Interpreting Service Using an Upper-level Ontology

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Abstract. The emergence of service analysis, design, architectures and solutions presented in service marketing and software engineering literature has created a need for understanding the nature of services. Services are often considered as possessing characteristics that are assumed to pose specific problems for service providers as opposed to providers of goods. This paper presents an ontological interpretation of the concept of service using a general and upper level ontology with a strong base in natural sciences. The Basic Formal Ontology (BFO) is used to interpret the concept of service, as defined in the Service Dominant Logic approach. The interpretation is demonstrated in an analysis of service characteristics, in relation to goods. The ontological and reductionist approach opens up to a formulation and analysis of service, a social and economical phenomenon, in terms of general natural science oriented concepts. The ontological grounding provides a language that supports alignment of specific service definitions used in different subject fields, as well as alignment with adjacent concepts such as capability. The interpretation and analysis support the conclusions that studied characteristics are relevant to the concept of service, although they cannot be considered as determinant characteristics of service, and from a practical point of view they contribute partially to observed concerns and problems.

Keywords: Service, Ontology, Basic Formal Ontology, Service Dominant Logic.

1 Introduction

This paper revisits the concept of *service* and explores a novel kind of ontological interpretation that enables a reductionist analysis of the nature of services, its similarities with and differences from goods.

The distinction between, and duality of goods and services have been a vibrant topic of economical, market, and software engineering research and practices. The word 'service' has been part of natural language since 13th century and subsequently carries substantial common sense meaning. The topics of services and goods have been discussed amongst economists [1], such as by Adam Smith in his book, The Wealth of Nations, from 1776, and the discussions continues even today.

The search for defining and distinguishing characteristics of service have constituted a key research topic, however practitioners [2] and researchers [3],[4] find that characteristics such as intangibility, inseparability, heterogeneity, perishability does

not constitute major service problems and are not determining criterion of services. The on-going debate illustrate that a deeper understanding of the concept of service is needed.

This paper address the question if it is possible to create a formulation, interpretation, of the concept of service, using a higher level ontology, that can be used to explain the differences in argumentation relating to service characteristics, relations between services and goods, and practical consequences of servicing.

This question is part of a design science inquiry into the requirements that influence the design of a knowledge organisation construct, Ability Perspective, an (Enterprise) Architecture Viewpoint [5]. In the design of an Ability Perspective it is important that knowledge about capabilities [6], and abilities are aligned with related, adjacent concepts such as service since service is sometimes considered as a mechanism to enable access to a set of one or more capabilities [7]. Furthermore, the use of an upper-level ontology provides an ontological grounding, a language, that support alignment of specific service definitions used in different subject fields, e.g. organisational design, marketing and information technology (IT).

The aim of this paper is to present of an ontological interpretation of the concept of service in terms of general concepts. The upper-level ontology - Basic Formal Ontology (BFO) [8] - is used to interpret 'service' as defined by Vargo and Lusch in their Service Dominant Logic (S-D Logic) work [9, 10]. The interpretation is explored and demonstrated in an analysis of service characteristics and relations to goods. For brevity, this paper covers an analysis of the frequently cited characteristics; intangibility, inseparability, heterogeneity, and perishability.

The main contributions of this paper are firstly, a novel ontological interpretation of the concept of service using a upper-level ontology that provides a bridge between natural and social sciences, and offers clarifications of the constituent parts of the concept of service. Secondly, conclusions that analysed service characteristics are relevant but not determinant, and that practical implications of the service characteristics depend on specific kinds of services. Thirdly, the introduction, in section 3.2, of the *'lead-to pattern'* that provides a novel and flexible approach for informed reasoning about value creation along *Result Ladders* up to the *Service Horizon*.

The paper is structure as follows: In section 2 an outline of the objects of analysis, services characteristics and aspects, is presented. In the 3rd section, the theoretical basis is introduced. I section 4 an interpretation of the S-D logic service definition using BFO is presented. The services characteristics are then analysed in section 5. The paper is concluded with sections with future research and conclusions.

