An Architecture for Managing the Lifecycle of Business Goals for Partners in a Service Network*

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Abstract. Networks of interdependent organizations cooperate to produce goods or, nowadays, services that are of value to their markets as well as to the participating organizations. Such co-operations can be supported by corresponding business processes which are based on SOA technology. Developing and managing SOA-based business processes in such service networks necessitates a *comprehensive* architecture which is on the one hand grounded on solid design principles, and on the other hand capturing best-practices and experiences. Such an architecture is currently lacking. This paper outlines a first attempt to develop and validate an architecture for developing, monitoring, measuring and optimizing SOA-enabled business processes in service networks. A case study from the telecommunications industry is analyzed, and different aspects of service networks are addressed.

Keywords: Service Value Network, Key Performance Indicator, Business Process Management, Business Activity Monitoring.

1 Introduction

The emerging service economy and the advances in information technology have dramatically increased the complexity of understanding how organizations evolve within a world of interactions and partnerships. Instead of large, vertically integrated organizations, we observe the emergence of globe-spanning networks of interdependent companies that cooperate to provide value to their markets based on services (so-called *service value networks*). Business processes technology is used to prescribe how organizations work internally and how they work together to achieve the value of the service network. But the overall management of the corresponding business processes is growing more complex because of the inter-organizational and intra-organizational nature of business processes supporting the complex web of interactions of service value networks.

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Several studies focus on creating and reconfiguring service value networks (see [1,3]). [1] proposes a methodology for analyzing the dynamics of value in networks at the operational, tactical, and strategic level with an emphasis on visualization and qualitative methods. In [2], the authors combine IT systems analysis with economic-based business modeling in order to build an e-business model that specifies e-business scenarios rather than on defining values. Besides the qualitative approaches, there is a growing need for quantitative methods. [3] presents a method for computing values by taking into consideration partners' satisfaction and additional value that is accrued by the relationship levels developed by the various partners.

In this paper we will focus our attention on *Service Networks* (SNs) (see [4,5]): it offers services that are obtained by composing other services provided inside the SN by a diversity of service providers by means of business processes.

From the operational view of the service network, one should focus on the management of the business processes and the monitoring of financial and operational measures of performance also called *Key Performance Indicators* (KPIs) in order to evaluate or improve them. Examples are overall process execution time, percentage of service requests fulfilling *Quality of Service* specifications, customer satisfaction index, etc. *Business Process Management* (BPM) together with Service Oriented Architecture (SOA) support organizations in the continuous improvement of their business's performance through the effective convergence of IT and business [6].

From the business view of the service network, there is a need to define the activities that achieve business goals such as cost cuts, market share increase, profit increase, customer satisfaction increase etc. Moreover, different partners may have different business goals, which may possibly be conflicting. For instance, one partner may be more interested in customer satisfaction, which may require an increase in costs to be achieved. This may be unacceptable for partners whose first priority is cost reduction. In [3] it is shown how the concept of value, properly defined, can be used as a unifying concept for studying service networks (called service value networks in that context) instead of the various heterogeneous business goals.

In this paper, we address the currently existing gap between business strategy and business models from one side and service system implementations on the other side. Strategic decisions (such as how to restructure the network; whether to leave a particular network to join another; or whether it is advantageous to join multiple networks at the same time; etc.) have to be made by the partners in order to increase their own value. Restructuring of a service network may be required to respond to competing networks or innovation in processes and technologies. Changes in the structure of the service network could drastically affect network partners' business objectives and/or network-wide business processes. Unfortunately, the current methods and tools for developing and managing service networks are highly fragmented, merely providing support for isolated parts of the huge task. This paper outlines a first attempt to develop and validate a comprehensive methodology for developing, monitoring, measuring and optimizing SOA-enabled business processes in SNs. We have developed the *Service Network Notation* (SNN) to represent participants in a SN and their interactions in terms of offerings and revenues. Such a comprehensive methodology is currently lacking. By adding SNs on top of the current BPM stack, analysts focusing on strategic goals of a business benefit from the detailed description and functionality of the business processes without being directly involved with BPM. This level of abstraction that is achieved through the linkage of SN to BPM provides them a better understanding of how to accomplish their goals.

The remainder of the paper is organized as follows. Section 2 introduces SNs through an example borrowed from the telecommunications industry. Section 3 introduces a meta-model of the SN. Section 4 shows how to analyze SNs and describe their basic properties. Section 5 describes standard BPM approaches, while section 6 proposes a novel architecture, SN4BPM, linking SN and BPM. Finally, section 7 provides some concluding remarks and discusses directions for future work.

