

# Defining a Pragmatic Based Web-service Discovery Mechanism

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**Abstract:** The discovery of contextually relevant web services is crucial to business organisations. Pragmatics (in terms of communication acts) and semiotics (the understanding of signs), intersect at an important point in relation to textual entities. The intersection of pragmatics and semiotics provides the fabric essential to model the interaction between humans and norm-based agents by moving beyond the traditional two-role communication loop model found in the Language/Action Perspective to a proposed multi-responsive model to discover appropriate web services in Service Oriented Architecture contexts.

**Keywords:** Pragmatics, Semiotics, Communication Acts, Norms, Service Oriented Architecture

**Categories:** H.1.0, H.1.1, H.1.2, H.4.0

## 1 Introduction

A function that pragmatics (*interpretation of communicative acts*) and semiotics (*the understanding of signs*) can have with the discovery of web services in a Service Oriented Architecture (SOA) context is reported in this paper. SOA is an approach to leveraging existing software systems to fulfil business processes. SOA, established as a mainstream software development paradigm is tightly coupled with the concept of web services. Web services follow the principle of building software that can be accessed across organisational boundaries, in a collaborative manner, between service consumers and service providers. Using web services as a way of implementing a SOA, is based upon the notion of identifying predefined capabilities that characterise what a web service can functionally achieve. Should a business organisation wish to use a web service, it would need to take into account the issues associated with web service discovery. For example, [Crasso et al, 08; Atkinson et al; 07; Huang et al, 08; Li et al, 07; Pastore, 08; Diamadopoulou et al, 08] all highlight the concerns surrounding web service discovery. They claim that web service discovery is the weak component of the tri-themed web service model (service requestor, service consumer and service discovery).

An example SOA framework by [OASIS, 08] stresses the importance of considering the organisational issues linked to SOA implementations. For example, recognised in the OASIS framework is the socially orientated nature of SOA resulting in an assembly of various types of models, such as the '*social structure*' [OASIS, 08]. Within the social structure, 'norms' emerge as a mix of constituents, for example

human agents, software agents (norm-based) and various SOA resources, of the social model interact. Various communicative acts are produced as a result of the different models interacting within the SOA framework. Pragmatics and semiotics outlined in this paper are amenable to the challenges of specifying a ‘communication act’ approach to initiate the discovery of web services. In diverse business organisation settings, pragmatics and semiotics can be used to take into account a multitude of different factors that need to be communicated prior to web service discovery and selection.

## 2 Pragmatics

Pragmatics in the linguistic domain is used to describe what ‘conversational partners’ in different contexts (taken as culture, language, time and place) communicate. Pragmatics in this sense is used to analyse the intentions contained in communicative acts between speakers and hearers. Pragmaticians converge on the analysis of different kinds of utterances and their associated meanings in human to human communication patterns. However, regarding the computational realm, the resolution of many computer scientists is to place computing as close to the human sphere as possible. Varied notations are used to describe the functioning of systems behaviour. Notations share a common theme, however, to specify processes that enable humans to interact with each other and with computers in meaningful ways. One route to achieve such as move is to simulate human to human communication acts between humans and computers. An established body of work exists which promotes such an interaction, the Language/Action Perspective (LAP). LAP provides the means to facilitate human to computer interaction in terms of web service discovery processes within a SOA framework.

### 2.1 Language/Action Perspective

The Language/Action Perspective (LAP) focuses upon ‘face-to-face’ communication acts to orchestrate activity between humans supported by computers to achieve business objectives [Weigand, 06]. LAP amplifies typical business process modelling notation with Speech Act Theory (SAT) so that actions can be defined in accord with responses to speech acts [Weigand, 06]. The basis upon which LAP was founded relates to ‘communication loops’ [Goldkuhl, 07] created originally by [Winograd & Flores, 86; Medina-Mora et al, 92; Dietz, 99]. They all share a common communication pattern – requester and performer.

