International Journal of Computer Information Systems and Industrial Management Applications.
ISSN 2150-7988 Volume 5 (2013) pp. 203-215

A Framework for Process and Performance Management in Service Oriented Virtual Organizations

Mohammad H. Danesh[1], Bijan Raahemi[1], S.M.Amin Kamali [1] and Greg Richards[1]

[1] Telfer School of Management, IBM Center for Business Analytics and Performance, University of Ottawa
55 Laurier Ave, E. Ottawa, ON. K1N 6N5 Canada
{mahma023, braahemi, skamali}@uottawa.ca, Richards@telfer.uottawa.ca

***Abstract*: Virtual Organization (VO) is a network of autonomous organizations sharing their competitive advantage to address a specific business opportunity. Due to autonomy of partners and the temporal and dynamic nature of VOs, collaborative VO management is crucial to its success. In addition, performance measurement plays an important role in non-centralized VO management solutions. In this research, we present a framework for process and performance management in service oriented virtual organizations. The framework comprises of 6 layers including an integrated performance management framework. In designing the components of the framework, standard reference architectures such as Open-EDI reference model and the IBM S3 Service Oriented Architecture (SOA), as well as best practices such as ITIL V3, PMBOK, SCOR and ECOLEAD are used. In addition to the framework, a distributed SOA-based architecture for business process execution and performance measurement is discussed. The proposed architecture is built using service zone specifications residing in each partner organization. It uses current SOA infrastructure of partner organizations to shape service zones which are federated into a virtual infrastructure that facilitates business process synchronization and execution. This infrastructure supports any of the common VO interaction topologies known as supply chain, star and peer-to-peer. This research facilitates inert-organizational business process design, synchronization of partner processes, collaborative performance management and distributed process automation in service oriented virtual organizations.**

***Keywords*:** Collaborative Process Management; Collaborative Performance Management; Service Oriented Architecture; Enterprise Service Bus; Service Federation.

I. Introduction

Participation in inter-organizational collaboration is inevitable in today's business environments, especially when organizations need to achieve a differentiated competitive advantage. While small and medium size enterprises (SME) do not have the power and resources to compete against large enterprises, the notion of collaboration is even more essential. Therefore, organizations are increasingly restructuring their process models and software infrastructures to facilitate dynamic and flexible environments to engage in more complex value creation chains, partnerships, and business ecosystems. This has resulted in more organized collaboration of enterprises, and a new area of interest known as Collaborative Networked Organizations (CNO). Temporary and opportunity based CNOs which are known as gatherings of multiple organizations to address a specific business opportunity, are called Virtual Organizations (VO). VO collaboration and interactions are usually supported by computer networks [1].

Computer aided data interchange and software interaction between different organizations has evolved over time. Several frameworks and standards have been developed, especially for Business-to-Business (B2B) interactions. Also, there have been studies on agile and flexible communications, within networks of organizations. At their early stages, these frameworks were mostly relying on data interchange, but as they evolve, they have aimed to address higher level business processes between organizations [2]. EDI (Electronic Data Interchange), RosettaNet, ebXML (Electronic Business using eXtensible Markup Language) and SOA (Service Oriented Architecture) based solutions are examples of such interaction frameworks. These solutions are designed to handle long term B2B interactions, while VO partner interactions and collaborations faces specific challenges due to their nature of partnerships. Among these challenges, dynamic reorganization during VO lifetime, privacy concerns of partners, and business process integration can be mentioned as examples [3].

As the world economy has shifted from a goods-based economy to a value creation-based economy, the service sector and service science have gained more and more attention. Therefore, SOA-based software adoption and usage have increased in the past decade. SOA-based solutions are strongly recommended for dynamic value creation systems [4]. Studies show that the success of SOA-based BPM-system (Business Process Management) implementations is highly dependent on the alignment of the solution towards organizational business strategies [5].

In this research, we provide a framework for business process design and performance management that depends on a service oriented architecture and implementation of VO collaborative processes. The proposed framework enables networks of organizations to form virtual workflows based on their software infrastructures, and share and monitor their performance metrics without the need for a central authority. The service zone interaction model provides an abstraction layer that facilitates organizations to share their designated services with other partners while keeping their core

competency private.

The rest of the paper is organized as follows. In Section 2, we discuss the background concepts. Section 3, describes the proposed framework and its various components. Section 4 presents the distributed architecture for implementing SOA-based BPM in VOs. In Section 5, we discuss characteristics of the proposed framework and architecture. Finally, the paper is concluded in Section 6.

II. Background

A. Virtual Organization

Collaborative networks focus on communication and exchange of information, knowledge and services for a mutual benefit. A simple example would be sharing of information on different experiences among business partners using a web communication tool. As these collaborative networks have evolved, various forms of CNOs have been formed among which virtual organizations are the most mature in terms of degree of inter-dependency and collaboration. While there are several definitions for VOs, none of them is unanimously accepted. In this paper, a Virtual Organization is considered as a dynamic, temporal consortium of autonomous legally independent organizations which cooperate with each other to take advantage of a business opportunity or cope with a specific need, where partners share risks, costs and benefits, and whose operation is achieved by sharing of skills, resources and competencies [6,7].

VOs have 4 phases in their lifecycle. First, the creation phase focuses on discovering and formalizing a collaborative business opportunity and proposes a collaborative solution to address that opportunity. The creation phase itself is usually divided into initiation and foundation stages. The second phase is VO operation, which consistently provides feedback from the VO's day to day activities and business processes. The third phase is called evolution. This phase concentrates on aligning the VO operations with its dynamic and fast changing environment; therefore the operation and evolution phases are closely related. Finally every virtual organization's purpose comes to an end. Therefore every virtual organization faces a dissolution phase. The dissolution phase focuses on separation of VO partners and inheritance of its shared resources [8].

Different classifications of VOs are derived from their characteristics. A common classification is based on VO topologies. In [7], three different topologies for VOs are discussed: the supply chain topology in which partners' collaboration follows a linear pattern where each partner communicates with its immediate neighbors. The star topology, also called hub and spoke, has a main contractor acting as the central partner. The collaboration between different partners is coordinated predominantly star-like between the central partner and other organizations. Finally in the third topology, peer-to-peer, partners interact with each other with no hierarchy or central control. The VO's processes are divided into operational processes and management processes. The operational topology describes the communication pattern and information flows needed for the production of a product or service, while the management topology describes authority and management principles of VO guidance process. A VO might follow one topology in its operation and another in its management [7].

B. Virtual Organization 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" [7]. As implied by its definition, VO management focuses on the foundation, operation and evolution phases. Its main focus is on effective communication between the operation and evolution phases. As VOs aggregate several autonomous partners, and operate in a highly dynamic and temporal environment, their management is complex, and also critical to their success. Efficient VO management faces challenges such as temporality in its nature, distributed operation between different business partners, and the need to adapt to a fast changing environment which may cause restructuring in the management approach or even VO topology. In addition, VO operation often requires some degree of process integration. In order to support dynamic and agile management, real-time actions, and consequently, efficient performance management with reliable real-time indicators are required [7].

