Semantic Interfaces for Personal and Social Knowledge Work

Konstantinos Christidis, National Technical University of Athens, Greece
Niki Papailiou, National Technical University of Athens, Greece
Dimitris Apostolou, University of Pireaus, Greece
Gregoris Mentzas, National Technical University of Athens, Greece

ABSTRACT

A large number of tools has recently emerged supporting information management for individuals in their work context. Semantic technologies play an important role in the development of such tools as they facilitate advanced organization, annotation, navigation, and search capabilities. This study contributes to the design of such tools by outlining how a user-centred design methodology can be applied to develop usable and effective user interfaces. SPONGE, the resulting system, encapsulates core functionalities that are needed for managing personal information and for seamlessly sharing personal information within knowledge networks.

Keywords: Collaborative Computing, Knowledge Management, Personal Computing, User Interfaces, Web-Based Interaction

INTRODUCTION

Interest in personal information management first became apparent in the 1980s (Lansdale, 1988) as part of the growing awareness of the potential of the personal computer to enhance human capabilities in processing and managing data. Personal information management is especially pertinent to ‘knowledge workers’—people whose work is to a large extent mental rather than purely physical. Personal information management acts as an aide-mémoire to knowledge workers, supplying the right information at the right time. In recent years, the number of ways to keep and manage personal information has increased considerably, in line with the overall increase in the number of devices, technologies and applications on which knowledge workers rely. The attendant fragmentation of personal information increases the probability of locking something away in a device, application or format and forgetting that this something was ever seen, heard, or read in the first place (Marshall & Jones, 2006). Additionally, knowledge workers are often out of sync with their personal information resources due to the escalation in web information resources.

Information does not only exist in personal spaces, but is continuously produced and revised in knowledge networks (Heller-Schuh &
Knowledge networks are social networks that are assembled to create, revise and transfer knowledge for the purpose of adding value (Seufert, Von Krogh, & Bach, 1999). Knowledge networks can be both formal (e.g., project teams) and informal (e.g., communities of interest). People involved in such networks may belong to different units in an organization, or even in different organizations, and work in dispersed locations. Knowledge workers handle personal information management tasks on a daily basis, while simultaneously participating in different knowledge networks in the context of their work.

Tools that support information management in knowledge networks include, inter alia, community management tools, synchronous and asynchronous communication tools, wikis and social software. Most of these technologies became popular during the rise of the collaborative World Wide Web and have gradually made their way through company firewalls as enterprise collaboration platforms. The information needs of knowledge workers often span both personal and social boundaries. A knowledge worker typically uses a variety of such tools, often switching between different types when moving from one assignment to another.

With the increased availability of data and evolved metadata standards over the years, applications of semantic technologies in organizational information systems have likewise increased (Linden, 2005). The application of ontologies in organizational information systems facilitates the integration of heterogeneous information items within the organizational memory (Caldwell, 2006; Mika, 2005). Semantic architectures bring together information sources that previously would have proved difficult to capture (Caldwell, 2006). Recently, we have noticed the propagation of semantic technologies in tools supporting information management for individuals in their work context (Caldwell & Linden, 2006; Linden, 2005). Nevertheless, our study shows that semantics-based tools impose an additional layer of information processing that poses challenges to their everyday use by knowledge workers.

In this paper we aim to contribute to the existing knowledge on the design of semantics-based personal and social information management tools. We first discuss related work and our research motivation and objectives. Next, we outline related theories and our research methodology. We then present SPONGE (Social and Personal Ontology-based Gadgets)—a collection of gadgets that aim at the efficient utilization of semantic technologies for supporting personal information management and ad hoc collaboration within knowledge networks. Finally, we analyse the results of the evaluation study, focusing on usability and perceived benefits for knowledge workers, summarize our contributions, derive conclusions and outline areas of further work.

RELATED WORK, MOTIVATION AND OBJECTIVES

To help individuals better manage their personal information, a wide variety of tools have emerged. The concept of metadata has largely influenced the development of these tools, prominent examples of which include GNOME-PIM, Gnowsis, Haystack, IRIS Semantic Desktop, KDE Kontakt, MyLifeBits and Bento. Metadata are used to characterize information; as such, they provide the means to organize information and enable machines automatically to process and interpret it. Learning to apply metadata is time-consuming, however, and consistently using this approach with different tools is burdensome; metadata can therefore add complexity to information management activities.