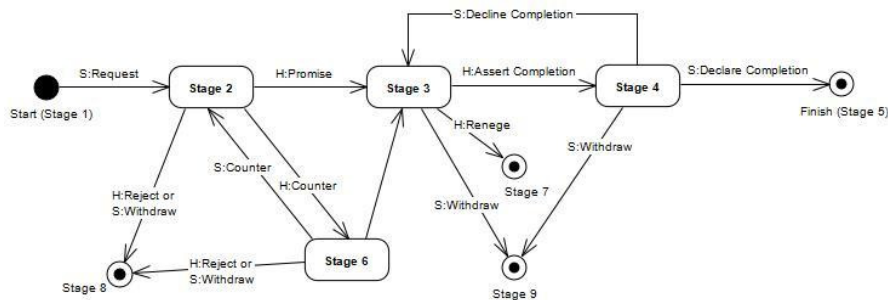


Figure 1: Communication loop

Implicit in figure 1 is a communication loop: request an action, agree to do an action, do the requested action, and report on the completion of the action. LAP therefore is based upon the analysis of communication patterns and the causal actions that people carry out in response to communicative acts. An example application from the LAP domain that closely relates to the objectives in this paper includes ‘Negoisst’ an e-negotiating system based upon control loop theory [Schoop, 05]. The foundational work by [Winograd & Flores, 86; Medina-Mora et al, 92; Dietz, 99] and the example system by [Schoop, 05] all use SAT as an intrinsic component.

## 2.2 Speech Act Theory

Speech acts are composed of *illocutionary acts*, *illocutionary points*, *illocutionary force*, and *propositional content*. An illocutionary act, described by [Austin, 62], captures a speaker’s intention in a communication act between a speaker (requester) and a hearer (performer). To strengthen an illocutionary act, [Searle, 69] adds to Austin’s [Austin, 62] theory illocutionary points which are classified as: *assertive*: commit the speaker (in varying degrees) to something being the case, or to the truth of the expressed proposition; *directive*: attempt (in varying degrees) to request the hearer to do something. These include both questions (which can direct the hearer to make an assertive speech act in response) and commands (which direct the hearer to carry out some linguistic or non-linguistic act); *commissive*: commit the speaker (in varying degrees) to promise to do some future course of action; *declaration*: bring about the correspondence between the propositional content of the speech act and reality; *expressive*: express a psychological state about a state of affairs (for example thanking). Illocutionary force expresses the strength of the illocutionary point by using vocabulary that details the intentions of a speaker. Propositional content carries the information or data in the illocutionary act. Hence the four elements of speech acts: *illocutionary act*, *illocutionary point*, *illocutionary force*, and *propositional content*, form a communicative act.

In summary, the term ‘communicative act’ refers to conversations that are used to capture intentions and to provide a negotiation procedure [Stamper, 96] resulting in an action. The action is often determined by a meaning making process attributed to Peircean semiotics – semiosis [Stamper 96; Liu 00; Liu 08].

## 3 Semiotics

Semiotics is based upon two positions related to [Saussure, 83] and [Peirce, 31-58] where both adhere to a subjective element to understanding signs. Signs can have different meanings across various cultural or social settings. Peirce’s view of semiotics is used in this paper due to its triadic grounding of semiosis. To shape understanding of a sign Peirce defined the term semiosis, the interplay between three unified parts: a sign, an object and an interpretant. A sign can take on various formats: symbolic, iconic and indexical. Symbolic signs are typically words, iconic signs are pictures, and indexical signs are signs that ‘naturally’ occur and have causal links to meaning. Each sign classification has an order of ‘agreed rules’ associated with them to make them work. For example, indexical signs are highly subjective and symbolic signs such as words are not so subjective.