2 Services characteristics

In this section the service characteristics that are chosen as subject of interpretation and analysis are presented. They are well known, and often cited as vital and relevant in service marketing literature by scholars [2], [1], [4], [3]. These characteristics are argued to separate services from goods and that they constitute major cause for service concerns and problems that are different from goods concerns and problems.

The **intangibility** characteristic of service suggests that the performance, application of competences don't have material qualities and cannot be experienced, seen, heard, felt, smelled, or tasted. According to Zeithaml [2] service specific problems include: services cannot be stored, services cannot be protect through patents, cannot readily display or communicate services, and prices are difficult to set.

The **inseparable** characteristic suggests that both a producer and consumer that must be both present at the time of performance of the service; i.e. a service is produced, delivered and consumed simultaneously, and centralised mass production of services is difficult [2].

The **heterogeneity** (inconsistency, variability) characteristic relates to the variability, inconsistency, of a service performance. A service may be rendered differently over time and space, and some qualities may vary across service producers, e.g. a person could by tired one day and well rested another day, standardisation and quality control are difficult to achieve [2].

The **perishability** (inventory) characteristic relates to that a service, a performance of services, or application of competences, cannot be stored for future reference, delivery, or use [2].

3 Theoretical basis

The theoretical basis consists of three parts; the subject of interpretation: a service definition from Service Dominant Logic, an upper level ontology - Basic Formal Ontology, and additional analytical tools.

For clarity the names, designations of previously defined concepts are prefixed with an abbreviation indicating the ontological domain they belong to: sdl: Service Dominant Logic, bfo: Basic Formal Ontology, ext: Analytical tools, extensions.

1.1 Services according to Service Dominant (S-D Logic)

As the subject of interpretation and analysis the service definition from Service Dominant Logic by Stephen L. Vargo and Robert F. Lusch [9] is selected because it is well known, contemporary, and consists of relatively few parts, thus making interpretation, reduction, reformulation and analysis feasible.

The Service Dominant Logic is an approach, perspective, mind-set, and theory about the nature of *service*, in relation to goods, within the realm of marketing and economic exchange. S-D Logic offers an alternative to the prevailing dominating goods perspective. Instead of focusing on the exchange of goods the focus should shift to a focus to the value that various activities, material and immaterial entities provide, i.e. to the service they provide.

In S-D Logic, service is defined as the process of using one’s competences (knowledge and skills) through deeds, processes and performances for the benefit of another part.

Alternatively a service focus may be formulated in terms of *operants* that operate on *operands* (goods, material and immaterial entities, and other services).

3.1 Basic Formal Ontology (BFO)

The Basic Formal Ontology is an upper-level ontology that supports the creation of lower-level domain specific ontologies.

The BFO project [8] started in 2002 with initial theoretical contributions from Barry Smith and Pierre Grenon. The aim of BFO is to provide a genuine upper ontology that specifically can be extended by domain ontologies developed for scientific research, such as for biomedicine. BFO is based on the principle of ontological realism [11], where ontologies are viewed as representations of the reality that are described by science.

Key elements of BFO are the support for formal (logical) reasoning enabled by its definition and the inclusion of common formal theories such as mereotopology and qualitative spatial reasoning. As part of the effort to formalize BFO, the BFO is defined using OWL and in first order logic using the CLIF (Common Logic Interchange Format) from ISO.

With respect to other public domain ontologies DOLCE, SUMO and CYC, BFO aims at, and provides a smaller core that is extendable and adaptable to specific domains [11], thus making it suitable for creation of a service specific extension. BFO shares some philosophical basis with DOLCE and SUMO, such as the inclusion of 'universals' and 'particulars' as well as the acceptance of a dichotomy between 'continuants' ('endurant') and 'occurrents' ('perdurant').