To support information management and sharing in the social work context of knowledge workers, several collaborative tools have been developed, including wikis. Wikis allow the collaborative editing of web pages with facilities for easily interlining pages, page version management and communication between users. Wikis can assist information management within knowledge networks and facilitate group collaboration. While a range of popular wiki
tools are available some of them are intended to utilize metadata and semantics – Semantic MediaWiki, OntoWiki and IkeWiki, for example. As with semantics-based personal information management tools, however, learning to exploit semantics in wikis is not straightforward. Moreover, the tendency towards scattered metadata and conflicting descriptive approaches can lead to islands of semantics (Mika, 2005). Ontology-based tools are often associated with complicated user interfaces that are not suitable for ordinary users, thus making the issue of improving the user interaction and developing more intuitive user interfaces critical. Research in this direction is presented in workshops such as Semantic Web User Interaction. For instance, full wiki systems are implemented in a more natural interface (Kuhn, 2008) and new visual metaphors for semantic web functions become available (Eustace & Srivastava, 1995; Russell, Smart, Braines, & Shadbolt, 2008).

Our research objective was to investigate alternative user interfaces that could provide a richer, faster and lighter-touch way of building personal knowledge spaces than those enabled by current semantics-based desktop applications. Moreover, we aimed at making provisions for supporting ad hoc collaboration of knowledge workers and enable seamless access to personal and shared resources reflecting the fact that knowledge workers are increasingly participating in knowledge networks in the context of their daily work.

**SUPPORTING INFORMATION MANAGEMENT FOR KNOWLEDGE WORKERS IN THEIR WORK CONTEXT**

**Personal Information Management**

Personal information management (PIM) is meant to provide activities such as acquisition, organization, maintenance and retrieval of information. Information is often scattered among different forms (e.g., paper, e-documents), applications and devices. Better PIM reflects in the ability to use time in a more convenient way. Users can benefit by spending less time on managing information and use the gained time for processing that information creatively and intelligently to accomplish their tasks. (Barreau, 1995) defines PIM in terms of functions provided by a PIM system; these are acquisition, organisation, maintenance, retrieval and presentation of information. Performing PIM in an effective manner has an impact in reducing spent time on managing information and thus benefit at the organisational level. There is evidence that the professionals’ PIM competences directly affect enterprise knowledge management (Tsui, 2002). Thus, organizations benefit when professionals perform PIM effectively. Tsui (2002) denotes “Implemented by one knowledge worker at a time, bottom-up tools and techniques demonstrate immediate and explicit benefits in terms of increased productivity and improved morale and build momentum to overcome the technological and sociological barriers to top-down, enterprise-wide KM initiatives”.

For PIM to be effective, several problems need to be addressed (Jones, 2007): Information is often dispersed in different applications and devices often resulting in information ignorance. Additionally, information that has not been acquired or acquired in the wrong way can be proved to be of great importance at a later stage while acquired information may be useless. Further, a specific location may contain a mess of unrelated information or obsolete information can distract from important information while other related information is scattered across separate locations. PIM tools should provide a holistic and unified solution. This is where semantic technologies play a role by providing unified access to information regardless of information device/application and location dispersion.

**Knowledge Networks**

The work context of knowledge workers includes interactions related to the participation of knowledge workers in knowledge networks. Knowledge networks are assembled in order to
accumulate and use knowledge mainly by means of knowledge creation and transfer processes, for the purpose of creating value (Seufert et al., 1999; Beerli, Falk, & Diemers, 2003) cite the characteristics of knowledge networks in terms of their evolution process, the roles assumed by network members and the relationships formed among them, as well as the type of knowledge shared within the networks. With regards to the evolution of knowledge networks, we can differentiate between intentional and emergent ones. Intentional knowledge networks are perceived as newly-created in their entirety, whereas emergent knowledge networks already exist but have to be cultivated in order to enhance their performance. This can be achieved, for example, by creating a common language among participants or developing a common set of values and objectives.

Members in a knowledge network can be individual knowledge workers, groups or communities. The type of membership within the network can be task-orientated or output-orientated. While some members may identify strongly with the network and demonstrate considerable dedication, others may be less attached and therefore less committed to it. Further, the type of membership can substantially vary depending upon one’s position within the network. A member can be at the core of the network or more at the periphery (Wenger, McDermott, & Snyder, 2002); s/he may assume a knowledge domain or practice role, a leadership role, a support role or an intermediary role (Fontaine, 2001).

