A Framework for Performance Measurement in Service Oriented Virtual Organizations

A Value Network Approach to Collaborative Performance Measurement

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Abstract: Management of Virtual Organizations faces unique challenges which traditional approaches cannot address. Based on service oriented architecture, this paper proposes a performance measurement framework that aligns the work of partners in a virtual organization at three different layers. The first layer is designed for partners' strategic alignment through coordination of the value creation network. In the second layer, five performance dimensions of partners' collaboration are defined which can be mapped onto the service choreography model. The third layer focuses on assessing effectiveness and efficiency of partners' domain specific services which is designed based on ITIL V3 service level management guidelines. In order to consolidate the proposed framework, these three layers are integrated using a procedure for extracting service choreography and SLA aggregation patterns from the value network. We propose an integrated solution for decentralized performance measurement without the need for a central authority. The proposed framework provides flexibility, scalability, and interoperability and enhances transparency of partners' performance information at an agreed-upon level as a basis for mutual trust.

1 INTRODUCTION

In a developing global economy, business is becoming more competitive as a result of worldwide, boundary less markets. Therefore organizations must operate with great flexibility and rapid adaptation to new demands. To survive this intense competition, companies need to improve competencies in terms of dealing with new business models, strategies, organizational and governance principles, processes and technological capabilities (L. M. Camarinha-Matos et al., 2009).

As a result organizations started to share their resources and skills by cooperation and outsourcing some components of their products and services. This cooperation was originally formed in relatively stable, static and classic associations like supply chains with well-defined roles and responsibilities. But facing further complicated and more dynamic markets, legally independent organizations started to collaborate and share their resources and skills to better respond to opportunities and form Virtual Organizations (VOs) (L. M. Camarinha-Matos et al., 2009).

Nevertheless collaboration does not guarantee the VO's success. Deficit in collaborative management is an identified reason of VO's failure (Westphal et al., 2007). An essential pre-requisite for an effective VO management is a sound information basis. Therefore performance measurement, as an important source for this information, plays a critical role in success of VOs. Furthermore traditional PM approaches do not meet specific requirements and characteristics of VOs (Westphal et al., 2007).

The purpose of this research project is to develop a performance measurement framework for virtual organizations that extracts key performance indicators from their SOA-based collaboration infrastructure. In the next section of this paper we define the concepts of Collaborative Networked Organization (CNO), Virtual Organization (VO), Performance Measurement (PM), and Service Oriented Architecture (SOA). This is followed by proposing a PM framework for service oriented VO and discussing structure and procedure for such a framework in Section 3. The characteristics of the proposed framework will be discussed in Section 4,

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followed by a conclusion in Section 5.

2 BACKGROUND

2.1 Virtual Organizations

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 (L. M. Camarinha-Matos and Afsarmanesh, 2008). Most forms of collaborative networks imply some kind of organization of the activities of their constituents, such as identification of roles and governance rules among their participants. Therefore, these can be called manifestations of collaborative networked organizations (CNOs) (L. M. Camarinha-Matos et al., 2009).

Virtual Enterprises (VEs) are specific types of goal oriented CNOs. A VE represents a temporary alliance of enterprises that come together to share skills or core competencies and resources in order to better respond to business opportunities. Cooperation among partners in the VE is supported by computer networks. However, in this paper we focus on goal-oriented, opportunity driven CNO called a Virtual Organization (VO). A VO is similar to a VE with the difference that it is comprised of legally independent organizations which are not limited to for-profit alliances. (L. M. Camarinha-Matos et al., 2009).

A VO goes through different phases in its life-cycle, including Creation, Operation, Evolution and Dissolution or Metamorphosis (L. M. Camarinha-Matos and Afsarmanesh, 2008).

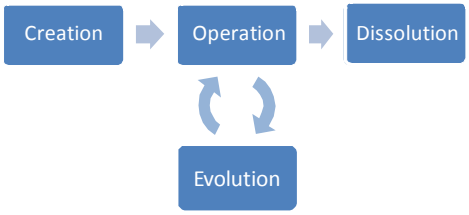

Figure 1: Various phases of VO's Life-Cycle.

Figure 1 shows the sequence of the phases in the VO's life-cycle. In contrast with traditional organizations, creation and dissolution phases of VO are complex and require considerable effort (L. M. Camarinha-Matos et al., 2009). In this research, we mainly focus on operation and evolution phases. In fact, we provide a mechanism to derive evolution and maintain operation of VO through performance measurement and improvement.

