the VO, in other words organizations outsource the control over who sees which part of the shared information to VO administrators. The service zone is protected with a security mechanism in two layers: the federation gateway is protected by a proxy setting (an optional feature) in the SFM admin module which provides secure communication between the two WESBs and WSRRs. The service itself is protected by WS-Security standards and the capabilities that it provides. These security policies need to be configured by each partner independently. Information is logged by every organization but due to the distributed environment and components it is hard to provide logging information to the VO, but every organization has the means to manage its own service's logs.

The second criterion is evaluated by facilitation of single sign on (SSO), effort needed to setup the infrastructure, and effort needed to build and execute collaborative processes. This solution fully supports SSO capabilities within the organization and partially supports SSO between organizations (some intermediary users need to be setup). We evaluated the effort needed by hours of work, level of expertise and line of code. Setup and configuration of the virtual infrastructure for a VO containing four partners took 25 hours for a software engineer with intermediate experience with IBM WebSphere and zero line of codes. Once the infrastructure is setup, it takes an average 25 hours to build, test and launch a collaborative process with 4 steps involving 4 different organizations. It will require 5 lines of code per sub-process if synchronous callout is required. As for changes in the infrastructure it depends on the level of changes. If the VO has a fully connected peer-to-peer topology, changes of collaborative processes and their immigration from one BPM engine to another happens in minutes. If topology changes are needed, the SFM admin needs to make the necessary changes which in our prototype took less than 2 hours to change a star topology to a peer-to-peer one.

Finally to evaluate how well the infrastructure supports distribution of authority, we will analyze its topology flexibility and level of performance measurement provision. The SFM has the ability to support any of the three main topologies, supply chain, star and peer-to-peer, as shown in Figure 25. Since the topology is configured based on service groups and not organizational domains the flexibility is at its highest level. The topology could be setup for business rules, events, processes and tasks individually or in groups. In terms of level of performance information accessible to the VO, the infrastructure provides full access to collaborative processes. It also provides access to whatever partner organizations share within the service zone, which are usually partner processes but could even be lower level business tasks. Therefore it’s up to VO management and partner negotiations to decide both the level of performance information accessibility.

CHAPTER SEVEN: A VO SCENARIO

In this chapter we will discuss a sample VO and how we have implemented some of its processes. This scenario is a prototype that models and implements an international transport collaboration that involves integrated services from four individual partners. The first partner is a Transport Company that provides transportation services. The second organization is a Law Firm that provides legal services such as customs clearance. The third partner is a Finance cooperation that provides LCs, Loans and handles financial transactions. Finally the fourth partner is an insurance company that provides insurance services. We have called this prototype VOTranspo. This chapter consists of four sections: (1) modeling of the VO, (2) setting up an infrastructure for the prototype, (3) implementation of the prototype by IBM products, and (4) observations and recommendation gained through the implementation.

1 Modeling VOTranspo

In this section we are going to focus on modeling the sample VO mentioned using our process management framework. As for the first layer of the framework, Business Value Coordination, we have discussed the opportunity that the VO is trying to address by identifying main values it brings. This VO association (1) provides more flexible plans, (2) facilitates a single point of interaction with end to end services to the costumer, (3) provides competitive total costs, and (4) reduces costumer risks by transferring it to the VOs different partners and integrated services. At this stage we propose the value network of the sample VO as we see it in Figure 29. Note that in e3Value four different value objects are defined: Information, Service, Money, and Good. Each arrow in the image is showing value transaction which means the tagged value object is being transferred from the source entity to the destination entity. The red circles in the value network are depicting the boundaries of the value network. If the red circle is accompanied with a grey circle it is indicating an end state. More description of the value network notation could be found in Figure 19. The following paragraph is describing different values mentioned in the diagram. The ID of the values would be later used to track them in the dependency matrix:

- Insurance [Service] – ID=1: it's a value that the insurance partner provides to VO. It is describing the actual insurance documentation and policy.
- InsurancePlans [Info] – ID=2: its describing the value in providing multiple insurance plans for a transport order.
- VPaysI [Money] – ID=3: a money interaction which is the main value that VO provides to the Insurance company.
- Route [Info] – ID=4: Is the information for routing schedule and transportation tasks provided by the VO to the insurance company.
- InsuranceClaimProcess [Service] – ID=5: this is the process in which the VO makes an insurance claim on a specific transportation order.
- HandlingTransaction [Service] – ID=6: it's the process in which a money transaction is ordered by the VO and handled by the finance partner.
- Loan [Service] – ID=7: providing some sort of loan or finance opportunity for the transportation task or costumers purchase order.
- Route [Info] – ID=8: is the information regarding the route of the transportation task and all partners processed requests.
- LC [Service] – ID=9: is the service that the finance department provides to facilitate a Letter of Credit (LC).

❖ FinancePlans [Info] – ID=10: providing multiple and consistent (consistent with other partners services and plans) financial service plans for the transportation task.

❖ VpaysF [Money] – ID=11: indicates the main value that the finance company receives from VO.

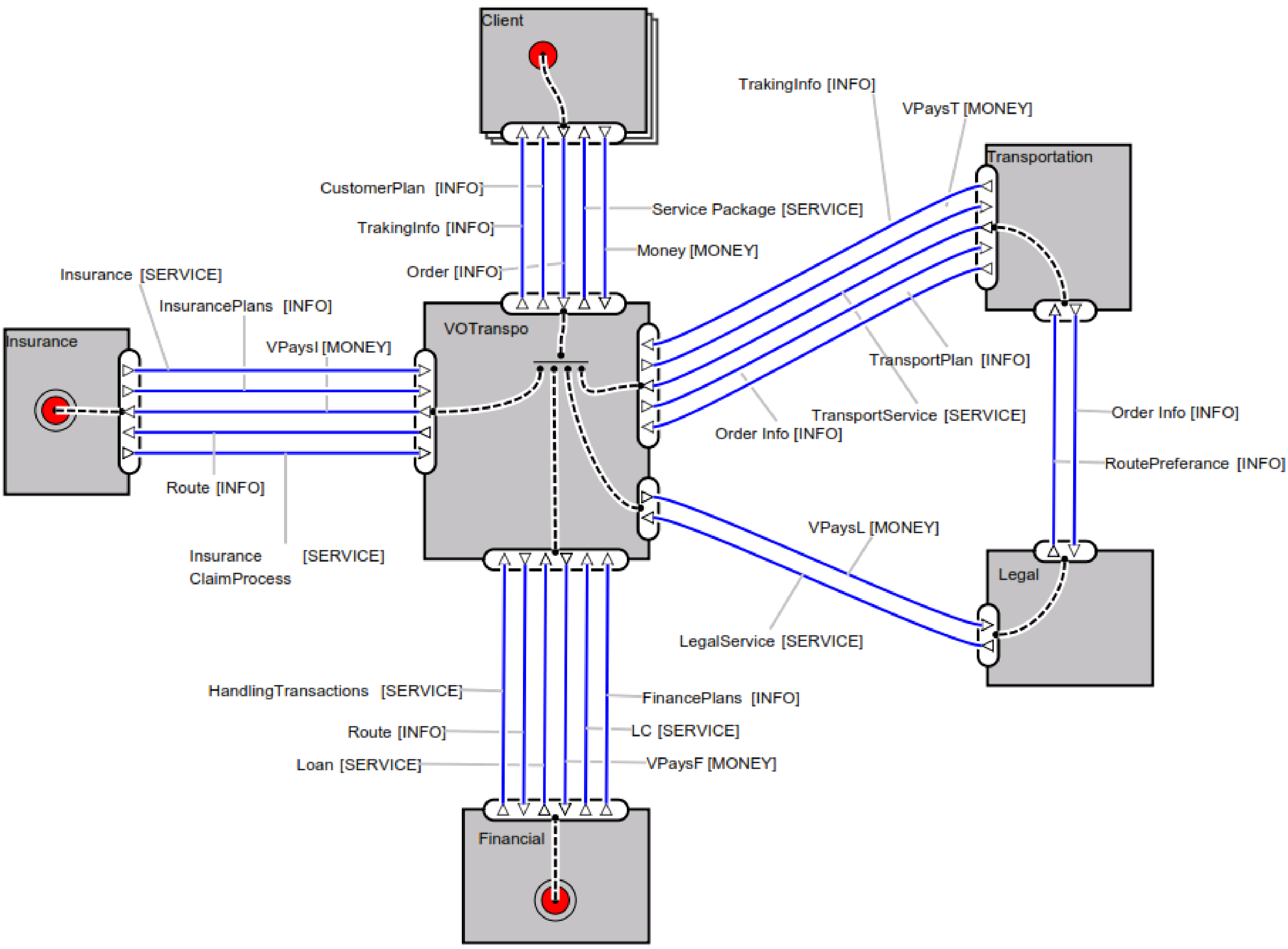

Figure 29: "VOTranspo" Value Network - Modeled by e3-Value

❖ TransportPlan [Info] – ID=12: is the process in which routing schedule and their costs are indicated and aggregated in a transport plan.

❖ OrderInfo [Info] – ID=13: is the information received from the costumer and transferred to the transport company by the VO.

- ❖ TransportServices [Service] – ID=14: is the actual service responsible for transporting the good.
- ❖ TrackingInfo [Info] – ID=15: online tracking of the product and its status which is a value added information provided to the VO.
- ❖ VPaysT [Money] – ID=16: money transfer from VO to transport company.
- ❖ OrderInfo [Info] – ID=17: is the information needed for the law firm to provide route preference.
- ❖ RoutePreferences [Info] – ID=18: is information on preferred routes according to the law firms resources.
- ❖ LegalServices [Service] – ID=19: could be any legal service such as custom clearance, consultancy or etc provided by the law firm to the VO.
- ❖ VTpaysL[Money] – ID=20: money transfer from VO to Law Firm.
- ❖ Money [Money] – ID=21: is the price that the customer pays for the services it receives from the VO.
- ❖ ServicePackage [Servcie] – ID=22: is the end to end service that the costumer receives.
- ❖ Order [Info] – ID=23: is the information provided by the costumer regarding its transportation task and needs.
- ❖ TrackingInfo [Info] – ID=24: integrated tracking information that the costumer receives from the VO.
- ❖ CostumerPlan [Info] – ID=25: choices of plans that the VO provides to the costumer.

At this stage the value network is completed and we move on to the second layer of the framework, Business Process Design. In this research our main focus is on service choreographies and collaborative processes. We use BPMN V2 modeling notation and specifications. All the processes, choreographies and events are described by XML files and BPMN. As the first step we model the service choreography from the value network. In doing so we use the process proposed earlier in section Chapter Five: 2.1. As the first step in the described methodology we need to build the dependency matrix which is presented in Figure 30.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1					1																	1			
2			1																						1
3	1																								
4		1																							
5																									
6																						1			
7																						1			
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10											1											1			1
11						1	1		1																
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25																					1				

Figure 30: Dependency Matrix for VOTranspo

At the next step we need to calculate each values depth of influence. The dependency graph in Figure 31 presents both the depth of influence and the sequence of choreography modeling resulted from it.

In Figure 32 the ultimate service choreography for VOTranspo is presented. The choreography is resulted from the dependency graph presented in Figure 31.