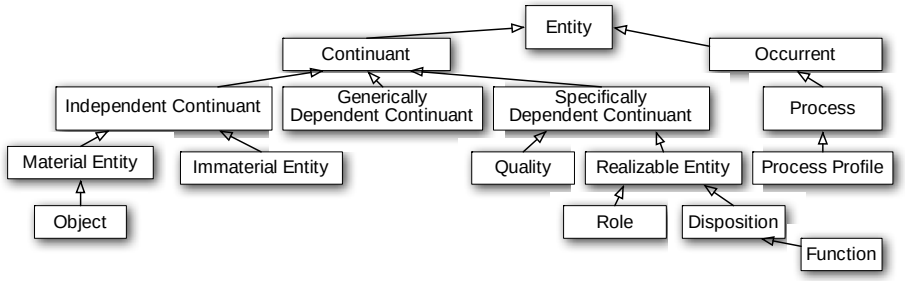

Fig. 4. Illustration of key concepts from the BFO Ontology, version 2012 July

Table 9. Description of BFO concepts used in the interpretation

BFO	**Description**
Entity	An entity is anything that exists, or has existed, or will exist
Continuant	An entity that persists, endures, or continues to exist through time while maintaining its identity. ('endurant')
Occurrent	An entity that unfolds itself in time, or it is the instantaneous boundary of such an entity (for example a beginning or an ending), or it is a temporal or spatiotemporal region, which such an entity occupies. ('perdurant').
Material Entity	Has some portion of matter as proper or improper continuant part. 'Portion of matter' is intended to encompass both mass and energy. Every material entity at any given time is localized in space at that time, and can move in space. Material entities are three-dimensional spatial entities, as contrasted with the processes in which they participate, which are four-dimensional entities. Example: a human, an aggregate of humans.
Object	A material entity, which manifests *causal unity* via physical covering (organisms,

	cells), or internal physical forces (portions of solid matter such as rocks and lumps of iron), or engineered assembly of components (engineered artifacts such as watches and cars). Objects can be joined to other objects and may include other objects as parts. Examples: cell, organism, grain of sand.
Immaterial Entity	Have no material entities as parts. Examples: surface, line, point
Process	Has temporal proper parts and for some time t, P s-depends-on some material entity at t. *has-participant* is an instance-level relation between a process, a continuant, and a temporal region at which the continuant participates in some way in the process. A process do not change, it is the change itself. Examples: the life of an organism, a process of sleeping.
Process Profile	A process that represents a selective cognition or abstraction of mutually dependent sub processes. Examples: a pair of rumba dancers is moving together across the dance floor form a mutually dependent process pair, the process of temperature changes in John

3.2 Analytical tools

For the purpose of analytical convenience we introduce 6 supporting concepts: Performer, Servicing, Result, Lead-to pattern, Result Ladder and Result Horizon.

A **Performer** is a *bfo:Material Entity* that can change the world. The *ext:Performer* concept facilitates an understanding of questions relating to interrogative 'who', 'who is doing what' and *sdl:Operants*. Examples include; Natural performers (organisms, humans,...), Man Made (machine, information system,...), Social (person, organisation unit, enterprise, ...), and Roles (actor, worker, ...).

The word "service" is often used as a sign for both the act of 'applying competences' and the resulting value, benefit part of (a) service(s). **Servicing** is a *bfo:Process* that specifically corresponds to the act of applying competences.

The following *Lead to pattern*, *Result Ladder*, and *Result Horizon* concepts provides the primary vehicles for reasoning about transfers of benefits from providers to beneficiaries.

The general three-part **Lead to pattern** is a pattern where *some source entities lead to some result entities* [6]. This pattern is pervasive in science, theories and frameworks, e.g. causality - effect from cause, means to some ends, marketing - attributes lead to consequences that lead to values [12] and templating [13].

