Open Service Network Analysis

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Abstract. Understanding how services operate as part of large scale global networks, the related risks and gains of different network structures and their dynamics is becoming increasingly critical for society. Our vision and research agenda focuses on the particularly challenging task of building, analyzing, and reasoning about global service networks. This paper explains how Service Network Analysis (SNA) can be used to study and optimize the provisioning of complex services modeled as Open Semantic Service Networks (OSSN), a computer-understandable digital structure which represents connected and dependent services.

1 Introduction

Services that offer different capabilities are also distributed over space and time. These services are related, dependent, connected, and form networks. They are brought together as new services through composition or aggregation. In many situations, the value of services and networks is influenced by existing suppliers, competitors, value-adders and customers. It is important to be able to understand and reason about these networks to assist, e.g., decision-making involving strategic investments in service innovation. However, this is hard because of their scale (number of services a network may have) and the complexity of technical aspects such as the temporal and spatial distribution, and the business aspects such as the diversity of marketing, operations, business models and financial aspects.

We resort to Service Network Analysis (SNA) that offers a systematic and scientific analysis of service networks to address the above challenges. SNA views service systems and service relationships [4] in terms of network theory, consisting of nodes (representing individual services within the network) and ties (which represent relationships between services such as *roles*, *level of integration*, *involvement strength*, and *cause-effect* [4] bindings).

The dynamic nature of service networks indicates that their topology might be shaped according to some intrinsic property, e.g. service cost, availability, or extrinsic property, e.g. perceived customer preference. This dynamic behavior has been verified in many fields. For example, Web Science looks at World Wide Web models as a large directed graph with an apparent random character. Nonetheless, the topology of this graph has evolved to a scale-free network [20] by preferential attachment [22], i.e. when establishing hyperlinks, documents prefer the 'popularity' of certain documents (of 'popular sites') which overtime become hubs. In the same vein, SNA targets to find explanations for the structure and behavior of service networks. Finding the mechanisms, laws, and properties of service networks can enable to better understand and explain the structure, evolution, cost, reliability, and coverage of service networks.

Having provided a motivation for the importance of SNA, the contribution of this paper is to aggregate and present four approaches originating from different fields that can be applied to analyse service networks:

1. Optimization,
2. Evolutionary analysis,
3. Cooperative analysis and
4. Value analysis.

While these approaches have been developed in isolation and have been often applied to distinct fields (e.g. complex systems, logistics, economics, and markets), they all constitute solutions for SNA. In the future, a convergence of these approaches is needed to build a comprehensive body of scientific methods for service network analysis. A second contribution of this paper is to describe how, from a technical perspective, these service networks can be build. We relied on the recent developments of the Linked USDL (`http://linked-usdl.org`) language to represent services and a service relationship model OSSR [4] to represent relationships between services of a network. An important aspects of these two models is that their encoding is based on Linked Data principles to retain simplicity for computation, reuse existing vocabularies to maximize compatibility, and provide a simple – yet effective – means for publishing and interlinking distributed service descriptions for automated computer analysis. These are fundamental aspects to support the creating of global service networks.

In this paper, we explore SNA as introduced above and offer some preliminary concepts, models and insights. Section 2 introduces the main terms and concepts that will be used throughout the paper. In Section 3 we provide a motivating scenario, from the field of cloud computing, to highlight the importance of constructing complex services by aggregating simpler building blocks into service networks. Section 4 explains how Open Semantic Service Networks (OSSN)[7] can be constructed by accessing remote and distributed computer-understandable service descriptions. In Section 5, we present the field of service network analysis and exemplify the objective of this new field of research. Section 6 presents the related work in this area. Section 7 offers our conclusion on the extraordinary implications and improvements to society that the construction of global service networks and there analysis can bring.

2 Terms and Concepts

To address the growing importance of connecting service systems, we have introduced the concepts that constitute an OSSN [7]. A *service network* is defined as a graph structure composed of service systems which are nodes connected by one or more specific types of *service relationship*, the edges. A *service system* is a functional unit with a boundary through which interactions occur with the environment, and, especially, with other service systems. Service networks are similar to social networks in their structure but connect service systems. When no ambiguity arises, we will simply use the term service to refer to a service system.

