Semantic Enterprise: A Step Toward Agent-Driven Integration

Knowledge-driven enterprises can become more adaptable, dynamic and collaborative by using semantic technologies to integrate openly available data into the ecosystem.

Executive Summary

Technology waves are rolling in faster than ever, and enterprises are being reshaped by emerging Web technologies. Across industries, technology is no longer just a support system but also an integral part of today's fast-moving, “learn as you go” business models.

For instance, beyond historical transactional data, businesses are looking for more current and up-to-date data for informed decision-making. Retailers are integrating external blogs, social sites and data from ubiquitous mobile devices into their analytics systems to better understand the market pulse. Insurance companies, agents and customers are collaborating more effectively by integrating their systems to work online.

But the job of incorporating external data or onboarding external agents today often involves manual processes and development cycles that span months. With the advancement of semantic technologies, however, businesses can integrate openly available data into the ecosystem more effectively.

In this white paper, we discuss semantic technology adoption and how these capabilities are reorienting the enterprise. We look at how semantic technologies can enable more agile and automated approaches to integration, and we highlight some of the challenges associated with semantic technology adoption.

Agents and Semantics

To understand how business is evolving, it is important to track the evolution of Web technologies, as these are currently a key business enabler. Even before the social Web (or Web 2.0) was fully realized, business leaders began leveraging emerging semantic technologies (Web 3.0) to enable data sharing among social networks, with user permission. Then, just as Web 3.0 was learning to walk, Web 4.0, the self-learning and self-organizing Web, began incubating. Figure 1, next page, describes these technology waves in detail.

To understand the semantic Web, it’s important to first grasp two core concepts: semantic technologies and agents.

- **Semantic technologies:** Data is meaningful only when it is accompanied by structure. While syntax is about grammatical structure, semantics governs the relationship between articles, vowels, consonants, verbs and associat-
ed rules. Both the syntax and the semantics of a domain need to be defined in machine language so that the machine or computer systems can interpret that domain. An example is the spell checker, a software agent that compiles work based on lexical syntax and semantics, articulated in machine language. Similarly, it is important to define the semantics of a business domain or enterprise so that the IT systems can operate more efficiently.

Semantic technologies aim to create a knowledge base for computer programs to work more intelligently by linking objects and building relationships. The knowledge base helps computer systems understand the context of the work being accomplished during runtime operations and anticipate the necessary actions, with the goal of building relationships between every object in the world and creating a web of data. (For more on this topic, see our white paper, "How Semantic Technology Drives Agile Business.")

- **Agents:** Agents are complex software systems that are designed to perform a variety of tasks by interpreting a machine-readable knowledge base. For example compilers are software agents that work based on the syntax and semantics defined for a programming language. Similarly, Web crawlers are complex agents that retrieve processes and harvest data automatically from Web sites. A smarter breed of Web crawlers is emerging for harvesting semantic Web content.

Figure 2 illustrates how a computer system can use data to develop wisdom by adding structure and meaning to data and processing it.

How Data Leads to Wisdom

![Figure 2](image-url)
Semantic Web

The semantic Web is about making it easier for computer systems to interpret content. Its primary focus is tagging the content based on what it “means,” thus adding structure to data. The semantic Web is an indirect response to the business need for efficiency and getting the most out of its investments, from employees to equipment.

For example, in 2010, the BBC upgraded its World Cup Web site with semantic Web technologies, curating and interlinking the site’s content, without employing a large fleet of editors. The result: a highly dynamic, interactive, information-rich and user-oriented site, with aggregation at many levels (such as player, team, geography and group).

The richness of the site’s information, which included 700 topical index pages, could never have been produced via traditional methods. Semantic Web technologies, on the other hand, added structure to the unstructured information, typically handled by media, through appropriate tagging.

Another key aspect of the Web site’s success was cross-document relationships; ontology helped capture the complex interlinking of the documents based on topics, authors, citations and multiple revisions. Managing these relationships through traditional relational databases would have been cumbersome and inefficient, increasing time to market. Semantic Web databases — generally known as knowledgebases — can store more sophisticated and referenceable metadata than relational databases. Thus, they allow complex algorithms to directly reason with inferences on the data structures.

The interlinked, metadata-driven nature of the semantic Web enables enterprises to stay abreast of constantly changing usage patterns. The standardized metadata helps computer systems decipher meaning and act on it. Agents, thus, can run complex algorithms to directly reason with inferences on the data structures. This is why semantic Web languages are a key part of the knowledge representation of artificial intelligence (AI).

Other organizations have created production systems with semantic Web technologies, as well, including Time, Inc., Elsevier and the Library of Congress.

