A Theoretical Investigation of the Emerging Standards for Web Services

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Keywords:
Service-Oriented Computing, Web Services, Web Services Standards, W3C web services, Semantic Web Services, ebXML, Standards Stacks, Layered Models, Language-Action Perspective, Reference Framework

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Abstract

Currently, standards for web services are being developed via three different initiatives (W3C, Semantic web services and ebXML). To the best of our knowledge, no theoretical perspectives underlie these standardization efforts. Without the benefit of a strong theoretical basis, the results, within and across these initiatives, have remained piecemeal. We suggest 'Language-Action Theories' as a plausible perspective that can effectively define, assess and refine web services standards. In this paper, we first investigate the existing initiatives to identify commonalities that point to theories of 'Language-Action' as an appropriate theoretical basis for web services standards. Next, we adapt work from these theories to develop a comprehensive reference framework for understanding web services standards. Finally, we use this reference framework to assess the three initiatives, and analyze the findings to provide insights for future development and refinement of web services standards.

Keywords:

Service-Oriented Computing, Web Services, Web Services Standards, W3C web services, Semantic Web Services, ebXML, Standards Stacks, Layered Models, Language-Action Perspective, Reference Framework

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[*] The authors would like to thank editors for this special issue and two anonymous reviewers for helpful comments on an earlier draft of this paper, and M. Hopkins for several editorial suggestions.

1 Introduction

Standards are an important component for web services because they facilitate interactions among applications within and across organizations. They must, therefore, cover a wide array of concerns such as messaging, publishing, discovering, and composing. Constructing a single, monolithic standard that encompasses all these is enormously difficult. Ongoing work on web services standards[1] has, therefore, developed separate core standards for *publish*ing (WSDL (WSDL, 2001)), *find*ing (UDDI (UDDI, 2005)), and *bind*ing (SOAP (SOAP, 2003)). Such 'separation of concerns' is a necessary attribute of web services standards, which can be achieved by segmenting the standards-space into different 'layers' (similar to (Kreger, 2001)). The resulting 'standards stack'[2] segregates the standards space into multiple layers which can provide boundaries for development and use of standards. An analogy can be seen in the OSI seven-layer model (OSI, 1994), which separates networking technologies into a seven-layer abstraction. A standards stack for web services can perform a similar function.

An important concern, however, is the identification of appropriate layers in this stack. Without an agreement about these layers, development of standards in this space remains a piecemeal effort. For example, standards that cross layers, such as WS-BPEL (WS-BPEL, 2005) and WS-CDL (WS-CDL, 2004), have been proposed over the last few years. Competing standards within a layer have also been proposed, such as WS-coordination (WS-CF, 2004) and WS-CDL (WS-CDL, 2004), causing confusion for information systems developers.

Our review of prior work shows that holistic efforts to identify these layers have been lacking. Prior work has either produced compilations of existing standards (Mukhi, Plebani,

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[1] Appendix A shows a list of standards proposed for web services following different initiatives.
[2] The term 'web services stack' refers to a 'stack of web service standards' (Sleeper & Robins, 2001).

SilvaLepe, & Mikalsen, 2004) or has been driven by considerations of adoption of standards (Gosain, 2003). Without the benefit of a holistic framework guided by appropriate theories, work in this space has suffered from false starts (WS Arch, 2005; WSCI, 2002).

An appropriate theoretical framework is found in the stream of research known as Language-Action Perspective (LAP), which maps well to the core of service-oriented computing, i.e., 'communication' (Lemniotes, Papadopoulos, & Arbab, 2004). LAP was originally developed in the context of human actors communicating with one another to achieve organizational goals (Lyytinen, 2004). We argue that this research stream can be adapted and applied to the web services standards space. Our objective in this paper is to *adapt research from the Language-Action perspective to construct a reference framework for the web services standards space, and demonstrate how it can be used to assess existing standards or develop new standards.* The paper starts by investigating how the three existing initiatives operationalize core web services concepts. Next, by adapting important concepts from LAP, we develop a reference framework for the web services standards space. We then demonstrate how the reference framework can be used to assess the existing initiatives. Finally, we discuss implications for refinement and development of future standards.

2 Web services as the realization of service-oriented computing

The service-oriented computing (SOC) paradigm[3] is currently being realized through three different initiatives. The first represents a major effort from the World-Wide Web Consortium (W3C), which builds on the premise that web services may be defined in a

[3] Service-Oriented Computing (SOC) refers to a re-conceptualization of software to its essence, that of service (Papazoglou & Georgakopoulos, 2003; Turner, Budgen, & Brereton, 2003). In an SOC environment, applications are recast as "services." They declare their functional and nonfunctional requirements and capabilities in an agreed upon, machine-readable format (Curbera, Khalaf, Mukhi, Tai, & Weerawarana, 2003).

programmatic manner so that companies can use them to integrate their operations (WS Arch, 2005). The second represents an effort that is backed by the research community interested in a vision of the Semantic Web that augments web services with semantic components (Paolucci & Sycara, 2004). The third represents an effort by the Organization for the Advancement of Structured Information Standards (OASIS) in conjunction with the UN as a way to build upon existing Electronic Document Interchange (EDI) infrastructure to facilitate global trade (ebXML-Req, 2001).

2.1 Alternative instantiations

The three initiatives conform to the same basic operations (publish, find and bind)[4] and roles (service provider, service discovery agency, and service requestor) (Manes, 2003; Papazoglou & Georgakopoulos, 2003). Each, however, operationalizes these with slight differences. We explain and contrast the three with an online travel agent example:

> "[WSClient], a potential customer, queries a business registry for online travel agent. The registry returns a list of online travel agent services. [WSClient] selects [TAService] service, which is most fitting to its requirements and then binds to that service."

The W3C initiative

To realize our example scenario using the W3C initiative, [TAService] would create a Web Services Definition Language document (WSDL, 2001) to describe its service interfaces, and publish it in the Universal Description, Discovery, and Integration registry (UDDI, 2005). [WSClient] will query the registry for services, which provide online travel agent capabilities. [WSClient] would select a service which meets its requirements. Assuming that [WSClient] selects [TAService], it would then bind its application to [TAService]. [WSClient] will generate

[4] A native capability of SOC applications is the ability to describe themselves (publish), locate service partners (find), and invoke these services as required (bind). These three operations provide the basic building blocks of a service-oriented architecture (Curbera et al., 2003).

