



Data, Information and Process Integration  
with Semantic Web Services

**DIP**

*Data, Information and Process Integration with Semantic Web Services*

**FP6 - 507483**

Deliverable

**D12.1**

**Report on current usage of Web Services and Semantic  
Web**

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June 30, 2004

## EXECUTIVE SUMMARY

Work Package 12 provides the DIP consortium and in particular the technology providers in DIP with real-world background information on potential application areas for Semantic Web Services (SWS). This deliverable gives an overview of Semantic Web Services and nine potential application areas and analyzes one application area, namely Business Process Management, in more detail.

Several application areas hold potential for semantic information and some of them will start integrating semantic techniques into their solutions in the near-term future. This will probably start with simple semantic features, such as the inclusion of metadata relating basic data to categories or conceptual hierarchies (ontologies). Once these semantic extensions have proven useful, more complex features such as reasoning could be tackled. It is also very likely that interfaces will be provided as Web Services in these application areas. Adding semantic descriptions to these interfaces will simplify their use and make discovery and (semi-)automatic composition easier.

It is not clear yet, however, whether the integration of semantic descriptions and metadata will be based on formalisms like RDF (Resource Description Framework), OWL (Web Ontology Language), or WSMO (Web Services Modelling Ontology). It is also possible that proprietary solutions will be developed based on plain XML. This would mean that some of the functionality and benefits promised by Semantic Web Services would become reality, without, however, actually applying Semantic Web Technology.

For the DIP project and researchers and companies involved in developing SWS technologies the following conclusions could be drawn:

- The application areas presented in this deliverable offer substantial potential for applying SWS technology. They are also a lot more specific than generic application areas such as E-Business, E-Government or Knowledge Management. By looking more closely at the issues arising in these specific application areas, clearly targeted use case examples could be constructed.
- In most application areas covered in this deliverable, Semantic Web Services do not seem to be considered as a relevant technology. It would thus be important to intensify knowledge transfer into these application areas. Ideally, targeted use case examples should be used to demonstrate the application potential and the benefit of SWS for a particular application area.
- Finally, it seems possible that “semantic” solutions based on proprietary techniques will be developed in some or all of the application areas in the near future. It would thus be important to clearly demonstrate the advantage of SWS technology based on standards opposed to such proprietary solutions.

A more detailed analysis of the application potential of SWS in Business Process Management (BPM) has shown that the key contribution of SWS to BPM would be techniques based on semantic descriptions of services. These descriptions could be used for enhanced service discovery, semi-automatic tools supporting the composition of service operations into processes, and for process monitoring based on semantic criteria. Whereas DIP already focuses on discovery and composition, monitoring is not yet prominently dealt with in DIP. It is recommended to take monitoring into account as a promising application area for SWS.

Finally, BPM solution vendors start supporting BPEL (Business Process Execution Language) in their upcoming product releases. The SWS solutions to be developed in DIP should therefore be compatible with BPEL in order to allow for a straightforward integration with products already established in the market.

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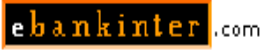





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## 1 INTRODUCTION

Work Package 12 provides the DIP consortium and in particular the technology providers in DIP with real-world background information on potential application areas for Semantic Web Services. This deliverable gives an overview of Semantic Web Services and nine potential application areas and analyzes one application area, namely Business Process Management, in more detail.

The three main sections of this deliverable:

- Semantic Web Services in a Nutshell
- Application Areas for Semantic Web Services
- Business Process Management with Semantic Web Services

are self-contained and can be read separately. In fact, work in WP12 will continue to produce concise briefs, which will then be compiled into deliverables.

Section 2 provides an overview of two innovative technologies, Web Services and Semantic Web, and their likely combination into Semantic Web Services. It describes the underlying visions, sketches the main languages and standards, and explains functionalities, benefits and challenges. The focus is on the question where Semantic Web and Web Services are likely to meet and what the combination of the two will probably look like.

There are two ways to combine both technologies into Semantic Web Services: on the one hand, Web Services and their descriptions can be semantically enriched to enhance the potential for discovering and combining services. On the other hand, Web Services can be used to provide interfaces to existing Semantic Web technology, e.g. ontologies or logic-based reasoners.

Section 3 evaluates the potential of Semantic Web Services in the application areas of Business Process Management, Content Syndication, Contextual Ads, Enterprise Application Integration, Enterprise Collaboration, Product Information Management, Single European Electronic Market, Search/Mining, and Social Software. Each application area is briefly sketched, and possibilities for using Semantic Web Services as well as alternatives are discussed. Finally, conclusions are drawn for the research project DIP. Those application areas having medium or high potential for SWS will be analysed in more detail in subsequent deliverables of WP12.

As a result of the analysis presented in Section 3, an exploitation of SWS technologies developed in DIP should target the most promising application areas, in addition to the general application areas listed in the technical annex, namely E-Business/E-Commerce, Knowledge Management, or EAI.

Section 4 analyzes the potential of Semantic Web Services in the application area Business Process Management (BPM). It contains brief descriptions of the vision underlying BPM and of the business process life cycle. Then, three technologies of BPM, namely workflow solutions, Enterprise Application Integration (EAI), and Business Intelligence (BI) are discussed in detail. Finally, application scenarios for Semantic Web Services are presented, focusing on semantic service descriptions, discovery, process composition, and process monitoring. The section concludes with recommendations for the DIP project.

Section 4 is thus an example for the detailed evaluations of promising application areas, which will be the content of D12.3.

## **2 SEMANTIC WEB SERVICES IN A NUTSHELL**

Semantic Web Services combine two innovative technologies, namely Web Services and Semantic Web. Web Services offer the ideal technology for providing access to functionality independent of the technology used to implement it. The Semantic Web aims at structuring and enhancing information in such a way that makes it easier to process automatically.

There are two ways to combine both technologies into Semantic Web Services: on the one hand, Web Services and their descriptions can be semantically enriched to enhance the potential for discovering and combining services. On the other hand, Web Services can be used to provide interfaces to existing Semantic Web technology, e.g. ontologies or logic-based reasoners.

Whereas Web Services are already established and widely used, Semantic Web is still rather visionary and development is mostly restricted to academic research. It is therefore likely that Semantic Web Services will build on existing Web Services Technology and incrementally add semantic features to increase their usability. The most obvious extension is the support of semantic descriptions of Web Services properties on top of WSDL.

Semantically describing Web Services could significantly facilitate discovery and composition of services.

This section gives an overview of two innovative technologies, Web Services and Semantic Web, and their likely combination into Semantic Web Services. It describes the underlying visions, sketches the main languages and standards, and explains functionalities, benefits and challenges.

The focus is on the question where Semantic Web and Web Services are likely to meet and what the combination of the two will probably look like.

New information technologies can be characterized on several different levels. On the one hand, an underlying vision is used to promote and sell the new technology. On the other hand, specific formats, languages or standards are used to implement this vision. Finally, each technology offers specific functionality and benefits and faces specific challenges.

### **2.1 Visions**

#### **2.1.1 Web Services**

The basic idea underlying Web Services is to facilitate the usage and integration of applications by making them independent from the technology with which they have been implemented. A Web Service should be accessible by a client regardless of the programming languages in which service and client have been implemented or the operating systems under which they are running.

Moreover, Web Services should enable the agile enterprise<sup>1</sup> by being highly reusable and easily combinable. The idea here is to allow for modelling and modification of business processes directly on the business level. Services are seen as building blocks for processes, which can be rearranged by business experts without the need to involve expensive developers. Finally, it should be straightforward to replace a service by another service offering the same technology.

Web Services are inherently process-oriented. A service, or more precisely a service operation, is an action performed by a program. Processes can then be constructed by combining individual service operations.

### 2.1.2 Semantic Web

The Semantic Web is usually explained by referring to Tim Berners-Lee and the vision first expressed in his roadmap paper.<sup>2</sup> Often the reference stresses the fact that Tim Berners-Lee invented the current World Wide Web, thereby implying that his vision will surely become the reality of tomorrow's World Wide Web.

The basic idea underlying his vision is to make websites machine processable by structuring and enhancing the information contained in them. This would allow the creation of various intelligent applications roaming the net and using the web's information to offer all sorts of services.

This vision is usually contrasted with the current situation, in which information on the web is only available as “unstructured” HTML pages. These are sufficient for human readers, who use their background knowledge when reading pages with a browser. They can thus identify relevant pieces of information when browsing websites. Examples would be the identification of room rates, special offers, room types, location information, etc. on a hotel website, the address, phone numbers, office locations on a company's contact page, or information concerning real estate, such as property, rent, fixtures.

It is not straightforward, however, to extract such information automatically. Programs doing this at the moment are usually hand-coded scripts, which are particularly tailored towards the websites from which they extract information. Reusability is low and even maintenance is costly as the scripts have to be updated if the structure or the layout of the underlying website changes.

How much easier would it be if information on the web contained “information about itself”, e.g. by explicitly stating that a piece of information is an address, a contact name, a room rate, a monthly rent, a deposit, etc. The Semantic Web aims at standardizing information in a way that such metadata can be added to the basic data currently put onto websites.

Note that the Semantic Web is primarily “static”, i.e. it aims at enhancing information representation in order to make automatic processing of this information feasible.

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<sup>1</sup> The term “agile enterprise” is widely used by analysts and software companies to promote new technologies, architectures and IT infrastructures. The main gist is that “businesses face increasing change, uncertainty and unpredictability in the business environment” and have to become agile or adaptive to survive (see <http://www.cheshirehenbury.com/agility/twodefinitions.html> for a good overview).

<sup>2</sup> <http://www.w3c.org/DesignIssues/Semantic.html>.

Combining it with the more dynamic concept of Web Services is thus facilitating its usage in process-oriented application contexts.

### 2.1.3 Semantic Web Services

The vision underlying the combination of Semantic Web and Web Services is twofold. On the one hand, Web Services provide the ideal technology for accessing semantic information. On the other hand, semantically enriching Web Services and their descriptions enhance the potential for discovering and combining services.

The first option of combining Web Services and Semantic Web is to use Web Services for the enhancement of existing Semantic Web technology. One potential weakness of the Semantic Web is its currently rather academic nature and its lack of integration with technology established in enterprises. In a sense, reasoners developed in Knowledge Representation or Artificial Intelligence are similar to legacy systems found in large corporations – they often are monolithic systems whose functionality is difficult to access and reuse in the current web-based IT environment. And they are usually written in special programming languages like LISP and not in Java, C++ or VB. The vision here is that providing Web Services interfaces for Semantic Web components would significantly lower the barriers for their integration into enterprise applications.

The second option of combining Web Services and Semantic Web is to use Semantic Web technology to enhance Web Services. The standard used for describing Web Services, WSDL, does not provide any means for semantically describing Web Services.<sup>3</sup> When publishing a service in a repository or registry it is therefore common practice to add additional information to the WSDL interface, most often in the form of free text descriptions. These descriptions help potential users to decide whether a service is in fact doing what they expect it to do. They are, however, not suited for automatic processing.

To better support discovery of services and (semi-) automatic composition of service operations into complex processes, a formal, standardized semantic description of services is needed. The idea here is that Semantic Web technology can be used to describe Web Services semantically. The ultimate objective then is to combine services on the fly in order to achieve a given goal. Based on the goal description and the descriptions of available services, a complex service yielding the desired result is automatically composed out of atomic building blocks.

## 2.2 Technologies, Languages and Standards

This section presents technologies, languages and standards used for Web Services, Semantic Web and Semantic Web Services. These are a lot more specific than the general vision.

### 2.2.1 Web Services

Web Services started out with a set of four basic standards, out of which three are generally accepted today, namely XML Schemas for describing data types, SOAP as a message format for exchanging information between a client and a service, and WSDL (Web Services Description Language) for describing service interfaces. The relevance

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<sup>3</sup> Although one could argue that describing data types of input and output arguments with XML Schemas is already a kind of semantic description. This depends on the exact notion of semantics one applies.

of the fourth basic standard, UDDI (Universal Description, Discovery and Integration), is less unanimous, however. Since most application projects using Web Services up to now focus on integration within the enterprise, there is not yet a real need for discovering available services.

In addition to these basic standards, a host of standards addressing specific aspects of Web Services usage has been developed within the last two years. Together they form a kind of a Web Services standards stack. Most of these standards, including those for security, reliable messaging, choreography of services, transactions, have been developed by IBM and Microsoft, in cooperation with varying partners such as BEA or VeriSign. This has drawn some criticism regarding the openness and transparency of the standardization process. Given the experience with SOAP and WSDL it is very likely that most of the standards will soon be supported by most software vendors and will ultimately be endorsed by official standard organizations. This is currently happening for the standards WS-Security<sup>4</sup> and BPEL4WS.

BPEL4WS (or BPEL for short) defines a notation for specifying business process behaviour based on Web Services. Based on “atomic” Web Service operations specified in WSDL one can define complex workflows by specifying sequences of operations, pre-conditions and post-conditions, data to be exchanged between operations, bifurcations and error cases. BPEL was originally developed by BEA, IBM, and Microsoft. Version 1.1 also includes input from SAP and Siebel.<sup>5</sup> The OASIS TC “Web Services Business Execution Language” now continues the standardization of BPEL.<sup>6</sup>

The pace of standardization progress in the area of Web Services is impressive. Not only are standards available for most aspects of Web Services by now, major software vendors also rapidly support them and integrate them into their product suites. Standard compliance is essential for Web Services since it is the key to achieving independence from technologies, vendors, and programming languages – the central vision of Web Services.