Four different approaches for VO management are identified. First, managing VO as a project using Project Management Body of Knowledge (PMBOK) [9] which defines a project as "a temporary effort to create a unique product or service". Therefore VO fits in PMBOKs definition of a project. However, some argue that VO management is much more complicated than a project. Because multiple organizations are involved, there is no central authority and VO creation requires initial preparation and continuous negotiation. The second approach is to define and employ decision protocols and mechanisms to manage VOs. This approach usually lacks the guidelines and supporting methodologies for management activities. The third approach is to use PMBOK and other related project management frameworks as a reference model for VO management. Finally, the fourth approach is based on collaborative discussions between different VO partners [6], [7]. VOs have a wide range of characteristics with respect to their structure, time span, lifecycle and behavior. As such, it is extremely difficult to define a one-size-fits-all model covering all the identified requirements of VO management. As a result, the focus in VO management is mainly on governance and management services [10]. The ECOLEAD project has further elaborated VO management services as a key components for a successful management of virtual organization [11].

C. Service Oriented Architecture (SOA)

SOA is defined by OASIS as "A paradigm for organizing and utilizing distributed capabilities that may be under the control of different ownership domains. It provides a uniform means to offer, discover, interact with and use capabilities to produce desired effects consistent with measureable preconditions and expectations" [4]. According to this definition SOA is not just a flexible technology but it rather reflects a new way of thinking in the IT industry. SOA is an IT paradigm that facilitates agility and reusability in organizations. 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" [12]. 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" [12]. 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" [12].

Today's economy has shifted from a goods-based economy to a value production-based economy where service organizations play an important role. In today's market, enterprises have to respond faster and more efficiently 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 [4]. Therefore organizations are moving towards reusing resources through using palettes of atomic or composite services that can be easily and dynamically assembled into business processes [5]. SOAs loose coupling, policy driven, composable service architecture shows a good degree of alignment to VOs specific needs. SOA's success stories on dynamic business processes implementations make it a suitable candidate for VO business process management [12].

One of the most common uses of SOA is in organizational process implementations. 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 that were caused by a sole web service implementation. SOA principles and best practices need to be used to design services in three different layers and to compose services on those layers to realize dynamic BPM. The first layer is collaborative services, which includes 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. Finally, the private services which are internal business activities within a business component [5].

D. Performance Measurement and Management

Performance Measurement (PM) is defined as a systematic approach to planning and conducting the collection of data regarding accomplishment of tasks and corresponding objectives [13]. PM has evolved through different stages as shown in Figure 1. The initial building blocks of all PM initiatives are guidelines related to the discipline of PM which may be termed PM recommendations. The accumulation of these recommendations forms the PM frameworks which can be categorized as structural and procedural. A structural framework specifies the typology and structure of performance indicators. On the other hand, a procedural framework introduces a step-by-step process for developing performance indicators from strategy [14].

Use of procedural framework to develop a specific structure of performance indicators, along with other performance management tools and techniques builds a PM system. Finally using PM systems to provide information in order to make positive change in organizational culture, systems and processes, is called Performance Management. Inter-Organizational PM system is a fast growing facet of the PM literature [14].

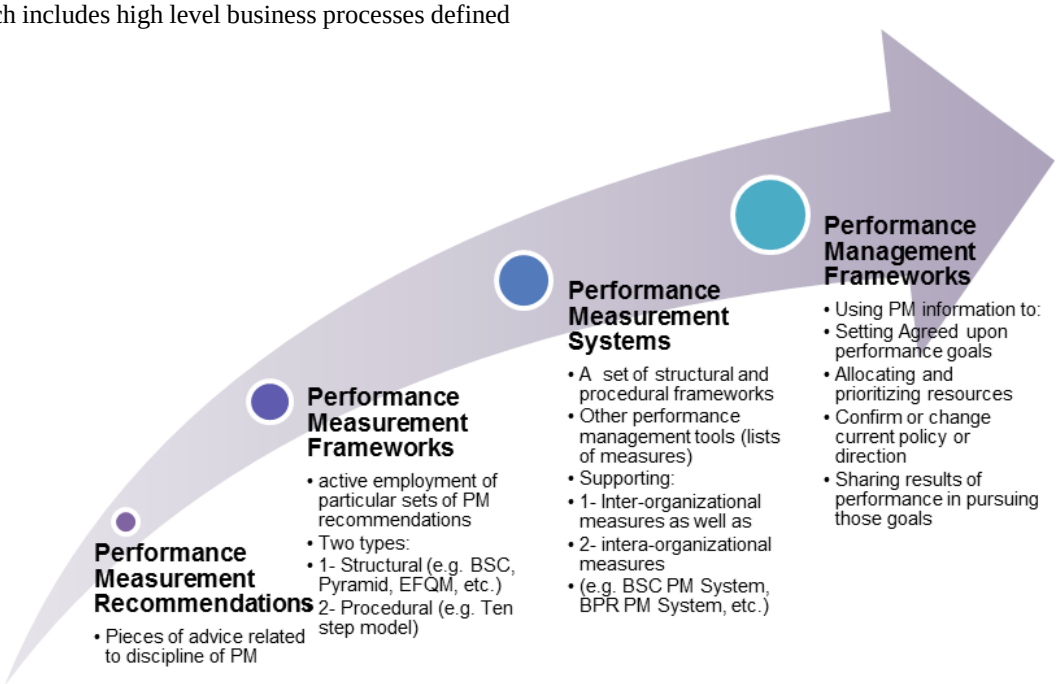

Figure 1: Performance Measurement Evolution – Toward Performance Management

1) Performance Measurement in VO

The challenges of VO performance measurement can be grouped according to two main differences between VO and traditional organization: (1) Impermanence & time restrictions and (2) Inter-organizational issues & complexities [15]. These characteristics affect the entire performance measurement process. For instance, performance measurement at the strategic level (for long-term purposes) is challenging due to the limited life-cycle of VO. As another example, the impermanence and dynamic nature of the VO makes the PM requirements temporal which in turn requires flexible PM framework to support rapid changes. In addition, inter-organizational relationships arise issues, such as coordination of various objectives of partner organizations, data sharing and trust issues, harmonization of business processes, measurement of collaboration performance, different internal PM systems, collaborative decision making and assignment of benefits and risks [15].

Among traditional approaches for PM [16] Benchmarking, Six Sigma, and EFQM are usually used for performance measurement in intra-organizational processes. The SCOR model was developed by Supply Chain Council to address interactions among organizations within a supply chain. This framework only supports performance measurement in static and stable interactions. The above mentioned approaches are not suitable for VOs due to lack of the ability to facilitate the relationship between strategies and operations and support of non-financial perspectives [16]. To fill this gap, another framework was introduced by Kaplan and Norton [17] named Balanced Score Cards (BSC). Providing a balanced approach which considers non-financial aspects, as well as financial ones, this framework introduces a methodology for translation of strategies to appropriate actions. This approach does not address inter-organizational interactions either. In summary, the current well-known frameworks for performance measurement have various gaps in meeting the requirements of VOs. As such, we are focusing on designing a new PM framework in this research.

