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Building an extended ontological perspective on Service Science

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Abstract. This paper presents an approach accounting for the classification of the main knowledge resources related to the new Science of Service. The main knowledge categories are defined as concepts integrated in an **extended Service Science ontology**. The ontology derived from several sources was captured using UML and Protégé, and then, through a RDF/OWL transformation, a semantically annotated wiki has been directly implemented offering an execution of the ontology together with implemented use cases. Further, a dedicated application was developed – the Service Science Knowledge Environment (SSKE) – in order to grant user access to different knowledge categories created along with the proposed ontology. The SSKE is a cloud based collaborative software service, aiming at providing co-created knowledge resources shared by academia, industry and government organizations. This application can be accessed through the Web (http://sske.cloud.upb.ro/) and it can be used for managing service related knowledge.

Key words: Service Science, service systems, ontology

1 Introduction

The service sector accounts now for over 70% of the activities and employment in the more advanced economies, and has been growing in all countries. Innovation in services is critical for sustainable societies, and there is an increasing support from information technologies in providing new services [1]. Service Science is an interdisciplinary approach to the engineering of service systems in which specific arrangements of people and technologies take actions that have value for others.

Recently, some research directions towards the development of an ontological foundation for Service Science have been put into action ([2], [3], [4], [5] and [6]). Each of them draw a clear conclusion to establish an unifying framework of service representation in different perspectives, based on the Service-Dominant Logic view [7] that considers services as value co–production complex systems consisting of people, technology, other internal and external service systems, and shared information (such as language, processes, metrics, prices, policies, and laws) [8]. In [5] the design of the Onto-ServSys ontology on service systems is reported, this integration being realized through a Systems Approach, that mainly consists of an *organizational system* view and a *service system view*. In [9] an investigation related to foundation concepts from the perspective of established service theories and frameworks is proposed. It maps the proposed service system concepts on the selected service theories and frameworks. The analysis is visualized in a multi-view conceptual model (UML representation), trying to explicitly and formally define service system ontology. In [10] main concepts related to service orientation in manufacturing are presented that a special extension of a general ontology (related aspects to service innovation and fundamental concepts in Service Science domain) should include for later developments.

All the above mentioned approaches refer only to specific parts of knowledge that can be related to Service Science and its supporting technologies.

The novelty of the approach proposed in this article is the *holistic view on knowledge* dedicated to this domain. According to this approach information related to the multidisciplinary sub-domains that can be gathered under the umbrella of the broader term "Service Science" is classified as specific *knowledge resources*. Based on literature review, including the DELLISS project [1], [11], section 2 describes the definition of a *knowledge model* in a *Knowledge Environment*, represented as a tree of interrelated concepts (an ontology-based classification of *knowledge resources*). Section 3 proposes a general integration perspective towards a Service Science ontology development, that is further reflected as a foundational step in the design of the extended SSKE ontology. Section 4 is based on an extended literature review and draws clear steps to extend the general Service Science ontology towards the formation of connections with other knowledge resources in the extended SSKE ontology. Section 5 presents a brief description of the Service Science Knowledge Environment. The article concludes with final remarks on the appropriateness of this application as an environment to bring together academia, business and governmental institutions, allowing them to contribute on building and sharing knowledge in the field.

2 Requirements Definition

During the last decades a huge amount of literature on Service Science was delivered on paper as well as digital content, drawing a clear need on designing a detailed classification of the main concepts related to this interdisciplinary domain. Starting from here, specific requirements for a dedicated environment were drawn. In this respect, the proposed *Knowledge Environment* was supposed to include and classify *knowledge resources* related to Service Science, for example `Articles`, `Projects`, `People` knowledgeable about `Projects`, that write `Articles` and use `Technology` in certain `Service Sectors`. It would have to host digital content collaboratively available to a whole community, to be used in three different perspectives [10]: (1) to exploit a database highlighting an educational *knowledge path* on Service Science, fostering *service innovation* in different *service sectors*, based on *fundamental concepts* related to Service Science; (2) to increase the service companies visibility; (3) to report new methods, tools and software applications in order to *develop IT services* and to accomplish *service automation*, fostering *service innovation*.

According to the approach proposed here information related to the multidisciplinary sub-domains gathered under the umbrella of the broader term "Service Science" was classified as specific *knowledge resources* in the **extended SSKE ontology** (Fig. 1). The relationships between the main *knowledge resources* were identified and they were interconnected to each other.

