A SEMIOTIC APPROACH TO WEB SERVICE DESCRIPTION

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Abstract: The discovery of suitable web services is a demanding challenge for organisations that plan to benefit from this technology. Strategic objectives, organisational structures, business processes and technology placed in a climate of constant change impact the normative behavioural patterns of people working in all kinds of organisations. Such dynamic conditions can have a profound influence over the discovery of appropriate web services. Advocated in this paper is a semiotic approach to web service description that configures a solution to take into account the dynamic conditions affecting web service discovery. The semiotic approach merges the articulation of dynamic conditions with web service description whilst facilitating the engagement of service providers and consumers in joint actions. Framed by affordance, joint actions capture the changeable normative behavioural patterns of people so that web service utilisation can be harmonised with organisational contexts.

1 INTRODUCTION

Based upon the principle of building software made accessible across organisational boundaries, web service technology is an approach to leveraging existing software to fulfil business objectives (Berkem, 2008; Carey 2008; Li et al, 2007). Web service technology is also a development of the 'software engineering' paradigm aligned to object oriented programming. Encapsulation is a concept found within web service utilisation, as a key aim is to present to a service consumer a highly cohesive data type parameter based interface whilst adhering to a notion of low coupling. Web services are particularly amenable to such a situation; a web service is a functioning software unit that is located on the internet and responds to incoming messages using web technology. Web services are therefore an instalment of software that can be reused by a multitude of participants as service consumers. A significant challenge emerges when service provider organisations attempt to describe web services effectively so that service consumer organisations can use those descriptions to achieve the fusing of web services with their own specialised organisational contexts. Organisations encompass contextualised social parameters established by strategic objectives, organisational structures, business processes and technology in a flux of constant change resulting in normative behavioural patterns that are only understood by people (Berkem, 2008, BMM, 2008, OASIS, 2008). To overcome the challenge of matching web services to organisational contexts, the purpose of this paper is to highlight the limitations of current approaches to web service description, show how semiotic theory can be used to enhance web service description, and propose a concept that draws semiotics and web service description and discovery into a unifying paradigm.

2 CONTEMPORARY WEB SERVICE DESCRIPTION

Web Service Description Language (WSDL 1.1) files are based upon the Extensible Mark-up Language (XML) and are constructed to list data type definitions, message types, port types (operations) and bindings (WSDL, 2001) whilst focusing upon the communication protocols that enable packets of data as Simple Object Access Protocol (SOAP) messages to traverse a network architecture (SOAP, 2007). Conventionally, a service provider publishes web service(s) in a service registry to a standard such as Universal

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Description Discovery and Integration (UDDI) (Atkinson et al, 2007; UDDI, 2004). The service registry provides the references to the web services available and the links to description files. The bind details of the web service enable a service provider and consumer to have some form of interaction where messages structured by the SOAP protocol are exchanged (Erl, 2008; Huang et al, 2008; Pastore, 2008). The syntactic nature of WSDL 1.1 files that facilitate the discovery of web services limit the identification of appropriate web services, as the connection properties of a web service are the only properties made visible. Implementation logic encapsulated within a web service is hidden from a web service consumer precluding the possibility of detailed examination. To overcome this limitation, the concept of Semantic Web Services, a branch of the Semantic Web, provides a way for service providers to describe web services more effectively using XML based ontology mark-up, and for service consumers to assess web services more accurately (Il-Woong et al, 2007; OWL-S, 2004; Papazoglou et al, 2007; Shadbolt et al, 2006).

The Semantic Web, Berners-Lee et al (2001), is founded on the idea that meaning can be obtained from data using standardised mark-up to represent ontologies. Prime examples of ontology languages particular to web service description are WSDL-S (2005), WSML (2008) and OWL-S (2004). These ontology languages describe web services from a data orientated perspective, and align web services to orchestrate business processes based upon clearly defined interfaces and the calling of various web service operations. However, these types of ontologies have restrictions when considering the dynamic conditions belonging to organisations (deMoor, 2005; Schoop et al 2006). While the description of data in a static structure is necessary when navigating organisational boundaries of all kinds to ensure consistency, data that are uniformly described may be applied uniquely under dynamic conditions. Rule based descriptions such as the Semantic Web Rule Language (SWRL) (2004) can be added to ontology languages like OWL-S to elucidate further the orchestration of business processes. For example, each OWL-S process (OWL-S, 2004) is based upon an Input Output Process Result (IOPR) model (Redavid et al, 2007). The inputs represent the information required to execute a process and the outputs are the result. Preconditions are imposed upon the inputs to invoke the process successfully. An OWL-S process may have several results with corresponding outputs whilst the result entity of the IOPR model provides a means to specify this situation. However, with SWRL, inferences made are based upon Modus Ponens and Modus Tollens, but according to Beller (2003, 2008) people are able to draw inferences based upon Denial of the Antecedent and Affirmation of the Consequent under 'exhaustive' conditions (where people consider all causally relevant factors to the situation) and a 'closed-world' principle (where people believe they have considered all causality until evidence proves contrary). A dynamic condition is the chronological representation of people's ability to draw inferences exhaustively and in 'closed-world' normative behavioural patterns that influence organisational activities (Liu and Benfell. 2009).

