Linking Semantic Personal Notes*

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Abstract. Semantic Web technologies are available and gain popularity both on the Web and on the desktop. However, in spite of common representation formats, personal and online data is still difficult to interlink, notably because of the different vocabularies used to describe it, as well as the lack of common identifiers between desktop and Web-based applications. In this paper, we describe a process for easily publishing and sharing of personal notes as Linked Data. Our approach can be used to publish any kind of information from the desktop to the Web, enabling integration of small chunks of personal knowledge into the Web of Data and focusing on a user-driven approach of knowledge management.

1 Introduction

Semantic Web technologies are now deployed in various domains and applications. Among the different sub-domains of the broader Semantic Web vision, two relevant fields are the Linked Data initiative, focusing on global interlinking on the Web, and the Semantic Desktop, focusing on personal information integration. While these two domains share compatible representation models (RDF(S)/OWL), there is still a gap between data from the Web and the desktop. Among others, vocabularies that they use are generally not well integrated and identifiers (URIs) are generally distinct. Such gap can be explained as the Semantic Desktop focused on using local identifiers and desktop-related ontologies, while the Linking Open Data (LOD) initiative focused on the global reuse of identifiers and ontologies.

In this paper, we tackle a particular issue regarding the integration of data from these two environments, offering an approach for publishing personal notes from the desktop (using Semantic Desktop technologies) to the Web (using the Linked Data principles). Especially, our need is to publish this data online without losing the personal context established on the desktop. Our approach consists of two main steps: (i) preparing the desktop data for sharing, and (ii) publishing it online. In addition, it requires two prerequisite steps, which are not the focus of this paper: (i) the note-taking process and annotation of the note (adding

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the context), and (ii) the identification of Web URIs which represent the same real-world thing as the desktop resources that belong to the context of a note. We will however describe (in less detail) these two initial steps to give the entire view of the workflow.

Transferring personal desktop data online requires some issues to be properly addressed. To achieve this goal, our contributions include: (i) mappings between the relatively small number of desktop vocabularies and the most popular Web vocabularies. The mappings are used in the transformation of the desktop data, represented with the desktop ontologies, to data represented with the Web vocabularies, ready to be published online; (ii) a process for publishing of desktop information on the Web using the Linked Data principles, while protecting the sensitive private data from being shared unwillingly, and (iii) a system implementation that allows sharing of semantic personal notes as semantic blog posts, interlinked with existing information within the LOD cloud.

The remainder of the paper is structured as follows. We first describe a motivating use case, from which we identified the main requirements of our system (Section 2). In Section 3, we continue with the background work on which our approach is built. Section 4 details the process and its realisation, focusing on the ontology mappings and the software architecture, and Section 5 evaluates the conformance of the system with the initial requirements. We then discuss related work and some challenges and lesson learnt we have found when implementing the system, before concluding the paper.

2 From Note-Taking to Weblogging: Use Case and Requirements

Two relevant characteristics of blog posts are: (i) their topics are of interest to the author and thus are very likely to have references to things present on the desktop (e.g. people, events); (ii) they belong to a context consisting of the references made in their content, such as places, projects, or other blog posts However, not all blog posts start by being a blog post. Some are just ideas or impressions jotted down for later, in one's preferred desktop note-taking application. Nevertheless, some of these notes do become posts after polishing and refining.

Tools from the Semantic Desktop [1] provide means to enhance these notes locally, by interlinking them with other desktop data — the contacts in the address book, the events from the calendar application, the projects worked on, the music listened to. Semantic note-taking tools like SemNotes[1] automatically generate relations between the notes and the desktop things mentioned in their content. For example, it allows to link one note about an upcoming concert to the performing artist which is in turn linked to the music files of that artist and pictures from earlier shows stored in a desktop photo application. Such annotations give context to the note and should be preserved when the note is published as a blog post on the Web, since it enables serendipitous browsing and information discovery, through the relevant additional links they contain.

[1] `http://smile.deri.ie/projects/semn`

Currently, personal notes, even the ones semantically enriched using Semantic Desktop applications, must be published as blog posts by being manually copied into a blogging tool. In this way, any additional semantic information available on the desktop becomes lost or, if copied, leads to broken references as they point to the local resources which are not accessible outside of the desktop. The note-taking to publishing process is sometimes shortcut by using the drafting functionality that some systems like WordPress or Blogger offer, so that users can directly take the notes in the blogging tool, usually online, thus replacing the desktop note-taking application. Using online tools deprives the user from having the personal context automatically added to the blog post, since desktop information cannot be easily integrated in Web-based interfaces.

