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# E-Learning on the Social Semantic Information Sources

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**Abstract.** E-Learning grows on the fertile soil of the Internet technologies; it fails, however, to reach their full potential. With new, emerging technologies of the second generation Internet there is even more to be captured and adopted: knowledge sharing with blogs, wikis, and social bookmarking services. In this article we argue that those technologies can be adapted to improve user experience in e-Learning; we present an online social bookmarking system called social semantic collaborative filtering. SSCF supports SIOC metadata which ultimately transforms it in to a browser of blogs, fora, and other community sites. We show how a digital library system, such as JeromeDL, utilizing this technology can be used in the e-Learning process, which takes advantage of recent research in the Internet.

## 1 Introduction

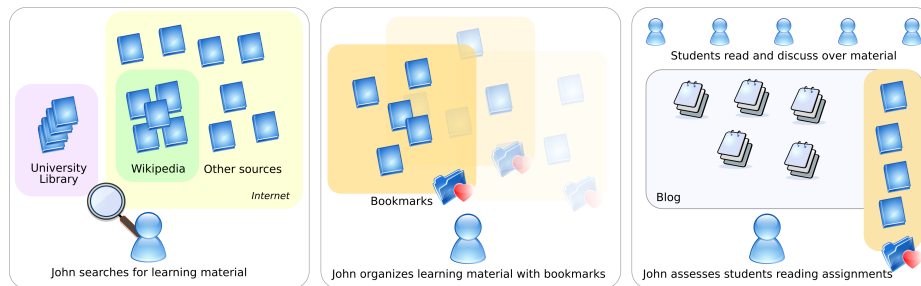
The Internet brings many changes to our lives; it helps to build an information society; it is sought to be a remedy for various problems, a new way of delivering various services. One of the services, however, which has not been facilitated by the Internet is e-Learning [20]; even though one can learn over the Internet, the style does not usually suit this new communication medium. The new, better Internet emerges through technologies, such as Semantic Web [2] or Web 2.0 [21]; the divergence with e-Learning, however, can become even more perceptible, unless the new technologies will be adopted to support e-Learning [26].

The new internet technologies, Semantic Web and Web 2.0, could be seen as competing solutions; the former focuses on delivering machine-processable content; the latter one defines collaborative computing services, such as wikis or blogs. Those technologies can be, however, combined [17] into a one, dynamic social semantic information source [7, 15]; e-Learning needs to leap-frog to using these new technologies in the most productive way.

In this article we present one possible e-Learning solution based on the social semantic information sources; we do not, however, claim that our solution is complete, but we expect it to be complemented with a number of other solutions, such as dynamic learning material assembling [26].

### 1.1 Use Case Scenario

Our motivation scenario finds John (see Fig. 1), a high school teacher, preparing a new course on biology for his class; his students, however, live in a number of small villages across the county; they attend classes over the Internet and they only meet twice a year for the exams.



**Fig. 1.** Use Case Scenario - John, a lecturer, prepares lessons for his students

John's course on biology consists of 15 lectures; each lecture is assisted with reading material. John would like to easily distribute the reading material related to each lesson a week in advance, no sooner, no later; he would like to make sure his students will read and understand delivered information. Furthermore he would like to pre-assess students based on their reading assignments and their comprehension of given material; additionally, he would like to pass the knowledge gathered by the current students to the next year's students.

John finds that most of the materials he would like to deliver to the students comes either from university library, Wikipedia, and other online sources. He also discovers that some bookmark sharing systems can help him with material delivering process. John decides to use a blogging platform to gather students opinions and references on the read material; he will assess his students' reading assignments based on their activity. The blog will also gather students' knowledge, which will be passed to next year's students.

John is quite pleased with his solution; he understands the potential of informal sources of knowledge, such as digital libraries, Wikipedia, bookmarks sharing, and blogs. He noticed, however, that using so many different services is time-consuming: he needs to discover the resources with different search features, and to bookmark them locally; then he copies bookmarks to shared space on the Internet bookmarking service; finally, he has to create a blog entry for each reading material item. John wishes there was an easier and more productive way.