2.1 Problem Definition and Solution

The syntactic nature of WSDL 1.1 and the extended semantic web service descriptions offer different ways to describe web services but are not effective when considering 'pragmatic web service description'. Pragmatic is defined here as the dynamic conditions affected by contextualised social parameters set by strategic objectives, organisational structures, business processes and technology in a climate of constant change that influence the normative behavioural patterns of people. The chance of meeting the needs of service consumers without any form of communication, questions current methods of web service description (Crasso et al, 2008; Il-Woong et al, 2007; Papazoglou et al 2007; Singh, 2002). The challenges addressed using pragmatic web service description in this paper are:

1. **Organisational context:** organisations encompass complexities and fine distinctions that must be catered for when documenting web services prior to consumption. People belonging to organisations have a deep understanding of the normative behavioural patterns they operate in and are therefore ultimately responsible for the web service descriptions they provide and consume.
2. **Consumers before providers:** the emphasis of pragmatic web service descriptions must focus upon the effect of information about web services on service consumers, rather than on the intended meanings supplied by service providers defined in static object type ontologies.
3. **An abundance of signs:** many different types are available within web service description and the promotion of them to ensure an accurate description of web services may be

accomplished by placing web service description into a semiotic framework. The signs inherent in various web service descriptions and their meanings must be communicable by any number of people 'verbally and nonverbally' and 'horizontally and vertically' across organisational boundaries.

4. **Dynamic conditions:** the execution of a web service in a dynamic condition is important as such a context will determine the meanings held in various ontologies that are time dependent. Sign meaning is dynamic so all people (as participants) must share in normative behavioural patterns. Changes made to the meaning of signs must be accounted for by developing a temporal vocabulary that can be pooled and understood by all participants engaging with a web service that support exhaustive and closed-world principles.
5. **Interaction is vital:** the dynamic interpretation of web services affects communication as the meanings generated in the process of interaction between service providers and consumers cannot be dependent on post deployment semantic and syntactic descriptions only.

To address the first three challenges listed above, semiotic theory by Peirce (1931-1958) positions a solution in this paper to add pragmatic descriptions to web services. Taking this approach, a unifying paradigm is specified to draw service providers and consumers into joint actions. To achieve this objective, Stamper's work on ontology and affordance is used. Stamper (1985) recognises three different types of ontology, whereby the first relates to the recognition of symbols typically found in any standard presentation format, and the second identifies distinct objects and object type classification. To satisfy the last two challenges in this paper, the third type of ontology is particularly relevant to web service description as it is based upon the view that the world known to a person consists of only the actions a person can carry out in their environment – called affordance. Web services are deployed in activity orientated situations, and people carry out activities commensurate with their expected duties, defined as normative behavioural patterns. People invoke web services to complete a specific activity; the description of web services therefore should follow this pattern to enable web service providers and consumers to fully appreciate the normative behavioural patterns that affect web service consumption.

3 SEMIOTICS AND WEB SERVICES

Peirce's particular semiotic theory of signs is applicable to web service description due to its triadic grounding. According to Everaert-Desmedt (2010) Peirce's version of semiotics is general (it accounts for the emotional, practical and intellectual experience of sign users), triadic (owing to the three foundational philosophical categories that Peirce created namely, firstness, secondness and thirdness), and pragmatic (in that it takes into consideration the dynamic context in which signs are produced and consumed). Peirce's version of semiotics also draws together three terms that constitute a sign: representamen; object; and interpretant. Firstness, secondness and thirdness are used to illuminate further each of these sign constituents. Peirce developed three semiotic accounts, 'early', 'interim' and 'final'. The early account includes some fundamental concepts that also appear in the interim and final accounts: representamen, object and interpretant, and also illustrates how Peirce establishes semiosis. Peirce uses different terms that relate to the triadic nature of signs, for instance often used is the term sign in place of representamen as one of the three components of a sign. For lucidity here, the term representamen is used in place of sign (to help clearly define the triadic relationship), and sign refers to the collective purpose of all three parts. The following texts describing Peircean semiotic theory are used (Atkin, 2006; Chandler, 2002; Commens, 2010; Short, 2007; Sowa, 2000) to place web service technology into a semiotic framework.