`Domain fundamentals` is a knowledge category in the ontology that refers information concerning specific fundamental concepts approached in three perspectives: (a) *business oriented*, b) *IT oriented* and c) *service orientation of processes* (Fig. 2). Two important and inter-related `Service Theory` approaches have emerged in past decade: a) *Service Science*, as an interdisciplinary approach to the study, design, implementation, and innovation of service systems, developed in 2004 by IBM [12] and *Service Dominant Logic*, developed in the marketing research community [13], [7] and considering the service as the basis of exchange. `ServiceScienceConcept` category (Fig. 3) undergoes entities, interactions, and outcomes to explain the evolution of value co-creation interactions. It can be derived by the generalization of the concepts offered by the study of service systems and by the emerging service dominant logic [14].

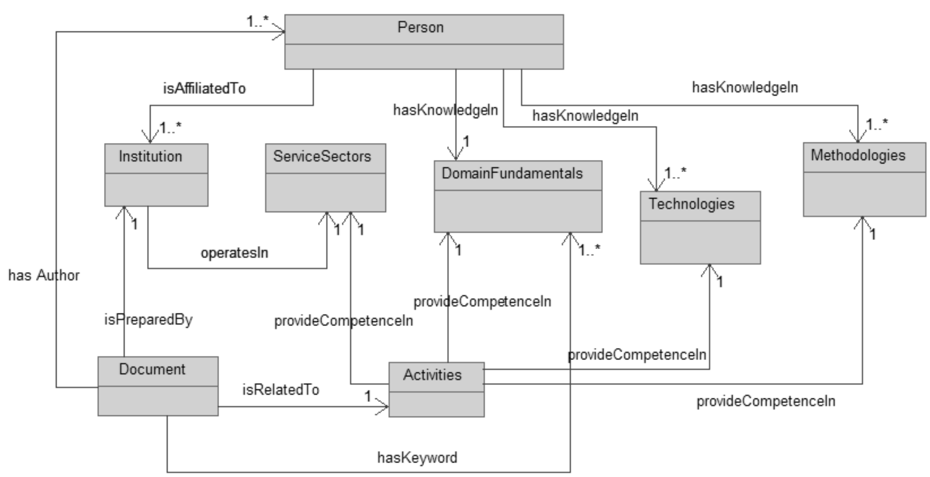

Fig. 1. Knowledge resources classification - extended SSKE ontology concepts

`Document` represent a knowledge category that describes the documentation stored on the knowledge environment, consisting mainly of articles, journals, case studies, books, patents, proceedings, reports, standards, theses and standard specifications. All the above-mentioned types of documents are built in the ontology as sub-classes of a main class called `Document`.

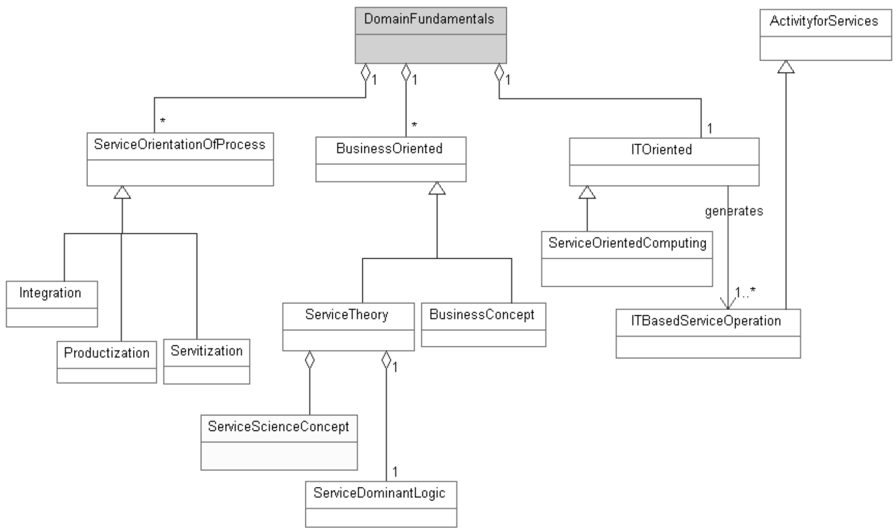

Fig. 2. Extended SSKE Ontology - `Domain Fundamentals` related concepts

`Institution` category sub-classifies in `Academic` and `Business` institutions. A subsequent classification divides the Academic institutions into `Faculties` and `Universities`. An `Institution` may operate in a certain service sector (usually this is available in the case of business companies, but also for some academic centers).