In order to enable a better translation from personal notes to blog posts, or simply to Web-based information available to others (for example, meeting notes published in a company intranet or lecture notes shared between students of a same class), we defined a list of requirements that a system for publishing semantic personal data online should fulfil:

R1 Publish the complete desktop data on the Web without losing any relevant information, including metadata and context (e.g. tags, relations, identifiers);
R2 Protect any machine readable and private data that might be unwillingly be included in the context being transferred;
R3 Publish the note according to the Linked Data principles and describe it use popular ontologies;
R4 Enable object-centred sociality by establishing connections between data published by different users.

3 Overview of the Approach

3.1 Background

In order to enable our approach for publishing notes from the desktop to the Web, we reused previous work and software components already available. In this section, we present them briefly and explain why we chose them and how they contribute to the global picture that our architecture provides.

Semantic Desktop. Extensive research has been done in the area of the Semantic Desktop. Systems like Haystack [2], IRIS [3] or NEPOMUK [1] bring Semantic Web technologies to the desktop. The vision of the Semantic Desktop is to create a space of interconnected resources, where applications encourage linking between new and existing resources and provide new and easy ways of browsing, searching and organising the data.

Our solution builds on the NEPOMUK realisation of the Semantic Desktop, more precisely Nepomuk-KDE[2]. It extracts metadata from the desktop (*i.e.* from files, address book, calendar, task manager, etc.) and integrates it into a central repository, making it available to all applications. The data is described using

[2] `http://nepomuk.kde.org`

a common representation – Nepomuk Representation Language (NRL)[3], and a set of ontologies[4], known as "desktop ontologies". They describe the desktop data, at different levels of abstraction, and can be complemented by additional ontologies, like Xesam[5].

SemNotes. SemNotes is a note-taking application for the NEPOMUK Semantic Desktop, which uses semantics to save the context of each note by linking it to the relevant desktop resources mentioned, such as people, events, projects, etc. It uses the "desktop ontologies" to describe its data structure and the relations between the notes and other resources from the desktop. We decided to add our Linked Data publishing functionalities to an existing note-taking application as SemNotes for two reasons: (i) usually blog posts or online articles start as personal notes that are refined until ready to be published, as we discussed earlier, and (ii) a familiar application such as SemNotes is more likely to be used than a new one, notably as users will not have to learn a new systems but keep to their existing note-taking habits.

Linked Data. The term Linked Data was first introduced by Berners-Lee in 2006 to define a set of best practices for publishing data on the Web [4]. In addition to these principles, the recent Linking Open Data[6] initiatives enables the creation of a huge amount of interlinked RDF data on the Web, from various datasets, ranging from HCLS information to the BBC programmes. Our system takes advantage of this increasing amount of structured data, about various kinds of entities available online [5], for defining and using identifiers so that desktop information and Web information can be related.

3.2 Overall approach

We propose an approach that enables the publishing and sharing of personal notes by extending the functionality provided by SemNotes. The process consists of two steps: (i) transformation and (ii) publication. In the first step, the note is transformed locally for publication, and private local data is replaced with public server references. In the second step, the transformed note is published online on a dedicated server, where the resources referenced and the tags assigned, are shared between the notes of all users. As we mentioned above, there are also two prerequisite steps: (i) the note-taking process and semi-automatic annotation of the note, which is the usual note-taking approach, and (ii) the identification of Web aliases for the desktop resources related to a note, where URIs are mined from the Web for locally defined resources, such as people, events or projects. These steps are required in the workflow, but will not be detailed in this paper.

The first prerequisite step — note-taking and annotation of the note with the relevant desktop resources — must be performed before any actual sharing of

[3] NRL is an extension of RDF which provides named graphs and a closed world assumption more suitable to the desktop environment.

[4] `http://www.semanticdesktop.org/ontologies/`

[5] `http://xesam.org/main/XesamOntology`

[6] `http://linkeddata.org`

notes can be done. The annotation is done semi-automatically and is an existing feature in SemNotes. For each note, the user is offered a list of possible related desktop resources from which he can choose the relevant ones. When a resource is chosen, a link (*i.e.* an RDF triple) is created in the local repository between it and the note.