Simple Object Access Protocol (SOAP, 2003) messages conforming to [TAService]'s service declarations, and invoke [TAService]. Both [WSClient] and [TAService] will now exchange messages to communicate.

The semantic web services initiative

The key difference between the W3C initiative and the semantic web services initiative is that the first depends on a syntactic description of web services, whereas the second utilizes more semantic descriptors derived from the OWL-based Web Services Ontology (Ankolekar et al., 2001). To realize our example scenario using Semantic Web Services, [TAService] would create a service profile of its capabilities using the semantic descriptors. The service profile contains a service model that describes how to interact with the service, and a service grounding that maps the information exchanges described in the service model into actual messages (Ankolekar et al., 2001; Paolucci, Sycara, Nishimura, & Srinivasan, 2003). The service profile is then published in a Service Registry. [WSClient] will query the Service Registry to find a required service, and when found, use its service grounding to bind the selected service. Assuming that [WSClient] selects [TAService], both services can then generate messages to communicate.

The ebXML initiative

Unlike the first two, the ebXML initiative builds on existing EDI standards (ebXML, 2005) to specify the ebusiness XML language that globally distributed business partners can use to signify their compliance with minimum requirements for trading and conducting business (ebXML, 2005). The example scenario is realized following the ebXML initiative in the following manner. [TAService] would request the Business Process Specification Schema (BPSS) (ebBPSS, 2001) from an ebXML registry (ebRS, 2002) and populate it with its own capabilities that describe its implementation of an online travel agent service along with a

Collaboration Protocol Profile (CPP) (ebXML-CPPA, 2002) that specifies the electronic interactions it can participate in. [TAService] will then submit the BPSS and CPP, i.e., its business profile to the ebXML registry. When [WSClient]'s query returns [TAService] as a potential business partner, it can download [TAService]'s business profile from ebXML registry. Both [TAService] and [WSClient] may then agree to conduct business (using their CPP), and will produce a Collaboration Protocol Agreement (CPA). Once the CPA is in place, [TAService] and [WSClient] are said to possess the required trading partner information, and may engage in conducting business electronically using a messaging service that is part of the ebXML specification (Rawlins, 2002).

2.2 Commonalities across instantiations

The three initiatives are similar, yet different from one another in their vision because of the different challenges they see at the core of the web services paradigm. For W3C, the key challenge is providing a set of application programming interfaces (APIs) that will allow existing applications to communicate with each other over the web (WS Arch, 2005). For the semantic web services research community, the challenge lies in describing and discovering web services not only syntactically but also semantically (Paolucci & Sycara, 2004). The third, OASIS, views the core challenge as developing a framework that utilizes existing EDI infrastructure. It, therefore, provides a consistent and uniform manner for exchange of electronic business data for B2B and B2C environments (ebXML-Req, 2001). Over the years, these three initiatives, which started as separate endeavors, have interacted with one another further emphasizing their commonalities[5]. Figure 1 highlights the commonalities among the three initiatives.

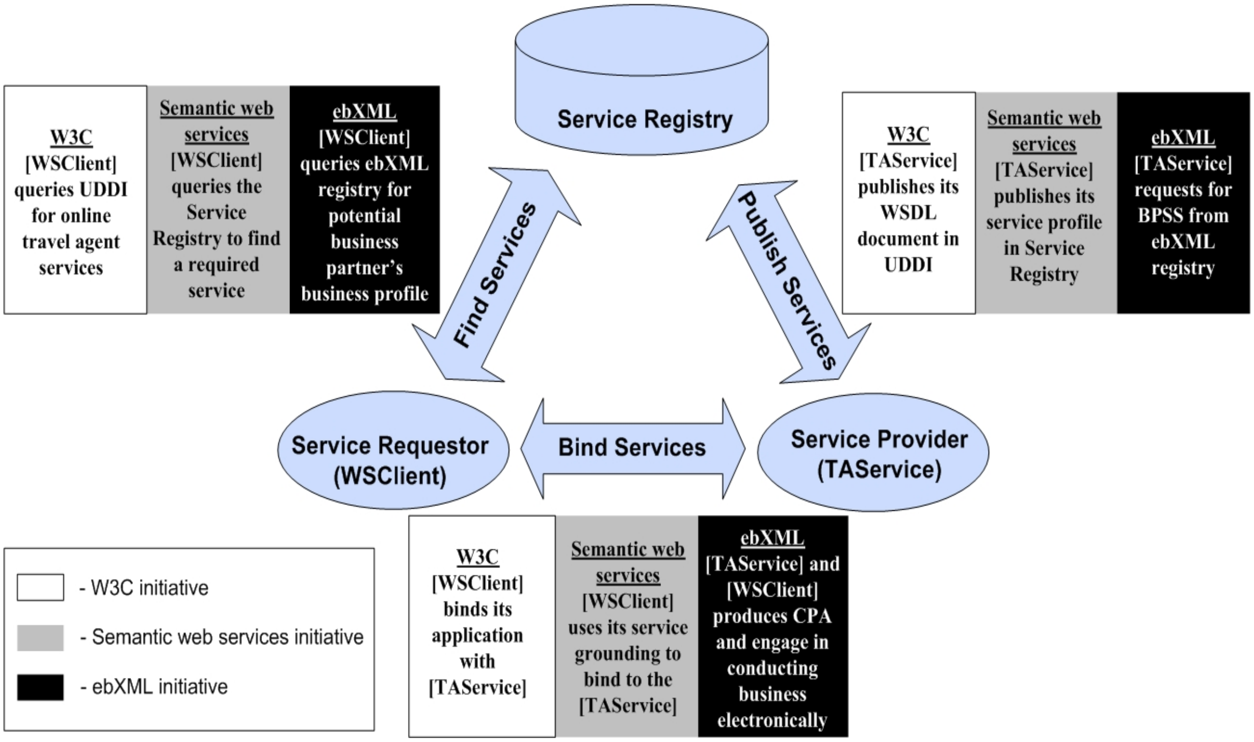

Figure 1: Comparing alternative instantiations with the travel agent scenario

The figure shows that 'communication' is at the core of the service-oriented computing paradigm (Lemniotes et al., 2004) – it is used to publish, find and bind services. The mechanism used to accomplish these *actions* is *communication* (e.g., publishing a service in a UDDI corresponds to the *action* of 'advertising available capabilities'). Communication, thus, represents 'action-taking' in the realm of web services and includes actions such as: (a) advertising available capabilities, (b) locating partners, (c) establishing commitment, (d) negotiating contract terms, (e) entering into a contract, (f) carrying out a transaction, (g) performing an exchange, (h) carrying out processes, (i) establishing trust, and (j) establishing relationships. These activities closely correspond to *business* activities that increase in time span

[5] For example, the W3C has a working group on semantic web services (WS SWSIG, 2002). The UDDI standard, initially developed by OASIS (OASIS, 2005), is now part of the core W3C standards, and the ebXML standard advocated by OASIS (ebXML, 2005) is being integrated within the W3C efforts (WS Activity, 2005).