`Activities` is a class that records various initiatives, holding a subclass for each of them: `Project`, `Educational Program`, `Event` and `Support Activities for Services`.

`ServiceSectors` is a special class dedicated to the areas where Service Science can be applied. It refers to different service sectors such as E-Administration, E-Government, Software Services, Manufacturing, Supply Chains and Logistics, E-Health, Telecommunications, Smart Grids.

Technology plays an important role in service innovation, that is why it was considered to be a stand-alone topic in SSKE that requires a dedicated class in the ontology, `Technologies` (e.g. *4G technology*). It is considered that a certain technology can be of either a software or a hardware nature, leading thus to a specialization of two subclasses from the main parent class: `Hardware` and `Software`. The current classification doesn't offer too much insight on further sub classing,

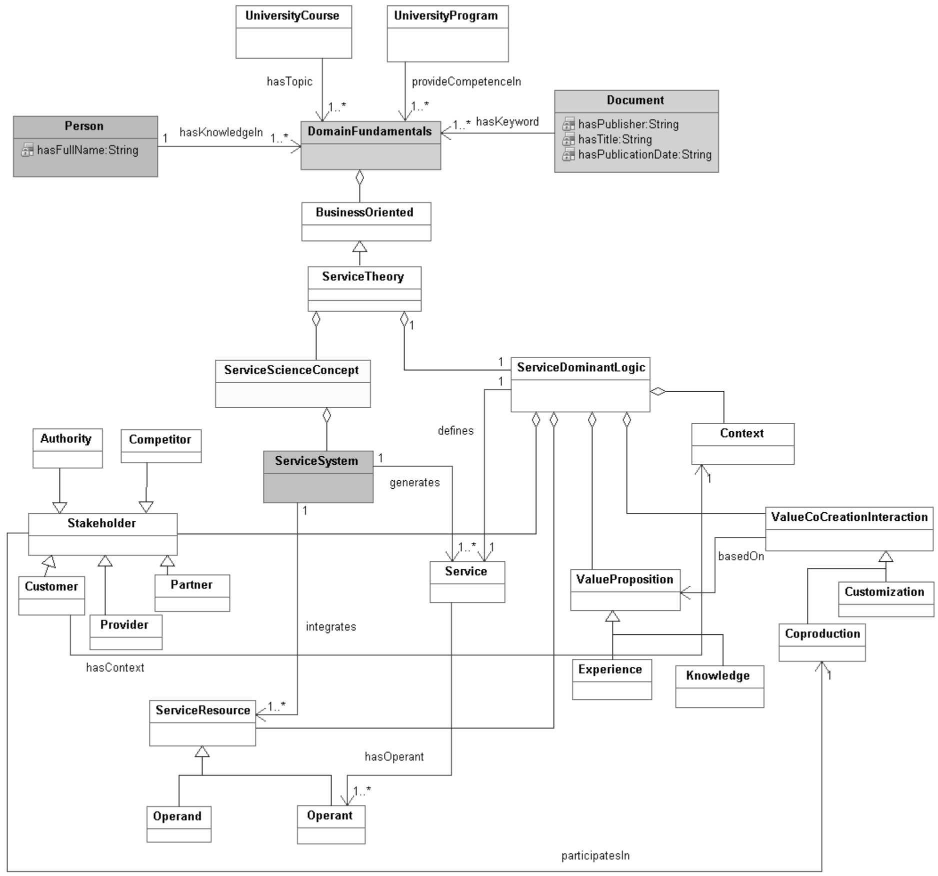

Fig. 3. Extended SSKE Ontology - Service Science related concepts

leaving enough room for future sub-categorization if needed. `Methodologies` is an ontology class created as a category for different instances of methodologies that apply in the Service Science, be they theoretical or practical (e.g. *Business Process Modeling*, *service blueprinting*, etc.).