3.1 Early Account and Web Service Description

Peirce formulates the triadic nature of semiosis based upon three elements of a sign: representamen, object and interpretant. Peirce suggests that a representamen generates an interpretant in three different ways, as an icon, an index and a symbol. A sign is an icon when a quality is shared between a representamen and its object, for example a portrait. When a representamen is causally linked to its object in some way it is an indexical sign. If a sign user applies convention to understand a sign, such as the rules of some language, a sign is symbolic. In line with this account, web service description includes two types of signs, indexical and symbolic. For example, the word operation is an indexical sign

as it points to an actual web service operation, and the word operation has a symbolic meaning in web service description. These two types of signs are an important classification for web service description, but for a complete analysis they fall short when considering the role of interpretant signs for web service description. The process of semiosis Peirce describes in this account is used to structure 'shared semiosis' between service providers and consumers.

3.2 Interim Account and Web Service Description

Building on his early account, Peirce devised a phenomenological theory based upon three categories: firstness as the conception of being independent of something else, that is a representamen distinguished by its own phenomenological category; secondness as the concept of a representamen being linked to or having a reaction with its object; and thirdness as a concept of mediation, where a first and second are brought in relation in which an interpretant is assigned to the way a representamen denotes its object. Peirce's phenomenological theory sets the format for describing web services as the representamen, object and interpretant are each divided into these three phenomenological categories. Following Peirce's principle of hierarchy amongst categories, a representamen (firstness) cannot belong to a higher category than its object (secondness) and in thirdness, an interpretant cannot be in a higher category than its object. Peirce yields ten mechanisms of sign meaning that can be used to understand phenomenon of all kinds that can equally be applied to web service description.

The Representamen

For the successful signification by a representamen of its object, qualisigns, sinsigns and legisigns are used by Peirce to divide the representamen based upon the three phenomenological categories. Qualisign – firstness (material quality) is a representamen that does not appear in web service descriptions. Sinsign –secondness (material index) is a representamen that relies upon an existential connective with its object. These types of signs are present within web service description, for example they would constitute the actual existence of all kinds of web service description files. Legisign – thirdness, (material convention), is a representamen based upon a law or habit, and in terms of web service description, these signs are the expected conventions, the syntax, of any web service description file.

The Object

The object is the notion of the representamen interacting with its object. In terms of web service description, the object provides the meaning associated with the syntax contained in a description file. Iconic signs – firstness (relational quality), are interpreted by some shared quality – a likeness to something as an interpretation by a sign user, for example the 'file icon' on a computer operating system. Indexical signs – secondness (relational index), are signs interpreted by causal connections. Example indexical signs in terms of web services include the actual existence of operations identified by their names and the endpoints that can be connected to. Indexical signs are found within the semantic descriptions made possible by ontology languages. Symbolic signs – thirdness (relational mediation), are linked to their representamen by knowing the conventional or habitual rules applicable to the representamen. For example, by practice a software programmer would accept that 'double', 'decimal' or 'float' would give a data type for floating point arithmetic.

The Interpretant

The interpretant represents the concept of mediation, where the representamen and object are brought into a relation in which the representamen's interpretant is linked to the way a representamen denotes its object. In essence, the interpretant is the reaction of someone's mind when a connection is made between a representamen and an object and the resultant sign meanings are expressed in a natural or artificial language (Sowa, 2000). Rheme – firstness (formal quality), the interpretant focuses a person's understanding of a sign based upon its (quality) in that a representamen determines its object by its quality only – for example a classifier for a set of objects. Dicent – secondness, (formal index) the interpretant focuses a person's understanding on the existential features of an object through proposition, for example an operation name to index an actual operation whilst the operation name used suggests its purpose. Argument – thirdness, (formal mediation) the interpretant focuses a person's mind on a rule of inference to derive an argument by applying some kind of convention or law. Current web service description does make use of such signs but may entail web service descriptions to indicate applicability under certain dynamic conditions.

