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An informational perspective on the ontology of services

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Abstract

The notion of services, although intuitive and used in many domains, is difficult to define from an ontological point of view. However, a formal representation of services would be particularly relevant in the healthcare and social services domain to support domain ontology alignment. In this article we draw on previous ontological work about services to propose an adaptation focused on Basic Formal Ontology and ontologies from the biomedical domain. We provide definitions and axioms following the OBO Foundry methodology with a focus on informational entities. This ontological model is a first step towards a better integration of existing domain ontologies in a healthcare services framework.

Keywords

information content entity, services ontology, healthcare

1 Introduction

Learning health systems (LHS) aim at improving concrete, significant problems in a health system by using data generated by the system to identify challenges, propose novel solutions and then facilitating the transfer of knowledge from research to care activities. To fulfill this goal, they rely on the interoperability between data that are often distributed in many clinical information systems [15]. However, such information systems may not share the same semantic. To address this issue, applied ontologies can provide a common, source-independent representation of clinical information [8]. With this goal in mind, several ontologies have been developed for domains such as drug prescriptions [10] or laboratory test results [4], as part of a distributed data access platform supporting LHS.

In a previous work, we proposed to represent the set of activities related to the improvement of health status of an individual or population using two classes of planned processes, *Health Procedure*, which are processes with an established objective of having a desirable impact on the health status, and *Health Activity* which constitute the building blocks of health procedures but can also be carried out independently of any health procedure [11]. Such classes allow us to represent health related processes as applied to individuals. While some processes might be carried out at the initiative of an individual in his or her home (e.g. measuring one's weight), a large portion of processes currently generating health data is instead originating from various stakeholders interacting together as part of the healthcare system. There is therefore a need to clarify how these activities are related to the general environment of healthcare and social services. To address this, we present here an ontological model of service that can encompass health procedures to better represent the integration of health procedures into an ontological framework for services.

In the following section we will review existing definitions (both terminological and ontological) for "service". We will then detail our proposal and the different classes needed to support this definition. As part of our endeavour to support LHS data sharing, we develop ontologies describing the structure

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of various clinical documents that are used to generate a relational database structure [16] that is then mapped to databases from various healthcare institutions, in order to support a system of data mediation. [9] Consequently, our work will focus primarily on informational entities that are generated during the course of a service.

2 Existing representation of services

Even leaving aside its military or religious meanings, the term “service” is highly polysemous in common language. For example, the Cambridge dictionary [21] offers several definitions of service, among which: “work done, or help provided, esp. for the public or for a person or an organization” or “a system, organization, or business that provides for a public need, or the operation of such a system”. In addition, definitions of “service” are based on terms that are themselves rather ambiguous such as “provider”, “consumer”, or “supplier”.

The term “service” is also extensively used in economics and a review of the literature on the use of the term “service” by Edvardsson et al. [7] suggests considering a service as a perspective on value creation from the customer point of view.

In the biomedical domain, several ontologies from the OBO Foundry [20] directly define service or service-related classes, with overlapping definitions:

- NCIT [19] defines *service* as: “Work, or a product of that work, done by one person or group that benefits another.”
- OBI [2] defines *service* as “A planned process in which a service provider performs a task (i.e. a planned process) for a service consumer.”

OBI defines also two roles realized in a service:

- A *service provider role*: “is a role which inheres in a person or organization and is realized in a planned process which provides access to training, materials or execution of protocols for an organization or person”
- A *service consumer role*: “a role which inheres in a person who uses a service”

Not limited to the biomedical domain but also based on BFO, the Common Core Ontology proposes a commercial exchange ontology [17]. However, while it defines the class *commercial exchange* as a process, it does not directly define the term “service” but a class *service provider* as: “An Organization whose purpose is to provide a service to other Agents.”

These definitions highlight the fact that, when used alone, “service” might refer to an outcome, the actual process of producing an outcome or even the capability of providing an outcome. Some authors [12] argue that the polysemy of the term “service” implies that one should not introduce a class *service* (simpliciter), but rather a set of interrelated classes representing different aspects of the service domain. Nardi et al. [18] details three phases of a service:

- service offer in which “services are publicized to target consumers”;
- service negotiation characterized by the “interaction between provider and customer in order to establish an agreement”;
- service delivery which consists of the fulfilment of said agreement.