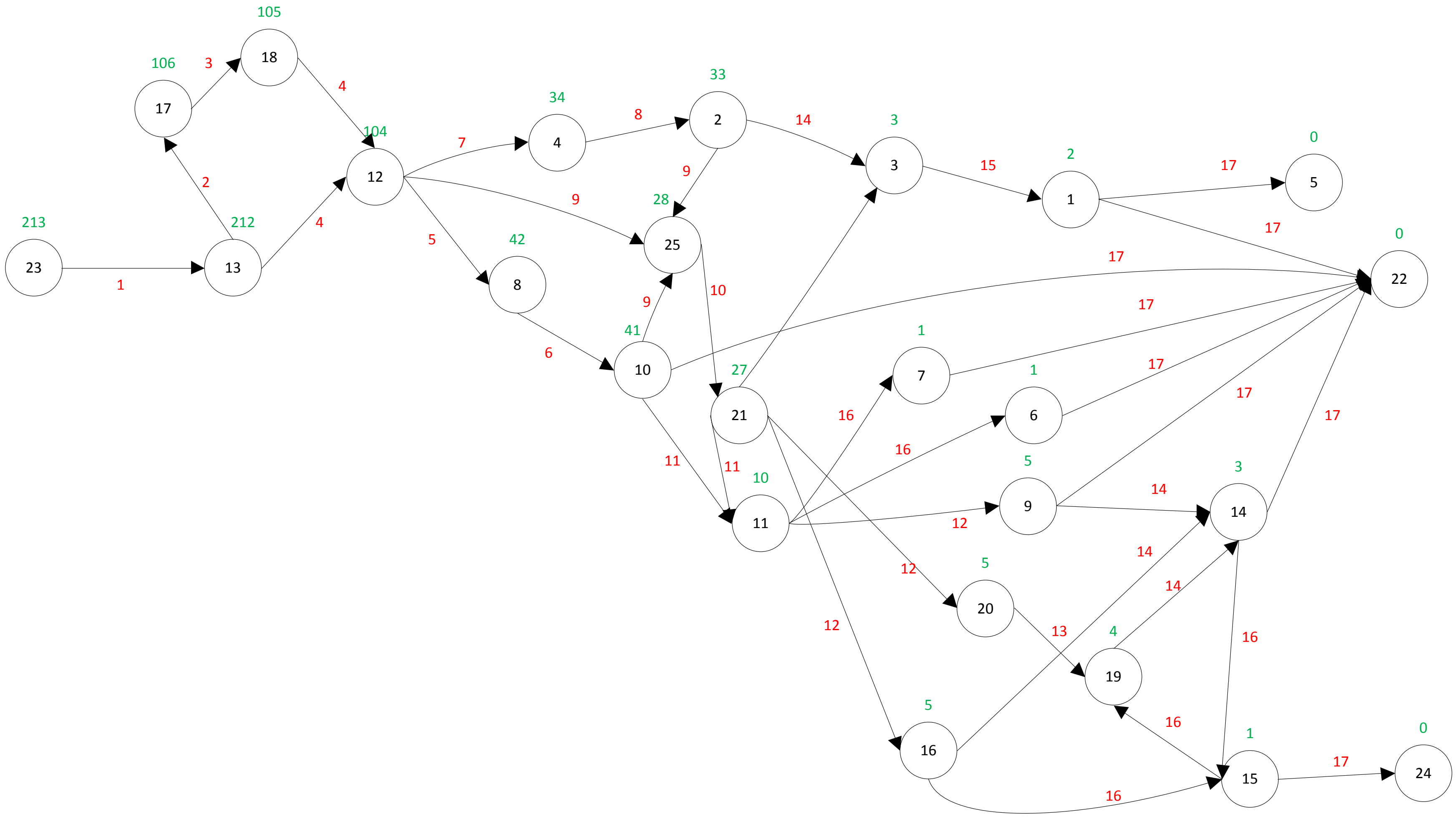

Figure 31: Value Dependency Graph for VOTranspo

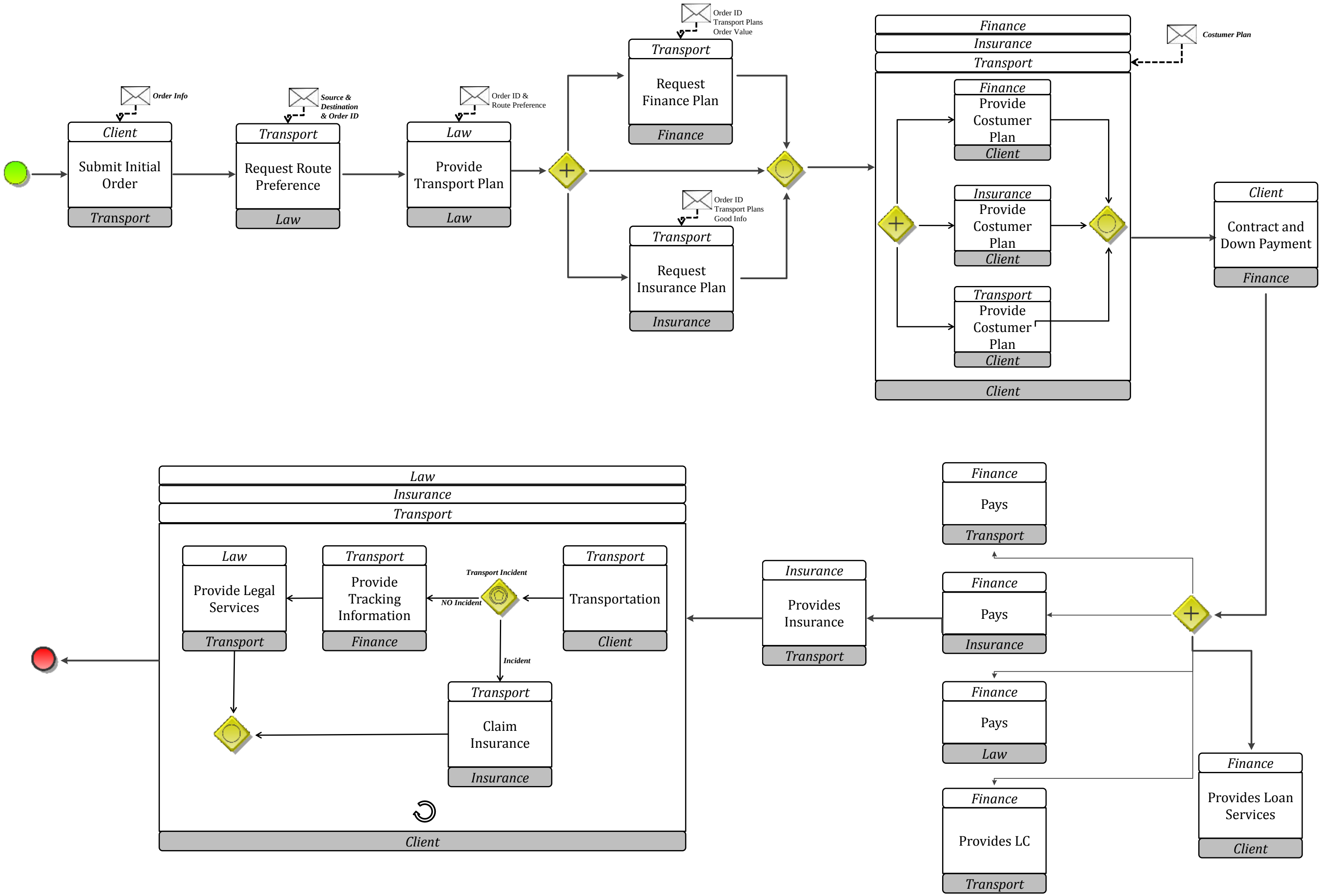

Figure 32: VOTranspo Service Choreography

Note that the choreography could be modeled in different way and there is no one solution for a process or collaboration. The intention of the dependency graph is to provide a road map for designing the service choreography. The presented approach guarantees alignment between service choreography and collaborative processes and high level business values. Now that collaboration principles between partners are identified, collaborative business processes can be defined. Figure 33 depicts a sample business process that is responsible to provide customer plan based on an order request to the costumer. The format of messages exchanges in this process were specified in the service choreography presented earlier.

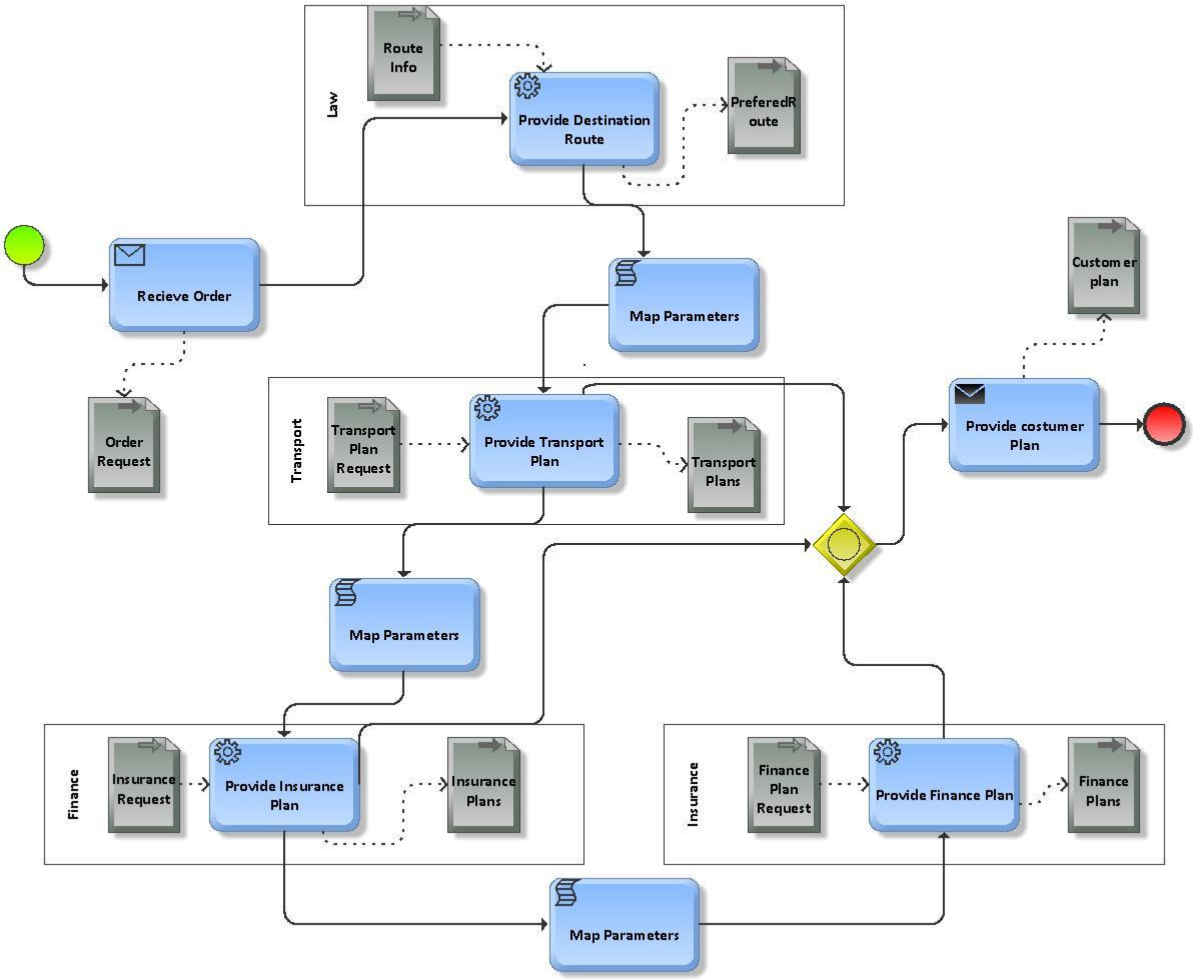

Figure 33: A sample Collaborative Process for VOTranspo: Providing Customer Plan

2 Preparing the Environment

In order to test the virtual hub (resulted from service federation between different ESBs) for the proposed prototype we decided to setup four individual organizations each with a full-stack SOA infrastructure. We used server virtualization techniques and VMware resource pool to optimize use of our hardware resources. We have two sets of computing resources: the first set in Telfer school of management in Knowledge Discovery and Data mining (KDD) laboratory and the second set at university of Ottawa Computing and Communication Services (CCS) center. Figure 34 shows the use of servers that are setup for each partner in the VO and how they are physically distributed.

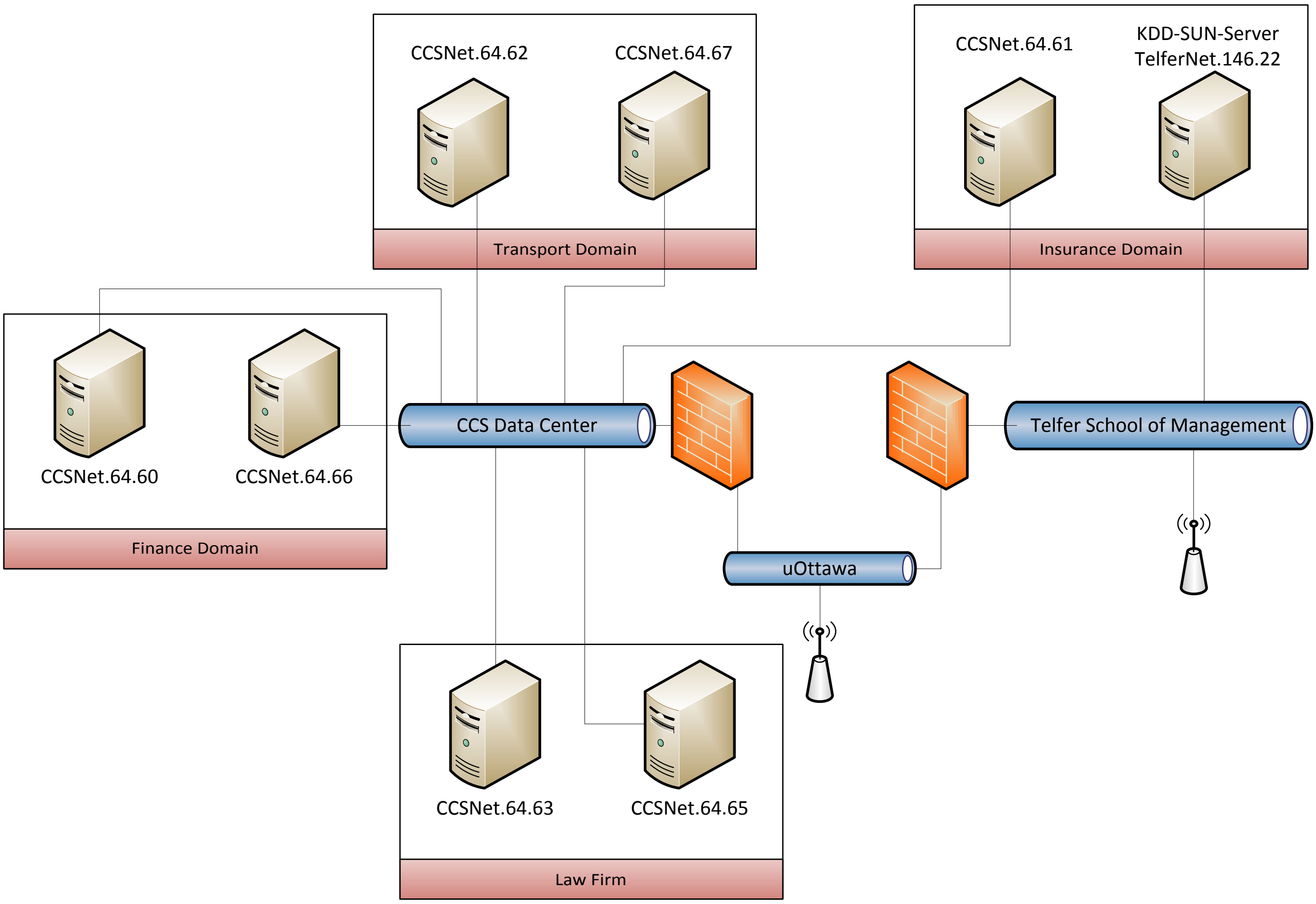

Figure 34: Computing Resources for TranportVO

The communication over different domains could be handled differently over the internet. There is no one model that can fit for all. But the proposed architecture in this research is flexible enough to function over different patterns. In our prototype the infrastructure are all in a LAN managed and owned by university of Ottawa. In real life, partners can communicate with each other directly over the internet using SSL security mechanisms. This solution is secure enough but the configuration could be complex due to firewall settings for different ports and certificates needed for the products. Another solution would be for partners to set a specific VPN for their collaboration. This would reduce the complexity in security settings but requires a certain level of trust between VO partners.