III. The Proposed Framework for Process and Performance Management in SOVO

Virtual organizations operate in a very dynamic environment. The collaborative, dynamic and temporal nature of VOs has forced them to adopt computer systems and networks to facilitate their collaboration. Shared infrastructure and interoperable information sharing structures are crucial components of computer-aided networked organizations [7]. VOs operation phase consists of a set of collaborative business processes, which need to use, synchronize and integrate current partner processes and resources to perform collaborative duties [18]. Accordingly, we propose a framework and implementation architecture for ***Service Oriented Virtual Organization (SOVO) Business Process and Performance Management***. The proposed framework is relies on reference architectures and best practices to ensure an effective service oriented process design and monitoring for SOVO. The layering of the framework is based on the Open-EDI reference model [19] and the S3 Service Oriented Reference Architecture [20]. Detailed descriptions of the components of the framework are derived from best practices of ITIL V3 [21] and PMBOK [9]. Figure 2, shows the framework and its components in six layers that are discussed further in this section. 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 architecture 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 enables the VO to manage and orchestrate its services as if it were the actual owner, while providing business partners with complete control and autonomy to manage or change their services within the boundary of the agreed collaborative policies and zone specifications.

A. 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 service matching using the service registry (with the Universal Description, Discovery and Integration (UDDI) standard or more advanced protocols such as RESTful web service compositions). Further discussion on VO partner search and VO creation phase can be found in [22] and [23]. 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 [24, 25] 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 resultant output of this phase is the network of collaborative value creation named "Value Network".

1) Value Networks

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 when alignment with the overall value co-production of the virtual organizations is necessary [26]. Therefore in this research we have used value networks to model business value creation and tracking. The value network serves as 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" [27]. This helps VO to identify service participants and their value expectations and value exchange relations. In [26], 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. e3-Value is an ontology defined for modeling value networks which is further discussed in [28]. In this research we recommend the use of e3value to model value networks.

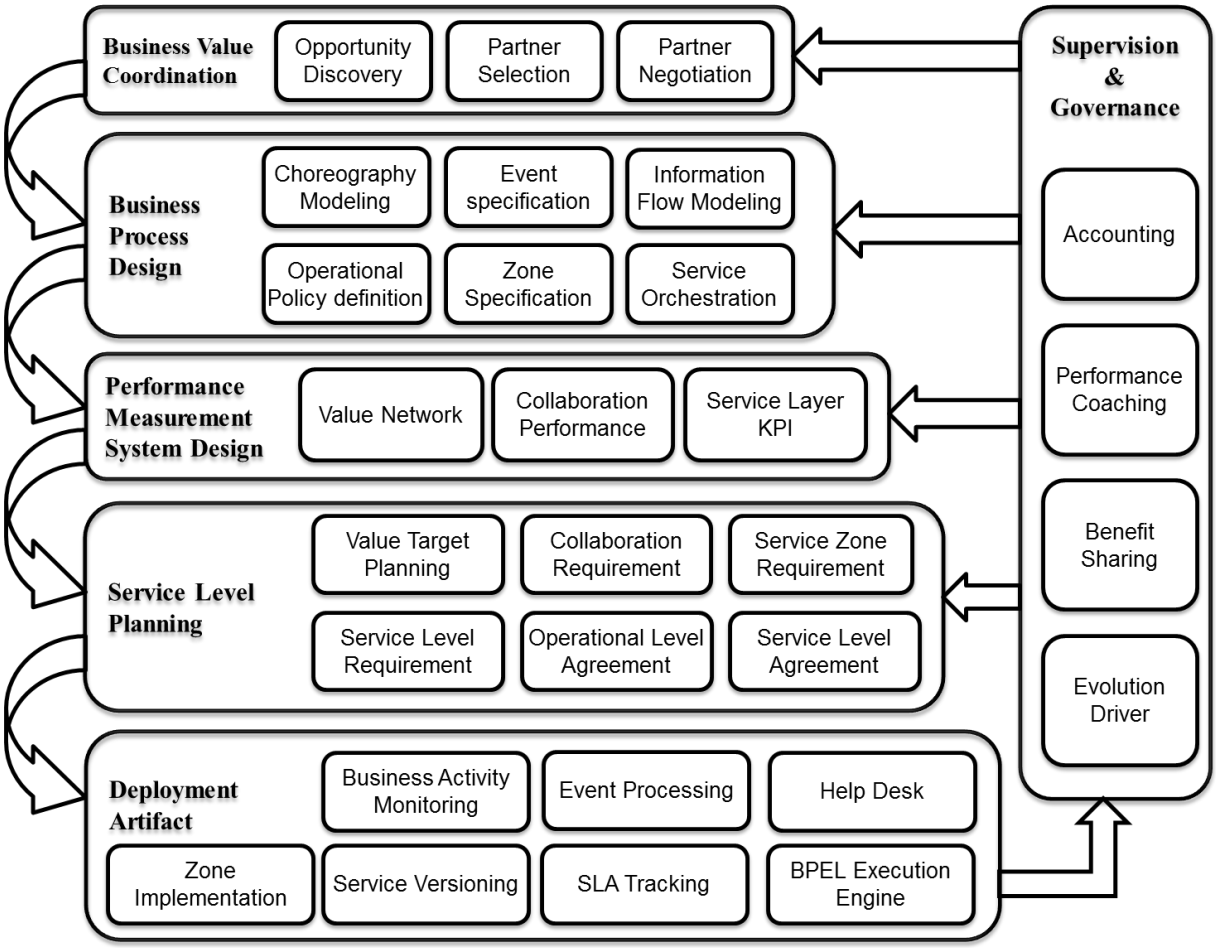

Figure 2: SOVO Process Management Framework

B. Business Process Design

This layer focuses on designing business processes and the flow of information between partners. It clarifies different requirements and dependencies between processes and their related roles and responsibilities. It is also responsible for design and correlation of individual services to form efficient healthy business processes. As stated in SOA-based BPM approach, the processes are designed in three different layers. First the collaborative processes which in our framework are modeled by service choreography. The choreography model focuses on partner collaboration and service interactions. It specifies each party's role and activities, and the sequences of service invocations. The level of information provided in the choreography model is left to the business partners and VO management consortium to decide. The choreography serves as an agreement between the participating business partners in their collaboration [29]. This step of the business process design may even alter some of the partner negotiation. As such, some iteration between the two layers 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 [12]. In this module VO event specification is defined and modeled using Business Process Model and Notation V2 (BPMN) [30]. The information flow is specifying data flow between different services in a process. It specifies what information at what time needs to be delivered to whom. BPMN will be used to model VO processes and information access. 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 [31]. The second aspect is the process layer policies which indicate the collaborative process rules. These rules represent the business logic and are implemented using business rule engines. The second layer of a SOA-based BPM system is public services, which in the case of SOVO consist of all the shared services that partners bring in the virtual hub presented in the next section. These public services are then orchestrated to satisfy the overall VO choreography. 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 private services (The third layer of SOA-based BPM) specifications. The zone specification is focused on how each partner of the VO organizes its service gateway. This component focuses on a representation of organizations private services, while it facilitates organizations privacy through a 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 definitions.

C. Performance Measurement System Design

Based on the classification provided in section II.D, we intend to provide an inter-organizational PM system which is

specifically tailored to the requirements of service oriented virtual organizations. This system includes a structure of performance indicators and the procedure for developing performance measures from strategies. These frameworks are discussed in following sections:

1) Structural Framework

Performance measurement in SOVO requires a specially tailored framework with the ability to address unique characteristics of SOVO [32]. The ECOLEAD project divides Performance indicators in CNs into three different categories: (1) The performance of the management approach and methods, (2) The performance of the partners' collaboration, (3) The performance in fulfilling the given tasks and the contributing performance of the partners [15].

