Semantic Web End-User Tasks

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Abstract

In order to make the Semantic Web reach "real world" end-users it is important to consider Semantic Web usability. User-Centered Design from the Human-Computer Interaction community might help in this respect. First of all, the user must be defined, together with the context. Then it is possible to study user tasks. We focus our study of Semantic Web user tasks in end-users and Semantic Web online applications, trying to contribute to establishing some UCD guidelines that help the adoption of Semantic Web applications. However, we consider existing analysis for Web systems and even online information systems in general in order to avoid constraining our view to the current state of development of the Se-mantic Web. The proposed set of end-user Semantic Web tasks is Search, Browse, Annotate, Mashup, Map, Share, Communicate and Transact. They are used in order to study an existing Semantic Web platform and an application based on it. This allows putting the tasks into practice and relates them to some interaction patterns. Future work continues in this line, trying to connect the identified patterns with existing and new interaction pat-terns in order to contribute additional guidelines for UCD Semantic Web applications development.

Keywords 1

Semantic Web, Human-Computer Interaction, User Task, User Experience, User Interface

1. Introduction

The Semantic Web has been around for some time and many people are asking why it has not taken off as quickly as the World Wide Web did [1]. One of the main impediments is that it is not reaching the end-users, who can give it the required critical mass for widespread adoption. End-users find Semantic Web applications very hard to use, it is difficult even for researchers and practitioners working in the Semantic Web field [2].

Once Semantic Web technologies seem to be quite mature, in order to facilitate its adoption, it is time to focus on the face Semantic Web applications show to users [3]. Human-Computer Interaction (HCI) is a multidisciplinary effort to improve the human-computer interface. The focus is placed on the user, i.e. to consider user needs from the beginning and through all the development process, and the objective is to get usable and accessible products.

In the context of HCI, User-Centred Design (UCD) proposes facing the development process of interactive systems focusing on the user and considering the Quality in Use, standardised in ISO/IEC 25010:2011 [4]. The proposed development process starts with a characterisation of the target users and the tasks they carry out with the interactive system in order to meet their needs, and the metrics it proposes to evaluate the quality in use have been extended to Semantic Web exploration tools [5].

The tasks supported by the early Web are now neatly defined and are becoming part of Web developers' common practice, making it relatively easy to develop tools adapted to these tasks following a UCD approach. Knowledge about tasks in the Semantic Web is much less clear due to its novelty, but it is necessary in

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order to be able to take a user-centred view on the Semantic Web [6].

However, before tasks can be identified, the first step is to determine who the intended users are and their context. There might be the temptation to say that users are "everyone", but UCD recommends dividing the target audience into groups. Considered that the objective is to facilitate Semantic Web adoption among end-users, this seems the target audience to focus on. On the other hand, the context is any online application based on Semantic Web technologies, which seem the best channel for a widespread adoption of the Semantic Web.

In the context of this paper, end-user is defined as a user with no or limited knowledge about Semantic Web technologies and methodologies. We do not include in this user profile domain experts, that might be also users with limited knowledge about the Semantic Web but who have specific needs related with the development of ontologies.

Once we have characterised the kind of Semantic Web user we are interested in, it is time to determine the tasks. As we are considering the Semantic Web as a whole, and not a specific Semantic Web application, the tasks should be generic and broad enough to accommodate tools that are not yet Semantic Web enabled but that might be so in the future.

In order to make the range of tasks broad enough and avoid constraining our view to the current state of development of the Semantic Web, the focus should be broader than existing Semantic Web applications and studies of Semantic Web user tasks. We also consider user tasks in the context of the Web and even in the context of information systems. This makes it possible to check the consistency and coverage of the proposal. The range of user tasks studies under consideration is presented in Section 2.

From the analysis of these existing studies, which range from Semantic Web to information systems user tasks, we build our proposal of a set of generic Semantic Web end-user tasks, which is presented in Section 3. Then, in order to study these tasks deeper, we have then put them into practice in Section 4. We have isolated them in the context of Rhizomer [7], a platform that makes it possible to develop Semantic Web enabled sites with content management capabilities. Finally, Section 5 presents the conclusions and the future work.

2. Related Work

Due to the importance of a clear definition of the user tasks when developing interactive systems, especially if an UCD approach is followed, there are many studies of this kind. Usually, they refer to the user tasks for a concrete application. However, there are also studies that consider a range of applications in order to help defining guides or analysing common practices.

