Services on the Move — Towards P2P-Enabled Semantic Web Services

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Abstract

Service-driven architectures promise a new paradigm providing an extremely flexible approach for building complex information systems. However, at the current moment, service architectures go little way beyond standardized remote procedure calls and textual directories to locate and describe a service provider based on human intervention. In this paper we consider three important dimensions for building next-generation service-driven systems building on enabling technologies such as Web services, Peer-2-Peer and Semantic Web.

Keywords: Semantic Web, Web Services, Peer-2-Peer

1 Introduction

Recently, so-called service-driven architectures, including a services-driven middle tier that mediates back-end resources with multiple channels (PCs, PDAs, wireless phones, etc.) to the end user have been proposed (see http: //www.sun.com/executives/sunjournal/v4n1/Feature3.html). The vision of service-driven architectures promises a new paradigm providing an extremely flexible approach for building complex information systems. In the future the overall vision of fully-enabled services within such architectures promises great benefits for tourism information systems, because they will *(i)* ease participation of SMEs to larger networks, *(ii)* facilitate virtual organizations, and *(iii)* allow the user to create bundled products tailored to his needs.

So far, however, the definition of these service architectures go little way beyond standardized remote procedure calls and textual directories to locate and describe a service provider requiring human intervention. In this paper, we argue that we need to consider three dimensions to fully enable service-driven architectures that accomplish the above mentioned objectives (cf. Figure 1):

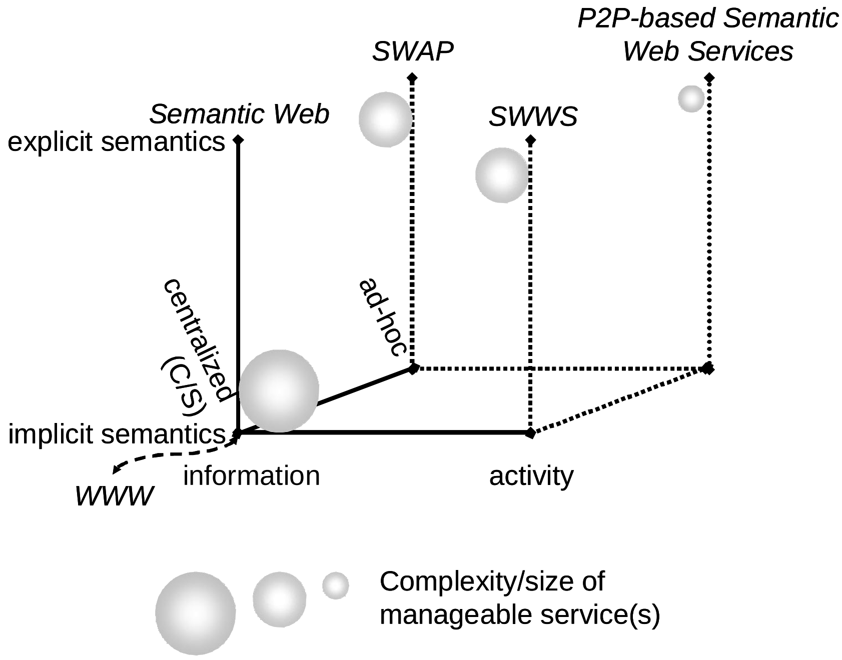

Figure 1: Towards P2P-based Semantic Web Services

1. **Information vs. activity**: This is the difference between a static HTML page or an information repository like the initial WWW on the one hand and a service that provides some complex activity (e.g., a room booking) on the other hand.

2. **Centralized vs. ad-hoc**: This dichotomy describes the difference between a client/server paradigm, where clients call dedicated servers (even if roles may switch), and a system that is assembled ad-hoc. Note that current Web Service standards assume one (or few) central directories (e.g., UDDI) to locate other services.

3. **Implicit vs. explicit semantic descriptions**: This dimension distinguishes between semantics that are only implicitly available, e.g. by convention (cf. EDI-FACT), and semantics that are explicitly specified, e.g. by an ontology.

Each of these three dimensions facilitates the automatic identification, location and invocation of services for tourism information systems increasing system flexibility. Together, they will create a new paradigm of building systems.