The second prerequisite step consists in finding Web resource for each of the desktop entity linked to the note that is about to be published. This step is currently executed by a desktop service that relies several Semantic Web indices (*i.e.* Sindice[7]) and public SPARQL endpoints (*i.e.* DBpedia, Semantic Web Dog Food Server) to retrieve results. The matching process is based on the one described in [6], which we developed further, to include more types of desktop resources. It is based on a combination of methods: type and property mapping and filtering and a combination of string matching algorithms. The service has access to, and uses all the information available on the desktop about a resource to identify only exact matches for it.

4 System Implementation Details

Based on the process described in the previous section, we engineered a system for publishing personal notes on the Web. The system is divided between its local part and its remote part, as shown Figure 1. The local part handles local *private* data, while the remote one handles online *public* data. The separation between them extends over 3 layers: ontology, data and application. On the *ontology* level, the NEPOMUK desktop ontologies are used locally while popular Web vocabularies are used on the server-side. These ontologies are used to describe the *data* exchanged between the applications. Desktop data is stored in the local NEPOMUK repository, which is provided with any NEPOMUK installation, while Web data is distributed in the Linked Data cloud. Finally, on the *application* level, the local component is an extension to SemNotes that provides publishing functionality for notes, and the remote component is a server that hosts and publishes online the notes received.

The first step of the process is executed on the local side, by an extension of the SemNotes application. Then, the publication step is done by the server, which receives information from the desktop and publishes the note, as we will describe next. These two application components, the communication between them, and the data translation process are described in detail below.

4.1 Ontologies

Although both the Semantic Desktop and the Semantic Web use the same representation languages, *i.e.* RDF(S)/OWL, they use different vocabularies to describe their data. This vocabulary gap makes data integration difficult. The NEPOMUK project uses "desktop ontologies" to describe its data. The central ontology here is the Personal Information Model[8] (PIMO). SemNotes represents

[7] `http://sindice.com/`
[8] `http://www.semanticdesktop.org/ontologies/pimo/`

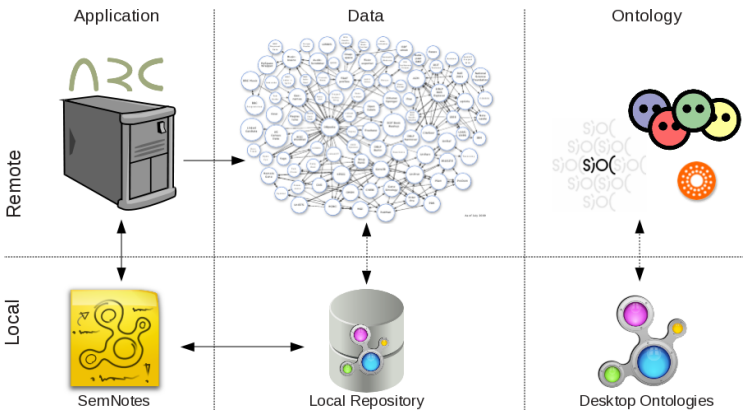

Fig. 1. Overview of the system.

personal notes as instances of `pimo:Note` and are linked to the `pimo:Things` they mention by the relation `pimo:isRelated`. When a desktop resource is found to represent the same real world entity as a Web resource, the relation is stored on the desktop as `pimo:hasOtherRepresentation`. This property is recommended by the PIMO specification as desktop equivalent to the `owl:sameAs` relation, although without the formal semantics that the latter provides. We also use the property `pimo:hasOtherRepresentation` to store the remote URL of a note when it is published. The property is replaced with `pimo:hasDeprecatedRepresentation` if the note changes on the desktop after publication.

While well-suited to represent desktop information, these ontologies are not used, so far, on the Web. However, numerous vocabularies have emerged for describing semantic data published online. Among them, a limited number have gained wide-spread adoption, including: (i) FOAF for describing people and their social relations; (ii) SIOC for describing communities and their interactions; (iii) DOAP[9] for software projects; (iv) GeoNames[10] for geographic information; (v) the Music Ontology for music-related information; and (vi) models such as Dublin Core for general metadata or SKOS to represent lightweight controlled vocabularies. Such ontologies have now been widely adopted and are recommended as best practices when publishing data on the Web [7].