2.2 Service Oriented Architecture

Service Oriented Architecture (SOA) builds applications as a set of service components, orchestrated to deliver a well-defined level of service. SOA services are *loosely coupled* which means the interdependencies in their relationship are minimized, and they have to interact just at the interface layer. This feature of SOA will boost interoperability and agility needed for VO formation and management. In SOA, services can be seen as black boxes. That means their context and inner logic is hidden from the outside world. This feature is called *service abstraction* which facilitates partners' security of business advantages. Services are also *reusable* which means the whole application can be decomposed into units (services) which may be used to compose other functionalities. *Autonomy* of services provides control over the logic they encapsulate, to their provider. As a flexible and extensible architectural framework, SOA reduces cost, increases revenue, and enables rapid application delivery and integration across organizations (Hurwitz et al., 2006).

2.3 Performance Measurement System

Performance Measurement (PM) is defined as the systematic approach to planning and collection of data regarding the accomplishment of tasks and corresponding objectives (L. Camarinha-Matos et al., 2008, p.239). PM has evolved through different sections as is shown in Figure 2. The initial building blocks of all PM initiatives are recommendations related to discipline of PM. The accumulation of these recommendations forms the PM frameworks which can be categorized as structural and procedural ones.

A structural framework specifies the typology and structure of performance indicators. This can be a hierarchy of performance indicators.

On the other hand a procedural framework introduces a step-by-step process for developing performance indicators from strategy (Folan and Browne, 2005).

Using a procedural framework to develop a specific structure of performance indicators, along

with other performance management tools and techniques is called a PM system.

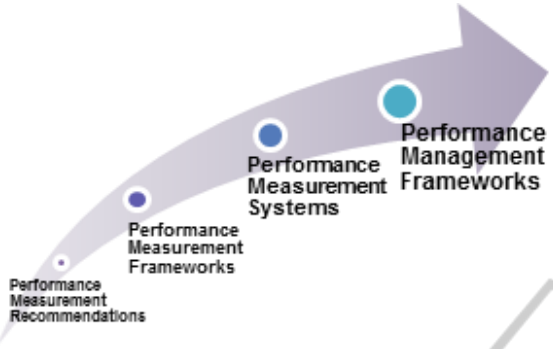

Figure 2: Performance Measurement Evolution – Toward Performance Management.

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 (Folan and Browne, 2005).

2.4 SOA based Infrastructure for VOs

Virtual organizations are usually highly dependent on computer networks to perform their day-to-day activities (Karvonen et al., 2005). Managing the interactions and collaborations of multiple organizations participating in a VO faces specific difficulties such as partners' autonomy, privacy concerns and interdependencies. In addition, VOs tend to be extremely dynamic and in most cases temporal in their nature (Drissen-Silva and Rabelo, 2009; Karvonen et al., 2004).

One of the best ways to implement dynamic business process management solutions is with a service oriented approach. 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. At each layer, processes are built using the underlying level of services (Marc Fiammante, 2009). In a service oriented virtual organization (SOVO) the focus is on sharing services between organizations and building collaborative processes on top of the organizational services. We use BPMN V2 notation and recommendations to model business processes in all three levels. The collaborative interaction of processes is modelled with service choreographies.

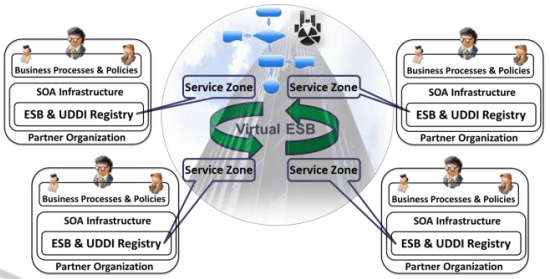

Figure 3: Virtual ESB Facilitating a Distributed SOA Infrastructure (Danesh et al., 2011).

In this research we have proposed a service zone interaction model that was first presented in (Danesh et al., 2011). "The service zone acts as an abstraction layer for partners and facilitates policy and security enforcement for every autonomous partner. This service zone provides a gateway for the VO to the partners' 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". The service zones are implemented as part of every organizations' SOA infrastructure. The federation of multiple service zones will build a virtual service bus that acts as the heart of a distributed SOA infrastructure for the VO. This virtual bus can support any of the common VO topologies known as supply chain, star and peer-to-peer. This will facilitate a dynamic and flexible infrastructure for VOs.

As the interaction model is shown in Figure 3, each partner has a SOA infrastructure with an Enterprise Service Bus (ESB) and a service registry. The service zone resides in these two components. The implementation of this infrastructure is done by IBM SOA infrastructure known as Websphere.