Ferrario and Guarino [12] identify five proper parts in a service: service commitment, service presentation, service acquisition, service process and service value exchange. These analyses of service have in common the notion that at the core of a service is a commitment that captures both the obligations of the entity which offer the service and the one who demands it. These analyses of service are based on different high-level ontologies, namely DOLCE [13] and UFO [14] and are not directly transposable to our BFO-based ontologies. In addition, since our methodology consists in developing ontologies describing the structure of various clinical documents that are used to generate a relational database structure, we need to describe the various informational entities that are involved with a service.

3 Methods

An important principle in ontology development is to ensure the univocity of terms, i.e. a term should have the same meaning on every occasion of use [1]. The previous section highlights the difficulty of attaining this for the term “service”. Therefore, rather than aiming to define a class *service*, which may be semantically too broad to be relevant, we will discuss the main entities involved in services. We will then introduce OWL classes and object properties to represent these entities.

These classes are built following a realist approach based on BFO. We will also emphasize the relevant informational entities. In this respect we adhere to Smith and Ceusters’s definition of *information content entity* (ICE) as a *generically dependent continuant* concretized by a *quality* that inheres in an *independent continuant* and that is about something [6]. Of note, information content entities can be concretized not only in a material support such as an ink pattern on a paper or a pixel arrangement on a computer screen, but also in what the authors call “mental quality” which “specifically depends on an anatomical structure in the cognitive system of an organism.” Thus, there is a continuity between mental entities and information externalized for communication purpose.

In addition, we use the object property “directs” and its inverse properties “is directed by” [3]. This property defines a relation of directedness between a directive information entity and a process.

In accordance with the OBO foundry principles, classes and properties from other ontologies are reused as much as possible to maintain orthogonality between OBO ontologies. In addition, textual definitions following an Aristotelian structure and important axioms are provided.

4 Results

Among the characteristics mentioned above, three aspects of services seem determinant to us and will be described in more details below:

- An intersection between an offer and a request;
- A negotiated agreement;
- The execution of some processes.

4.1 An intersection between an offer and a request

Nardi et al. [18] consider that the starting point is the establishment of a service offering between a service provider and a target community. From an informational entity point of view, we consider two information content entities at this level, a “service offer” and a “request”

A *service offer* details the kind of processes a party is willing to fulfill, as well as the necessary conditions (the expected compensation for example) for them to accept to attempt to realize these processes. A menu in a restaurant for example. A service offer is an ICE that is about some type of processes, and usually includes specifications intending to direct these processes.

A *request* describes one or several processes a party wants to see instantiated (whether for its own benefit or that of another party). For example, what a customer will order in a restaurant, whether it is on the menu or not. A request involves an aim at directing processes, but as it can also contain non-directive information, such as the identification of the requester, we classify *request* as a subclass of *ICE*, rather than a subclass of *IAO:directive information entity*.

There is no fixed sequential order of appearance established between the *request* and the *service offer*: in some cases, the *request* may arise from the awareness of a *service offer* while in other cases, the latter follows the *request*. We consider that not only the presence of these two entities is necessary for services, but also that the request party and the service offer party are distinct. Indeed, in the common use of the term “service”, what people do for themselves does not enter into the domain of service. For example, I may initiate the request to have my lawn mowed. If I do it myself, the lawn mowing process does not take place in a service context. However, if I hire a gardening company that presented me a lawn mowing service offer, the lawn mowing process would then take place in a service context. While an individual can satisfy his own requests, the service offer must originate from another party.

We propose the following Aristotelian definitions and axioms:

*request*_{=def.} “An information content entity specifying one or several types of processes that a party, whether a person or an organization, wants to see instantiated for the benefit of itself or another party.”

*service offer*_{=def.} “An information content entity describing the processes a person or an organization is willing to perform, usually for a compensation.”

request subClassOf (has_part some *directive information entity*)

4.2 A negotiated agreement

We have identified two parties, which can be individuals or organizations, at the origin of services: one expressing a request (request party) and the other proposing an offer (service offer party). In a subsequent step, both parties interact to reach an agreement. After a certain number of back and forth, if the negotiation is fruitful, the service offer party commits itself on a series of specifications to be followed when fulfilling the processes and the request party accepts this commitment as satisfactory and in turn commits itself to fulfill the required conditions for the realisation of these processes, such as compensation or availability. Both commitments will constitute a service agreement. To note, service agreements are social entities, and their descriptions in such an ontological framework is a complex subject that goes beyond the scope of this article (see e.g. [5] for more discussion on socio-legal entities in the context of BFO). Instead, we propose an informational perspective on this question. We introduce the informational entity that specifies the social agreement: a “social agreement specification”.