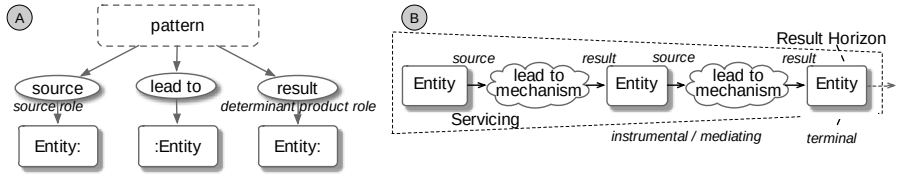

Fig. 5. Illustration of (A) Lead-to pattern, and (B) Result Ladder and Result Horizon concepts

- A ***Source*** *entity* participates in a thematic source role, e.g. source entities are instrumental in bringing about a result. Examples: material and immaterial entities, humans, competence, skills, knowledge, information, and performers.

- A ***Result*** *entity* participates in a thematic determinant product role. Examples include; value; benefit; satisfaction of objective; and entity, quality, functioning that comes into being, dies, does not come into being; and a state-of-affair; and a change or no change; and some act that is completed-done-not done.
- The ***Lead-to*** *entity* is an entity that provides a link between the source and the result, where results are lead to, brought about, achieved, accomplished, realised, made, generated, etc. Examples of lead-to mechanisms include; a realising process, mechanism, causality, logical entailment, counter factual specification, probabilistic specification, and mathematical formulas.

A **Result Ladder** is a partially ordered set of *ext:Results* with *ext:Lead-to* links in-between, where a *ext:Result* may play the role of a *ext:Source entity* for following *ext:Lead to* links. A ext:Result Ladder may include intermediary *ext:Lead to* links that *mediate* a transfer between *source entities* and terminal *result entities* over time and space.

In marketing and in services research numerous examples of ladders are found, e.g. Means-End Theory where product attributes (A) lead to consequences in product use (C), to individuals' values (V) [14], value theories [15] such a Rokeach instrumental and terminal values, and Cocktons worth maps [16]. In the analysis no specific value theory is assumed.

The *ext:Result Ladder* concept enable a detailed analysis of a number of benefit related aspects and questions: What is valued, which value is attributed to whom? Where and when are *ext:Results* observed and measured? How many *ext:Result Ladders* exist simultaneous (customer, provider, worker, owner, society, ...)? Is there a single terminal end point, or multiple? If so, does the value ladder terminate in some universal value space ("everything"), or at some value attributed to some single entity ("the"), or in societal values ("we"), or in experiential values of (all) sentient beings ("i"), or in some values that evolve over time?

A **Result Horizon** specifies the time, space and end result(s) of *ext:Result Ladders*. As such it is analogous to an investment horizon.

The ext:*Result Horizon* concept enables a detailed analysis of questions and aspects that influence design, management and governance of services: Where does a *ext:Result Ladder* ends, or should end? Is it at servicing completion, or at the exchange of service performance for money, or should/must the horizon be longer? Higher order values such as dignity, justice or gender equality may be assumed to be even (qualitative) better than money, or emotional values.

4 BFO based interpretation of the S-D Logic service definition

In this section the interpretation of the service definition using the Basic Formal Ontology (BFO), is presented. The following S-D Logic definition constitute the base for interpretation and subsequent analysis:

"the application of competences for the benefit of another" [10].

The service definition involves two agentive entities that play two roles, the **applyer** (producer, provider) and, **another** (consumer, beneficiary). From a systems perspective the two entitles may be considered as two (hard or soft) systems [17].

In the following diagram the rectangles represent concepts, the ovals represent concept relations, and the lines represent arguments of a concept relation.

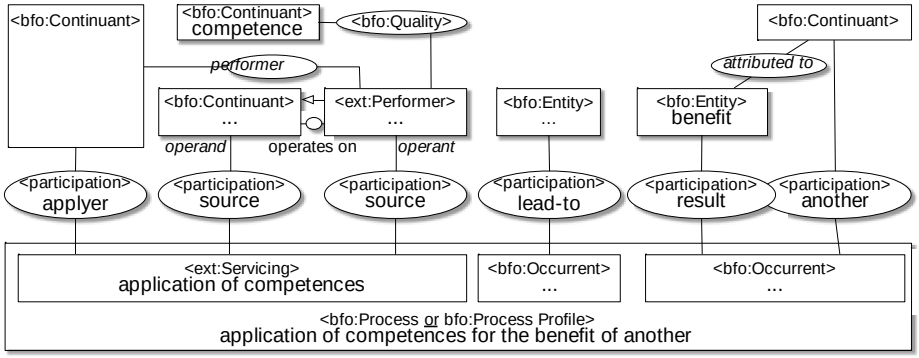

Fig. 6. Illustration of the BFO based interpretation of S-D Logic service definition