3 PROPOSED FRAMEWORKS FOR SOVO PM

Based on the classification provided in section 2.3 we 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 strategy. These frameworks are discussed in the following sections:

3.1 Structural Framework

Performance measurement of SOVOs needs a specific framework which can address the characteristics of SOVO that make it different from traditional organizations (Wenan Tan et al., 2008). The ECOLEAD project divides Performance indicators in CNs into three different categories: (1) The performance of the management approach and management methods, (2) The performance of the partners' collaboration, (3) The performance in fulfilling the given tasks and the contributing performance of the partners (Graser et al., 2005).

We have used this classification as the base to develop structural framework for SOVO. Based on the specific requirements of SOVO, we have proposed a structural framework as is shown in Figure 4. In the following sections three layers of performance indicators are introduced.

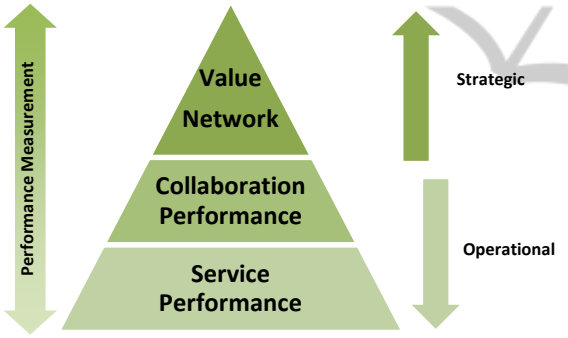

Figure 4: SOVO Performance Indicators Pyramid.

3.1.1 Value Network

The first layer copes with the strategic long term performance of the alliance. However in the case of a VO, due to the temporary nature of the alliance, it does not seem rational to focus on the indicators of long term performance like strategic goals and objectives. A better approach is instead to measure the high level performance of the VO by considering its success in creating value for the client. This can be measured considering the mechanism of creating value in a set of multidimensional chains, which is called a Value Network (VN).

Value networks are ways in which organisations interact with each other forming complex chains including multiple providers/ administrative domains to drive increased business value (SAP AG, 2008). The most familiar value networks are supply chains which are the simplest form in terms of the interaction topology. Different topologies of value networks are discussed in Wang et al. (2010). The most general topology is peer-to-peer in which each partner is capable of interaction with all of the other partners. The values exchanged among SOVO partners may be of any kind of product, service, money, and information.

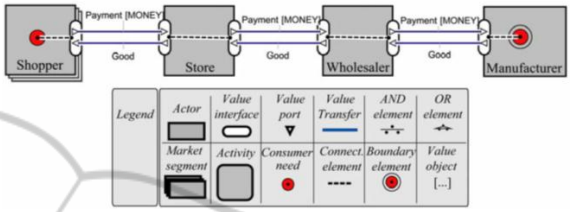

Figure 5: e3value model for supply chain (Carol Kort and Jaap Gordijn, 2007).

A comprehensive method for modelling a business as a value network is e3value (Gordijn et al., 2000). The e3value ontology provides modelling constructs for representing and analysing a network of enterprises exchanging things of economic value with each other. This method provides a UML based notation for modelling value segments, actors, activities, interfaces, and transactions. Figure 5 shows a sample of e3value model for a supply chain.

3.1.2 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 (Westphal et al., 2010). Collaboration is a kind of "lubrication" or "catalyst" for the value creation and supporting processes in the VO (L. Camarinha-Matos et al., 2008, p.250).

The indicators at this layer are necessary to assess the effectiveness and efficiency of how partners work together in joint processes for a common goal. This layer of performance measurement is the key for coordination among partners and the success of SOVO (L. Camarinha-Matos et al., 2006).

Meeting the performance targets at this layer enables effective merging of the processes to accomplish a common task in a non-hierarchic way (Graser et al., 2005).

SCOR model (Supply Chain Council, 2010) and ECOLEAD project (L. Camarinha-Matos et al., 2008, p.250) are considered as reference 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 upon quality, quantity, time and cost. Flexibility describes the ability to respond to external influences and the ability to adapt to new situation. External influences may include non-forecasted increases or decreases in demand, suppliers or partners going out of business, natural disasters, etc. Responsiveness describes the speed at which collaborative tasks are performed such as cycle-time metrics. Communication dimension represents the ability to communicate, which includes the aspect of using ICT as a means of communication (Westphal et al., 2010). This includes two sub-dimensions of re-active and active commitment. Re-active aspect describes how the VO members react on critical situations or problems. The active aspect describes the intention of partners to actively collaborate to avoid critical situations (L. Camarinha-Matos et al., 2008, p.250).

These five dimensions of collaborative performance can be mapped directly on the service choreography model. 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.