OSSNs are global service networks which relate services with the assumption that firms make the information of their service systems openly available using suitable models. Therefore, service systems, relationships, and networks are said to be *open* when their models are transparently available and accessible by external entities and follow an open-world assumption. The objective of open services is very similar to the one explored by the linked data initiative (`http://linkeddata.org`): exposing, sharing, and connecting pieces of data and information on the Semantic Web using URIs and RDF. Networks are said to be *semantic* since service and relationships can be represented by using shared models, common vocabularies, and semantic Web theories and technologies. Service networks bring together several players (e.g. *service creators*, *aggregators*, *providers*, *marketplaces*, and *consumers*) that work together to deliver value to consumers.

The (re)construction of OSSNs is the result of a peer-to-peer social process. Firms, groups and individuals (i.e. the community) are equal participants which freely cooperate to provide information on services and their relationships to ultimately create a unique global, large-scale service network. The principles of OSSN (re)construction were presented in our previous work [7] and call for self-governance, openness, free-access, autonomy, distribution, and decoupling.

3 Motivation Scenario

Our scenario is from the field of cloud computing. As cloud applications spread, such as platform-as-a-service (PaaS) and software-as-a-service (SaaS), the dependencies between applications increases. For example, Heroku, Instagram, Pinterest and Netflix all establish a relationships with Amazon EC2 since they dependent on its services. This has many implications e.g., a change in Amazon EC2 characteristics (e.g. its cost, reliability, and performance) can influence all the dependent services.

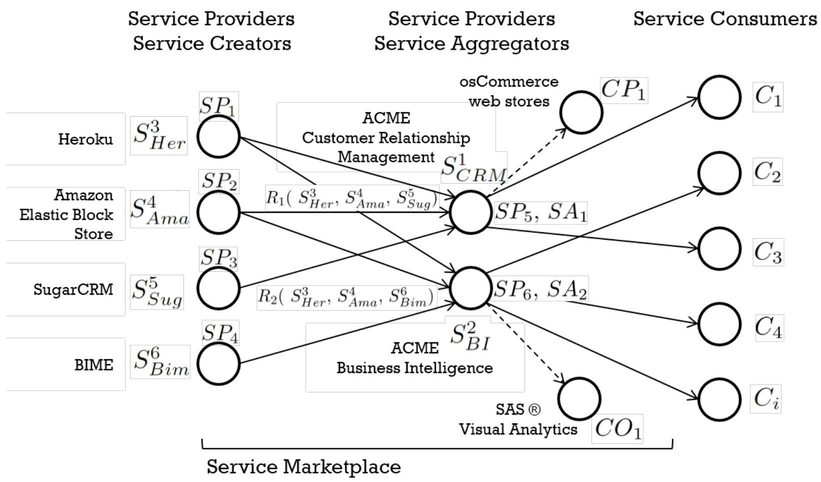

Fig. 1. A service network involving various cloud computing services

Let us consider the service network from Fig. 1. Two service aggregators (SA_1 and SA_2), part of the ACME corporation, decided to construct two new services: ACME Customer Relationship Management (S^1_{CRM}) and ACME Business Intelligence (S^2_{BI}). These two services where constructed from the aggregation of an existing cloud processing service provided by Heroku[6] (S^3_{Her}) and a storage service provided by Amazon Elastic Block Store[7] (S^4_{Ama}). In addition, S^1_{CRM} also relied on the SugarCRM service[8](S^5_{Sug}), an open-source, web-based customer relationship management SaaS platform. On the other hand, S^2_{BI} relied on the BIME service[9] (S^6_{Bim}), a SaaS solution for business analytics and data visualization. The relationships [4] between services (i.e. R_1 and R_2) can be summarized as follows ($x \leftarrow R(y_1, y_2, ..., y_i)$ is to be read as x aggregates $y_1, y_2, \ldots, y_i$):

- $S^1_{CRM} \leftarrow R_1(\ S^3_{Her}, S^4_{Ama}, S^5_{Sug})$
- $S^2_{BI} \leftarrow R_2(\ S^3_{Her}, S^4_{Ama}, S^6_{Bim})$

The two new services, i.e. S^1_{CRM} and S^2_{BI}, are commercialized by service provider SP_5 and SP_6. The atomic services S^3_{Her}, S^4_{Ama}, S^5_{Sug}, and S^6_{Bim} are provided by SP_1, SP_2, SP_3, and SP_4, respectively. Service consumers (C_i) can

[6] http://www.heroku.com/
[7] http://aws.amazon.com/ebs/
[8] http://www.sugarcrm.com/
[9] http://www.bimeanalytics.com/

purchase and use any of the aggregated services. To operate, aggregated services must purchase computing/processing units from atomic services. In other words, there is a dependency between, e.g., S^1_{CRM} and S^3_{Her}. Furthermore, S^1_{CRM} has a service complementor osCommerce[10] CP_1 and S^2_{BI} has a service competitor SAS Visual Analytics CO_1.

