Semantic Web Languages and Semantic Web Services as Application Areas for Answer Set Programming *

Extended Abstract

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Abstract

In the Semantic Web and Semantic Web Services areas there are still unclear issues concerning an appropriate language. Answer Set Programming and ASP Engines can be particularly interesting for Ontological Reasoning, especially in the light of ongoing discussions of non-Monotonic extensions for Ontology Languages. Previously, the main concern of discussions was around OWL and Description Logics. Recently many extensions and suggestions for Rule Languages and Semantic Web Languages pop up, particularly in the the context of Semantic Web Services, which involve the meta-data description of Services instead of static data on the Web only. These languages involve OWL-S, SWRL, WSML, SWSL, etc. This provides a glance at ongoing efforts, initiatives and challenges in this area and initial pointers where Answer Set Programming research could possibly hook in.

1 What is the Semantic Web

By the "Semantic Web" [4] we refer to the idea of bringing the Web to its full potential by making the overwhelming amount of data on the Web machine-processable. In order to make the Web machine-usable as the gigantic database is represents, we need to be able to store and publish not only human-readable web-sites but also provide machine-readable annotations for this content. Additionally, we need standards and languages describing the structure of this

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knowledge published on the Web. Consensual formalizations of such knowledge and its structure are often referred to under the common term *Ontologies*. The World Wide Web consortium (W3C) has picked up this challenge and proposed several recommendations for languages for the formalization of ontologies, such as the Resource Description Framework (RDF) [17], RDF Schema [6], and the Web Ontology Language (OWL) [10]. Recently, efforts towards the combination of these ontology languages with more expressive rule languages gain momentum; cf. W3C workshop on "Rule Languages for Interoperability" [1] which was held this April in Washington.

2   What are Semantic Web Services

Web services.   The current Web is not only a repository for static data, but furthermore offers interfaces to Web-accessible services to the human user, ranging from simple dynamically generated pages for pure information provision to more complex services for purchasing books, booking trips or trading with other internet-users over commercial or private marketplaces. The next step after making the data on the Web machine processable is facilitating the direct interaction of applications, i.e. services, over the Web. Making this vision real should not solely be viewed in the context of the Web as such, but has high potential benefits in the areas of Enterprise Application Integration and Business-to-Business Integration, being the two most prosperous application areas of current Information Technology. Current technologies around SOAP [23], WSDL [8] and UDDI [3], often subsumed under the term "Web services" only partly solve this integration problem by providing a common protocol (SOAP), interface description (WSDL) and directory (UDDI), but operating at a purely syntactic level.

Semantic Web services.   The goal of what is called semantic Web services (SWS) [19] is the fruitful combination of Semantic Web technology and Web services. By using ontologies as the semantic data model for Web Service technologies adoption of Semantic Web technologies shall be adopted, i.e. Web services shall have machine-processable annotations just as static data on the Web. Semantically enhanced information processing empowered by logical inference eventually shall allow the development of high quality techniques for automated discovery, composition, and execution of Services on the Web, stepping towards seamless integration of applications and data on the Web. The W3C Semantic Web Services Interest Group has shown a strong interest in having more integrated semantics inside the Web Services stack, and also provides evidence of a rich variety of research proceeding in this area. This work aims towards the general objective of a more comprehensive, more expressive framework for describing all aspects of services, which can enable more powerful tools and fuller automation of a broad range of Web services activities. Semantic Web services

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[1] `http://www.w3.org/2004/12/rules-ws/`

frameworks, such as OWL Service Ontology (OWL-S) [2] and, more recently, the Web Service Modeling Ontology (WSMO) [24] and the Semantic Web Services Framework (SWSF) [21] aim at providing means to semantically describe al necessary aspects of services in a formal way for creating such machine-readable annotations. An upcoming W3C workshop on "Frameworks for Semantics in Web services"[2] with the goal of creation of a Working Group towards standardization in this area will be held in June 2005 in Innsbruck.

The areas of Semantic Web and Semantic Web services build a natural application area for ASP, namely for querying and reasoning about structured knowledge and semantic descriptions of services and their interfaces on the Web. Particularly, in the open context of the Web, one needs to deal with vague or imprecise information, incomplete knowledge, reasoning about preferences and in presence of inconsistencies, cf. also [20, 1].

3 Research Challenges in the Semantic Web Language stack

The development of reasonable languages in the W3C and other standardization bodies is still not finished and offers many research challenges, some of which the ASP community is a natural candidate to tackle them.