3 A Systems Approach for a General Service Science Ontology

This section presents a novel approach towards the integration of different multidisciplinary concepts related to the Service Science domain. It basically starts with the integration of a systemic approach towards an ontological description of service systems, correlating major knowledge categories from three perspectives: *Service Science*, *Theory of Organizations* and *Systems Theory*. It is reflected in the extended SSKE ontology under the `Domain Fundamentals` knowledge resource category, in Fig. 3. This structure was firstly proposed in [5], based on the *Systems Approach* introduced by [18] and on the *systems models formalization* discussed in [19] and [20]. The version adopted here (Fig. 4) is simpler and reflects directly the basic concepts and relations derived from Service Science, and the relations of these concepts with the more general basic concepts derived from *organizational systems theory* and *systems of systems and viable systems theory* [18], [21], [17], [22], [23], respectively.

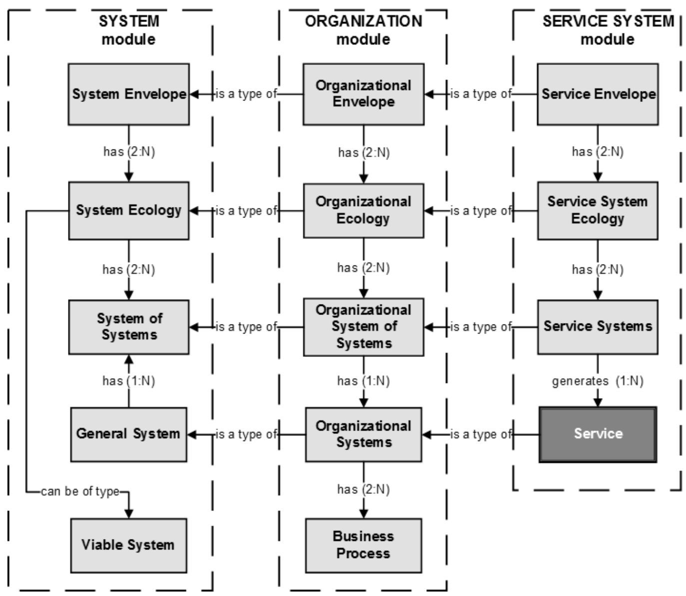

Fig. 4. A general ontology structure for Service Science domain as reflected by the extended SSKE ontology

As current literature reflects, Service Science is an interdisciplinary approach to the study, design implementation of service systems that was developed in 2004 by IBM [15]. Service Science is based on ten foundational concepts [16]: (1) **Resources**, (2) **Entities**, (3) **Access rights**, (4) **Value co-creation interaction**, (5) **Governance interaction**, (6) **Outcomes**, (7) **Stakeholders**, (8) **Measures**, (9) **Networks**, and (10) **Ecology**, which are described and discussed in the service literature, from different perspectives [17]), [9], [5], see also Fig. 5.

The ontological description for Service Science domain, thought from a systemic perspective, is structured here into three main modules, with increasing levels of generally, respectively (Fig. 4): (1) service system description (the *SS module*); (2) organizational system of systems description (the *Organization module*); and (3) systems of systems description (the *Systems module*).

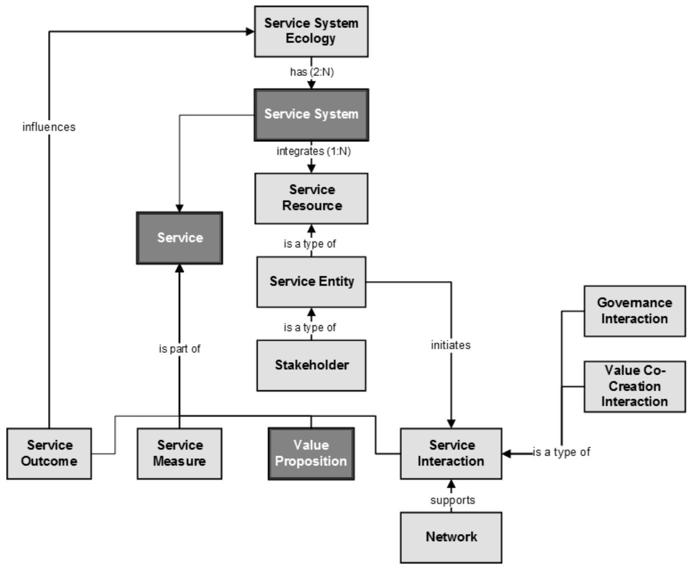

Fig. 5. Ten foundational concepts for Service Science

There are two main reasons for adopting a philosophy very similar to the one proposed in [5]. Firstly, OntoServSys [5] relies upon a very rigorous formalization of the concepts of *System of Systems*, *General System*, and *Organizational System*, respectively, presented in earlier works [19]; this permits proposing non-ambiguous relations between more specific concepts, like *Service System*, and more general ones, like *Organizational System of Systems* or *System of Systems*. Secondly, considering Service System from the System of Systems perspective allows an adequate description of the role and place of System Viability. The *Viable Service System* concept [17] plays an important role in understanding the implementation of intelligent, IT-based Service System instances; in this view, a *Viable Service System* is thus only a subclass of a *Viable System*.