When analysing existing work, we have considered different studies at different scale levels, from the more general online information systems, through Web information systems, to Semantic Web applications in general and finally some specific Semantic Web scenarios. The objective is to not pass through potential tasks that might be considered in the context of the Semantic Web but that haven't been considered yet in that context.

Therefore, starting from the broader context, Heath et al. [8] propose a set of user tasks users carry out on-line with information systems. They take a quite broad point of view as they include the Web but also other Internet application like electronic mail or instant messaging. The list includes *Locating*, *Exploring*, *Grazing*, *Monitoring*, *Sharing*, *Notifying*, *Asserting*, *Discussing*, *Evaluating*, *Arranging* and *Transacting*.

Locating is about users looking for something known or expected to exists. *Exploring* refers to gathering information to gain understanding or background. *Grazing* is moving speculatively without a specific goal. *Monitoring* is about checking known source expected to change. *Sharing* refers to making something available to others. *Notifying* is informing others about something that happens. *Asserting* is about making statements of fact or opinion. *Discussing* refers to exchanging information on a topic with others. *Evaluating* is determining if some information is true or alternatives. *Arranging* is about coordinating with third parties. *Transacting* is transferring money.

Getting into a more specific context, Kellar et al. [9] present a quite complete summary of studies about Web information systems user tasks. In their web information task classification, they identify a set of user tasks that are classified in three information goals: information seeking (*Fact Finding*, *Info*

Gathering and *Browsing*), information exchange (*Transacting* and *Communicating*) and information maintenance (*Maintaining*).

Fact finding is usually a short task that stands for looking for specific pieces of information. *Information Gathering* involves the collection of information and *Browsing* is a serendipitous task where users have no specific goal in mind. In relation with the information exchange goals, there are *Transacting*, which stands for performing an on-line action that often involves user/password authentication, and *Communicating*, connected to web-based communication, e.g. e-mail or blogs.

The last goal defined by Kellar is information maintenance that includes just one user task, *Maintaining*. This task is about editing web resources in order to make them work properly, e.g. no broken links, and update them. Kellar et al. also consider a potential task, *Monitoring* as returning to a previously visited page in order to obtain updated or dynamic information. However, they do not consider a user tasks per se, but a task dimension, re-occurrence, that might be a characteristic of any of the previous user tasks, especially *Browsing*, *Transacting*, *Fact Finding* and *Information Gathering*.

If we concentrate now on Semantic Web applications, Battle [10] provides starting points for describing Semantic Web users and their tasks. **¡Error! No se encuentra el origen de la referencia.** shows the three high-level categories of Semantic web users and the kind of tasks commonly associated with each group, together with an example for each task. Her characterisation of end-users is "users that do not know what the Semantic Web is and that do not care as long as they can get what they need quickly".

Table 1

Some proposed user groups and task types for the Semantic Web [10]

User Group	Task Types	Examples of tasks
End users	Information seeking tasks	to look for a restaurant near the theater that will still be open when the movie is over.
	Information synthesis tasks	to organise the agenda of a conference attendant.
	Action-oriented tasks	to build a personalized portal to manage research tasks
	Information sharing tasks	to share pictures with friends and family
Content curators	Content update tasks	to add new books to a catalog of published books and edit the metadata of previously added ones
	Content distribution tasks	to provide information to museum visitors
Ontologists	Ontology update tasks	to reorganise a library categorisation scheme
	Ontology creation & mapping	to map between different medical ontologies

On the other hand, Mäkelä et al. [11] present three very generic tasks that need to be handled in any information system with semantic capabilities:

- *Semantic Content Consumption* is about consuming semantic content when users are searching, browsing or other tasks like aggregating an RSS syndication service.
- *Content Indexing* stands for the tasks where ontologists or end-users produce semantic metadata by indexing and publishing content with references to shared vocabularies. End-users may play a role of content indexers when they are sharing videos or blogging.
- *Ontology Maintenance and Publishing* includes maintaining and publishing ontologies, which might be done by dedicated information workers, i.e. ontologists, or by end-users themselves in Web 2.0 sites when they develop their vocabulary in an ad-hoc manner alongside indexing.

Finally, Sabou et. al [12] propose the analysis of very specific Semantic Web applications from the point of view of users' tasks. The kind of tasks under consideration in this work, Ontology Matching, Folksonomy Enrichment and Word Sense Disambiguation, are quite complex and can be decomposed in simpler ones. Moreover, these tasks are targeted to users with some, or quite a lot, knowledge about the Semantic Web.