We have used this classification as a base to develop a structural framework for SOVO. This structural framework is shown in Figure 3.

a) Value Network

The first layer copes with the strategic long term performance of the alliance. However in case of VO, due to the temporary nature of alliances it does not seem rational to focus on long term performance indicators such as strategic goals and objectives. Instead, we recommend to measure high level performance by focusing on VOs success in value creation. This can be measured using value creation mechanisms which are represented by value networks. Value networks were discussed earlier in section III.A.1) Using E3-Value ontology [28] we can model and provide a basis to measure the values which are transacted between VO partners. These value transactions will be linked to the lower level KPIs in collaboration and service layers.

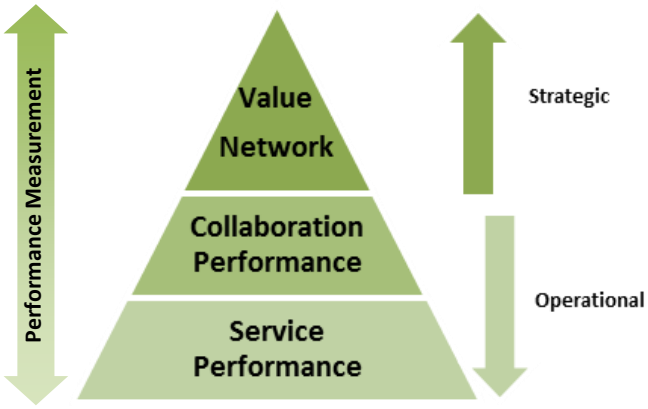

Figure 3: SOVO Performance Indicators Pyramid

b) Collaboration Performance

The characteristic that makes VOs different from traditional organizations is "Collaboration". Collaboration is interacting in an incompletely determined and non-hierarchic manner in order to enable joint processes with other independent organizations and human actors that are performed to reach common goals [33]. Collaboration is a kind of "lubrication" or "catalyst" for the value creation and supporting processes in the VO [13].

The collaboration indicators are necessary to assess the effectiveness and efficiency of how partners work together in joint processes towards a common goal. This layer of performance measurement plays an important role in organizing partners coordination and SOVO overall success [34]. Meeting targets in this kind of performance indicators enables synchronization and integration of partner processes which will in turn facilitate implementation of a common task in a non-hierarchic pattern [15].

SCOR model [35] and ECOLEAD project [13] are considered as references for this layer. Five dimensions are considered to measure collaboration performance including: Reliability, Flexibility, Responsiveness, Communication, and Commitment. Reliability is defined as the ability to deliver material, information, and services within agreed quality, quantity, time and cost. Flexibility describes the ability to respond to external influences and the ability to rapidly adapt to changes. External influences may include non-forecasted increases or decreases in demand, changes in suppliers or partners, occurrence of natural disasters, and etc. Responsiveness describes the speed at which collaborative tasks are performed such as cycle-time metrics. The Communication dimension represents the ability to communicate. In today's business environment the aspect of using ICT is a significant way of communication and plays a major role in it [33]. Commitment as the fifth dimension consists of two sub-dimensions of re-active and pro-active commitment. The re-active aspect, describes how the VO members react on critical situations or problems. But the pro-active aspect, describes the intention of partners to actively collaborate to avoid critical situations [13]. These five dimensions of collaboration performance can be mapped directly on service choreography model discussed in section III.B. Each component of the choreography model represents an interaction between two or more partners and the messages which are transacted. All of the characteristics of each interaction can be defined under the five dimensions of collaboration performance.

c) Service Performance

The third layer of performance indicators in VO, are related to fulfilling given tasks and guaranteeing performance of public and private services shared by each organization through the service zone. The low-level performance indicators in SOVO would be used to assess the effectiveness and efficiency of services shared by a specific partner in a collaborative process. These indicators are mostly domain specific, however they must be agreed upon by related partners. This layer of indicators can be considered as the most operational one. The specification of each service, their target level and the responsibilities of service providers must be agreed upon among partners and be documented in the form of Service Level Agreements (SLA) [36]. An SLA guarantees the expected quality of service to different stakeholders. The structure of an SLA contains three parts of name, context and terms. Basically each contract needs an official name. The context indicates the initiator, responder, provider and timeframe. Service terms define the functional attributes of agreement whereas the guarantee terms indicate non-functional ones.

2) Procedural Framework

There should be a mechanism to plan, implement, communicate and improve VO performance. This mechanism will characterize a performance measurement system which

has to be defined based on VO specific requirements. The processes needed to define a business performance measurement system can be categorized in five main groups [37]:

1- Selection and design of measures;
2- Collection and manipulation of data;
3- Information management;
4- Performance evaluation and rewards;
5- System review.

Mapping these categories into a VO, based on its specific characteristics, will result in the procedural framework which is shown in Figure 4.

The first phase includes identification of stakeholders' needs, designing of the structure of performance indicators, setting the targets, and configuring the distributed dashboards. This is basically done regarding the PM structural framework. KPIs of partners' collaboration can be directly mapped onto the service choreography model, considering that each block in that model represents an interaction between two or more partners. An SLA aggregation pattern is also derived from value network model. To do so each partner will be considered as an aggregation point, which is considered a consumer to some services and provider of others. This implies an SLA choreography model which is introduced in [38]. This is followed by setting the targets for KPIs in each level and also setting the level of access to the VO's performance information for each partner. This phase will result in a definition of a hierarchy of performance indicators in three layers of value network, collaboration performance, and service performance in addition to a configuration design of partners' dashboards.

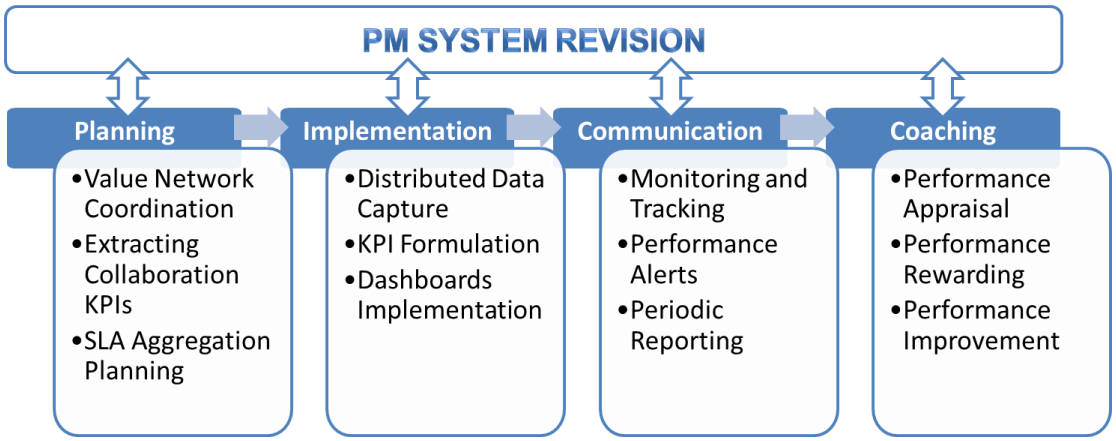

Figure 4: Procedural Framework for VO PM

The second phase includes the process of capturing data from distributed sources throughout the partners' performance information repositories. This implies establishing links between the performance data and performance indicators by implementing KPI formulations. Physical implementation of dashboards using business intelligence tools will be the last step of implementation phase.