2 SN by Example

In this section we describe the structure of service networks through an example taken from the telecommunications industry. Considering the methodology developed in [3], we model the service network of the telecommunications companies as a flow graph which comprises nodes (economic entities) and transfer objects (offerings which could be goods, services, information).

Our example is based on the Enhanced Telecom Operations Map (eTOM) [7] which is a reference framework for categorizing all the business activities that a service provider may use. In particular, we will describe the service network that is formed in order to set up a new service. We consider the following entities that collaborate with each other: the service provider (SP) offers services (realized as bundles of services such as orders for digital subscriber line, wireless, Internet data centre services, etc) to the subscribers. The external partners of the SP include the suppliers who provide resources (equipment, infrastructure, etc) and content providers with whom the SP co-operates in order to produce the bundle of services offered to the subscriber (e.g. video on demand, music educational content etc.) The internal partners of the SP (who can be outsourced and become external partners as well) are the call centre who provides information to subscribers over the telephone, the sales agent who provides prices for the different services to the subscribers, the service agent who is responsible for the set up and configuration of a subscriber's order, the field agent who performs service installations at the subscriber's site, the account manager who creates updates and manages accounts once the order is fulfilled and the billing agent who is responsible for the management of the billing system.

In Fig. 1, we provide a representation of the service network showing the relations created among the various entities. The economic entities are represented by circles and offering flows are represented through arcs. There are two types of offerings: services (depicted by solid arrows) and revenues (depicted by dashed arrows). A possible scenario for this example could be the following: A new subscriber contacts the call centre and orders the digital subscriber line service. The call centre enters the subscriber's information (name, address, etc.) to a customer information system and asks the sales agent to determine which services can be provided to this specific subscriber. The sales agent provides a list of possible services to the call centre which in turn informs the subscriber. The subscriber selects the service he wants and makes the order. The call centre submits the order to an order management system of the service provider. The account manager creates a new account for the subscriber and the service

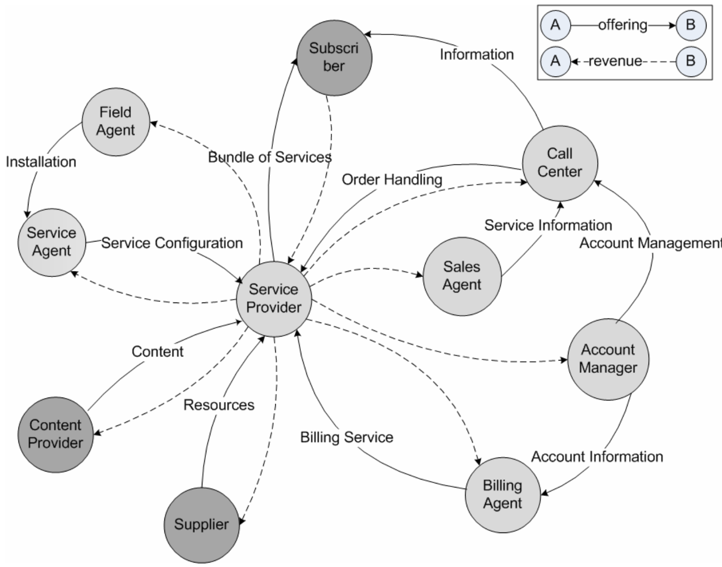

Fig. 1. The service network for a new service set up

agent configures the requested service and asks the field agent to install the equipment at the subscriber's site. As soon as the field agent completes his work, the service agent activates the new service.

The participants of the network, at the business level, are primarily interested in making sure that they derive value from their participation in the network. Participants in the network are also interested in promoting their own more general business objectives through their participation in the network, such as for example their market share, or their effectiveness in responding to market needs and being innovative, or their customer satisfaction. In section 4, we show how all these business objectives can be interconnected and also linked to IT level performance criteria such as SLAs, business processes, workflows performance etc.