Regarding semiosis the sign refers to an object, and the object verifies its sign. For example, smoke (the sign) may signify fire (the object), if a fire is discovered the fire verifies the sign – smoke. The link between the sign and the object is known as the sign/object relation. The sign/interpretant relation enhances the meaning of the sign/object relation in the mind of someone, for example, if fire is seen it may mean danger depending upon its location, hence the role of semiosis creates an improved meaning of the sign/object relation. The interpretant therefore is an enhanced sign created from the sign/object relation; it includes the contextual meaning given to a sign. To crystallise the meaning making process (semiosis) of a sign, Morris [Morris, 38] devised three levels: syntactic: recognition of the sign in relation to other signs; semantic: comprehension of the intended meaning of the sign; and pragmatic: contextual meaning added to the sign. In terms of semiosis and communicative acts ‘emergent properties’ (the deontic operators obligation, permission and forbiddance) materialise that expose a semiotic response to a communication act. Normative actions such as carrying out a task without coercion (obligation), being persuaded into doing a task (permission), and absolute refusal to do a task (forbidden) by a recipient of a message in a communication act, are responses to the pragmatic meaning of a sign [Stamper, 96; Liu, 00].

### 3.1 Norms and Norm-based Agents

According to [Boella et al, 06] social norms “exist where models of human activity are normatively regulated”. Essentially social norms provide a mechanism by which human agents through consensus, recognise and adhere to. Social norms also introduce unpredictable behaviour [Young, 08]. Social norms are ‘enforced’ by coordination motives. Coordination motives are social phenomena as they are shared expectations about a solution to a given problem, essential in a negotiation framework such as a SOA. Rigid enforcement is therefore not required [Young, 08]. Social norms are governed by expected patterns of behaviour; ‘legal’ norms however require a different form of control. Legal norms are sustained by social disapproval or a form of punishment for norm violation. Legal based norms are an expression of obligations and rights that an individual human agent (or a machine-based agent) has within a social system [Boella et al, 06; Liu, 00]. Typically legal norms are supported by a consenting mechanism. Should a machine (norm-based) agent ‘own’ a legal norm, or a set of legal norms, consent for action is implied. Legal and social norms can be used to ensure that web service selection is compliant within a SOA.

Norm-based agents, according to [Boella et al, 08], can communicate, distribute, detect, create, modify and enforce norms in a Multi-Agent System (MAS). Norm-based agents in a normative business organisational system (which includes a SOA) interact with the system in various ways. Norm-based agents (human and software based) are expected to communicate with other norm-based agents [Boella et al, 08]. Business organisations that implement a SOA are in fact implementing a normative system. The exemplar [OASIS, 08] as previously described ‘is’ a normative SOA framework.

## 4 Research Challenge

The foundational elements of the LAP domain provide a suitable mechanism to coordinate communication between humans and norm-based (software) agents to discover web services from within a SOA context. The typical two-role communication [Goldkuhl, 07] exchange pattern, evidenced in work by [Winograd & Flores, 86; Medina-Mora et al, 92; Dietz, 99; Schoop, 05] as previously shown in figure 1, demonstrates that ‘S’ the speaker makes a request, ‘H’ the hearer promises to do the request, or counters the request and so on. This approach however appears to be prohibitive in terms of business process modelling in a normative SOA context, for example:

*The communication loop (with its two roles) is used in business process modelling as a generic template. As I conceive it to be an over-simplification of business processes, it can deceive people to perform such a restricted analysis [Goldkuhl, 07].*

With regard to business process modelling notations, such as Unified Modelling Language (UML) Activity Diagrams [UML, 08] and its range of available semantics, mechanisms are available that facilitate what [Goldkuhl, 07] calls ‘multi-responsive’ actions. The orchestration of web service discovery in SOA contexts rely on business process modelling techniques that have multi-responsive communication patterns, hence there appears to be a mismatch between what is required as business process modelling in SOA contexts and the foundational aspects of LAP. As such, the general mismatch between the two is pointed out by [Goldkuhl, 07]. Hence, it is fair to say that the traditional speaker-hearer schema bars securing appropriate ‘pragmatic’ decision making in a normative SOA context. There is a need to move from the traditional communication-loop pattern exhibited in [Winograd & Flores, 86; Medina-Mora et al, 92; Dietz, 99] to provide a richer communication act pattern and decision making process to build a truly pragmatic negotiation mechanism within a SOA framework.