Relationships within networks can vary in duration, intensity, as well as the frequency of the interactions (Seufert et al., 1999). This naturally implies the personal involvement, commitment, and care behind the relationship. The immediacy and interactivity of the communication of the knowledge networks’ members is inextricably linked with the media richness of the communication tools they use. Centralisation, formalisation, posture, or geographical scope of the network influence the way knowledge is exchanged (Seufert et al., 1999). Entry barriers, participation possibilities, and ownership can restrict the flow of knowledge. Moreover, the integration of business, the origin of the network, and the ownership play a distinct role.

Knowledge shared within the network can vary: it can be explicit or tacit. Tacit knowledge, being rooted in personal experience, subjective perceptions, values, and emotions, can only be transferred via direct communication. Sharing explicit knowledge, coded in formal language, through electronic media or other forms of documents, is also more difficult than sending a file: one need to account for various types of heterogeneities (Apostolou, Mentzas, & Abecker, 2009) that not only restricts knowledge sharing but also entails the danger of erecting barriers to the inter-personal exchange of explicit knowledge.

The Focus of this Study

We have identified three areas where appropriately designed semantics-based tools are ripe to be applied in order to improve knowledge work productivity by supporting personal information management and collaboration within knowledge networks. First, knowledge workers need to work on a number of different tasks at any one time, e.g., salespeople handle several sales proposals simultaneously. Each knowledge worker has a number of different working contexts, and information organisation needs to reflect the different contexts. This should be achieved without resulting in scattered metadata and conflicting descriptive approaches when using different desktop application or when browsing Web pages.

Second, knowledge workers need to share information between colleagues and be able to reuse parts of existing documents in new collaborative contexts. This has to be done easily, without expecting people to spend time using an elaborate system which requires information to be carefully categorized. It also has to be done unobtrusively, without overwhelming people with technical details of the underlying knowledge representation approach used by the system.
Thirdly, knowledge workers need to be able to collaborate in the context of knowledge networks. By knowledge networks we do not refer to formal organisational structures such as business units — which are, of course, important — but rather about those social settings in which people do participate to achieve common tasks in their daily work. When a salesperson prepares a customer proposal there are certain things which she does by seeking assistance, information and advice by experienced colleagues, for example, get the approval on proposal budgeting. Group Support Systems have leveraged collaborative work by improving participation and understanding (Jessup, Connolly, & Galegher, 1990), shortening task duration (Dennis & Wixom, 2002) reducing interpersonal conflicts (Miranda & Bostrom, 1997), and reducing domination (Daly, 1993; Shaw, 1981; Gallupe, Bastianutti, & Cooper, 1991; Gallupe et al., 1992) and enhancing group cohesiveness and participant relationships (Anson, Bostrom, & Wynne, 1995; Wheeler & Valacich, 1996; Chidambaram, Bostrom, & Wynne, 1990). Employing a GSS for every collaborative task, however, is neither always beneficial (Miranda & Bostrom, 1997; Fjermestad & Hiltz, 1998), nor economical and possible in practice. These are probably some of the reasons why users rely increasingly on personal communication tools to coordinate their work.

Email, however, do not unequivocally improve productivity — for example a New York Times blog post from December 2007 described email as a ‘$650 Billion drag on the economy’. Beyond email, the spectrum of communication and collaboration tools to which knowledge workers have to adhere to accomplish their daily tasks includes wikis, blogs, micro-blogs and other social networking platforms. The diversity of available tools adds complexity to the already convoluted work processes. To reap the benefits of knowledge networking, there is clear need for leveraging simultaneous management of information at the personal and group level, i.e., to enable knowledge workers seamlessly to manage both their personal documents, tasks, and contacts and information shared between them via knowledge networks.

**RESEARCH METHODOLOGY**

The application domain of our research was professional business services firms — organizations that provide business services based on the application of highly specialized knowledge and expertise (Dawson, 2000). Examples include investment banks, solicitors, and consultants. Being knowledge intensive organizations, business services firms employ professionals who can be characterized as typical examples of knowledge workers. The case study for our research was TMI, an international management consultancy typifying the professional business services firm. TMI operates through a network of local partners in 40 countries. It offers training, consulting and tools for individuals, teams and organizations seeking to transform organizational culture.