In spite of the advanced state of standardization, however, interoperability is not always guaranteed. On the one hand, the existing standards are very extensive and software products usually support only subsets of the complete standards – and not necessarily the same subsets. This is in particular the case in the first product releases supporting a new standard. On the other hand, standards are not always unambiguous and different vendors sometimes interpret specifications differently.

The WS-I Group (Web Services Interoperability) has been founded to overcome these challenges. Its purpose is to promote Web Services interoperability across platforms, operating systems, and programming languages. WS-I Basic Profile 1.0, authored by BEA, IBM, Microsoft as well as webMethods, clarifies open issues in Messaging (SOAP) and Service Description (WSDL).<sup>7</sup> It is a first step towards facilitating

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<sup>4</sup> The OASIS TC “Web Services Security” is responsible for the standardization of WS-Security: [http://www.oasis-open.org/committees/tc\\_home.php?wg\\_abbrev=wss](http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=wss).

<sup>5</sup> <http://www-106.ibm.com/developerworks/library/ws-bpel/>.

<sup>6</sup> [http://www.oasis-open.org/committees/tc\\_home.php?wg\\_abbrev=wsbpel](http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=wsbpel).

<sup>7</sup> <http://www.ws-i.org/>.

interoperability and Web Services products will soon be made compliant to the profile. The final specification of the profile was released on April 04, 2004.

Most software vendors have declared their commitment to ensure that their products will be WS-I profile compliant. And some products already offer functionality testing WS-I profile compliance.

### 2.2.2 Semantic Web

So far the Semantic Web Activity at the W3C has released two recommendations: RDF (Resource Description Framework) and OWL (Web Ontology Language).<sup>8</sup> Although RDF is seen by many as the basic Semantic Web standard, some argue that it does not add anything to plain XML except syntactic sugar.

Basically, RDF<sup>9</sup> allows the description of resources via simple statements of the form: <resource,property,value>. Since RDF is based on XML, the “real” statement in XML notation looks a lot more complex, of course. RDF offers several different notational variants, however, some of which hide the underlying XML complexity. As these variants are purely notational, they can all be mapped into each other.

*RDF: Resource Description Framework*

Just as XML, as a standard, only stipulates the general syntax of XML documents and data without restricting the set of permissible tag names or attribute names, RDF itself does not fix the potential range of properties and values. And just as XML Schemas can be used to further specify the structure of XML documents in an application area, RDFS (RDF Schemas) provides information about RDF statements for a particular domain. RDFS can be used to define a set of properties and values permitted in RDF statements.

OWL<sup>10</sup> goes one step further and allows the specification of logical relationships between properties, classes and values. It is based on Description Logics and provides the basis for reasoning on given information. Thus, given a list of OWL statements additional statements can be automatically derived.

OWL, just like its ancestor Description Logics, uses class hierarchies as a central means for structuring. It thus has similar mechanisms of inheritance as object-oriented languages or XML Schemas. In contrast to these formalisms it also supports defined classes, i.e. the specification of sufficient conditions in addition to necessary conditions. It is thus possible to infer that a resource belongs to a certain class, given a set of properties and values.

Work on Semantic Web in general and on OWL in particular is very much dominated by researchers coming from the Artificial Intelligence and Knowledge Representation community. As there are alternative approaches to Description Logics in these areas such as F-Logic, the choice of Description Logics as a basis for OWL is not unanimous. In fact, heated debates between supporters of different formalisms are not uncommon. It should be noted, however, that Description Logics and F-Logic both are logic-based

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<sup>8</sup> <http://www.w3.org/2004/01/sws-pressrelease>.

<sup>9</sup> <http://www.w3.org/RDF/>.

<sup>10</sup> <http://www.w3.org/2001/sw/WebOnt/>.

formalisms, as are other similar languages. That is they have a lot in common despite differences regarding expressivity.<sup>11</sup>

One criticism raised against OWL and the logic-based approach in general is its complexity. While it is true that OWL provides a sound formal basis for logical reasoning, it is also telling that logic-based formalisms have not yet reached any significant usage outside comparatively small communities.

It is also often pointed out that the real challenge for Semantic Web standards is not the standardization of representation formalisms for ontologies, such as RDF or OWL, but the standardization of ontologies itself. Roughly put, this position would argue that a set of terms for describing a specific domain, e.g. hotel room booking, has to be fixed. Whether this set of terms is specified in XML Schemas, RDF or OWL is secondary. This is analogous to standardization in EDI: fixing the syntactic format was comparatively easy compared to the task of agreeing what exactly should be included in a purchase order. The latter is specified in a specific EDI standard such as EDIFACT and is often called the semantics of transactions.

The counter argument insists that the representation format does actually matter. Though this point is valid, there is a certain tendency for research in Semantic Web to focus on issues regarding the representation formalism. It remains to be seen whether the recommendation of OWL by the W3C puts an end to this debate or whether work on representation formalisms in this area continues.

Regarding practical applications, RDF fares slightly better than OWL. One of the “oldest” RDF applications is Dublin Core.<sup>12</sup> The Dublin Core Metadata Element Set (DCMES) contains 15 broad categories, such as subject, title, creator, date, to describe (web) information resources. It can be carried in HTML, XML or RDF.

A more recent standard is FOAF (Friend of a Friend), a RDF-based format for describing people and the links between them.<sup>13</sup> It can be used to create machine-readable homepages representing information about people, which is easy to process, merge and aggregate. It thus strives at turning the vision underlying the Semantic Web into reality for a specific domain.

Finally, RSS, which stands for RDF Site Summary or Really Simple Syndication, is a widely used format. Several versions of RSS are available and one of them, RSS 1.0, is based on RDF.<sup>14</sup> RSS is a format for syndicating news and most news-like sites offer so-called RSS feeds, which can be read by RSS-Feed Readers.

### 2.2.3 Semantic Web Services

Given the general vision underlying Semantic Web Services, one would expect to see two areas of standardization: on the one hand, languages for semantically describing

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<sup>11</sup> They are, for example, equally distant from statistic approaches, which constitute a completely different paradigm in information processing. This paradigm does not seem to be represented in the Semantic Web community at all.

<sup>12</sup> <http://dublincore.org/>.

<sup>13</sup> <http://www.foaf-project.org/> and <http://rdfweb.org/>.

<sup>14</sup> A good overview over RSS and the different formats can be found in Mark Pilgrim, “What is RSS”, xml.com, December 18, 2002 (<http://www.xml.com/pub/a/2002/12/18/dive-into-xml.html>).

Web Services, on the other hand standardized Web Services interfaces to Semantic Web technology. So far, it is only the former area, which has seen some activity. And even here, standardization has just begun.

There are two major initiatives which are currently developing standard proposals for the semantic description of Web Services. On the one hand, OWL-S defines an ontology for semantic mark-up of Web Services. On the other hand, the SDK cluster, composed by the EU projects SEKT, DIP, and Knowledge Web, currently develops WSMO (Web Services Modeling Ontology).<sup>15</sup>

OWL-S, as the name suggests builds on top of the OWL standard and was initially named DAML-S.<sup>16</sup> OWL-S contains language constructs for describing the properties and capabilities of Web Services in order to facilitate automation of service discovery, composition and execution monitoring. It is thus intended to extend WSDL. Whereas WSDL uses XML Schemas for the definition of data types, OWL-S also supports the use of OWL classes. In OWL-S a service description specifies the resource a service provides, the ServiceProfile it presents (what the service does), the ServiceModel it is described by (how it works), and the ServiceGrounding it supports (how to access it).

WSMO<sup>17</sup> is still in the early stage of development and has a similar purpose as OWL-S. Whereas OWL-S is centrally focused on the concept of services, WSMO uses four basic concepts, namely goals, mediators, ontologies and services. Ontologies can be used to explicitly account for heterogeneity and mediators are used to cope with this heterogeneity. Finally, goals allow for goal-oriented discovery of services.

Both approaches are thus developing specific ontologies or terminologies for the description of services. In doing so they build on existing representation formalisms such as WSDL or OWL.

## 2.3 Functionalities, Benefits and Challenges

Having outlined the visions and existing standards for Web Services, Semantic Web and Semantic Web Services, this section describes the main functionalities, benefits and challenges of these areas. These aspects of innovative technologies are often very practically oriented.

### 2.3.1 Web Services

The basic functionality provided by Web Services addresses issues relevant to all distributed software systems. Web Services allow for modularization or decoupling of components, which is indispensable for keeping large systems manageable. In principle, Web Services are thus similar to other existing technologies for distributed environments.<sup>18</sup>

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<sup>15</sup> There is also a Semantic Web Services Interest Group at the W3C, which does not produce any standards at the moment, however.

<sup>16</sup> <http://www.daml.org/services/owl-s/>. DAML stands for DARPA Agent Markup Language and formed the basis for the development of the OWL standard.

<sup>17</sup> <http://www.wsmo.org/>.

<sup>18</sup> Examples for such technologies are CORBA (Common Object Request Broker Architecture), Microsoft's COM/DCOM, or J2EE (Java 2 Enterprise Edition).

As a consequence, some of the benefits provided by Web Services can also be achieved without actually using Web Services technology in the narrow sense. The term Service-Oriented Architecture (SOA) is often used to describe the design principles allowing for loosely-coupled systems and providing a high degree of flexibility and reusability.

While SOAs can be realized with a wide range of technologies, Web Services offer the best technological foundation for SOAs at the moment. A major benefit of Web Services technology is the wide-ranging vendor support and its ambition to provide independence from technology, vendors, and programming languages. Despite minor problems with interoperability, Web Services are successfully used in real-world applications and many of the promises associated with Web Services have been kept.

The main remaining challenge is the completion of the “Web Services standard stack” and the use of the technology in large-scale inter-enterprise applications. So far, Web Services are still predominantly used in integration projects within an enterprise or as APIs for offering existing functionality for access over the internet.

### **2.3.2 Semantic Web**

So far, real-world applications of Semantic Web Technology are hard to come across. Most existing applications have been developed in academic contexts or in research projects funded by public institutions. Descriptions of functionality and benefits therefore tend to refer to the vision of the Semantic Web and not to experiences gained in actual applications.

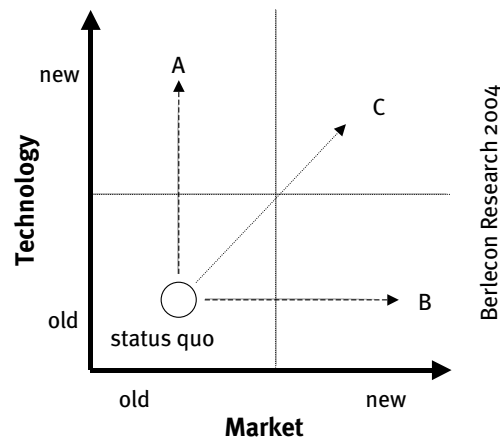
The functionality expected from the Semantic Web mostly regards the enhancement of information with metadata. As explained in the previous section, work on RDF and OWL can only be seen as a first step towards this goal. These standards provide formats in which metadata can be represented. Neither do they provide a set of metadata to be used, nor do they say anything about how these metadata are to be obtained.

The latter point has far reaching consequences and is one of the major challenges regarding metadata.<sup>19</sup> Suppose a set of metadata has been standardized for a specific domain. Will these metadata have to be annotated manually, or will they be derived automatically? A fashionable answer to this dilemma is semi-automatic annotation, i.e. a combination of automatic derivation and manual annotation. But unless the exact division of labour between manual and automatic processes is specified, it is difficult to judge the feasibility of this approach.

In general, it will be difficult to build applications which at the same time tackle several major challenges, e.g. applying a new language like OWL, modelling a new ontology, producing new content and metadata, and establishing new provider/consumer relations. The diagram below shows an overall challenge for new technologies.

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<sup>19</sup> Given the close relationship between Semantic Web and Artificial Intelligence it might be worthwhile to point out that this issue has been studied as Knowledge Acquisition in AI.



Given the status quo, it is generally feasible to move to point A by applying a new technology in an already established market. This case reflects the much-cited “better mouse-trap”. Similarly, one could move from the status quo to point B by applying an established technology in a new market. The combination of established Internet technology and auction processes to create the new market of online auctions (eBay) is an example. Creating a new technology as well as a new market at the same time, however, i.e. trying to move to point C directly, is a challenge that is often underestimated by proponents of new technologies and a frequent source of failure.

One of the reasons, why RSS gained acceptance so quickly is that the content and the provider/consumer relations were already established. RSS just provided a new format to be used on top of the existing content. Moreover, RSS is simple and easy to use.

Finally, the strong fixation to the logic-based approach within the Semantic Web seems a bit contingent, given the general vision of making information machine processable. Suppose an analyzer based on statistical methods would produce pairs of attributes and values from HTML pages. Would this be Semantic Web technology? A standardized list of attributes and values can be seen as a very simple metadata format. And having pairs of attributes and values available is already a good basis for automatic processing, even if it does not allow formal reasoning<sup>20</sup>

It is thus perfectly possible that the vision underlying the Semantic Web will one day be realized, however, without the application of current Semantic Web technology.