Table 1: Sign Mechanisms and Web Services.

	Firstness	*Secondness*	*Thirdness*
R	**Qualisign** (A quality)	**Sinsign** (An existent thing) 1. A WSDL file, an OWL-S file	**Legisign** (A convention or law) 2. Description file syntax.
O	**Icon** (A similarity)	**Index** (Causal connection) 1. A web service. 2. An actual operation. 2. An actual data type. 2. Proper noun – an object.	**Symbol** (refers to its object by convention or law) 2. Operation naming convention. 2. Data type conventions.
I	**Rheme** (Quality only – a common noun) 2. Class names. 2. Data type variables : age for example.	**Dicent** (An sign of actual existence – a sentence) 1. The web service used for a general task. 2. An actual operation invoked for a sub task .	**Argument** (An inference from dicent signs in context)

The interpretant (table 1) provides a semiotic frame that can be used to address the limitations of matching web services to the dynamic conditions of organisational contexts. For example, rhematic-index-legisigns provide the classification of things belonging to a web service that would normally be found in a WSDL file (labelled as '2' in table 1). Dicent-index-sinsigns are available within WSDL (denoted by '1' in the table 1) and are also present if web services are described using semantic mark-up (denoted by '2' in table 1). For example, a web service operation exists (legisign as a firstness), an actual operation by a name (secondness as an index), and that a named operation can be called upon to carry out a task, such as a process descriptor or workflow in OWL-S for example (dicent as a thirdness). Evidently missing from the framework in table 1 is the sign classification argument-symbol-legisign. This particular sign classification synchronises the full mechanism of the interpretant for all signs and therefore for pragmatic web service description. To specify how pragmatic web service description can work using argument-symbol-legisigns for web service description, Peirce's final account is referred to.

3.3 Final Account and Web Service Description

In this version Peirce divides the object and interpretant to take into account a chronological process of inquiry. This approach is applicable to web service description when the dynamic conditions of organisational contexts affect accurate web service description and discovery. Peirce introduces two important considerations with regard to dividing an object and dividing an interpretant. The terms Peirce uses are the 'immediate' and 'dynamic' object. The immediate object is the object as a person would know it to be an object at any instance in time. The dynamic object is the object as it is known to be at the end of 'exhaustive' inquiry. The static representations within WSDL 1.1 and semantic ontology languages must be validated against a process of inquiry to ensure that a web service fits a changeable organisational context – achievable as a dynamic object. However, to explain fully what a web service realises, the mechanism Peirce uses to divide the interpretant into three, 'immediate', 'dynamic' and 'final' is also particularly important. The dynamic interpretant is an understanding of the relation between a representamen and a dynamic object at any stage, and the immediate interpretant is a generalised understanding of the relationship between a representamen and a dynamic object. The final interpretant is the complete understanding of a dynamic object that all people would agree to. In the case of web service description, the final interpretant is the agreement reached between service providers and consumers about the pragmatic nature of using web services in organisational contexts. For instance, the reaction of the dynamic object with the final interpretant determines how an argument-symbol-legisign is arrived at and requires a service provider and consumer to join forcefully in a process of inquiry. The argument-symbol-legisign is a norm or standard that can be derived from a line of inquiry into the applicability of a web service in various dynamic conditions. Peirce's 'pragmatic maxim' - three grades of clarity Peirce (1931-1958) is applied to arrive at argument-symbol-legisigns for the web service description and discovery process. The first grade of clarity is to have an unreflective grasp of the structure of textual web service description – immediate interpretant. The second grade of clarity is being able to define the generalised concepts within textual descriptions agreed dynamically between a service provider and consumer – dynamic interpretant. The final grade of clarity determines what effects that are held in relation to the concepts of study that are considered to be true, for example a list dynamic conditions that both the service provider and consumer agree to be true – the final interpretant. The pragmatic maxim ensures that the effects of web service information on consumers are understood by service providers. The pragmatic conditionals (as dynamic conditions) for web service description aligned to texts, is linked to Peirce's account of modality. Possibility and necessity are

based upon the epistemological facts in relation to the meaning of signs within a text. To say something is necessary is to confirm that something must be the case by a service provider or consumer. To say it is possible is to say that under varied dynamic conditions a service provider and consumer know something to be the case. This reduces the signs, made by an author of a textual web service description explicable and translatable by a consumer using modal representations. For example, from the perspective of a service provider, alethic modal operators to explain what may happen in certain dynamic conditions, and for the service consumer deontic modal operators to intimate the normative behavioural patterns that must be adhered to when activating and calling various components of a web service under the same set of dynamic conditionals.