The research challenge in this paper focuses on defining a pragmatic (normative SOA based) web service discovery mechanism based upon a multi-responsive communication pattern. The motive behind this research challenge is based upon the required use of norm-based agents (typically machine orientated but also includes humans) [OASIS, 08] to discover relevant web services. To achieve such a move semiotics (semiosis) provides a route to coordinate actions of agents (human and machine-based) and have agency (such as intentions) communicated non-verbally by norm-based agents.

The intersection of semiotics and pragmatics as advocated by [Cooren, 08] where ‘agency’ can be attributed to textual entities is built upon as a pivotal theme in this research challenge. Cooren shows that agency can be attributed, not only to the person who created a non-verbalised speech act, but also to the resultant textual entity. The notion of agency credited to textual entities opens up the traditional speaker-hearer schema that generates communication loops originating from within the LAP domain. This notion allows norm-based agents to make and respond to communicative acts whilst carrying out duties in a SOA based implementation.

## 5 Defining a Multi-responsive Communication Pattern

Based upon figure 2, the web service discovery communication pattern consists of a sign (content of a communication act) that embodies some form of agency, in this case ‘intentions’. Human semiosis is very much a part of the communication model, as human semiosis is used to guide, through negotiation, norm-based agent behaviour. The model however allows norm-based agents to confer with other norm-based agents and other humans. Norm-based agents have access to a norm base ‘shared’ with human agents, and hence invoke communicative acts. Evidently, humans make meanings of signs contained in the sign/interpretant relation using a range of faculties that machines do not have. To capture this aspect [Benfell and Liu, 09] proposed that human agents, through semiosis, should be an integral element of a web service discovery process in a normative SOA framework.

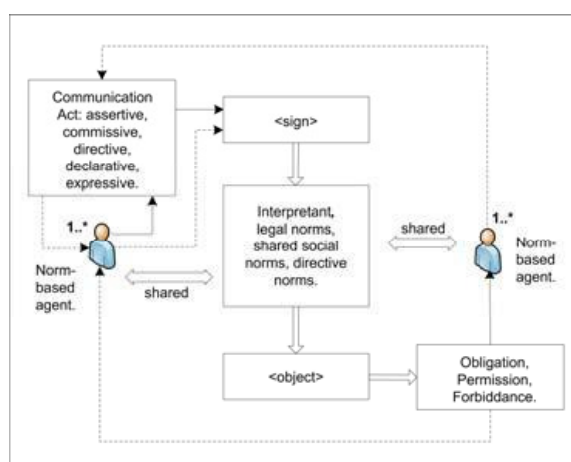


Figure 2: Multi-responsive communication and semiosis

To formalise the multi-responsive communication pattern various message types based upon SAT are used to communicate with norm-based agents. Normative behaviour is governed by the process of semiosis whereby emergent deontic states indicate actions to be carried out (or not to be carried out) according to the content of the communication act a norm-based agent receives.

### 5.1 Setting the Multi-responsive Communication Pattern in a SOA Context

Norms are used in this paper as an interleaving mechanism to assist business modelling. Norms, therefore, are central to modelling a business (in this solution) by identifying ‘directive’ (pragmatic high-level contextual norms) to guide the behaviour of norm-based agents. The term ‘directive norm’ is unique to the approach devised here. Business modelling is achieved through various modes of describing directive norms thus enabling norm modelling to traverse through a SOA framework. Two such approaches that fulfil norm modelling are the Business Motivation Model [BMM, 08] and the UML [UML, 08].