### 2.3.3 Semantic Web Services

Since Semantic Web Services is still in its early stage, it is difficult to assess benefits and challenges. Given the work on WSMO and OWL-S, the main functionality to be expected in this area concerns semantic description of services. This will yield benefits for the discovery of services and semi-automatic composition of services. The main challenges are the specification of a suitable ontology for semantic description of services and its actual application.

Although no standardization activities are visible at the moment that aim at providing Semantic Web functionality via Web Services interfaces, functionality for semantic

<sup>20</sup> A good example for the successful application of statistical methods is the use of Bayesian Nets in spam filters. It provides a very good basic functionality, which can then be enhanced by adding “symbolic” rules.

mediation<sup>21</sup> is a good candidate in this area. It would allow the transformation between different data formats based on a common ontology.

## 2.4 Conclusion

The field of Web Services is already rather advanced. It will mature further in the next few years, mostly through the adoption and product support of standards regarding security, composition and management. Web Services will become the mainstream technology for making functionality accessible.

Although the Semantic Web offers a promising vision, it is not clear yet whether it will ever be taken up in industrial applications. Standards and technology produced so far are still predominantly academic and no real-world success stories are available. This might change in the near-term future.

Adoption of Semantic Web technology will probably proceed in stages. It is to be expected that adoption will begin with making content available in RDF format. In his WWW2004 keynote speech, Tim Berners-Lee urged developers to use RDF more aggressively and to make existing database content available not only as HTML but also as RDF.<sup>22</sup> Once the benefits of RDF have been demonstrated, adoption of OWL could follow up in a second stage.

However, it is also possible that applications will become more “intelligent” by using plain XML or RDF formats for metadata and statistical methods instead of logical reasoning based on OWL. This would mean that some of the functionality and benefits promised by Semantic Web would become reality, without, however, actually applying Semantic Web Technology.

Finally, although Semantic Web Services are somehow based on Semantic Web, their future development is not necessarily dependent on development in Semantic Web Technology. As Web Services will be used more and more heavily in a large variety of contexts, semantic information about services will become more and more useful. It is highly likely that a standard format for the semantic description of services will be adopted, e.g. in connection with UDDI. It is unclear yet, however, how deep the semantics of this format will go and whether it will be as encompassing as WSMO, for example.

## 3 APPLICATION AREAS FOR SEMANTIC WEB SERVICES

The basic vision of the Semantic Web is to add semantic information to data, in order to make website content self-explaining and machine processable. Semantic Web Services combine Semantic Web and Web Services in two ways (see Section 2). On the one hand they offer Web Services interfaces to Semantic Web technology. On the other hand, they allow one to semantically describe Web Services interfaces.

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<sup>21</sup> The term mediation is used in the context of the Semantic Web to describe the concept of transforming data at an intermediate layer in order to support interoperability among heterogeneous systems. It is thus similar to the notion of mapping or transformation as applied in EAI but in general implies a more complex or intelligent behaviour than simple data mapping.

<sup>22</sup> Paul Ford, Berners-Lee Keeps WWW2004 Focused on Semantic Web, xml.com, May 2004, <http://www.xml.com/pub/a/2004/05/20/www-timbl.html>.

Berlecon has analyzed nine application areas and ranked them with respect to their potential for applying and benefiting from Semantic Web Services in the near to medium term future.

In all application areas, integration of Semantic Web Services would be highly useful. The areas differ, however, with respect to maturity and the degree to which they would benefit from integrating Semantic Web Services technology. Based on the analysis presented in this section, Berlecon ranks the respective potential of the application areas as follows:

- Low potential: Single European Economic Market (SEEM)
- Medium potential: Enterprise Application Integration (EAI), Contextual Ads, Product Information Management
- High potential: Business Process Management (BPM), Content Syndication, Enterprise Collaboration, Search and Mining, Social Software

It is very likely that most of these application areas will integrate semantic techniques and metadata in the near-term future. It is not evident, however, whether these techniques will be based on Semantic Web standards such as RDF or OWL.

The assessment of the potential of Semantic Web Services (SWS) for the various application areas is based on two main types of functionality provided by SWS (see Section 2 for details):

1. SWS enhance Web Services with semantic descriptions, e.g. metadata concerning service properties or mappings of data types to ontologies. These semantic descriptions allow, for example, the (semi-)automatic discovery of services and the (semi-)automatic composition of service operations into complex processes. They also support the evaluation and monitoring of process execution based on semantic criteria.
2. SWS provide functionality based on Semantic Web technology, e.g. derivation of metadata or ontology-based reasoning, with Web Services interfaces. These interfaces make Semantic Web functionality available over the Internet, so that it can be used by arbitrary applications.

This section evaluates the potential of Semantic Web Services in the application areas of Business Process Management, Content Syndication, Contextual Ads, Enterprise Application Integration, Enterprise Collaboration, Product Information Management, Single European Electronic Market, Search/Mining, and Social Software. Each application area is briefly sketched, and possibilities for using Semantic Web Services as well as alternatives are discussed. Finally, conclusions are drawn for the research project DIP.

The presentation of each application area is structured as follows:

- Brief description of the application area
- Aspects related to Semantic Web or to Web Services
- Potential applications of SWS
- Alternative to SWS usage
- Conclusion

The list of application areas is not necessarily complete. However, it provides a good starting point for assessing the potential of Semantic Web Services in real-world applications. It should also be noted that the assessments presented in this section reflect the current state of evaluation. Future work within the DIP project will focus in more detail on the application areas having medium and high potential for SWS.

In the following sections the application areas are presented in alphabetical order.

### 3.1 Business Process Management (BPM)

Business Process Management (BPM) is concerned with the modelling, automation, administration, monitoring, measuring, evaluation and optimization of business processes.<sup>23</sup> It combines several existing technologies, such as workflow tools, EAI (Enterprise Application Integration) products and Business Intelligence software.<sup>24</sup>

BPM has gained considerable momentum during the last two years. Software vendors from the various areas related to process automation are currently using BPM buzzwords to update their sales pitch. Depending on their respective background, the offers tend to focus either on technical integration, on workflow modelling, or on process monitoring.

Technical integration concerns the automation of process execution and the task of connecting the central business process to the various systems involved in the process. This is the area in which traditional EAI vendors possess considerable know-how. Some experts claim that the field of EAI will vanish as an application area of its own within the next years and will instead merge completely with BPM.

Workflow modelling, on the other hand, focuses on the task of providing formalisms, methodologies, and tools supporting the graphical design of complex processes. The main challenge here is to facilitate the design process and to hide the complexities of the technical format used to internally represent workflows from the end user.

Finally, process monitoring addresses the issue of how to collect and present information on process execution. This concerns real-time monitoring and administration of running services, as well as the retrospective analysis of service executions, e.g. in the context of auditing or Business Intelligence.

Despite these different focal points, the various players in BPM share the same overall vision. They aim at providing solutions allowing business experts to model, monitor and optimize processes on the business level. The underlying technological details should be hidden from the business experts and adapted as automatically as possible according to the actions performed on the business level. Current offerings still lack this deep integration and provide only partial functionality. Therefore, the manual effort to map high level business process models to actual software implementations is still rather high.

With the advent of Web Services and Service-Oriented Architectures (SOAs) services have become one of the most obvious “atomic” building blocks for constructing

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<sup>23</sup> See, for example [http://www.bpmg.org/classic/Articles\\_CaseStudies/Briefing-What%20is%20BPM.htm](http://www.bpmg.org/classic/Articles_CaseStudies/Briefing-What%20is%20BPM.htm) or <http://www.staffware.com/landing/BPM/default.asp?ComponentID=4056&SourcePageID=4080> for “definitions” of BPM.

<sup>24</sup> Enterprise Application Integration (EAI) will be discussed as a separate application area below.

processes. This makes Web Services a key technology for BPM and standardization efforts regarding choreography or orchestration abound in the Web Services community.<sup>25</sup>

There are at least two aspects in BPM which are directly related to Semantic Web

- Metadata are seen as highly useful for the modelling, monitoring and evaluation of business processes.
- Business rules are often cited as an important ingredient or extension to BPM.

There are two main application scenarios for SWS technology in BPM:<sup>26</sup>

- Semantic description of services could make it easier for business experts to find appropriate services when modelling a complex business process. They could also facilitate combination and arrangement of services into complex processes.
- When processes are executed, input and output data as well as timestamps are usually logged in a database. This logged information is the basis for online monitoring, auditing/tracking, or offline evaluation and reporting of process performance. Based on semantic annotations of resources, people, roles involved in processes, such evaluations can be performed on a higher, semantic level.

It is difficult to imagine alternatives to these applications of SWS. The probability that BPM will use Web Services as underlying technology is very high. And that metadata will be needed to improve BPM quality in areas such as monitoring is also almost certain. However, it is far from obvious, in which format these metadata will be applied. Instead of using RDF or OWL to represent these metadata, vendors may also offer proprietary approaches. Thus each BPM solution could offer its own metadata support via attributes and values without using a standard format. This scenario could be avoided if a standard metadata format for semantic descriptions of processes were available and if benefits of the format were clearly visible.

BPM has a high potential for SWS as it is service-oriented and can profit from the integration of Semantic Web Technology, i.e. from a layer containing semantic description of services. Moreover, the market is growing and moving fast with various vendors trying to distinguish themselves by offering innovative features that their competitors lack.

### 3.2 Content Syndication

Content Syndication is concerned with combining or integrating content stemming from various sources. It is related to the application areas Search/Mining and Social Software.

There are several areas in which content syndication is applied. The most obvious application area for Content Syndication is probably “news”, i.e. the integration of news feeds stemming from different news agencies. But examples for content syndication also include articles, commentary, photos, video clips, comics, games and software

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<sup>25</sup> The most prominent standard in this area is WS-BPEL [http://www.oasis-open.org/committees/tc\\_home.php?wg\\_abbrev=wsbpel](http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=wsbpel).

<sup>26</sup> One could argue that process mediation would be a third application area. However, process mediation is still an advanced research theme and it is not yet clear to which degree it will be covered in DIP.

programs. Content Syndication is also a topic in large corporations, as is shown by the example of the Nokia Content Syndication Program (NCSP), which offers direct links to Nokia documents, toolkits, videos, images, etc., all through standard XML and JavaScript interfaces.<sup>27</sup>

Moreover, Internet directories also provide a form of content syndication. The Yahoo!-like Open Directory Project (ODP) is the largest, most comprehensive human-edited directory of the Web. It is constructed and maintained by a vast, global community of volunteer editors.<sup>28</sup> RDF dumps of the Open Directory database are available for download.<sup>29</sup>

Finally, multi-vendor catalogues are an example for content syndication in a specific domain, namely product information.

Basically, content syndication has two major aspects:

- First, syntactic syndication is needed, i.e. a syntactically unified content, e.g. a web page containing links, an RSS Feed (see below) containing RSS entries, or a catalogue containing information on products from various vendors.
- More ambitious is semantic syndication, e.g. the grouping of news articles covering the same topic or of products offering identical or similar functionality. To achieve this, a categorization or classification system is needed.

Aspects of both Semantic Web and Web Services are relevant in the context of Content Syndication. Web Services are one of the best available technologies for connecting content sources with a content syndicate. Sources and syndicate are often websites and it thus straightforward to use XML as the data format and the Internet as the communication channel.

Regarding Semantic Web aspects, metadata can be used to provide information on content to be syndicated. This would be especially useful for text-based content without explicit formal structure.

Moreover, RSS (Real Simple Syndication or Rich Site Summary) is an increasingly popular, XML-based format for exchanging and integrating content from news sites and blogs. More and more sites are providing their news and blogs via RSS Feeds, which can then be centrally read by an RSS reader such as NetNewsWire or FeedDemon. Different versions of RSS exist, one of which, namely RSS 1.0, is based on RDF. RSS 1.0 would thus be a good candidate for integration of additional Semantic Web technology.<sup>30</sup>

Atom, a competitor to RSS, is currently under development and aiming to support a broader functionality than RSS.<sup>31</sup> It will be specified in XML though, not in RDF, and

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<sup>27</sup> <http://ncsp.forum.nokia.com/csp/>.

<sup>28</sup> <http://dmoz.org/about.html>. The ODP is also known as DMOZ, an acronym for Directory Mozilla.

<sup>29</sup> <http://rdf.dmoz.org/>.

<sup>30</sup> See Mark Pilgrim, "What is RSS?", xml.com, December, 2002, for a good overview (<http://www.xml.com/pub/a/2002/12/18/dive-into-xml.html>).

<sup>31</sup> <http://www.atomenabled.org/>.

Web Services interfaces in WSDL are envisaged. It is not clear yet whether it will address the issue of semantic categories for content classification.

Semantic Web Technology could be used to (semi-)automatically categorize content, which in turn would allow filtering and personalization and make RSS Readers much more user friendly. The most likely scenario for this would be Web Services interfaces to categorization and classification tools.

Basically, such services would receive free text content as input and would return semantic categories or other metadata describing the semantic content of the input. To increase flexibility, they might also support more than one classification scheme and thus allow users to select their preferred classification scheme when invoking the service. These services could be called either after content is created, i.e. by the content provider, or when content is syndicated, i.e. by the content consumer.