We used IBM products to implement the service zone model. Before providing detail specification of the servers in Figure 34 and the products they are running, we will introduce each IBM product we used briefly:

❖ IBM BPM V7.5 Advance: its IBMs business process management product which has combined its previous Lombardi and WebSphere engines capabilities. It provides support for business process modeling, business process executing, simple rule execution, human task implementation, load balancing for human tasks, and role based access control to users and BPEL execution. It also facilitates system integration using IBM integration designer V7.5. This BPM engine consists of two individual profile, first the previously Lombardi server and second the previously IBM WebSphere Process Server which are integrated together. Note that the Lombardi process server has a great process modeling tool and it's easy to model and deploy processes with it since it does not require much technical capabilities. The modeling tool is not complicated and uses BPMN V2.0 notation which makes it easy to understand and work with for most business analysts. The process server on the other hand is extremely well designed software which provides a higher performance. Its component based and extendable but unfortunately more complicated to work with. It fully supports J2EE multi-tier architecture. The process server needs its business process choreographer, business space or IBM portal to function properly. The process design environment is an eclipse based software and extremely complicated for business analysts to work with.

- IBM WebSphere ILOG JRules V7.0: it's a business rule engine that handles more complicated business rules and it facilitates use of rules as web services.
- IBM WebSphere Enterprise Service Bus V7.1: it's IBMs ESB that facilitates integration of new composite SOA and BPM applications. It provides services such as complex integration logic and adapters, consistent connectivity across point-to-point infrastructures, service mediation and supports dynamic endpoint resolution.
- IBM WebSphere Service Registry and Repository V7.1 (WSRR): provides the facility to publish, share and discover organizational services. It provides service catalogs, service lifecycle management facilities and supports service level agreement management and along with the ESB provides enforcement of contracts and policies.
- IBM Service Federation Management Feature Pack V7.1 (SFM): it's a feature pack added to WSRR that supports sharing information and services between service domains and handles the connectivity setup required to make services useable between domains. Although it is

installed on WSRR but it requires a WESB or WebShere Message Broker in the product stack to function completely.

- ❖ IBM WebSphere Application Server V7.1 (WAS): is IBMs webserver that all the other mentioned products build up on. It provides facilities to host java-based web applications.

For this prototype we have considered every partner mature enough to have a SOA infrastructure. This allows sharing of resources and loosely coupled distributed infrastructure. The SFM will allow many topologies and service directories. Table 6 provides detail specification of the infrastructure resources and all products installed and configured.

Table 6: Detail Server Specifications

Partner	***Domain***	***Server IP Address***	***Products Installed***	***Server Resources***
Transport	Bpmdomain.com	CCSNet.20.67 Windows Server Data Center	WAS v7.1	CPU: 3 vCore x 1.86
			BPM v7.5.1	
			ILOG JRules	VMware CCS – V4
			Domain Controller	RAM: 4GB
			DNS server	Disk: 85GB
		CCSNet.20.62 Windows Server Standard	WAS v7.1	CPU: 3 vCore x 1.86
			WSRR v 7.1	VMware CCS – V4
			WESB v7.1	RAM: 2.5GB
			SFM v7.1	Disk: 85GB
Insurance	Insurance.com	TelferNet.146.22 Windows Server	WAS v7.1	2 CPUs – Dual Core 2.2
			BPM v7.5	KDD Server

		Data Center	Domain Controller	RAM: 8GB
				Disk: 200GB
		CCSNet.20.61 Windows Server Standard	WAS v7.1	CPU: 2 vCore x 1.86
			WSRR v 7.1	VMware CCS – V4
			WESB v7.1	RAM: 2GB Disk: 85GB
Finance	finance.com	CCSNet.20.66 Windows Server Data Center	WAS v7.1	CPU: 3 vCore x 1.86
			BPM v7.5	VMware CCS – V4
			Domain Controller	RAM: 2GB Disk: 85GB
		CCSNet.20.60 Windows Server Standard	WAS v7.1	CPU: 2 vCore x 1.86
			WSRR v 7.1	VMware CCS – V4
			WESB v7.1	RAM: 2GB Disk: 85GB
Finance	finance.com	CCSNet.20.65 Windows Server Data Center	WAS v7.1	CPU: 3 vCore x 1.86
			BPM v7.5	VMware CCS – V4
			Domain Controller	RAM: 3GB Disk: 85GB
		CCSNet.20.63 Windows Server Standard	WAS v7.1	CPU: 2 vCore x 1.86
			WSRR v 7.1	VMware CCS – V4
			WESB v7.1	RAM: 2GB Disk: 85GB
BPM Testing Server		CCSNet.20.69 Windows Server Standard	WAS v7.1	CPU: 4 vCore x 1.86
				VMware CCS – V4
			Web Sphere Process Server V7.1	RAM: 4GB
				Disk: 85GB

3 The Prototype in Action

We have implemented the VOTranspo virtual hub and hosted the sample collaborative process presented in Figure 33. In this section we present a step by step approach of what needs to be done and we will finally present the implemented collaborative process. All the organizational processes are developed using IBM BPM V7.5 and are modeled by IBM Process Designer and hosted on Process Center profile (prior to v7.5 known as Lombardi BPM). Since the first step of our sample collaborative process is getting the Law firms preferred route through "Provide Destination route", we will see how this is implemented and shared to the VO. This process is implemented using a simple process that receives Source and Destination addresses and provides an array of string as the preferred route.

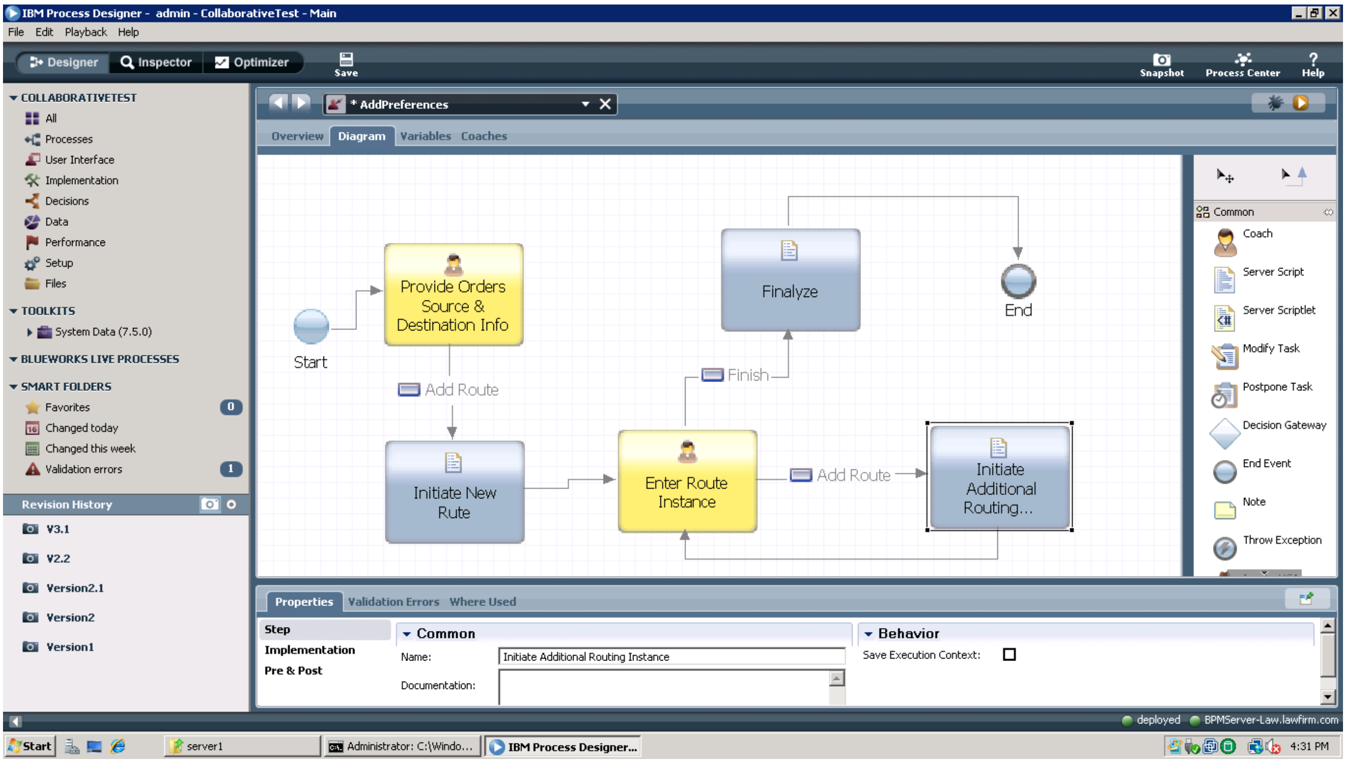

Figure 35: Law Firm - Provide Prefered Route Process Diagram

At the second stage the transport partner receives the preferred route and the order info to provide transportation plans. We have implemented a simple human task to enter different transportation routes, duration and cots. Figure 36 depicts this process.

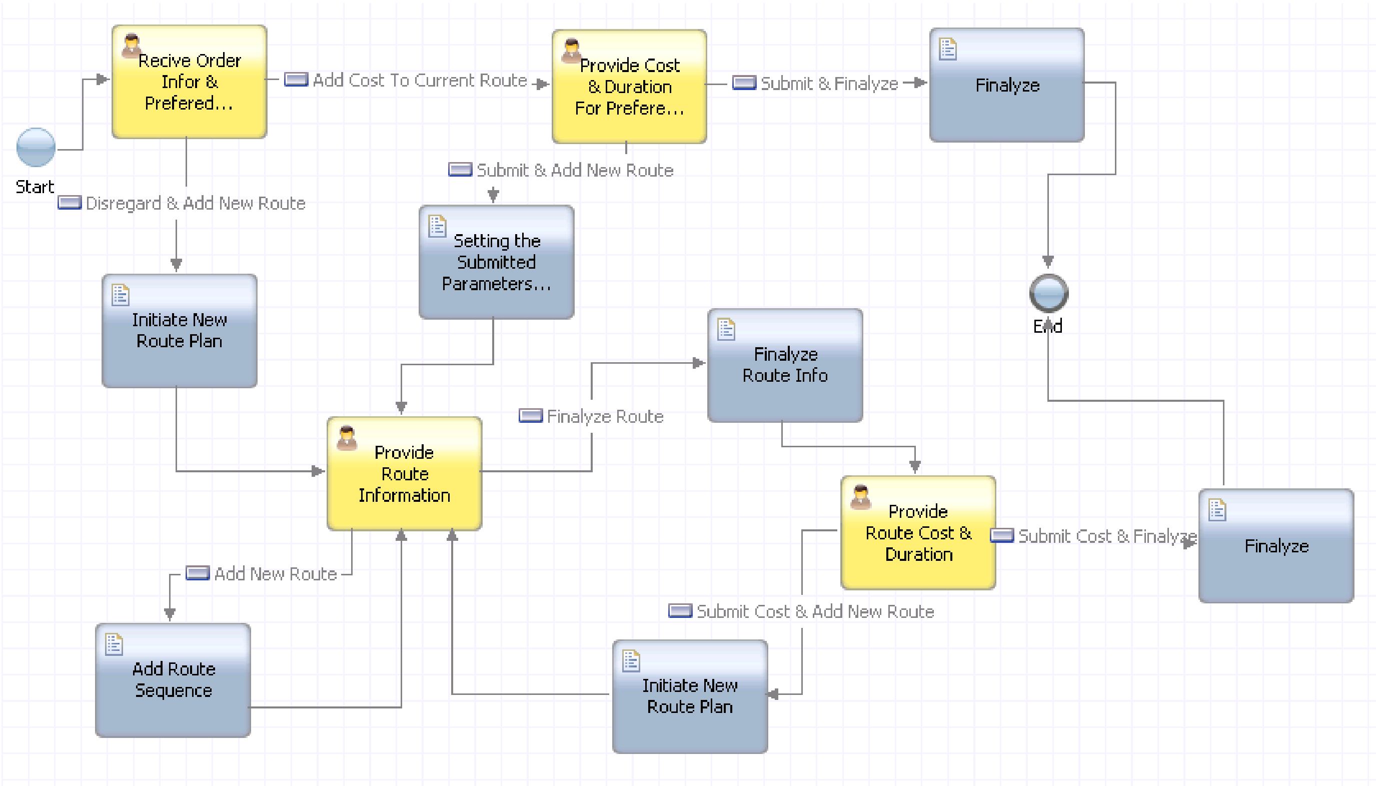

Figure 36: Transport Partner - Provide Transportation Plans Process

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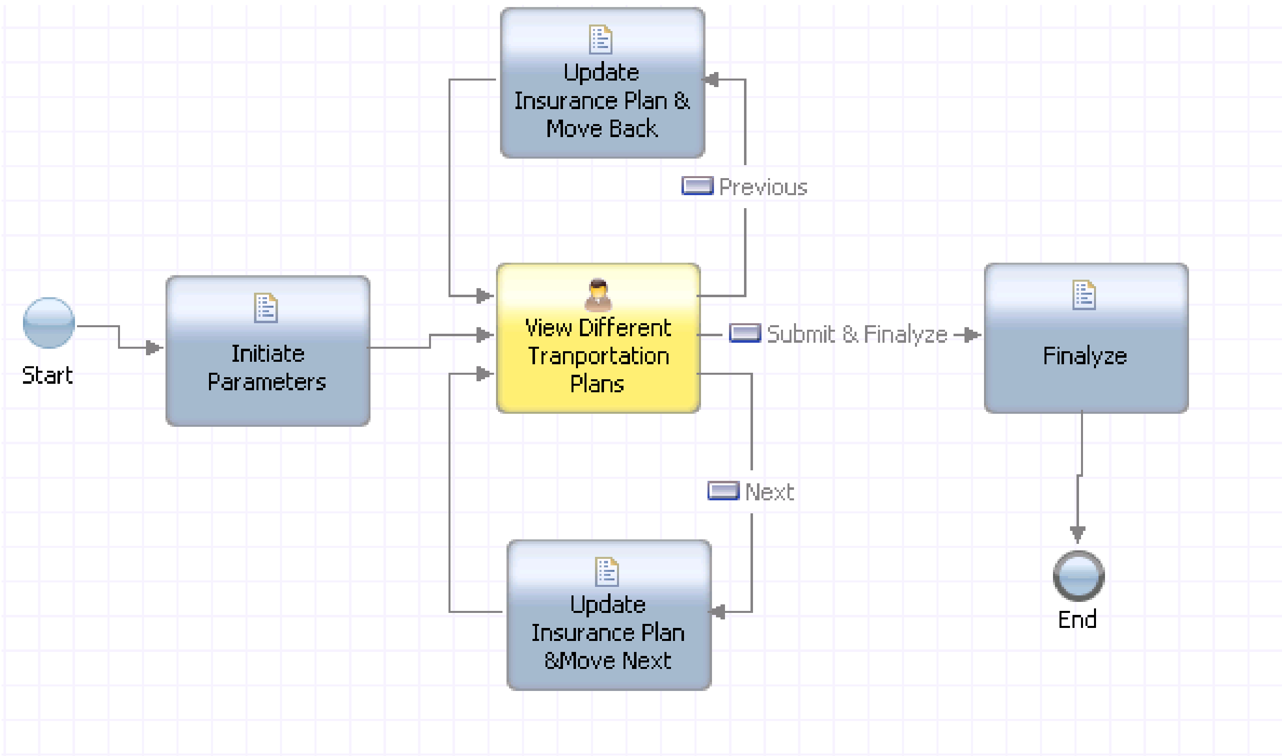

