



Data, Information and Process Integration
with Semantic Web Services

DIP

Data, Information and Process Integration with Semantic Web Services

FP6 - 507483

Deliverable

WP 12: Market Observation

D12.3

**Report on Key Technology Issues in Current EAI, E-
Business and Knowledge Management
(Enterprise Collaboration with Semantic Web Services)**

Joachim Quantz, Berlecon Research
Thorsten Wichmann, Berlecon Research

January 4th , 2005



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 continues the work started in D12.1 and provides an in-depth analysis of the potential of SWS in Enterprise Collaboration. Enterprise Collaboration is the second application area investigated in detail after Business Process Management, which is evaluated in Section 4 of D12.1. Subsequent deliverables will analyse the other application areas having high potential for SWS, namely content syndication, search/mining, and social software.

Enterprise collaboration is an application area combining technology from portals, groupware and personal information management (PIM). It comprises basic groupware solutions (e.g. Microsoft Exchange), collaboration infrastructure (e.g. Lotus Workplace), and complex portal technology (e.g. Plumtree). Its main purpose is to provide all functionality needed for business collaboration within and across enterprise boundaries. 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

Semantic Web Services could be used in enterprise collaboration to

- realize the interfaces provided by the various collaboration components,
- provide centralized information used throughout the individual collaboration components, e.g. contact information, topics, or access rights,
- provide complex collaboration services based on basic collaboration functionality and using an ontology containing collaboration goals, thematic hierarchies, and information on employees

The most straightforward way of using SWS in enterprise collaboration would be to add semantic layers on top of already existing standards and formats. In doing so, already existing proposals developed in Semantic Web (e.g. FOAF [35,36], RDFical [53,54,55,56]) should be taken as a starting point.

The main challenge will be to clearly demonstrate the added value provided by SWS. This could, for example, be achieved by using SWS-based collaboration technology in DIP itself. If such an added value is not made visible, it is highly likely that proprietary solutions will be offered by vendors, using plain attribute/value pairs instead of RDF, OWL, or WSMO.

Disclaimer: The DIP Consortium is proprietary. There is no warranty for the accuracy or completeness of the information, text, graphics, links or other items contained within this material. This document represents the common view of the consortium and does not necessarily reflect the view of the individual partners.

Document Information

IST Project Number	FP6 – 507483	Acronym	DIP
Full title	Data, Information, and Process Integration with Semantic Web Services		
Project URL	http://dip.semanticweb.org		
Document URL			
EU Project officer	Brian Macklin		








Deliverable	Number	12.3	Title	
Work package	Number	12	Title	Market Observation









Date of delivery	Contractual	M 12	Actual	M 12
Status	Version 1.0		Final Version	
Nature	Prototype <input type="checkbox"/> Report <input checked="" type="checkbox"/> Dissemination <input type="checkbox"/>			
Dissemination Level	Public <input checked="" type="checkbox"/> Consortium <input type="checkbox"/>			

Authors (Partner)	Joachim Quantz (Berlecon Research), Thorsten Wichmann (Berlecon Research)			
Responsible Author	Joachim Quantz		Email	jq@berlecon.de
	Partner	Berlecon	Phone	+49 30 28 52 96 0

Abstract (for dissemination)	This deliverable gives an overview of the standards/formalisms used in DIP.	
Keywords	Enterprise Collaboration, WSMO/WSML, RDF, FOAF, RDFical	

Project Consortium Information

Partner	Acronym	Contact
National University of Ireland Galway	NUIG  National University of Ireland, Galway <i>Ollscoil na hÉireann, Gaillimh</i>	Prof. Dr. Christoph Bussler Digital Enterprise Research Institute (DERI) National University of Ireland, Galway Galway Ireland Email: chris.bussler@deri.org Tel: +353 91 512460
Fundacion De La Innovacion.Bankinter	Bankinter 	Monica Martinez Montes Fundacion de la Innovacion. BankInter Paseo Castellana, 29 28046 Madrid, Spain Email: mmtnez@bankinter.es Tel: 916234238
Berlecon Research GmbH	Berlecon 	Dr. Thorsten Wichmann Berlecon Research GmbH Oranienburger Str. 32 10117 Berlin, Germany Email: tw@berlecon.de Tel: +49 30 2852960
British Telecommunications Plc.	BT 	Dr John Davies BT Exact (Orion Floor 5 pp12) Adastral Park Martlesham Ipswich IP5 3RE, United Kingdom Email: john.nj.davies@bt.com Tel: +44 1473 609583
Swiss Federal Institute of Technology, Lausanne	EPFL 	Prof. Karl Aberer Distributed Information Systems Laboratory École Polytechnique Fédérale de Lausanne Bât. PSE-A 1015 Lausanne, Switzerland Email : Karl.Aberer@epfl.ch Tel: +41 21 693 4679
Essex County Council	Essex 	Mary Rowlett, Essex County Council PO Box 11, County Hall, Duke Street Chelmsford, Essex, CM1 1LX United Kingdom. Email: maryr@essexcc.gov.uk Tel: +44 (0)1245 436524
Forschungszentrum Informatik	FZI 	Andreas Abecker Forschungszentrum Informatik Haid-und-Neu Strasse 10-14 76131 Karlsruhe Germany Email: abecker@fzi.de Tel: +49 721 9654 0

<p>Institut für Informatik, Leopold-Franzens Universität Innsbruck</p>	<p>UIBK  Universität innsbruck</p>	<p>Prof. Dieter Fensel Institute of computer science University of Innsbruck Technikerstr. 25 A-6020 Innsbruck, Austria Email: dieter.fensel@deri.org Tel: +43 512 5076485</p>
<p>ILOG SA</p>	<p>ILOG  Changing the rules of business</p>	<p>Christian de Sainte Marie 9 Rue de Verdun, 94253 Gentilly, France Email: cma@ilog.fr Tel: +33 1 49082981</p>
<p>inubit AG</p>	<p>Inubit  the integration experts</p>	<p>Torsten Schmale inubit AG Lützowstraße 105-106 D-10785 Berlin Germany Email: ts@inubit.com Tel: +49 30726112 0</p>
<p>Intelligent Software Components, S.A.</p>	<p>iSOCO </p>	<p>Dr. V. Richard Benjamins, Director R&D Intelligent Software Components, S.A. Pedro de Valdivia 10 28006 Madrid, Spain Email: rbenjamins@isoco.com Tel. +34 913 349 797</p>
<p>The Open University</p>	<p>OU </p>	<p>Dr. John Domingue Knowledge Media Institute The Open University, Walton Hall Milton Keynes, MK7 6AA United Kingdom Email: j.b.domingue@open.ac.uk Tel.: +44 1908 655014</p>
<p>SAP AG</p>	<p>SAP </p>	<p>Dr. Elmar Dörner SAP Research, CEC Karlsruhe SAP AG Vincenz-Priessnitz-Str. 1 76131 Karlsruhe, Germany Email: elmar.dorner@sap.com Tel: +49 721 6902 31</p>
<p>Sirma AI Ltd.</p>	<p>Sirma  Ontotext Knowledge and Language Engineering Lab of Sirma</p>	<p>Atanas Kiryakov, Ontotext Lab, - Sirma AI EAD Office Express IT Centre, 3rd Floor 135 Tzarigradsko Chausse Sofia 1784, Bulgaria Email: atanas.kiryakov@sirma.bg Tel.: +359 2 9768 303</p>
<p>Tiscali Österreich GmbH</p>	<p>Tiscali </p>	<p>Dieter Haacker Tiscali Österreich GmbH. Diefenbachgasse 35 A-1150 Vienna Austria Email: Dieter.Haacker@at.tiscali.com</p>