The "**application of competence**" is interpreted as consisting of five constructs:

1. The **applyer** entity that is attributed to the 'application of competence for the benefit of another', is interpreted generally as a *bfo:Continuant*. For specific kinds of service a more suitable subtype may be defined, e.g. a Human being can be represented as a *bfo:Material Entity*.
2. An *applyer* incorporates of at least one entity that can **perform** the "application of competences", i.e. change the world and deliver benefits. This entity is interpreted as a *ext:Performer*, that is competent (have requisite or adequate ability or qualities). In many cases the *applyer* and *performer* are the same entities, e.g. a human. In other cases they are different, e.g. an organisation consist of persons performing the servicing.
3. **Competences** are for the purpose of brevity interpreted as *bfo:Continuant* qualities of a *ext:Performer*.
4. The S-D Logic service definition do not explicitly include references to entities other than competences it is however implicitly understood in S-D Logic that more entities can participate in a *ext:Servicing* process, such as material and goods. These **additional entities** are added to the interpretation as participating *bfo:Continuants*.
5. The **application of competences** occurrence is interpreted as a *ext:Servicing process* in which the *applyer* participates, together with at least one *ext:Performer* and possibly one or more *bfo:Continuant* in source roles.

The "**the benefit of another**" is interpreted as consisting of three constructs:

1. An **another** entity that is interpreted as a *bfo:Continuant.*
2. The **benefit** entity is interpreted as an *bfo:Entity* attributed to the *another* entity.

3. Both *another* and the *benefit* entities participate in an *bfo:Occurent* where the benefit comes (or not) into being. The *benefit* entity participates in a *result role* and the *another* entity in an *another role.*

The last part of the definition to interpret is the "**for**" part that links the "application of competences" with the "benefits of another". The separation of the two (or more) agentive entities implies that some form of transfer of results, must exist, directly or through intermediary entities and/or over time and/or space. Here the *ext:Lead to pattern* is applied to represent linking and transfer aspects between *applyer* and *another*. The competent *ext:Performer*, and additional entities attributed to the *applyer* corresponds to entities playing the *source role*, the *benefits* attributed to *another* corresponds to *result role entities*, and the overall *application of competences for the benefit of another* process corresponds to the *ext:Lead to* part.

Depending the specific kind service defined or analysed, the overall "application of competence…" *bfo:Process* can be represented as one large *bfo:Process*, or as a group of smaller *bfo:Processes*, or as a *bfo:Process Profile* in alignment with soft systems thinking [17].

For a specific kind of service it is possible to consider both the *applyer* and *another* as causally united *bfo:Objects* and then associate a *bfo:Process* with each, possibly together with *intermediary bfo:Occurrents*, or *bfo:Processess*, that mediate the transfer of benefits. This kind of separation opens up to *ext:Result Ladder* and *ext:Result Horizon* reasoning.

A **Service horizon** is defined as a *ext:Result Horizon* that determines the scope of service benefits *ext:Result Ladder(s)* to consider. It should be noted that the *applyer* and *another* entities may value intermediary results and terminal benefits differently.

The **Triple-O** service constructs: *sdl:Operant* is interpreted as a *ext:Performer*, and *sdl:Operant* as additional *bfo:Continuants* participating in a *bfo:Occurent*.

5 Analysis of a interpreted service definition

This section presents an analysis of service characteristics based on the Basic Formal Ontology based interpretation of service as defined in S-D Logic. The analysis focuses on exploring the following questions: Is the characteristic **relevant** to the definition of the concept of service? Is the characteristic **determining**/distinguishing service from goods? Does the characteristic impact **practical** considerations?