- **Fix problems in layering and semantics in ontology languages.**
  Layered languages like OWL/SWRL and do provide a not always clean semantic layering. The original goal to have a layered language based on RDF/RDFS with added expressivity and computational complexity in the OWL "dialects" OWL Lite, OWL DL and OWL Full has not yet been achieved in the current W3C specifications: For instance OWL Lite and OWL DL are not properly layered on top of RDF, imposing severe syntactical restrictions. Even worse, the layering within OWL itself is flawed allowing different conclusions to be drawn from the same ontology in OWL DL semantics and OWL Full semantics [7]. Furthermore, OWL DL (with its Description Logics based semantics) does not naturally extend to combination with rules. Even the straightforward combination of OWL DL with Horn Rules as suggested by the Semantic Web Rule Language (SWRL) [15] leads to immediate undecidability. We plan to tackle these problem by providing suggestions for fixing these issues and incorporate a strictly layered Ontology language in the Web Service Modeling Language (WSML) [22]. This language shall further allow (local) closed world reasoning and ASP by default negation and incorporation of constraints. The logical language underlying WSML is inspired by Frame Logic (F-Logic) [16] which recently became one of the main competitors of OWL/RDF towards a usable ontology language. Besides WSML, also

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[2]`www.w3.org/2005/04/FSWS/`

the language proposal of the SWSL committee which was recently published [21] a syntactic variant of F-Logic. Interesting enough all supporting systems for F-Logic such as Flora-2 or the commercial system Ontobroker do not implement full F-Logic (which can be seen as purely syntactic extension of first-order logic including support for object-oriented modeling) but a logic programming variant of F-Logic evaluated under the well-founded semantics. ASP engines supporting this syntactic variant would allow for immediate support of these emerging Web Languages.

- **Extend ontology languages cautiously for uncertainty, preferences.** After fixing the layering problem and solving semantic mismatched between different ontology languages possible extensions towards non-classical logics for reasoning under incomplete knowledge, uncertainty and reasoning with preferences should be taken into consideration. Particularly for the semantic description and selection of services published on the Web, it should be possible to take user preferences and incomplete knowledge into account. Here, the ASP community can provide valuable background and fundamental research in place already. Extensions towards non-classical logics for reasoning under qualitative and quantitative uncertainty and reasoning with preferences, such as [18, 12, 5, 14, 11] could serve as a starting point for the integration with ontology languages in a common ASP framework.

- **Extend/Apply action languages for SWS interface and capability descriptions.** In order to automatize the orchestration and choreography of Web Services, formal languages are needed to describe the capabilities and interfaces of the participating services in a communication. Current languages for defining the interfaces of services however either lack combinability with ontologies (WSDL, BPEL4WS) or do not have a clearly defined semantics yet (OWL-S process models [2], WSMO [24] in their current specifications. After defining the semantics of interface descriptions and dynamics in Web Services, one of the promises of semantically annotating Web Services is to support the (semi-)automatic discovery and composition of Web services. In this context, we assume that research in the ASP community conducted in application areas such as action theories and planning could provide valuable starting points.

4 Why ASP is suitable?

After this short overview of currently ongoing efforts and main challenges, I want to summarize my position why Answer Set Programming can be a good candidate for reasoning tasks on the semantic Web as follows:

- ASP can provide semantics to "missing parts" in the Semantic Web layer cake such as formalizing preferences and dealing with uncertainty.

- ASP engines can provide the underpinning for powerful reasoners for Semantic Web and Semantic Web applications integrating different used semantics in an integrated reasoning framework. Initial results such as [13, 9, 7] allow an optimistic view that the ASP community could have significant impact in this application area.

- Ongoing research in the community on formalizing actions and change can serve as a basis for reasoning about the semantics of services and their dynamics towards semi-automatic discovery and composition of services

- I believe that the focus should switch from prototypes towards practical applications to disseminate the community results and I appreciated to see several moves in this direction during the Seminar in Dagstuhl.

References

[1] S. Arroyo, C. Bussler, J. Kopecký, R. Lara, A. Polleres, and M. Zaremba. Web service capabilities and constraints in WSMO. In *W3C Workshop on Constraints and Capabilities for Web Services*, Oracle Conference Center, Redwood Shores, CA, USA, October 2004.

[2] A. Barstow, J. Hendler, M. Skall, J. Pollock, D. Martin, V. Marcatte, D. L. McGuinness, H. Yoshida, and D. D. Roure. OWL Web Ontology Language for Services (OWL-S), Nov. 2004. `http://www.w3.org/Submission/2004/07/`.