## 1.2 Related Work

Blogs [3, 1] has recently become a major mean of the free publishing; they are used by many people to tell about their everyday life. Blogs are being applied to the commercial and political world [23]; companies use blogs to inform their clients about new product releases; politicians communicate through blogs with their electors. Blogs are also considered as one of the additional sources of e-Learning material [12]. Since blogs can be rich sources of information a number of research activities has been initiated to enrich blogs with semantic technologies. SemiBlog [19] allows users to link other resources related to the blog post, and semantically annotate the blog and the references. Cayzer [6] presents how blogs can be used to create a collective knowledge space. Finally, initiatives, such as the SIOC project [5], allow to export blogging metadata for further processing in semantic applications.

Sharing knowledge through social bookmarking services has become very popular; their implementations adapt one of two models: sharing tagged information or sharing folders with bookmarks. The former, such as del.icio.us<sup>1</sup>, digg<sup>2</sup> or connotea<sup>3</sup>, allow users to assign keywords (*tags*) to each resource they find interesting. The latter enables users to collaboratively filter information [8] by transcluding eachothers' folders [15]. A number of scenarios have been discussed for using online social bookmarking in enterprises [18]. Intriguing social aspects of sharing knowledge through social bookmarking have initiated research on the folksonomies [17] and data mining on social relations between bookmarks and users [25].

Social networks and semantic technologies are starting to be adopted by the e-Learning solutions [11]. Collaborative learning [22] is presented as a low cost model. The Didaskon project [26] delivers a course composition solution based on semantic annotations and social interactions. E-Learning has also gained focus from the digital libraries community; by adapting semantic web and social networking technologies digital libraries, such as JeromeDL [16], are becoming rich sources of e-Learning material [24, 26].

## 1.3 Contribution

This paper contributes to the subject of e-Learning and research on the online social networks:

- it presents how a digital library can be combined with services providing access to social semantic information sources;
- it exemplifies how modern e-Learning can benefit from a digital library system using semantic web and social technologies.

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<sup>1</sup> Del.icio.us: <http://del.icio.us/>

<sup>2</sup> Digg: <http://digg.com>

<sup>3</sup> Connotea: <http://www.connotea.org/>

## 1.4 Outline

This article is structured as follows. The next section presents how knowledge can be created using online community portals, such as blogs or fora. Section 3 describes how knowledge can be shared among members of the social network; followed by section 4 which presents how a knowledge repository can be extended to utilize social semantic information sources. Finally, section 6 describes future research planned by the authors of this paper; followed by conclusions in section 7.

## 2 Creating Knowledge in Online Communities

Online services, such as blogs, boards, or fora are based on collaborative contributions and interactions between the members of the online community. Users create a social network where they feel free to band together: share ideas and opinions, publish links and works, and comment them. Everything can be annotated and shared; therefore, a lot of relevant data are passed around. In fact, online communities live by virtue of users working together. Members can, based on given opinions, read a better article, watch a better movies, or bake an even more tasty cake by using a proven recipe. An online community becomes a powerful source of informal knowledge; this knowledge, harvested from the online communities, play a great role in the learning process.

It is easy to get lost among all information gathered. Users, however, can easily get lost, while navigating through this vast information space; without dedicated solutions they are presented with a garbage information. Online communities are also scattered in the Internet, and isolated from each other; it may be difficult to effectively harness relevant information [5].

SIOC<sup>4</sup> [5] is a framework for interconnecting online communities. SIOC can be used in publish or subscribe mechanisms; it stores community metadata, such as information about the post's author, enclosed links, the creation time, and connections with other posts. The core of SIOC framework is the SIOC ontology which is based on RDF [13]. The most essential concepts, defined in the SIOC ontology, are *Site*, *Forum*, *Post*, *Usergroup*, *User* [19]. A *site*, represented with a *Site* concept, is the location of an online community or a set of communities. *Forum* is a discussion area, housed on a site, where *posts* are published. A post can be an article, a message or an audio- or videoclip. Each post has an author, a member of an online community, represented by a *User* concept. Then, *Usergroup* is a set of accounts of users interested in a common subject matter.

After the success of the first version of the ontology, the SIOC community decided to expand the ontology with support for other collaborative services; it is now possible express data from services, such as wikis, image galleries, event calendars, address books, audio and video channels.