(from facilitating single interactions with business partners to carrying out processes that include multiple interactions to facilitate business relationships that may include multiple processes). This view of communication and language is different from the traditional database perspective, which views language as a mechanism to record facts from the universe of discourse (Brodie, Mylopoulos, & Schmidt, 1984; Navathe, Elmasri, & Larson, 1986). The next section builds on this perspective to identify a theoretical perspective for the web services standards space.

3 A theoretical framework for the web services standards space

The two arguments above, (a) communication as action, and (b) emphasis on business activities, lead us to suggest Language-Action Perspective (LAP) as an appropriate theoretical perspective for the web services standards space. Following LAP, we can view information systems as actors, i.e., communicative social entities, with different roles, knowledge, and processes (Klein & Huynh, 2004), engaged in performing business activities A number of frameworks (e.g., SAMPO (Auramaki, Lehtinen, & Lyytinen, 1988) and DEMO (Dietz, 1994)) have been constructed on this foundation for modeling of *business* activities as *communicative* actions.

The choice of LAP as a theoretical perspective also meets the criteria for theory selection suggested by Holmstrom and Truex (Holmström & Truex, 2001): (a) selected theory's historical context, (b) selected theory's sensitivity towards details of the phenomenon under study, (c) selected theory's impact on the choice of research method and (d) selected theory's contribution to cumulative theory-building.

The *first* criterion is met by the historical application of LAP to message-oriented phenomena. Other information systems based on LAP theories include Coordinator (Winograd & Flores, 1986), SAMPO (Auramaki et al., 1988), Action Workflow (Medina-Mora, Winograd, Flores, & Flores, 1992), DEMO (Dietz, 1994), MILANO (De Michelis & Grasso, 1994), and BAT (Goldkuhl, 1996). These systems provide a historical lineage that makes LAP theories appropriate for application to the new domain of web services. The *second* criterion ensures that the selected perspective focuses on appropriate constructs. LAP theories do, indeed, focus on communication instead of data (Verharen, Dignum, & Weigand, 1996) following the constructs suggested by theories of speech acts, hermeneutics and sociology of knowledge (Goldkuhl & Lyytinen, 1982). The *third* criterion, which describes how the selected theory impacts the choice of research method, is largely inapplicable in the context of this work because our research method relies on the conceptualization of a new reference architecture, and an analysis of existing standards as a validation mechanism. The *final* criterion assesses whether the selected theoretical perspective would contribute to cumulative theory-building in the target domain. LAP views an organization as a network of interrelated conversations (Aakhus, 2004) similar to actions performed by web services in concert with others. This perspective has been largely absent in web services. By suggesting this perspective, our selection directly contributes to theory-building in the target domain of web services standards.

3.1 A brief review of research on the language-action perspective

The use of Language-Action perspective (LAP) for information systems can be traced to Flores and Ludlow (Flores & Ludlow, 1980), who argued that human beings are linguistic beings and act through language (Schoop, 2001). LAP formulates a norm-based and interpretive alternative of how language is constituted in social life to analyze its implications for the design of information systems (Auramaki et al., 1988; Goldkuhl & Lyytinen, 1982, 1984; Hirschheim, Klein, & Lyytinen, 1995; Lyytinen, 2004). It conceives of the use of information systems primarily as a medium or tool for communication (Goldkuhl & Lyytinen, 1982) drawing upon linguistic and social rules that govern the use of language (Goldkuhl & Lyytinen, 1984). It is, therefore, not so much centered on perfecting computational models and techniques. Instead, it seeks to explain and understand relations between computational phenomena and social behaviors that are embedded in or enabled by information systems (Lyytinen, 2004). The Language-Action approach is, thus, based on the premise that much in organizations is performed through language, i.e., communication is primarily action which, in turn, facilitates coordination and interaction (Ljungberg & Holm, 1997).

An *action* view on language and communication for the analysis of *business* activities is, thus, the essence of LAP. An important theoretical foundation for LAP is the Speech Act Theory (Austin, 1962; Habermas, 1984; Searle, 1969). Uttering a sentence is the performance of a purposeful act, a so-called speech act. LAP emphasizes the need for regarding the performance of business processes as patterns of inter-related speech acts (Flores & Ludlow, 1980). Winograd & Flores (Winograd & Flores, 1986) extend this idea and introduce a conversation-for-action schema, which covers a number of state changes, e.g., someone (A) states a request, someone else (B) makes a promise and then reports completion, which in the end A declares completed.

Several frameworks have been developed based on the language-action perspective, such as a layered pattern approach for electronic commerce transaction (Weigand, Heuvel, & Dignum, 1998), generic layered patterns for business modeling (Lind & Goldkuhl, 2001) and an aggregative atoms, molecules and matter model (Dietz, 2002). Other approaches include Action Workflow (Medina-Mora et al., 1992), Dynamic Essential Modelling (DEMO) (Dietz, 1994, 2001; Reijswoud, Mulder, & Dietz, 1999), and Business Action Theory (BAT) (Goldkuhl, 1996, 1998; Lind & Goldkuhl, 1997, 2001). These efforts, which have built a layered view of communication-oriented business activities, provide further support to the argument that LAP can provide the basis for understanding the web services standards space.