The third phase encompasses the processes of information provision, interpretation, and communication. The modules in this phase are progress monitoring and tracking, performance alerting and periodic reporting. In fact communication of performance information should support both active and re-active approaches. Monitoring, tracking, and forecasting KPIs in a relatively real-time manner and providing periodic reports are means for active monitoring. On the other hand performance alerting as reporting specific events or outlier performance levels will facilitate re-active monitoring.

The fourth phase includes rewarding partners based on processes of performance evaluation. This keeps VO on track towards its target goals and values through supporting relevant improvements in operations and collaborations of partner organizations. This phase consists of performance appraisal, rewarding and improvement. The agreed upon levels of performance indicators in the most abstract layer (value network) can be used as a criterion to reward the partner organizations, based on their success in realizing added value for the customer.

The last phase includes different review procedures to improve each and every part of the PM system. These procedures will ensure that there is a feedback loop which facilitates revision and improvement of the system. Determining the details of this phase will enable inter-organizational learning which is considered as potential future research.

D.Service Level Planning

This layer is derived from ITIL V3 service level management principles [21]. 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. This layer is highly dependent on the previous two layers. Identification of services and their functionalities come from the business process design layer while the quality measures of services are derived from the performance measurement layer. Service Level Agreements (SLAs) are produced based on the mentioned derived functional and non-functional specifications. SLA monitoring and service level management guarantee service consistency and continual improvement, which also facilitates better monitoring and quality assurance. In order to achieve effective service level management the following components are required. The value target planning focuses on the overall value constellation. This is based on a feasibility analysis using the e3-value model defined in the first layer. 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, while bottom-up logic is followed for the definition of the

performance indicators. The service zone describes the gateway requirements per each partner participating 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 different partners and users involved in the service choreography model. The service layer KPI boundaries are set in this phase through the SLR and OLA, and finally 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.

E. Deployment Artifacts

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. The components in this layer support VO decision making through providing required information to the supervision and governance layer. 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. The above 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.

F. 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. 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. Accounting is related to the financial shared activities of the VO which is affected by the benefit sharing component of this layer. It 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 VOs based on performance monitoring activities [6]. 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 affects VO service choreographies, and it triggers higher level of changes in VO; and finally, the third category which involves changes in VO value creation and might even result in renegotiation between partners.

IV. A Distributed Architecture for Business Process Management in Virtual Organizations

A. Service Zone Interaction Model

We propose a service zone interaction model for inter-organizational collaborations. This model is based on a distributed service oriented infrastructure which facilitates business process operation, monitoring and management in a peer-to-peer topology. Depending on the configuration of the infrastructure, it can support other topologies such as star or supply chain as well. We believe that this approach provides faster VO deployment, enhances peer-to-peer VO management and collaboration. The service zone model is built using existing infrastructure resources and federates them to build a virtual collaboration environment for the VO. The distributed infrastructure is based on multiple ESBs collaborating with each other, while creating zone gateways to guarantee specific organizational rules and policies. Figure 5 depicts this interaction model. With the zone interaction model, organizations have total control over what services to share securely and conveniently. It is easier to control competitive advantage through zones without worrying about complex integration processes. Generally, ESBs are the enablers of service interaction. ESB facilitates large scale implementation of SOA principles and management of heterogeneous solutions and software resources [31,40]. In addition to providing the basic infrastructure for service interactions, the ESB provides a set of common patterns for construction of on demand applications. It also provides specific capabilities to support realization of distinct service categories that play particular roles in those patterns [39]. We use these different collaboration patterns to create a specific service zone for the partners participating in the VO to build an ESB federation (Virtual ESB) to support VO collaborations. Further detail of the virtual ESB implementation and federation are discussed in [40].

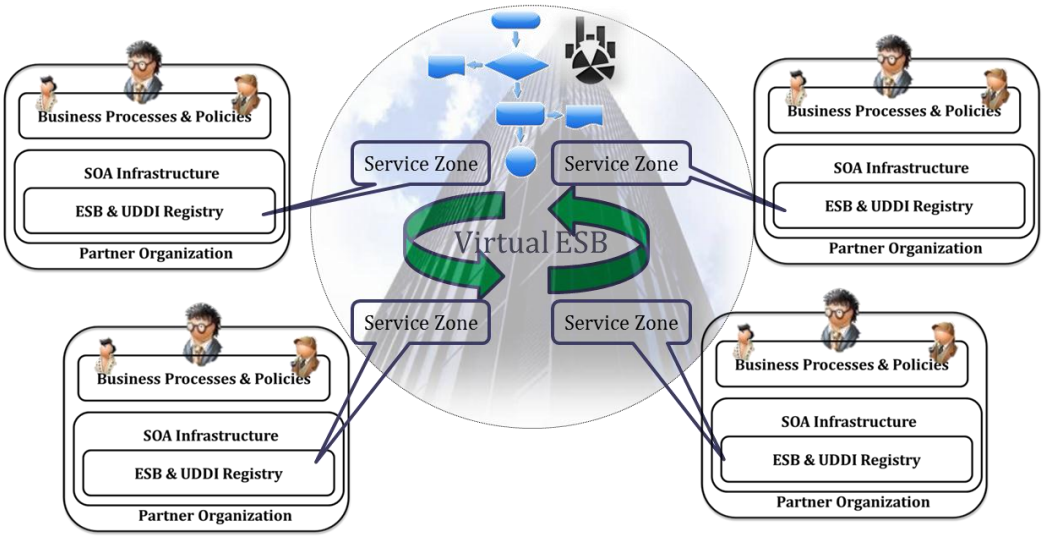

Figure 5: Virtual ESB Facilitating a Distributed SOA Infrastrcuture

B. SOA Infrastructure

We described some of the ESB capabilities and how we use them to facilitate service zone implementation. Except the ESBs that facilitate the virtual ESB in every organization, we assume that a service oriented infrastructure is in place which helps organizations to implement their own services and processes. Therefore VO process execution relies on the existing SOA infrastructure of organizations and the virtual ESB. In an ideal service oriented world, deployment of a VO would only require zone specific configurations.