SNA can be used to, e.g., minimize the cost of providing the aggregated service S^1_{CRM}. The study of the network can suggest the use of other data storage and processing services which are less expansive than S^3_{Her} and S^4_{Ama}, possibly with a slightly lower reliability. Minimizing the cost of a service network can be mapped to an assignment problem which in turn is mapped to fundamental combinatorial optimization problems. This branch of service network analysis will be explored in section 5.1. The effect of having a higher number of complementors CP_i and a lower number of competitors CO_i can also be studied since it influences the perceived value of services S^1_{CRM} and S^2_{BI}. In this case, findings from the filed of social network analysis can be used to explore the influence of actors in a network.

4 Constructing an OSSN

The service network from the previous section can be constructed and represented using OSSN by accessing, retrieving and combining information from *service* and *relationship models*. OSSN are networks which relate services with the assumption that firms make the information of their services openly available using suitable models. In other words, we make the assumption that the description of services S^1_{CRM}, S^2_{BI}, S^3_{Her}, S^4_{Ama}, S^5_{Sug}, and S^6_{Bim} is openly and remotely available.

4.1 Open Service Descriptions

In OSSN, services are modeled using the family of languages named *-USDL (the Unified Service Description Language)[5,8] to provide computer-understandable descriptions for services. USDL relies on a shared vocabulary for the creation of service models and includes concepts such as pricing, service level, availability, and roles. These languages[11,12,13] allow to formalize business services and service systems in such a way that they can be used effectively for dynamic service outsourcing, efficient SaaS trading, and automatic service contract negotiation.

As an example of service description modeling, we illustrate how the service SugarCRM S^5_{Sug} from Section 3 was modeled using Linked USDL. The information used to model the service was retrieved from its web site. A service and a vocabulary model were created. The vocabulary contained domain dependent

[10] http://www.oscommerce.com/ is a vendor specialized in customizable web shops platforms
[11] Linked-USDL = http://linked-usdl.org/
[12] α-USDL = http://www.genssiz.org/research/service-modeling/alpha-usdl/
[13] USDL = http://www.w3.org/2005/Incubator/usdl/

concepts from the field of CRM systems (e.g., taxonomies of common installation options). Since Linked USDL only provides a generic service description language, domain specific knowledge needs to be added to further enrich the description of services. The excerpt from Listing 1.1 illustrates the description of the SugarCRM service (the example was written using the Turtle language[14]).

```
1 <#service_SugarCRM> a usdl:Service ;
2     ...
3   dcterms:title "SugarCRM service instance"@en ;
4   usdl:hasProvider :provider_SugarCRM_Inc ;
5   usdl:hasLegalCondition :legal_SugarCRM ;
6   gr:qualitativeProductOrServiceProperty
7     crm:On_premise_or_cloud_deployment ,
8     crm:Scheduled_data_backups ,
9     crm:Social_media_integration ,
10    crm:Mobile_device_accessibility .
11    ...
12 :offering_SugarCRM a usdl:ServiceOffering ;
13    ...
14    usdl:includes <#service_SugarCRM> ;
15  usdl:hasPricePlan
16    :pricing_SugarCRM_Professional ,
17    :pricing_SugarCRM_Corporate ,
18    :pricing_SugarCRM_Enterprise ,
19    :pricing_SugarCRM_Ultimate ;
20  usdl:hasServiceLevelProfile :slp_SugarCRM .
21    ...
```

Listing 1.1. SugarCRM service modeled with Linked USDL

The description starts with the identification of the provider (line 4), the legal usage conditions (line 5), the general properties of the service (e.g., deployment, schedules backups, integration, and mobile accessibility), and its price plans (line 15).