Consequently, while representing similar objects, the two sets of vocabularies must be aligned so that on the one hand, desktop information can be moved to the Web and understood by usual SW applications (that rely on the aforementioned vocabularies) and on the other hand, Web information could be understood and imported by SD applications. In order to enable interoperability between the desktop and the Web, we defined mappings between the sets of

[9] `http://trac.usefulinc.com/doap`
[10] `http://www.geonames.org/ontology/`

Class	Subclass of
pimo:Note	sioc:Post
nao:Tag	sioct:Tag
pimo:Person	foaf:Person
pimo:Project	doap:Project
pimo:Event	ical:Vevent

Property	Subproperty of
nao:prefLabel	rdfs:label
nao:created	dcterms:created
nao:lastModified	dcterms:modified
nao:hasTag	sioc:topic
pimo:isRelated	sioc:related_to

Table 1. Sample of the mapping between (i) classes, and (ii) properties.

ontologies. The mappings create appropriate subclasses or subproperties of the relevant concepts from the chosen vocabularies.

SIOC is probably the most widely used vocabulary for interlinking social media within the Linked Data cloud. There are already many tools for creating and using SIOC data [8]. This is why we chose to represent the `pimo:Note`s as `sioc:Post`s when they are published online with our system. The rest of the desktop resources are also transformed into concepts from the vocabularies listed above (see Table 1 (i)), the mappings being published at `http://rdfs.org/sioc/nepomuk`. The note's properties, like title, creation and last modification time, are translated to the appropriate Dublin Core properties: `dcterm:created`, `dcterms:modified` and `dcterms:title`. The tags associated locally to the notes are transformed into `sioct:Tag`s associated with the post using the `sioc:topic` property. Table 1(ii) lists the proposed mappings for properties[11].

4.2 Server Schema

In order to publish the resources with a consistent URI scheme, we defined patterns for naming of the various objects published from the desktop on the Web. In the schema definition, we apply several Linked Data patterns described in [9]: (i) *patterned URIs* for all the entities, to make them more human readable; (ii) *proxy URIs*, (iii) *annotation* and (iv) *equivalence links* for the resources related to the notes, to unify various sources; (v) *natural keys* in the tag URIs.

For each note the server generates a new unique identifier `id` which is used to create the note's URI in the form: `http://semnotes.deri.ie/notes/note/id`.

According to the *proxy URIs* identifier creation pattern, we generate new URIs for the resources related to the notes. This ensures that the publishing process is consistent and avoids having to choose among several Web aliases a resource could have. Like the notes, each resource has a unique identifier on the server, which is used to create the resource URI according to the following format: `http://semnotes.deri.ie/notes/resource/id`. Each resource is shared by all the notes that link to it, which increases the interlinking and the consistency of the data. For each resource, the server keeps internally a list of Web aliases (*i.e.* Web URIs that were found to represent the exact same real world thing) using `owl:sameAs` links.

[11] Although `nao:lastModified` and `dcterms:modified` do not have the same semantics, defining subproperty relations between them is acceptable.

Tags are considered a particular type of resources, and are also shared on the server. The specific format for the URI differentiates them from regular resources: `http://semnotes.deri.ie/notes/tag/label`. The label of the tag acts as a unique identifier, and is case sensitive. They are created on the fly, and are persisted when they are used for the first time.

Non-information resources[12] also got their own URI, and we distinguish URI of the resources and URIs of the pages describing them.

4.3 Transformation of the Note for Sharing

The first step of the process consists in the preparation of the note for publishing. This phase consists of including all the relevant information about the note in the content, specifically the title, creation and last modification time, the tags and the referenced resources. This transformation is necessary, so that less only the HTML content of the note is sent to the server, and not the entire RDF graph describing the note. The content is already stored as HTML, but to include in it all the metadata about the note, it has to be enriched with RDFa before it is posted to the server.

The preparation step is done on the desktop side, by the extension to the note-taking tool, but still requires to communicate with the publishing server to retrieve Web URIs for the note and the linked resources. In case the note has already been published, the user can overwrite the old post (on the Web) or create a new one. Depending on this choice, the server is requested a new URI or the existing one is used (that was saved in the local repository when the note was published the previous time). The referenced resources are shared by all the published notes, therefore the server must create the URI for a resource only if it has not been created before. To decide if a local resource already has a server URI created, the list of Web aliases found for it — in the second prerequisite step of the process — is sent to the server (see Fig. 2). If a resource with the same type and a similar list of aliases exists, the server reuses it, otherwise it creates a new one and saves the information about it in its own RDF repository. On the server, the URI aliases are saved as `owl:sameAs` as it is customary for Linked Data. The server URIs for the note and the resources are also stored on the desktop for reuse, as `pimo:hasOtherRepresentation`.

