Frameworks for Semantics in Web Services Workshop

MITRE Position Paper

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1. Introduction

Semantics play an increasingly important role not only in web services but also in information systems. Structured web service standards have addressed some key challenges in terms of enterprise interoperability. Semantics based standards such as RDF/S and OWL have matured to a point where wide proliferation appears inevitable. These standards today offer facilities for building ontologies. However, in order for web service based solutions to reach their full potential, platforms provided by middleware vendors must take advantage of the semantic standards. This will allow many of our customers to explicitly specify the semantics of their web services and the semantics of each service's context. In our opinion, progress can be achieved when we can establish a clear set of relationships between web services standards and semantic based standards. These relationships can take the form of RDF/S and OWL/SWRL mappings or other potential encoding approaches, but it is critical that such mappings are standardized. Lacking those relationships, organizations will not be able to fully leverage their investments in web services. In figure 1, we show semantic based standards, structure-based standards, and syntax based standards as we see them today [for an introduction, see 10].

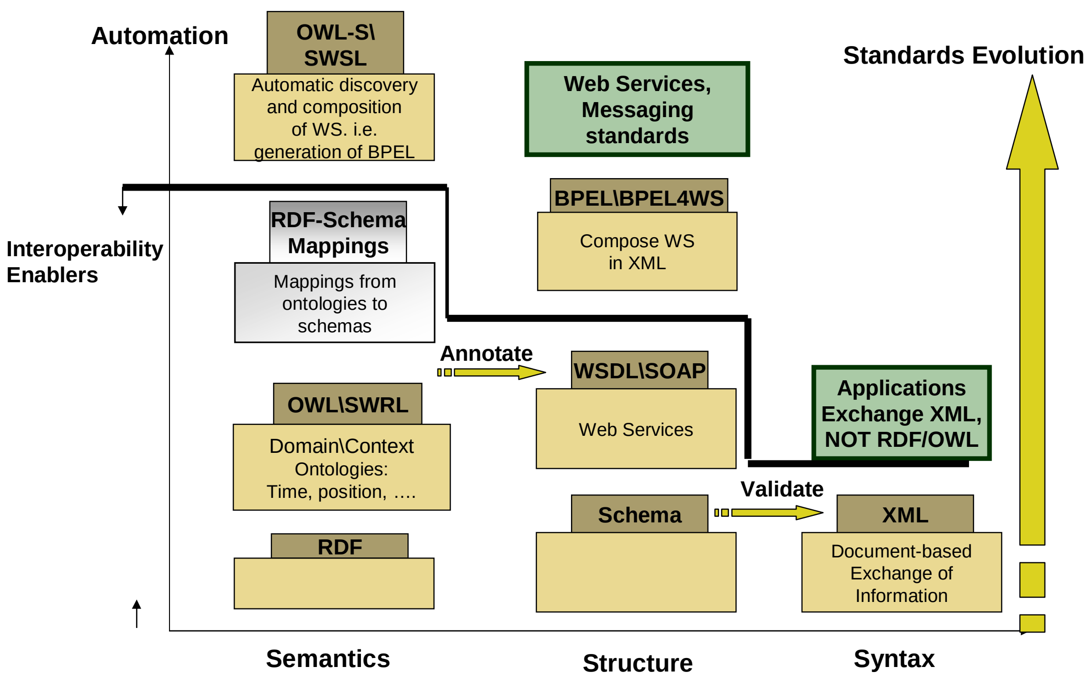

Figure 1. Standards and Their Relationships

The line in bold font shows how Standards facilitate interoperability. For example, when XML became widely adopted, we achieved a boost on the interoperability scale.

One of MITRE's primary roles is to advise and evaluate our customer's selection of technologies and designs. As a result we provide this position paper submission from our customer's adoption point of view. We have covered a limited set of topical areas related to possible web service framework standards with a set of example scenarios to act as a discussion facilitation mechanism. These include annotation, orchestration, upper ontologies, and cross-domain information sharing.

2. Annotations

The second boost to interoperability was achieved when XML Schema, SOAP, and WSDL were standardized. To achieve the next boost in interoperability, we must standardize on the mappings between the ontologies created in RDF/S and OWL and XML schemas. This mapping is critical since it constitutes the annotation relationships that connect the structured documents with their ontologies. By doing this annotation, organizations would also preserve ALL current investments in their XML schemas. For justifications of these findings, we invite the interested reader to review our publications [1, 2, 3].