		Tel: +43 1 899 33 160
Unicorn Solution Ltd.	<p>Unicorn</p> 	<p>Jeff Eisenberg Unicorn Solutions Ltd, Malcha Technology Park 1 Jerusalem 96951 Israel Email: Jeff.Eisenberg@unicorn.com Tel.: +972 2 6491111</p>
Vrije Universiteit Brussel	<p>VUB</p> 	<p>Carlo Wouters Starlab- VUB Vrije Universiteit Brussel Pleinlaan 2, G-10 1050 Brussel ,Belgium Email: carlo.wouters@vub.ac.be Tel.: +32 (0) 2 629 3719</p>

TABLE OF CONTENTS

EXECUTIVE SUMMARY	II
TABLE OF CONTENTS	VII
1 INTRODUCTION	1
2 THE VISION OF ENTERPRISE COLLABORATION	2
2.1 What is Enterprise Collaboration?	2
2.2 Why is Enterprise Collaboration Useful?	2
3 EXISTING TECHNOLOGIES	4
3.1 Collaboration Tools	4
3.2 Personal Information Management and Groupware	5
3.3 Portal Technology	6
3.4 Shortcomings of Existing Technologies	6
4 BENEFITS AND CHALLENGES OF ENTERPRISE COLLABORATION	7
5 EXISTING STANDARDS AND EMERGING TRENDS	8
6 SEMANTIC WEB ACTIVITIES IN ENTERPRISE COLLABORATION	10
6.1 FOAF and Extensions	10
6.2 Semantic Calendars	12
6.3 Thematic Hierarchies and Ontologies	13
7 APPLYING SWS IN ENTERPRISE COLLABORATION	14
7.1 Where do SWS fit into Enterprise Collaboration	14
7.2 What benefit could SWS bring to Enterprise Collaboration	15
7.3 Examples for applying SWS in Enterprise Collaboration	16
8 RECOMMENDATIONS FOR DIP	17
REFERENCES	18

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 (SWS). This work was started with Section 3 in Deliverable D12.1, which briefly evaluated 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. Based on these initial evaluations, Section 4 of D12.1 contained an in-depth analysis of the potential of SWS in Business Process Management.

This deliverable continues the work started in D12.1 and provides an in-depth analysis of the potential of SWS in enterprise collaboration. Subsequent deliverables will analyse the other application areas having high potential for SWS, namely content syndication, search/mining, and social software.

Enterprise collaboration is an application area combining technology from portals, groupware and personal information management (PIM). Its main purpose is to provide all functionality needed for business collaboration within and across enterprise boundaries. Instead of having separate standalone products for functionality such as document exchange, conferencing, messaging or scheduling, an integrated solution will be required.

Enterprise collaboration comprises basic groupware solutions (e.g. Microsoft Exchange), collaboration infrastructure (e.g. Lotus Workplace), and complex portal technology (e.g. Plumtree). It is expected that these technologies will converge within the next years.

Semantic Web Services could be used in enterprise collaboration to

- realize the interfaces provided by the various collaboration components,
- provide centralized information used throughout the individual collaboration components, e.g. contact information, topics, or access rights,
- provide complex collaboration services based on basic collaboration functionality and using an ontology containing collaboration goals, thematic hierarchies, and information on employees

The most straightforward way of using SWS in enterprise collaboration would be to add semantic layers on top of already existing standards and formats. In doing so, already existing proposals developed in Semantic Web (e.g. FOAF [35,36], RDFical [53,54,55,56]) should be taken as a starting point.

The main challenge will be to clearly demonstrate the added value provided by SWS. This could, for example, be achieved by using SWS-based collaboration technology in DIP itself. If such an added value is not made visible, it is highly likely that proprietary solutions will be offered by vendors, using plain attribute/value pairs instead of RDF, OWL, or WSMO.

This deliverable contains brief descriptions of the vision underlying enterprise collaboration (Section 2). Then, three technology areas relevant for enterprise collaboration are presented, namely collaboration tools, groupware solutions, and portal

technology (Section 3). Benefits and challenges of enterprise collaboration are briefly discussed (Section 4), as are existing and emerging standards and formats (Section 5). Finally, Semantic Web projects addressing aspects of enterprise collaboration are presented (Section 6) and it is shown how Semantic Web Services could be used in enterprise collaboration (Section 7). The deliverable ends with recommendations for the DIP project (Section 8).

2 THE VISION OF ENTERPRISE COLLABORATION

This section introduces the vision underlying enterprise collaboration. Section 2.1 briefly sketches what enterprise collaboration is about, whereas Section 2.2 explains why it is useful.

2.1 What is Enterprise Collaboration?

Enterprise collaboration is an application area combining collaboration technology from portals, groupware and personal information management (PIM). Its main purpose is to provide all functionality needed for business collaboration within and across enterprise boundaries in an integrated manner.

Collaboration here covers a wide range, e.g.

- Exchange of emails between employees
- Joint processing of a workflow by employees and external partners
- Collaborative projects involving several departments and external suppliers

Due to this diversity, most solutions available today focus on particular aspects of collaboration. It is very likely, however, that future solutions will cover more and more of the various aspects involved in different collaboration scenarios.

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.

2.2 Why is Enterprise Collaboration Useful?

Enterprise collaboration promises three major advantages:

- Facilitate collaboration
- Leverage available know-how
- Increase process quality

These benefits are already relevant today but will become even more important in the future. It is to be expected that work will be more and more organized around projects: “In the company of the future, static hierarchical organizations will be replaced by

teams of employees focused on specific activities, collaborating across organizational boundaries inside and even outside the company.” [1]

Facilitate Collaboration

The main purpose of software for enterprise collaboration is to facilitate collaboration, which can occur in a number of different scenarios. Three major types of collaboration can be distinguished:

- Collaboration on a permanent basis, e.g. within departments
- Collaboration centred around a project
- Collaboration on an ad-hoc basis

Ideally, a solution for enterprise collaboration should support all these scenarios, which differ considerably with respect to their respective requirements. This includes, for example,

- The need for documentation of the collaboration process
- The level of synchronicity required
- The level of intrusion acceptable

Different collaboration tools differ considerably with respect to the requirements they are meeting. An integrated enterprise collaboration solution aims at providing users with a wide range of collaboration components, allowing them to choose for each task at hand the best-suited component.