3. Semantic Web End-User Tasks

From the analysis of the existing literature, Semantic Web applications and our experience with the Rhizomer platform [7], presented in Section **¡Error! No se encuentra el origen de la referencia.**, we have synthesized a set of generic user tasks that can assist Semantic Web developers while following a UCD approach. As it has been mentioned in the introduction, if this approach is followed, it is required to define user tasks before the development process can continue. And prior to this, the target user must be defined.

Though the objective is to define a set of generic tasks, not specific to a particular application, it is important to provide a minimal characterisation of the user and avoid defining them as just any user. This is also motivated by the fact that the objective is to define the foundations for UCD of applications to be adopted by as many users as possible. The most populated user profile is end-users, that from the point of view of the Semantic Web will in most cases stand for user with no or limited knowledge about the Semantic Web technologies and methodologies [10].

One particularity is that we do not include in this category domain experts with some knowledge to be formalised as ontologies. They might have limited knowledge about the Semantic Web particularities, but they might not be considered end-users because they have very different objectives, and consequently they will carry out quite different tasks in order to accomplish them.

The users we are considering are used to web and other Internet applications like electronic mail or instant messaging. Therefore, we should also consider a broader categorisation of tasks users carry out online. It is necessary to consider a wider range of tasks because, although the Semantic Web is not widely deployed right now, its opportunity is to underpin the whole range of online user experiences and contribute new ways to do things in a more usable and accessible way.

The next subsections present the set of generic Semantic Web end-user tasks we propose. Each task is first considered from the point of view of an end-user, i.e. without considering the particularities of the Semantic Web. Some examples of particular end-users' tasks are then presented, together with references to the related tasks in the literature previously analysed. Finally, the tasks are analysed deeper, considering what the Semantic Web might contribute to them, what technologies and methodologies make them possible and constitute and added value for them.

All the considered tasks are basic ones. Usually, in the context of concrete Semantic Web application, user tasks will be composed of a mixture of these basic tasks. The objective is to define a basic set of user tasks, that would facilitate tasks analysis and UCD while being easily combinable in order to derive more complex and specific user tasks. In order to illustrate these features, this categorisation of tasks will be put into practice in order to analyse a generic platform for Semantic Web applications in Section **¡Error! No se encuentra el origen de la referencia.**, where we anticipate that basic user tasks will. In the latter, the idea is that more specific user tasks will be detected, which might be built from one or more of these basic Semantic Web user tasks.

3.1. Search

In general, this kind of tasks corresponds to those when a user poses a query and obtains a set of results that might be rendered in different ways. We include here when the search might be delayed or repeated in the future, like in monitoring scenarios.

3.1.1. Examples

Concrete examples of this task are when a user performs a simple keyword-based search using a Web search engine, an advanced query that allows constraining different search dimensions, query by example, monitoring elections results or a sports match, etc.

3.1.2. Semantic Web Search

In the context of the Semantic Web, the user can benefit from the implicit semantics when performing a search and get more accurate results, i.e. higher precision and recall.

Moreover, the knowledge captured in ontologies can be used in order to guide the user through the query construction process, in order to facilitate query by example or results presentation [13].

However, it is important to consider that most users are used to perform this kind of tasks by simple means like an input field where they type the keywords they are interested in. Consequently, they might be confused if a more sophisticated form or syntax is required in order to pose a query.

In some cases, and after some user testing, it might be concluded that it is preferred to hide all these subtleties from the user, to keep a simple user interface, make use of the available semantics as part of the query engine internal mechanisms and exploit the semantics from the point of view of user interaction when presenting the results and as part of the browsing user tasks, presented next.

3.1.3. Related Work

This task includes *Locating* and *Monitoring* (Heath), is similar to *Fact Finding* and considers the temporal dimension of monitoring scenarios (Kellar). It also considers *Information Seeking* (Battle) though some of the examples Battle et al. propose may require other tasks, e.g. some sort of mash up in the case of combining news from different news sources. This task is also related to *Semantic Content Consumption* (Mäkelä), though it is more specific because *Semantic Content Consumption* also includes when users browse search results. Moreover, it is also a component of the complex user task *Word Sense Disambiguation* (Sabou).

3.2. Browse

This task is performed when the user moves through the information currently displayed. In the context of Web information systems this is usually done by following the links that connect the information to related information pieces.

