Semantic Web Services

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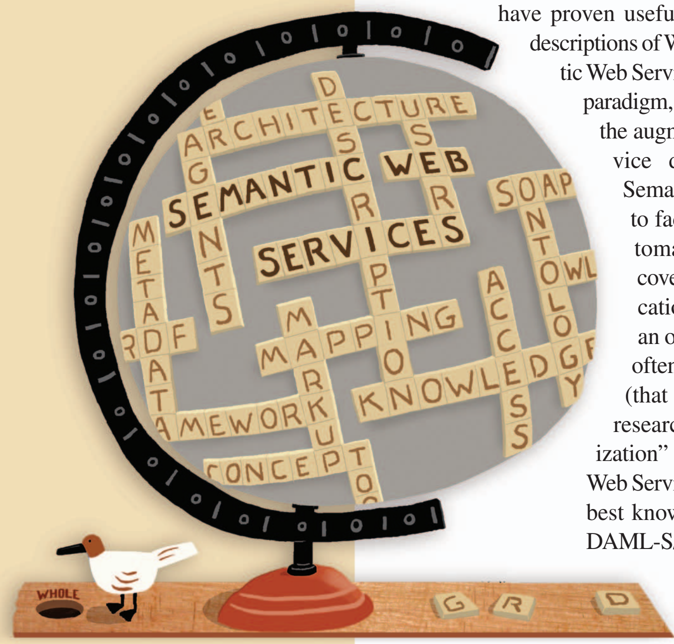
The Semantic Web[1] is a vision of a new architecture for the World Wide Web, characterized by the association of machine-accessible formal semantics with more traditional Web content. The Semantic Web's original motivations were to increase automation in processing Web-based information and to improve the interoperability of Web-based information systems. The development of representational issues and logical frameworks (such as OWL[2]) will take us only so far; to fully realize this vision, we must tackle behavioral issues (for example, interactions between "Semantic Web agents"). Serendipitous interoperability—that is, the unarchitected, unanticipated encounters of agents on the Web—is an important component of this realization.

Semantic Web techniques, which consist of applying knowledge representation techniques in a distributed environment (potentially on a Web-wide scale), have proven useful in providing richer descriptions of Web resources. Semantic Web Services, as a new research paradigm, is generally defined as the augmentation of Web Service descriptions through Semantic Web annotations, to facilitate the higher automation of service discovery, composition, invocation, and monitoring in an open, unregulated, and often chaotic environment (that is, the Web). Several research and "prestandardization" activities in Semantic Web Services have emerged, the best known perhaps being the DAML-S/OWL-S work[3] developed in the DAML research program. Semantic Web Services represent an important step toward the full-blown vision of the Semantic Web, in terms of utilizing, managing, and creating semantic markup.



The relationship between the Semantic Web and the current Web Service architecture depends on your viewpoint. In the near term, the deployment of Web Services is critical, and Semantic Web techniques can enhance the current service architecture. In the longer term, the Semantic Web vision itself becomes more interesting, with Web Services offering a (hopefully) ubiquitous infrastructure on which to build the next generation of deployed multiagent systems.

This issue features seven articles based on submissions to the 2004 AAAI Spring Symposium on Semantic Web Services (held at Stanford University on 22–24 Mar. 2004). These articles represent the best and most representative work in the field. They address several important aspects of Semantic Web Services, from discovery, to planning and composition of services, to mapping between different ontological representations, to the more pragmatic issues of access policies and security.

Because services can randomly appear and be withdrawn, we need a framework that describes their functionality and behaviors and that can subsequently be used for location. Much conventional research in this area has focused on representing services from an artificial intelligence perspective, which uses functional descriptions oriented toward supporting composition through AI-based planning. In "Value Webs: Using Ontologies to Bundle Real-World Services," Hans

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Akkermans and his colleagues present the business perspective of services, described in a formal semantic framework. Unlike research on other contemporary services, this article focuses on describing real-world services while emphasizing description frameworks (such as higher-fidelity models of resources) and the customer-provider service mismatch. An important contribution of this article is the description of relations that might exist between services (such as supporting and enhancing) that facilitates the formation and configuration of service bundles.