3 SNN Meta-model

The meta-model for the SNN is shown in Fig. 2 as a UML2 Class Diagram. A Service Network consists of participants that are connected by relations. Participants and relations are represented by instances of the interfaces Participant and Relation. Instances of service networks, participants and relations have a name and are uniquely identified by an identifier. The interface Participant is implemented by the class Business Entity, representing providers and consumers of functionalities that generate value in a service network. SNN models comprise two kinds of relations: offering and revenue. Both kinds of relations connect a source and a target participant. Offering relations (modeled by the class Offering Relation) specify what services are offered (specified by the field offering) by the source participant (acting as service provider)

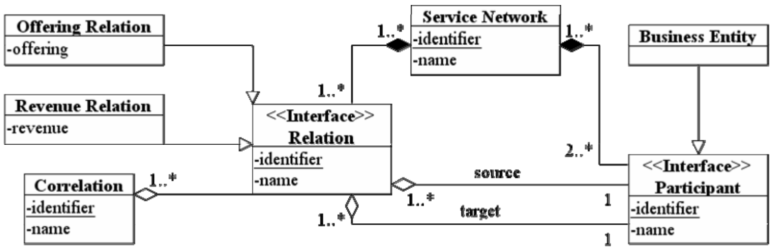

Fig. 2. A UML2 Class Diagram describing the SNN meta-model

to the target. Offerings could be goods or services, or a combination of both. Revenue relations (class Revenue Relation) describe the gain that the target participant has from the source in exchange for provided service. Revenues (modeled by the field revenue) are usually sums of money.

Generally, a SNN model describes interactions among a set of participants that take place over multiple, unrelated business processes. All the offering and revenue relations that take place over the same business process are *correlated*. Correlations allow to immediately visualize which parts of an SNN models pertain to a given business process, and which not.

4 Analysis of SNs

Organizations are expected to work worldwide fostering complex relations and developing complementary skills to generate and exchange goods, services or information. In order to evaluate and measure the performance of an organization within a service network and define business objectives as part of the firm's strategic behavior, the organization identifies specific KPIs [8]. Apart from measurements that take place at the BPM lifecycle (described in Section 6), KPIs are connected to parameters given in SLAs and parameters given by the interacting participants. For example, the value that a participant derives from the network is a KPI and could be connected, among other factors, to the satisfaction of this participant's customers. Satisfaction, in turn, depends on many factors such as the service delivery time, which usually should not exceed an upper bound specified in the relevant SLA.

To implement this service network, quite a few business processes must be deployed and operate such as: "order receipt", "order handling", "service configuration", "service installation", and "inquiries and complaint handling". These processes are distributed between several business units and business partners. To efficiently implement all these processes, SLAs will have to be agreed between partners. For example a cost KPI and cost reduction target for the SP will be affected by SLA requirements that a new service installation has to handled within a very limited timeframe, since the SP will have to pay service technicians and engineers to be available and on call to cover all new services requests by customers. Value derived from the network for, say, a content provider is affected by costs incurred for having sufficient equipment available to handle any real-time requests for content. On the other hand, if SLAs are not satisfied, then penalties for non-SLA compliance may have to be applied and customers' satisfaction may drop, thereby reducing the value derived for the content provider from its participation in the network.

It can therefore be seen that if business processes are implemented in sloppy and inefficient ways, or system and/or human resources are not used judiciously and are either wasted or under-provided, then the whole service network may break down, simply because the individual partners will not be achieving their desired KPIs and/or they will not be deriving sufficient value from their participation in the network. We now present elements of our modelling effort that tries to link satisfaction of business objectives and KPIs with SLAs and business process performance yardsticks.

The partners of a service network need to monitor on a periodic basis their KPIs and take corrective action as need be. The partners' job could be made significantly easier if they could use models that predict what the effect on a specific KPI, of a corrective action will be, and even better, what would be the optimal change (if this can be found) of parameter values and processes to yield the best possible change of a specific KPI. We are working on such models, and in what follows, we show how these models could be applied to our telecom' example to improve a specific KPI.

In our models, the KPIs are perceived as functions of all parameters that may affect their value. The shape of these functions can be affected by the structure of the business processes (for example, if the telecom provider in our example innovates and elimininates the need of technicians to install a new service, then a technician labor rate will obviously cease to have an effect on the function expressing the dependence of a cost KPI to various cost parameters). Let $\vec{x}_i = (x_{i1}, \ldots, x_{iK}), i = 1, \ldots n$ be the input vector (e.g. services, resources, prices etc.) of a node (economic entity) b_i that is used by the various functions expressing the KPIs of interest. For example, in the telecommunications example the vector $\vec{x}_i$ for the SP could be prices he imposes for the services he offers and the labor rates he pays to his employees. Consider now the function $f_i(\vec{x}_i)$ that denotes a KPI for b_i due to its participation in the network. For example, this function could represent a revenues KPI, resulting from the sum of revenues of b_i, from all its network partners, to whom b_i sells his services.