It is not clear whether metadata to be used in Content Syndication will be based on Semantic Web standards such as RDF or OWL. Vendors currently offering solutions for content classification, such as Autonomy, Convera, Inxight, Stratify, or Verity do not seem to be actively involved in Semantic Web activities. Nor is there any indication that standards such as RDF or OWL will play an important role in their product roadmaps.

Content Syndication has high potential for SWS. The RDF-based RSS 1.0 could be used as a basis for adding semantic information on content to allow for advanced personalization, filtering and search. The major challenge will be the automatic derivation of this additional information as manual annotation of metadata is usually not feasible in practice. Commercial products currently available for automatic categorization are not using any Semantic Web technology, however.

### 3.3 Contextual Ads

Contextual Ads form a very specific application area, namely the placement of advertisement based on the context in which the ad is to be embedded.<sup>32</sup> This is usually done automatically or semi-automatically.

A famous example is Google's AdWords, which allows one to link ads to specific keywords. These Keywords are selected manually when advertisers place the order for Google's AdWords. On the one hand, the ads will be displayed if the keywords are used in a Google search. A more semi-automatic approach extracts the keywords on websites viewed and places ads accordingly.

This can even be extended towards a "detailed" content analysis of websites. Note that Contextual Ads are thus not restricted to "search mode" but can be also placed when users are in "browse mode". Examples for sophisticated Contextual Ads are ads triggered by the local weather. These ads are shown "only in certain zip codes, and only when the current weather or forecast meets certain conditions. For instance, an

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<sup>32</sup> See, for example, the good introduction to Contextual Ads in Danny Sullivan, Google Throws Hat Into the Contextual Advertising Ring, SearchEngineWatch, March 2003, <http://searchenginewatch.com/sereport/article.php/2183531>.

advertiser could sell air conditioners on a hot day in Miami – or snow tires during a blizzard in Milwaukee.”<sup>33</sup>

In addition to the placement of Contextual Ads, solutions for managing these ads are required. These solutions keep tab on bid amounts and the effectiveness of individual keywords.<sup>34</sup>

There is an immediate connection between Semantic Web and Contextual Ads: the vision underlying the Semantic Web, namely that information on websites is self-explaining and machine processable, would make the delivery of Contextual Ads a lot easier. Ads could be placed based on Semantic Web information instead of on extracted keywords.

As regards Web Services, they would offer the natural approach for implementing functionality selecting the appropriate ad given a website’s content.

Semantic Web Services could thus be used to (semi-)automatically categorize content and match it to the appropriate ads. This is somehow related to the application areas Content Syndication and Search/Mining.

One advantage of this restricted application scenario is that the additional overhead for manually specifying categories to which an ad belongs is probably acceptable. The increase in likelihood to reach the desired target groups should be incentive enough for advertisers to accept this overhead.

As the market for Contextual Ads seems to be in rapid development at the moment, it is highly probable that solutions will be primarily based on proven, keyword-based algorithms. It will then depend on the quality of these algorithms and customer satisfaction regarding ad placement, whether a demand for more sophisticated technologies will arise or not.

Contextual Ads has medium potential for SWS. On the one hand, it is a limited application area which is currently dominated by Google. On the other hand, it is not yet clear, whether there really is a need to improve keyword-based algorithms or whether they produce good enough results without integrating Semantic Web Services.

### 3.4 Enterprise Application Integration (EAI)

According to the Webopedia, Enterprise Application Integration (EAI) “is the unrestricted sharing of data and business processes throughout the networked applications or data sources in an organization.” It is specifically concerned with connecting systems and applications such as “inventory control, human resources, sales automation and database management (which) were designed to run independently (...) and were often proprietary systems.”<sup>35</sup>

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<sup>33</sup> Rajesh Jain, Paid Search and Contextual Ads, Emergic.Org Weblog, August 2003, <http://www.emergic.org/archives/indi/006283.php>

<sup>34</sup> See Stefanie Olsen, DoubleClick jumps into search, News.Com, May 2004, [http://news.com.com/2100-1030\\_3-5214387.html](http://news.com.com/2100-1030_3-5214387.html).

<sup>35</sup> <http://www.webopedia.com/TERM/E/EAI.html>.

Whereas EAI initially focussed on fundamental integration issues, such as data transformation and back-end integration, interest is currently shifting towards higher levels of integration, e.g. in the context of Business Process Management.<sup>36</sup>

Due to the fact that EAI is placed in the middle of functional systems or applications in an organization, the term middleware is often used for EAI products and technologies.

Since Web Services is an innovative integration technology, it is immediately relevant in the context of EAI. However, as EAI has evolved long before Web Services appeared on the scene, they constitute just one potential technical ingredient for EAI amongst many others. Most EAI vendors now support Web Services standards such as WSDL or SOAP in addition to more traditional integration technologies such as CORBA or MOM (message-oriented middleware).

There also is a connection between EAI and Semantic Web. The data contained in enterprise applications is just as difficult to process automatically as information on today's websites. To cope with this challenge, metadata are needed, e.g. in the form of "enterprise data models".

One key issue in Enterprise Application Integration is the transformation of data from one format into another. This is usually achieved by building so-called adaptors or connectors, which map the format used in one application into the format used by another application.

An alternative to this approach could be the use of a central meta format. This is already sometimes used in EAI, but the contribution of SWS would be to use a semantically rich ontology.<sup>37</sup> Instead of writing adaptors between all pairs of formats, each format would have to be mapped to the central ontology only once, thereby reducing the number of converters for  $n$  formats from  $n*(n-1)/2$  to  $2n$ . Data mediation<sup>38</sup> between two formats would then be achieved by using the central ontology as an intermediate format.

The major benefits of such an approach based on SWS would be its formal character, i.e. a formal approach to management and integration of information, services, and processes, which is done informally at the moment.<sup>39</sup>

Ideally, adaptors or connectors could be replaced by mediation Web Services, accepting as input arguments the data in source format together with a specification of the source format and the required target format. They would then return the input data in the target format.

The Semantic Web part of this SWS application in EAI could probably be hidden inside the mediation services. The services would access the central enterprise ontology to perform the mapping from source formats to target formats.

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<sup>36</sup> See for example Madhavan Krishnan, The EAI Paradigm Shift, Ittoolbox EAI, April 2004 (<http://eai.ittoolbox.com/documents/document.asp?i=3028>).

<sup>37</sup> See, for example, Susan Osterfelt, Data Diversity: Let It Be, DM Review Magazine (June 2002) [http://www.dmreview.com/article\\_sub.cfm?articleId=5255](http://www.dmreview.com/article_sub.cfm?articleId=5255).

<sup>38</sup> Mediation is the preferred term for data transformation in Semantic Web Services.

<sup>39</sup> See David S. Linthicum, Leveraging Ontologies & Application Integration, EAI Journal (May 2003) <http://www.bijonline.com/Article.asp?ArticleID=716 &DepartmentID=5>.

However, it is sometimes argued that the benefit gained by an intermediate format would be substantially higher than the overhead generated by creating it. Basically this depends on the number of different formats used (the higher the number, the higher the benefit of an intermediate format) and of the complexity of the formats (the less complex, the lower the overhead for creating the intermediate format). Moreover, some EAI tools already use a central intermediate format, though not a semantically rich or formal one.

In any case, proponents of SWS technology would have to convince EAI vendors that including ontologies would substantially reduce costs of EAI projects. And since the initial development of an enterprise ontology will generate considerable overhead, it is far from trivial to make the case for a convincing ROI (Return on Investment).

As a conclusion, EAI has only medium potential for SWS, since the benefit of integrating semantic information could be contended. Moreover, the EAI market is in a process of consolidation – some experts predict that it will be merged completely into BPM, i.e. it will cease to exist as a market of its own and will rather become a submarket of BPM. Finally, EAI vendors already offer solutions for data mediation. Although these solutions are costly to maintain and extend, there is no real need for companies to replace them. Especially not as the replacement candidate has not been proven in application projects yet. To heighten the potential of EAI it would thus be important to prove SWS benefits as intended by the DIP project.

### 3.5 Enterprise Collaboration

Enterprise Collaboration is currently emerging as an application area, combining portal and collaboration technology. It comprises tools and processes supporting the collaboration within organisations. Instead of having separate standalone products for functionality such as document exchange, conferencing, messaging or scheduling, an integrated solution will be required in the future.

The basic functionality of Enterprise Collaboration solutions is currently similar to existing PIM (Personal Information Management) solutions. It will most likely comprise more and more collaboration tools used for advanced tasks such as collaborative product design.

The rationale for setting up an Enterprise Collaboration solution in an organization is to make better use of the knowledge held by its employees and to facilitate exchange of this knowledge in collaborative work. Enterprise Collaboration is thus taking up fundamental ideas from Knowledge Management but puts more emphasis on the processes, in which knowledge is applied, shared, and exchanged.

Due to this social aspect of Enterprise Collaboration, there is some overlap with the application area Social Software. Since collaboration is a complex process and Enterprise Collaboration software aims at optimizing this process there is also a connection to the area of Business Process Management.

Adoption of Enterprise Collaboration will be forcefully driven by increased regulations, as Enterprise Collaboration solutions help to ensure compliance and also provide means to prove this compliance to regulations in audits.

The potential of Enterprise Collaboration is also underscored by OSAF's (Open Source Application Foundation) Chandler project.<sup>40</sup> Chandler is intended to be an open source personal information manager for email, calendars, contacts, tasks, and general information management. It will also support a collaboration environment based on messaging and document management. Chandler is designed by Mitch Kapor, the founder of Lotus Development Corporation and designer of Lotus 1-2-3.

Due to the distributed process nature of Enterprise Collaboration there is a natural fit with Web Services technology. Web Services can be used to provide the interfaces of individual collaboration components and their respective interactions.<sup>41</sup>

Given the functionality of individual collaboration components and their relation to Knowledge Management, there is also potential for Semantic Web technologies in Enterprise Collaboration. RDF or OWL could be used to model relevant metadata or ontologies for events, knowledge areas, thematic hierarchies, roles and access rights, etc.

Enterprise Collaboration could make use of full-fledged SWS technology by providing semantically described Web Services interfaces for collaboration components. This would include both APIs for accessing collaboration functionality, e.g. entering an appointment in the calendar component, as well as APIs for exchanging data between components, e.g. importing or exporting contacts or synchronizing calendars.

On the one hand, this would allow (semi-)automatic discovery and composition of adequate collaboration functions in a given context. On the other hand, semantically rich data based on RDF or OWL could be used as arguments of the service operations and would allow "intelligent" handling of information passed between collaboration components.

The main challenge here is to automatically filter and select the information relevant for specific users in specific contexts. Software tools could help, for example, to determine who should be invited to or informed about a scheduled meeting and what kind of input material should be distributed to the attendees. To achieve this, a consistent and detailed model about topics, interests, skills, and profiles has to be maintained in the Enterprise Collaboration system.

Instead of using SWS, proprietary solutions could emerge either using Web Services but no Semantic Web technology, or even using APIs in Java or some other programming language. Whether SWS is picked up will probably depend on how fast standards are available to be used in Enterprise Collaboration. And this does not mean technical standards like RDF or OWL but rather standardized ontologies or metadata for content used in Enterprise Collaboration, such as events, topics, or roles.

Enterprise Collaboration has high potential for Semantic Web Services. It is an emerging area and still open for innovation and standardization. Modelling interfaces

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<sup>40</sup> <http://www.osafoundation.org/>.

<sup>41</sup> In June 2002 the OMG (Object Management Group) issued a Request for Proposals on "Web Services for Enterprise Collaboration (WSEC)". WSEC should be based on OMG's Enterprise Collaboration Architecture (ECA) and should provide Web Services implementations for the enterprise collaborations described in Component Collaboration Architecture (CCA).

for collaboration modules as Semantic Web Services could significantly improve their usability and help users to combine basic operations into complex workflows.

### 3.6 Product Information Management

Product Information Management provides functionality for an integrated approach to managing and synchronizing product information. Enterprises usually store product-related information in several different applications or databases, such as ERP systems, product catalogues for different customers or systems containing marketing information. This distribution of information is a serious challenge as it is often impossible to get all relevant information at one view. Moreover, modifying product data is far from trivial and often results in internal or external inconsistencies. Usually, the task of spreading changes across the different information sources to avoid these inconsistencies is called synchronization.

Product Information Management is still a niche market but has recently experienced some leverage by the fact that major players in the retail industry require electronic product information from their suppliers. It is also possible that the market will get another boost once a larger vendor in the ECM (Enterprise Content Management) or ERP (Enterprise Resource Planning) markets offers functionality for Product Information Management or acquires one of the small vendors in this area.

In several aspects Product Information Management is similar to the general task of EAI. However, whereas EAI is feasible by transforming data from one format into another, the benefit of a central data model is much more apparent for Product Information Management.