4.2 Open Service Relationships

Service networks rely on a fundamental element which connects service systems: *relationships*. The Open Semantic Service Relationship (OSSR) model [4] is used to capture the dependencies that exist between aggregated SaaS and atomic SaaS applications (i.e. services which do not depend on other services). The model considers that service systems are represented with existing description languages, such as Linked USDL, and derives a rich, multi-level relationship model. Service relationships are very different from the temporal and control-flow relations found in business process models. They relate service systems accounting for various perspectives such as roles, associations, dependencies, and comparisons.

[14] Turtle – Terse RDF Triple Language, see http://www.w3.org/TR/turtle/

4.3 Service Network Construction

An OSSN network is modelled as a time-varying hypergraph SN, such as $SN(t) = \{S(t), C(t), R(t)\}$, where $S(t)$ is the set of services provided and $C(t)$ is the set of service consumers, with both being modeled with USDL. $R(t)$ is the set of relationships modeled with OSSR connecting consumers and services provided.

For example, binary relationships can be depicted as edges in a directed graph (see section 5). Time is represented by the parameter t, whose granularity is set to appropriately model the market (e.g., days). Consumers alter the topology of a service network by diffusion when they adopt or abandon a service by adding or deleting an OSSR relationship to it.

To construct a service network SN, USDL and OSSR models are remotely accessed and retrieved (an overview description of the infrastructure to access and retrieve USDL and OSSR instances is described in [7]). OSSR models are mapped to relationship $R(t)$.

5 Service Network Analysis

A wide spectrum of techniques and algorithms can be developed to study OSSNs. For example, reasoning techniques can be developed to explore the notion of relationships as bonds. By discovering strong cliques, we can hypothesize that the stronger the relationships, the stronger the unification and the greater the commonality of fates. As a result, it would be possible to infer that a tightly coupled service network will sink or swim together. Other fundamental algorithms which are valuable to implement come from the field of network science. For example, algorithms to detect if an OSSN is a *scale-free networks* [15]. This property strongly correlates with the robustness of a network to failures. This can prove to be important in financial markets. As another example, the *preferential attachment* [22] can be explored to forecast the structural evolution of service networks.

We present four methods under the umbrella of SNA: 1) OSSN optimization, 2) evolutionary analysis of OSSN, and 3) cooperative analysis of OSSN, and 4) value analysis. Fig. 2 conceptualizes and contextualizes these methods with service networks. Optimization deals with constructing networks by selecting the best services, with regard to some criteria, from some set of available alternatives. Evolutionary and cooperative analysis deals with the study of networks' structures as a function of time. In other words, how do networks expend, adapt, or collapse overtime based on internal and external factors. Finally, service value network analysis deals with the establishment of rules and regulations which ensure that the construction of networks in society follows a fair and unbiased processes.

These four methods enable to study different aspects of a service network and, therefore, they do not compete between them. They provide different views on a network. For example, optimization (the first method described in the next section) can be used to selected the most desirable combination of services to

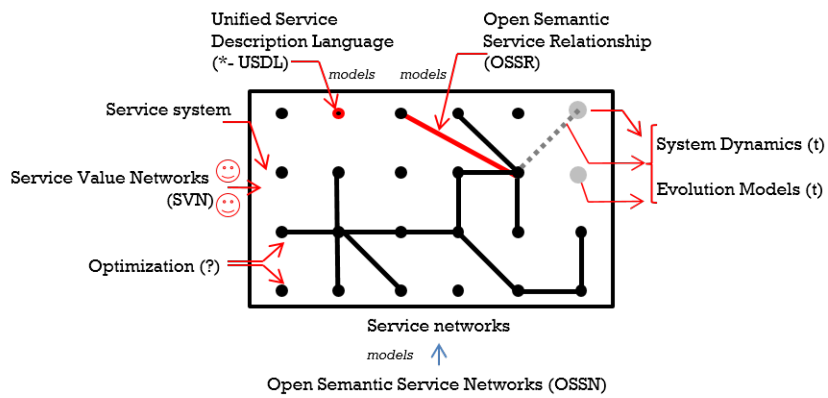

Fig. 2. Overview of service network analysis methods

achieved an initial goal. On the other hand, cooperative analysis studies how the behaviour of customers (e.g. a new service subscription or a change of the service provider) and the characteristics of the service offered (e.g. its price) influence the flows of material and/or immaterial resources (e.g. raw materials) inside a service network.