## 5.2 Achieving Pragmatic Web Service Discovery in a SOA Context

BMM promotes a range of core features that are applicable to structuring business organisation objectives. The ones used here are *Mission*, *Strategy*, *Tactic* and *Directives*. Each is used to provide input, in increasing detail, from *Mission* to *Strategy*, *Strategy* to *Tactic*, and *Tactic* to *Directives*. The *Directive* component is used to contain the pragmatic high-level directive norms to guide the modelling of business objectives within the multi-responsive communication pattern.

Taking into account directive norms as an approach to contextual web service discovery, a SOA representation is formulated next. With reference to figure 3, the package *Business Organisation Model* is made up of three ‘packages’, *Social Structure*, *Stakeholder and Participants*, and *Needs and Capabilities*. These are taken directly from the OASIS SOA framework [OASIS, 08]. The *Social Structure* defines the power relationships amongst a set of participants that belong to a business organisation. The *Stakeholders and Participants* package sets out the major actors that relate to SOA implementations. The *Needs and Capability* package is linked to the fulfilment of business objectives, and to achieve this, the model uses four elements taken from the BMM, *Mission*, *Strategy*, *Tactics* and *Directives*. In the SOA model, the crucial element is *Directive*, as this holds directive norms that are communicated by all agents.

To validate the use of directive norms, an example application based upon a hypothetical on-line journal subscription business organisation called, Journals on-Line (JOL), who wish to use web services as their implementation strategy, is shown. For the communication of directive norms to occur and to demonstrate the actions taken by norm-based agents, appropriate packages (figure 3) are selected from the *Business Organisation Model* and the *SOA Specification Model*. First business objectives are described using *Mission*, *Strategy*, *Tactics* and *Directives* to set directive (high-level) norms.