Figure 37: Insurance Partner - Provide Insurance Plans Process

At the third stage in the presented process in Figure 33, the insurance company provides insurance plans based on transportation routes and durations provided by the transport partner. This has been implemented in a simple human task process which is presented in Figure 37.

Finally the finance partner receives information such as total transportation costs and duration and provides financial service plans. This process is implemented using a simple web form that receives the order info and transportation costs and provides plan description. Figure 38 shows the implemented web form.

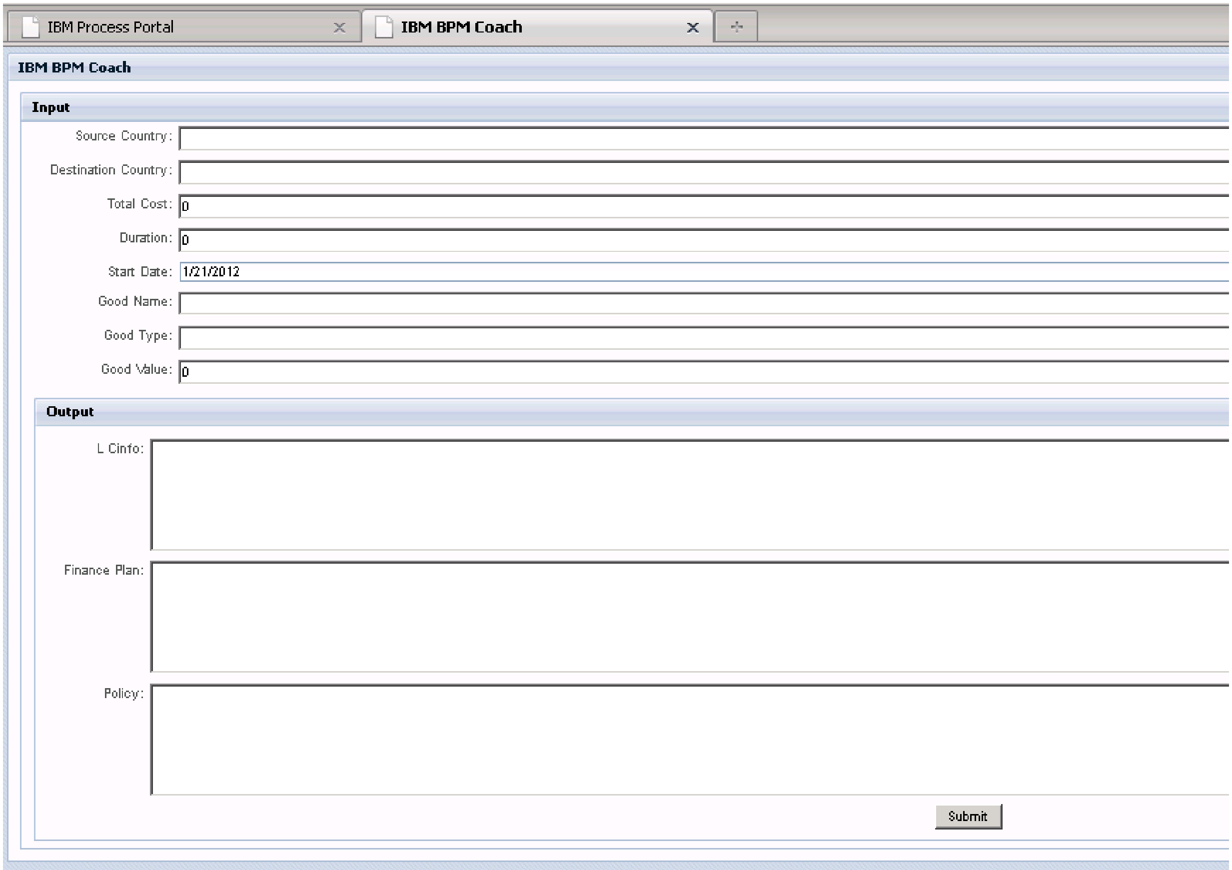

Figure 38: Finance Partner - Provide Finance Plan - Web Form

Now that we have established all the individual partner processes we still have a few more steps until we can share these processes as services in the virtual hub. Since these processes were developed in the Process Center profile of IBM BPM they do not have a web service interface. In fact the Process Center lacks the ability to provide web service callouts unless implemented as callout events which will not trigger a response. Therefore we use IBM Integration Designer V7.5 to implement a web service callout for our processes. The Process Center process is called using an SCA implementation of it facilitated by IBM BPM. Note that Service Component Architecture (SCA) is standard format for calling objects and it’s considered part of SOA standards (Keen & (Firme) 2004). In implementing a web service callout for a process dependent on humans we need to develop a synchronous callout. In IBM products all web service interfaces are considered asynchronous. There are two solutions for implementing a synchronous callout for an SCA binding. The first solution is to use IBM BPM and WAS queue which indicates implementing a POJO (Plain Old Java Object) component that calls the SCA components and puts the request in a queue and then listens for a response from the asynchronous SCA service callout. Figure 39 presents the process and more information on how to implement such POJO components is provided in (Fong 2009).

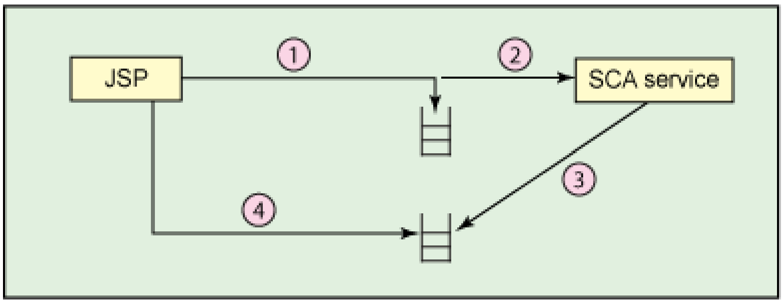

Figure 39: Implementing Synchronous Callout with POJO (Fong 2009)

The second solution for synchronous callouts is to use IBM WebSphere message broker which is a product that facilitates different queue implementation and provides messaging services and mediations. Using message broker to implement such task will guarantee a higher performance and better security. It also facilitates better monitoring and tracking capabilities. But it takes more time, effort and resources to set it up.

In this research we used the first approach to implement synchronous callouts for our processes. The assembly diagram of the transports company's process exposed by a web service callout is presented in Figure 40. The POJO component in the diagram has a simple java code which is presented in Figure 41. These two components with the web services export component build up what we need for exposing a business process as a reusable web service.

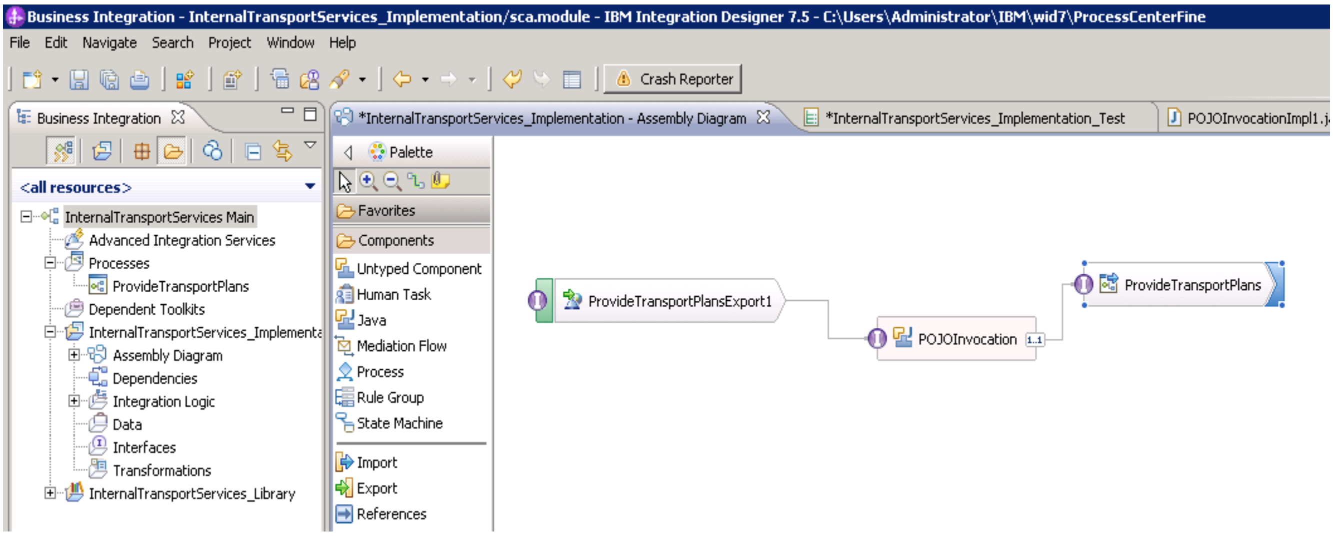

Figure 40: Assembly Diagram for Implementing a Synchronous Callout for Transport Sample Process

```
 * The presence of commonj.sdo.DataObject as the return type and/or as a parameter
 * type conveys that it is a complex type. Please refer to the WSDL Definition for more information
 * on the type of input, output and fault(s).
 */
public DataObject invoke(DataObject transportPlanRequest) {
    locateService_ProvideTransportPlansPartner();
    Ticket tik=_ProvideTransportPlansPartner.invokeAsync("invoke", transportPlanRequest);
    DataObject ServiceResponse= (DataObject) _ProvideTransportPlansPartner.invokeResponse(tik, -1);
    return ServiceResponse.getDataObject("TransportPlanResponse");
}
```

Figure 41: Sample POJO Code

This expose needs to be repeated for any process implemented with IBM BPM Process Center. If the organization uses the Process Server profile of IBM BPM v7.5 to implement business processes by BPEL, a similar implementation is still necessary if the BPEL contains long-running tasks (such as human tasks). So we repeated this for all the mentioned processes of VO partners. At the next stage we published these services on the organizations WSRR. Figure 42 is showing Law partners process published on WSRR on address CCSNet.64.63. The graph shows the service published, its methods and parameters and all its dependent description files.

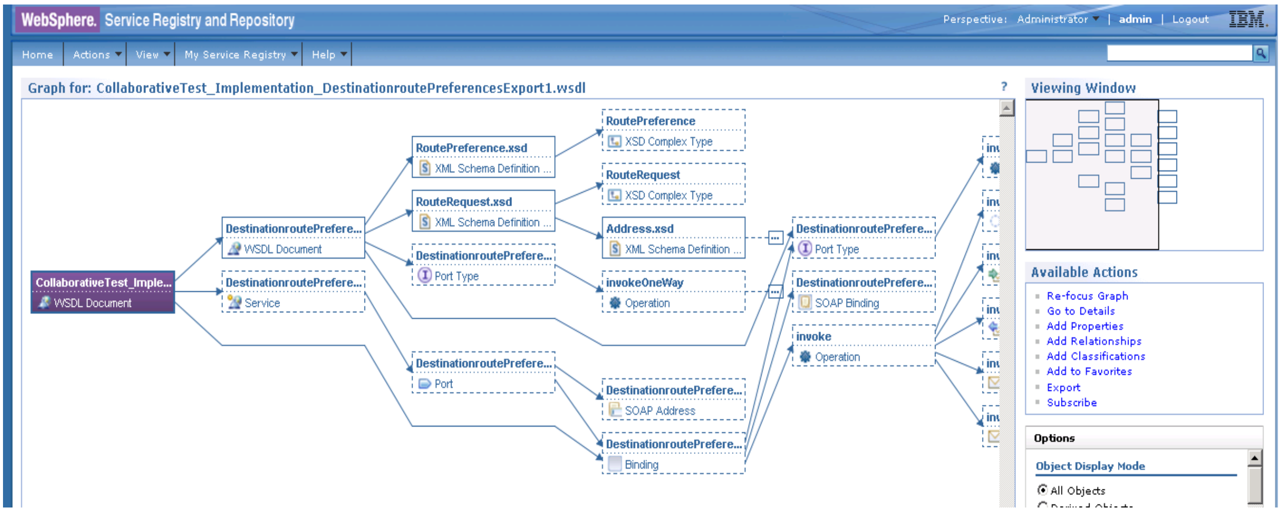

Figure 42: Law's Process Published on its WSRR

WSRR provides a fine grained access control. In order to deny access of some of the object, we need to specify it in the role access control. One of the ways to manage access control is by objects description. Therefore we manage our web service descriptions files (WSDL) by private and public description. We will define a VO role that has only access to WSDLs with description “public”. Figure 43 shows such role configured in Insurance’s WSRR (CCSNet.64.61). We also need to define a separate perspective and home page to access WSRR for this group of users. In these settings we have the ability to define which object groups the users have access to.