On the other hand, any prediction of improvement or even optimization of a KPI in our models, should also take into account constraints that exist. There are two forms of constraints: those that are intrinsic to the partner, such as maximum capacity of resources (number of people employed, maximum storage and CPU power available, etc.) and those that are imposed to the partner through the SLAs, for example maximum price tolerated by a partner's services buyer, or maximum delay tolerated for installing a new service in our telecom example, etc.

In general therefore, we can define the following maximization problem:

$$\max f_i(\vec{x}_i) \; s.t. \; \vec{x}_i < \vec{C} \qquad (1)$$

where $\vec{C} = (C_1, \ldots, C_K)$ is the vector of constraints.

Next, we apply this framework to the telecommunications example. We choose to focus on value created for each partner, since this KPI has also been studied by us for other examples as well, see [3]. Though there are multiple ways to express value in models, we choose a relatively simple one: each participant captures value which is given by the sum of profits from interacting with nodes in a time interval and the expected value in the next time interval. The expected value of a participant represents the effect that all its relations have upon it and depends on the expected revenues of the next time period and on the expected degree of satisfaction that the participant's buyers have for his services.

How close is this representation of value to common practices in the marketplace? We claim that it is very close. The value of a business entity is usually estimated as the sum of several components, some of which are relevant to our service networks such as the profits of a business unit over a certain period (revenues minus costs) and the expectation of revenues over the next time period, and some of which are not related such as savings, capital equipment, etc. Notice also that estimating revenues is harder when a business unit is operating alone in the marketplace (its customer list being unpredictable and volatile) as opposed to when a business entity is operating within a network where buyers and sellers are fixed (at least for some period of time) and where customers tend to have long term relationships with their service providers. In such a network it is also feasible to get customers evaluations about the quality of their providers' services and integrate them into a "satisfaction index". Satisfaction index Sat in our example is a function of the service delivery time, the price p paid by the customer for the service, the requests/hour n_1 performed by agents, the number n_2 of customers that withdrew in the last period and the number n_3 of customers that complained in the last period. Although we give here simple examples of dependencies between the satisfaction index and the other parameters, empirical market studies can establish more accurate relationships.

Let us now apply the above ideas to our example and formulate a simple price optimization problem. We assume that calculations take place within a fixed time interval in which the network remains stable in number of participants. The value V_{sp} of the service provider at the end of time interval $[T_{N-1}, T_N]$ as given in [3] is:

$$V_{sp}(T_N) = R_{sp}(T_N) - P_{sp}(T_N) + v_{sp}(T_N) \tag{2}$$

where $R_{sp}(T_N) = \sum_{i=1}^{n} p_i$ are the revenues by setting price p_i for service type i, $P_{sp}(T_N) = \sum_{i=1}^{m} r_i$ are the payments by setting labor rate r_i for type of employee i and $v_i(T_N, Sat)$ is the expected value due to all the relations partner b_i has in $[T_N, T_{N+1}]$. (For a more detailed description see [3].)

In order to calculate value according to equation 2 we need to calculate the above parameters. An upper bound on price p and a labor rate r are given in Service Level Agreements (SLAs) between the service provider and the customer and the service provider and his employees respectively. Response time t is given in SLAs as upper bound and is calculated by the lower levels of the BPM layering stack. n and n_1 are calculated by the BPM layering stack and are used in order to calculate t. n_2 and n_3 are calculated by the BPM layering stack and are given together with t and n in the SN level in order to calculate the satisfaction and the value of the participants according to the equation 2.

In order to determine price p such that the value of the service provider is maximized we solve the maximization problem given in equation 1 that is formed in the given example as follows:

$$\left.\begin{array}{l}\max V_{sp}(\vec{p}) \\ s.t.\ \vec{p} < \vec{p}_{SLA}\end{array}\right\} \Rightarrow \left.\begin{array}{l}\max(\sum_{i=1}^{n} p_i - \sum_{i=1}^{m} r_i + v_{sp}(T_N, Sat(t, p, n_1, n_2, n_3)) \\ s.t.\ \vec{p} < \vec{p}_{SLA}\end{array}\right\} \quad (3)$$

where $\vec{r}$ is a function of $\vec{p}$: $\vec{r} = g(\vec{p})$ and $\vec{p}_{SLA}$ is the upper bound of the price vector given in the SLA between the customer and the service provider. We assume that time t is a parameter that is given to us by the analysis phase of the lifecycle described in section 6. We then calculate the price vector that maximizes value according to that price vector. In section 6 we will explain how this procedure enables the business analyst to adapt a changing environment to the participants' needs.