SIOC allows to exchange community data by importing and exporting information to/from different native vocabularies. SIOC-enabled sites take advantage

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<sup>4</sup> Semantically-Interlinked Online Communities: <http://sioc-project.org/>

of exchanging relevant information with other SIOC-enabled services. SIOC allows perform cross-site queries, topic related searches and importing SIOC data from other sites. SIOC can also provide statistics mechanism, e.g., to find the most active user. Finally, SIOC metadata can be detected by using crawlers or using browser plugins [4].

In the world of classic literature and classic teaching methods brick and mortal libraries were always perceived as the source of high quality information; this situation did not change much in the era of the Internet, digital libraries and e-Learning. The next generation Internet, however, is a convergence between social communication and semantically-rich information; therefore, it is pushing the goal posts for libraries even further. Digital libraries can no longer be *only* libraries; in order to serve the next generations of users they need to become isomorphic with other Internet services; they need to adapt both semantic web and social networking technologies, to continue their mission.

Digital libraries boast high quality information; their content, however, remains virtually immune to the knowledge acquired by readers; they are unable to pass the knowledge to other readers in forms other than "word of mouth". One of possible solutions is to allow users to extend the information space related to each resource with their own comments and thoughts; a blog or a forum platform can be integrated with a digital library system for that purpose. Users' comments, on library resources, in a form of blog responses can be integrated with other social semantic information sources, by exposing information using SIOC metadata, or similar. As a result, current readers can easily deliver new knowledge for future readers; this contribution, however, does not have to be constrained library world only; other users can facilitate this knowledge using SIOC aggregation services like PingSemanticWeb.com.

### 3 Sharing Knowledge in Social Networks

A social network is a set of people, with some pattern of interactions or "ties" between them [10]. A social network is modelled by a digraph, where nodes represent individuals; a directed edge between nodes indicates a direct relationship between two individuals.

In our scenario, John and his students are connected in one social network. Each individual has different interests, very often has more knowledge on one subject than the others. John can be seen as an expert in the subject (biology) he teaches. The main aim of the Social Semantic Collaborative Filtering (SSCF) [15] is to allow users to save the knowledge and share it with others.

Users maintain their private collections of bookmarks to the interesting, valuable resources. In other words, each user gathers, filters, and organises a small part of knowledge. What is important, SSCF allows a user to share this knowledge with others within a social network; one could easily import friends' bookmarks and utilise their expertise and experience in specific domains of knowledge.

In SSCF users collect the bookmarks and store them in special directories; each directory is semantically annotated using a popular taxonomies, such as

WordNet [9], DMoz<sup>5</sup> or DDC. They can be used to determine the content of the directory or to find the correct one. A student is able to easily find the subject or the topic, which she or he is interested in, related to the course that she or he attends to.

Another important aspect is the security in the SSCF. Very often users collect information that should be shared only within specific group of people: closest friends, class mates, students, etc. SSCF allows users to set fine grained access rights for every directory; access control is based on the distance and the friendship level between friends in the social network. For example, a resource can be shared only with friends with distance not bigger than two and at least 50% friendship level. *Distance not bigger than two* refers to maximal two degrees of separation between the owner and the requester. Friendship level is an extension to the FOAF model introduced with FOAFRealm [14] which allows users to express how well one person knows, or trusts, another. For example 0% can be interpreted as *Never met*, and 100% as *the best friend*. A user could freely set this value, according to her/his feelings. Friendship level between indirect friends is computed by multiplying the values on the path.

In our scenario John is able to share resources concerning the specific part of the course just after this part was introduced. With SSCF it is possible to have all bookmarks ready before starting the course. Initially all directories, one for each part of a course, have a strict access policy, so none of the students can access them. During the course John changes the access rights on the directories; students can easily find and import interesting bookmarks. They are able to broaden their knowledge in the topic that is currently taught at John's course.

## 4 Knowledge Repository on Social Semantic Information Sources

We have introduced the SIOC standard for knowledge creation (see Sec 2); we have presented possible ways of using it in online communities. We have presented SSCF (see Sec. 3) and explained how it can be used for knowledge sharing. In this section, we will show how we incorporate SIOC into SSCF and into the Social Semantic Digital Library - JeromeDL.