However, we here also argue that automation is limited because each of these dimensions adds new complexity to the overall task that may be accomplished by a service. Therefore, there will be a trade-off: ad-hoc configured, activity-oriented, services with explicit semantics will be created, offering new chances to the tourism industry (e.g. dynamic product configuration by customers). However, they will not replace conventional approaches that will still be able to manage tasks that need a higher degree of complexity or reliability (e.g. enterprise resource planning).

2 Enabling Technologies

In this section, we briefly survey the underlying technologies necessary to achieve ad-hoc configurable, activity-oriented, semantic-descriptions based services.

Web Services. Web Services can be defined as software objects that can be assembled over the Internet using standard protocols to perform functions or execute business processes. The key to Web Services is on-the-fly software creation through the use of loosely coupled, reusable software components. This has fundamental implications in both technical and business terms. Software can be delivered and paid for as fluid streams of services as opposed to packaged products. They also facilitate interoperability between systems to accomplish business tasks. Businesses can be released from the burden of complex, slow and expensive software integration and focus instead on the value of their offerings and mission critical tasks. Then, the internet will become a global common platform where organizations and individuals communicate among each other to carry out various commercial activities and to provide value-added services.

Peer-to-Peer (P2P). The essence of Peer-to-Peer computing is that nodes in the network directly exploit resources present at other nodes of the network without intervention of any central server. For this purpose P2P platforms like JXTA (see http://www.jxta.org) provide a layering over communication networks that abstract from lower level transport protocols. They provide a namespace mechanism that allows for direct P2P communication even if that means to cross the boundaries of different networks or firewalls. New nodes may join the network and be integrated ad-hoc. On the basis of such communication services higher-level application services like indexing, search, file exchange or querying may be built. Every peer may fully participate in the services offered by the network. However, there exist possibilities to structure the overall network into *peer groups* facilitating the creation of interest groups and groups with dedicated rights for accessing critical information.

Semantic Web. The Semantic Web, a term coined by the inventor of the WWW, Tim Berners-Lee, describes the next generation of the Web, which does not only provide information as text and graphics understandable to the human reader, but also gives a semantic description interpretable by machines. By defining the semantics of terms, the Semantic Web will include, will build on, but will also significantly extend the current XML revolution in order to achieve better interoperability between tourism information systems (cf. (Maedche & Staab, 2002)). Therefore, we consider the Semantic Web as a prime enabler of future advanced Web-enabled applications and services such as intelligent Web services, next generation knowledge management solutions, and collaborative e-business in dynamic value constellations.

Ontologies are universally recognised as an essential technology to achieve the Semantic Web. Ontologies provide both human-understandable and machine-processable semantic mechanisms needed to let enterprises and application systems collaborate in a smart way. An ontology is a conceptual information model that describes “the things that exist” in a domain (hence the name): concepts, relations, facts and rules, in a consensual and formal way. An ontology thus acts as a standardised reference model, providing a stable baseline for shared understanding of some domain that can be communicated between people and inter-organisational application systems.

3 Towards Services on the Move

This section describes our vision towards ad-hoc configurable, activity-oriented, semantic-descriptions based services. The vision builds on technologies currently being developed in four recent EU-IST projects Ontologging, WonderWeb, SWAP and SWWS.

3.1 KAON — Semantic Web Infrastructure

In (Maedche & Staab, 2002) we have argued for the wide spread adoption of Semantic Web ideas in information systems. However, most current systems still take a static view of the Semantic Web and support only a simplistic kind of “read and query” modus. In the EU IST projects WonderWeb and OntoLogging we have been developing the KAON ontology and Semantic Web infrastructure (Bozsak et al., 2002; Motik et al. 2002,a; Motik et al. 2002b; we refer the interested reader to http: //kaon.semanticweb.org, where the KAON open-source software is available for download). KAON targets semantics-driven business applications including a comprehensive infrastructure allowing easy ontology management and application. The main focus of KAON is on integrating traditional technologies for ontology management and application with ones used in typical business applications, such as relational databases. It is based on an ontology model introduced in (Motik et al., 2002a), derived as a minor extension of RDF(S), with some proprietary extensions, such as inverse, symmetric and transitive relations, cardinalities, modularization, meta-modeling and representation of lexical information. The infrastructure and its associated server does not only take into account the interactions as required by modifications of atomic logical statements, but rather provides mechanisms for dealing with complex behavioral requirements, e.g. transactions and evolution mechanisms. Thus, it provides the basis for the building blocks that follow.