As Product Information Management is an integration task, Web Services are a natural candidate for connecting the various systems in which product-related information is stored. However, since these systems are usually all under the control of the same enterprise, proprietary solutions are possible as well.<sup>42</sup>

The Semantic Web could be used to develop the central data model or enterprise schema. On the one hand, such a schema is subject to constant change. On the other hand it has to mediate between multiple simultaneous hierarchies (reflecting the respective views on product information by different business units) without duplication of data.<sup>43</sup>

In principle there is thus a high potential for standardizing a central data model and providing mediation functionality based on Semantic Web Services.<sup>44</sup> But then it is unclear, how feasible such a central data model really is. Experience has shown that different departments in an enterprise require different perspectives on product data.

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<sup>42</sup> This situation might change in the near future, when vendors are including more and more third party products in their catalogues.

<sup>43</sup> A good overview of the challenges of Product Information Management is given in Sandeep Nawathe, PIM Realizes its Potential, XML Journal, March 2004, <http://www.sys-con.com/story/?storyid=44005&DE=1>. Nawathe argues for the use of XML to achieve this but does not mention Semantic Web technology.

<sup>44</sup> Mediation is the preferred term in Semantic Web terminology for referring to “intelligent” transformation or mapping between different data types.

Trying to harmonize the different requirements within a single data model might easily turn out to be intractable.

Leaving feasibility questions aside, it would be the natural approach to include semantic annotations in the central model as well. Connecting the central model with the various systems and applications using product information, on the other hand, can be best achieved via Web Services. A Semantic Web Services solution would thus have several benefits for Product Information Management.

But an alternative approach without the use of Web Services is also possible. Current techniques often use mining methods to extract product information in batch mode from unstructured information. This information is usually collected in large text files, which are generated by the different systems in an enterprise. Batch mode extraction can thus be achieved without using Web Services or Semantic Web technology. The main question is whether maintenance costs for this approach will remain within acceptable boundaries.

Product Information Management therefore has medium potential for Semantic Web Services. It is a natural application area for SWS technology, but the market is still emerging and it is not yet clear whether it will be based on more traditional mining techniques or employ SWS methodology.

### 3.7 Search and Mining

Search and Mining are distinct though related application areas. Whereas Search is more concerned with finding texts and documents, Mining supports the exploration of (semi-)structured data, such as database contents, transaction logs or website statistics. There is also a tendency to view Search as a major building block for Knowledge Management and to relate it to internet and intranet applications, whereas Mining is seen more intimately tied with Business Intelligence and reporting.

However, as exemplified by the evolving area of Text Mining, Search and Mining will probably converge in the years to come. Using Semantic Web Technology might even speed up this convergence, as it would enhance the potential of both search and mining techniques, which are currently still rather syntactical.

The search market had consolidated at the end of the 90s and has been clearly dominated by Google in the last couple of years, but it has recently started to move again. One example is the release of a search service by Amazon A9 combining Google's web search with search capability within books available at Amazon.<sup>45</sup>

In particular, the market of Enterprise Search is expected to grow rapidly in the years to come, making it one of the key markets for IT innovation.

Since search is closely related to Internet and intranet applications, Web Services are a natural candidate for integrating it into other applications. Google and Amazon already offer Web Services interfaces to access their search functionality.

The relationship to Semantic Web is twofold. On the one hand, it is often claimed that search results would be of higher quality if search queries would be interpreted semantically instead of purely syntactically. This would require the interpretation of

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<sup>45</sup> <http://a9.com/-/company/whatsCool.jsp>.

search queries as semantic categories instead of just plain keywords. Thus, when entering a search term, semantic search engines would not only retrieve documents containing this search term but also documents containing other terms belonging to the same semantic category.

An example of this approach is SHOE (Simple HTML Ontology Extension), which uses ontologies to annotate and search websites.<sup>46</sup> Other experimental techniques for semantic search are developed by NITLE (National Institute for Technology & Liberal Education).<sup>47</sup> Finally, SemanticWebSearch, operated by Intellidimension Inc., based on RDF Gateway allows the use of RDF tags to further qualify search terms.<sup>48</sup>

On the other hand, special purpose search will become increasingly important.<sup>49</sup> An example is Yahoo's SmartView, which it introduced after replacing Google as its underlying search engine by its own technology. With SmartView, Yahoo is offering localized content about restaurant, hotels, parks, automatic teller machines and post offices.<sup>50</sup> Since the results of these specialized searches are very specific types of information, it is possible to develop standardized formats for describing them. And Semantic Web languages such as RDF and OWL would be the natural candidate for this standardization.

What has been said about the relevance of Web Services and Semantic Web for Search is also valid for Mining, though to a lesser degree. For one thing, Mining is often used in the context of Business Intelligence and Data Warehouses. Thus the need for integrating distributed information sources is less relevant, as information may already be available in a central Data Warehouse.

Semantic Categories would be useful in the context of Mining to allow a more abstract evaluation of service execution data and thus make qualitatively better reporting tools possible (see below).

Semantic Web Services provide an ideal technology for implementing interfaces to both specialized search systems and semantic search engines. A major contribution of SWS would be the use of ontologies to standardize information returned by specialized search systems and to categorize and search websites.<sup>51</sup>

It would also be feasible to initially develop such interfaces on top of existing traditional search engines. Thus a Semantic Web Service could take a search term, use an ontology to map it to a list of keywords, send this to a standard search engine and return the results.

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<sup>46</sup> SHOE was developed in a research project and has never reached real application status, however. See <http://www.cs.umd.edu/projects/plus/SHOE/>.

<sup>47</sup> NITLE uses LSI/LSA (latent semantic indexing/analysis) and CNS (Contextual Network Search) [http://www.nitle.org/semantic\\_search.php](http://www.nitle.org/semantic_search.php).

<sup>48</sup> <http://www.semanticwebsearch.com/>.

<sup>49</sup> See, for example, the ALVIS Superpeer Semantic Search Engine at CoSCO (Complex Systems Computation Group), University Helsinki <http://cosco.hiit.fi/search/alvis.html>

<sup>50</sup> See <http://news.com.com/2100-1038-5171748.html> for details.

<sup>51</sup> A detailed discussion on using Semantic Web and Web Services in Semantic Search can be found in R. Guha, R. McCool, E. Miller, Semantic Search, WWW2003, May 2004 <http://www2003.org/cdrom/papers/refereed/p779/ess.html>.

Similarly, a Semantic Web Service could take the results of a specialized search system and transform it into a list of results described in RDF or OWL.

This “add-on” approach would leverage existing search technology and avoid the costs of implementing expensive robot, indexing and retrieval software. On the other hand, the benefits of integrating semantic information might only be fully exploited if semantic information is tightly integrated with indexing and retrieval techniques.

As regards Mining, it could benefit from using semantically described services or operations as basic building blocks of processes. This would allow the use of semantic information when evaluating service executions. It would, for example, be possible to use semantic categories or metadata such as “product type”, “responsible business unit”, “partner category” when evaluating the raw execution data.

Though Semantic Web Services are ideal technologies for realizing the next generation of search engines, there is no guarantee that proprietary techniques are not used instead. It should not be taken for granted that operators of specialized search systems have an interest in providing their search results in a standardized format.

Finally, though it seems plausible that Semantic Search is superior to purely syntactic approaches it has not been proven yet. After all, Google significantly improved search results compared to previous search engines without using semantic techniques. It is thus possible that further ameliorations can be achieved without using ontologies and Semantic Web Services.

To conclude, the application area Search and Mining has high potential for SWS. On the one hand, it is likely that specialized search services will become more wide-spread in the years to come. Semantic Web Services can help to standardize formats (ontologies) for such specialized services. On the other hand, semantic search technologies could become mature in the near future and Semantic Web Services would be the ideal technology for implementing their interfaces.

### 3.8 Single European Economic Market (SEEM)

Ten IST projects from the EU Framework 5 Programme have established a cluster with the acronym SEEM exploring the vision of a Single European Economic Market. Their approach is largely based on ebXML, an ambitious E-Business standardization effort backed by OASIS and UN/CEFACT.<sup>52</sup>

ebXML is a modular suite of specifications with the aim of enabling enterprises of any size and in any geographical location to conduct business over the Internet. It builds on experience and strengths of existing EDI knowledge and combines it with emerging XML technology. ebXML standards cover business processes, core data components, collaboration protocol agreements, messaging, and registries and repositories.

As ebXML is already using the Web Services standard SOAP for messaging, there is a close relation between ebXML and Web Services. There are even some discussions as to whether Web Services and ebXML are in fact two competing approaches trying to achieve the same goals.<sup>53</sup> Most experts agree, however, that the two approaches are

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<sup>52</sup> <http://www.ebxml.org/>.

<sup>53</sup> See, for example, James Snell, The Web services insidert, Part2: A summary of the W3C Web Services Workshop, April 2001, <http://www-106.ibm.com/developerworks/webservices/library/ws-ref2/> or Dieter

more to be seen as complementing each other: whereas Web Services provide a generic technology for integration, ebXML focuses on business transaction services. It is thus to be expected that ebXML will use some of the generic technology provided by Web Services in the future.

There seems to be no close connection between ebXML and Semantic Web yet.

In principle, it would be straightforward to integrate SWS into ebXML. Ontologies and mediation functionality could be used to make integration of business partners easier. Thus, Vasiliu et. al propose to realize machine-to-machine negotiation via a web service incorporating semantic web technologies and Bayesian updating beliefs.<sup>54</sup> This negotiation service could be used for automatically agreeing Collaboration Protocol Profiles (CPPs) in ebXML.

Given the fact that ebXML is still under development and constitutes a quite ambitious and generic framework it is very likely that it will focus on open issues first, before trying to incorporate a new technology such as Semantic Web Services.

From a long-term perspective, there is considerable potential for SWS technology to be used in this application area. Since both ebXML and SEEM are still under development, however, and have not yet penetrated the market significantly, SEEM has currently only low potential for SWS.

### 3.9 Social Software

Social Software is a hyped application area comprising ingredients such as blogs, wikis, social networking sites, recommendation systems, forums, and potentially Personal Information Management (PIM).<sup>55</sup> In particular, social networking services on the internet, e.g. Friendster, myspace.com, Tribe.Net, LinkedIn, Rzye, Orkut or openBC, are at the centre of attention from venture capitalists and analysts.<sup>56</sup> In addition to these services, Social Software includes tools for collaboration over the internet, such as weblogs, wikis, instant messaging, and special software for combing through address books or outlook contacts – with the aim of detecting relationships between people.

There is thus some overlap between Social Software and the application areas Content Syndication, Enterprise Collaboration and Search/Mining.

Though it is not yet clear, which direction Social Software will take and what business models will be successful, it is a promising application area, not the least because of its high visibility and appeal to almost all Internet users.

There is a lot of discussion on the relationship between Semantic Web and Social Software. In general, Semantic Web technology could be used by Social Software to

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E. Jenz, ebXML and Web Services – Friends or Foes?, WebServices.Org, June 2004, <http://www.webservices.org/index.php/article/articleview/451/1/24>.

<sup>54</sup> L. Vasiliu, M. Zaremba, M. Moran, C. Bussler, Web-service semantic enabled implementation of Machine vs. Machine business negotiation, DERI Technical Report, February 2004, <http://www.deri.org/publications/techpapers/documents/DERI-TR-2004-02-04.pdf>.

<sup>55</sup> Communication Studies at York have published a good academic lecture on Social Software: <http://communicationstudies.ca/courses/3310/node/view/47>.

<sup>56</sup> For an extensive list of social networking sites see <http://socialsoftware.weblogsinc.com/entry/9817137581524458/>.

semantically annotate basic data, e.g. blog entries or personal information.<sup>57</sup> Eric Gradman proposes to use Semantic Web technology to proceed from current service-centric view of Social Software to a novel user-centric distributed Social Software.<sup>58</sup>

But as David Weinberger points out, whereas metadata about bus schedules are unambiguous and predictable, the metadata around social software “leads you to delightful surprises”.<sup>59</sup>

The RDF-based FOAF (Friend of a Friend) standard,<sup>60</sup> intended to create and use “machine-readable homepages that describe people, the links between them and the things they create and do”, is the most obvious already existing link between Social Software and the Semantic Web.

On the one hand, SWS could be used to standardize information describing social relationships on the basis of RDF or OWL. The FOAF standard is a good example of this approach.<sup>61</sup> On the other hand, SWS would allow the semantic categorization of information used in Social Software.

Again, there is no guarantee that metadata, which would doubtlessly benefit Social Software, will necessarily be based on Semantic Web standards such as RDF or OWL.<sup>62</sup>

Due to its close relation to the vision of the Semantic Web and its strong reliance on the internet, Social Software is seen to have high potential for Semantic Web Services.

### 3.10 Recommendations for DIP

Semantic information will become more important in coming years. It is yet unclear, however, whether this information, which is often called metadata, will be represented based on standards such as RDF or OWL, or by using proprietary solutions. Several application areas hold potential for semantic information and some of them will start integrating semantic techniques into their solutions in the near-term future. This will probably start with simple semantic features, such as the inclusion of metadata relating basic data to categories or conceptual hierarchies (ontologies). Once these semantic extensions have proven useful, more complex features such as reasoning could be tackled.

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<sup>57</sup> See, for example, How to Make Blogging More SemWebFriendly, <http://www.picklematrix.net/archives/000933.html>

<sup>58</sup> Eric Gradman, Distributed Social Software, to be presented at LayerOne Conference, June 2004, <http://gradman.com/projects/dss/final/>.