5 BPM Layering

From our study so far we have realized that in order to calculate KPIs and improve the performance of the network, we need to connect SN to BPM. For example, the response time depends on how business processes are performed and can only be calculated based on a detailed description of the corresponding business processes.

The currently accepted Business Process Management Layers will serve as a basis for the implementation/enactment of SNs. These different layers exhibit different levels of abstraction and different purpose of the models involved. The introduction of SNs as an additional layer on top of that stack has the goal of simplifying the procedure of modeling business processes that achieve strategic goals and hence reducing the gap between the business experts' view and the IT view on business processes. The extended BPM layering is shown in Fig. 3.

The process models layer contains process models defined in an abstract technology-independent manner. The target user group is mainly the group of business analysts. The processes are modeled in a coarse-grained manner - the main functional blocks are identified and connected, and no implementation details are specified here.

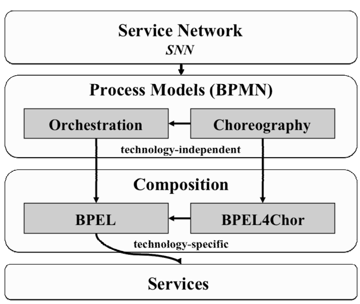

Fig. 3. Enhanced BPM Layering

This layer contains choreographies as well as orchestrations ([9], [10], [11]. The composition layer is the one with technology-specific definitions of process models. The target user group is the technical analysts. Both, choreographies and orchestrations are represented at this layer in terms of artifacts of a particular technology and refined and enriched with implementation-specific details [12], [13].

The service layer represents the set of available services that are exposed for use by the composition layer. The implementations of services are transparent, as well as the platforms on which they are deployed.

6 Enhanced BPM Lifecycle

In the BPM state of the art, the different techniques and technologies focusing on business processes are connected with each other by the *BPM lifecycle*, presented in Fig. 4 on the left. It comprises six phases: *analysis*, *modeling, IT refinement, deployment, execution* and *monitoring*.

The *analysis* phase consists of the elicitation of the requirements for the business processes. The *modeling* phase revolves around the design of abstract, high-level business processes (e.g., BPMN models, abstract BPEL processes) from the requirements gathered during the analysis phase. The abstract business process models, while not immediately executable, outline the overall structure of the final processes to a level of detail suitable to humans. Often during the modeling phase there are defects that emerge in the collected requirements. In such cases, the lifecycle reverts to the analysis phase in order to solve the issues. Abstract business processes models are transformed into executable process models during the *IT refinement* phase. The *deployment* phase deals with deploying on the enterprise information infrastructure the executable processes models produced in the IT refinement phase.

Once deployed, executable business process models enter the *execution* phase, where they are finally run. During their execution, processes instances produce events conveying information about executed activities, their performance, exceptions and faults that occur, and more. The events are collected and analyzed in the *monitoring* phase to adapt business process instances, measure KPIs, keep track of the overall state of the system, capture trends and patterns in the current usage of the processes, etc. The data processed in the monitoring phase are also taken into account in the analysis phase of the following iteration of the BPM lifecycle, providing feedback to evolve the business process models.

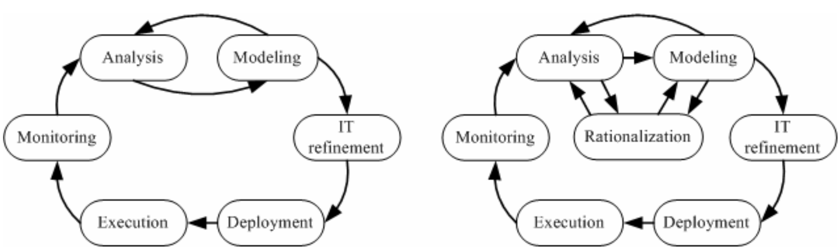

Fig. 4. The comparison between BPM lifecycle and enhanced BPM lifecycle

The canonical BPM lifecycle explained so far needs to be extended in order to benefit from the SNN and the analysis methods introduced in section 4. Fig. 4 (right side) presents the *Enhanced BPM Lifecycle*, obtained by adding a new phase, called *rationalization*, which deals with the modeling and analysis of SNN models.