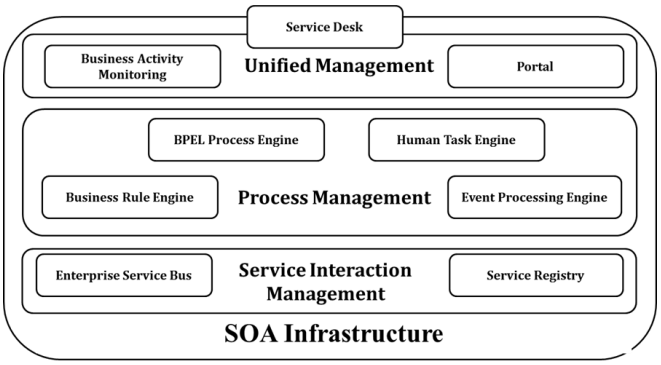

Figure 6: A Proposed Architecture for SOA infrastructure **[40]**

Figure 6 illustrates the architecture of a SOA infrastructure which is fairly discussed in [40]. The first layer includes ESB and service registry. The second layer intends to handle organizational business process and logic. It consists of a business process engine which mainly supports BPEL executions and service compositions, Human task implementation engine, a business rule engine, and an event processing module that triggers various events. The business rule engine facilitates the enforcement of business rules throughout the service execution lifetime. The Business Activity Monitoring (BAM) module monitors the infrastructure, and the performance of the services to facilitate SLA management. The portal module is the interface of the infrastructure and facilitates user interaction and access control. The 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 of ITIL. Most of the features and benefits of the proposed framework is realized by employing a suitable ESB.

C. Proposed Implementation Architecture

In this section we describe specific software architecture for implementing service zone interaction model. This architecture provides a model for distributed business processes execution using a federation approach to integrate and synchronize organizational processes and services between different SOA infrastructures. Figure 7 shows the proposed architecture. More detail of the implementation of the architecture is presented in [40].

Every partner in the VO has its own infrastructure. The better the configuration of partners SOA infrastructure is the higher flexibility they experience when enforcing policies and security measures. A SOA infrastructure with the architecture discussed in Figure 6 would be able to manage its collaboration with different levels of privacy setup. If a partner does not have any SOA infrastructure, it could also participate in the VO using other partner's services through the virtual hub. The service federation management component could be set anywhere in the infrastructure and supports the gathering of partner services. The Zones specified in every SOA infrastructure are a set of specifications that act as an abstract layer which provides complete autonomy for an organization and shares the services to other organizations at the same time. These zones should be implemented using gateway mediation patterns of the organizations ESB. Any component above the curve is loosely coupled which facilitates distribution of VO business processes, events and rules among different components. The Business Process Management and Business Rule Engines (BPM & BRE) specified above the curve could be anywhere in the partner organizations and are responsible for executing VO business processes. As long as the implemented VO processes and rules comply with web service standards, they can be transferred according to the VO interaction topology from one node to another.

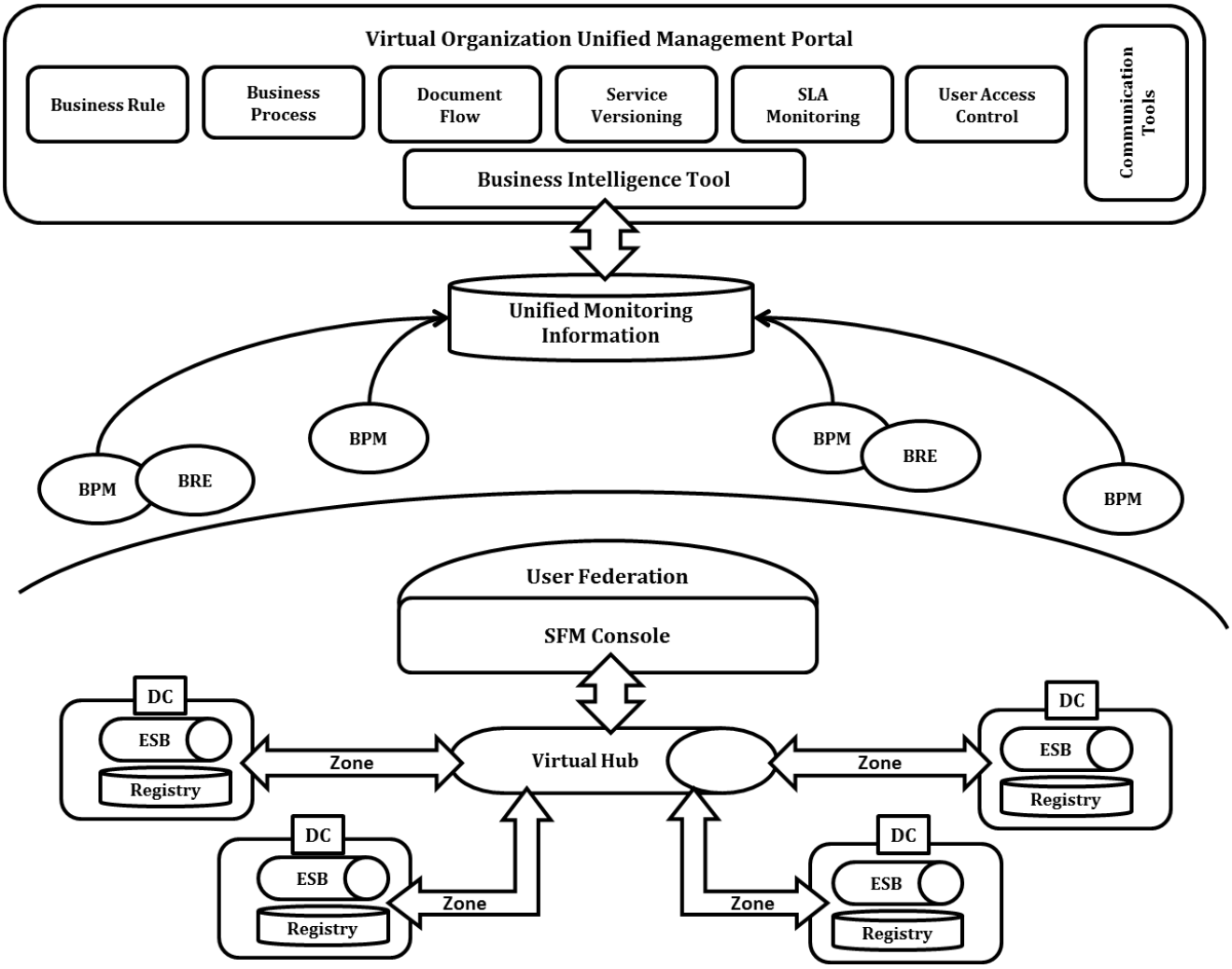

Figure 7: Distributed SOA-Based BPM Architecture for Virtual Organizations **[40]**

The following step should be taken after the establishment of the service federation and virtual hub to build and execute VO business processes:

1. Every organization publishes its shared services to its service zone where they would be automatically published on the virtual hub through their VO zone.
2. Create VO business rules and related business objects and publish them to the virtual hub using their host service zone.
3. Create collaborative business processes using the organizational services and business rules. The idea is to be able to reuse every component shared in the virtual hub to build collaborative processes. These processes can be executed on any of the BPMs on the network of the organizations as long as the VO topology allows them to.
4. SLA related KPIs of the collaborative processes are stored in the unified monitoring information repository. The Business Intelligence (BI) tool uses this information to build and share dashboard and reports for VO performance monitoring.

V. Analysis of the Solution

A. Implementation Success Criteria

Based on inter-organizational process management requirements [2] and VO infrastructure requirements [3], [18], [41], we have identified three major performance criteria for the implementation of the infrastructure and collaborative business process management. These criteria are (1) degree of partner's privacy in information sharing, (2) effort needed for process integration, and (3) degree of authority distribution. Any implementation of this architecture should be evaluated against these criteria and domain specific requirements. *Table 1* summarizes a proposed set of indicators and success factors.