The communication between SemNotes and the server is done with a single REST call, in order to minimise network delays. The reply contains the newly created URI for the note, if one was required, as well as a list of server URIs for the resources (see Figure 3).

Using the information received from the server, the note content is enriched with RDFa. The metadata about the note, like type, creation and last modification times and the tags, is added in `meta` tags in the `head` of the HTML page. RDFa is added to the `title` tag and in the `body`, to the links. Figure 4 shows the content of a note prepared for publishing.

[12] For a discussion about *information resources* and *non-information* resources, we refer the reader to `http://www.w3.org/TR/webarch#id-resources`

```
{
    "id" : "",
    "resources": [
    {
        "id": "nepomuk:/res/bfcdcd1a-4898-492f-940b-4cc4c67799a7",
        "type": "mo:MusicArtist",
        "uris": [
            "http://dbpedia.org/resource/Scorpions_(band)",
            "http://musicbrainz.org/artist/c3cceeed-3332-4cf0-8c4c-bbde425147b6"
        ]
    }
    ]
}
```

Fig. 2. JSON formatted message sent to the server.

```
<note uri="http://semnotes.deri.ie/notes/note/4baccab834e20">
    <resource local="nepomuk:/res/bfcdcd1a-4898-492f-940b-4cc4c67799a7"
              uri="http://semnotes.deri.ie/notes/resource/4bacca84ca8bb"/>
</note>
```

Fig. 3. Server reply with the server URIs for the resource aliases sent.

4.4 Publication Step

After preparation step, which takes place on the desktop side, the RDFa enriched content is sent to the server via another REST call. The publication step of the process only handles public data. When the content is received it is parsed and the server extracts the contained RDF triples and stores them in its repository. The content (as it is received) is also stored.

The server implementation uses ARC2[13], as it provides out of the box RDFa parsing and an RDF repository. It is easily deployable due its minimal setup requirements (a PHP enabled Web server and a MySQL database), thus making our system easily deployable as well.

[13] `http://arc.semsol.org`

```
<!DOCTYPE html PUBLIC '-//W3C//DTD XHTML RDFa 1.0//EN'
                      'http://www.w3.org/MarkUp/DTD/xhtml-rdfa-1.dtd'>
<html about="http://semnotes.deri.ie/notes/note/4baccab834e20">
    <head>
        <meta content="sioc:Post" property="rdf:type"/>
        <meta rel="sioc:topic" href="http://semnotes.deri.ie/notes/tag/concert"/>
        <title property="dc:title">concert sunday</title>
    </head>
    <body> ...
        <a rel="sioc:is_related"
             href="http://semnotes.deri.ie/notes/resource/4bacca84ca8bb">Scorpions</a> ...
    </body>
</html>
```

Fig. 4. RDFa-annotated XHTML content of note.

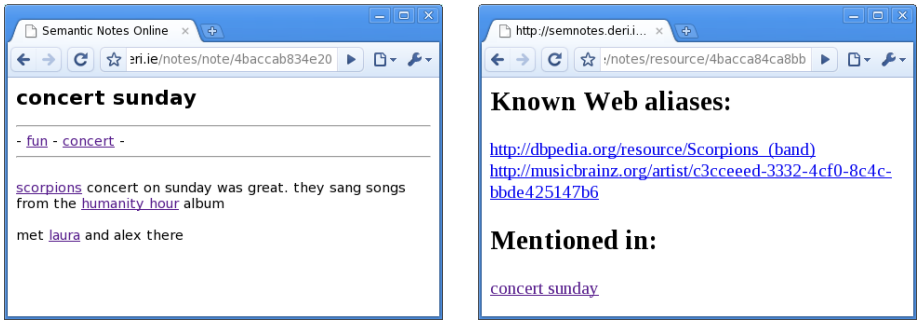

Fig. 5. Online view of a note (i) and a resource (ii).