5.1 Intangibility

In the service interpretation three sources of *intangibility* are identified:

- *bfo:Occurrent*, the occurrence of "application of competences.", e.g. hair cutting.
- participating source intangible *bfo:Immaterial Entities*, e.g. hair style.
- resulting benefit *bfo:Entity* at the end of a *Service Horizon*, e.g. customer value.

In the service interpretation *Tangible* phenomenons are identified:

- *ext:Performers*, *sdl:operants*, e.g. hairdresser and customer.
- *bfo:Material entities*, *sdl:operands*, e.g. chemicals, pair of scissors and hair.

What could be argued is that goods, in an opposite sense, can be seen and tasted, e.g. a cake, hair cut. However some goods are intangible; e.g. hairstyle, news, patents and intellectual properties.

The relevance of tangibility depends on one or more *Service horizons*, e.g. an intangible hairstyle, lead to a tangible hair cut, which leads to emotional intangible values at a later dinner. One argument for intangibility is that all *Service horizons* finally end up in sentient beings or humans with resulting intangible terminal emotional values. This argument is problematic, from a practical point of view, since service agreements often are specified in terms of shorter *Service horizons* and tangible results, such a cut hair or other functional qualities. Furthermore the actual *ext:Result Ladders* and *Service horizons* relevant to the provider, and beneficiary are in general different.

From a practical point of view, the qualities of a service depend on the mix of participating tangible *bfo:Performers*, and *bfo:Continuants (material or immaterial).*

Goods produced in manufacturing processes can be viewed as the sum of processing steps, or a historical embodiment of *ext:Servicing* [18]. The last production steps can be viewed as embedded services performed by the supplier on behalf of the consumer.

Based of the analysis I find that intangibility is a relevant characteristic of a service, although not a determinant characteristic. From a practical point of view intangibility is relevant, however a focus on intangibility may obfuscate the relevance of tangible entities along *ext:Result Ladder* and at the *Service horizon.*

5.2 Inseparability of production and consumption

In a hairdressing service case, a hairdresser (*applyer*) and consumer (*another*) meets, rendezvous directly in several *bfo:Processes*, 'wash hair', 'modify hair', etc. where the application of competences lead to benefits (cut hair) for the consumer, i.e. a direct transfer *ext:Lead to* mechanisms are present. However benefits may materialise at a later stage, in some other location, possibly at a dinner, mediated by the hair and the mental state of the consumer. The *ext:Result Ladder* (and *Service horizon*) may be longer than the time and space where hairdresser and consumer rendezvous, or the period of *ext:Servicing*, or the duration of a service agreement.

When buying a tree in order to facilitate clean air for our children; the transfer (lead-to) processes between the tree buyer, planter and future beneficiaries are many and separated by time and space.

Based on the analysis I find that inseparability is a relevant characteristic of service, although not a determinant characteristic. From a practical point of view, reasoning about inseparability could be replaced by reasoning about *ext:Lead to* processes, *ext:Result Ladders* and *Service horizons.*

5.3 Heterogeneity (inconsistency, variability)

Two separate services, applications of competence, implies two distinct *bfo:Processes*, leading to differences in the quality. Three sources of variability in servicing are identified in participating *bfo:Continuants*:

- *ext:Performer*, e.g.hairdresser, numerically controlled machine, computer.
- *bfo:Material entity*, e.g. pair of scissors, shampoo.
- *bfo:Immaterial entities*, e.g. hair style.

In goods production processes the qualities of participating *ext:Performers* have an impact on the variability in the qualities of goods. Labour intensive production processes involve variability patterns that differ from processes executed by high quality man-made machines, or computers. In cases where the supply of goods are demand driven and engineered-to-order, the production process may involve higher variability due to re-tooling, configuration of machines, and human creative activities that cannot fully benefit from being repeatable and standardised.

Analogous to production of goods, the same *ext:Performer* and *bfo:Material entities* may participate in two different *ext:Servicing processes,* which may lead to lower expected variability. Variability in service availability may be mitigated by sourcing and dynamic capacity management of participating *bfo:Continuants*.