The methodology proposed here for building the ontological description comprises two major processes: (1) a gradually refinement of the granularity of the service system description, starting from the ten foundational concepts, on one side, and (2) the interconnection of the *Service System* description with the *Organizational System* description and *System of Systems* description, respectively. These design stages are briefly discussed below.

A. A basic Service System ontology. Fig. 6 describes a first approach in the description of the Service System, based on the ten foundation concepts of Service Science. The relations, or conceptual links, are of same types as the ones proposed in [5]. Except the central concept, `Service System`, the other two concepts which are not among the ten foundational Service Science concepts are: `Service` and `Value Proposition`. In the proposed *Service System* basic ontology, the concept `Service` collapses a twofold significance: (1) A *clas-*

sical economic meaning: `Service` as a client-provider value proposition based interaction and (2) A *Systems Approach meaning*: `Service` as a subsystem of the `Service System`, composed of interconnected `Business Processes` aimed to generate value propositions and corresponding service interactions.

Type of link	Significance
B is a type of A	The concept named B is element of an upper category named A
B can be of type A	A concept named B can be abstractly instanced in a category named A. The "can be of type" relation is less restrictive than "is a type of" relation.
B is part of A	The concept named B is a mandatory part of the concept named A.
A has(min:max) B	The concept named A has between a min and a max number of concepts named B.
B is instance of A	The concept named B is a particular real or conceptual case of a concept named A.
B general relation A	The concept named B is in a user defined relation with a concept named A.

Fig. 6. Relations and their significance (adapted from [5])

With this last meaning, the `Service` is composed of its major parts: `Service Outcomes`, `Value Proposition`, `Service Interactions` and, of course, the `Service Measures` making possible the performance evaluation of the outcomes. `Value Proposition` - if successfully repeated, understood as a business model [16] of the firm modeled as `Service System` - is the promise the provider makes to the customer, if the last one accepts to interact and "buy" this promise. The relation "`Service System` *generates* `Service`" emphasizes the fact that the `Service System` triggers the events that start the business processes in the `Service`, considered as a subsystem. In this view, the `Service Resource` and `Service Entity` concepts, i.e. the means and actors, are related to the `Service System` upper level, and not to the `Service` lower level.

B. Including details: a finer granularity Service System ontology. An increase in the granularity of the basic Service System ontology can be obtained by processing the specifications concerning the ten foundational Service Science concepts [16], [17]. This drives to a richer domain and a richer set of relevant conceptual relations [24].

In this proposal, the details included in the basic Service System ontology refer new relations between existent concepts (Fig. 7) and new concepts (Fig. 8) together with the new corresponding relationships (Fig. 9).

Source Concept name	Relation	Destination Concept name
Stakeholder	Evaluates	Service Measure

Fig. 7. The basic Service System ontology – new relations between existent concepts

New concept name	Significance
Service Envelope	Supra-system for Service Envelop
Economic System	
Socio-Cultural System	
Technological System	Subclass of Service Envelope
Political-Legal System	
Natural Ecological System	
Owned Outright	
Leased-Contracted	
Shared Access	Subclass of Access Right
Privileged Access	
Technology	
Shared Information	
Person	Subclass of Service Resource
Organizational System of Systems	
Customer	
Partner	
Authority	Subclass of Stakeholder
Competitor	
Provider	
Quality	Subclass of Service Measure
Productivity	
Compliance	
Sustainable Innovation	
Value	Subclass of Service Outcome

Fig. 8. The basic Service System ontology – relations between new concepts [16]