<sup>59</sup> David Weinberger, Semantic social software, many2many weblog, November 2003, [http://www.corante.com/many/archives/2003/11/10/semantic\\_social\\_soft-ware.php](http://www.corante.com/many/archives/2003/11/10/semantic_social_soft-ware.php)

<sup>60</sup> <http://www.foaf-project.org/>.

<sup>61</sup> Before operators of social networks start supporting a standard like FOAF, they need to be convinced of the benefit it offers for applications, however. Reid Hoffman (LinkedIn CEO) argues that he already has two years of features to build and does not see any immediate application of FOAF [http://www.socialtext.net/red-herring-spring/index.cgi?page\\_id=reid\\_hoffman\\_may\\_17\\_3\\_49pm](http://www.socialtext.net/red-herring-spring/index.cgi?page_id=reid_hoffman_may_17_3_49pm).

<sup>62</sup> See, for example, the polemic and slightly inaccurate article by one of the proponents of Social Software: Clay Shirky, The Semantic Web, Syllogism, and Worldview, November 2003, [http://www.shirky.com/writings/semantic\\_syllogism.html](http://www.shirky.com/writings/semantic_syllogism.html).

It is also very likely that interfaces will be provided as Web Services in these application areas. Adding semantic descriptions to these interfaces will simplify their use and make discovery and (semi-)automatic composition easier.

For the DIP project and researchers and companies involved in developing SWS technologies the following conclusions could be drawn:

- The application areas presented in this section offer substantial potential for applying SWS technology. They are also a lot more specific than generic application areas such as E-Business, E-Government or Knowledge Management. By looking more closely at the issues arising in these specific application areas, clearly targeted use case examples could be constructed.
- In most application areas covered in this section, Semantic Web Services do not seem to be considered as a relevant technology. It would thus be important to intensify knowledge transfer into these application areas. Ideally, targeted use case examples should be used to demonstrate the application potential and the benefit of SWS for a particular application area.
- Finally, it seems possible that “semantic” solutions based on proprietary techniques will be developed in some or all of the application areas in the near future. It would thus be important to clearly demonstrate the advantage of SWS technology based on standards opposed to such proprietary solutions.

#### **4 BUSINESS PROCESS MANAGEMENT WITH SEMANTIC WEB SERVICES**

Business Process Management (BPM) is concerned with the modelling, automation, administration, monitoring, measuring, evaluation and optimization of business processes.

BPM is an emerging application area combining technology from process modelling, workflow execution, Enterprise Application Integration (EAI) and Business Intelligence (BI). Several vendors from these areas are currently positioning themselves as BPM solution providers. Although their respective strengths differ considerably and tend to focus either on technical integration, on process modelling, or on process monitoring, they share a common vision of BPM.

The ultimate goal of BPM is to allow business experts to model and modify business processes, without the need to involve technical experts from the IT department. This would provide the basis for adaptive, agile, Real-Time Enterprises, which could react immediately to internal and external events and would be very flexible with respect to their processes.

Semantic Web Services could be used in BPM to semantically describe processes and the individual service operations making up the processes. This would

- facilitate discovery of services,
- could be used as a basis for semi-automatic tools supporting the composition of services into complex processes,
- and would allow enhanced semantic-based monitoring capabilities.

This section analyzes the potential of Semantic Web Services in the application area Business Process Management (BPM). It contains brief descriptions of the vision

underlying BPM and of the business process life cycle. Then, three technologies of BPM, namely workflow solutions, Enterprise Application Integration (EAI), and Business Intelligence (BI) are discussed in detail. Finally, application scenarios for Semantic Web Services are presented, focusing on semantic service descriptions, discovery, process composition, and process monitoring. The section concludes with recommendations for the DIP project.

#### 4.1 The Vision of Business Process Management (BPM)

Business Process Management (BPM)<sup>63</sup> is concerned with the modelling, automation, administration, monitoring, measuring, evaluation and optimization of business processes.<sup>64</sup> It combines several existing technologies, such as workflow solutions, EAI (Enterprise Application Integration) products and Business Intelligence software.

##### 4.1.1 Business Process Life Cycle

The business process life cycle basically comprises three main phases, as illustrated in Figure 1:

- **Planning and Modelling:** The initial phase comprises the analysis and design of the business process.
- **Implementation and Execution:** The second phase concerns the actual implementation and execution of processes modelled in the first phase.
- **Measuring and Evaluation:** The final phase involves the measuring of actual process performances and the comparison of these data with the initially planned properties. As a result of this evaluation, a redesign of the process may become necessary. This then restarts the initial phase of planning and modelling.

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<sup>63</sup> BPM has previously been used as an acronym for Business Process Modelling, which is a sub task of Business Process Management.

<sup>64</sup> See, for example [http://www.bpmg.org/classic/Articles\\_CaseStudies/Briefing-What%20is%20BPM.htm](http://www.bpmg.org/classic/Articles_CaseStudies/Briefing-What%20is%20BPM.htm) or <http://www.staffware.com/landing/BPM/default.asp?ComponentID=4056&SourcePageID=4080> for “definitions” of BPM.

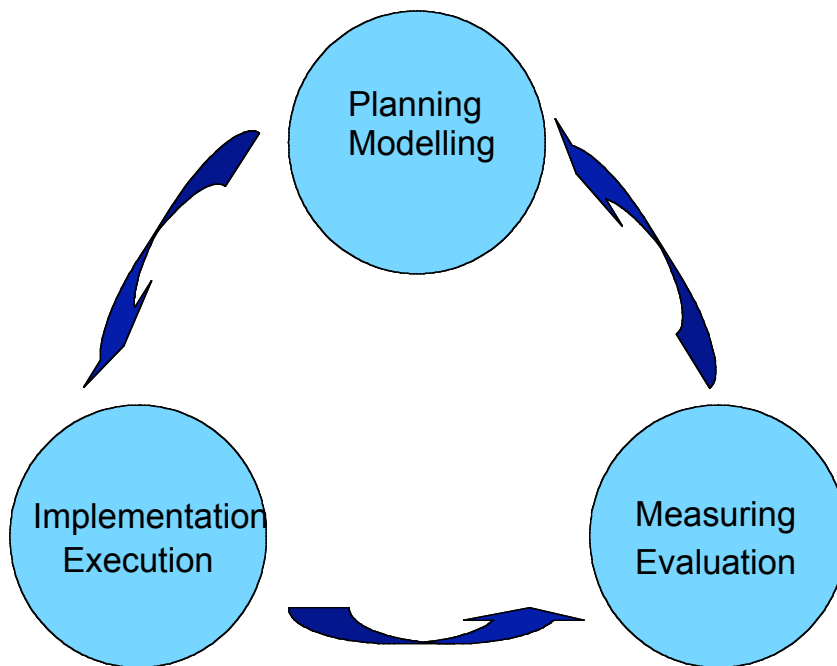


Figure 1: Business Process Life Cycle.

The three phases roughly correspond to the three core technologies of BPM: workflow solutions, Enterprise Application (EAI), and Business Intelligence (BI). These technologies will be presented in more detail in Section 4.2.

#### 4.1.2 Benefits of BPM

BPM has gained considerable momentum during the last two years. Software vendors from the various areas related to process automation are currently using BPM buzzwords to update their sales pitch. Depending on their respective background, the offers tend to focus either on technical integration, on workflow modelling, or on process monitoring.

Technical integration concerns the automation of process execution and the task of connecting the central business process to the various systems involved in the process. This is the area in which traditional EAI vendors possess considerable know-how. Some experts claim that the field of EAI will vanish within the next years and will merge completely with BPM.

Process modelling, on the other hand, focuses on the task of providing formalisms, methodologies, and tools supporting the graphical design of complex processes. The main challenge here is to facilitate the design process and to hide the complexities of the technical format used to internally represent workflows from the end user.

Finally, process monitoring addresses the issue of how to collect and present information on process execution. This concerns real-time monitoring and administration of running services, as well as the retrospective analysis of service executions, e.g. in the context of auditing or Business Intelligence.

Despite these different focal points, the various players in BPM share the same overall vision. They aim at providing solutions allowing business experts to model, monitor and

optimize processes on the business level. The underlying technological details should be hidden from the business experts and adapted as automatically as possible according to the actions performed on the business level. Current offerings still lack this deep integration and provide only partial functionality. Therefore, the manual effort to map high level business process models to actual software implementations is still rather high.

An important aspect of BPM is the central place it assigns to business processes. Usually, processes span several business departments and applications. If the central role of processes is taken seriously, organizational changes are thus necessary. For example, process owners, responsible for the overall process, have to be identified. In current enterprise structures, ownership is usually assigned within the boundaries of a business unit. Instead of a single process owner there are thus several owners, each one being only responsible for the part of the process belonging to the respective business unit.

Since business processes are applications used by customers, suppliers, partners, and employees, orienting IT towards business processes also increases orientation towards customers or users in general. Moreover, an incremental development process can be applied in which each individual project is ideally responsible for a single process. This minimizes the risk of project failure and ensures a fast return on investment. It is sometimes possible to start BPM with a small project and to finance the next project with the savings obtained through the first project.

BPM is specifically targeting business experts. By using graphical tools, business experts should be empowered to model processes on the business level. These models are then to be mapped more or less automatically to technical implementations. In particular, the modification of implemented business processes should be feasible on the business level. The corresponding updates on the underlying technical level should then be performed as automatic as possible. The aim here is to significantly reduce development costs and to avoid bottlenecks at the interface between business experts and software developers.

The ultimate goal of BPM is the adaptive, agile Real-Time Enterprise. Creation, introduction, modification, and optimization of processes should become significantly easier, cheaper and less time-consuming. This is only possible if processes are highly flexible.

Flexibility is required with respect to both the internal optimization of existing processes and the integration of new application and systems, e.g. following a merger or acquisition. The aim is to reduce time-to-market for new products and to ensure fast reactions to changing (market) environments. Today's enterprise ITs are often not adequately prepared for these requirements and act as obstacles. BPM is promising to change this situation.

## 4.2 BPM Technologies

As already indicated in the previous section, BPM combines technologies from three areas, as illustrated in Figure 2:

- Workflow Solutions
- Enterprise Application Integration

- Business Intelligence

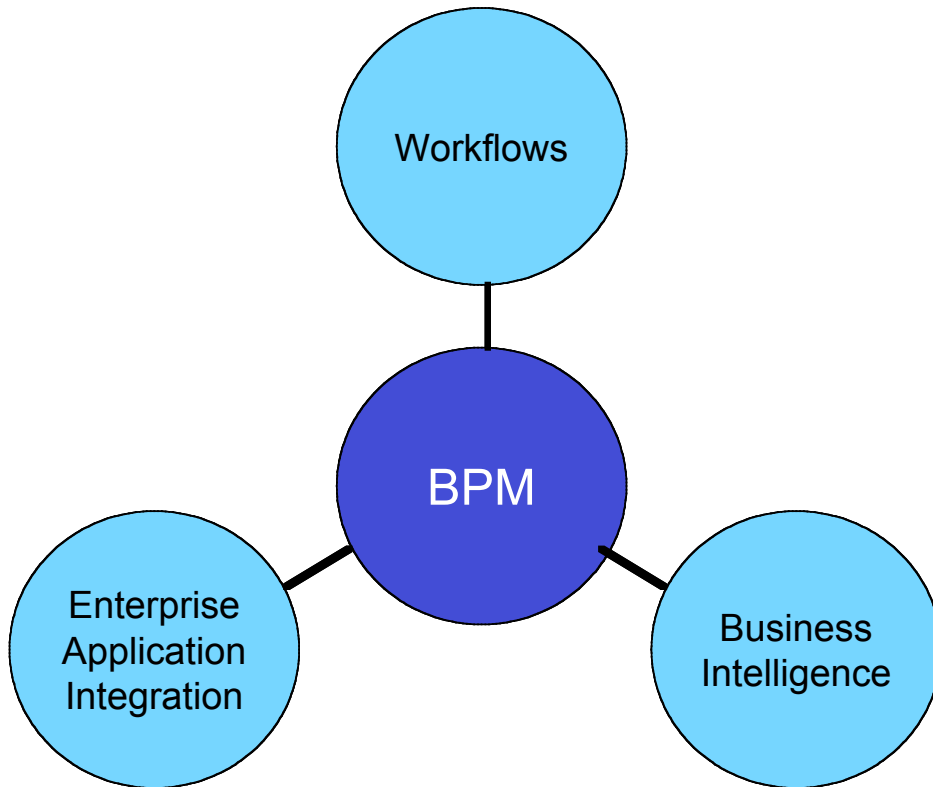


Figure 2: BPM Technologies.

Figure 3 shows how these technologies can be used in a BPM architecture.