### 4.1 Problem Solution

The goal of Social Semantic Collaborative Filtering (SSCF) is to enhance individual bookmarks with shared knowledge within a community.

A user is given a chance to annotate directories of bookmarks with semantic information. Resources stored in one's bookshelf (collections of directories and bookmarks) can be browsed by his or her friends, who are interested in a particular subject and are allowed to access it. Furthermore, contents of directories one has access to can be easily imported to his or her own bookshelf. Users

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<sup>5</sup> <http://dmoz.org/>

can include information from different friends by importing their directories into her/his own.

The knowledge is based on the bookmarks of interesting and valuable books, articles or other materials. SSCF can be used to bookmark various types of resources, e.g., those provided by digital libraries; a digital library with SSCF can act as a knowledge repository. We can share bibliographic resources through the social network; this information can be enhanced with knowledge from other community portals, which also use SSCF service.

## **4.2 Bookmarking Community-based Content**

In the current Web, blogs become more and more popular. There are many different types of blogs; sometimes, they are published by a person with a good expertise in a certain domain. A lot of knowledge is also delivered through the Web fora; the discussions are topic-oriented. They, very often, contain solutions to problems, or point to other interesting posts, which add valuable views in to the debate. Such sources are rich in knowledge; therefore, it is crucial to use their potential. So far SSCF had no mean for utilising information sources like blogs or fora.

We have delivered such features by incorporating SIOC into SSCF model and SSCF bookmarks interface (see Fig. 2). There is a special directory dedicated for storing SIOC data in a private bookshelf. This catalogue can maintain three types of SIOC concepts (see Sec. 2); users can bookmark posts, or whole fora or sites. For each resource, it is possible to browse the content. The SIOC-specific resources behave just like classic SSCF ones; a user can copy a SIOC entry and paste it into another SSCF directory. This way, a standard knowledge repository is enriched with community based content.

In our scenario John was using a separate bookmarking tool for saving the links to the resources from the digital library and links to community sources (blogs). SSCF used in a digital library and enriched with SIOC creates the first step to the better knowledge repository. John can browse resources, then bookmark them, and finally incorporate knowledge from other interesting sources from the Internet in one place.

## **4.3 Resources Annotations**

In our scenario John has shared with students some material from a digital library; for each material he had to create a blog entry, where he was gathering the comments from students. With SSCF annotations and evaluations component, each library resource becomes blog post; users can comment on the resource directly in the digital library.

This solution brings a lot of opportunities for John; he can now track the progress of assimilating the material by the students; he knows their opinion on a specific resource. Furthermore, every student's comment enriches the learning material with additional knowledge. This knowledge can be utilised by the next



## Private Bookshelf



Fig. 2. SSCF Bookmarks interface with SIOC resource browsing

year's students. Year by year this will bring a broader and more complete view of a specific resource or topic.

SSCF annotations and evaluations component uses SIOC vocabulary. Every comment is saved as a SIOC resource (*sloc:Post*) and can be exported with semantic description. This can be reused later on in other pages or services. We can also display the comments on the resources in the SSCF bookmarks interface. It is an easy way to explore in one place the comments for many different and interesting, bookmarked by a member of the social network, resources.

## 4.4 Knowledge repository

Our solution allows John to incorporate in one place the digital library, social semantic bookmarking service and the semantic blog. John can store the resources required in his course, find and bookmark links to other interesting resources. These resources can be then shared with students in the correct order. Students are able to comment the resources in a blog-style discussion; the students are able to share and import the bookmarks to the bibliographic or community based resources, and browse all the bookmarks and resource comments with one interface.

## 5 JeromeDL - Social Semantic Digital Library

JeromeDL [16] is a Digital Library with semantics; it uses the SSCF component (see Sec. 4) for knowledge aggregation and sharing. Every library user can bookmark interesting books, articles or other materials in semantically annotated directories. Users can share them with others within a social network. We enriched the standard SSCF browser with the ability to bookmark and browse community based data. JeromeDL also has a feature which allows it to treat a single library resource as a blog. With SIOC based annotations users can comment the content of the resource and in this way create a new knowledge.