3.2 An LAP-inspired framework for the web services standards space

Developing an LAP-inspired framework for the web services standards space requires one key adaptation of the premises underlying LAP. The participants in the communicative action represent computationally described web services instead of organizational actors (Aakhus, 2004). As established in the previous section, the objective remains carrying out specific business activities. Following LAP, this can be achieved if (a) there is a common platform through which participants can share, exchange and reach common understanding on assumptions, values and norms of their interaction; (b) participants can advertise, negotiate and reach mutual commitments for performing purposive business activities; and (c) participants engage in rational discourse to perform their committed business actions and resolve any breakdowns that may occur during their interaction (Klein & Huynh, 2004). The framework we propose, accordingly, consists of three levels: (a) communication platform, (b) communicative act, and (c) rational discourse.

Communication platform

The first level is the enabler of communicative acts between communicating parties. In LAP, the process of performing a communicative act is a social action (Goldkuhl & Agerfalk, 2000; Searle, 1969). In order to make a communicative act successful, four conditions are required (Dietz, 2001, 2004):

- There must be a communication channel, i.e., there should be a transportation protocol to transport communicative messages between parties.
- There must be a common syntax, so that messages are correctly recognized by the parties.
- There must be common semantics, so that messages are correctly interpreted by the parties.

- There must be common social culture between parties, so that they have full agreement on the commitments raised by the communicative acts.

The above conditions suggest that a prerequisite to successful communicative acts is a communication platform. It can be divided into three layers: [channel], [messaging] and [guarantee]. The first condition establishes the need for a communication channel between parties as a conduit of messages. The second and third conditions establish the need for common syntax and semantics for messages. The fourth condition guarantees that the expectations for interpretation of messages are shared by the communicating parties.

Communicative act

The second level creates commitments between communicating parties (Dietz, 2001) for some future action (Searle, 1969) and creates a "shared understanding" against a shared background (Habermas, 1984). The participants achieve this goal through four phases (Goldkuhl, 1996, 1998):

- First, the participant who has ability (capacity and know-how) to perform an action offers and exposes it in a form searchable by other participants.
- Second, a participant who needs certain performance of an action, searches for partners who offer this ability.
- Third, after the participants find each other, they establish contact, exchange proposals and negotiate with each other to reach an agreement (Schoop, 2002).
- Finally, the participants establish a formal contract which expresses mutual commitments of the participants for future actions.

The four phases directly map to four layers: [capability exposure], [capability search], [proposal and negotiation] and [contract establishment].

Rational discourse

The third level emerges out of the performance of patterns of communicative acts (Auramaki et al., 1988; Klein & Huynh, 2004; Lyytinen, Lehitnen, & Auramäki, 1987). Rational discourse occurs among actors, when they pursue their own goals and harmonize their plans of action based on a common definition of the situation (Cecez-Kecmanovic & Janson, 1999; Reijswoud et al., 1999). This coordination via rational discourse can include four layers:

- First, interaction between actors consist of patterns of triggers and responses (Dietz, 2002; Lind & Goldkuhl, 2001), i.e., conversations among actors are made up of a finite sequence of communicative acts (Dietz, 2002; Weigand et al., 1998).
- Second, a composition of related exchanges can lead to a goal state that is satisfactory to the needs of the actors (Dietz, 2002; Lind & Goldkuhl, 2001). Each exchange, thus, represents a step that facilitates transition from an initial state to a goal state (Klein & Huynh, 2004; Lind & Goldkuhl, 2001).
- Third, recurring or long-term transactions require establishing relationships among actors, and sustaining or improving them over time (Lind & Goldkuhl, 2001).
- Finally, concurrent contracts may be run with several parties (Weigand et al., 1998). This includes the need to regulate long term contracts, and the ability to change business transactions as the contracts changes (Goldkuhl & Melin, 2001), i.e., it requires a global overview of running contracts and explicit control of the running transactions and existing relationships (Weigand et al., 1998).

These map to the four layers: [exchange], [transaction], [relationship management] and [managing concurrent contracts] respectively.

Table 1 outlines the LAP-inspired framework. The first level (at the bottom of the table), communication platform, describes 'how' communicative acts are enabled; the second level (in the middle of the table), communicative act, focuses on 'what' the acts themselves constitute; and the third level (at the top of the table), rational discourse, emphasizes 'why' patterns of communicative acts are carried out, e.g., to achieve business goals.

The next section demonstrates how the proposed 'reference framework' can be used to assess existing web services standards stacks.