B. Benefits of the Proposed Framework

The collaboration model and the architecture proposed in this paper facilitate a peer-to-peer inter-organization collaboration through existing SOA infrastructures in the organizations. The proposed framework specifies the design and management of VO business processes in a service oriented environment. This offers several benefits including 1) an integrated solution for decentralized business process management and performance measurement without the need for a central authority; 2) facilitation of an alignment between strategic value creation, business process design and execution, and performance measurement; 3) A framework that provides flexibility, scalability, and interoperability and enhances transparency of partners' performance information at an agreed level as a basis for mutual trust; 4) facilitation of global VO-creation faster and easier through web services. With this framework, organizations in various geographical positions can form a secure infrastructure for their inter-organizational interactions with less cost and easy configuration; 5) 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; 6) VOs dependency to its

partner organization is reduced because of a loosely coupled service oriented infrastructure; 7) The implementation architecture facilitates collaboration among any network of organizations using any common topologies; and 8) 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.

Success Criteria	*Properties*	*Property Criteria*	*Indicants*	*Scale*
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 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
		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 uthority	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

Table 1: Collaborative process management solution criteria

VI. Conclusion

In today's value-based economy, organizational partnerships and collaborations play an extremely important role. Allies of organizations are providing increasingly more value added services to their end costumers than traditional enterprises. Therefore, organized collaboration between partners and their effective and strategic management have become a major concern in the past decade. These collaborations in a global economy are facilitated by computer networks. Virtual Organizations - as the most mature collaborative networked organization - face challenges in their management due to their temporality, inter-dependency and partner autonomy.

In this research, we have proposed (a) an integrated framework for business process management and performance measurement that is aligned to its higher level value network and lower level implementation technology. The proposed framework consists of two major components, the business process design and the performance measurement system. Each component is designed and integrated using known reference frameworks; (b) Along with the framework; we have provided distributed implementation architecture based on the proposed service zone specifications and interactions.

The proposed architecture facilitates VO interactions by reusing existing partner resources. The architecture is based on federation of multiple enterprise service buses which provides a virtual hub with desired VO interaction topology such as supply chain, star, and peer-to-peer.

Acknowledgment

This project is jointly supported by MITACS-Accelerate program and IBM center for business analytics and performance.

References

[1] L. M. Camarinha-Matos, H. Afsarmanesh, and M. Ollus, "Ecolead And Cno Base Concepts" in *Methods and Tools for Collaborative Networked Organizations*, L. M. Camarinha-Matos, H. Afsarmanesh, and M. Ollus, Eds. Boston, MA: Springer US, pp. 3–32, 2008

[2] J. Dorn, C. Grun, H. Werthner, and M. Zapletal, "A Survey of B2B Methodologies and Technologies: From Business Models towards Deployment Artifacts" in *40th Annual Hawaii International Conference on System Science*. *HICSS 2007*, pp. 143a–143a, 2007

[3] A. Gehre, P. Katranuschkov, and R. Scherer, "Managing virtual organization processes by semantic web ontologies" in *CIB-W78 Conference on Bringing ITC Knowledge to Work*, Maribor, Slowenien, 2007.

[4] H. Demirkan, R. J. Kauffman, J. A. Vayghan, H.-G. Fill, D. Karagiannis, and P. P. Maglio, "Service-oriented technology and management: Perspectives on research and practice for the coming decade" *Journal of Electronic Commerce Research and Applications*, vol. 7, no. 4, pp. 356–376, 2008.

[5] M. Fiammante, *Dynamic SOA and BPM: best practices for business process management and SOA agility*. IBM Press and Pearson, 2010.

[6] M. V. Drissen-Silva and R. J. Rabelo, "A Model For Dynamic Generation Of Collaborative Decision Protocols For Managing The Evolution Of Virtual Enterprises" in *Innovation in Manufacturing Networks*, vol. 266, A. Azevedo, Ed. Boston, MA: Springer US, pp. 105–114, 2008

[7] I. Karvonen, I. Salkari, and M. Ollus, "Characterizing Virtual Organizations and Their Management" in *Collaborative Networks and Their Breeding Environments*, vol. 186, L. M. Camarinha-Matos, H. Afsarmanesh, and A. Ortiz, Eds. New York: Springer-Verlag, pp. 193–204, 2005.

[8] L. M. Camarinha-Matos and H. Afsarmanesh, "A comprehensive modeling framework for collaborative networked organizations", *Journal of Intelligent Manufacturing*, vol. 18, pp. 529–542, 2007.

[9] Project Management Institute., *A guide to the project management body of knowledge (PMBOK Guide)*, 4.ed. Newton Square Pa: Project Management Inst., 2008.

[10] K. Jansson, I. Karvonen, M. Ollus, and Negretto, Ugo, "Governance and Management of Virtual Organizations" in *Methods and Tools for Collaborative Networked Organizations*, L. Camarinha-Matos, H. Afsarmanesh, and M. Ollus, Eds. Springer, 2008.

[11] U. Negretto, J. Hodík, L. Král, W. Mulder, M. Ollus, L. Pondrelli, and I. Westphal "VO Management Solutions VO Management e-Services" in *Methods and Tools for Collaborative Networked Organizations*, L. M. Camarinha-Matos, H. Afsarmanesh, and M. Ollus, Eds. Boston, MA: Springer US, pp. 257–274, 2008

[12] K. Holley and A. Arsanjani, *100 SOA Questions: Asked and Answered*. Pearson Education, 2010.

[13] I. Westphal, W. Mulder, M. Seifert, "Supervision of collaborative processes in VOs", in *Methods and Tools for Collaborative Networked Organizations*, L. M. Camarinha-Matos, H. Afsarmanesh, and M. Ollus, Eds. Boston, MA: Springer US, pp. 239–256, 2008.

[14] P. Folan and J. Browne, "A review of performance measurement: Towards performance management" *Computers in Industry*, vol. 56, no. 7, pp. 663–680, Aug. 2005.

[15] F. Graser, I. Westphal, and J. Eschenbaecher, "Roadmap on VOPM challenges on operational and strategic level." *ECOLEAD*, 2005.

[16] F. Graser, K. Jansson, J. Eschenbächer, I. Westphal, and U. Negretto, "Towards Performance Measurement in Virtual Organizations" in *Collaborative Networks and Their Breeding Environments*, vol. 186, L. M. Camarinha-Matos, H. Afsarmanesh, and A. Ortiz, Eds. New York: Springer-Verlag, pp. 301–310, 2005

[17] R. S. Kaplan and D. P. Norton, "Using the balanced scorecard as a strategic management system" *Harvard Business Review*, vol. 85, no. 7, pp. 150–152, Jun. 2007.

[18] M. V. Drissen-Silva and R. J. Rabelo, "A Model for Dynamic Generation of Collaborative Decision Protocols For Managing the Evolution of Virtual Enterprises" in *Innovation in Manufacturing Networks*, vol. 266, A. Azevedo, Ed. Boston, MA: Springer US, pp. 105–114, 2008

[19] ISO, *ISO 14662: Open-EDI Reference Model*, International Organization for Standardization, 2004.