3.2.1. Examples

Concrete examples of this task are when a user gets informed about the latest news, reading blogs, entertainment, listening to music, viewing movie trailers, to follow a link received in an e-mail, etc.

3.2.2. Semantic Web Browse

In the context of the semantic web, it is possible to build a richer browsing experience because the underlying model is built from component of a smaller granularity, the triples formed by a subject, a predicate and an object. The combination of many triples builds up a graph. This graph might be browsed by following the links between graph nodes following different criteria, not but just showing the graph structure to the user [14].

For instance, those triples might come from different “documents”. All the triples from a document, identified by a URI might be displayed to the user, who can follow the links to external documents or browse the current data if it is not displayed all at once. An example of this behaviour is followed by Tabulator [15]. It shows all the triples from a Semantic Web document as an unfoldable tree.

Another alternative is to provide a faceted view if the metadata being browsed is homogeneous, all the resources being browsed have similar properties describing them. This is possible using tools like Exhibit [16]. In addition to the explicit metadata structure, it is also possible to take profit from the underlying ontologies in order to derive new links among resources using mechanism like inference, clustering [17] or semantic queries to other sources, for instance in order dynamically suggest related products based on the semantic description of the product being browsed.

3.2.3. Related Work

This task is related with both *Exploring* and *Grazing* (Heath), and also with *Browsing* (Kellar). Some of the examples of *Information Seeking* (Battle) also include aspects related with this task, e.g. learning more about a topic. This task is also related to *Semantic Content Consumption* (Mäkelä), though it is more specific because *Semantic Content Consumption* also includes searching. Additionally, it is also a component of the complex user task *Word Sense Disambiguation* (Sabou).

3.3. Annotate

In this task the user describes a resource by providing properties and values that model its characteristics, its relations to other resources, etc. This task includes providing a completely new description but also complementing an existing one, modifying it or deleting some or all of the attributes currently available.

3.3.1. Examples

Concrete examples of this task are when a user tags a particular URL as it bookmarks it, providing the title and the description of a video, geographically locating a photo, defining a user profile that includes personal details and preferences, etc.

3.3.2. Semantic Web Annotate

The main particularity of this task, in the context of the Semantic Web, is that the annotations are based on a formal model. Consequently, annotations go beyond informal and ambiguous tags into properties and values that might be constrained by the specifications captured in schemas and ontologies. This feature is not just a way to facilitate machine processing; it might be also as a way to facilitate the annotation task for the user.

The user can benefit from a domain specification defining the available kinds of resources, their properties depending on the resource type and the corresponding values. It is up to the user interface to guide the user through this knowledge space, dynamically constraining the choices to be made depending on previous user actions, the context of use and the intended goals.

An example of a tool giving support to this task in the context of the Semantic Web is the Semantic Forms extension[2] for Semantic MediaWiki [18], which takes profit from the underlying semantic models that structure available types, properties and their values. Tabulator also has recently introduced some support for metadata edition [19].

3.3.3. Related work

This task is connected with *Asserting* (Heath), especially if we consider that the statements made are metadata. It is also related with a broader task that considers maintaining information, *Maintenance* (Kellar), and also with a more specific one that concentrates on updating content, *Content Update* (Battle).

Considering tasks identified in the literature in the context of Semantic Web applications, this task is related with C*ontent Indexing* (Mäkelä) in the sense that by that task semantic annotations are generated, but just as long as some user intervention is required. Otherwise, it is not a user task but a system task. It can be also related with *Ontology Maintenance and Publishing* (Mäkelä), though from the end-user characterisation we have made this task lays outside the set of user tasks under consideration.

3.4. Mashup

This task is about the user gathering different pieces of information and combining them in order to get something more than the simple aggregation of those pieces. In other word, the user tries to get something from the aggregation of the data that cannot be or is difficult to obtain from those pieces separately, without combining them into a coherent view.

3.4.1. Examples

Concrete examples of this task range from simple mashups such as combining a set of resources that are geographically situated in order to, for instance, which are the hotels near a venue, or resources with temporal dimension that are arranged in a calendar or timeline in order to facilitate scheduling. More complicated scenarios are also possible, which are based on combining the sources of information without a predefined output view, like combining a local list of publications with information about their impact factor in order to compute the overall impact, detect trends, highlight the more relevant publications, preparing a research activity report, etc.