This contrasts with an approach often taken today, namely the use of email as a universal collaboration medium. Although email has several advantages, in particular its wide availability, it is not optimal for all tasks. Almost everyone will probably have made negative experience with endless discussions conducted via email or problems resulting from using email for sharing documents developed in a team.

Leverage Available Know-How

Basically, enterprise collaboration has to make sure that the know-how available in an enterprise is actually leveraged in the day-to-day work and to minimize the overhead for involving this know-how. There is thus some overlap between enterprise collaboration and the area of knowledge management. One distinction is that enterprise collaboration is much more process-oriented than traditional knowledge management.

The main challenge is to involve employees exactly in those steps of a process in which their know-how is needed. Consider again the example of email-based collaboration as it is often occurring in today’s projects. Most often, emails are distributed to a wide range of recipients to make sure that no one misses information potentially important to her. This usually results in a considerable overhead, as recipients are flooded by information not really relevant to them.

A full-fledged enterprise collaboration solution aims at a more fine-grained approach to information dissemination. To make sure that relevant information is not “lost”, it also provides searchable archives allowing those getting involved in a process to access information previously compiled.

Increase Process Quality

A major aspect of enterprise collaboration concerns the quality assurance of collaboration processes. Using enterprise collaboration tools can help to standardize collaboration processes thereby taking a first step towards quality assurance.

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. In general, these regulations require some documentation of process steps and integrated archiving/search functionality.

3 EXISTING TECHNOLOGIES

Enterprise collaboration is not a new technology. In fact, collaboration technologies are widely used already. This section will present an overview of currently existing technologies by covering three main categories:

- Collaboration tools
- Personal information management and groupware
- Portal technology

Enterprise collaboration comprises technical ingredients from all three categories.

3.1 Collaboration Tools

A wide range of collaboration tools is already available today, some of them widely used, some of them used only infrequently.

- *Email* is widely used and well-suited for asynchronous communication, it is challenged, however, by spam and viruses and problems resulting from using it for the “wrong” tasks.
- *Instant messaging* is used more and more often in the enterprise context. It is well-suited for synchronous communication but often lacks enterprise-level security and archiving features.
- *Presence*¹ provides functionality about current availability and is expected to become more and more important in the near future, especially for mobile workers and virtual offices.
- *Audio, video, and web conferencing* provide means for synchronous group interaction reducing the need for physical face-to-face meetings.
- *Collaboration platforms* provide a central repository for document exchange and also include communication facilities such as emails or forums.
- *RSS* stands for Really Simple Syndication, Rich Site Summary or RDF Site Summary. It allows content, e.g. news or blog entries, to be aggregated in RSS feeds, which can then be read by RSS feed readers. Since a user can decide

¹ “The ability to detect whether other users are online and whether they are available. Presence services are commonly provided through applications like Finger and instant messaging clients, although a number of companies are developing products in other areas that leverage presence, such as VoIP.” [66]

when to check which feeds, RSS is often seen as an alternative to email and its spam problems.

- *Wikis* provide a very light-weight technology for the collaborative authoring of web pages.
- *Blogs* enable people to create and post diary-like entries and are often used to refer to news or other blog entries and to comment on them.

These collaboration tools are available as standalone solutions, but are also bundled together into integrated solutions, e.g. in groupware solutions as discussed in the next section.

3.2 Personal Information Management and Groupware

Solutions for personal information management and groupware offer basic collaboration functionality and provide integrated access to underlying components. Most of them also address issues such as synchronization, which is an important feature for mobile workers.

Standard functionality usually includes:

- *Calendars*: supporting collaboration features for calendar sharing, invitations, and scheduling.
- *Email*: supporting collaboration features such as shared mail folders.
- *Address books*: supporting the use of a central address book.
- *Task lists*: supporting collaboration features such as task assignments and monitoring of task's status.

Microsoft Exchange Server and IBM Lotus Notes are the dominant solutions in the market today. Recently, a couple of alternatives to Microsoft Exchange have emerged. These include

- *Open source groupware server* such as eGroupware [2], exchange4linux [3], Kolab [4], OpenGroupware [5] and Open-Xchange/Suse-Linux Openexchange [6,7];
- *Open source groupware clients* such as KDE Kontact [8] and Novell Evolution [9,10];
- *Proprietary groupware server* such as Kerio Mailserver [11], Net Integration Technology ExchangeIt [12], Scalix [13] and Stalker CommuniGate Pro [14];
- *Proprietary groupware systems* such as IBM Lotus Workplace [15], Novell Groupwise [16] and Oracle Email and Calendar [17].

Although these solutions differ with respect to the functionality they are offering, they share the core groupware functionality provided by Microsoft Exchange, namely email, calendars and task lists. They will probably be extended with more and more groupware functionality in the next years.

IBM, Microsoft, and Oracle are currently developing full-fledged collaboration suites, integrating a wide range of collaboration tools. IBM is developing Lotus Workplace into IBM Workplace [18], Microsoft is offering SharePoint Services as an extension of its Exchange product [19], and Oracle is using its relational database as a basis for its

Collaboration Suite [20]. All three companies position their suites as integrated solutions offering a single point of access to functionality that has been based on disconnected systems in the past. Section 5 will discuss this trend towards integrated solutions and alternatives based on a best of breed strategy.

Interestingly, there are also two major groupware developments, namely Groove and Chandler, headed by former Lotus Notes' gurus.. Groove Networks, whose CEO is Ray Ozzie, creator of Lotus Notes, is currently developing a groupware solution with particular focus on office virtualization [21,22]. The main challenge here is to offer mobile workers a secure, self-synchronizing collaboration environment.

OSAF's (Open Source Application Foundation) Chandler project [23] 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.

3.3 Portal Technology

Finally, Portal technology is the third technical area from which enterprise collaboration will derive. Focus here is clearly on integration, as a portal aims to provide an integrated access point towards a wide range of functionality: "it is a platform that aggregates information, applications and processes and delivers them to internal and external users." [24]

Portals often support functionality for content management, workflow and personalisation. Thus, navigation in a portal is usually taking into account individual profiles and roles: employees working in marketing will be provided a different view than those working in development, sales or support.

It is common practice in enterprises to use different portals for customers (extranet) and employees (intranet). However, it has become apparent by now that an integrated portal for customers, partners, suppliers, and employees will be better suited to fully leverage the potential of automated collaboration.