In order to understand user needs and requirements, we conducted user research at TMI using ethnographic methods such as contextual observations and interviews. From our study we identified requirements in respect of typical processes and used personas (Calabria, 2004; Goodwin, 2001) as a means to encapsulate user needs. Although personas are fictitious, they are based on the knowledge of real users and therefore identify users’ behaviour patterns, motivation, expectations, goals, skills, attitudes and environment. Using these typical processes and personas we developed a number of use cases representing the information creation and sharing work processes within TMI. Based on these cases, we customised the desktop application provided by Social Semantic Desktop (SSD), so that is was able to support our use cases. The user interface of the SSD desktop application is similar to most existing semantics-based personal information management tools. Then, we iteratively developed improved prototypes, each of which was evaluated in small groups of TMI employees. This software engineering process led to the development of an improved
tool, SPONGE, by working backwards from the desired functionalities and requirements, while simultaneously refining the prototypes and incorporating user feedback.

We used two methods to evaluate SPONGE: the unobtrusive observation method using the “think aloud” protocol was applied, in which end users continuously think out loud while using the system, expressing their understanding of the system features, difficulties encountered, preferred features, expectations, etc. In addition, we collected feedback on the quality, user friendliness and perceived benefits of the system, using a questionnaire that was distributed to users at the end of the evaluation sessions. In order to define and validate the questionnaire, we first developed a model and questionnaire based on similar published work, which we then evaluated using statistical methods. From this we derived a validated questionnaire for evaluating SPONGE. This approach has also been followed for similar purposes by (Saarinen, 1996; Palvia, 1996; Etezadi-Amoli & Farhoomand, 1996; Aladwani & Palvia, 2002). In more detail, the questionnaire development process consisted of four steps: initial evaluation model and questionnaire development; data collection; model and questionnaire empirical evaluation; model and questionnaire refinement. The first step constitutes the exploratory phase, where the hypothesized evaluation dimensions are developed, while the next three steps constitute the confirmatory phase, where the hypothesized dimensions are tested and validated empirically.

Based on prior research on information systems evaluation focusing on information systems success (Saarinen, 1996; DeLone & McLean, 1992), user satisfaction with knowledge management systems (Ong & Lai, 2007; Eustace & Srivastava, 1995), user perceived web quality (Aladwani & Palvia, 2002), end user computing satisfaction and user performance (Etezadi-Amoli & Farhoomand, 1996), and web system quality (Cao, Zhang, & Seydel, 2005), we developed a core model for evaluating personal and collaborative knowledge management systems. This conceptualized model consisted of three global items: system quality and use, perceived benefits at a personal level, and perceived benefits at group level. Each global item was further elaborated with hypothesized lower-level items (or dimensions). In an effort to test the conceptualized model empirically, we conducted a survey in which we asked respondents to rate each item in the model by responding to one or more associated questions based on their experience of using personal and group information management systems such as e-mail applications, file explorers, desktop search engines, and groupware applications. Responses were measured using a five-point Likert scale ranging from (1) “strongly disagree” to (5) “strongly agree”. Questionnaires were available on-line for a three-month period and knowledge workers from three international professional business services firms were asked to complete them. A total of 115 responses were collected, of which 83 were fully completed and 32 partially completed.

Corrected Item to Total Correlation (CITC) and Correlation R-matrix were used in the data collected to purify items. The rule used for filtering out items is the one suggested in (Cao et al., 2005): items with a CITC score of lower than 0.5 were eliminated. The correlation R-matrix was calculated to identify items that correlated too highly with other items; items with R value greater than 0.8 were removed from the model. Factor analysis was used for the assessment of item validity – the degree to which an item actually measured that for which it was intended. Factors loadings emerging from the factor analysis indicated item correlation to global items (factors). Factor loadings below 0.5 indicated that respective items were not appropriate for their intended purpose and could produce error and unreliability. Finally, Cronbach’s alpha was used for the assessment of model reliability based on internal consistency. Cronbach’s alpha was over 0.8 for all items.

Following the aforementioned statistical analysis, a refined model and corresponding questionnaire was developed in which some questions were removed because they did not contribute significantly to the model (CITC index lower than 0.5) or their correlation with...
other questions was high (R index higher than 0.8). The refined questionnaire was used by test users to evaluate SPONGE.

SYSTEM DESCRIPTION

Overview and Interfaces

Design Approach

The design and development of SPONGE was based on three principles. First, both usability and friendliness of the graphical user interface were deemed highly important. SPONGE is intended to present a usable and highly intuitive interface for SSD. In many cases, the complexity of semantic applications prevents non-expert users from using them. In our case, even partial understanding of knowledge representation concepts, techniques and languages cannot be expected; nor can they be a prerequisite for using the applications.