4 SETTING PRAGMATIC WEB SERVICE DESCRIPTION

Returning to Stamper's (1985) overview of ontologies, attaining interpretant signs such as argument-symbol-legisigns, requires that all participants understand the dynamic conditions in a domain that a web service belongs to, referred to by Stamper as affordance. The theory of affordances originates from Gibson (1977) and can be extended to the study of the real world for understanding normative patterns of human behaviour (Liu, 2000), additionally aligning itself to the ontology specification provided by Stamper (1985). Society as an environment makes many patterns of behaviour possible; should a person (participant) be separated from its environment, the repertoire of behaviour the participant owns would cease to exist. The purpose of identifying 'affordance' (see figure 1) is to provide the contextual setting for web service description for all interpretant signs. At an abstract level an affordance, for web service description, shares some characteristics similar to business capability modelling, Ulrich (2006). Affordance is also applied similarly in other situations such as Customer Relationship Management, Finnegan and Currie (2010), and on-line communities, Welser et al (2009). The purpose of affordance is to place shared semiosis into a framework. For example, semiosis for a service provider starts when authoring syntactic or semantic description files by soliciting description from other existing texts – called intertextuality, Chandler (2002). Semiosis for a service consumer occurs when examining preliminary description files to assess the functional properties and capabilities of a web service. These two activities comply with Peirce's first grade of clarity, as they initiate shared semiosis to form the representamen that is required for joint actions to be effective:

1. The representamen – the elements (composition of web service description) designating the codes as dynamic objects in a shared vocabulary (first grade of clarity);
2. The dynamic objects as they relate to the semantics describing the codes contained in a shared vocabulary. Dynamic objects also correspond to the data structures and processing capabilities of a web service (second grade of clarity);
3. The final interpretant signs that describe all features and capabilities of a web service in dynamic conditions using high-level descriptions based upon various modalities (third grade of clarity).

With reference to figure 1 below, shared semiosis profiles the representamen between a service provider and consumer to understand the various codes related to web service description whilst working as the starting point in a chronological series of joint actions. Codes hold the syntactic and semantic meanings that describe web service elements. Arrow 1 in figure 1 illustrates that syntactic documentation such as computer program source code, analysis and design specifications and any other suitable text (also shown later in table 3) can be used to describe an existing web service. Intertextuality (relationship to other texts) and encoding work together to create the codes, hence codes are generated, as a first grade of clarity, that encompass various elements of a web service.

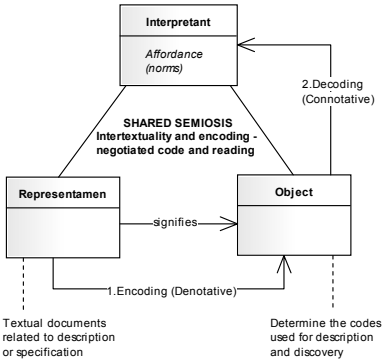

Figure 1: Shared Semiosis.

The codes produce an initial shared vocabulary as part of shared semiosis (formalised in table 2

below). Shared semiosis then moves onto 'negotiated code and reading' (Chandler, 2002) to agree the pragmatic meanings, between service providers and consumers, of the codes contained in a shared vocabulary. The shared vocabulary is an XML mark-up file structured by an XML Schema (XSD) that a service provider and consumer have access to. The codes have dependencies of different kinds, first, with the elements of a web service, and second with normative behavioural patterns. Norms (Boella, 2006; Stamper, 1996; Young, 2008) (as normative behavioural patterns) are dependent upon affordances (figure 2 below), thus final interpretant signs (table 1) are contingent upon the codes that describe a web service linked to the norms contained within affordances. The dependencies between the codes, norms and the affordances facilitate the matching of web services with dynamic organisational contexts captured by modal descriptors. For example, a service provider may submit a description based upon some dynamic conditions, specified as affordance qualifiers, to suggest a 'possible' mode of interaction. A service consumer, who has a set dynamic conditionals for that particular affordance may have some related 'obligatory actions', the matching of obligations to affordance qualifiers that may be deemed as 'possible' harmonises web service description and discovery. Affordance qualifiers are part of the semantic description as codes, for example a workflow (refer to figure 2 for code) that is structured in accord with a qualifier but could over time change according to the organisational context. The implication of this approach is that qualifiers do not need to relate purely to the calling of web service operations; they illustrate a complete affordance context. Affordance qualifiers are also captured and represented in a chronological format, thus allowing the representation of normative behavioural patterns to evolve. The valid-time of a norm in the 'real-world' and any transaction-times Liu (2000) and Stamper (1996) when a 'temporal' web service description is updated configures the time dependent character of affordances. To summarise, the semiotic branches advocated by Morris (1938) are used in table 2 to show that web service description is based upon the process of shared semiosis and informed by affordance (also refer to figure 2 below).