5.1 OSSN Optimization

$SN = (N, E, l_n, l_e)$, is a node and edge labeled directed graph (initially we are modeling acyclic graphs) where

$$\begin{aligned} N &= S \cup C \\ E &= S \times S \cup S \times C \\ l_n &: N \rightarrow \mathit{Description} \\ l_e &: E \rightarrow \mathit{Color} \end{aligned}$$

The nodes N are either services S or consumers C.

The consumer nodes are sinks (no outgoing edges).

Certain services are atomic (i.e., not formed as compositions of simpler services).

In our initial modeling we consider them to be sources (i.e., no incoming edges).

There will be edges from services to other services as well as consumers.

To support constructing optimal constructions of OSSNs at particular time points, we model a service network as follows: $SN = (N, E, l_n, l_e)$ is a node and edge labeled directed graph (initially we are modeling acyclic graphs) where

$$\begin{aligned} N &= S \cup C \\ E &= S \times S \cup S \times C \\ l_n &: N \rightarrow Description \\ l_e &: E \rightarrow Color \end{aligned}$$

The nodes N are either services S or consumers C. The consumer nodes are sinks (no outgoing edges). Certain services are atomic (i.e., not formed as compositions of simpler services). In our initial modeling we consider them to be sources (i.e., no incoming edges). There will be edges from services to other services as well as consumers.

The node labels indicate the semantics of services or the demands of customers. The edge labels are abstract representations of type. A service, in general, takes one or more input types (colors) and produces one or more output types (colors). Initially, type matching is simple, but we plan to generalize it to model subsumption hierarchies. The color of an edge will be set to the most general of the two matching colors (i.e. the more general type). If there is no match, there will be no edge. Below, an algorithm will be outlined for maximal service network construction. This network will then be trimmed with its flow quantified by using mathematical optimization techniques.

The optimal construction of a service network is divided into two phases: maximal color-compliant service network construction and cost minimization. The algorithm for phase I builds a service network from three sets of nodes, atomic services (sources), composite services (intermediate nodes), and consumers (sinks). Starting with the sources, all intermediate and consumer nodes are connected by edges that are color compliant, e.g., if an intermediate node needs a blue input and green input and there exist sources producing/outputting these colors, then this intermediate node is added to the graph. This process continues through k stages, a parameter indicating the maximum number of stages (i.e., distance from source to sink) desired.

Once the graph has been created, it can be reduced to an optimal form using Linear Programming. Such problems require an objective function in terms of decision variables, and constraints on the values of those decision variables. Our objective function is the cost of the network, and our decision variables represent the flow of material through the network and the amount of production at intermediate nodes. Flow is determined by the edges and intermediate nodes, so each of these will have a decision variable. The flow is constrained by the supply, production, or demand capacity of the nodes in the network, and by the required number of inputs for each non-source node. Once the constraints are gathered, a Linear Programming algorithm such as the Simplex algorithm, can be used to find the optimal values for the decision variables. These values determine the optimal amount of flow through the network and the value of the objective function estimates the minimum cost.

5.2 Evolutionary Analysis of OSSN

In our second example, let us assume that each service system contains a value proposition communicated to customers (i.e, the attractiveness elements or preferential attachment). Service value is judged from the perspective of consumers as they compare services among the alternatives. For simplicity reasons, we assume that the value proposition is similar for all service systems and it is the `price` of the services calculated from a `usdl-price:PricePlan`[15]. This concept if part of the Linked USDL family.

Since our objective is to forecast the evolution of a service network over time, we use the following function to calculate the Market Share of each service provided $MS(s_i) = degree(s_i)/m$; where $degree(s_i)$ is the number of relationships established by service s_i with service consumers and m is the total number of relationships established between providers and consumers. Overtime, customers change preferences by changing from one service system to another service system provider.