Portal technology is offered by enterprise software vendors such as SAP and Siebel, by infrastructure companies such as IBM and Sun, and by dedicated portal software vendors such as Plumtree.

Portal solutions usually focus on building specific workflows or processes for collaboration and not so much on integrating basic collaboration technology. They are thus much more oriented towards a particular application or sector than generic infrastructure solutions.

3.4 Shortcomings of Existing Technologies

The main shortcoming of existing technologies for Enterprise Collaboration is the lack in integration. Most solutions are available as standalone tools only and information sharing between collaboration components is far from straightforward and seamless. Section 4 will discuss in more detail the benefits and challenges of an integrated approach to Enterprise Collaboration. Section 5 will then present existing standards and emerging trends.

Semantic Web Services have the potential to considerably facilitate information sharing between collaboration components. On the one hand, ontologies can be used to provide central data models to be used by the individual components. On the other hand, complex services can be built on top of basic collaboration functionality. Sections 6 and 7 discuss such enhancements in detail. A major benefit of an integration approach based on SWS is the flexibility and vendor independence it provides through the use of open standards.

4 BENEFITS AND CHALLENGES OF ENTERPRISE COLLABORATION

As discussed in the previous section, basic technology needed for enterprise collaboration is already available. The main challenge is to provide a platform seamlessly integrating all this functionality. Such an integrated platform would offer several advantages

- *Single sign-on:* Using standalone tools for collaboration means that the user has to sign on for each tool separately. An integrated collaboration solution, on the other hand, allows a single sign on requiring the user to provide her access data only once and thereby obtaining access to all functionality integrated.
- *Availability of information:* In an integrated platform, information is available across collaboration components. Thus, when setting up a web conference the meeting information will become immediately visible on calendars.
- *Unified search and archiving:* The integration of collaboration functionalities allows the support of unified information processing tools, e.g. for search and archiving. It will thus be possible to use a single search interface to retrieve data from emails, instant messages, blogs, or documents (see, for example, [25]).
- *Enforcement of policies:* Using an integrated platform for enterprise collaboration can help to enforce policies. On the one hand, this is achieved through well-defined workflows implemented in the platform. On the other hand, a centralized configuration of aspects such as archiving, security, or access rights guarantees that these policies are respected regardless of which collaboration component is used.²
- *No duplication of information:* Currently, information is often duplicated since it is needed in various collaboration tools. Contact information, for example, is stored both in the address book used by a mail tool and the contact list used by an IM tool. Within an integrated platform, information has to be maintained at one central place only without the need to duplicate it.
- *Centralized personalization:* Similarly, an integrated platform allows a centralized approach to personalization, instead of performing personalization on the individual tool level. For example, topics of interests can be chosen and used to filter emails, blog entries and documents.
- *Reduced administration overhead:* A key advantage of any integrated solution is that it reduces the administration overhead. Instead of several software products

² [26] discusses security and regulatory problems with current use of IM (instant messaging) by traders.

only a single product has to be maintained. In particular, access rights have to be managed once only.

In order to achieve these benefits, standardized interfaces have to be developed for the individual collaboration components. In addition, information shared by components has to be standardized as well, e.g. calendar information, address information, and access rights. The most appropriate solution is to use a central data model for such information, which is centrally managed and accessed by the individual collaboration components.

However, even if these technical challenges are met, a major challenge to all collaboration solutions remains the disciplined adoption by the end user. If end users do not enter their appointments into their electronic calendars, scheduling meetings does not become any easier. In general, the potential of enterprise collaboration can only fully be leveraged if users are willing to invest a small individual overhead in using the tools appropriately. This overhead is then compensated by a significant reduction of coordination overhead.

The next two sections will discuss existing and emerging standards and sketch how Semantic Web Services can contribute to enterprise collaboration.

5 EXISTING STANDARDS AND EMERGING TRENDS

The key idea underlying enterprise collaboration is to integrate a wide range of collaboration functionality to offer users a single, unified solution in which information can be easily shared between the various collaboration components. In principle, two approaches can be distinguished to achieve this goal:

- A monolithic approach in which a single vendor offers an integrated collaboration suite containing all the collaboration tools required.
- A best-of-breed approach in which standalone collaboration tools offer interfaces based on open standards, which allow their seamless integration with other tools.

As has been discussed in Section 3, IBM, Microsoft, and Oracle are currently pursuing the first approach and several groupware vendors and projects are also extending the functional scope of their software. However, it is very likely that standalone tools will continue to be widely used and that enterprises will deploy several systems to satisfy all their collaboration requirements. As long as these systems can be easily integrated, such a best of breed solution can be as reasonable a choice as a monolithic collaboration suite (see, for example, [27]).

In any case, the need for information sharing between the components used for enterprise collaboration will increase. This concerns information to be exchanged between individual components. Moreover, information will have to be managed centrally so that it can be accessed by all components. This is, for example, useful for contact information or access rights.

In order to allow integration with third party functionality, basic infrastructure will offer open interfaces. It is very probable that Web Services will be used as one form of interface format. In addition, open standards will be used for the respective functional applications. IMAP, iCalendar and WebDAV are examples for standards already in use today (see Table 1 for an overview of relevant standards).

<ul style="list-style-type: none"> ✓ Active Directory, is Microsoft's directory service and integrated into the operating system Windows Server. It provides centralized access and management functionality to information on users, resources and access rights. ✓ LDAP (Lightweight Directory Access Protocol) is an open protocol for accessing directory services. Exchange alternatives often use LDAP-based directories instead of Active Directory. ✓ MAPI (Messaging Application Programming Interface) is the proprietary Microsoft API used for communication between server and client in an Exchange-based system. ✓ IMAP (Internet Message Access Protocol) is a protocol which allows mail clients to manage emails on a server. IMAP supports synchronization between client and server, server-side functionality such as search and sorting, as well as multi-person access to mail folders. ✓ POP3 (Post Office Protocol 3) is a lot more restricted than IMAP – it supports downloading and deleting of emails but no server-side functionality. ✓ SMTP (Simple Mail Transport Protocol) standardizes the transport of emails and allows sending emails via a Mail Server. ✓ iCalendar (Internet Calendaring and Scheduling Core Object Specification) is an ICM standard (Internet Mail Consortium) for the exchange and storage of calendar information. ✓ iMIP is the transport mechanism for iCalendar and supports the exchange of iCalendar data and iTIP methods through emails. ✓ iTIP extends iCalendar with groupware functionality, allowing group calendaring and scheduling. ✓ CAP (Calendar Access Protocol) is an emerging IETF proposal to turn iCalendar into a client/server system. It defines how clients can access and manipulate data in a server-based calendar store. ✓ SyncML is a standard for the synchronization of data initiated by Nokia, Palm, IBM, Motorola, Ericsson, Symbian and Lotus. SyncML-compliant clients can exchange data with SyncML-compliant servers, such as addresses, calendar entries or emails. ✓ vCard is a specification of the Internet Mail Consortium for a platform-neutral electronic business card, allowing the exchange of personal contact data. ✓ WebDAV (Web Distributed Authoring and Versioning) is a protocol for the management of data on a Web Server and ensures data integrity of files maintained by more than one user.³ ✓ XMPP (Extensible Messaging and Presence Protocol) is the IETF's formalization of the core protocols created by the Jabber community for instant messaging and presence.