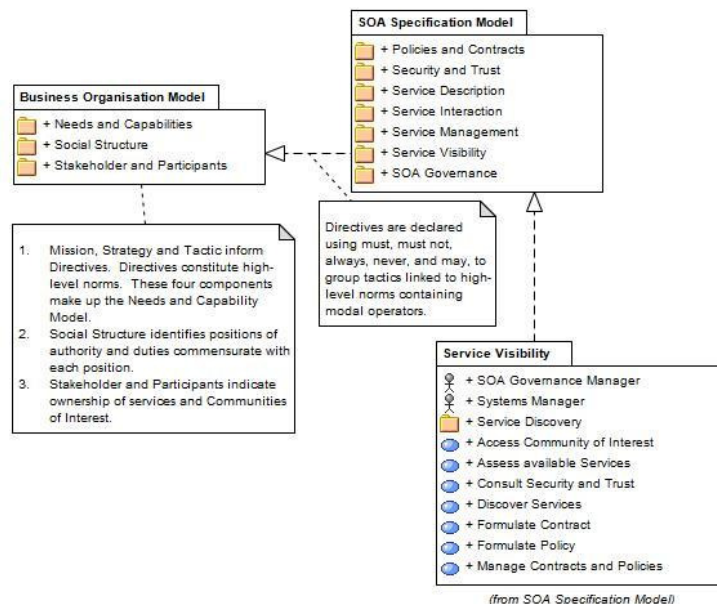


Figure 3: Organisational Models



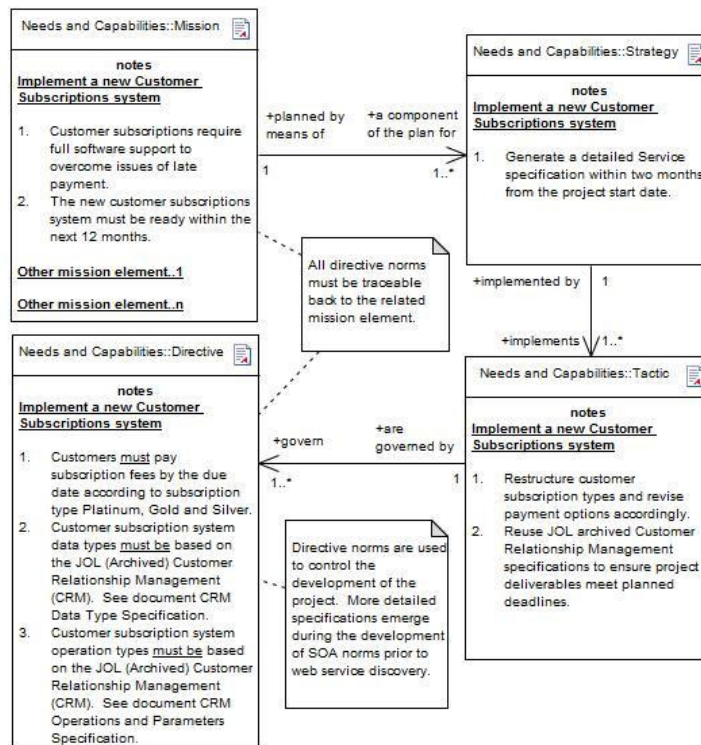


Figure 4: Needs and Capabilities

Using the *Needs and Capabilities* package (figure 4), a selection of directive norms that are pertinent to web service discovery are identified so that they can be communicated by norm-based agents. In a real case scenario this list would be much greater. The multi-responsive communication pattern in figure 5 below is discussed next.

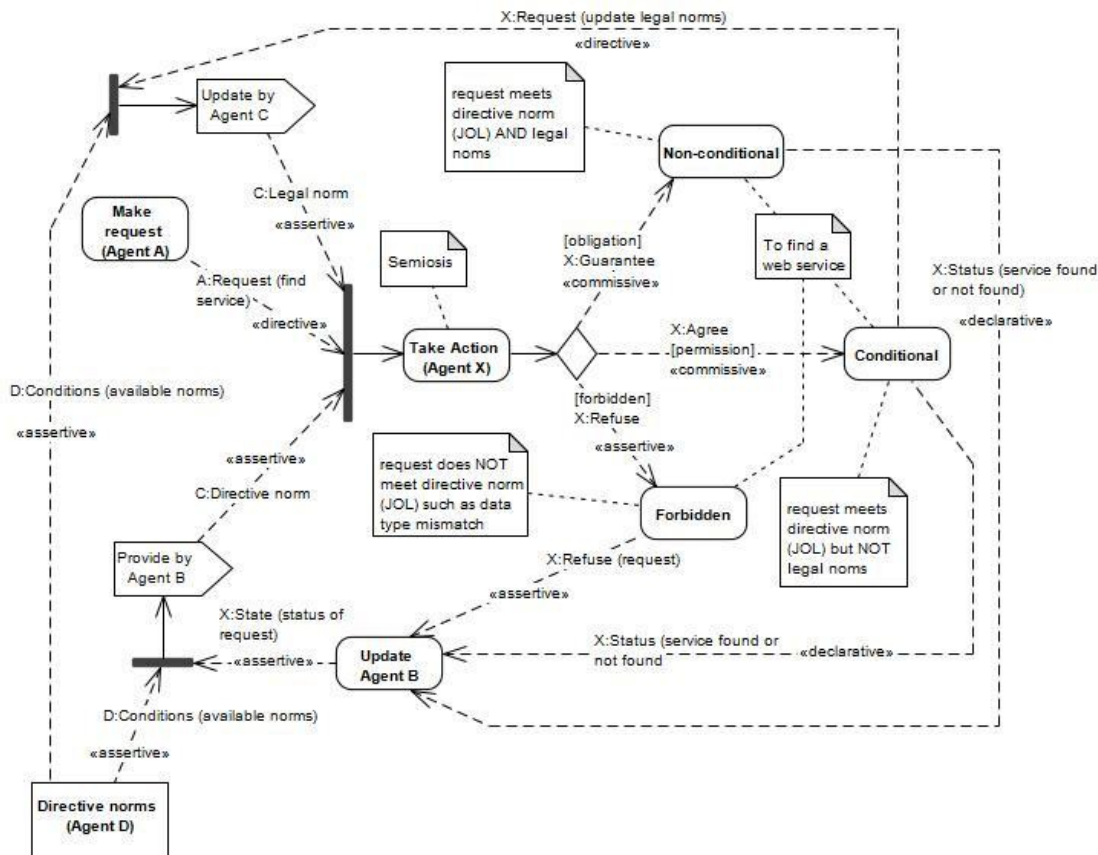
### 5.3 The Multi-responsive Communication Pattern – a discussion