Table 1. An LAP-inspired framework for the web services standards space

Rational discourse (coordination among actors based on commitments for achieving business goals)	
[Managing concurrent contracts] (Weigand et al., 1998)	Managing concurrent contracts, i.e., managing contracts with multiple partners, " interactions between several contracts that run concurrent between several parties." (Weigand et al., 1998), "a global overview, a representation of the contracts" (Weigand et al., 1998).
[Relationship management] (similar to transaction group (Lind & Goldkuhl, 2001), contract (Weigand et al., 1998))	Relationship management deals with multiple or recurring transactions with one partner following a long term contract, "The recurrent business transactions need to be framed within a wider agreement. .. (Lind & Goldkuhl, 2001), "… creation and sustainment of business relations'" (Weigand et al., 1998)
[Transaction] (similar to business transactions (Lind & Goldkuhl, 2001), business process (Dietz, 2002), workflow (Weigand et al., 1998), contract (Weigand et al., 1998))	A pattern built from different types of exchanges related to each other (composition of interrelated activities or interactions to achieve a goal) "..composition of connected interactions." (Dietz, 2002), "… transaction includes a number of different exchanges, where each of these exchanges constitutes the … transaction's different phases." (Lind & Goldkuhl, 2001), "..a set of related transactions aimed at some goal." (Weigand et al., 1998)
[Exchange] (Exchange in (Lind & Goldkuhl, 2001), includes Action pair (Lind & Goldkuhl, 2001), similar to interaction (Dietz, 2002), similar to transaction (Weigand et al., 1998))	A exchange involves interaction between actors consisting of patterns of trigger and response, "patterns of triggers and responses." (Lind & Goldkuhl, 2001), "An exchange means that one actor gives something in return for something given by another actor." (Lind & Goldkuhl, 2001), " …acts appear to occur in particular patterns. ….. we call these patterns conversations. (Dietz, 2002), "the smallest possible sequence of actions (speech acts) that leads to a certain…state" (Weigand et al., 1998)
Communicative act (creating commitments between communicating parties)	
[Contract establishment] (Goldkuhl, 1996, 1998; Habermas, 1984; Lind & Goldkuhl, 1997)	Provider and customer enter into commitments to perform a business transaction. "Customer and supplier come to an agreement concerning the business transaction. The contract is a mutual communicative action expressing the mutual commitments made; i.e., commitments for future actions." (Goldkuhl, 1998)
[Proposal and negotiation] (Goldkuhl, 1996, 1998; Habermas, 1984; Schoop, 2002)	Participants negotiate with each other through interpretation of the situation at hand and seek to achieve consensus. "Bids and counter-bids are made. The desire and demand of the customer are expressed. The supplier can make different offers." (Goldkuhl, 1998), ".. characterized by highly dynamic and interactive exchanges that can range from simple orders from a product catalogue to complex negotiations involving offers, counter-offers, bargaining etc." (Schoop, 2002).
[Capability search] (Goldkuhl, 1996, 1998; Habermas, 1984; Lind & Goldkuhl, 1997)	Customers desiring a capability seek contact with providers providing the capability. "The customer does not have the corresponding ability … needs which may be satisfied by potential suppliers and their products (goods/services)"(Goldkuhl, 1998).
[Capability exposure] (Goldkuhl, 1996, 1998; Habermas, 1984; Lind & Goldkuhl, 1997; Reijswoud & Lind, 1998)	Participants offer and exposes their business in a form searchable by other participants, "ability is offered and exposed to the market" (Reijswoud & Lind, 1998), "The supplier must have an ability (a capacity and a know-how) to perform business; to make offers and contracts and to fulfill these contracts." (Goldkuhl, 1998)
Communication platform (preconditions to make communicative acts successful)	
[Guarantee] (Dietz, 2001; Habermas, 1984)	Ensuring delivery without distortion, "free from any kind of distortion, any form of coercion and ideology "that excludes all force...except the force of the better argument." (Habermas, 1984).
[Messaging] (Dietz, 2001; Habermas, 1984)	Common syntax and semantics , "The concept of communicative action presupposes the use of language as a medium for a kind of reaching understanding…" (Habermas, 1984)
[Channel] (Dietz, 2001)	Conduit to carry messages

Legend (followed throughout the remainder of the paper): Level [Layer within a level]

4 Assessment of existing web services standards stacks

4.1 Assessment of the W3C initiative

Table 2 summarizes the results of assessing the W3C initiative (WS Arch, 2005) against the LAP-inspired reference framework.

Table 2. Assessing the W3C initiative against the LAP-inspired framework

LAP-inspired framework	Corresponding layer in W3C initiative (WS Arch, 2005)	Standards proposed (see Appendix A)
Rational discourse		
[Managing concurrent contracts]	*Management*	MUWS and MOWS
[Relationship management]	*None*	
[Transaction]	*Aggregation*	WS-BPEL
[Exchange]	*Choreography*	WS-CDL, WS-CF, WS-TXM
Communicative act		
[Contract establishment]	*None*	
[Proposal and negotiation]	*None*	
[Capability search]	*Discovery*	UDDI
[Capability exposure]	*Description*	WSDL
Communication platform		
[Guarantee]	*Messaging Extensions*	WS-Security, WS-Addressing, WS-Reliability
[Messaging]	*Messaging*	SOAP
[Channel]	*Communications*	HTTP, FTP

The communication platform layers demonstrate the clearest mapping between the LAP-inspired framework and the W3C initiative. The *communications* layer outlines the requirements for communication between services similar to the [channel] layer in the LAP-inspired framework. Key standards in this layer include HTTP (HTTP, 1999) and FTP (FTP, 1985). The *messaging* layer facilitates communication between services by providing them a flexible and extensible mechanism for exchanging messages (Gottschalk, Graham, Kreger, & Snell, 2002; Kreger, 2003). It specifies a common syntax necessary for formulating messages. This layer, thus, corresponds to the [messaging] layer in the LAP-inspired framework. *Messaging extensions* include security, addressing and reliability, which correspond to the notion of providing guarantees that ensure communication without distortions. This layer, thus, corresponds to the [guarantee] layer in the LAP-inspired framework. Some of the available standards in the

Messaging and *Messaging extensions* layers include SOAP (SOAP, 2003) and extensions such as WS-Security (WS-Security, 2004), WS-Addressing (WS-Addressing, 2005) and WS-Reliability (WS-Reliability, 2004).

The communicative act layers demonstrate the least mapping between the LAP-inspired framework and the W3C initiative. The *description* layer provides a functional description of a service in terms of its interface and implementation (Turner et al., 2003); (Kreger, 2003). This layer, thus, corresponds to the [capability exposure] layer in the LAP-inspired framework. The key standard in this layer is the WSDL (WSDL, 2001). The *discovery* layer specifies mechanisms for discovering a service, i.e., locating a machine-readable description of a service (WS Arch, 2005). This layer, thus, allows service providers to publish their services descriptions to a business registry, so that service requestors can search and discover services that meet their requirements. This layer, thus, corresponds to the [capability search] layer in the LAP-inspired framework. The standard available in this layer is UDDI (UDDI, 2005). Layers from the LAP-inspired framework with no corresponding efforts in the W3C initiative, therefore, include [proposal and negotiation], and [contract establishment].

Finally, the rational discourse layers also demonstrate significant mapping between the LAP-inspired framework and the W3C initiative. The *choreography* layer defines the sequence and conditions under which messages are exchanged among services in order to achieve a goal state (WS Arch, 2005). This layer, thus, corresponds to the [exchange] layer in the LAP-inspired framework. Available standards in this layer include WS-CDL (WS-CDL, 2004), WS-CF (WS-CF, 2004), and WS-TXM (WS-TXM, 2003). Second, the notion of *aggregation* in the stack proposed by the W3C initiative refers to the composition of web services (including any interaction and message flows between them (WS Arch, 2005)) and their representation as a higher-level web service (Gottschalk et al., 2002). This directly corresponds to the [transaction] layer in the LAP-inspired framework. Existing standards in this layer include WS-BPEL (WS-BPEL, 2005). Finally, the *management* layer provides a mechanism to monitor and control the execution of web services. It defines the model for managing web services as a resource. This corresponds to the [managing concurrent contracts] layer in the LAP-inspired framework. Standards in this layer include MUWS (WSDM, 2005) and MOWS (WSDM, 2005). Layers from the LAP-inspired framework with no corresponding efforts in the W3C initiative, therefore, include [relationship management]. The next two sub-sections assess the other two initiatives. The discussion that follows is not as comprehensive as that in section 4.1 to reduce redundancy.