The rationalization phase produces information which is used during either the modeling or analysis phase. We envision three ways of sequencing analysis, rationalization and modeling in the enhanced BPM lifecycle: *analysis–rationalization–analysis*, *modeling–rationalization–analysis* and *analysis–rationalization–modeling*. In the analysis–rationalization–analysis sequence (Fig. 5), the requirements resulting from the analysis phase are used in the rationalization one to create SNN models that represent the values flows among the participants. For example, the value calculation analysis described in section 4.1 is based on the requirements (e.g. an upper bound of the service delivery time) obtained from the analysis phase. The results are taken into account when modifying the abstract processes in order to maximize value. The new information on the desired characteristics of the process are then integrated with the previous set of requirements during another iteration of the analysis phase, during which takes place the resolution of conflicts that may arise between the original and new set of requirements.

In the modeling–rationalization–analysis sequence (Fig. 6), the existing abstract process resulting from the modeling phase is transformed into an SNN model through a *BottomUp transformation*. The value-maximizing analysis is then applied to the SNN model, producing a new set of requirements (e.g. a decreased upper bound of the service delivery time), which are integrated with the already existing ones in the upcoming iteration of the analysis phase. By analyzing SNN models extracted from abstract processes coming from outside the enterprise, it is possible to study the value flows from the point of view of the adopter of the processes and, for instance, take strategic decisions such as re-negotiate of the processes shared among participants.

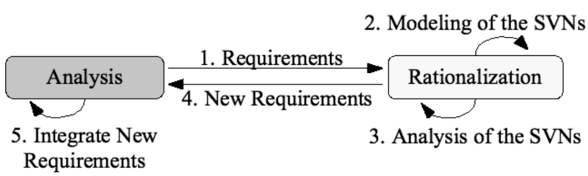

Fig. 5. The analysis-rationalization-analysis sequence

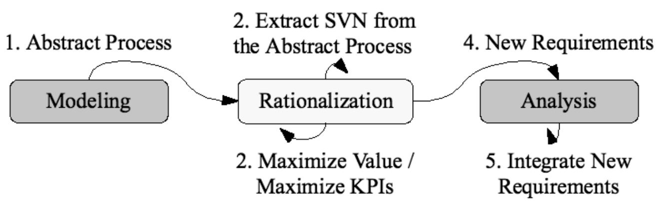

Fig. 6. The modeling-rationalization-analysis sequence

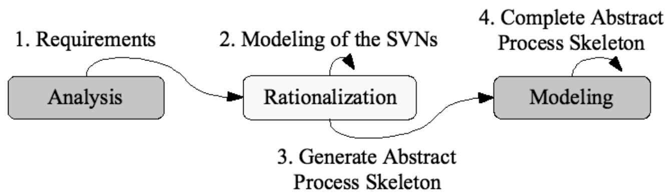

Fig. 7. The analysis-rationalization-modeling sequence

In the analysis–rationalization–modeling sequence (Fig. 7), the requirements resulting from the analysis phase are used in the rationalization phase to realize one or more SNN models. These models are transformed into *abstract process* models by applying *TopDown* transformations. The transformations use the correlations among offering and revenue relations to define the boundaries of the conversations involving the participants in the service networks.

The analysis–rationalization–modeling and modeling–rationalization–analysis sequences create a bond between SNN models and the abstract process models developed during the enhanced BPM lifecycle. Revenue and offering relations connecting parties in SNN models are translated into conversations and interactions in the abstract processes. Changes to SNN models (i.e., the removal of a revenue relation) can be mapped, through changes in the requirements, to changes to be applied to the abstract processes.

7 Conclusions and Future Work

Currently, we are witnessing an evolution in service oriented economies that need technological means to support them. In this paper we propose an architecture to coordinate business processes lifecycle and bridge existing gaps between technical and business perspectives. Our approach provides an abstract way to support business processes (in the SN level) and conversely a detailed description of the service network (in the BPM level). Next, we aim to formulate variations of optimization problems involving different kinds of KPIs and SLAs. The behavior of competing networks is also an open problem to be addressed possibly through means of game theoretic concepts. In this context, as interaction among different business roles in the process of providing a service is a key element in understanding and observing service systems, the field of game theory becomes a useful tool for identifying rules and strategies that optimize business objectives. As it was already done, all these studies have to be linked to the lifecycle management of business processes so that any progress made at the optimization level can be exploited by the business analysts.

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