Source Concept name	Relation	Destination Concept name
Service Envelope	has(2:N)	Service System Ecology
(Economic System, Socio Cultural System, Technological System, Political Legal System, Natural Ecological System)	Is part of	Service Envelope
(Owned Outright, Leased Contracted, Shared Access, Privileged Access)	Is a type of	Access Right
(Socio Cultural System, Political Legal System)	Influences	Access Right
(Technology, Shared Information, Person, Organizational System of Systems)	Is a type of	Service Resource
(Customer, Partner, Authority, Competitor, Provider)	Is a type of	Stakeholder
(Customer, Partner, Authority, Competitor)	Is part of	Service System Ecology
Service Measure	Can be of type	(Quality, Productivity, Compliance, Sustainable Innovation)
Service Outcome	Can be of type	Value

Fig. 9. The basic Service System ontology – new relations between new concepts and other concepts

C. A systemic perspective – Integrating the Service System ontology with a System ontology. In the sense discussed in [24], one can consider the Service System ontology a domain ontology that can be related to more general, upper level ontologies.

Fig. 4 depicts the fundamental aspects of this integration process. The **System** module is a simplified representation of a *System of Systems* top-level ontology, while the **Organization** module is a simplified representation of *Organizational System of Systems* ontology. This last ontology refers artificial Systems of Systems and it has a higher degree of generality than the Service System ontology. The `Business Process` concept included in the management subsystem in the operational subsystem of an organization [19] represents an upper class for the service processes evolving in the `Service` as a subsystem of the `Service System`. Note also that the link from the `Service System` concept to the `Organizational System of Systems` concept, and, finally, from this point to the `System of Systems` concept and to the `Viable System` concept illustrate the high level of generality of systems′ viability, as key survival condition: natural and artificial systems may both share this attribute. In a specific way, modern IT-based technologies provide the opportunity, for artificial systems, to mimic the specific behavior patterns of viable natural systems.

4 Extending the general ontology structure for Service Science

This section presents a working style in extending the general Service Science ontology towards relation formation with other knowledge resources in the extended SSKE ontology. It presents the integration of a specific knowledge category, `Activities for Services`. As Fig. 4 presents, an `Organizational System` is a type of `General System` and consists of a set of business processes performed into two main subsystems: the management system and the productive system [19], [5]. According to [25], a `Business Process` consists of a set of activities that are performed in coordination in an organizational and technical environment. These activities jointly realize a business goal. Each `Business Process` is enacted by a single organization, but it may interact with business processes performed by other organizations. At the same time, an `Activity for Services` (Fig. 10) is a kind of `Business Process`.

The activities that a company fulfills in order to achieve its business goal or business functions [25], [26] can be partitioned into primary, or core functions and support functions. Each of `Core Activities for Services`, `Support Activities for Services`, `Service Performance Evaluation` *is part of* `Activities for Services`. Also, as the management system always needs a feedback to its decisions, and as value co-creation is a characteristic desired `Service Outcome`, creating value makes necessary the process of `Service Performance Evaluation`. In a `Service System`, the `Service Performance Evaluation` process is aimed to monitor and analyze the information provided by `Service Measures` (Fig. 11). From different perspectives, defined by the `Stakeholder`′s interests, the service measures as Key Performance Indicators (KPIs) contribute to define the service performance.

5 SSKE Implementation

The extended SSKE ontology for Service Science was implemented in a collaborative physical platform available on-line at `http://sske.cloud.upb.ro` and

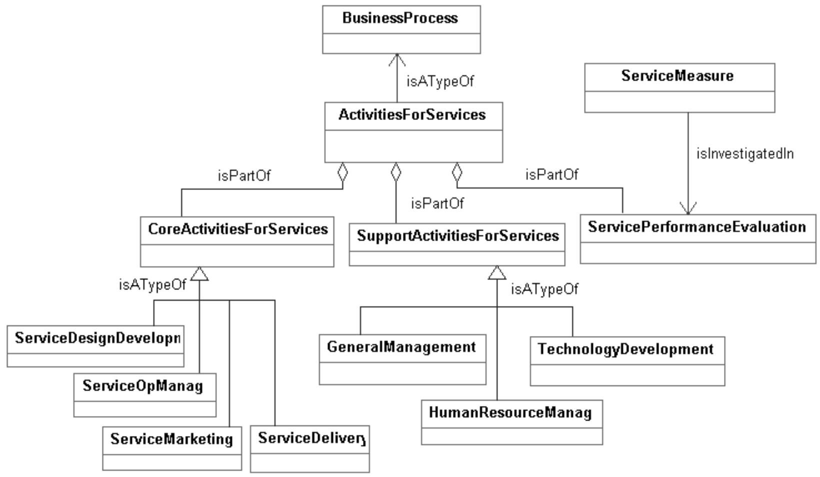

Fig. 10. Extending the Service Science ontology - `Activities for Services` in the extended SSKE ontology