One prospective use of annotations with respect to ontologies, for example, could involve the notion of labeled deduction [5]. An ontology assertion (expressed in RDF/S, OWL/SWRL) or inference step is annotated with other logical information, so that multiple logics exist and act over the same expression [4]. For each primary logical assertion or deductive step, annotations exist. These annotations (labels) are themselves symbolically interpreted according to the logic they are expressions of, at each step in the primary assertion or deductive step. Typically, the annotations are expressed in simpler logics (say, propositional logics) than the primary assertion/deductive step (say, a predicate logic). The effect is therefore that the most computationally resource-intensive deduction using the logical assertions drives the inference, with the annotations (expressing security, strength of belief, provenance information, etc.) represented in less expressive and therefore more efficiently executed logics (typically propositional logics, some of which can be implemented in bit-vector operations). The result is that a Modus Ponens proof can simultaneously cause the composition of security and/or belief-confidence annotations according to simpler logics, and propagate the annotations through the ontological space. The labeled deduction framework thus makes the annotations themselves interpretable symbolically and correlated with the semantic assertions and proofs involving the ontology.

In a framework for semantic web services, one can imagine that a semantic web service (driven by an ontology for that service) has a number of annotations, including contextual information related to policies of various types (security, privacy/intellectual property, even supply-chain/partnering information), all of which have their own ontologies). Labelled deduction may be a mechanism for simultaneous correlation of that annotation information – semantically.

2.1 Scenario 1: Belief Statements For Online Identification

"John" logs onto his computer by typing in his userid and password. This information is typically passed to a user authentication service on a corporate server. John's user profile, which stores its access levels and preferences, allows him access to human resources related sensitive information including payroll records, medical and benefit selections of

Company X's employees, and corporate strategy and planning documents. Prior to John's access to this information his identity must be established with a certain level of belief. Company X's policy is to allow access to some of this information if John is accessing their system from inside their physical campus, and only allow limited 'ready only' access to strategy information if he is logging in over an external connection. Thus, a level of belief about John's location is a critical element this scenario.

3. Orchestration

Agility is a key term used by our customers today. They consider it the number one characteristic of their future information technology (IT) enterprises. At the same time they are adopting web service technologies and looking for a way to loosely couple those services into sequences of value-added business capabilities. Increasing the maturity of the orchestration standards is critical to progress in this area. Standards such as BPEL4W, WSCI, and BPML are intended to reduce the complexity and explicitly encode both the physical requirements of these service-to-service interactions (dynamic contracts) and the business value of the overall service "chain". Without a common set of standards, each customer group will construct their own orchestration management approach. This will in turn result in a less than optimal enterprise management and enterprise evolutionary environment.

OWL-S (and perhaps SWSL) takes a mostly reactive planning view of the semantics of web services. The reactive planning view means that services and their complex compositions are generally viewed as a three-phase operation: planning, scheduling, and execution. There is some set of objectives or goals that a developer or user wants to achieve. This set might be viewed as the rationale for the desired web service. One might have multiple plans (various compositions of web services) that could achieve those desired goals. A given plan is selected or composed from a library or registry of services/plans. That plan can be represented as a more-or-less complex task or process model, as Figure 2 depicts.