Table 1: Overview over existing standards

To integrate existing components into a portal portlets can be used. The Portlet Specification [28], JSR 168 (Java Specification Request), defines APIs for portlets, standardizing preferences, user information, portlet requests and responses, and security.⁴ The Web Services for Remote Portlets (WSRP) Technical Committee at OASIS has released the WSRP 1.0 specification in August 2003 [30]. Release of version 2.0 is envisaged for mid 2005.

³ CalDAV (WebDAV for Calendars) is currently developed at IETF (see the internet draft at www.ietf.org/internet-drafts/draft-dusseault-caldav-04.txt, expiring June 2005).

⁴ A good source of information on portlets is [29].

Whereas JSR 168 provides a standard way for building and using portlets on the Java platform, WSRP1.0 allows the remote use of portlets independent of programming languages and platforms. Though there is some overlap between both standards, they should rather be seen as complementing each other (see, for example, [31,32]).

6 SEMANTIC WEB ACTIVITIES IN ENTERPRISE COLLABORATION

There are a couple of ongoing Semantic Web projects that directly address the application area of enterprise collaboration. The following sections will present three main areas of research:

- FOAF and extensions
- Semantic calendars
- Thematic hierarchies

There also is a company called Radar Networks working on a “Semantic Mozilla”, i.e. a PIM suite based on an OWL ontology. The public open-source release is set for Summer 2005 [33,34], but apart from that not much information is available at the moment.

6.1 FOAF and Extensions

FOAF (Friend of a Friend) is an RDF-based standard for representing personal information and relationships [35,36]. It contains classes such as “Person”, “Organization”, “Document”, or “Image” and properties such as “name”, “homepage”, “mbox”, “knows”, “interest”, or “publications”.⁵ There is thus some overlap with the vCard standard used by many groupware systems and tools are available for converting data between vCard and FOAF (see, for example, [38]).

Here is how FOAF works in a nutshell: basically, a FOAF file contains information about a person, e.g. her name, her interests, her home page, as well as links to her friends. Since FOAF is RDF-based, the RDF property `rdfs:seeAlso` can be used to link to other RDF documents. One important characteristic about FOAF (and RDF) is thus, that information is generated and provided in a distributed but interconnected manner – just like traditional web pages contain links to other web pages.

To continue the analogy with web pages: just as there are programs for distributed Web indexing (usually called harvester, spider, or robot), there are so-called scutters in the context of FOAF/RDF. A scutter is a program that “loads, parses, interprets and acts upon the contents of a Web of interconnected RDF/XML documents” [39].

One major challenge in aggregating FOAF fragments is “smushing”, i.e. “merging data based on knowledge of uniquely identifying properties” [40]. FOAF uses properties like “homepage” or “mbox” to establish identity, i.e. two person data sets having the same value for “mbox” or “homepage” are considered to be about the same person.

Several tools are already available to generate and visualize FOAF information. FOAF-a-matic is a Javascript application allowing the creation of FOAF descriptions through web forms [41]. FOAFnaut is an SVG-based FOAF user interface and allows, for example, visualizing social networks based on the values of the property “knows”

⁵ See [37] xmlns.com/foaf/0.1/ for the full FOAF vocabulary specification.

specified in FOAF descriptions [42]. The Foaf Explorer transforms FOAF descriptions from the raw RDF/XML format to XHTML, which can then be rendered by any standard web browser [43].

The most obvious application for FOAF are social networks (see, for example, [44]). Since social networks belong to the application area of social software and not to enterprise collaboration in the narrow sense, they will not be discussed here. There are, however, additional application scenarios of FOAF in the context of enterprise collaboration.

As is evident from the overlap with the vCard standard, FOAF can be used as a basis for address books and directory services. The potential value-add would be the additional information provided by FOAF. A user could thus search for contacts with specific interests or for contacts of his direct contacts. This is very similar to the added value promised by social networking software in general.

Similarly, FOAF information could be used for single sign on or for providing personal information when registering at web sites or for services. Instead of filling in web forms for registrations, a user could simply provide a pointer to his FOAF file.

Another application discussed in the context of FOAF is the use of friendship relations for spam filtering of emails. The basic ideas are to use so-called white lists for filtering out potential spam mails and to use FOAF information for compiling the white lists (see, for example, [45]).

Most of the initial activities around FOAF were conducted in a more or less academic context. However, FOAFnet.org [46] is an “industry consortium committed to getting FOAF built into commercial systems” [47]. Most of the approximately 30 members of FOAFnet.org are social networking sites (e.g. Orkut, Plaxo, Tribe) and companies from the weblog area (e.g. Blogware, SixApart, Technorati).

FOAFnet has started with identifying a subset of the FOAF specification to guarantee interoperability between online systems such as blogging tools, on-line email, social networks, or other membership-based web applications and services. Interoperability here basically refers to the import and export of FOAF descriptions by such online systems.

There already is a large number of FOAF data available on the web. FOAFspace, a search engine indexing FOAF documents has already indexed more than 1.5 million documents, most of them stemming from www.livejournal.com, a weblog hoster and social networking site. A good overview over available FOAF data sources and related tools is provided at rdfweb.org/topic/DataSources.

Although there is growing support for and pick-up of FOAF there are also some ongoing discussions on challenges still to be met. Plaxo has published a detailed analysis on how it might use FOAF and what the most obvious challenges are [48].

Not surprisingly, privacy issues rank very high on this list. This regards the general issue of making personal information publicly available and the particular problem of making email addresses public and thereby risking spam. FOAF offers the `mbox_sha1sum` to address the latter concern: instead of including one’s email address in plain text, it can be included as a hash sum. This guarantees that it can be used for unique identification or email white lists without making mail addresses publicly available.

Another issue related to privacy concerns is the visibility of information represented in a FOAF file. Currently, this information is provided in a one size fits all manner, i.e. there are no means to tailor information towards specific target groups, such as business colleagues, friends, or customers.

Finally, a recurring criticism of FOAF is that it is too coarse grained. Thus, using the property knows does not really provide sufficient information about the nature of this relationship. The good thing about FOAF is that it can be easily extended. It is thus possible to add more fine-grained relationships, as has been done in the relationship module [49]. This module contains properties such as friendOf, acquaintanceOf, parentOf, etc.