In the case of a custom-made toy making service, a company may choose to manufacture toys with high performance man-made machines, using steel as material, or human craftsmen that carves toys out of wood. Here an interesting questions arise, what is more relevant, the variability of servicing or the variability of the participating material? Depending on how variability is measured a highly variable, man made, old and ragged, toy made out of wood may be considered as more (emotionally) valuable than a durable, hard, cold and low variable steel toy.

Based on the analysis I find that heterogeneity is a relevant characteristic of service, although not a determinant characteristic. From a practical point of view all sources of variability should be considered along relevant *ext:Result Ladders*.

5.4 Perishability (inventory)

In the service interpretation four sources of perishability are identified:

- *bfo:Process* ("application of competences"), e.g. cutting of a hair,
- *ext:Performer*, e.g. hair dresser that gets older and forgets,
- source *bfo:Entities*, e.g. shampoo and pair of scissors that degrades over time.
- resulting *bfo:Entity*, e.g. emotional values of a haircut that diminish over time.

An “application of competences” (*bfo:Process*) cannot be stored for future use. On the other hand, *ext:Performers* and participating *bfo:Material entities* (pair of scissors, rental facilities) can be stored, and they can be acquired or produced in advanced for later participation in delivery. Neither *ext:Performers* and *bfo:Material entities* need to

be owned or controlled. In a sourcing scenario they can be accessible (in mint condition) and thus replace inventory.

Goods (interpreted as *bfo:Material entities)*, as well as *ext:Performers* and *bfo:Material entities* that participate in manufacturing processes may perish over time; people and machines get old, material decompose, chemicals degrade, etc. *bfo:Immaterial entities* such as hair styles, songs, digital and reproducible material exist over time without diminished capacity, although they may be forgotten.

Based on the analysis I find that perishability is a relevant characteristic of service, although not a determinant characteristic of service. From a practical point of view the temporal and inventory aspects of participating *ext:Performers*, *bfo:Material entities* and *bfo:Immaterial entities* are highly relevant for both services and goods.

6 Future Research

Through a formalization of the service definition, using the same first order logic construct used in the formalisation of BFO, a domain specific service extension to BFO can be created. Such formalisation provides a platform for detailed analytical comparisons between a wider range of service definitions, service aspects, such as *co-creation of value*, and inquiries into larger systems based on services and goods.

The use of BFO as an ontological grounding (language) can be used to integrate a service construct with adjacent constructs such as capability. In the paper "What Capability Is Not" [6] I provide a conceptualisation of a Capability construct, "a substantial possibility that source entity(ies) lead to a result", based on the *ext:Lead to* pattern, that integrates well with presented service interpretation.

The BFO interpretation together with the Triple-O concepts (operant, operand, occurrence) suggests that a simplified, socially oriented, definition of service may be possible, e.g. "use of effort (energy, material) leading to a result of another".

7 Conclusions

In this paper, I have revisits the concept of service and presented an interpretation of the concept of service as defined by the Service Dominant Logic framework, using a higher level ontology - Basic Formal Ontology. The use of BFO enables an inter-theoretical reduction and a bridge between social and natural sciences.

Based on the interpretation and analysis I argue that the use of BFO provides clarifications, of the constituent parts of the concept of service (as defined in S-D Logic), and of similarities and differences between goods and services. However the interpretation and analysis of a single service definition reduces the possibility for making more general conclusions.

Furthermore I conclude that the studied characteristics are relevant to the concept of service, although they cannot be considered as determinant characteristics. From a practical point of view the studied characteristics contribute *partially* to observed concerns and problems.

In order to obtain a complete understanding for, both services and goods, it is necessary to consider the nature of all participating *bfo:Material Entities*, *bfo:Immaterial Entities*, and *ext:Performers* along one or more *ext:Result Ladders* up to the relevant or desired *Service horizon*.

These findings are consistent with studies [2], and the view that a service involves a *service perspective* on value creation rather than a category of market offerings [19].

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