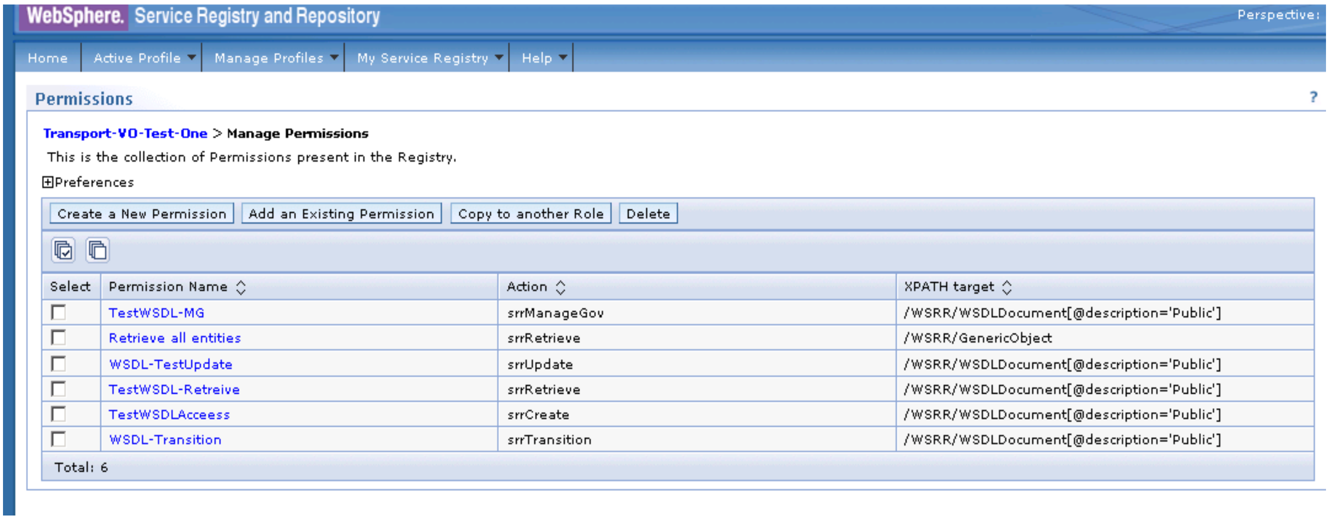

Figure 43: VO Role Permissions Defined in WSRR

Now it's the time to setup VO's virtual hub. Our Service Federation Management feature pack is installed on transport's WSRR with the address CCSNet.64.62. General steps for configuring SFM were discussed in section Chapter Six: 2. For this specific prototype we have defied four domains that each represents one of our partner organizations. Figure 44 depicts the definition of each partners WESB and WSRR interfaces. The top panel contains its users and passwords to access these interfaces.

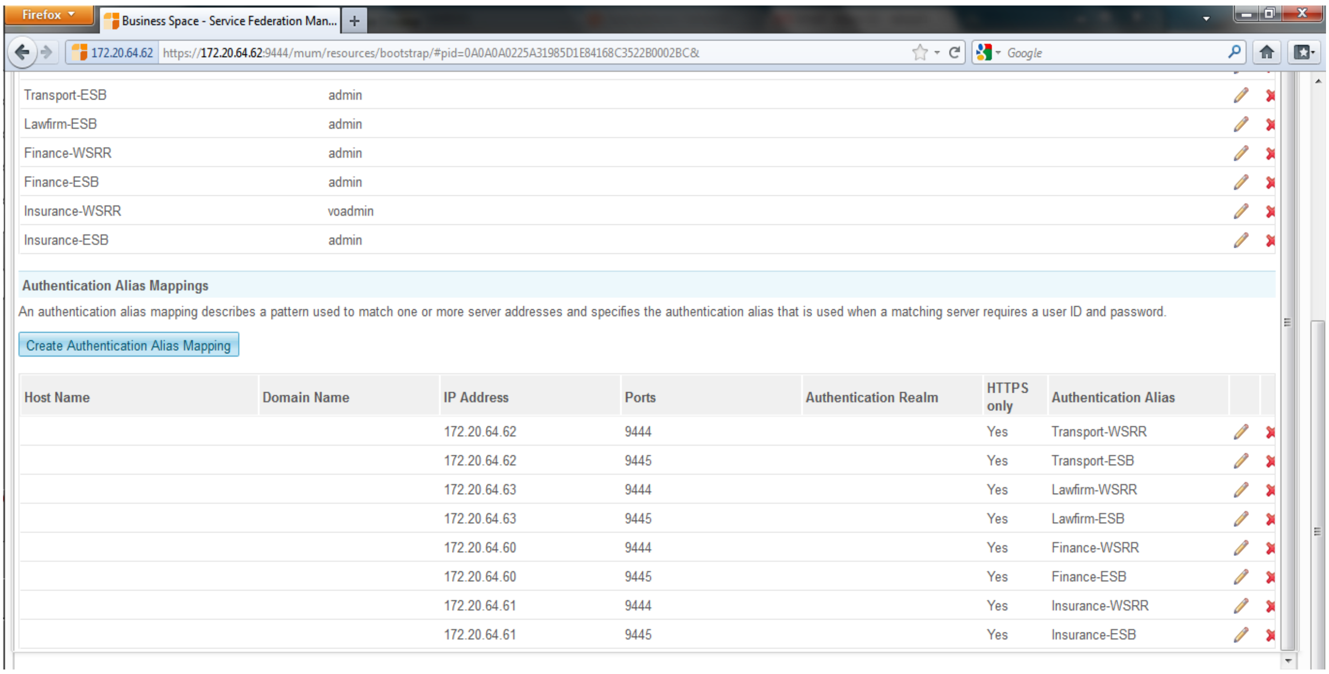

Figure 44: Service Federation Manager - Alias Mappings

After creating each partners interfaces we define a domain for them. In each domain we have defined one service group for this specific VO. Note that depending on the topology this may differ from one case to another. Figure 45 is showing Law firm's domain and a service group that we have defined for it which shares an endpoint that is for the process published in the WSRR in Figure 42. Other organizations have similar setting.

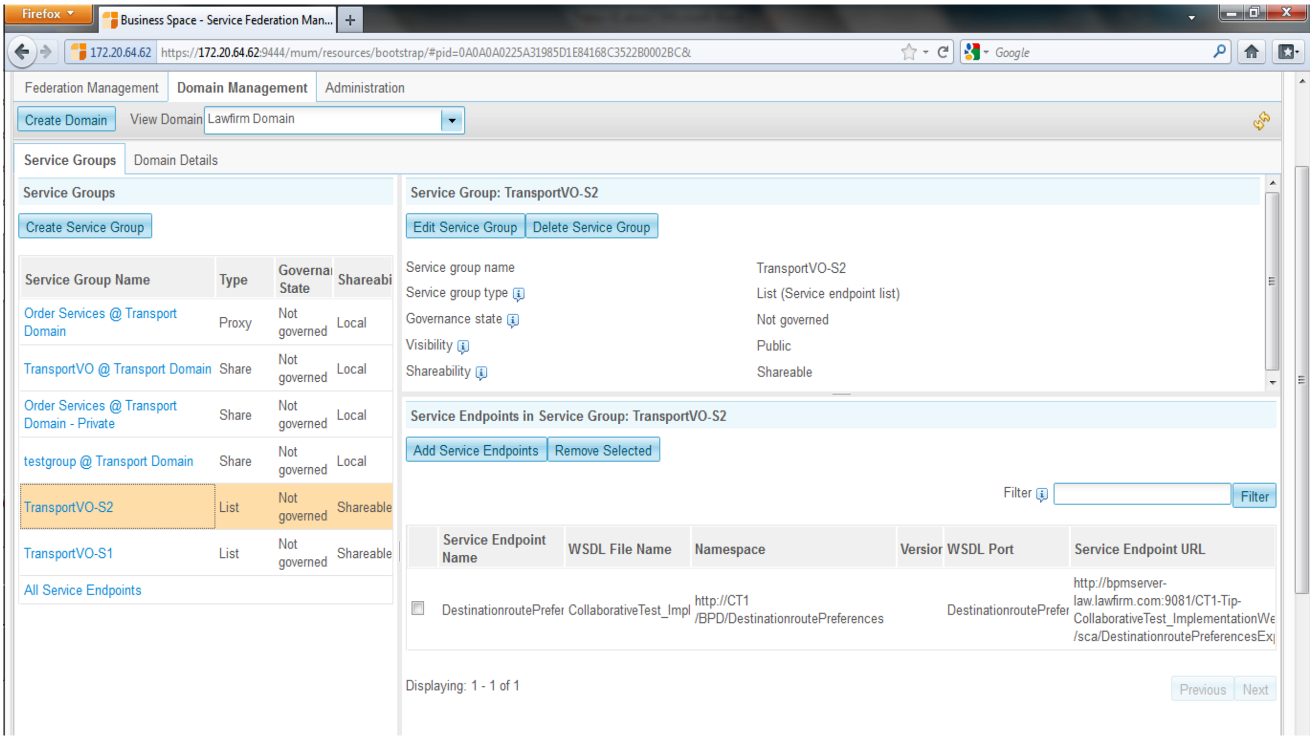

Figure 45: Laws Firm Domain - TransportVO Service Group

Figure 46 is showing how a service group from one domain is federated to other domains. For example in this screen shot we are federating the service group depicted in Figure 45 from the Law firm domain to the Finance domain. At the top right configuration panel we choose the service group we intend to share. In doing so, several options on the edges of the federation are available. For example we could validate the messages passed from the guest domain to the host domain. We could also define proxy gateways that ensure security in the communication on either sides or one side. If the proxy gateway is set at both sides the federation would be similar to a VPN tunnel.

Now in Figure 47, we present the overall topology of our VO. The SFM provides the flexibility to build any kind of interaction topology for the partners in the VO. This topology is showing that all the organizational service are available in the finance domain but the two transport and law firm have specific peer-to-peer interaction and sharing of services. Note that this is a sample showing a combination of two of the common topologies to prove the flexibility in the model presented.