The power of a service-based approach for achieving tasks is realized by combining different services from different providers. However, because these services might assume different ontologies, agents and service requesters must translate the service descriptions into a familiar ontology to formulate valid requests. In "Dynamic Invocation of Semantic Web Services That Use Unfamiliar Ontologies," Mark Burstein proposes a model of service invocation that includes this translation by employing a set of articulations, or bridging axioms. He also argues that this translation process should be integral to planning and composition.

The Grid is a service-oriented environment that the scientific community uses heavily to carry out complex experiments and analyses across several organizations. Typically, this involves manually constructing workflows that combine various services with available data. Users can then employ existing grid-based middleware to schedule and execute these workflows. In "Automatically Composed Workflows for Grid Environments," Jim Blythe, Ewa Deelman, and Yolanda Gil explore the benefits of AI-based scheduling and planning for such services, given semantic characterizations of the processes and data used. Their approach uses the types of knowledge available in current grid services to construct executable workflows from high-level descriptions of a user's desired data products and from any intermediate data-staging requirements.

In "Filtering and Selecting Semantic Web Services with Interactive Composition Techniques," Evren Sirin, Bijan Parsia, and James Hendler take an alternative approach to generating service compositions that satisfy user requirements, through an interactive metaphor. Their composition tool uses contextual information to locate semantically interoperable services that it can present to the user at each stage of the composition framework. Sitting atop the OWL-S service framework, it employs semantic discovery and filtering to determine a meaningful set of candidate services based on advertised Semantic Web Service descriptions.

In "ODE SWS: A Framework for Designing and Composing Semantic Web Services," Asunción Gómez-Pérez, Rafael González-Cabero, and Manuel Lama present a framework for the design and composition of Semantic Web Services at a knowledge- and language-independent level. Their work is based on a set of different ontologies and associated axioms, each describing a different aspect of Semantic Web Services. They model services as problem-solving methods that describe the service decomposition, and show how to use this representation to control the reasoning process for executing the service.

Two important aspects of any service-oriented environment are security and privacy. Services may be available only to requesters that have authority to use those services—likewise, there might be mechanisms that preserve specified access rights or prevent malicious or unauthorized invocations of restricted services. In "KAoS Policy Management for Semantic Web Services," Andrzej Uszok and his colleagues present justification for defining policies and contracts that are applied to service-oriented architectures. They briefly introduce the KAoS (Knowledgeable Agent-Oriented System) policy language and explain how it relates to OWL. They describe three service deployments, each presenting a different aspect of Semantic Web Services that's addressed by using KAoS:

- Fine-grain management of service use in a grid environment
- Policy compliance for service discovery
- Verification and local policy satisfaction during service composition and planning

In "Authorization and Privacy for Semantic Web Services," Lalana Kagal and her colleagues also review policies. They present a framework for incorporating security annotations in OWL-S service descriptions (based on a security ontology). The authors illustrate how to use the Rei policy language to augment the OWL-S process model, and they offer a framework for enforcing defined policies in an OWL-S execution environment.

These articles represent only a sample of the increasing body of Semantic Web Services research. Representing the fusion of research areas as diverse as agent-based systems, description logics, computational grids, and Web Services, Semantic Web Services will be essential to the realization of ubiquitous services in the Semantic Web.

References

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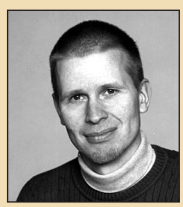

Ora Lassila is a Research Fellow at the Nokia Research Center in Burlington, Massachusetts. His research focuses on the Semantic Web and its applications to ubiquitous computing and mobile systems. He is an elected member of the Advisory Board of the World Wide Web Consortium (W3C) and represented Nokia in the W3C Advisory Committee from 1998–2002. In 1996–1997 he was a Visiting Scientist at the MIT Laboratory for Computer Science, working with Tim Berners-Lee and launching the Resource Description Framework standard; he served as a coeditor of the RDF Model and Syntax Specification. He is a founding member of the DAML-S/OWL-S working group and an original member of the DAML Joint Committee, participating in the creation of DAML+OIL. He received his MSc in computer science from the Helsinki University of Technology. Contact him at the Nokia Research Center, 5 Wayside Rd., Burlington, MA 01803; ora.lassila@nokia.com.