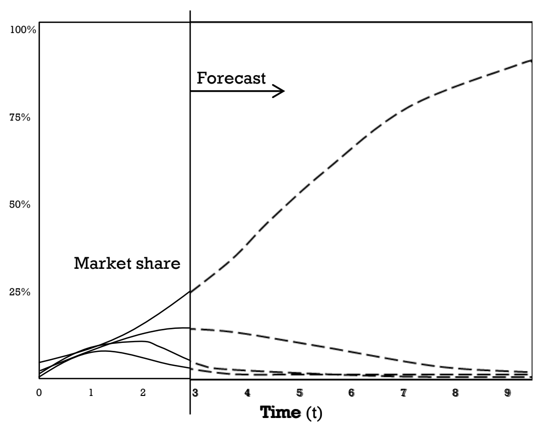

Fig. 3. Service market share evolution overtime [6]

Let us assume that the (re)constructed SN topology shows that overtime the market share is the one represented in Fig. 3 at $t = 3$. One question to be answered is: *"what will happen to the market in the future if the conditions are not changed?"* (i.e. the value propositions of s_i remain the same and $m \ngtr c_i$). According to Bass model [2], the leading service system will reach a fixedpoint market share according to the following formula (a and b are constants):

$$MS(s_i, t) = \frac{1 - e^{-bt}}{1 + ae^{-bt}}; 0 \leq t \leq 9 \quad (1)$$

[15] For simplicity reasons, we consider that each service has only one pricing plan.

Fig. 3 illustrates that from the four services provided, three also rise in market share during the early stages, reach a peak, and then decline as the service leader accelerates because of the increasing returns effect of preferential attachment. In this case, all but one service provided leaves the market, leaving one monopoly competitor. The SNA field can, therefore, develop mathematical models which can help to forecast the evolution of service network overtime.

5.3 Cooperative Analysis of OSSN

In our third example, we explored the suitability of OSSNs to model system dynamics. Instead of looking at causes and their effects in isolation, we analyze service networks as systems made up of interacting parts. Once an OSSN is created from distributed service models, cause-effect or network effect diagrams can be derived for the network. For example, Fig. 4 shows service systems S_i, S_j, S_k, and directed edges illustrating internal and external relationships.

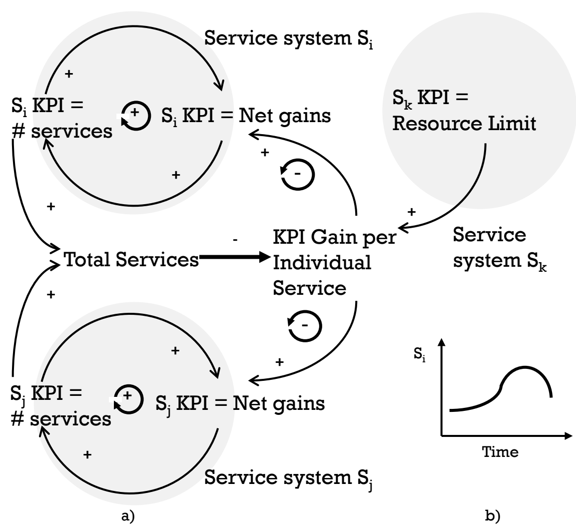

Fig. 4. Service networks and system dynamics [6]

Causal relationships connect Key Performance Indicators (KPI) from different services' and within services. The pattern represented by this OSSN is commonly known as the 'Tragedy of the Commons' archetype. It hypothesizes that if the two services S_i and S_j overuse the common/shared service S_k, it will become overloaded or depleted and all the providers will experience diminishing benefits. Service S_i and S_j provide services to costumers. To increase net gains, both providers increase the availability of service instances. As the number of instances increases, the margin decreases and there is the need to increase even more the number of instances available. As the number of instances increases, the stress on the availability of service S_k is so strong that the service collapses or cannot respond anymore as needed. At that point, service S_i and S_j can no longer fully operate and the net gain is dramatically reduced for all the parties involved as shown in Fig. 4.b).

5.4 Service Value Networks

While the previous three sections considered structural aspects, such as the analysis, optimization and evolution of the network, the described methods do not take into account the participants' behavior in a service network. For example, depending on the market mechanism implemented in the service marketplace, providers might have an incentive to report their service characteristics (such as price, non-functional attributes, etc.) untruthfully to the system in order to increase their chance of being allocated. Hence, the market mechanism used in the marketplace has to be able to handle such behavior and still yield an efficient market outcome. This is the focus of the economic concept of Service Value Networks (SVNs, see [3,14,13]). SVN are defined as "Smart Business Networks that provide business value by performing automated on-demand composition of complex services from a steady but open pool of complementary as well as substitutive standardized service modules through a universally accessible network orchestration platform" [14]. The setup is very similar to Fig. 1. The main constituents of SVNs are service providers which offer atomic or complex services, service aggregators that perform the (automatic) composition of (atomic) services to complex service compositions, and service consumers. The services are described by a number of attributes such as availability, throughput, latency, and price. Consumers request either atomic services or aggregated services with certain functionalities, and have preferences over the service attributes (e.g. an acceptable price range, availability thresholds, etc.).