3.1.3 Service Performance

The third layer of performance indicators in a VO is related to fulfilling given tasks and contributing to performance of the partners. Based on the supporting infrastructure which is service oriented, the tasks are done by executing different services of partner organizations. Therefore, the low-level performance indicators in a 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 provider must be agreed upon among partners and be documented in the form of Service Level Agreement (SLA) (Long, 2008). 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.

3.2 Procedural Framework

The procedure for extracting performance indicators from strategy (procedural framework) along with the structural framework forms the PM system. The basic assumption is that the business model is derived from an opportunity in the market and represented as value network. This opportunity may be a growing demand for a new product or service which can be addressed by putting together the capabilities of different organizations. Next steps are about linking the value network to two other layers of performance indicators.

3.2.1 Extracting Service Choreography from Value Network

There have been different attempts to derive business choreographies from value networks. Among these attempts authors in (Wang et al., 2010) and (Wieringa and Gordijn, 2005) developed the service choreography description and dependencies based on inter-dependencies among values in the value network. Wang et al. (2010) start this 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, however we do not develop our choreographies based on sets of decoupled value chains. Instead 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. Now we assign every value in the network an ID as result we will have a set of values which can be defined as V=$\{v_1, v_2, \dots, v_n\}$.
2. 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 be performed 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 $p_{ik} = 0$.

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

3. For each value in V, count its successive values (SV_i) : $SV_i = \sum_{k=1}^{n} p_{ik}$
4. 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 $SV_i = 0$) :

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

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

5. Rank the values based on DF_i
6. 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 following lines we discuss an example of implementing this method. Figure 6 shows a hypothetical value network consisting of three value actors and one market segment.

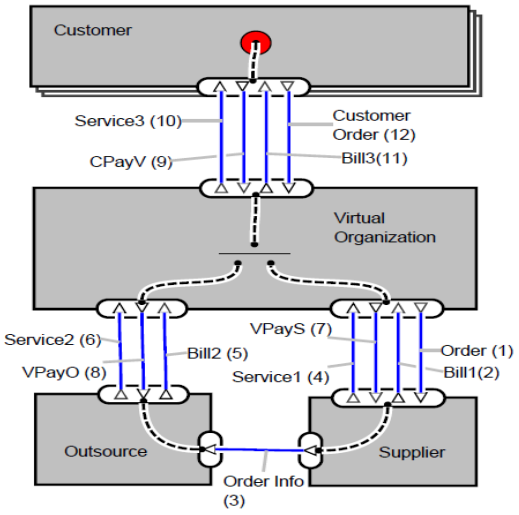

Figure 6: Value Network Model of a VO.

The client submits an order for Service3 which is a composition of Service1 and Service2 provided by the Supplier and Outsource. The order information needed by outsource needs to be processed by the supplier. Each payment is made based on the bill provided by the payment recipient. V will be defined as the set of above values. V= $\{v_1, v_2, \dots, v_{12}\}$. Matrix M will be formed as follows:

$$M = \begin{array}{c} \\ v_1 \\ v_2 \\ v_3 \\ v_4 \\ v_5 \\ v_6 \\ v_7 \\ v_8 \\ v_9 \\ v_{10} \\ v_{11} \\ v_{12} \end{array} \begin{array}{c} \begin{array}{cccccccccccc} v_1 & v_2 & v_3 & v_4 & v_5 & v_6 & v_7 & v_8 & v_9 & v_{10} & v_{11} & v_{12} \end{array} \\ \begin{bmatrix} 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \end{array}$$

Dependencies between pairs of value instances are shown in Figure 7.

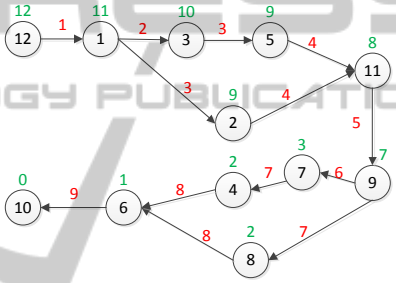

Figure 7: Value Dependencies.

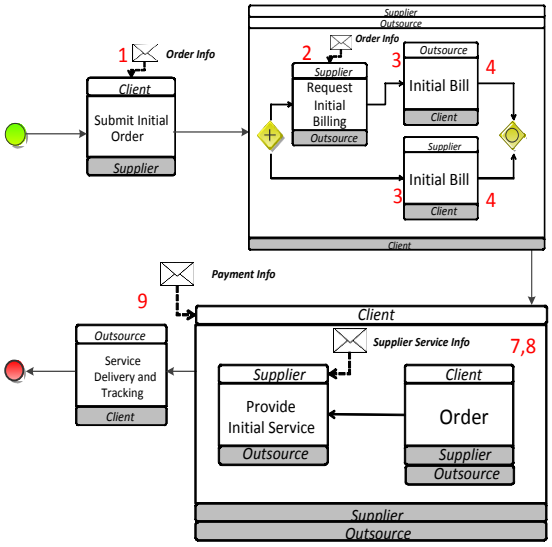

Figure 8: Service Choreography Model.