3.4.2. Semantic Web Mashup

[2] http://www.mediawiki.org/wiki/Extension:Semantic_Forms

In the context of the Semantic Web, this task involves combining two or more pieces of metadata about common resources in order to aggregate the available descriptions about them. It is also possible that the metadata is about different resources, but in this case, they should be similar in some sense in order to make possible the aggregation in some dimension, e.g. they all have geographical coordinates or are situated in time and can be placed together in a map or timeline respectively.

The main benefit of Semantic Web technologies and methodologies for this task is that as semantic metadata and ontologies are available, it is easier to implement some sort of assistance for the user during the aggregation process. The assistance may range from the ability to propagate the aggregations made to one particular resource property to all the uses of that property in the metadata being mashed up, like in the Potluck mashup tool [20], or exploiting in a more automatic way the available semantic metadata using semantic and statistical measures in order to provide a preliminary mashup that the user might then customise, like in the case of the semantic information mashup tool Sig.ma [21].

3.4.3. Related work

This task is related with, though slightly more specific than, *Information Gathering* (Kellar) and includes the main characteristics of both *Evaluating* and *Arranging* (Heath), which might also involve search and browse but whose added value is about combining information and extracting something more that its pure addition. It is also related with *Information Synthesis* (Battle) and the S*emantic Content Consumption* user task (Mäkelä), which is much wider and also includes searching and browsing.

3.5. Map

This task takes place when the user defines mappings among terms from different vocabularies. It is not constrained to a particular set of resources like in the case of the Mashup task, and it does not operate at the level of particular resource descriptions. On the contrary, in this task, the user is working at the level of the vocabularies. These vocabularies might be used in descriptions for many resources, some of which the user might not be aware of it at the moment.

Results from a mapping task might be used in order to facilitate or automate a mashup, or both tasks might be carried out alternatively and co-ordinately as a process where the user is mashing up a set of resource descriptions and during that process some mappings among the vocabularies being used are defined.

It might be the case that mappings are derived from the analysis of the interaction of many users, however this is a system task, the user does not directly and consciously intervene in this case. Here we are referring to tasks initiated by the user.

3.5.1. Examples

Examples of this task range from simple scenarios like stating that two tags are equivalent to more complex ones like relating different product categories or stating that all the things that one repository classifies as papers are also a kind of publication as specified in a second repository vocabulary.

3.5.2. Semantic Web Map

In the context of the Semantic Web, and also considering that we have characterised all these tasks as those for an end-user, this task corresponds to when the user defines simple mappings among classes, properties and values specified in different ontologies. It is not about exhaustive mappings among ontologies but instead about specific mappings that might be usually justified by the need of facilitating mashing up some resource descriptions, or making the mashup more systematic.

3.5.3. Related work

This task is a particular case of *Ontology Mapping* (Battle), geared towards very simple mappings and usually triggered by the system that asks users for confirmation because we focus on end-users that are not ontologists. It is also related with *Ontology Maintenance and Publishing* (Mäkelä) but that is also a task geared toward ontologists and domain experts, not end-users. The same applies when considering *Content Indexing* (Mäkelä). The same applies for *Ontology Matching* (Sabou) while *Folksonomy Enrichment* might be easier and more appropriate for end-users.

3.6. Share

This task considers uploading, publishing, updating and deleting pieces of content with the intention of making them available to other users, who can access the content from a place and at a time individually chosen by them. This last statement allows to clearly distinguishing this task from the Communicate task, which is presented next.

This task is also differentiated from Annotate in the sense that what is added, edited or removed is not metadata, data about data, but data itself. This data will usually correspond to different kinds of content that users want to share online, like videos, text, images, etc.

3.6.1. Examples

Examples of this task are posting a blog or micro-blogging, participating in a forum, sharing a photo in a social network, making a file available through a Peer-to-Peer network, etc. The participation in forums might also be seen as a communication task, described below, but the intention in most forums is to build a piece of information around a subject and to make it available for later use.

3.6.2. Semantic Web Share

In the context of the Semantic Web, this task, as long as related with data and not with metadata, is not directly supported by Semantic Web technologies and methodologies. However, it might be enriched by triggering some sort of content indexing and automatic metadata generation. The metadata just generated can then trigger an Annotate task, which allows the user editing and managing this metadata.

However, there might be also scenarios where the distinction between data and metadata is somehow blurred. For instance, in the context of Linked Data [22] publishing, where bunches of semantic data are made available without considering the specific resources being described, the task from the point of view of the user is a Share, not an Annotate as the user does not perceive as being describing something.