Another extension to FOAF that is of interest in the context of enterprise collaboration is MeNow, which allows representing often-changing variables, such as current location, chat accessibility or status [50,51]. Such presence information is particularly useful for instant messaging and is, for example, part of the Jabber standard XMPP.

Summarizing this section, FOAF seems like a very good starting point for developing SWS application in enterprise collaboration. It is being picked up steadily and offers an open standard format for basic information required in enterprise collaboration. The fact that FOAF is RDF-based makes it straightforward to integrate with additional ontological information.

6.2 Semantic Calendars

Calendaring is also addressed by several Semantic Web projects.⁶ The RDF Calendar Task Force has worked on representing iCalendar in RDF (RDFical) (see [53,54,55,56]). Very active in 2003, work seems to have slowed down in 2004, however.

RDFical is more than a syntactic variant of iCalendar. Its main benefit is its ability to connect the core event information to additional information, e.g. on people attending, nearby locations, or topics addressed (see, for example, [57,58]). This is the general idea underlying the Semantic Web and its formalisms, such as RDF, OWL, or WSMML: providing a uniform framework for representing information on arbitrary resources.

An example for connecting information along these lines is given by Leigh Dodds, who ties together a FOAF description and a calendar [59]. At a SWAD-Europe (Semantic Web Advanced Development for Europe) workshop, held in Bristol in October 2002, several use cases for Semantic Web calendaring were discussed [60]. These use cases do not contain any apparent killer application for semantic calendaring. They also show, however, that semantic calendars would provide useful benefits in several application contexts.

Using the widely accepted iCalendar standard as a basis has several advantages. First, RDFical data can be easily created by converting existing calendars. Several tools are available for converting between iCalendar and RDFical, e.g. Masahide Kanzaki's online RDF iCalendar converter [61].⁷ The Retsina Semantic Web Calendar Agent developed at Carnegie Mellon University provides interoperability between RDF based

⁶ The University of Washington has an online semantic calendar developed by the Mangrove project [52].

⁷ The site also contains an introduction to RDFical in Japanese.

calendar descriptions on the web and PIM systems such as Microsoft Outlook [62]. Finally, EventSherpa, a commercial product, supports both iCalendar and RDFical [63].

The remaining challenge, however, is that there is not enough additional information available in RDF, which could be connected to the calendar entries. It is thus difficult to demonstrate the benefits to be obtained by using RDFical instead of plain iCalendar. The sample applications discussed in [57,58,59,60] are thus still theoretical and not yet validated by practical experiences.

The most promising and straightforward applications of semantic calendars combine the topic or location of a meeting with additional ontological information. These could be information on hotels, restaurants or special events close by to the meeting location. Or it could be information on relevant documents, such as reports that have to be read before a meeting, drafts that are to be discussed during the meeting, meeting agendas, or meeting minutes.

Semantic calendars are a very good starting point for integrating SWS into enterprise collaboration. SWS could be used to offer high-level scheduling services based on ontological information (see also Section 7.3).

6.3 Thematic Hierarchies and Ontologies

In addition to Semantic Web standardization efforts for particular collaboration components, there are some collaboration solutions already using large ontologies.⁸ SemanticOrganizer is a collaborative knowledge management system designed to support distributed NASA projects [64]. As it was developed before the W3C standardization OWL/RDF was completed, it is based on a proprietary Semantic Web language similar to RDFS, but not supporting subclassing of relationships. Currently, SemanticOrganizer allows over 500 users to access a web of 45,000 information nodes connected by over 150,000 links. This corresponds to more than 500.000 RDF-style triples. To these users the system is known as ScienceOrganizer [65].

SemanticOrganizer is an excellent example for the use of Semantic Web technology in enterprise collaboration. It is therefore worthwhile to take a closer look at the major challenges and the lessons learned in this application. Keller et al. report that fixing a terminology for collaboration is one of the major purposes of any knowledge management application. SemanticOrganizer achieves this by providing a “semantically-structured information repository” [64]).

In addition to specific requirements related to the application areas of SemanticOrganizer, four key technical challenges can be distinguished:

- The terminology should allow easy and intuitive use by different project teams. This calls for the use of rather specific and task-dependant terms instead of a generic indexing scheme.
- The system should be centrally administrated but locally customizable.
- Support for knowledge acquisition and automatic ingestion of information was crucial.

⁸ The idea of semantic integration underlying this approach is a major selling point of several companies offering ontology-based solutions, such as Ontoprise [67].

- Scalability was mandatory to ensure rapid and precise access even for large volumes of data stored in the system.

Using Semantic Web technology helped especially with respect to the first and the third challenge. Using links and relations allowed a much finer grained information model than simple hierarchies. And inference engines were used to support the knowledge acquisition task and the automatic ingestion of new information.

However, it also turned out “the notion of connection information using multiple, non-hierarchical relationships was very disorienting to some users”. Moreover, whereas most regular users annotated and linked new material appropriately, some users, especial casual ones, became frustrated, “if their new material didn’t align easily with the existing semantics” [64]. In order to accommodate the casual organizers, the notion of semantic correctness therefore had to be relaxed.⁹

NASA’s SemanticOrganizer is probably the largest real-world application of Semantic Web technology today. It clearly demonstrates feasibility and benefits of an ontology-based approach to collaborative knowledge management.

- | |
|--|
| <ul style="list-style-type: none"> ✓ FOAF (Friend of a Friend) is an RDF-based standard for representing personal information and relationships. Several tools exist for converting data between vCard and RDF, and for visualization and generation of FOAF files. ✓ RDFical is an RDF variant of the iCalendar standard, allowing connecting calendar information with additional RDF-based information on events, topics, locations, or people. ✓ NASA’s SemanticOrganizer is a large-scale collaborative knowledge management system using an RDF-style format. It allows over 500 users to access a web of 45,000 information nodes connected by over 150,000 links. |
|--|

Table 2: Summary of Semantic Web activities related to Enterprise Collaboration

7 APPLYING SWS IN ENTERPRISE COLLABORATION

This section looks more closely at the potential of using Semantic Web Services (SWS) in enterprise collaboration. In particular, it addresses the following questions:

- Where do SWS fit into enterprise collaboration?
- What benefit could SWS bring to enterprise collaboration?
- What would be good examples for applying SWS in enterprise collaboration?

7.1 Where do SWS fit into Enterprise Collaboration

As demonstrated by WSRP (Web Services for Remote Portlets)¹⁰, Web Services are a natural candidate for realizing interfaces of collaboration components. SWS could be

⁹ This is a good example for the adoption challenge of collaboration technology mentioned in Section 4.