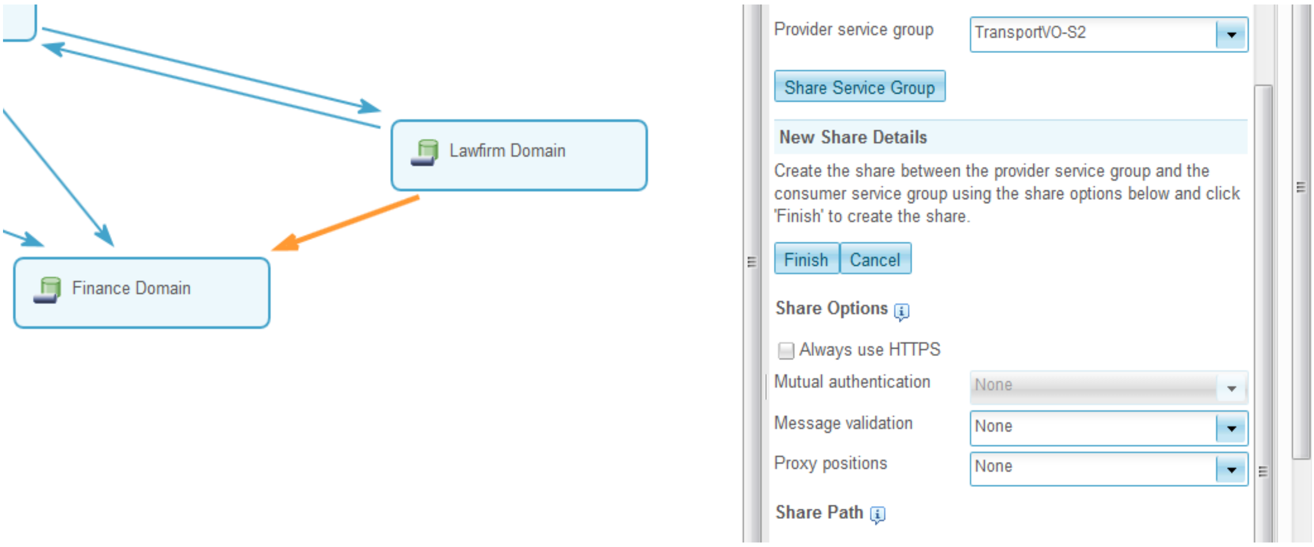

Figure 46: Federating Service Groups in SFM

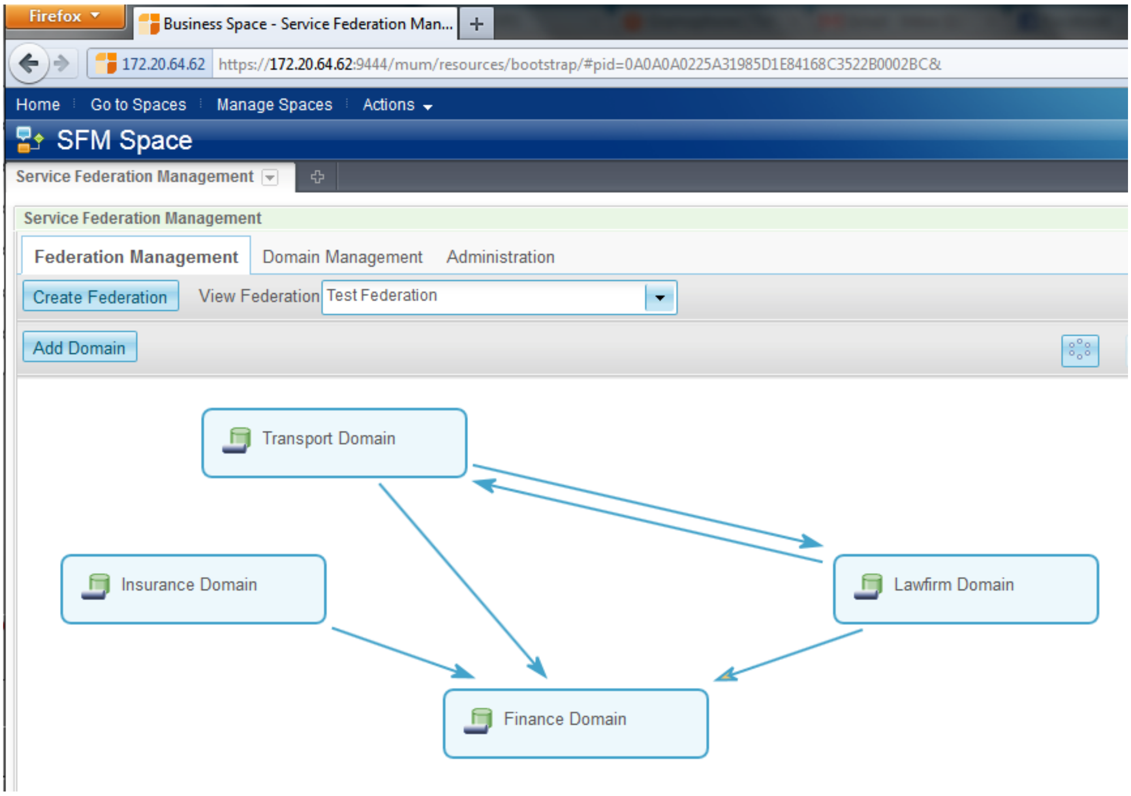

Figure 47: VOTranspo SFM - Interaction Topology

Now at the final stage we present the collaborative process modeled in Figure 33 implemented on finance BPM-Process Server profile. Figure 48 depicts the BPEL of the process.

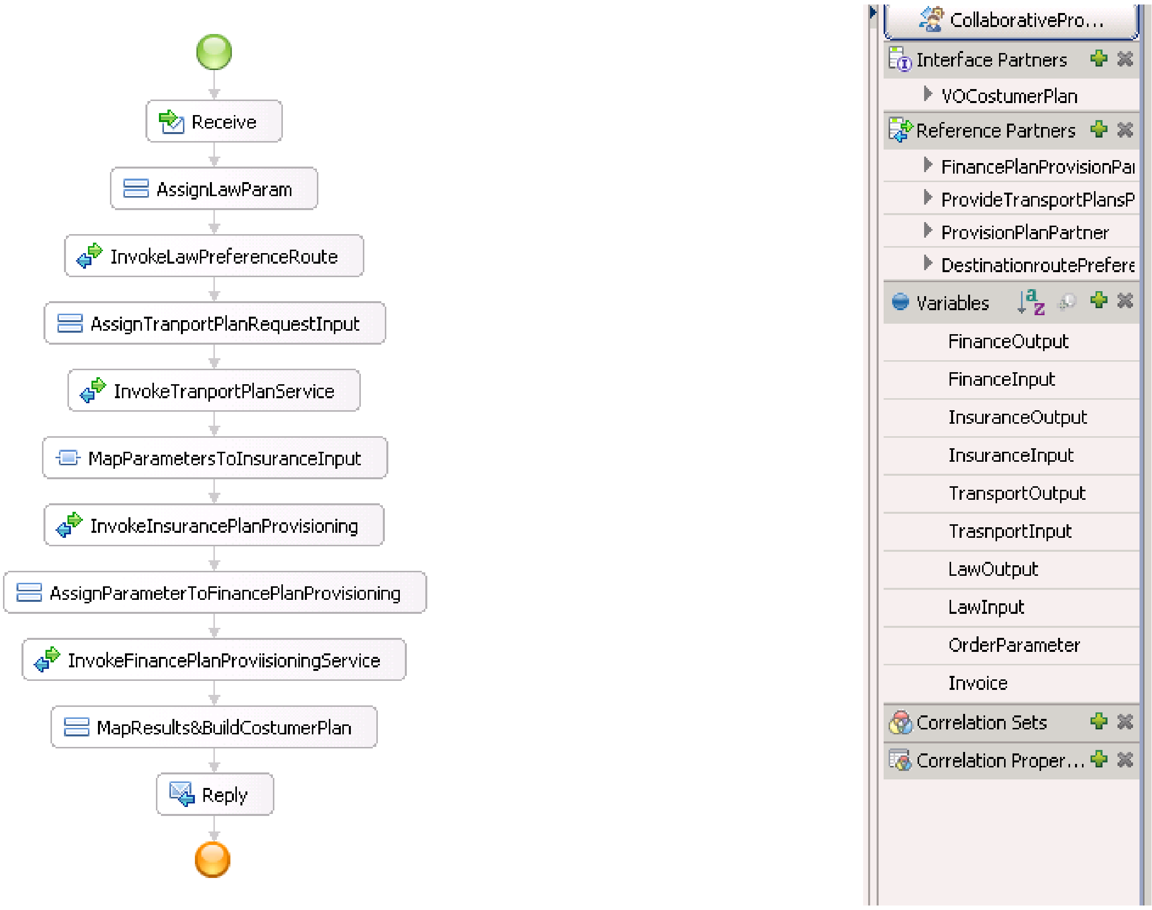

Figure 48: VOTranspo Collaborative Process - Implemented with BPEL

Figure 49 is showing the assembly diagram. The reference partners you can see in the right panel of Figure 48 are showing these components. The POJO implementations are needed if you need additional control features over the callout. If not you could partner the actual service interfaces. The blue components are web service interfaces that are extracted from finance WSRR and imported into this process, which are the federated services discussed earlier.

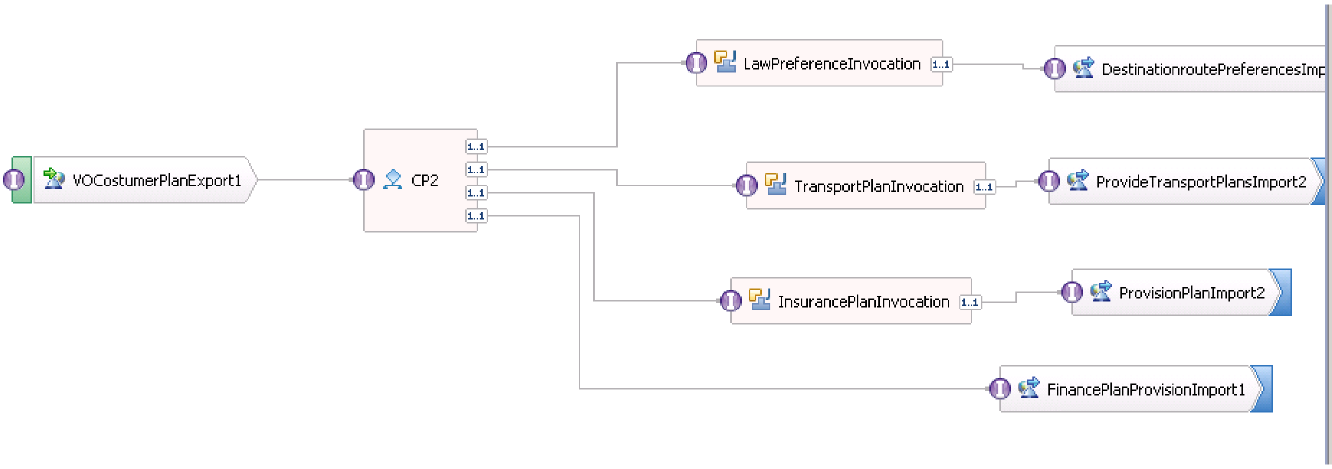

Figure 49: Assembly Diagram of the Implemented Collaborative Process

The following chains of screen shots are showing the prototype in action. Note the IP addresses at the top of the screens as we move from one partner to another. This is the process for providing a costumer plan for an order as shown in Figure 48. Note that these steps might not be accurate according to real life situation and their only purpose is to demonstrate information sharing through a process between different organizations.