Second, it is important that different levels of user familiarity with SSD functionalities and ontologies are supported. Users who are apt to try advanced features, e.g., for customizing the ontology, they may use the desktop application of SSD. Other users may prefer the simplicity of the SPONGE interfaces, even though being unable readily to use the full set of available SSD functionalities provided by the SSD desktop application. The availability of both tools to the end user allows users with different levels of familiarity to take advantage of the available functionalities.

Third, for the development of the user interfaces we exploited physical desktop interaction patterns with which users are familiar. For instance, we introduced the concept of SPONGE Notes, a means to create RDF triples by adding digital yellow notes on information resources. There are two parts in a SPONGE Note: the top underlined part is the predicate while the bottom one is the object. This idea for SPONGE Notes was inspired by the widespread use of yellow sticky (Post-it®) notes for annotating physical desktop resources such as books or printouts.

The concept of gadgets (or widgets) was selected as the main user interaction approach. A desktop gadget is a small footprint application, which resides on the user’s desktop using little desktop space and limited computer resources providing information management functionality in a non-intrusive manner. Examples of widget engines are shown in Figure 1.

In SPONGE, gadgets are easily accessed: minimal windows that assist the knowledge worker in her/his everyday information organization and retrieval tasks without requiring changes in the established habits of knowledge workers. Gadgets have limited available desktop space, however, and can eventually present a limited amount of information. A solution to this limitation is to combine gadgets with the web browser in order to present dynamic web pages containing the required additional information. For example, while the presentation of search results would be impossible in a small window, it is possible to present a large set of annotated search results in a web page. SPONGE is designed as a combination of a small gadget and dynamically generated pages accessible from the web browser. The gadget is preferred for user actions where a small part of screen area is required, such as entering a query, while the web browser is used for presenting more information: for instance, the results of a semantic search.

System Walkthrough

SPONGE provides support for three areas of user activity: searching for information, characterizing information by means of annotation with keywords and collaborating with colleagues.

The Search gadget provides a text-box interface for locating resources, not only in the local desktop, but also in shared workspaces and the computers of other colleagues. The results appear in a web page, which pops up after the user types her/his query in the Search gadget (Figure 3). Annotations of each result are presented in a table of SPONGE Notes.

Results are organized in categories that appear on the top of the results page. At first level, results are categorized based on their
Resources are further categorized into specific types—Documents, People, Topics and Tasks. Types are dynamically derived from the classes of the underlying ontology. Retrieved results include information resources containing terms that both match exactly the query terms and semantically similar terms. Similarity is derived from the proximity of terms in the ontology.

The SPONGE Notes gadget is used to present and add annotations to desktop resources that are translated in RDF triples. This gadget allows users to drop a resource on it (e.g., a file). At the first drop the resource is scanned for metadata, such as the name and the author of the resource, and a new instance of an appropriate class in the underlying ontology is created. The metadata are displayed in yellow notes (Figure 3), following the visual metaphor of sticky notes. To add a SPONGE Note, the user clicks on an icon with a “pile” of SPONGE Notes. Clicking on the pile brings up a dialog box with all possible relations (RDF predicates) and metadata (RDF objects) for annotating this resource.

The SPONGE Notes gadget displays buttons for sharing the resource in the peer network and for ontology editing (by clicking on the wrench icon). Another capability of the gadget is the suggestion of annotations to the user by utilizing SSD components that provide metadata recommendations. Recommendations are presented as SPONGE Notes with a distinct magenta colour and labeled with the keyword ‘Suggestion’ (Figure 2).

Collaboration between users is supported by SPONGE workspaces. The idea behind workspaces is to provide a placeholder for storing, organizing and sharing resources needed to accomplish personal and collaborative tasks and organize work-related tasks. Workspaces can support either the personal work of individual users or the collaborative work of groups. Each workspace consists of one or more wiki pages placed in a hierarchical structure (Figure 4). Any user can create a workspace and invite members to participate. Any workspace member can browse workspace pages, create new pages, edit pages using typical wiki functionality and communicate in workspace forums and chats.