3.2 SWWS — Semantic Web enabled Web Services

SWWS (see http://swws.semanticweb.org) is about bringing web services and fully enabled E-commerce to reality. Everybody must be able to trade and negotiate with everybody else. However, such an open and flexible E-commerce has to deal with many obstacles before it becomes reality (cf. (Fensel et al. 2002a)):

- Current web service technology around UDDI (Universal Description, Discovery and Integration of business for the web; http://www.uddi.org), WSDL (Web Service Description Language: http://www.w3.org/TR/wsdl), and SOAP (Simple Object Access Protocol; http://www.w3.org/TR/SOAP/) does not yet provide a mature technology as it leaves the semantics of data, business logics and message exchange sequences undefined. SWWS combines ontology technology with workflow approaches in order to support automated discovery, invocation and composition of web services.

- Means for scalable mediation between different and heterogeneous services have to be developed. The mediation framework will substantially rely on the semantics-driven descriptions of data and business logics. This framework will also include means for configuration, composition and negotiation of Web Services.

SWWS Case Study. The vision of Semantic Web Enabled Web Services is introduced by providing the following concrete B2B case study: A newly hired employee requires a laptop for his workplace. In order to buy one he defines the characteristics of the laptop like processor speed and disk size. The purchasing process makes sure that the new employee's manager authorizes the purchase. Based on the configuration of the laptop, alternative hardware vendor's offerings have to be collected and a price comparison has to be done. Once the cheapest laptop is determined, a service contract for three years has to be found and purchased together with the laptop. The service contract might be from the laptop vendor or might be from an independent insurance company. It might be that a same or better-equipped laptop together with the service contract is cheaper than if both are bought separately. Once the cheapest combination is found, the laptop purchase order is issued. Finding alternative laptops and service contracts as well as the final purchase should be automatically supported without human user involvement. The mediation related problems that have to be solved within this use case are:

- Business process execution: The whole process must be modeled and executed. The set of tasks may include human ones as well as ones performed by machines.

- Transmissions over networks must be secured according to the trading requirements of the partners and the B2B protocols involved.

- Possible laptop vendors as well as service contract vendors have to be discovered and messages have to be exchanged with them. The search should be reduced to 10 service providers.

- Different document type formats have to be understood and transformed into each other to make the prices and products comparable.

- Alternative purchase approaches will be necessary if a separate company buys the service contract. The reason is that in this case the purchases, the laptop and the service contract, must both succeed simultaneously or they must not be accomplished at all.

SWWS technology will offer the mechanism to realize the scenario introduced above. Various aspects can be identified as being necessary to achieve such an intelligent and automatic web service discovery, selection, mediation and composition into complex services. Among others, the focal aspects of the SWWS framework are:

- Semantics: First, elements of document types must be populated with correct values so that they are semantically correct and are interpreted correctly by the service requesters and providers. This requires that a vocabulary is defined that enumerates or describes valid element values, for example, a list of product names or products that can be ordered from a manufacturer. Further examples are unit of measures as well as country codes. Ontologies provide a means for defining the "concepts" and therefore the semantics of the data to be exchanged. If ontologies are available then document types refer to the ontology concepts. This ensures consistency of the textual representation of the concepts exchanged and allows the same interpretation of the concepts by all trading partners involved. Finally, the intent of an exchanged document must be defined. For example, if a purchase order is sent, it is not necessarily clear if this means that a purchase order needs to be created, deleted or updated. The intent needs to make semantically clear how to interpret the sent document.

- Data & Process Mediation: It is not expected that there will be one global and consistent definition of a vocabulary. Actually, there will be many vocabularies leading to data heterogeneity. One of the most important paradigms of SWWS is to support strong mediation capabilities. Thus, mechanisms for mapping heterogeneous vocabularies will be provided. Additionally, not only data that is exchanged may be heterogeneous, also processes may not match to each other.