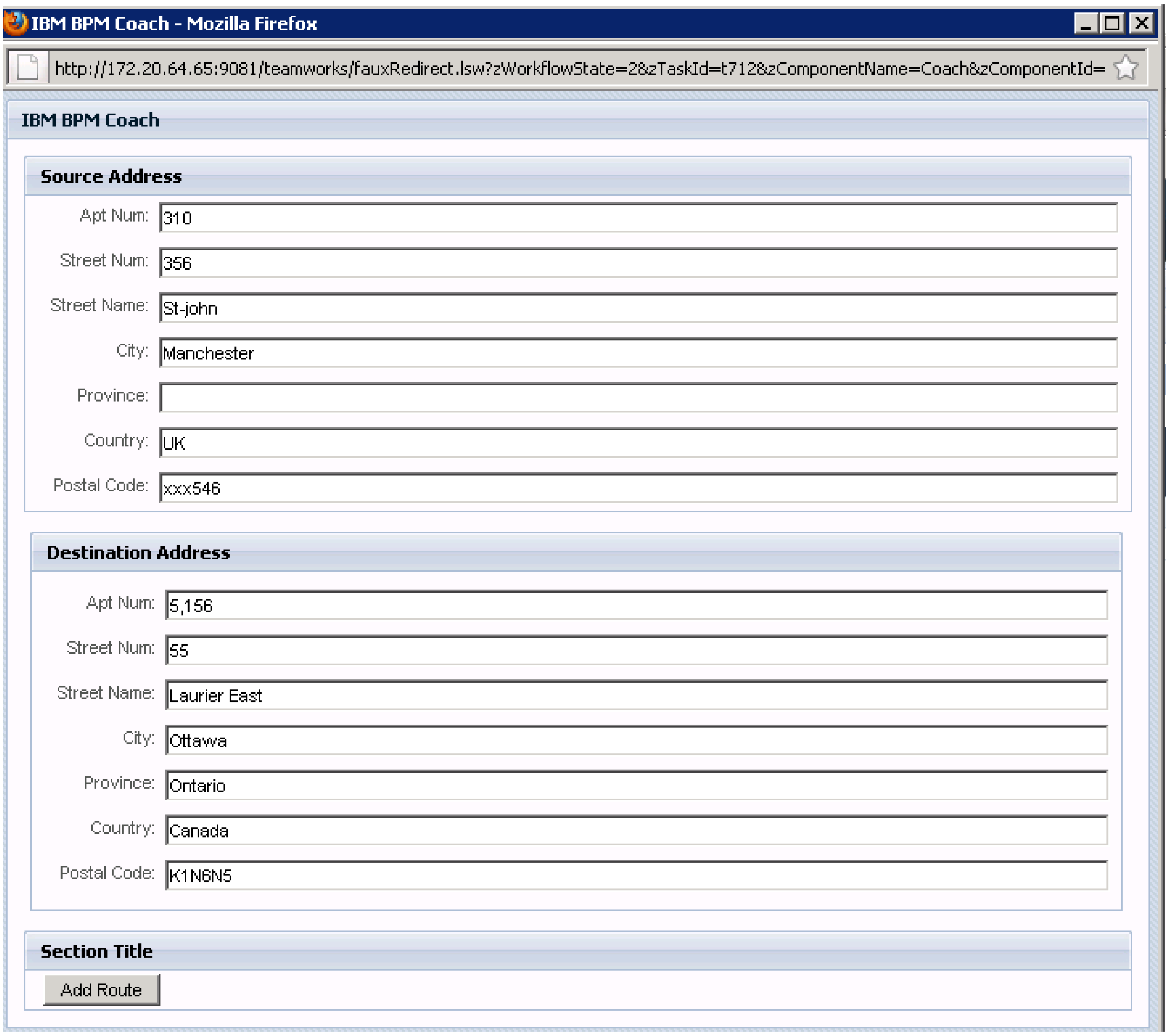

Figure 50: Law Firm Service - Landing Page

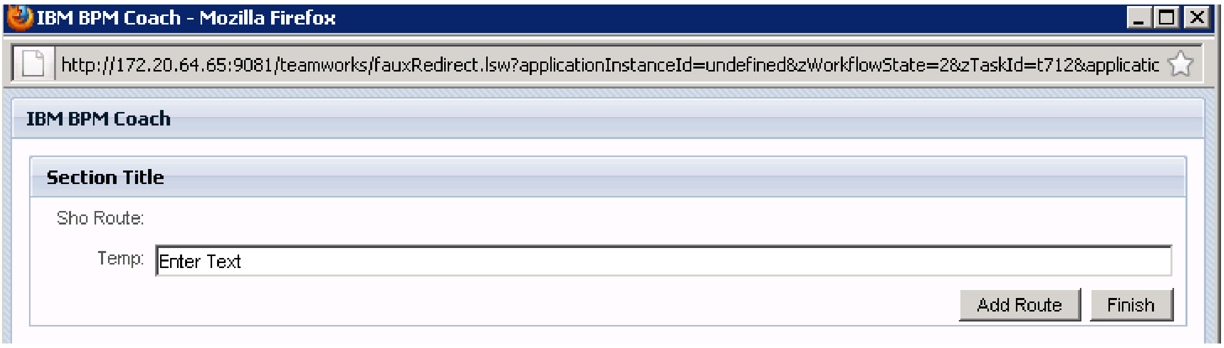

Figure 51: Law Firm Service - Step 1 - Providing Route Preference

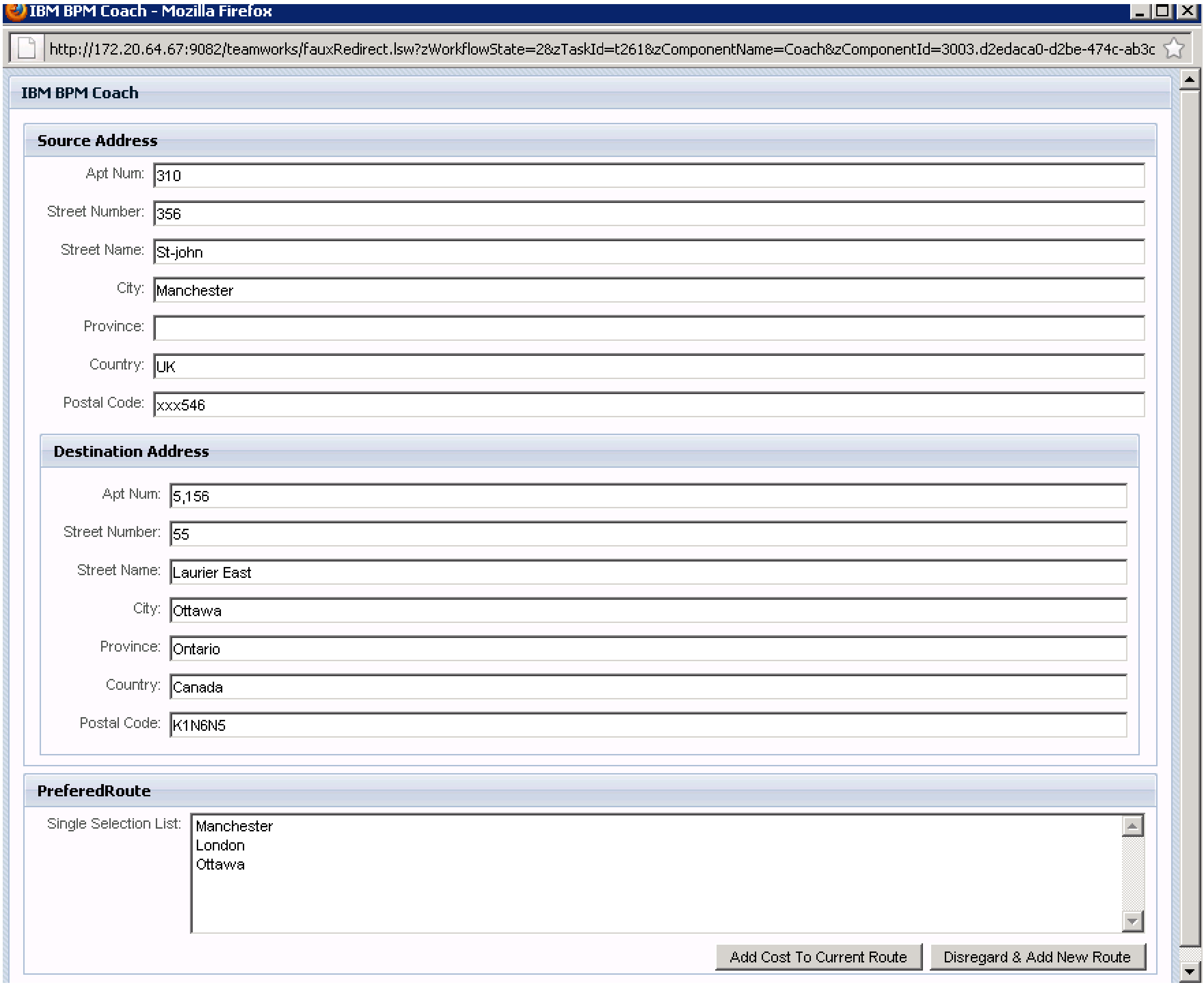

Figure 52: Transport Service - Landing Page

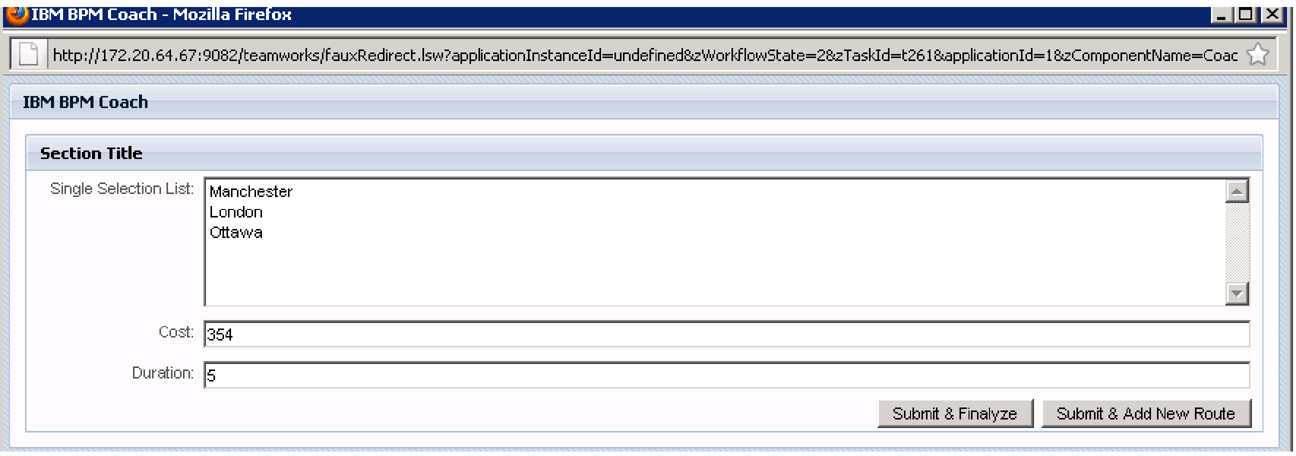

Figure 53: Transport Service - Providing Cost & Duration for a Routing Schedule

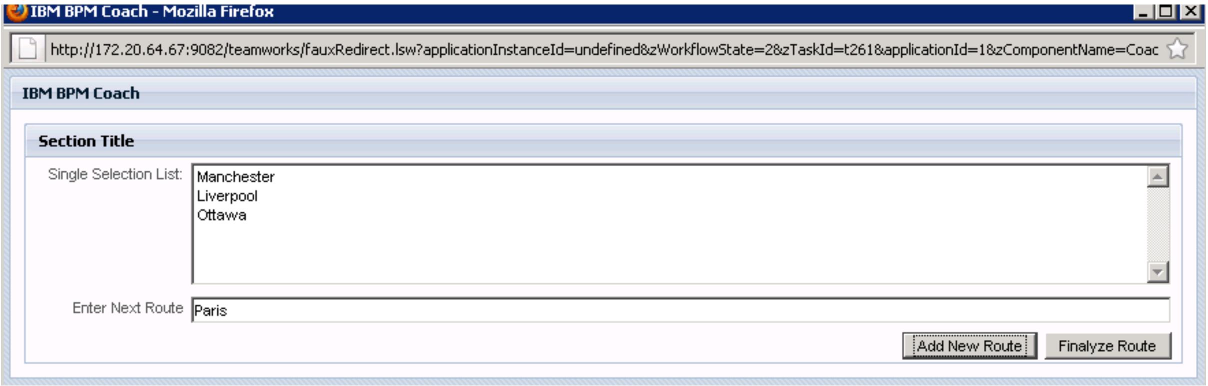

Figure 54: Transport Service - Adding Routing Schedule Info

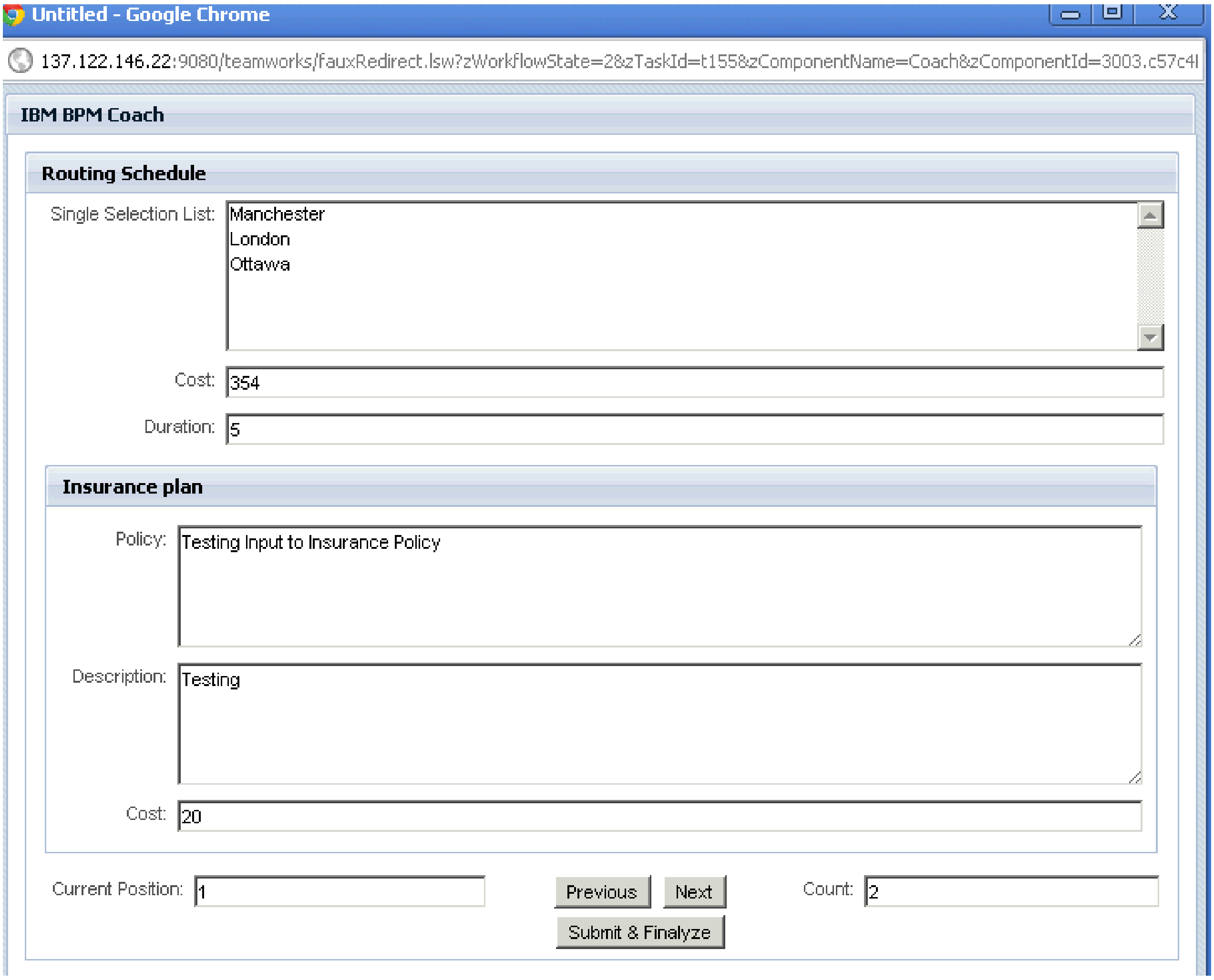

Figure 55: Insurance Service - Viewing Current Plans and Adding Insurance Info – Instance 1 of 2

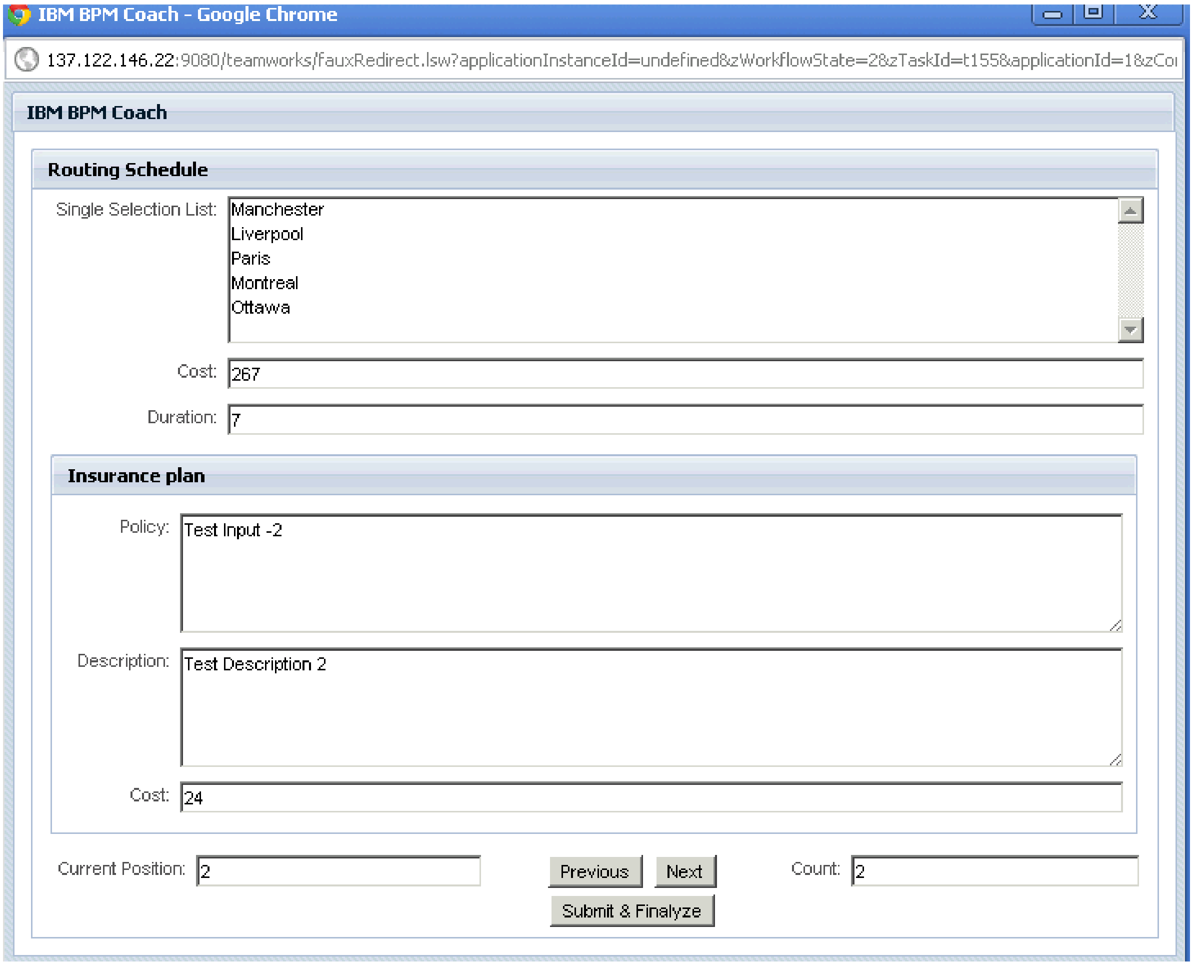

Figure 56: Insurance Service - Viewing Current Plans and Adding Insurance Info – Instance 2 of 2