SPONGE workspaces provide semantic annotation facilities using SPONGE Notes (Figure 5). Notes can be attached to every page to capture semantic annotations with the same look and feel as when annotating desktop information resources.
Technical Architecture

SPONGE is developed in a two-part architecture comprising local and workspace. The local architecture components create the gadgets and the web environment that handles the dynamic creation of web pages. The local web environment is provided by a servlet application following the Java Enterprise Edition EE technologies, where jetty server is used for deployment and Ajax for the presentation of search results and for annotation. Asynchronous calls keep the application responsive when massive time-consuming access to local and remote RDF stores is required. These calls also allow the use of intuitive interfaces, while enabling only applicable predicates and objects to be loaded. Moreover, SPONGE utilises the Dojo JavaScript framework to create the SPONGE Note and the dialogs, and for performing XML calls when loading suggested objects.

The local SPONGE services connect the SSD components providing services such as storing metadata, mapping desktop resources to the Personal Information Model (Sauermann, Van Elst, & Dengel, 2007) and providing metadata recommendations based on an analysis of the ontology structure, the social context of the user and the textual content of the resource in conjunction with public metadata repositories such as DBpedia. Moreover, SSD interconnects desktops in a peer-to-peer network and allows distributed storage and search based on P-Grid and GridVine (Cudre-Mauroux, Agarwal, & Aberer, 2007; Aberer, Cudré-Mauroux, Hauswirth, & Van Pelt, 2004).

The SPONGE workspaces architecture extends IkeWiki (Schaffert, 2006). IkeWiki is an open source semantic wiki offering, in addition to collaboration-related functionalities (e.g., WYSIWYG editor, discussion forums, etc.), RDF support for storing formal knowledge. It...
is implemented in Java using the Ajax and Dojo frameworks and thus is technically compatible with the local architecture of SPONGE. Our extensions include an improved interactive user interface in order to support collaboration in workspaces, a sophisticated role management system allowing restricted access to the workspaces and, using SPONGE Notes, easy semantic annotation of pages.

Figure 6 displays an integrated overview of the technical architecture of SPONGE and its inter-relation with SSD and IkeWiki. Communication between the local SPONGE services and SSD components utilizes the OSGi framework. The SPONGE gadget engine stands on top of the services that are built into the bundles. Local SPONGE services connect to the remote workspace server using remote XML and JSON
calls to the server. These requests are hidden to the presentation layer, allowing for possible extensions of the system and providing a unified user interface to the end user.

**EVALUATION**

SPONGE has been evaluated by eleven employees from offices of TMI in Bonn and Athens, the professional business services firm that was used as a case study in our research. In each office, employees from all business areas were invited to the evaluation: trainers, managers, directors, trainees, designers, analysts, etc. SPONGE was configured with a TMI-specific ontology, which users could extend. Users were asked to test SPONGE by following predefined scenarios with no prior tutorial or demo. The scenarios consisted of realistic work-related tasks to be accomplished with SPONGE in combination with existing tools such as mail and office applications. Evaluations took place in company offices during office hours, in accurate simulations of work conditions. A usability expert was present during the usability testing and she explained, controlled and validated the process while assessing the system usability. In addition, at the end of each session users were asked to complete the evaluation questionnaire.

The usability testing focused on three areas: interface and visual cues, learnability and help, and integration between components with the desktop environment. In terms of interface design, the Search gadget was assessed as intuitive and easy to use. The one-step search interface was positively evaluated, as was the fact that it is easily accessible. Search result presentation was perceived as meaningful. Further, the multi-dimensional categorization of results was well received. SPONGE uses different visual representations for different types of documents. This feature was considered useful, although the specific symbolic language used was not universally accepted; some users expressed difficulties in identifying the nature of some resources. Another issue that emerged during usability testing is the fact that the different SPONGE Notes appeared in the exact same way and format, i.e., there is no visual differentiation between topics, tags, etc.

Figure 5. Adding a new SPONGE note in a workspace page

![Figure 5. Adding a new SPONGE note in a workspace page](image-url)
SPONGE learnability was positively evaluated. During usability testing, all users were able easily to use SPONGE without prior training. Users could browse through gadgets and intuitively understand their functionalities. Nevertheless, the sense of user orientation can be improved by more appropriate labeling of retrieved resources, categories, system menus, etc. Users interacting with SPONGE expected a unified environment that could help them find, edit and annotate documents, share knowledge and create workspaces. They appreciated the easy transition between the different SPONGE components (Search, Notes, and Workspaces) but they would have preferred even better integration between them (e.g., the ability to upload a document onto a workspace by right-clicking on the resource from the search results page). Moreover, they would have preferred not to have to use the PSEW application for any of the scenario tasks in order to avoid the interchange of different environments.