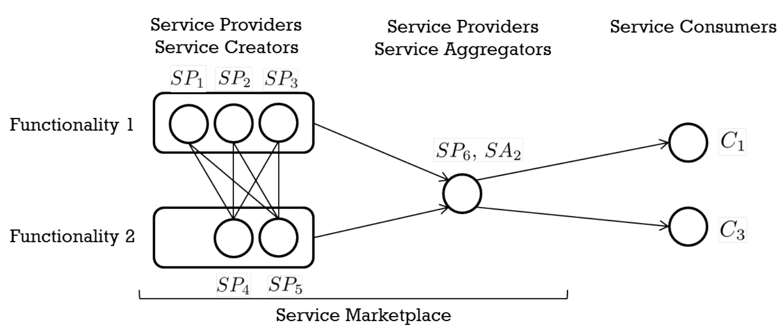

Fig. 5. Service Value Network and combination of atomic services to aggregated services

The abstract model and topology of service aggregation in SVNs is shown in Fig. 5. Given that the consumer requests an aggregated service consisting of two service functionalities, we have two candidate pools of atomic services from different service providers. From a Mechanism Design perspective, which is the focus of most current work on SVNs, the question is how we can select a combination of these atomic services out of the candidate pools that best satisfies the consumer requirements (in Fig. 5, there are $3 \times 2 = 6$ different combinations for the requested aggregated service). In SVNs, this is implemented through a "complex service auction" [3]. The main goal of this mechanism is to maximize the welfare of the SVN, which is the sum of consumer and provider utilities. The provider utility depends on the costs of service provisioning and the revenue for the service. The consumer utility is calculated as the difference of the consumer's monetary valuation of the aggregated service and its price. Based on desired minimum and maximum values for the service attributes, each customer has a certain valuation (maximum willingness to pay) for a perfect service, i.e. a service that completely fulfills (or exceeds) the requirements. This valuation is then multiplied by the score ($\in [0, 1]$) for the actual aggregated service, which depends on how close the aggregated service attributes are to the consumers requirements.

The mechanism implements two steps. In the first step, the calculation of the allocation, the mechanism computes the different potential combinations of atomic services to the desired aggregated service (the aggregation operation of service attributes depends on the attribute type, e.g. the price for the aggregated service is the sum of prices for the atomic services). The mechanism selects the aggregated service with the highest (positive) difference between consumer valuation minus the costs of the atomic services. In the next step, the calculation of the payments, the mechanism implements a Vickrey-Clarke-Groves (VCG) payment scheme to determine the actual payments to the providers of the allocated atomic services. In contrast to other payment schemes, the VCG scheme is desirable as service providers have the incentive to report the attributes and prices of their services truthfully to the marketplace, without the incentive to manipulate. This property is achieved by rewarding service providers according to their relative importance (added value) to the SVN, which means they can receive an additional discount on their service provisioning price.

This mechanism, with the described allocation and payment calculations, has certain desirable properties. For example, it is known to be allocative efficient, i.e. it selects the best combination of atomic services given the consumer preferences. Further, as mentioned earlier it is also strategy-proof, which means that the dominant strategy for service providers is to submit their service attributes truthfully to the marketplace, as other strategies will not yield better outcomes for the providers. However, the Impossibility Result by [16] shows that such a mechanism is not budget-balanced, which means that in certain circumstances the discounts to the providers together with the price for the allocated atomic services exceeds consumer payments. In other words, in such case the market would have to be (externally) subsidized which might not be practical for many scenarios. On the other hand, implementing other payment schemes to achieve budget-balance yield a loss of the strategy-proofness, i.e. service providers might gain by misrepresenting their service attributes to the SVN which can lead to complex strategic behavior.