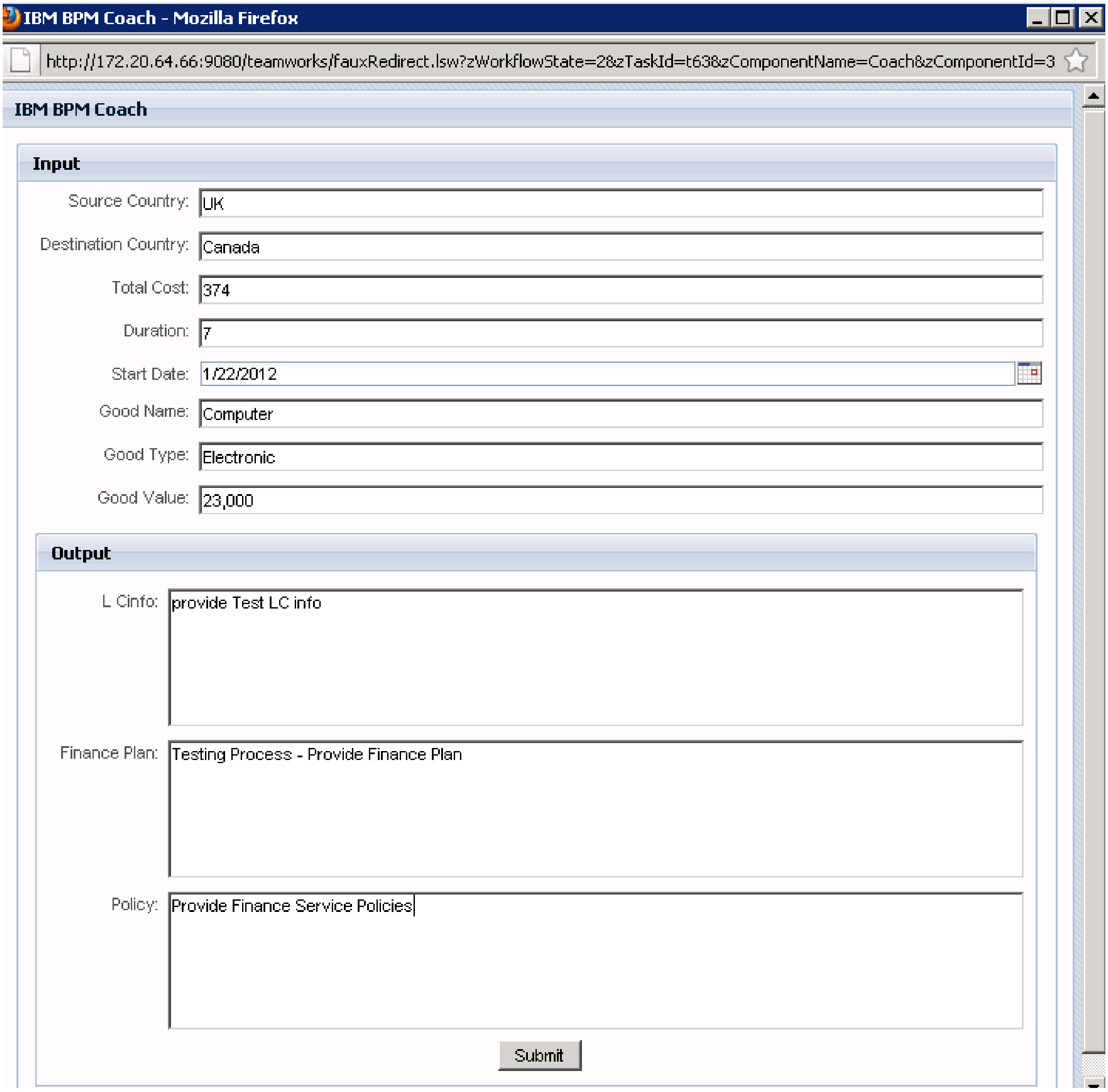

Figure 57: Finance Service - The Only Step

4 Observations and Recommendations

1. IBM products (WAS) support integration of Microsoft Active Directory users. That means if an organization is using Microsoft active directory to manage user access throughout the organization, they could make use of the same users with their IBM products. For federating a group of users between multiple domains Microsoft Windows Server 2008 has a federation feature which allows users of multiple domains to be federated

and have controlled access to each other's resources. This feature would make single sign on (SSO) throughout the entire VO smooth and easy. Unfortunately IBM WAS (the foundation and user control of all the products we use rely on this product) will not support an active directory federated user. It means that no matter what permissions are set for this user in the guest domain; IBM WAS will deny access to a user that is not part of its domain. Therefore options for user control are limited to IBM WAS authentication and authorization mechanisms. The WAS has a feature to provide federated user repositories which will provide the ultimate goal in our infrastructure but will bring some limitations which could be resolved by intermediary users defined for VO. Therefore a suggestion to IBM would be to support federated users of Microsoft active directory.

2. When using IBM BPM Process Center, we discovered it lacks the capability to use complex and linked WSDL files published to a WSRR registry. We did not further explore the issue as to why it cannot interpret this WSDL files which are created by IBM BPM integration designer v7.5. Instead we used the same description files with IBM Process Server profile and faced no problem. We recommend that IBM should explore this issue further in its next versions.
3. Unfortunately when using IBM BPM v7.5 we were unable to get the required help out of IBM forums. There is not enough information on the info center to run more advanced integration projects and complex processes. In our experience in posting on IBM forum either responses

were late or there were no response at all. Therefore we recommend to IBM to expand its online knowledge base.

4. IBM WSRR provides a different methodology comparing to other IBM products for access and permission controls. This method and the XML path of it are a bit complex. The identification of its different objects is not easy and the info center does not provide enough information. Therefore grouping objects and setting permission controls is complex and the user needs to be extremely careful. This will be even more complex in big organizations with multiple departments and different levels of access rights. We suggest a classification technique such as what IBM SFM uses with service groups. With this classification it’s going to be easier to define permission for organizational groups and departments.

CHAPTER EIGHT: CONCLUSION

1 Summary of the Thesis

Today's businesses are showing growing interest in inter-organizational collaborations. Concepts such as collaborative networked organizations and virtual organizations are gaining significant attention. Businesses need adaptive and intelligent partnerships to survive in this competitive business environment. Computer networks and systems are playing an important role in these collaborative organizations. Managing such collaborative environments is challenging and requires dynamic IT infrastructures to support the variety of topologies. The focus of computer supported B2B interactions has changed from information exchange to process oriented collaborations over time. Although many solutions have been provided for B2B collaborations, virtual organizations still face specific challenges because of their temporal and dynamic nature. Partners in a virtual organization highly depend on each other to fulfill their business objective but at the same time need to preserve their privacy and protect their competitive advantage. In this research, we analyzed VO lifecycle and extracted its requirements during its operation and evolution phases. We specifically focused on virtual organization management requirements. Our literature review on virtual organizations revealed the need for a solution that supports business process synchronization, is easy to deploy and preserves partner's privacy. SOA, an IT architectural framework, promises a flexible reusable technology that is adapted to support dynamic business process management. Therefore in this research, we proposed a distributed service oriented software architecture that handles business processes management by reusing partner's existing resources such as infrastructure, hardware, services and processes to form new value added services and processes for the VO. The architecture is based on a service zone interaction model defined to provide an abstract specification of organizational resources and is considered a gateway to the VO shared resource pool.

Analysis of SOA-based business process management implementations has shown that most of the failure scenarios lacked an alignment between business strategies and lower level web service implementation, or in other words most of them had a purely technology oriented implementation. Hence in this research we provided a service oriented business process management framework to design, coordinate and track collaborative business processes in virtual organizations. The main contribution of the framework is the service choreography extraction model which facilitates the alignment of lower level business processes to the higher level value production. This method focuses on dependencies in the value network, and models service choreographies between different partners of the VO. It narrows the gap between process management and VO business model and facilitates a better roadmap in designing collaborative processes. The framework is based on known best practices and reference frameworks such as ISO EDI-B2B reference architecture and ITIL. We used a globally known notation for modeling business processes named BPMN V2. These references were used to produce a customized framework for VO requirements which facilitates a smooth path from business strategies and values to lower level IT services.

The proposed architecture and framework were validated by implementing an infrastructure for business process management for a specific VO scenario. This prototype contains four different partners, a transport company, a law firm, a finance company and an insurance cooperation that come together to provided value added international transportation services. We started by modeling a value network that describes how the four partners share their resources to produce value added services to their final costumers. We provided a service choreography model based on the proposed value network using our unique method. After designing the overall service choreography, a VO can start modeling its collaborative business processes based on the proposed choreography. We modeled and implemented a sample collaborative process in the proposed prototype. This prototype is implemented using IBM SOA foundation known as WebSphere.

The collaboration model and the infrastructure proposed in this research facilitate a peer-to-peer inter-organization collaboration through existing SOA infrastructures. This offers several benefits including 1) facilitation of global virtual organizations creation, faster and easier through web services. With this architecture, organizations in various geographical positions can form a secure infrastructure for their B2B interactions with less cost and easy configuration; 2) B2B interactions and VO formation is done more efficiently and the total cost and effort of VO formation and maintenance are reduced; 3) The framework provides agile inter-organization process automation, and brings dynamicity as a competitive advantage to the VO. The VO will adapt and integrate with partner's information systems much easier with less cost; 4) VOs dependency to its partner organization is reduced because of a loosely coupled service oriented infrastructure; 5) This infrastructure facilitates collaboration among any network of organizations using any common topologies; and 6) Since the proposed infrastructure is based on current partners SOA infrastructure, and due to the SOAs scalable and reusable nature, the risk of VO creation will be reduced significantly because of lower initial investment.

2 Contribution of the Thesis

In this research, we proposed (1) a framework for designing and modeling Service Oriented Virtual Organizations processes. The framework consists of six main layers, and embeds a continual improvement cycle. In the heart of the proposed framework, the service choreography extraction method acts as a roadmap to design lower level services, and facilitates VO strategic alignment. The various components in each layer are described using standard reference models and best practices customized for a VO environment. (2) We provided a SOA-based architecture for a distributed virtual infrastructure that supports inter-organizational process management. This architecture is especially aligned with virtual organizations and their characteristics. A virtual hub resides at the heart of the infrastructure that is built using partner organizations ESBs and service registries. This virtual hub relies on the zone interaction model proposed in this research, which consists of a set of service zones – an abstract layer that resides in partner organization but is owned by VO – containing shareable services and processes federated together to facilitate inter-organizational collaborations. The federation allows dynamic and flexible topology setup using SFM admin console. It also facilitates dynamic binding of loosely coupled BPM engines on top of the virtual hub. The infrastructure is implemented using IBM SOA foundation (WebSphere™ stack) and facilitates secure, controllable sharing of services to its partner organizations while reducing the cost and effort for VO initiation. It supports various topologies for inter-organizational collaborations such as supply chain, star and peer-to-peer.

<u>Publications Resulted from this research:</u>

1. M. H. Danesh, B. Raahemi, M. A. Kamali, and Greg Richards, ***"A Distributed Service Oriented Infrastructure for Business Process Management in Virtual Organizations",*** to be presented at IEEE 25th Canadian Conference on Electrical and Computer Engineering 2012, Montreal, Canada
2. M. H. Danesh, B. Raahemi, and M. A. Kamali***, "A framework for process management in service oriented virtual organizations,"*** in 2011 7th International

Conference on Next Generation Web Services Practices (NWeSP), 2011, pp. 12-17.

3. M. H. Danesh, M. A. Kamali, B. Raahemi, and G. Richards, ***"A SOA Infrastructure for distributed process execution in virtual organizations",*** IBM CASCON 2011, November 2011, Toronto, Canada.

3 Limitations and Future Work

The proposed process management framework does not cover some of the PMBOK knowledge areas such as risk management, knowledge management; and human resource management. In future these areas could be added to the framework. The virtual hub formation and configuration in this research was solely based on IBM products. Therefore integration of other vendor products could be challenging. This is the main limitation of this prototype. Also at least one of the partner organizations needs to have some sort of SOA infrastructure in place. In future the architecture should be extended to multi-vendor federation based on SOA standards. This will result in formation of a cloud oriented environment for inter-organizational process management. The interaction of smaller organizations will help realize full inter-organizational capacity. The cloud architecture will facilitate design of agent based partner discovery and negotiation for VO creation in future.

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