Semantic Enterprise

The semantic, or knowledge-driven, enterprise describes content using ontologies by tagging and linking information. This results in an interlinked, rich information tree of knowledge that continues to grow over time. The semantic enterprise provides contextual connections to both the identity of the enterprise and the assets that keep it running, creating a knowledgebase for computer systems to interpret the meaning of their actions. This results in more efficient processing and decision-making.

Assets are defined by the people, process and technology resources associated with the enterprise, and identity is defined by capturing the enterprise vision, mission, strategy and principles.

The Department of Defense (DoD) makes use of semantic technology across systems to form an executable, integrated and consumable architecture. Since 2011, the DoD’s Business Mission Area has mandated the use of semantic Web technologies as the foundational architecture for new integration projects. The organization links disparate information systems by overlaying them with semantic models, which has decreased the time it takes to get a new enterprise system up and running from six to nine months to less than 90 days.

Current tools enable enterprise modeling to define the relationships among various enterprise entities. When these models are maintained, the semantic enterprise can distinguish the present state from the past, add constraints, guide the present and predict the future.

However, current enterprise architecture tools are not flexible enough for extending the model with respect to newer entities. For example, these tools cannot be extended to capture physical assets along with the technology assets. Because these tools are not semantically aware, they provide a model that can neither be interpreted by other software nor be exchanged with the extended enterprise or the external world. As such, it becomes an uphill task for the enterprise to adapt to the dynamics of change.

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Semantic Technologies and Agent-Driven Integration

With traditional business-to-business integration, partners end up making a series of changes to their underlying systems in order to use each other’s services. This is a long and drawn-out process that involves risk, time and money. In the end, even if the integration is successful, the partnership that once seemed lucrative may no longer be so due to the vital time lost in getting the services up and running.

Imagine a situation where online retailers can integrate services of new vendors in weeks if not days. This is possible if a comprehensive, standard semantic model is used that contains object definitions with create, read, update, delete and store (CRUDS) operations that are linked to associated services and data mapping details. In this case, an integration agent can identify the required service for fetching the set of attributes of a specified object.

Figure 3 partially depicts an enterprise that is semantically described by linking resources. A semantic-aware agent program can be used to integrate multiple enterprises or services within an enterprise, provided the partner enterprise extends the integration ontology that is understood by the agent program.

In a hypothetical example of an online retailer’s integration architecture, the business partners describe their assets (such as watches, shoes and perfumes) and services (such as search, order and payment) by providing mapping or extensions to the abstract product and service ontology. The business partners register themselves with the retailer by extending an abstract partner ontology.

When a consumer visits the portal that is provided by the retailer to make a purchase, the agent fulfills the request to list all the watches. The agent does this by discovering all the business partners that provide watches and deciding which services need to be invoked to display the required list, as well as the mediation needed for such an invocation. The search request is executed afterwards, and the result is rendered in the portal. Thus, the rendering agent, being semantic-aware, can seamlessly display products that contain the required attributes, without any prior awareness of them.

Disadvantages of Semantic Technologies

The flexibility inherent in semantic Web applications introduces some drawbacks. Sometimes, a problem can be more efficiently solved by using other tools. The following are just a few characteristics of applications that can hamper the effectiveness of semantic Web tools:

- **Data volume:** The data volume stored in a relational data warehouse cannot be handled by a single semantic solution. A workaround (such as a just-in-time data mart and query

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**Agent-Driven Enterprise Integration Ontology**

![Agent-Driven Enterprise Integration Ontology Diagram](image-url)
federation) may be employed to boost the scale of effectiveness. However, doing so will increase the complexity of the solution to a great extent and may not be feasible in certain cases.

- **Update transaction volume:** Semantic solutions are not suitable for handling high-volume transactions, such as thousands of reads or writes per second to a single server. These solutions are especially not recommended for high-volume writes.

- **Computational scale:** Present-day semantic Web tools are not optimized for high-scale numeric computations on a huge amount of numeric data. Therefore, the recommended workaround is to pull data from semantic Web systems into traditional business intelligence tools for calculation and visualization.

Barring these drawbacks, because semantic Web solutions are storage-agnostic, a relational database for the high-volume transactional server can be wrapped within semantic query endpoints in order to integrate it with a broader semantic Web application or strategy. Similarly, an existing data warehouse containing petabytes of data can be consumed by semantic Web applications by defining ontologies for the subsets of warehoused data that need to be consumed.

### Looking Ahead

Relational systems are still superior for transactional and operational systems. However, they deal with certainty and logical objects. It is difficult to extend relational systems to support an uncertain real-world object network. Because of this, they fall short in enabling knowledge management, which is incomplete, changing and uncertain. The semantic Web ensures that artificial thresholds are not placed on information, and it encourages collaboration between enterprises.

As open standards evolve, semantic technologies will thrive. And as the business world adopts semantic technologies, the semantic enterprise will emerge.

### References


### Footnotes

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