For the study of SVNs, Service Network Analysis has been applied in various research questions. Considering the dynamic behavior of the SVN, we can look at the incentives the providers have to join the network. As a competitive and vital SVN has to provide many (functionally) different services to accommodate for diverse consumer requirements, Conte et al. [9] propose a scheme that rewards service providers to participate in SVNs (even if their services are not selected). The value of each service provider is calculated through a metric that is a proxy for the relative power of the provider in the network. Once service providers are participating in the SVN, their goal is to be allocated and receive revenues from their allocated services. As unsuccessful providers might leave the network, an important question is how the providers can select or adjust their service attributes such that they better fit the customer requirements. Haas et al. [13] show that through appropriate learning strategies, the providers are able to adjust to (potentially time-dependent) consumer requirements, and are even able to tacitly collude by dividing existing market segments among the providers.

While current work on SVNs has mainly focused on economic topics, the augmentation of the SVN concept with semantic capabilities to an OSSN along with the use of Social Network Analysis promise to be fruitful. Such an amalgamation would enable a better description and usability of SVNs as well as an improved understanding of their dynamic behavior.

6 Related work

In most work done so far, existing approaches fail to adhere to service-dominant logic [18] and focus too much inward the company instead of the service network they belong to (c.f. [12,1,10,11,17]). Service networks are not viewed as global structures. Furthermore, the efforts to analyze networks was carried out as isolated activities from the Business Process Management (BPM) field (e.g. [10]) or from the economical side (e.g. [11,17]), among others.

For example, e^{3}service [12] provides an ontology to model e-business models and services. The model targets to represent very simple relations between services from an internal perspective, e.g. core-enhancing, core-supporting, and substitute. From an external perspective, the value chains proposed do not capture explicitly service networks across agents and do not try to analyze quantitatively the effect of relationships.

In [10], the authors look at service networks from a BPM and Service Oriented Architecture (SOA) perspectives and present the Service Network Notation (SNN). SNN provides UML artifacts to model value chain relationships of economic value. These relationships take the form of what we can call 'weak' relationships since they only capture offerings and rewards which occur between services. The notation is to be used to describe how a new service can be composed from a network of existing services. The focus is on compositions, processes, and on establishing how new services can be created using BPM to describe the interactions of existing SOA-based services.

Allee [1] uses a graph-based notation to model value flows inside a network of agents such as the exchange of goods, services, revenue, knowledge, and intangible values. In the same lines, Weill and Vitale [21] have developed a formalism, called the e-business model schematic, to analyze businesses. The schematic is a graphical representation aiming at identifying a business model's important elements. This includes the firm relationships with its suppliers and allies, benefits each participant receives, and the major flows of product, information, and money. Both approaches only take into account value flows and do not consider other types of relationships that can be established between agents.

From a business perspective, there is an apparent trend for companies (e.g. service providers) to specialize by focusing on core competencies and becoming a member of adaptable networks [11]. As the transition to such networks of specialized service providers leads to challenges and new requirements for business models and service components, the field of service networks has been identified as important research priority [17].

Nonetheless, a challenge yet to be solved involves modeling and optimizing the functions of service-centric organizations from technological, business and legal points of view, extending work on optimizing Web process [19]. Semantic Web technologies of today will need to be extended to provide or at least support large-scale modeling, analytics, and optimization. In this regard, new approaches are need to express and quantify the impact that one service has on other services, as well as to understand the collective behavior and performance/profitability characteristics of service networks.

7 Conclusions

We envision a world that is well connected via global OSSNs. Semantics will have a major role in creating a large-scale and integrated service network. Organizations, groups and individuals will have tools and platforms to advertise their know-how, capabilities and skills in the form of services to the world. A huge number of detailed firm-generated (or even user-generated) services will be available worldwide. Some services will be shared, composed, co-created, personalized, others are crowdsourced.

As service networks emerge, their study will enable to understand how a service-based society grows and changes overtime. Service network analysis (SNA) can provide theories, mathematical models, algorithms, techniques, and tools to achieve this goal. This paper presented four applications of SNA: optimization, evolution, network effect, and service value. Optimization targets to construct networks of services which minimize the overall cost. Network evolution relies on time to study and forecast how a network structure will evolve overtime. Network effect explores the impact of changing the characteristics of one or more service nodes in the other services and in the network itself. Finally, service value network enable to analyze the influence providers' strategies in the network. These four methods provide the first building blocks to demonstrate the practical application of SNA to better understand how service networks function in a global, interconnected service-based societies.

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