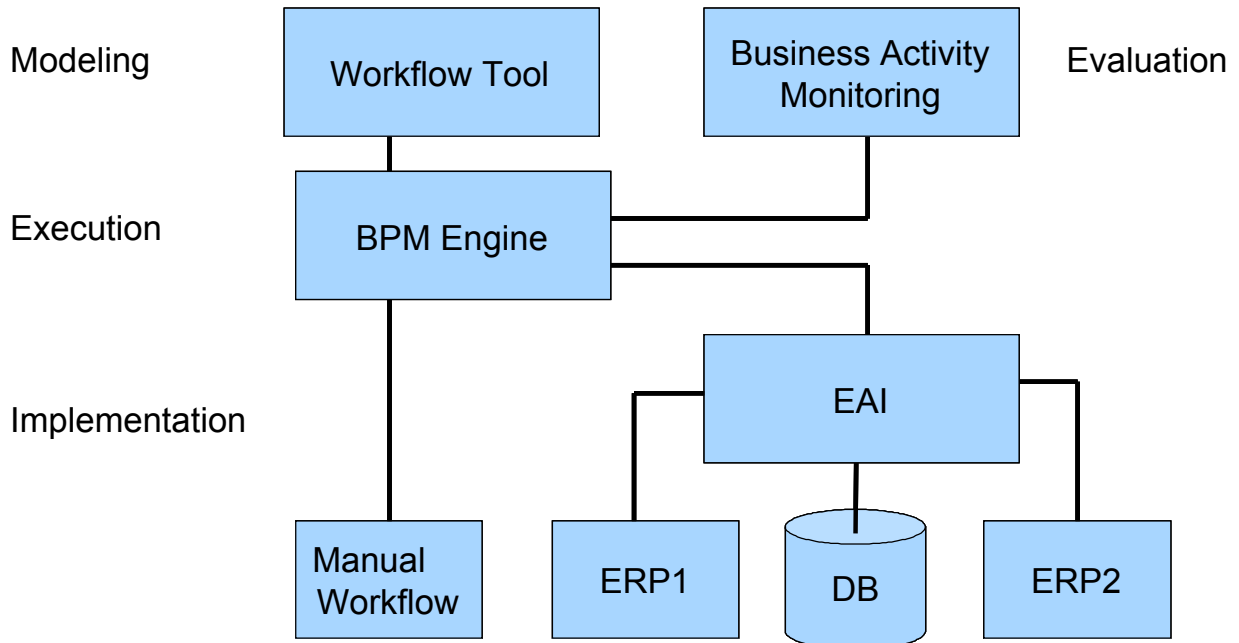


Figure 3: Architecture of BPM Solutions.

Whereas EAI provides the basic integration of enterprise applications, usually by transforming data formats through adaptors and connectors, the BPM Engine is responsible for managing complex workflows and business processes. Since EAI tools also provide some workflow support there is some overlap between these components. This is one of the reasons why EAI is expected to become a subfield of BPM in the near future.

The following sections describe the main characteristics of these technologies and their respective contribution to BPM. The descriptions are concluded with a summary on likely convergence trends in the near future.

#### **4.2.1 Workflow Solutions**

Workflow solutions comprise two main ingredients: on the one hand, a process modelling tool focusing on the modelling and visualization of processes; on the other hand, a workflow execution engine providing functionality for process automation and integration of manual workflows.

Process modelling tools usually offer graphical tools for modelling, e.g. based on Microsoft Visio. They target business experts rather than technically-oriented architects or developers. Their primary strength is the support of established business process languages, such as EPK (Ereignisbasierte Prozesskette – event-based process chain) from IDS Scheer.

Some of these tools have been developed for more than ten years and have thus reached a high level of maturity and sophistication regarding the modelling of complex business rules. Many workflow solutions have their roots in document management, i.e. they offer specific support for workflows occurring when managing documents in an enterprise.

The main challenge for process modelling tools is the (lack of) technical integration. Traditionally, these tools have been used to compile diagram representations of processes. These diagrams are then used as a basis for development teams implementing the underlying functionality.

A more integrated approach aims at mapping the graphical representation in a formal process specification. This formal specification in turn serves as a basis for automating the workflow execution, either through a workflow execution engine or through code generation.

Some tools already provide functionality for both process modelling and workflow execution. Often, however, separate tools are used for modelling the process and for automating the workflow. Process specification languages, such as EPK or BPEL, are used to provide the modelled process as input for workflow execution engines or code generators.

A current trend in BPM is the tighter coupling of process modelling and workflow execution. The ultimate goal is to have business experts modelling, extending, updating, optimizing processes without requiring support from IT developers.

However, it is not clear yet whether this long-term goal is achievable or not. On the one hand, some experts criticize that formal process languages such as BPEL are not expressive enough to represent complex processes. On the other hand, business experts

might not be capable of providing the detailed information needed as input for code generation or workflow engines.

But even if a complete automation is not feasible, reducing the dependency on the underlying IT is an important prerequisite for achieving an agile, adaptive enterprise.

There are several vendors of pure BPM solutions, the most important ones being FileNet (Business Process Management), Fuego (FuegoBPM), Intalio (Intalio/n3), Savvion (BusinessManager), and Staffware (Process Suite). There are also several vendors of workflow solutions in the German market, e.g. Gedilan, IDS Scheer, Pikos, or Sementation<sup>65</sup>.

Finally, some vendors offer workflow solutions for specialized applications, such as Enterprise Content Management (e.g. Dokumentum, Open Text, Interwoven, and Vignette).

The market for process modelling and workflow solutions will probably consolidate considerably in the next two years. In particular, vendors of workflow solutions will partner or merge with vendors of modelling tools.

#### **4.2.2 Enterprise Application Integration**

For convenience, the Webopedia definition of EAI already cited in Section 3.4 is repeated here: "Enterprise Application Integration (EAI) is the unrestricted sharing of data and business processes throughout the networked applications or data sources in an organization." It is specifically concerned with connecting systems and applications such as "inventory control, human resources, sales automation and database management (which) were designed to run independently (...) and were often proprietary systems."<sup>66</sup>

One key issue in Enterprise Application Integration is the transformation of data from one format into another. This is usually achieved by building so-called adaptors or connectors, which map the format used in one application into the format used by another application. The main strength of EAI products is their ability to connect "arbitrary" systems and applications in an enterprise. Since these products are put in the middle between two or more applications they are often called "middleware" as well.

Whereas EAI initially focussed on fundamental integration issues, such as data transformation and back-end integration, interest is currently shifting towards higher levels of integration, e.g. in the context of Business Process Management.<sup>67</sup> The main challenge is to adequately support complex processes both on the technical and the business level.

Most EAI products already offer tools for modelling and visualizing workflows. However, these tools are often targeted towards system engineers and developers and focus rather on the technical level than on the business level. Moreover, no widely accepted standard has been available in the past for the formal representation of these technical workflows.

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<sup>65</sup> Sementalk is also supporting ontologies and RDF/OWL.

<sup>66</sup> <http://www.webopedia.com/TERM/E/EAI.html>.

<sup>67</sup> See for example Madhavan Krishnan, The EAI Paradigm Shift, Ittoolbox EAI, April 2004 (<http://eai.ittoolbox.com/documents/document.asp?i=3028>).

With the advent of Web Services, which have been integrated into the products of all major EAI vendors by now, BPEL has become the most promising candidate for such a standard. Several EAI vendors have already announced BPEL support in upcoming releases of their products. This will allow the interchange of workflow models between different vendors on the basis of import and export functionality for BPEL.

EAI products are offered both by major software companies such as IBM, Microsoft, Oracle, or SAP, and by specialized EAI software vendors such as BEA, Iona, Novell, SeeBeyond, Seeburger, Software AG, Tibco, Vitria, or webMethods.

As exemplified by Tibco's acquisition of Staffware,<sup>68</sup> EAI vendors will aim at integrating more and more BPM functionality into their product suites within the next two years.

#### 4.2.3 Business Intelligence

"Business intelligence (BI) is a broad category of applications and technologies for gathering, storing, analyzing, and providing access to data to help enterprise users make better business decisions."<sup>69</sup> Traditionally, Business Intelligence has been realized through Data Warehouses. These data warehouses collect data from running business applications, which are then processed offline and in batch-mode to extract patterns, perform analyses based on business metrics, and compile business reports.

Due to the offline character of Business Intelligence no tight integration is required. Thus, functionality is often provided by specialized products that are not integrated into process execution or application platforms. This situation might change when business intelligence is required to provide real-time functionality, e.g. in the context of Business Activity Monitoring (BAM).<sup>70</sup>

BAM is a relatively new market, which is rapidly developing, partly driven by the development of the BPM market. In contrast to traditional Business Intelligence, BAM is much more concerned with providing integrated real-time information about process executions.<sup>71</sup> This comprises, for example, visualization of process execution, performance measurements (e.g. time stamps, round trip times, response times), and information regarding customer, employee, and supplier behaviour.

An important aspect of BAM is the comparison of actual process execution data with the target value specified in service level agreements or service contracts. This allows

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<sup>68</sup> See Drew Cullen, TIBCO swoops on Staffware, *The Register*, April 2004, [http://www.theregister.co.uk/2004/04/23/tibco\\_buys\\_staffware/](http://www.theregister.co.uk/2004/04/23/tibco_buys_staffware/) and Clint Boulton, TIBCO Bags Staffware for \$217M, *internetnews.com*, April 2004, <http://www.internetnews.com/ent-news/article.php/3344271>.

<sup>69</sup> McGraw Hill, Online Learning Center, Glossary, [http://highered.mcgraw-hill.com/sites/0072315326/student\\_view0/chapter10/glossary.html](http://highered.mcgraw-hill.com/sites/0072315326/student_view0/chapter10/glossary.html). See also a list of definitions under <http://www.google.com/search?hl=en&lr=&ie=UTF-8&oi=defmore&q=define:business+intelligence>.

<sup>70</sup> See, for example, Curt Hall, Business Process Intelligence, *Business Process Trends*, Newsletter June 2004, <http://www.bptrends.com/publicationfiles/06%2D04%20NL%20BPI%20%2D%20Hall%20PH%2D%2Epdf>.

<sup>71</sup> See Gary H. Anthes, Eyes Everywhere: Business activity monitoring offers a constant watch on business processes, *Computerworld*, November 2003, <http://www.computerworld.com/softwaretopics/software/story/0,10801,86895,00.html?SKC=news86895>.

the efficient detection of critical areas in a process implementation and provides the basis for optimization.

The vision underlying BAM is to enable the Real-Time Enterprise, in which information is available in the right place at the right time. In contrast to traditional BI which is usually analysing data with hindsight, BAM is expected to support more proactive behaviour, e.g. promotion sales when goods are approaching their best-before-date or cross-selling in call centres.

The main challenge in this area is a tighter integration of the business intelligence components with the other components involved in BPM, i.e. process modelling, workflow execution and EAI.

There are different categories of vendors involved in this area. On the one hand, there are vendors of software for Business Services Management in general, e.g. BMC Patrol, CA UniCenter, HP Open View, or IBM Tivoli.

Several smaller companies are specifically addressing the field of Business Activity Monitoring, e.g. Celequest, iSpheres, Metanomix<sup>72</sup>, Rhysome, Seerun, or Verilytics.

And then there are vendors of “traditional” BI solutions, such as Arcplan, Business Objects, Cognos, or SAS.

It is not yet clear whether products in this area will remain separate or whether they will become more integrated with the core BPM technologies of workflow solutions and EAI.

#### **4.2.4 Convergence of BPM Technologies**

Currently, BPM is still a rather heterogeneous application area. Vendors from different technology areas are using slightly different visions of BPM in their sales pitches. And the exact scope of functionality provided by a BPM solution is far from clear cut.<sup>73</sup>

A convergence of the core technologies of BPM seems very likely.<sup>74</sup> This would include process modelling, workflow execution, and EAI. Web Services and BPEL could accelerate this convergence. BPEL allows the exchange of process specifications between different modelling tools. These process specifications can also serve as input for process automation through workflow execution and EAI tools.

Whether analysis functionality will also be integrated directly in BPM solutions is still an open issue, however. A scenario in which such functionality will be provided by separate products is absolutely realistic.

The main challenge here will be the required real-time support, e.g. in the form of Business Activity Monitoring. This could be achieved through tight integration and a

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<sup>72</sup> The metatomix product Hologram Store supports data integration and aggregation based on RDF, [http://www.metatomix.com/cont\\_pr\\_hologram\\_1.jsp](http://www.metatomix.com/cont_pr_hologram_1.jsp).

<sup>73</sup> For a good overview on functionality to be expected from BPM solutions see Paul Harmon, BPM Tools, Business Process Trends, Newsletter April 2004, <http://www.bptrends.com/publicationfiles/04%2D04%20NL%20BPM%20Tools1%2Epdf>.

<sup>74</sup> This trend is anticipated by inubit, a member of the DIP consortium, which is one of the first movers and early adopters on building a BPM management solution that covers all relevant aspects of BPM modelling, EAI, Human Workflow, BAM and BI.

homogeneous BPM suite, as well as by coupling a BPM solution with a separate BAM tool.

### 4.3 Applying SWS in BPM

This section discusses how Semantic Web Services could be applied in Business Process Management. Since Web Service operations are already being used as building blocks for business processes in more and more applications, adding SWS technology to BPM is straightforward. Such an extension would mainly consist in enhancing service descriptions with semantic information. This enhancement would be beneficial for discovery of services, composition of services, and process monitoring.

#### 4.3.1 Description of Services

WSDL, the established standard for describing Web Services interfaces, allows the specification of input and output arguments of a service operation. Such a description is largely syntactic, though one could argue that minimal semantic information is provided by specifying the data types of the arguments.