### 5.1 Integration process

The application and technologies mentioned in the paper are based on the Semantic Web technology. JeromeDL and SSCF are built upon the Semantic Web standards, they store and exchange RDF data. JeromeDL and SSCF define an ontology which describes how the information is organised and how resources are related to each other.

The role of SIOC is slightly different; the SIOC project defines an ontology that can be used to describe the community-based content on the Web. Information on blogs and fora described with SIOC is easier to find and connects with other sources. Applying SIOC to the Web resources increases their interoperability.

To achieve our goals and build the social semantic digital library we had to:

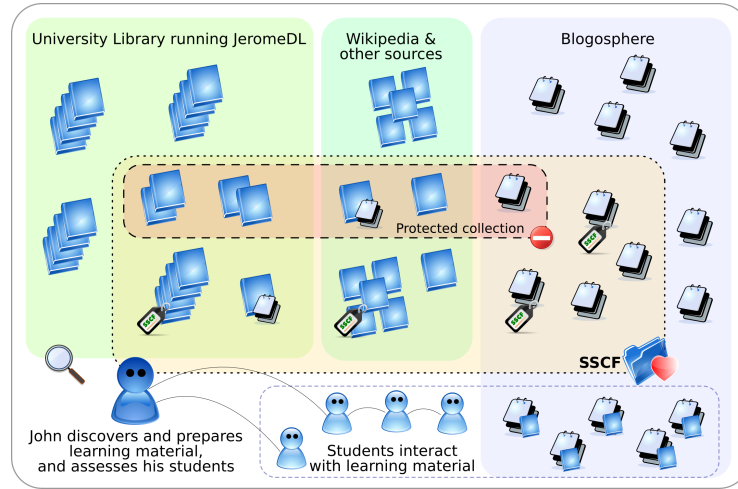
1. Support the SIOC ontology in both JeromeDL and SSCF – since both applications use RDF, for storing and exchanging information, SIOC information is handled on the data (RDF) level.
2. Align the SIOC ontology with existing ontologies – the knowledge added by the users of digital library is saved with SIOC concepts.

*SIOC ontology support* In our social semantic digital library users can bookmark an interesting post, forum or site by giving its URL. We use SIOC Browser<sup>6</sup>, which takes the URL of the post, forum or site, to access RDF with SIOC metadata about the given URL. The description is filtered out from unnecessary information which could make the bookshelf unclear and difficult to browse. All relevant data is saved in the SSCF RDF repository.

The SSCF module which generates the bookmarks tree was enhanced to be able to display SIOC information. As we already mentioned (see Sec. 4.2) the SIOC-based items are saved in a special directory and can be browsed just like the standard SSCF resources; they can be freely pasted into the bookmarks directories. The interface is based on AJAX technology, so all actions on bookmarks or directories are performed in a real time, without reloading the browser window.

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<sup>6</sup> <http://sparql.captsolo.net/browser/browser.py?url=URL>



**Fig. 3.** John prepares lectures with SSCF and JeromeDL

In JeromeDL users can annotate and evaluate the resources. Our implementation is based on the integration with SIOC ontology (see Sec 4.3). Annotations and Evaluations are stored as a SIOC:Posts (with limited number of properties, see Tab. 1) in an RDF repository. JeromeDL displays this information in the resource description page. Therefore, each resource can be treated as a blog post. A registered user can comment on a resource or others notes the same way he used to annotate a generic post on a blog or a forum. Consequently, relying on the community opinions, a user filter out a proper resource out of many.

The annotation mechanism was implemented in the AJAX technology. When user reads a resource, she/he can read summarises of the discussion threads as well. The thread could be expanded to show the full content of the comment and all the possible replies. A user can write her/his own annotation or reply to the existing one. It is also possible to export the annotations in SIOC RDF.