The analysis of the questionnaire responses revealed that the majority of test users (82%) perceived that the speed of interacting with SPONGE and of building knowledge spaces was high. 64% of the test users perceived SPONGE as offering rich information about their resources by means of recommended annotations, crawled metadata, etc, though their opinion concerning the accessibility of information available in SPONGE was neutral. One reason for this may be that fact that only a limited number of information resources from the corporate intranet had been crawled by SPONGE prior to the tests. Moreover, some users (55%) did not find all system outputs straightforward, thus reflecting the need for improvements in system labeling as identified also in the usability tests. Perceived benefits when working at a personal level were the abilities to create rich information about desktop resources (100% of test users), flexibly organize their resources (100% of test users), search and retrieve resources (100% of test users), edit and change resources (82% of test users) and create new resources (82% of test users). Perceived benefits when working at group level were the abilities to search and retrieve resources created by others (100% of test users), collaboratively create new information (100% of test users), share know-how and experiences (100% of test users), express and develop ideas in teams (82% of test users), improve quality in management of shared resources (82%) and provide comments and feedback to groups (46% of test users).

CONCLUSION

Our study contributes to the design of semantics-based personal and social information management tools. It outlines how a user-centred design methodology can be applied to develop usable
Table 1. Questionnaire responses

<table>
<thead>
<tr>
<th>System quality and use</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Indifferent</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of use</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terminology understand-ability</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Easy of switch between functions</td>
<td>7</td>
<td>4</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Understandability of outputs</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed of Interaction</td>
<td>9</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Availability of information</td>
<td>7</td>
<td>4</td>
<td>2</td>
<td></td>
<td></td>
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<tr>
<td>Information Presentation</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td></td>
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<tr>
<td>Advanced Search</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Makes job easier</td>
<td>5</td>
<td>4</td>
<td>2</td>
<td></td>
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<tr>
<td>Personal</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Create Useful Informa- tion</td>
<td>3</td>
<td>8</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creativity to develop new ideas</td>
<td>9</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organize information items</td>
<td>4</td>
<td>7</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Edit and change informa- tion items</td>
<td>4</td>
<td>5</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Search find and retrieve</td>
<td>7</td>
<td>4</td>
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<td></td>
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<tr>
<td>Social</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Collectively create new information</td>
<td>7</td>
<td></td>
<td>4</td>
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<tr>
<td>Express &amp; develop ideas in terms</td>
<td>2</td>
<td>7</td>
<td>2</td>
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<tr>
<td>Add quality information in teams</td>
<td>2</td>
<td>7</td>
<td>2</td>
<td></td>
<td></td>
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<tr>
<td>Share know-how, ideas &amp; experience</td>
<td>5</td>
<td>6</td>
<td>2</td>
<td></td>
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</tr>
<tr>
<td>Find &amp; access informa- tion created by others</td>
<td>4</td>
<td>7</td>
<td>2</td>
<td></td>
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</tr>
<tr>
<td>Provide comments &amp; feedback in groups</td>
<td>2</td>
<td>3</td>
<td>4</td>
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and effective user interfaces. SPONGE, the resulting system, encapsulates core functionalities that are needed for managing personal information and for seamlessly sharing personal information within knowledge networks. The evaluation revealed several limitations of SPONGE and facilitated the derivation of useful suggestions for improvements towards further take-up and exploitation of the prototype. Better control of automatically generated metadata at crawl time could be achieved; superfluous metadata such as ‘label’ should not be displayed to the end user. Standard symbols should be used for standard resources such as office files. Semanti-
cally similar notes (e.g., referring to previous uses of a specific resource) could be merged into a single note. Short textual descriptions of resources (either user-defined or automatically generated) would help users decide whether specific resources match their requirements. Better integration between SPONGE components can be achieved; action links can be added alongside the resources displayed in the results page to enable users to share resources in workspaces or the p2p network.

Our research provides some evidence about the usability and perceived benefits of light-touch interfaces for the SSD in professional business services, a highly representative domain of knowledge work. It helps in understanding the usefulness and limitations of applying semantic technologies and concepts in everyday tasks of knowledge workers. It revealed trade-offs for users in working and collaborating with more structured information. Issues such as performance, reliability and scalability are often considered challenging for enterprise semantic information systems. The field trial showed that pragmatic issues such as usability, interface design and terminology play a significant role in the design of ontology-based systems addressing end users, too, and should not be underestimated.