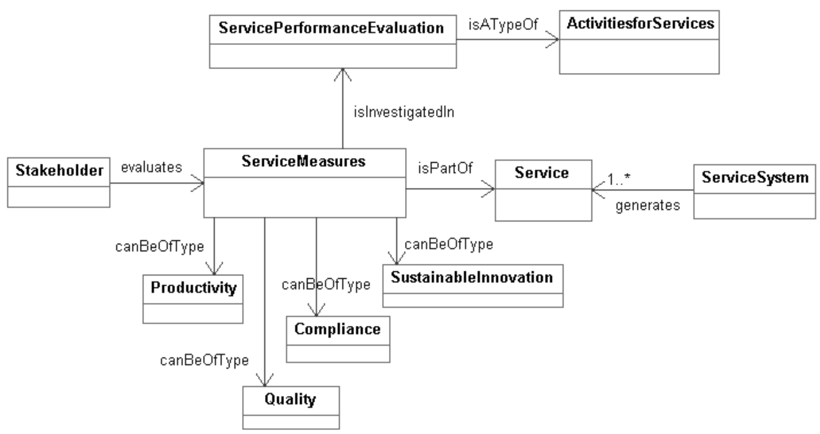

Fig. 11. Extending the Service Science ontology - Service Measures

the map of information classified in the SSKE as knowledge resources dedicated to the Service Science domain can be inspected in the `Keywords` section. Wiki technologies were chosen to store the environment in the cloud [27].

The flow of work consisted on firstly building the ontology and then integrating it in the cloud-based deployed wiki. The entire flow actually consists of multiple steps, briefly described as follows:

1. The *design of the ontology* dedicated to Service Science *knowledge sharing*. The main entities and the relationships between them were identified and

presented in section 2. Further, the ontology was built using an ontology editing tool (e.g. Protégé), that stores the internal representation of the graphical UML model in one of the possible ontology languages, like RDF or OWL. Next, the conceptual model exported in a RDF file was imported it into the wiki. Once the model is imported into the wiki, the wiki engine offers a graphical view of the ontology;
2. *Deployment in the cloud.* The SSKE is the knowledge resource sharing component of the INSER@SPACE [28] for which the cloud computing technology along with its related business model were used;
3. *Knowledge retrieving.* This working capability allows stored knowledge to be retrieved on a graphically form through the query interface.

6 Conclusions

The main goal of the approach proposed in this work was to define an extended view on different concepts related to the development of the Service Science domain of study, reflected in the **extended SSKE ontology**. Based on this extended ontology classifying different knowledge resources related to this domain, a collaborative environment – the **Service Science Knowledge Environment** (**SSKE**)– intended to gather together different academic partners was developed with the overall aim of creating a body of knowledge in the areas of *science*, *design* and *management of services*, while promoting *service innovation* in different service sectors. It supports sharing relevant information on Service Science stored in a structured way based on a common vocabulary using the extended integrated ontology.

The perspective introduced by this approach connects Service Science fundamental concepts to business related concepts. The SSKE was developed on three directions, i.e. *research*, *education* and support for *business alliances*. In a *Service Science* approach, service *organizations* are studied as *service systems* evolving in their environment (*service system ecology*), in the pursuit of their business goal, according to a specific business model called service business model. Service business models reflect the features of the *service sector* to which the organization belongs to and finally they describe *activities for services* as *business processes*. Successful *service business models* are crucial for the *service system viability* and they are related to *service innovation*.

As this work describes, specific items of service business models such as a) target markets and *customers*, b) product offerings or *value propositions*, c) distribution channels (*activities for services*), and d) constraints and profits, together with the description of case studies and business solutions in various *service sectors* are subject of intense research and debate in the *Service Science* literature.

The SSKE platform foster service innovation by allowing different stakeholders to arrive to a consensus in terms of Service Science fundamentals and build together the future knowledge in the field of Service Science. In the future, research groups can also come together to further extend the proposed shared conceptualization.

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