**Table 1.** Aligning SIOC:Post concepts with the information about the annotations in JeromeDL.

Class or property name	Description
sIOC:Post	Annotation of the resource
dc:title	Title of the post
sIOC:related_to	Points to the annotated resource
dc:description	Body of the annotation
dcterms:created	When the annotation was created
sIOC:has_creator	Author of the annotation
sIOC:has_reply	Represents a reply for that annotation

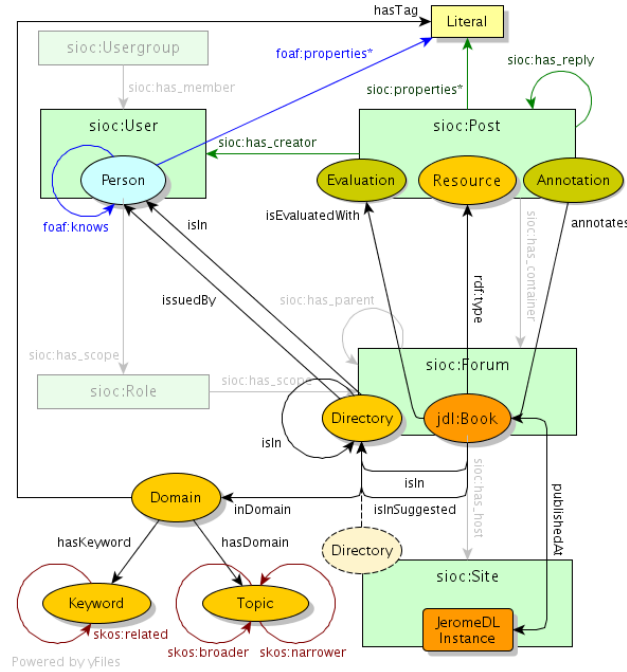
*Ontology alignment* To fully utilise the benefits of JeromeDL and SSCF integration with SIOC we needed a compliance of the used ontologies. The main reason for doing this would be the ability to expose the information gathered in JeromeDL (especially in resources blogs) in an understandable SIOC format. We achieve that by creating some content using SIOC metadata and delivery mediation mechanism for other SSCF/JeromeDL content (see Fig. 4).

A module for annotating and evaluating the content in JeromeDL uses the SIOC:Post class for representing the information in RDF. There is no need to map or translate this resources; they are ready to be exported.

The rest of the classes in SSCF and JeromeDL ontologies required mapping to the SIOC ontology. A JeromeDL instance is presented as a site containing the fora; a forum represents the resource in the digital library - JeromeDL's book concept. Directory, the SSCF class, can also be seen as a Forum or as a Site (a root directory). A user (Person) is translated to SIOC:User; the Resource is simply mapped into SIOC:Post concept.

## 5.2 Evaluation

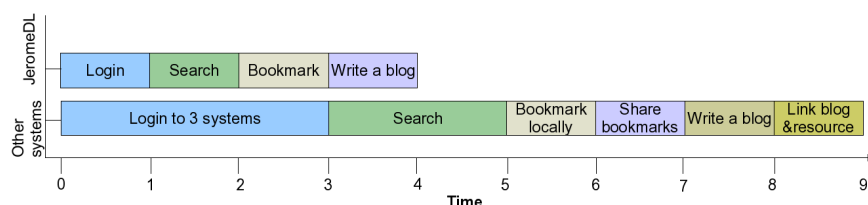
We have created a complete answer to the problem stated in the scenario (see Fig. 3). Based on JeromeDL we have built a platform that joins three separate



**Fig. 4.** Alignment of SSCF and SIOC ontology

applications: digital library, blog and bookmarking application. Eventually we created a social semantic digital library, which answers John's needs; is a place where he can keep the resources needed for his biology course and any additional materials which can help him. In the JeromeDL, every resource becomes a blog (with SIOC support), so John can track his students opinions and progress. SSCF incorporated into JeromeDL, allows John and his students to freely create, share and import bookmarks to the resources. With SSCF and SIOC integration also community based materials can be added and browsed with SSCF interface.

Integration of services provided by JeromeDL platform clearly decreases effort needed for completing the described scenario. We present a simplified comparison of times (see Fig. 5) required to perform a sequence of activities done by John in order to prepare the course. Using JeromeDL with SSCF component, it takes roughly half the time, to perform all necessary actions, than by using standard, separate solutions.



**Fig. 5.** Comparison of time required for performing a task with JeromeDL and other systems

John finds out that working with an integrated platform such as JeromeDL is less time consuming. He spends less time on logging-in to different systems and searching through them. John can immediately bookmark resources and start a blog about them, without copying or linking to other systems.