From the technological point of view, the SPONGE interface represents a set of light-touch gadgets that create bridges to information resources stored in different applications and environments. In developing the gadgets, we encountered various challenges, the main one being the lack of a standardised interface implementation for developing gadgets. As a guideline and proposal for practitioners wishing to develop similar interfaces to the SSD or similar platforms, we would suggest the interface definition language should be semantically-enhanced, while the actual communication protocol should support RDF as message payload. For the latter, some very good choices would be XML-RPC, or REST-based communication.

Besides technical considerations, a number of general working directions and principles can be provided to practitioners working on semantics-based desktop tools: One should explore novel interaction metaphors and GUI concepts such as gadgets, widgets or upcoming ones such as micro-blogging. Moreover, there should be support, technical and conceptual, for the stepwise formalization of ideas, explicit information, data, and metadata. Further, developers should invest in integrating added value services such as powerful recommendation algorithms. The integration of the PIM and collaboration functionalities should be as seamless as possible not only inter-alia but also with other everyday desktop tools and knowledge worker activities.

This research provides a reality check of the adoption of semantics-based PIM and collaboration tools by knowledge workers. The field trial showed that, provided usable interfaces are in place, semantics-based PIM and collaboration tools do provide benefits to knowledge workers. Even so, apparently, a complete adoption of such tools and replacement of existing ones does not seem likely. Reasons for this are related to the general mentality of not changing a system that is already there. But, at the same time, another reason is the fact that some aspects of semantics-based tools and SPONGE in particular are not clearly understood. In particular, our study showed that users do not feel comfortable working intensively with abstract concepts, even if these are presented to them via simple interfaces. Overall, we believe that more steps need to be taken before semantics-based desktop tools will prove to be a success. Further research should be directed towards new methods for lowering the barriers of applying semantic technologies to desktop applications and for facilitating everyday usage of semantics-rich models by knowledge workers.

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REFERENCES


Konstantinos Christidis holds a Diploma (2007) from the School of Electrical and Computer Engineering of the National Technical University of Athens (Greece). His Diploma Thesis was in the area of Web Services and Mobile Communications. He has also worked as an Administrator in the Computer Center of the School of Electrical and Computer Engineering. He is currently a research engineer at the Information Management Unit. His current research interests include ontology-based modeling, web services and incorporating semantics to the personal desktop and to collaborative workspaces.

Niki Papailiou graduated from the School of Mechanical Engineering of the National Technical University of Athens (Greece) in 2002. Her Diploma Thesis was on Risk Management in construction project. She then received her Diplom as Wirtschaftsingenieurin (equivalent to Master of Business Administration & Economics) from RWTH Aachen. Her thesis was on Quality Management in multi-national corporations, in which she took account of cultural differences and approaches. Her current research interests include knowledge management and business engineering. She is a teaching assistant in the Project Management course.

Dimitris Apostolou is a adjunct Lecturer in the Informatics Department of the University of Piraeus and senior researcher in the Institute of Information and Computer and Communication Systems at the National and Technical University of Athens (NTUA). He holds a PhD on knowledge management and decision support from the School of Electrical and Computer Engineering, NTUA, an MSc in IT with distinction from Univeristy College London, UK, an MSc in Chemical Engineering from New Jersey Institute of Technology, USA, and a Diploma Degree in Chemical Engineering from NTUA. He has an extensive experience as a management consultant. Dimitris is currently working in a number of research projects developing technological infrastructures that aim to leverage knowledge sharing, both at an enterprise and at an-inter-enterprise level. In the past he has participated in research and consulting projects in the areas of Geographical Information Systems, Data Warehousing and OLAP applications, Business Process Modeling as well as projects dealing with the technical analysis of energy and environmental systems.

Gregoris Mentzas is Professor of Management Information Systems at the School of Electrical and Computer Engineering of the National Technical University of Athens (NTUA) and Director of the Information Management Unit (IMU), a multidisciplinary research unit at the University. His area of expertise is information technology management and his research concerns the integration of knowledge management, semantic web and e-service technologies. He has spoken at conferences and guest seminars world wide, and is internationally known for his scholarly work in the area of knowledge management and e-government. Prof. Mentzas holds a Diploma Degree in Engineering (1984) and a Ph.D. in Operations Research and Information Systems (1988), both from NTUA.