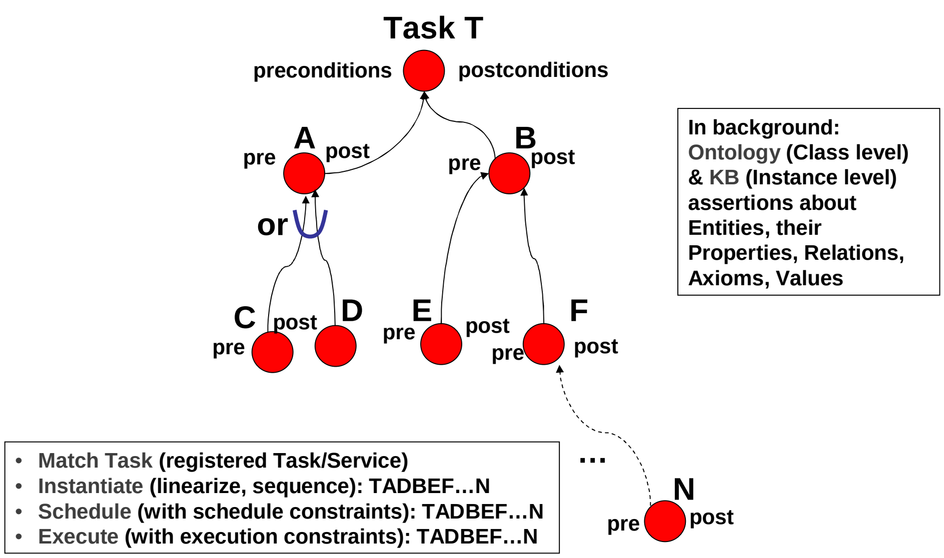

Figure 2. Planning, Task, Process Representation

In this figure, the Task T is the plan that has been selected and instantiated, to achieve some needed goals (rationale). T is complex and has multiple choreographed/orchestrated subtasks (sub-processes or services) that must eventually be scheduled and executed: A, B, C, …, N. Each of those subtasks has preconditions and postconditions that must hold, as does T itself. Those preconditions and postconditions are properties that must hold either prior to or posterior to the planning, scheduling, or execution of that task/subtask. They are constraints on those phases of the complex service. Some examples of preconditions (these are preconditions at the planning phase, i.e., only choose plans that can provide guarantees that these constraints will be met; they can also be considered postconditions that correlate in actuality with the planned preconditions): timeliness (this needs to execute successfully within 1 day), cost (this needs to cost in total no more than $10k), availability/receiving (this needs to deliver its products to my location in Akron, Ohio). Some examples of postconditions (in addition to precondition actual realizations): quality (this executed with some demonstrable quality function, e.g., the gloves that were delivered had less than a 5% defect rate), etc.

In this scenario, the plan of Task T has been selected, instantiated, scheduled, and executed. Preconditions and postconditions apply at each task/subtask and at each phase of the operation, where appropriate: planning, instantiation, scheduling, execution. These conditions or constraints can range from necessary to optional, with any range of gradations one desires, with any associated behavior at its violation (stop the service and demand remuneration, throw adjudication to the user/service-requester, execute my preferred rule-set that handles constraint violations and exceptions, etc.)

3.1 Scenario 2: Agile Investment Tracking

Company X provides a real-time monitoring and alerting service for their world wide stock market customers. They track each customer's portfolio of investments and provide a variety of alerting services globally. As customers change their investment holdings and as new messaging technologies proliferate, Company X's customers expect to get the same level of service regardless of the device, location, or current size and attributes of their holdings. To accomplish this, Company X needs to have a highly flexible set of information flows that can evolve with the changes in customer investments and the changes in messaging technologies. If such a system rested on a web service framework, it would be essential that the customer alerting services could adopt new distribution services as well as new feeder stock tracking sensor services.

4. Upper Ontologies

The idea of some limited upper ontology has been considered for a number of years [12, 13, 14, 15, 16, 17, 18]. Current work in this area focuses the encoding of non-domain specific high-level concepts that allow an organization to conceptually associate entities from different fields. The scenario below contains one example. One of the fundamental "hard problems" with the standardization of an upper ontology or a way to define them, is that basic assumptions regarding the nature or state of the world must be presumed. This assumption set, no matter how generalized it is, will always fail to cover some domain of community of interests viewpoint. Therefore, it may be necessary to consider a set of logically related or relatable upper ontology and reference ontology modules (a reference ontology is an ontology that acts as a reference in a specific domain such as medicine, against which ontologies within that domain can correlate/map), a so-called lattice-of-theories approach. A lattice of theories simply means that in the large ontological space, individual ontologies (considered as logical theories about domains) are related logically at the macroscopic level in much the same way classes are related within an ontology at the microscopic level, i.e., in terms of logical entailment relations. As the semantic web progresses, however, we expect that grounding distributed ontologies into reference, middle ontologies, and upper ontologies will be required, to facilitate more precise comparisons of their meanings.