3.3 SWAP — Semantic Web and Peer-to-Peer

SWAP (see http://swap.semanticweb.org) is about demonstrating that the power of Peer-to-Peer computing and the Semantic Web can actually be combined to support decentralized, ad-hoc environments where participants can maintain individual views of the world, while sharing knowledge in ways such that administration efforts are low, but knowledge sharing and finding is easy (cf. (Fensel et al., 2002b)):

- Key to the success of combining Peer-to-Peer solutions with Semantic Web technologies is the use of Emergent Semantics. Emergent semantics builds on light-weight and/or heavy-weight ontologies that different individuals, departments, or organizations have created.

- SWAP develops intelligent tools and graphical user interfaces that allow for the use of precise definitions such that knowledge may be nicely structured and easily re-found. The exchange of knowledge in a virtual tourism organization will be enabled without without overhead through central administration.

SWAP Case Study. The SWAP case study involves the connection of SMEs from the tourism industries in the Balearic Islands for the purposes of tourism quality management and sustainable development. Tourism is a highly competitive industry, and the European tourism sector can no longer compete on the basis of cost alone. Quality is therefore a key element for the competitiveness of the tourism industry. It is also important for the sustainable development of the industry and for creating and improving jobs (Lladóo et al., 2002). An integrated approach to quality management is necessary because so many different elements affect the tourist's perception of a destination (such as transport, accommodation, information, attractions, the environment etc.). Integrated Quality Management (IQM) needs to take into account tourist businesses, tourists' interests, the local population and the environment, and to have a positive impact on all of them. The agreed-upon definition of quality in tourism is in line with that of the World Tourism Organisation, emphasising that quality is the perception by the tourist of the extent to which his expectations are met by his experience of the product. Quality is not to be equated to luxury, and must not be exclusive, but must be available to all tourists, including those with special needs. Tourism providers in a location such as the Balearic island are in a cooperation situation. A tourism enterprise there is competing for tourists and therefore aims at outperforming its peers. However, it is not sufficient to be better than the immediate competitor. The quality criterion as defined above require that the natural environment, transport, cultural events and other factors are given special consideration. This cannot be achieved by any enterprise there alone. Rather, all enterprises need to cooperate in order to achieve a high-quality impression by their tourist clients.

The SWAP technology will offer a natural way to exchange information on tourism quality management and sustainable development as it allows for easy, minimal invasive knowledge exchange between tourism enterprises. For instance, a hotel manager may want to exchange information on the measures of sustainable development that his company pursues (for instance, water preserving measures).

Common water preservation means will not only help to bring down water costs of one's own enterprise, but it may reduce water costs in general and it will improve the general impression that a tourist receives of the Balearic islands.

In SWAP a hotel manager will simply select appropriate folders (and subfolders) as well as databases (or views on them) for information exchange with selected peer groups (e.g. to competitors on the Balearic islands, but not to ones in Turkey or *vice versa*). He himself may similarly query other peers in his group for related information taking advantage of the precision resulting out of semantic technologies and peer group selection.

4 The Vision: P2P-based Semantic Web Services

P2P-based Semantic Web Services combine the three enabling technologies in order to support scenarios like the following:

A customer might plan an itinerary in the southwest of Germany visiting restaurants with at least 15 of 20 gourmet points (http: //www.gaultmillau.de/gmd/index.php3) and some classical concerts.

Because such a specific wish may hardly be pre-configured, it will be necessary to locate and integrate several services on the fly. Thereby, providers want to facilitate the use of information to their customers and describe it via semantics that can be processed by machines and understood by the customer. The customer may — ad-hoc — integrate constraints coming from different services (a restaurant may be closed on Mondays, hotels may have restricted number of non-smoking rooms, events are pre-scheduled, other constraints may come from a route planning service) in order to answer his request. In order to facilitate assembling the services from virtual networks (e.g. restaurants know about hotels and event organizers in their vicinity and automatically forward requests) based on P2P query routing. Services, such as hotel reservations, may then be invoked (semi-)automatically.

5 Conclusion

Service-driven architectures promise a new paradigm providing an extremely flexible approach for building complex information systems. However, at the current moment, service architectures go little way beyond standardized remote procedure calls and textual directories to locate and describe a service provider based on human intervention. In this paper we have considered three important dimensions for enabling the development of fully-enabled service-driven systems building on enabling technologies such as Web services, Peer-2-Peer and Semantic Web. The vision of fully-enabled service-driven systems is pursued within the four different EU-IST funded projects Ontologging, WonderWeb, SWAP and SWWS that have been shortly introduced in this paper.

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