¹⁰ A similar approach has been initiated in June 2002 by the OMG (Object Management Group), which 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).

used instead of traditional Web Services for this purpose as well. In principle, two use cases can be distinguished:

- SWS could be used to offer generic collaboration functionality
- SWS could be used to offer value-add collaboration services, combining basic underlying functionality.

Regarding the former approach, SWS technology could provide semantically described Web Services interfaces for basic 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.

However, the latter approach seems even more promising as generic collaboration functionality is already provided by established vendors.¹¹ Based on such functionality, complex collaboration services could be provided by SWS, using an ontology containing collaboration goals, thematic hierarchies, basic collaboration services, and information on employees and their skills and availabilities.

Examples for such high-level services would be complex scheduling tasks performed on the basis of specified goals, automatic archiving and distribution of information, or goal-driven search of information sources. Section 7.3 below will discuss such sample applications in more detail.

7.2 What benefit could SWS bring to Enterprise Collaboration

Using SWS would offer two major benefits for enterprise collaboration:

- An integrated ontology would provide a central data model based on open standards, which could be used across the individual collaboration components;
- High-level, goal-oriented services would simplify collaboration tasks and provide intelligent and easy-to-use functionality.

As has been pointed out in Deliverable D12.1, Semantic Web Services offer advantages with respect to mediation, service discovery, (semi-)automatic composition, and monitoring. In the context of enterprise collaboration, it is in particular the composition aspect that is important. Given a collaboration goal, basic service functionality has to be combined on the fly to provide a complex service satisfying the goal.

Service discovery would have to be used within the composition task and might also be useful for end users to discover available collaboration resources, e.g. employees with specific skills or know-how. Monitoring could be used in connection with archiving, i.e. to help retrieve process steps by specifying semantic information.

Despite these potential benefits, adoption of SWS in enterprise collaboration is not yet apparent. It is very probable that interfaces based on Web Services will become a standard ingredient of enterprise collaboration tools. What is less likely, however, is the integration of Semantic Web technology. Standards currently used in enterprise

¹¹ The home page of the OASIS WSRP TC lists 16 companies which have already announced that their products will support WSRP v1.0, among them BEA, Fujitsu, IBM, Microsoft, Plumtree, Sun, Vignette and webMethods.

collaboration, such as IMAP, iCalendar, vCard or WebDAV are not using Semantic Web technology yet.

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, OWL, or WSMO but rather standardized ontologies or metadata for content used in enterprise collaboration, such as events, topics, or roles.

7.3 Examples for applying SWS in Enterprise Collaboration

This section briefly discusses three examples for applying SWS in enterprise collaboration:

- Finding experts with specific skills or know-how
- Scheduling a meeting
- Linking relevant documents to a meeting

For each example, it is also indicated how it could be prototypically realized and applied in the context of the DIP project itself.

The first example consists in finding experts with specific skills or know-how. Here, the user would have to specify the skills or know-how required by the expert as well as the information in which time-frame and for which purpose the expertise is needed.

In the context of DIP, this could be used to assign internal reviewers to deliverables. On the one hand, a thematic model of topics addressed in DIP deliverables would have to be compiled and each deliverable would have to be categorized according to the topics it covers. Members of DIP would then have to maintain personal profiles indicating for which topics they consider themselves experts. These profiles should be based on (extensions of) FOAF.

Finding internal reviewers for a deliverable would take this information as a basis and access additional information as well. This includes information about the authors of a deliverable and their respective affiliations, information on review assignments and potentially also calendar information on availability of experts and time frames in which reviews are to be expected to take place.

The second example concerns the scheduling of a meeting. Basically, the task here is to determine the participants required for the meeting, a time slot suitable for all or most of the participants, and the appropriate meeting mode (i.e. face-to-face, web conference, or conference call). Ideally, such a service would provide the details of the scheduled meeting directly to the calendars of all participants.

In the context of DIP, such a service could be used to schedule conference calls of work packages, task forces, or teams jointly producing a deliverable. This would require access to calendar information of DIP members as well as an ontology containing information on who is involved in which task forces, work packages, and deliverables.

Finally, a third example for combining SWS and Enterprise Collaboration in the context of DIP would consist in linking meeting information available in a semantic calendar to relevant documents. These could be meeting agendas and minutes as well as deliverables or drafts. The task would basically consist in annotating documents

available on DIP's BSCW appropriately and to use these annotations for automatic linking to meetings included in a semantic calendar.

When browsing an event in the calendar, users could be presented with a list of relevant documents available on DIP's BSCW. Such lists could also be compiled and sent to participants of a ConCall via email.¹² A major value-add to be demonstrated by this example would be the linking between calendar data and documents maintained on the BSCW. For users, the main benefit would be that such a linking would ensure the availability of up-to-date information concerning relevant documents.

- ✓ SWS could be used to provide complex collaboration services based on an ontology containing collaboration goals, thematic hierarchies, basic collaboration services, and information on employees and their skills and availabilities
- ✓ An integrated ontology would provide a central data model based on open standards, which could be used across the individual collaboration components.
- ✓ SWS could combine basic service functionality on the fly to provide a complex service satisfying a collaboration goal.
- ✓ Examples for including SWS into enterprise collaboration include meeting scheduling, finding experts with specific skills and know-how, and linking relevant documents to meetings.

Table 3: Summary of application potential for SWS in Enterprise Collaboration

8 RECOMMENDATIONS FOR DIP

Enterprise collaboration has high potential for SWS. On the one hand, collaboration components to be integrated will offer interfaces based on Web Services. Extending these service interfaces with semantic descriptions will facilitate their usage considerably. On the other hand, information to be shared throughout a collaboration platform, such as contact information, access rights, or topics, can best be represented in a central ontology.

Several basic standards are currently used in collaboration tools, e.g. IMAP, LDAP, iCalendar, vCard or WebDAV. These could be extended with a semantic layer, e.g. for filtering or classifying information. In doing so, RDF-based standards such as FOAF and MeNow should be used as a starting point. Good examples for this approach are projects working on semantic calendars compatible with iCalendar.

Based on basic collaboration functionality, complex collaboration services could be provided by SWS, using an ontology containing collaboration goals, thematic hierarchies, basic collaboration services, and information on employees and their skills and availabilities.

It will also be important to clearly demonstrate the value add provided by a semantic layer, e.g. by actually using semantically enhanced collaboration tools within SWS projects such as DIP. This could, for example, be achieved by integrating FOAF information or semantic calendars into the DIP website. A sample application could be realized which helps finding internal reviewers for DIP deliverables. Such an

¹² Such an application would also provide functionality similar to functionality belonging to the application area search/mining, which will be investigated in D12.4. Microsoft and Apple are currently developing technology, which will significantly enhance search facilities for documents on the operating system level (see, for example, Apple's spotlight [68]).

application would have a manageable scope, would provide a visible benefit but would not be mission-critical. It would also be complex enough to demonstrate the value add provided by SWS technology.