To summarise, JeromeDL became a service that allows users to keep old and create new knowledge. It is a tool that can be very helpful in many domains, especially in e-Learning. JeromeDL is a place where a community meets and individuals influence each other.

## 6 Future work

Currently, we are developing SSCF into a few directions. One of them is turning SSCF, enriched with SIOC, into a universal bookmarking tool for the Internet.

SSCF will offer many interesting features that are currently not part of Web bookmarking applications. One of these is a fine grained access rights control to the bookmarks. For instance, a user can share a directory only with her/his closest friends, other directories with co-workers, or the family. In almost all current bookmarking services it is not possible as they allow a user to only say that some of bookmarks are private or public.

Another interesting SSCF feature is connected to the SIOC integration. A user is able to take advantage of semantically enabled blogs and easily, with one click, insert them into the bookmarks structure with all related information. The blog can then be browsed from the bookmarks interface level and blogs, fora and posts can be freely mixed with standard Internet bookmarks.

In the further stream of development, SSCF is separated from the FOAF-Realm project and moved into the new project called Social Semantic Search and Browsing (S3B). S3B will consist of SSCF, multifaceted browsing and query expansion modules. It will play a service role to other applications in which developers would like to use advanced methods of search and retrieval. It will be based on SOA (Service-Oriented Architecture) layer and will use REST Web Services approach. It will expose the features of SSCF to other applications in a simple and clear way, based on the HTTP protocol and unique identifiers of resources.

## 7 Conclusions

The integration of social semantic information services into an e-Learning architecture provides capabilities that have not existed to date. e-Learning needs new models of interaction and knowledge sharing to move beyond the existing page turner style of systems. A more collaborative architecture is needed to provide tomorrow's students with learning environments that mirror the data rich, virtual community driven world they live in.

Social semantic information services provide this collaborative architecture. They support the complex interactions which learners can use to trade information, express knowledge, achieve consensus and synthesise knowledge from e-Learning environments.

An example of this is the synthesis of knowledge possible when collaboration is supported in a semantic fashion. As multiple users collect information on a subject, from differing sources and in differing types, a social semantic network can be enabled which aids in the correlation and validation efforts of the users. For example, video clips being harvested from the web on a topic such as procedures in a bio lab can be correlated with another user's collection of bookmarks to Wikipedia articles, university class notes, and online e-books. Another user collects still images of related techniques. The semantic nature of their collaboration environment then aids them in associating the This supports validation or usefulness of materials by illuminating the relationships between the learning objects and by isolating those which do not pertain or which cannot be confirmed through a resolution with other elements

In a business context, a task team in an organisation would use such a semantically powered community environment to interrelate policy documents to historical operations. For example, one user collects invoices and accounts payable documents while another researches corporate policy documents on compliance and governance. The semantic nature of the collaboration environment (SIOC, SSCF, and JeromeDL) provides the ability to interrelate the policy documents

(large, unstructured, and with the knowledge deeply encoded in language) with the business documents (small, structured, and with more precise records of events).

This works if both types of documents are tagged with semantic information either as they are being reviewed or, more preferably, when they are being stored. The best way for this tagging to be accomplished remains an open problem, but SIOC and SSCF provide ways forward.

Both examples (and the story of John elsewhere in this paper) result in synthesis of knowledge. At the outset, the community has a rather scattered and disconnected set of knowledge. At the completion, it has been correlated and what has emerged is not only the better organised dataset, but new knowledge about the relationships between the components, a consensus view from the community as to what elements are important and which are valid and which are in-valid. From that view, the entire community is better aware of the knowledge that was, before the effort, hidden not just in the documents and images and videos, but hidden in their lack of connectedness.

If this approach is applied to an e-Learning task, one sees formal learning objects distributed in a learning space. Instructors posed with the task of creating a course about the specifics of a topic (business compliance policy for example) can collaborate to build examples and exercises, reusing resources and being better assured that the results are both accurate and relevant. Students can form collaborative communities to study the formal source material thus created, followed by dynamic exercises using the same original objects from the semantic digital library. Finally, the now trained personnel can use the same collaborative environment to research and extract knowledge from the live data and documents. The semantically powered environments for collaboration extends from the trainer to the trainee to the professional.

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