With reference to figure 5 should the ‘present situation’ be modelled only, where Agent A makes an initial request, Agent X infers through semiosis if it is obliged, permitted, or forbidden to carry out the request and so on, indicative of the original communication loop, proves its worth in this case. However, the following observations can be made:

- (i) It is a very narrow modelling scenario as there are other background features that should be solicited in this situation to fully capture an appropriate analysis. Shown in figure 5 are three occurrences of multi-responsiveness (indicated using UML Activity Diagram fork and join notation – heavy emboldened lines) representing background features to the present case;
- (ii) Regarding multi-responsiveness (where there is a response to several earlier actions) Agent X in figure 5 receives a number of ‘trans-situational grounds’ (Goldkuhl, 07] as communicative acts. Agents D and B generate communicative acts based upon directive norms (a textual entity exhibiting



agency) that are communicated to Agent X at ‘some point in time’. Goldkuhl refers to this as ‘memory traces’ and cites [Giddens, 84]. Modelling trans-situational grounds facilitates the specification of a MAS in accord with the specification of norm-based agents by [Boella et al, 08]. Should a typical communication loop construct be used to model the example scenario only, this information is unlikely to be present. This could have severe ramifications for the quality of an Information System, as it prohibits the identification of other norm-based agents and their role in this particular (and any) scenario;



- (iii) Inferences that can be made from a model devised using the traditional communication loop would suggest that Agent X would be responsible for updating its own legal norms and taking ownership of directive norms – opposite to the requirements laid out in the OASIS SOA framework for software-based agents;
- (iv) Directive norms are owned by a business organisation, and by nature, are independent of any one stakeholder. They are also documented as textual entities that according to [Cooren, 08] can exhibit agency. This promotes the need for them to be modelled accurately, and therefore, communicated (as a communication act) in a normative SOA framework implementation.
- (v) The multi-responsive pattern of communication acts also strengthens the notion of pragmatic web service discovery by identifying more clearly the origin of relevant norms belonging to the ‘present situation’.

## 6 Conclusions and Future Work

The web service discovery mechanism (devised here) driven by a normative SOA framework uses the linkage of pragmatics and semiotics to make possible the contextual discovery of web services using a multi-responsive communication pattern. The assertion that a textual entity can demonstrate ‘agency’ normally attributed to human agents [Cooren, 08], was used as the foundation for this hypothesis. Additionally, the web service discovery mechanism manages the interface between agents (human and machine-based). The purpose of capturing communication acts and applying semiosis to the related symbolic signs provides a means to capture intentions and have norm-based agents act upon them.

Three areas require further exploratory work to ensure that the web service discovery mechanism is consistent with the purpose of using pragmatics and semiotics as a method to overcome the limitations of traditional communication loop modelling, and to further enhance the pragmatic nature of discovering web services in diverse business organisation settings:

- (i) Further exploration of notation, for example UML, that can more accurately specify triggers for actions as opposed to a mix of modelling triggers and background initiatives. Also identified by [Goldkuhl, 07];
- (ii) Translation of directive norms into ‘executable’ norms that govern the actions of norm-based agents to derive semantic and syntactic specifications of web services prior to discovery;
- (iii) Specification of norm-based agents to include their aggregated elements and specialised roles within a normative SOA framework.

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