[3] T. Bellwood, L. Clément, D. Ehnebuske, A. Hately, M. Hondo, Y. Husband, K. Januszewski, S. Lee, B. McKee, J. Munter, and C. von Riegen. UDDI Version 3.0, July 2002.

[4] T. Berners-Lee, J. Hendler, and O. Lassila. The semantic web. *Scientific American*, 284(5):34–43, May 2001.

[5] G. Brewka. Preferred Answer Sets. In *Proceedings Workshop on Logic Programming and Knowledge Representation, at ILPS '97*, Port Jefferson, October 1997.

[6] D. Brickley and R. V. Guha. RDF vocabulary description language 1.0: RDF schema. Recommendation 10 February 2004, W3C, 2004. Available from `http://www.w3.org/TR/rdf-schema/`.

[7] J. D. Bruijn, A. Polleres, R. Lara, and D. Fensel. OWL DL vs. OWL Flight: Conceptual modeling and reasoning for the semantic web. In *Proceedings of the 14th World Wide Web Conference (WWW2005)*, Chiba, Japan, May 2005.

[8] E. Christensen, F. Curbera, G. Meredith, and S. Weerawarana. Web Services Description Language (WSDL) 1.1. http://www.w3.org/TR/wsdl, March 2001.

[9] J. de Bruijn, C. Feier, U. Keller, R. Lara, A. Polleres, and L. Predoiu. WSML Reasoner Implementation. Deliverable D16.2v0.2, WSML, 2004. Available from http://www.wsmo.org/TR/d16/d16.2/v0.2/.

[10] M. Dean and G. Schreiber, editors. *OWL Web Ontology Language Reference*. 2004. W3C Recommendation 10 February 2004.

[11] J. Delgrande and T. Schaub. Expressing Preferences in Default Logic. *Artificial Intelligence*, 123(1-2):41–87, 2000.

[12] T. Eiter and T. Lukasiewicz. Probabilistic Reasoning about Actions in Non-monotonic Causal Theories. In C. Meek and U. Kjærulff, editors, *Proceedings Nineteenth Conference on Uncertainty in Artificial Intelligence (UAI-2003), August 7-10, 2003, Acapulco, Mexico*, pages 192–199, San Francisco, CA, 2003. Morgan Kaufmann Publishers.

[13] T. Eiter, T. Lukasiewicz, R. Schindlauer, and H. Tompits. Combining answer set programming with description logics for the semantic web. In *Proceedings Ninth International Conference on Principles of Knowledge Representation and Reasoning (KR 2004)*, pages 141–151, Whistler, British Columbia, Canada, June 2004. Morgan Kaufmann.

[14] B. Grosof. Prioritized conflict handling for logic programs. In *Proceedings of the International Logic Programming Symposium (ILPS)*, pages 197–211, 1997.

[15] I. Horrocks, P. F. Patel-Schneider, H. Boley, S. Tabet, B. Grosof, and M. Dean. SWRL: A semantic web rule language combining OWL and RuleML. Member submission 21 may 2004, W3C, 2004. Available from http://www.w3.org/Submission/SWRL//.

[16] M. Kifer, G. Lausen, and J. Wu. Logical foundations of object-oriented and frame-based languages. *JACM*, 42(4):741–843, 1995.

[17] G. Klyne and J. J. Carroll. Resource description framework (RDF): Concepts and abstract syntax. Recommendation 10 February 2004, W3C, 2004.

[18] T. Lukasiewicz. Probabilistic Logic Programming with Conditional Constraints. *ACM Transactions on Computational Logic*, 2(3):289–339, July 2001.

[19] S. McIlraith, T. C. Son, and H. Zeng. Semantic web services. *IEEE Intelligent Systems, Special Issue on the Semantic Web*, 16(2):46–53, 2001.

[20] L. Predoiu, F. Martín-Recuerda, A. Polleres, , C. Feier, A. Mocan, J. D. Bruijn, F. Porto, D. Foxvog, and K. Zimmermann. Framework for representing ontology networks with mappings that deal with conflicting and complementary concept definitions. Project Deliverable D1.5, DIP, 2004. Available from http://dip.semanticweb.org/.

[21] The Semantic Web Service Language (SWSL) Committee. Semantic web services framework (SWSF) version 1.0, 2005. `http://www.daml.org/services/swsf/1.0/`.

[22] The WSML working group. WSML homepage, since 2004. `http://www.wsmo.org/wsml/`.

[23] W3C. SOAP Version 1.2 Part 0: Primer, June 2003.

[24] WSMO working group. WSMO homepage, since 2004. `http://www.wsmo.org/`.