However, a WSDL description does not contain information about pre-conditions or post-conditions, about quality of service, about access rights, or about other relevant (non-functional) properties of service operations. Note that this can include information belonging to the “service contract”, i.e. which is essential for service usage, as well as information which is not essential but useful for certain applications.

Usually, such information is added as free text when publishing a service via a registry or a repository. A more systematic approach would provide predefined formats for modelling the respective information as metadata. These metadata could then become part of the formal service descriptions.

OWL-S (previously DAML-S)<sup>75</sup> and WSMO<sup>76</sup> are two standards aiming at integrating semantic aspects in service descriptions. WSMO, which is still under development, will offer means to specify pre-conditions and post-conditions, as well as non-functional properties, e.g. related to quality of service. The general idea underlying these standards is to use ontologies, based on OWL or F-Logic, to enhance service descriptions with semantic information.

The following sections will discuss in more detail how BPM could benefit from such semantic descriptions. As the general benefits are independent from the specific format used for representing the semantic aspects, no reference to such formats will be made.

#### 4.3.2 Discovery of Services

When discussing semantic description of services, the main benefit usually cited regards discovery. The idea is to allow searching for available services based on semantic properties.

There are several scenarios, in which discovery is relevant:

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<sup>75</sup> <http://www.daml.org/services/owl-s/>. DAML stands for DARPA Agent Markup Language and formed the basis for the development of the OWL standard.

<sup>76</sup> Web Services Modeling Ontology, <http://www.wsmo.org/>.

- The basic discovery scenario involves the search for a well-defined service operation to be integrated in a business application. This could be something like CreditScoring, Billing, Purchasing, or TrafficInformation. It is usually assumed that several providers offer such services and that the consumers want to integrate them rather than develop them themselves.
- A slightly different but much more common scenario in current integration projects concerns the search for already implemented services within an enterprise. This is based on the idea of Service-Oriented Architectures (SOAs) and the aim of increasing reuse of services. When developing a new process, a central, enterprise-wide repository is used to look for potential services offering functionality needed in the process to be developed.

In both cases, discovery usually proceeds in two stages:

1. In a first step, a search will be performed to collect potentially appropriate services.
2. In a second step, the services found in the first step will be examined more closely to determine whether they actually fulfil all requirements. This stage usually involves manual verification of service properties, which are often described as full-text annotations to services.

Semantic Descriptions could allow the use of more accurate search criteria in the first step, which could significantly minimize the manual effort required in the second step. The more properties of a service are made available via formal representations, the easier it will be to search for services having certain properties.

It should be noted that the exact requirements on discovery depend to a large degree on the context in which discovery is used. Often, discovery is associated with a scenario in which services from arbitrary sources are to be integrated into a workflow. Some experts doubt that the need for this type of discovery will actually arise in the near to mid-term future. They argue that enterprises usually have long-term contracts with suppliers and do not choose services on the fly.

However, with the growing interest in service outsourcing, this type of discovery could become more important. In the area of computer manufacturing, there seems to be a growing tendencies for manufacturers to avoid long-term contracts and to choose suppliers of building parts only shortly before actual assembly of computers.

In general, the areas of manufacturing and logistics require a specific form of discovery in the context of resource planning. Resources can be modelled as services and BPM in this case involves planning the production of specific goods and the logistics involved in producing or delivering them. Here, discovery consists mostly in the search for available resources fulfilling the respective requirements (availability, costs, physical location, etc.).

#### **4.3.3 Composition of Services into Complex Processes**

One of the main challenges of BPM is the composition of individual service operations into complex processes. Several issues are relevant in this context:

- The basic task in modelling a complex business process is to specify the individual steps in the process and to combine them correctly. Once this has

been done on the business level, a mapping to technical workflows has to be provided.

- Closely related to the initial specification of business processes is the task of changing a process. Such changes are usually performed on the business level and the underlying technical workflows have to be adapted accordingly.
- Finally, (semi-)automatic composition is an issue. This concerns tool support for combining individual service operations to obtain a workflow achieving certain goals.

In the initial modelling phase, semantic service descriptions can help to identify suitable service operations to be included in a process. This is similar to the discovery task described in the previous section: it involves the search for services providing certain functionality and fulfilling the necessary requirements.

However, in a strict top-down approach, processes are often modelled without any services being implemented yet. In these cases, there is no need for discovery and supporting composition is hardly feasible either, at least not for the modelling on the business level.

More demanding is the mapping of a business-level process specification to technical workflows. On the one hand, the specification of technical workflows usually involves many details not taken into account on the business level. On the other hand, operations which are taken to be “atomic” on the business level are often mapped to technical workflows comprising several operations.

In a sense, the mapping from the business level to the technical level thus mirrors the task of the initial process composition. However, as technical details are involved in this mapping, this step is usually not performed by business experts but rather by software architects or developers.

On the basis of detailed semantic descriptions of both business services and technical service operations, tools for semi-automatic composition could considerably simplify the mapping process. Such tools could, for example, check whether a technical service satisfies requirements stated on the business level, e.g. with respect to Quality of Service. They could also verify whether preconditions and post-conditions of the operations to be combined do actually match.

To implement such semi-automatic composition tools, meta-data or semantic descriptions of services are indispensable. Moreover, such tools could also benefit considerably from reasoning capabilities.

Similar functionality could be also used when changing a process model. Here the vision is that changes on the business level automatically lead to corresponding changes on the underlying technical workflow level. To achieve this, tools are needed which verify that a rearrangement of technical service operations, for example, is actually feasible. Again, preconditions and post-conditions have to be analyzed.

Composition is a task already addressed by Web Services standards. BPEL (Business Process Execution Language)<sup>77</sup> and WSCDL (Web Services Choreography Description

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<sup>77</sup> OASIS Technical Committee Business Process Execution Language. [http://www.oasis-open.org/committees/tc\\_home.php?wg\\_abbrev=wsbpel](http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=wsbpel).

Language)<sup>78</sup> are the most prominent standards in this area. BPEL is already taken up by many software vendors in BPM and it is expected to soon become the de-facto standard for describing processes on the technical level. BPEL would thus be a natural starting point for adding more sophisticated semantic annotations.

#### 4.3.4 Process Monitoring

The applications of SWS in BPM discussed so far were related to process modelling and workflow execution. These applications also tend to dominate the discussion in Semantic Web Services, which often focus on discovery and service composition. However, semantic annotations can also be useful in the analysis of process execution, i.e. in process monitoring.

When processes are executed, input and output data as well as timestamps are usually logged in a database. This logged information is the basis for online monitoring, auditing/tracking, or offline evaluation and reporting of process performance.

Based on semantic annotations of resources, people, or roles involved in processes, such evaluations can be performed on a higher, semantic level. For example, such a semantic-based monitoring would allow selecting all operations involving products belonging to a certain category or all operations involving certain departments.

As target-performance comparisons are a major challenge for Business Activity Monitoring, semantic descriptions of targeted properties could also be used for the automatic computation of variances occurring in actual process executions. This could also involve the use of complex reasoners.

To achieve these semantic enhancements, an ontology for describing service properties would be needed. Such an ontology should, for example, contain Quality-of-Service properties. It should also be extendable to allow the inclusion of application or enterprise-specific annotations.

It should be noted that the use of semantic information in monitoring will probably occur on two levels:

- On the one hand, the level of service descriptions, where properties belong to the process or service type;
- On the other hand, the level of service instantiations, where properties belong to a specific instance of an operation and not to the operation as a generic type.

Take for example a business process in a hospital. A service operation in such a process might be a particular surgical operation, e.g. a kidney removal or a kidney transplantation. The process description will probably contain an abstract service “surgical operation”. When this service is actually executed, specific values will be available, e.g. “begin”, “end”, “type of operation”. These instance values can then be used in monitoring. An underlying ontology could then allow a semantic analysis of business data. For example, data could be retrieved for all surgical operations performed of type “transplantation”. The underlying ontology would make sure that this would cover “kidney transplantation”, “heart transplantation”, etc.

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<sup>78</sup> W3C Working Draft. Web Services Choreography Description Language. Version 1.0, 27 April 2004. <http://www.w3.org/TR/ws-cdl-10/>.

In addition to evaluating properties of service instances, evaluating properties of service operation types is also useful in monitoring. Consider again the modelling of a surgical operation process including preparation and post-surgical surveillance. For each service operation comprised in this process, a specification of roles involved might be included, such as nurse, anaesthetic, or surgeon. In monitoring process data could then be retrieved for service operations involving anaesthetics.

What these examples show is that domain-specific ontologies are needed, and hierarchical reasoning on these ontologies would be rather useful in the monitoring context.

#### 4.4 Recommendations for DIP

BPM has a high potential for SWS as it is service-oriented and can profit from the integration of Semantic Web Technology, i.e. from a layer containing semantic description of services. Moreover, the market is growing and moving fast with various vendors trying to distinguish themselves by offering innovative features that their competitors lack.

The key contribution of SWS to BPM would be techniques based on semantic descriptions of services. These descriptions could be used for enhanced service discovery, semi-automatic tools supporting the composition of service operations into processes, and for process monitoring based on semantic criteria.

The probability that BPM will use Web Services as underlying technology is very high. And that metadata will be needed to improve BPM quality in areas such as modelling, discovery, and monitoring is also almost certain. However, it is far from obvious, in which format these metadata will be applied. Instead of using RDF or OWL to represent these metadata, vendors may also offer proprietary approaches. Thus each BPM solution could offer its own metadata support via attributes and values without using a standard format.

This scenario could be avoided if a standard metadata format for semantic descriptions of processes were available and if benefits of the format were clearly visible. In addition to providing a general framework for semantically describing services it would thus be important to provide specific ontologies. Such ontologies should, for example, allow the specification of Quality-of-Service properties of services. They should also support the integration of enterprise or application-specific ontologies for describing service properties.

In general, the monitoring component of BPM, e.g. in the form of Business Activity Monitoring (BAM), offers several opportunities for applying Semantic Web Services. Using Ontologies and reasoning could substantially enhance the usability of BAM tools. Demonstrators could start with converting available logging data of process execution in RDF or OWL. Based on these converted data examples for complex monitoring queries could be built.

It is thus recommended to focus not only on discovery and composition in DIP, but to also address monitoring as an application with high potential for Semantic Web Services.

Finally, BPM solution vendors start supporting BPEL in their upcoming product releases. The SWS solutions to be developed in DIP should therefore be compatible

with BPEL in order to allow for a straightforward integration with products already established in the market.

## 5 CONCLUSION

The field of Web Services is already rather advanced. It will mature further in the next few years, mostly through the adoption and product support of standards regarding security, composition and management. Web Services will become the mainstream technology for making functionality accessible. Although the Semantic Web offers a promising vision, it is not clear yet whether it will ever be taken up in industrial applications. Standards and technology produced so far are still predominantly academic and no real-world success stories are available. This might change in the near-term future.

Adoption of Semantic Web technology will probably proceed in stages. It is to be expected that adoption will begin with making content available in RDF format. Once the benefits of RDF have been demonstrated, adoption of OWL could follow up in a second stage. However, it is also possible that applications will become more “intelligent” by using plain XML or RDF formats for metadata and statistical methods instead of logical reasoning based on OWL. This would mean that some of the functionality and benefits promised by Semantic Web would become reality, without, however, actually applying Semantic Web Technology.

Several application areas hold potential for semantic information and some of them will start integrating semantic techniques into their solutions in the near-term future. This will probably start with simple semantic features, such as the inclusion of metadata relating basic data to categories or conceptual hierarchies (ontologies). Once these semantic extensions have proven useful, more complex features such as reasoning could be tackled. It is also very likely that interfaces will be provided as Web Services in these application areas. Adding semantic descriptions to these interfaces will simplify their use and make discovery and (semi-)automatic composition easier.

For the DIP project and researchers and companies involved in developing SWS technologies the following conclusions could be drawn:

- The application areas presented in this deliverable offer substantial potential for applying SWS technology. They are also a lot more specific than generic application areas such as E-Business, E-Government or Knowledge Management. By looking more closely at the issues arising in these specific application areas, clearly targeted use case examples could be constructed.
- In most application areas covered in this deliverable, Semantic Web Services do not seem to be considered as a relevant technology. It would thus be important to intensify knowledge transfer into these application areas. Ideally, targeted use case examples should be used to demonstrate the application potential and the benefit of SWS for a particular application area.
- Finally, it seems possible that “semantic” solutions based on proprietary techniques will be developed in some or all of the application areas in the near future. It would thus be important to clearly demonstrate the advantage of SWS technology based on standards opposed to such proprietary solutions.

A more detailed analysis of the application potential of SWS in BPM has shown that the key contribution of SWS to BPM would be techniques based on semantic descriptions of services. These descriptions could be used for enhanced service discovery, semi-automatic tools supporting the composition of service operations into processes, and for process monitoring based on semantic criteria. Whereas DIP already focuses on discovery and composition, monitoring is not yet prominently dealt with in DIP. It is recommended to take monitoring into account as a promising application area for SWS.

Finally, BPM solution vendors start supporting BPEL in their upcoming product releases. The SWS solutions to be developed in DIP should therefore be compatible with BPEL in order to allow for a straightforward integration with products already established in the market.