All server URIs are dereferenceable, as required by the Linked Data principles. For notes, the URI redirects to the RDFa annotated HTML page containing the note itself (as shown in Figure 5 (i)), the URI of the note being the URL of this page. For the linked resources, the URI is also dereferenceable and provides RDFa information about itself, linking to the known existing Web aliases of the same resource. The description also includes a list of backlinks to all the notes that reference the resource (see Figure 5 (ii)). The page for a tag will contain backlinks to all the notes tagged with it.

The RDFa annotated page for the note is generated on the user's desktop by the SemNotes plugin, as we have seen in the previous step, while the one describing each resource and tag is generated on the fly, by the server, when the URI is requested.

5 Conformance with the Initial Requirements

When establishing the specifications of the framework, we identified four main requirements (Section 2). Our proposal conforms with them as follows.

R1*: Publish the complete desktop data on the Web without losing any relevant information, including metadata and context (e.g. tags, relations, identifiers).*
By translating existing desktop data in RDF an putting it online, available as RDFa, the whole information available on the desktop side is made available on the Web for further reuse. In addition, all information from the original note-taking tool, including title, tags, etc. is publicly made available on the Web.

R2*: Protect any machine readable and private data that might be unwillingly be included in the context being transferred;.*
By replacing the private desktop data with equivalent public Web data, we protect the former. On the desktop there is much private personal information stored about the resources, like the email address or telephone number for people, or the list of attendees of an event. When the person or event linked to by a note that is afterwards published online, such private information is not exported, because the reference to the local resource is replaced by a reference to already

public Web data representing the same thing. In this manner, the context of the note being published is preserved, but the private details are not exposed.

***R3**: Publish the note according to the Linked Data principles and describe it use popular ontologies.*
Our system publishes notes on the Web using the Linked Data principles. Each note has its own URI, as well as resources, and these URIs are made dereferenceable, while distinguishing information resources and non-information resources. In addition, while original desktop data is provided using "desktop ontologies", the published information is made available using FOAF, SIOC, Dublin Core, etc. and the mappings have been validated through Vapour[14].

***R4**: Enable object-centred sociality by establishing connections between data published by different users.*
Since resources and tags are shared between users, notes can be browsed serendipitously through shared topics, or tags. This enables "object-centred sociality" [10], since people can interact around these shared tags and topics, such as projects or people that they know in common.

6 Related Work

Semantic blogging has received much interest since it was introduced by Cayzer and Shabajee in [11], and later when Karger and Quan described semantic blogging in the context of the Semantic Web with the Haystack browser [12]. So far, existing systems for semantic blogging fall into two categories: (i) desktop applications that involve publishing the actual local resource information together with the blog post, or (ii) online application that does not have access to desktop data relevant to the user.

The main benefit of the first category, represented by tools like SemiBlog [13] or SemBlog [14], is the fact that the user has better access to the relevant data from the desktop. However, both tools require that the resources that contain sensitive private information are published together with the blog post, which might lead to privacy issues. The SemBlog project allows users to add data from personal ontologies to their blogs. SemiBlog, allows integration of personal data in the posts by drag in drop from various desktop applications like the address book. They are used for exchange of personal information in the blog posts, which differs from our approach of using already published web data as to protect the privacy of the personal information. The process described implies manually adding the metadata, while our approach relies on automatic export. Both tools comply with our first requirement, but not with the last three.

Online services like BlogAccord [15] for music information or Zemanta[15] blogging assistant, belong to the second category. They have access to various online resources to create the context of a blog post and enhance the blogging experience, but not to the personal context of the user.

[14] `http://vapour.sourceforge.net/`
[15] `http://www.zemanta.com`

7 Conclusion

In this paper we presented an approach for publishing personal notes as Linked Data on the Web. The aim of our work was to provide a way for publishing and sharing complete information by preserving the personal context of the notes without compromising privacy. Our solution makes a step towards bridging the gap between Semantic Desktop data and Linked Data.

We defined a publishing process that comprises two steps: (i) preparation – the note is transformed into a SIOC-based Web representation; and (ii) publication / sharing – the note is published online following the Linked Data principles. In addition, we provided a related implementation and tested it against a set of requirements regarding publishing personal content from the desktop to the Web as Linked Data. While we do not address security issues in this current release, we consider SW-compliant authentication systems such as FOAF+SSL [16] for the upcoming version of our application.

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