[20] A. Arsanjani, Liang-Jie Zhang, M. Ellis, A. Allam, and K. Channabasavaiah, "S3: A Service-Oriented Reference Architecture" *IEEE Journal of IT Professional*, vol. 9, no. 3, pp. 10–17, Jun. 2007.

[21] OGC, *ITIL V3 Core Books*. UK: Office of Government Commerce, 2007.

[22] L. M. Camarinha-Matos and H. Afsarmanesh, "A framework for virtual organization creation in a breeding environment" *Annual Reviews in Control*, vol. 31, no. 1, pp. 119–135, 2007.

[23] L. M. Camarinha-Matos, I. Silveri, H. Afsarmanesh, and A. I. Oliveira, "Towards a Framework for Creation of Dynamic Virtual Organizations" in *Collaborative Networks and Their Breeding Environments*, vol. 186, L. M. Camarinha-Matos, H. Afsarmanesh, and A. Ortiz, Eds. New York: Springer-Verlag, pp. 69–80, 2005.

[24] C. Huemer, P. Liegl, R. Schuster, H. Werthner, and M. Zapletal, "Inter-organizational systems: From business values over business processes to deployment" in *2nd IEEE International Conference on Digital Ecosystems and Technologies*. DEST 2008, pp. 294–299, 2008

[25] V. Pijpers, J. Gordijn, and H. Akkermans, "Exploring inter-organizational alignment with e3alignment – An Aviation Case" *BLED 2009 Proceedings*, Paper 2, Jan. 2009.

[26] Zhongjie Wang, Dianhui Chu, and Xiaofei Xu, "Value Network Based Service Choreography Design and Evolution" in *IEEE 7th International Conference on e-Business Engineering (ICEBE2010)*, pp. 495–500, 2010

[27] I. Ul Haq and E. Schikuta, "Aggregation patterns of service level agreements" in *Proceedings of the 8th International Conference on Frontiers of Information Technology*, New York, NY, USA, pp. 40:1–40:6, 2010

[28] C. Kort and J. Gordijn, "Modeling Strategic Partnerships Using the E3value Ontology: A Field Study in the Banking Industry" *Handbook of ontologies for business interaction*, 2008.

[29] U. A. Mohamed, G. H. Galal-Edeen, and A. A. El-Zoghbi, "Building Integrated Oil and Gas B2B E-commerce Hub Architecture Based on SOA" in *International Conference on e-Education, e-Business, e-Management, and e-Learning*. IC4E '10, pp. 599–608, 2010.

[30] T. Allweyer, *BPMN 2.0*, BoD, 2010.

[31] M.-T. Schmidt, B. Hutchison, P. Lambros, and R. Phippen, "The Enterprise Service Bus: Making

service-oriented architecture real" *IBM Systems Journal*, vol. 44, no. 4, pp. 781–797, 2005.
[32] Wenan Tan, Xianhua Zhao, Chuanqun Jiang, Xuebai Chen, and Anqiong Tang, "The Differences and Conjunctions on Performance Management between Entity Enterprise and Virtual Enterprise" in *Third International Conference on Pervasive Computing and Applications*, ICPCA 2008, vol. 1, pp. 65–69, 2008
[33] I. Westphal, K.-D. Thoben, and M. Seifert, "Managing collaboration performance to govern Virtual Organizations" *Journal of Intelligent Manufacturing*, vol. 21, no. 3, pp. 311–320, 2010.
[34] J. Hauge, A. Imtiaz, M. Auerbach, J. Eschenbacher, and M. Seifert, "Enhancement in performance through virtual collaboration among SMEs" in *Network-Centric Collaboration and Supporting Frameworks*, vol. 224, Boston, MA: Springer US, pp. 255–264, 2006
[35] Supply Chain Council, "Supply Chain Operations Reference (SCOR®) model Overview - Version 10.0", *Supply Chain Council*, 2010.
[36] J. O. Long, *ITIL® VERSION 3 AT A GLANCE*. New York: Springer, 2008.
[37] M. Franco-Santos, M. Kennerley, P. Micheli, V. Martinez, S. Mason, B. Marr, D. Gray, and A. Neely, "Towards a definition of a business performance measurement system" *International Journal of Operations & Production Management*, vol. 27, no. 8, pp. 784–801, 2007.
[38] I. Ul Haq and E. Schikuta, "Aggregation patterns of service level agreements" in *Proceedings of the 8th International Conference on Frontiers of Information Technology*, New York, NY, USA, pp. 40:1–40:6, 2010
[39] M. Keen and S. B. O. (Firme), *Patterns: Implementing an SOA using an enterprise service bus*, IBM International Technical Support Organization, 2004.
[40] M. H. Danesh, M. A. Kamali, B. Raahemi, and G. Richards, "A Distributed Service Oriented Infrastructure for Business Process Management in Virtual Organizations", in the *IEEE 25th Canadian Conference on Electrical and Computer Engineering*, Montreal, Canada, 2012.
[41] R. J. Rabelo, S. Gusmeroli, C. Arana, and T. Nagellen, "The Ecolead ICT Infrastructure For Collaborative Networked Organizations" in *Network-Centric Collaboration and Supporting Frameworks*, vol. 224, Boston, MA: Springer US, pp. 451–460, 2006

Author Biographies

Mohammad H. Danesh (Iran, 1987). He has received his bachelor degree in information technology engineering from Amirkabir University of technology in 2009. He has graduated from University of Ottawa with an MSc in E-Business technologies in 2012. His main experience is in developing and deploying web-based information systems and portals. Currently, he is a research assistant at IBM-Center of business analytics and performance at Telfer school of management. His recent research is focused on collaborative business process management and Information System Integration using SOA Technologies.

Bijan Raahemi is an associate professor at the Telfer School of Management, University of Ottawa, Canada, with cross-appointment with the School of Electrical Engineering and Computer Science. He received his Ph.D. in Electrical and Computer Engineering from the University of Waterloo, Canada, in 1997. Prior to joining the University of Ottawa, Dr. Raahemi held several research positions in Telecommunications industry, including Nortel Networks and Alcatel-Lucent, focusing on Computer Networks Architectures and Services, Dynamics of Internet Traffic, Systems Modeling, and Performance Analysis. His current research interests include Information Systems, Data Mining, and Data Communications Networks and Services. Dr. Raahemi's work has appeared in several peer-reviewed journals and conference proceedings. He also holds 10 patents in Data Communications. He is a senior Member of the Institute of Electrical and Electronics Engineering (IEEE), and a member of the Association for Computing Machinery (ACM).

S.M.Amin Kamali (Iran, 1987) received his BSc in Industrial Engineering from Sharif University of Technology, Tehran, Iran in 2010. Currently he is MSc student in Systems Science at University of Ottawa, Canada. He has participated in different projects of design, development, and implementation of business information systems. Currently, he is a research assistant at IBM-Center of business analytics and performance at Telfer school of management. His main research interests include performance measurement and management, business intelligence in collaborative networked organizations, and supply chain operations management.

Gregory Richards is currently Professor of Performance Management at the Telfer School of Management, University of Ottawa and Director of the IBM Centre for Business Analytics and Performance. His research interests include examining the impact of tools and techniques for managing organizational performance in public and private sector organizations, organizational learning, data-based decision making, and management process innovation.