If such a value add is not made visible, it is very likely that metadata and centralized data used by several collaboration components will be based on proprietary formats using simple attribute/value pairs but not RDF, OWL or WSMO.

REFERENCES

- [1] Rick Whiting, „As Work Changes, New Tools Are Needed“, InformationWeek, August 2004, www.informationweek.com/showArticle.jhtml?articleID=29100174
- [2] www.egroupware.org
- [3] www.exchangeforlinux.com.
- [4] www.kolab.org.
- [5] www.opengroupware.org.
- [6] www.open-xchange.org.
- [7] www.suse.de/de/business/products/openexchange/.
- [8] www.kontakt.org.
- [9] www.novell.com/products/evolution/
- [10] www.gnome.org/projects/evolution/.
- [11] www.kerio.com.
- [12] www.net-itech.com/products/exchangeit.php.
- [13] www.scalix.com.
- [14] www.stalker.com.
- [15] www-306.ibm.com/software/lotus/.
- [16] www.novell.com/products/groupwise/.
- [17] www.oracle.com/collabsuite/.
- [18] IBM Workplace extends more transformational power to more businesses, IBM Software News, November 2004, www-306.ibm.com/software/swnews/swnews.nsf/n/jmae664pzt?OpenDocument&Site=lotus.
- [19] Making Collaboration the Engine of Team Productivity, Microsoft, March 2004, www.microsoft.com/windowsserver2003/techinfo/overview/WSSvision.msp.
- [20] The Unified Workplace: A Single Place for Doing Business, Oracle, 2004, www.oracle.com/collabsuite/OracleUnifiedWorkplace_final.pdf.
- [21] www.groove.net/
- [22] Thomas Claburn, Q&A With Groove Network’s Ray Ozzie, Information Week, April 2004, www.informationweek.com/story/showArticle.jhtml?articleID=18900796 for details.
- [23] www.osafoundation.org
- [24] Anthony Plewes, Analysis: Choosing enterprise portal technology, Silicon.com, March 2004, www.silicon.com/research/specialreports/portals/0,3800002620,39119499,00.htm
- [25] Michael Voelker, Into Thin Air, Compliance Pipeline, July 2004, www.compliancepipeline.com/showArticle.jhtml?articleID=23905027
- [26] Francis Good, Collaboration Technologies About To Hit Wall Street?, RobinGood, September 2004, www.masternewmedia.org/news/2004/09/23/collaboration_technologies_about_to_hit.htm

-
- [27] Jim Murphy, Collaboration: Sharing, Playing Nice With Others, and Getting Down to Business, AMR Research, August 2004, www.amrresearch.com/Content/View.asp?millid=17489&docid=11810.
- [28] Introduction to JSR 168 – The Portlet Specification, developers.sun.com, July 2003, developers.sun.com/prodtech/portalserver/reference/techart/jsr168/
- [29] portlets.blogspot.com/.
- [30] www.oasis-open.org/committees/tc_home.php?wg_abbrev=wsrp.
- [31] Robert Stone, JSR-168 and WSRP: Competitors or Partners?, TheServerSide.com, April 2004, www.theserverside.com/reviews/thread.tss?thread_id=25598 or
- [32] Rachel Greenblatt, JSR and WSRP: Setting High Standards, WebLogicPro, October 2004, www.fawcette.com/weblogicpro/2004_11/magazine/features/rgreenblatt/.
- [33] www.radarnetworks.com/
- [34] Nova Spivack, Google's Browser Project ... And Ours..., Minding the Planet, September 2004, novaspivack.typepad.com/nova_spivacks_weblog/2004/09/googles_browser.html.
- [35] www.foaf-project.org/
- [36] Leigh Dodds, An Introduction to FOAF, XML.com, February 2004, www.xml.com/pub/a/2004/02/04/foaf.html.
- [37] xmlns.com/foaf/0.1/
- [38] rdfweb.org/topic/FoafAndVcard.
- [39] rdfweb.org/topic/Scutter.
- [40] rdfweb.org/topic/Smushing.
- [41] www.ldodds.com/foaf/foaf-a-matic.html.
- [42] www.foafnaut.org/.
- [43] xml.mfd-consult.dk/foaf/explorer/.
- [44] Edd Dumbill, XML Watch: Finding friends with XML and RDF, IBM Developer Works, June 2002, www-106.ibm.com/developerworks/xml/library/x-foaf.html.
- [45] Dan Brickley, RDF for mail filtering: FOAF whitelists, April 2003, www.w3.org/2001/12/rubyrdf/util/foafwhite/intro.html.
- [46] foafnet.org.
- [47] rdfweb.org/topic/FOAFnet_2eorg.
- [48] Joseph Smarr, Plaxo and FOAF: What's the right model?, Plaxo's Personal Card, February 2004, blog.plaxo.com/archives/000007.html.
- [49] www.perceive.net/schemas/20021119/relationship/.
- [50] crschmidt.net/semweb/menow/
- [51] schema.peoplesdns.com/menow/.
- [52] abstract.cs.washington.edu/~semweb/public/webcal/week.php.
- [53] ilrt.org/discovery/2001/04/calendar/
- [54] www.w3.org/2002/12/cal/,
- [55] esw.w3.org/topic/RdfCalendar
- [56] esw.w3.org/topic/RdfCalendarPresentation.
- [57] Leigh Dodds, The RDF Calendar Task Force, XML.com, July 2001, www.xml.com/lpt/a/2001/07/25/rdfcalendar.html
- [58] Libby Miller, Combining foaf, RDFical and geo, and maybe RSS 1.0 ..., Plan B, September 2003, planb.nicecupoftea.org/archives/2003_09.html.

- [59] Leigh Dodds, Get Your FOAF On: Events, Lost Boy, February 2004, www.ldodds.com/blog/archives/000117.html.
- [60] www.w3.org/2001/sw/Europe/reports/dev_workshop_report_2/.
- [61] www.kanzaki.com/courier/ical2rdf.
- [62] www.daml.ri.cmu.edu/Cal/.
- [63] www.eventsherpa.com/.
- [64] R.M. Keller, D.C. Berrios, R.E. Carvalho, D.R. Hall, S.J. Rich, I.B. Sturken, K.J. Swanson, S.R. Wolfe, “SemanticOrganizer: A Customizable Semantic Repository for Distributed NASA Project Teams”, in S.A. McIlraith et al. (Eds.), ISCW 2004, Springer LNCS 3298, 2004, pp. 767-781.
- [65] sciencedesk.arc.nasa.gov/organizer/
- [66] www.webopedia.com/TERM/P/presence.html
- [67] www.ontoprise.de/solutions/semintegrate_en
- [68] www.apple.com/macosx/tiger/spotlight.html