These agreed specifications might differ from the initial service offer as they represent a compromise acceptable to both parties. This is the archetypal case. In some cases, the negotiation is mostly an exchange of commitments based on pre-existing service offers or other considerations. For example, ordering from a fast-food should minimise the negotiation phase, otherwise the “fast” part of the endeavour might not be met. Another important aspect is that a core participant to the service delivery might not participate to the negotiation. For example, pediatric care with toddlers usually involves a parent as a request party and a health organisation as a service offer party. The child him/herself is often not part of the decision (vaccines being a contemporary example). A similar situation occurs in court mandated mental-health hospitalisation where the request party is the court and the service offer party is the health organisation.

We therefore define a *service agreement negotiation* process that takes as input a *request* and a *service offer* and that aims to generate a service agreement through a negotiation between the parties involved. This process will not always output a service agreement because it can fail if the parties do not agree. In addition, this negotiation is limited in some cases to the acceptance of the terms of the service offer party service by the request party.

We propose the following Aristotelian definitions and axioms:

*service agreement negotiation*_{=def.} “A planned process of interaction between a request party and a service offer party having as specified input some request and some service offer and that aims to generate as output a service agreement.”

*service agreement specification*_{=def.} “An information content entity that specifies a service agreement made between a request party and a service offer party. A service agreement specification can direct some processes that correspond to what has been agreed between the parties.”

service agreement negotiation subClassOf (has_specified_input some *request*)

service agreement negotiation subClassOf (has_specified_input some *service offer*)

4.3 The execution of some processes

The dimension that is arguably the most easily associated to services is the execution of processes, resulting from an agreement, for the benefit of someone or a community. Nardi et al. [18] proposes to differentiate these processes according to whether they are carried out by one, the other or both of the parties involved, and includes them in a service delivery entity. The authors separate these processes according to their participants by dividing them into two categories: customer and provider. We believe that this distinction, although commonly used, may be incomplete for delimiting them. Therefore, we prefer in a first step to identify a generic type of process, *service delivery*, that includes all service specific processes performed by the parties involved. An important common factor in all these processes is that they are detailed in the service agreement.

In BFO-oriented ontologies, we consider a *service delivery* as a subclass of OBI:*planned process*. What distinguishes it from other planned processes is the fact that it is directed by a *service agreement specification*. We propose the following Aristotelian definitions and axioms:

*service delivery*_{=def.} A planned process that aims at fulfilling the commitments of a service agreement.

service delivery subClassOf (is_directed_by some *service agreement specification*)

5 Discussion and conclusion

With this work we propose a representation of services related entities based on Nardi et al. seminal work adapted for BFO ontologies with a perspective focused on informational entities. It is built around a *service negotiation process* that takes as input a *request* and a *service offer*, and a *service agreement specification* that is about a service agreement and directs some *service delivery*. This representation allows us to integrate our previous work on health procedure into a more global healthcare service framework. As a *health procedure* is a *planned process*, we can assume that it can also be a *service delivery* if it is directed by a *service agreement specification*.

Yet, there are some points in the representation of services that have not been addressed here, particularly concerning the processes' participants and their roles. While it is usually established to characterize services processes, participants or roles in terms of "provider" or "customer", we consider that these notions are not as clearly delimited as they seem and are even sometimes overlapping. Instead of hiring a company to mow my lawn, I could participate in a service exchange with another person who would come in exchange for piano lessons, for example. Moreover, it seems to us that roles evolve between the different stages of the services. Indeed, the role born by the service offer party does not seem to us to be necessarily the same as the one born by the participants in the resulting service process from the service offer party. For example, the role worn by a restaurant as a whole differs from the roles of the different people who work there, from washing dishes to accounting. This strikes us as especially relevant in a healthcare context, where it seems arbitrary to assign, for example to a hospital or a surgeon, the similar roles of "provider".

A possible solution would be, instead of using precise roles in order to distinguish between parts of *service delivery* processes, to define instead different object properties characterizing the various possible forms of participations of actors to processes and more specifically service delivery.

Finally, we believe that this work also highlights the need for mid-level ontologies between upper-level ontologies and domain ontologies. While the notion of "service" is not domain-independent enough to be directly integrated into an upper-level ontology like BFO or UFO, it also seems to us to go beyond the purely biomedical or commercial domain.

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