4.2 Assessment of the semantic web services initiative

The semantic web services initiative provides a framework based on a set of roles and requirements for machine-readable semantic descriptions for deployment of web services (SWS Arch, 2005). Table 3 summarizes the results of assessing the semantic web services initiative against the LAP-inspired framework.

The communication platform layers demonstrate the clearest mapping between the LAP-inspired framework and the semantic web services initiative because they utilize the foundation provided by the W3C initiative, enhancing it with the Ontology Web Language (OWL, 2004).

The communicative act layers also demonstrate significant mapping between the LAP-inspired framework and the semantic web services initiative. First, the *published advertisement and service model* layer provides protocols that service providers can use to advertise their services (SWS Arch, 2005) corresponding to the [capability exposure] layer in the LAP-inspired framework. Next, the *client characterization of service provider* sub-layer provides clients the ability to formulate abstract descriptions of requirements that candidate services must meet

(SWS Arch, 2005). The *service discovery query process* sub-layer provides a protocol that a broker service can use to respond to client queries (SWS Arch, 2005). Together, these two sub-layers correspond to the [capability search] layer in the LAP-inspired framework. The next layer, *client characterization of desired activity*, provides the means to exchange information about goals and capabilities of parties involved in the communicative act (SWS Arch, 2005). This layer corresponds to the [proposal and negotiation] layer in the LAP-inspired framework. The next layer, *service contract negotiation*, provides a protocol that service providers and clients can use to negotiate and establish contracts (SWS Arch, 2005). This layer corresponds to the [contract establishment] layer in the LAP-inspired framework. The standard that crosses all these layers is SWSL-Rules (SWSL, 2005).

Table 3. Assessing the Semantic Web Services-initiative against the LAP-inspired framework

LAP-inspired framework	Corresponding layer in the Semantic Web Services initiative (SWS Arch, 2005)	Standards proposed (see Appendix A)
Rational discourse		
[Managing concurrent contracts]	*Status monitoring; termination and compensation*	SWSL-FOL
[Relationship management]	*None*	
[Transaction]	*Contact initiation; status monitoring; termination and compensation*	SWSL-FOL, OWL-S
[Exchange]	*None*	
Communicative act		
[Contract establishment]	*Service contract negotiation*	SWSL-Rules
[Proposal and negotiation]	*Client characterization of desired activity; Service contract negotiation*	
[Capability search]	*Client characterization of service providers; service discovery process*	
[Capability exposure]	*Published advertisement and service model*	OWL-S, WSDL, SWSL-Rules
Communication platform		
[Guarantee]	Uses the W3C initiative: [channel], *messaging* and *messaging extensions*, enhanced by Ontology Web Language (OWL).	WS-Security, WS-Addressing, WS-Reliability
[Messaging]		SOAP, OWL
[Channel]		HTTP, FTP

The rational discourse layers demonstrate the least mapping between the LAP-inspired framework and the semantic web services initiative. First, the *contract initiation* sub-layer provides a protocol for clients to invoke the selected service. Next, the *status monitoring* sub-layer facilitates monitoring service execution, including mechanisms for stopping, resuming or restarting the service. The *termination and compensation* sub-layer provides a protocol for indicating success or failure. Together these three sub-layers correspond to the [transaction] layer in the LAP-inspired framework. The *status monitoring* and *termination and compensation* sub-layers also contain elements that correspond to the [managing concurrent contracts] layer in the LAP-inspired framework. Standards available for these layers include OWL-S and SWSL-FOL (SWSL, 2005). Layers from the LAP-inspired framework with no corresponding efforts in the semantic web services initiative, therefore, include [exchange] and [relationship management].

4.3 Assessment of the ebXML initiative

The ebXML initiative combines components from divergent XML initiatives to develop a single business standard (ebXML-Req, 2001) that can operate on existing EDI implementations (ebXML-TA, 2001). Table 4 summarizes the results of assessing the ebXML initiative against the LAP-inspired framework.

Table 4. Assessing the ebXML-based initiative against the LAP-inspired framework

LAP-inspired framework	Corresponding layer in the ebXML based initiative (ebXML-TA, 2001)	Standards proposed (see Appendix A)
Rational discourse		
[Managing concurrent contracts]	*None*	
[Relationship management]	*None*	
[Transaction]	*Business process and information modeling*	BPIM
[Exchange]	*Business process specification schema*	BPSS
Communicative act		
[Contract establishment]	*Collaborative protocol agreement*	CPA
[Proposal and negotiation]	*None*	
[Capability search]	*Registry*	ebXML RS, ebXML RIM
[Capability exposure]	*Collaborative protocol profile*	CPP
Communication platform		
[Guarantee]	*Messaging service*	SOAP, ebXML MS
[Messaging]		
[Channel]	*Communication protocol*	HTTP, FTP

The communication platform layers show a clear mapping between the LAP-inspired framework and the ebXML initiative. First, the *communication protocol* layer utilizes standards such as HTTP and FTP for sending and receiving messages. This layer, therefore, corresponds to the [channel] layer in the LAP-inspired framework. Next, the *messaging service* layer provides the mechanism for sending ebXML messages over SOAP (ebMS, 2002). This layer, therefore, corresponds to the [Messaging] and [Guarantee] layers in the LAP-inspired framework.