Table 2: Formalising Shared Semiosis.

Semiotic branch	**Intent and Real World Effect**	**Semiosis**
Syntactic Encoding (denotative sign).	Capture through existing texts the elements to form codes that structure the syntactic and semantic features of a web service description file.	**Representamen – Textual code (intertextuality and encoding)** Source code, analysis and design specifications – narrative and diagrammatic models.
Semantic Decoding (connotative sign).	Comprehension by consensus (dynamic objects) the web service elements symbolised as codes in relation to their functions and capabilities that belong to an affordance.	**Dynamic object – Connotative sign (negotiated code and reading)** Ontological dependencies linked to the contextualised interpretation by an Interpreter (Participant).
Pragmatic (All interpretant signs).	Linking the interpretations of the codes with potential contexts and effects on all participants and specifying a meaning of all codes congruent with all participants.	**Final interpretant –** Connotative signs (argument-symbol-legisigns) linked to the social parameters of a business organisation defined as affordances and structured using norms and amplified using modal operators.

Affordances convey intent as participant behaviour in order to have an effect within the real-world and are tempered further by antecedents like an organisation, the social structures within an organisation, and society, Stamper (1996). In order to model the constancy of affordances that represent the social parameters of organisations, real-world effects influence the creation and modification of the shared vocabulary, evidenced by the communicative actions of participants. A Multi-responsive communication framework Benfell and Liu (2009) based upon communicative act theory by Austin (1962) and Searle (1969) underpins the communication segment of affordances.

5 CONCLUSIONS

Referring to figure 2, 'WebService' and 'Code' is a mixture of syntactic and semantic web service description. WebService is the syntactic representation of the properties of web services and the semantic meanings of those properties are structured by codes during encoding. 'Norm' and 'Affordance' are the pragmatic element (interpretant signs) of web service description. Not until argument-symbol-legisigns are created can web service description be fully achieved. Furthermore, such signs are time dependent and owned by the people who represent an organisation. The model in figure 2 demonstrates the fulfilment of all challenges initially outlined in this paper.

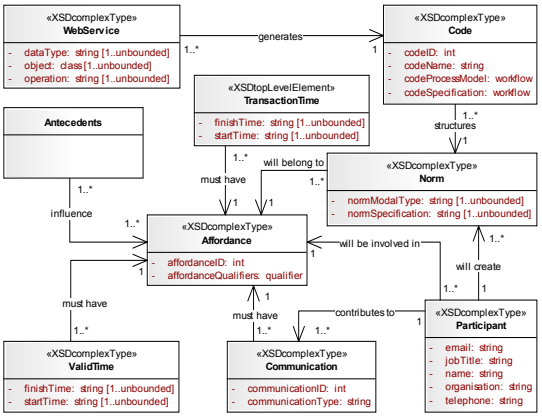

Figure 2: Affordance Structure.

Proposed in this paper is an alternative approach to web service description. It promotes the idea of 'affordance' as a route to achieve the description and therefore discovery of web services within the dynamical conditions of different organisations whilst enabling service providers and consumers, through shared semiosis, to forcefully join. The Peircean triadic viewpoint of a sign as representamen, object and interpretant and the different Peircean accounts of semiotic theory prove in this case the applicability of such theory to address the challenges outlined in this paper. The dynamic organisational parameters are captured as affordances to inform the composition of the final interpretant as argument- symbol-legisigns, and to structure joint actions. The work contained in this paper is a supplement and not a replacement of syntactic and semantic description files. However, the limitations of syntactic and semantic description files were shown. For implementation, a WSDL file must be present but semantic description files based upon OWL-S for example could be included within affordances to describe the data elements and processing features of web services.

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