4.1 Scenario 3: In-Store Product Classifications versus External Ordering from Suppliers

Company X's has a set of in-store product identification classifications that they use to organize their chain of facilities and their supply ordering system. Within their stores they have electronics goods and a set of these are consider personnel entertainment systems. However these items come from a variety of vendors who all have their own classification taxonomy that benefits their own marketing agendas. In some cases, Vendor Y does not want to compete with Vendor Z, so they have labeled their MP3 playing video capturing widgit as an exercise environment device. Vendor Z, who has a similar device, although theirs is less expensive due to only a still frame capture capability, is sold as a personnel consumer product. In this situation, the owners of the chain of consumer stores have to map their inventory and store space allocations to what appear to be different types of products. But are they really?

Business-to-business (B2B) electronic commerce has this problem. [11] tries to describe the situation. If the semantics of products and services that transcend individual catalogs are to be captured, ontologies are required. In fact, in the representation of supply chain semantics, distinct nodes of the supply chain have to use different portions of the relevant set of domain ontologies. An example: a chemical manufacturer of various chemicals occurs early in a supply chain. Those chemicals are represented in an ontology of chemistry that has properties such as the physical properties of distinct chemicals, their combinational properties, and purity of the chemical product. However, another node in the supply chain may be a manufacturer of paints and coatings. The paint and coatings manufacturer will use a similar chemical ontology, but now the ontology has to represent that manufacturer's desired functional properties, including viscosity, light-reflecting capability, drying-time of the coating.

5. Cross Domain Information Sharing

It is our experience that most of our customers have a number of different business operations, many of which use their own semantic definitions. These are often rooted in historical developments of those sub-business organizations and their functional role within the enterprise as a whole. While the majority of the information in these disparate communities' remains internal, there are specific cases where cross-domain information sharing must occur and thus semantic translation.

5.1 Scenario 4: Privacy Rights Enforcement

Company X has a set of in-store customer tracking technologies that help them associate trends in overall sales to specific customers or groups of them. This information is a valuable commodity and at this time only limited legal restriction exists when it comes to sharing the information with other business. Last week, Bank of Global Trust, who finances Company X proposed a significant loan interest rate reduction if Company X would share their customer information on specific product purchases, amounts, etc. This is sometimes called Level 2 purchasing information around Company X. While it might be interesting to argue the rights of the consumer, Company X is out to make a profit these days given lagging sales. The only question is how will they translate their customer information into the semantics that the bank has specified. What does a purchase event mean? Do you have to include the product category or just the bar code number and how will all the group/trend information be rolled up.

We anticipate that a set of mappings between at least two distinct ontologies will have to occur. In the general case, those mappings will in fact constitute an integration ontology, i.e., an ontology in its own right. One of the problems in fact with older style common models (in the Department of Defense world, policy 8320 constituted a common model mandate) was that semantic distinctions were obliterated and disparate organizations, applications, and databases were shoehorned into a common model that did not represent the semantic distinctions that were necessary for them to make to transact their business.

6. Some Recommendations

1. Research has shown that an upper ontology for Web services is needed. For example, OWL-S Service Profile. This should include conditions and constraints on Web Services, as a well as RDF/S and OWL links to attach an instance of this Web service ontology to domain and contextual ontologies. Note we are not necessarily intent on standardizing OWL-S as a whole. This upper ontology for web services may in turn need to be grounded in an upper ontology or set of upper ontology modules, to situate its meanings.
2. RDF/S and OWL mappings from WSDL to ontologies are needed. This can take the following form: A WSDL can have a corresponding ontology. Then, RDF/S and OWL links can be used to map the ontological representation of WSDL to other ontologies. However, we are also aware of other approaches that implement this mapping by using the extensibility feature of WSDL. Both of these approaches may be acceptable to us.
3. It is important that semantic web technologies be applied to any data or service on the web. Towards this, simple input/output standards that would allow the mappings of semantic translations to be consumed by a web service (that is serving as a delegate between communities, for example) would be very helpful.
4. The future web service framework standards should allow polymorphic reasoning on the contents of an ontology. This may entail contextual reasoning and the automated transition (coercion) of semantics from one context to another.
5. Semantic constraints (preconditions and postconditions) on web services will be necessary. A standard rule/constraint language grounded in the symbols of ontologies that support web services will be necessary.

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