The communicative act layers also show a significant mapping against the LAP-inspired framework. First, the *collaboration protocol profile* layer describes partner capabilities and service interface requirements (ebXML-TA, 2001). This layer contains CPP (ebXML-CPPA, 2002) as the key standard, and, therefore, corresponds to the [capability exposure] layer in the LAP-inspired framework. Second, the *registry* layer facilitates information sharing between parties by providing a centralized repository (ebRS, 2002). It includes two elements: a registry service (interface for accessing the registry including interaction protocols, message definitions and schemas) (ebRS, 2002) and a registry information model (types of metadata of documents that are stored in the registry including relationships among the various metadata classes) (ebRIM, 2002). These elements correspond to the [capability search] layer in the LAP-inspired framework. The key standards in this layer include ebXML RS (ebRS, 2002) and ebXML RIM (ebRIM, 2002). Third, the *collaboration protocol agreement* layer describes the agreement between partners about their respective commitments and expectations (ebXML-CPPA, 2002; Ibbotson, 2001). The key standard in this layer is CPA (ebXML-CPPA, 2002). This layer corresponds to the [contract establishment] layer in the LAP-inspired framework. One layer from the LAP-inspired framework with no corresponding effort in the ebXML initiative, therefore, is [proposal and negotiation].

The rational discourse layers demonstrate the least mapping against the LAP-inspired framework. First, the *business specification schema* layer (ebBPSS, 2001) provides a nominal set of elements necessary to specify collaboration between business partners (Rawlins, 2002). This layer corresponds to the [exchange] layer in the LAP-inspired framework. The key standard in this layer is BPSS (ebBPSS, 2001). Next, the *business process and information modeling* layer provides mechanisms for trading parties to capture specific details of a business scenario and model a business process using a consistent modeling methodology (eBPOver, 2001). This layer corresponds to the [transaction] layer in the LAP-inspired framework. The key standard in this layer is BPIM (eBPOver, 2001). Layers from the LAP-inspired framework with no corresponding efforts in the ebXML initiative, therefore, include [relationship management] and [managing concurrent contracts].

5 Discussion

The assessment of the three web services initiatives reported in the previous section suggests several recurring themes. As expected, the communication platform level appears to be common across the three standardization efforts, and shows the clearest mapping against the LAP-inspired framework. In particular, it shows clear agreement on the [channel] layer. This further translates to all three initiatives relying on standards recommended by the W3C. The agreement is also significant for the [messaging] layer (i.e., SOAP). The semantic web services initiative augment these basic standards by including OWL and the ebXML initiative augments these with additional syntax and delivery mechanisms. While no agreement has been reached yet on the [guarantee] layer (instantiated, for example, by the W3C initiative as WS-security and WS-reliability), adherence to common W3C standards on the lower layers suggests such agreement is a likely outcome in the near future.

At the communicative act level, all three initiatives provide standards for the [capability exposure] layer, although with slight variations. All three initiatives also provide standards for the [capability search] layer. The semantic web services initiative expands this to include the ability to specify desired characteristics of service providers. The semantic web services initiative is also the only initiative to provide standards for the [proposal and negotiation] layer. The W3C and ebXML initiatives indicate no standards for this layer, proposed or recommended. Useful directions for creating standards in this layer are available elsewhere (Jertila & Schoop, 2005; Schoop, 2003). Finally, the W3C initiative is the only initiative that does not provide any standards for the [contract establishment] layer.

At the rational discourse level, the W3C initiative efforts are better developed than the semantic web services and ebXML initiatives. For the [exchange] layer, the W3C and ebXML initiatives provide competing, though well-developed alternatives. All three initiatives contain standards that provide partial support for the [transaction] layer. However, none provides protocols for conversation policies that can guide interaction between services including mechanisms to handle any exceptions. Useful research in this direction is available elsewhere, which can be leveraged for creation or refinement of standards (Fan, Umapathy, Yen, & Purao, 2004; Kimbrough & Yang, 2004; Moore, 2000, 2001; Umapathy, Purao, & Sugumaran, 2003).

None of the initiatives propose standards for managing relationships established through a contract or provide the ability to extend contracts over a long-term. As business transactions cross national and cultural boundaries, [relationship management] is an important aspect that can benefit from formalized approaches. This is a significant drawback for all three initiatives. Useful research in this direction is available elsewhere (Goldkuhl & Melin, 2001; Goldkuhl & Röstlinger, 1999). Finally, there is minimal support for the uppermost layer, [managing concurrent contracts]. The standards proposed by the W3C and semantic web services initiatives manage only a single contract or transactions related to that single contract, i.e., they do not provide a global overview of multiple contracts and their related multiple transactions as suggested by the LAP-inspired framework. Table 5 summarizes the above observations and provides pointers to additional research that may be useful for refinement of current standards.

Table 5: Assessment of the three standards initiatives against the LAP-inspired framework

<table>
<tr><th rowspan="2">LAP-inspired Framework</th><th colspan="3">Current Initiatives</th><th rowspan="2">Comments</th></tr>
<tr><th>W3C</th><th>Semantic web</th><th>ebXML</th></tr>
<tr><td colspan="5">Rational discourse</td></tr>
<tr><td>[Managing concurrent contracts]</td><td colspan="2">Partial support</td><td>No support</td><td>W3C and the semantic web services initiatives do not support management of concurrent contracts spanning multiple relationships and transactions</td></tr>
<tr><td>[Relationship management]</td><td colspan="3">No support</td><td>Needs mechanisms to create and manage relationships (see (Goldkuhl & Melin, 2001; Goldkuhl & Röstlinger, 1999)).</td></tr>
<tr><td>[Transaction]</td><td colspan="3">Partial support</td><td>Needs mechanisms to support long running multi-party conversations (see (Fan et al., 2004; Kimbrough & Yang, 2004; Moore, 2000, 2001; Umapathy et al., 2003)).</td></tr>
<tr><td>[Exchange]</td><td>Full support</td><td>No support</td><td>Full support</td><td>No separate standard in the semantic web services initiative</td></tr>
<tr><td colspan="5">Communicative act</td></tr>
<tr><td>[Contract establishment]</td><td>No support</td><td colspan="2">Full support</td><td>W3C initiative needs mechanisms to create binding commitments on participants.</td></tr>
<tr><td>[Proposal and negotiation]</td><td>No support</td><td>Partial support</td><td>No support</td><td>Needs mechanisms for complex negotiations (see (Jertila & Schoop, 2005; Schoop, 2003)).</td></tr>
<tr><td>[Capability search]</td><td>Partial support</td><td>Full support</td><td>Partial support</td><td>W3C and ebXML initiatives do not provide the ability for service requestors to describe desired provider characteristics.</td></tr>
<tr><td>[Capability exposure]</td><td colspan="3">Full support</td><td></td></tr>
<tr><td colspan="5">Communication platform</td></tr>
<tr><td>[Guarantee]</td><td>Full support</td><td colspan="2">No support</td><td>Possible that W3C standards may be adapted by the other initiatives.</td></tr>
<tr><td>[Messaging]</td><td colspan="3">Full support</td><td></td></tr>
<tr><td>[Channel]</td><td colspan="3">Full support</td><td></td></tr>
</table>