The nodes are representing value transactions. The numbers on top of each node are depicting that specific value's depth of influence. The numbers on

the edges of the graph are depicting choreography modelling steps. Following the sequence of steps we come up with the service choreography model which is shown in Figure 8.

3.2.2 Extracting SLA Aggregation Pattern from Value Network

The final step is to extract SLA aggregation pattern from the value network. Within a business network, services can be composed together to make a value added service for the client. This implies some form of aggregation pattern of SLAs for business partners, which is discussed by Ul Haq and Schikuta (2010). For each partner, a zone is defined as that partner's view. For each partner, this zone is defined as a set including consumer oriented SLAs, provider oriented SLAs, and dependencies to those SLAs. The views show the level of access to the SLA information for each partner.

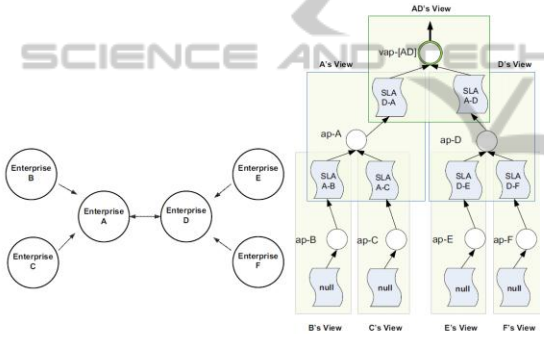

Figure 9: SLA aggregation in VOs (Ul Haq and Schikuta 2010).

In this research, performance indicators of VO partners' contributing services are defined based on this structure. With focusing on the value network (Figure 6), we can extract the SLA aggregation pattern using this method as shown in Figure 10.

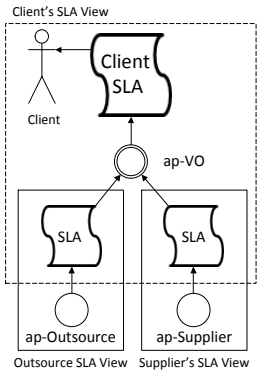

Figure 10: SLA Aggregation Pattern.

VO's view is shared with partners based on the management topology which enables the partners to access final SLA. In this simple example supplier and outsource share the same view as they occupy the same level in VO.

4 CHARACTERISTICS OF THE PROPOSED FRAMEWORK

Strategic alignment of partners in CNOs generally, and VOs specifically, is one of the most important challenges in managing such alliances. The proposed PM framework addresses this important issue through coordination of partners' value creation network. Consequently, partner's values will be compatible following a common goal, i.e. providing value added services to the customer. The core characteristic of a VO is collaboration, and the way to tackle this issue is by identifying attributes and providing performance dimensions to measure their effectiveness and efficiency. The proposed framework also addresses interdependencies among partners' services by mapping the collaboration performance on the service choreography model. The dynamic nature and rapid changes characteristics of a VO, calls for flexibility. These changes can be handled based on their scope by referring to the related layer of the performance structure. Realizing distributed performance measurement of the SOVO with no necessity of a central authority is enabled by defining SLA aggregation pattern, and independent SLA views. This also provides transparency at an agreed-upon level which is the basis for mutual trust. On the other hand, privacy and security which are important concerns for autonomous partners are realized by implementing service zones in partners' SOA infrastructure layer.

5 CONCLUSIONS

To keep pace with the growth of global economy and the intense hyper-competition, organizations tend to form strategic alliances to better deliver value to customers. These alliances, formed with the main purpose of collaborative value creation, have evolved to form today's well known Virtual Organizations. The literature on performance measurement has not addressed inter-organizational relationships in much detail. As such, the need to conceptualize such interactions exists. This research

focuses on meeting this demand, and providing a base for aligning VO partners at their strategic levels, as well as their operational activities. Our work on value network analysis along with service choreography and SLA aggregation enables such a pervasive multi-level alignment within a VO. In the infrastructure layer, Service Oriented Architecture is used to maintain agility and scalability of partner's collaboration, and at the same time, provide an agreed upon level of privacy and security. The proposed solution provides a base for collaborative performance measurement. We are expanding this work to include guidelines about performance monitoring, evaluation, and improvement in collaborative environments. This will realize inter-organizational performance management.

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