One additional observation follows from the assessment of the three initiatives against the LAP-inspired framework. The framework suggests crisp boundaries built on the notion of "layers" as emphasized in prior work in the LAP research stream. This is apparent in the writings of Weigand (Weigand et al., 1998), Goldkuhl (Lind & Goldkuhl, 2001) and Dietz (Dietz, 2002) among others. Each has implicitly argued that the phenomenon (communicative action among actors in an organization) is complex, and needs to be unpacked into several layers to understand this complexity. This is particularly true for web services, where the standards should be carved into crisp components in order to ensure interoperability. Such crisp boundaries are not evident in many of the standards being developed negating the benefits of 'separation of concerns' known in the computing community. For example, the semantic web services initiative uses SWSL-Rules as a standard that spans as many as four layers (see Table 3). Similar outcomes are seen for the ebXML initiative, with standards spanning multiple layers in the communication platform (see Table 4). The W3C initiative appears to do well in this regard, perhaps due to the presence of multiple strong market participants, who may be implicitly enforcing the boundaries across layers as a way of ensuring separation of concerns.

We believe that the development and refinement of standards in a domain as important as web services should be guided by theoretical considerations. We hope that the analyses and assessment we have reported here, following the LAP theories, can suggest useful guidelines and constraints for these emerging standards. Our future work focuses on discovering foundational constructs that underlie LAP theories to provide insights into specific functionalities of web services standards.

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Appendix A. Proposed web services standards[6]

Standard	Initiative	Name	Description of the standard	URL
BPIM	ebXML	Business Process Information Modeling	Specifies aspects of interoperability required for business processes.	http://www.ebxml.org/specs/bpOVER_print.pdf
BPSS	ebXML	Business Process Specification Schema	Specifies a configuration to support execution of (collaborative) business transactions.	http://www.ebxml.org/specs/ebBPSS_print.pdf
CPA	ebXML	Collaborative Protocol Agreement	Defines the capabilities that two parties need to agree upon.	http://www.ebxml.org/specs/ebcpp-2.0.pdf
CPP	ebXML	Collaborative Protocol Profile	Defines the capabilities of a party to engage in e-Business with other parties.	http://www.ebxml.org/specs/ebcpp-2.0.pdf
ebXML MS	ebXML	ebXML Messaging Service	Specifics protocol for exchanging secure and reliable messages.	http://www.ebxml.org/specs/ebMS2.pdf
ebXML RIM	ebXML	ebXML Registry Information Model	Specifies high-level schema of the ebXML Registry.	http://www.ebxml.org/specs/ebrim2.pdf
ebXML RS	ebXML	ebXML Registry Services	Specifies a set of services that enable sharing of information among partners.	http://www.ebxml.org/specs/ebRS_print.pdf
FTP	All three	File Transfer Protocol	Specifies a protocol to share documents remotely.	http://www.w3.org/Protocols/rfc959/
HTTP	All three	HyperText Transport Protocol	Specifies protocol for distributing and presenting documents.	http://www.w3.org/Protocols/rfc2616/rfc2616.html
MOWS	W3C	Management of Web Services	Defines manageability of web service endpoints and resources exposed.	http://docs.oasis-open.org/wsdm/2004/12/wsdm-mows-1.0.pdf
MUWS	W3C	Management Using Web Services	Defines manageability of a resource exposed via web services.	http://docs.oasis-open.org/wsdm/2004/12/wsdm-muws-part1-1.0.pdf
OWL	Semantic web services	Ontology Web Language	Facilitates greater machine interpretability of web content by providing additional vocabulary along with a formal semantics.	http://www.w3.org/2004/OWL/
OWL-S (includes SWSL and	Semantic web services	OWL-based Web Service Ontology	Describes service profile, service model and service grounding.	http://www.w3.org/Submission/OWL-S/

[6] Compiled, October 2005. Glossaries of *terms* used for web services following the three initiatives are available elsewhere: W3C initiative (WS Glossary, 2004); Semantic web services initiative (SWS Glossary, 2005); and ebXML (ebXML Glossary, 2001).

Standard	Initiative	Name	Description of the standard	URL
SWSL-Rules)				
SOAP	All three	Simple Object Access Protocol	Specifies protocol for exchanging structured information in a decentralized, distributed environment.	http://www.w3.org/TR/soap/
UDDI	W3C	Universal Description, Discovery and Integration	Defines a set of services supporting the description and discovery of web services.	http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=uddi-spec
WS-Addressing	W3C	Web Services Addressing	Defines a set of abstract properties to facilitate end-to-end addressing of endpoints in messages.	http://www.w3.org/TR/ws-addr-core/
WS-BPEL	W3C	Web Services Business Process Executing Language	Defines a formal language to specify business processes and business interactions.	http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=wsbpel
WS-CDL	W3C	Web Services Choreography Description Language	Defines a formal language to specify external observable behavior as the presence or absence of messages that are exchanged among web services.	http://www.w3.org/TR/ws-chor-reqs/
WS-CF	W3C	Web Services Coordination Framework	Specifies a mechanism for coordination of transactions among web services.	http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=ws-caf
WS Context	W3C	Web Services Context	Defines a mechanism to share context of an activity across multiple execution endpoints.	http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=ws-caf
WSDL	W3C	Web Services Description Language	Defines a formal language to describe the abstract functionality as well as the concrete details of a service.	http://www.w3.org/TR/wsdl20/
WS-Security	W3C	Web Services Security	Specifies a mechanism to provide message integrity and confidentiality for SOAP messages.	http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=wss
WS-Topics	W3C	Web Services Topics	Defines topic expression dialects and metadata associated with the web services notification system.	http://docs.oasis-open.org/wsn/2004/06/wsn-WS-Topics-1.2-draft-01.pdf
WS-TXM	W3C	Web Services Transaction Management	Specifies a suite of transaction models, each suited to solving a different problem domain.	http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=ws-caf