3.6.3. Related work

This task is similar to *Sharing* (Heath) and *Information Sharing* (Battle). There are not tasks related with this one in the studies of Semantic Web tasks we have analysed. This seems related with the fact that, as we have previously said, in the context of the Semantic Web sharing semantic descriptions is a task included in annotation tasks.

3.7. Communicate

This task is about sharing information directly with particular users, without the intention of making it available to other users from a place and at a time individually chosen by them. The process is in this case driven by the user participating in this task as the emitter.

3.7.1. Examples

Examples of this task are to participate in a chat, to send an e-mail, video-conference, etc. We have included here e-mails because they are usually kept private and not intended to make them publicly available to other users apart from the recipient. Moreover, the communication is driven from the emitter as long as the recipient has the e-mail client up and listening.

3.7.2. Semantic Web Communicate

Thought communication management is fundamentally related with other tasks, like searching for a specific e-mail, browsing conversations or annotating an e-mail, there might be room for semantic technologies to play a role during this task. In any case, this is one of the areas with less results coming from the Semantic Web, and also the one that seems to provide less room for them.

For instance, Haystack [23] is a tool for the web and desktop that helps the user manage whatever information a user considers important, which includes communications based on e-mail. The e-mail is processed and semantically annotated in order to perform communication management based on these semantic annotations.

3.7.3. Related Work

This task is related with *Notifying* and *Discussing* (Heath).

3.8. Transact

This is the last task, it is associated with user actions that provoke a change in the state of a real-world entity or of a resource in a system outside the scope of the system the user is interacting with.

3.8.1. Examples

Examples of this task are buying a book, ordering a money transfer between bank accounts, etc. The range of specific tasks included in this category might vary a lot depending on the interactive system attention is focused on. If we concentrate on the user tasks for a specific application, any task that involves interacting with other systems might be considered a transaction as a way to focus the analysis.

On the other hand, if a broader system is considered, for instance any information system, the study might be detailed further and particular tasks among the ones presented before might be identified as the goal of that interaction. In any case, actions that take place in the real world, outside interactive information systems, might be considered transactions in the context of this end-user tasks proposal.

3.8.2. Semantic Web Transact

Together with communicate, this is the task that might be less influenced by Semantic Web technologies and methodologies. This is due to the fact that by the definition of this task, they correspond to interactions of the user with systems outside the Semantic Web.

In any case, applications might take profit from these technologies and methodologies while supporting this task before and after the processing outside the Semantic Web takes place. For instance, by facilitating form filling while the user provides the required data to complete the transaction. Another way to support the transaction might be adapting the results to user preferences and context, for instance performing currency conversions following user preferences.

3.8.3. Related Work

This task is present in two of the tasks lists considered. There are *Transacting* (Heath) and *Action-oriented* (Battle) tasks.

4. The Rhizomer Platform Testbed

Rhizomer[3] is a platform based on Semantic Web technologies that facilitates publishing semantic data and building interactive Semantic Web applications on top of it. Rhizomer differs from semantic web browsers in the sense that it is not just a browser application; there is also a server part that allows defining datasets to be explored and which interacts with the SPARQL endpoints holding the datasets semantic data. However, it is also capable of browsing data not stored in SPARQL endpoints but linked from them.

For instance, if some resource from DBPedia [24] is used in a description stored in dataset published through Rhizomer, it is possible to retrieve the associated metadata by following the Linked Data principles and to perform all the user tasks available for local data in a way totally transparent for the user.

Moreover, Rhizomer also provides mechanisms that facilitate integrating external web services in a dynamic way. The external services to be integrated should be semantically described and those descriptions should specify the kind of resources (classes) the get as input. Rhizomer implements the mechanisms that allow associating at run time the resources classified as being of the input type with the corresponding service.

These associations are implemented as links that allow the user invoking the service, that will receive the resource description as input, process it and return some output. Usually, this output will be HTML content to be integrated into the interface. This way, it is easy to plug in external services that provide bridges to other

[3] Rhizomer, https://rhizomer.rhizomik.net

services but also new ways to interact with resources.

The backend is based on a web application providing an API to interact with the defined datasets and the SPARQL endpoint that constitute them. The backend is built on top of previous API and implemented using a web framework based on HTML and JavaScript that makes the user interface highly interactive. Rhizomer gives support to most of the users' tasks presented in the previous section, with the exception of the *Communicate* task:

- **Search**: pose semantic queries using HTML forms, which are dynamically generated and obtain resource descriptions rendered as HTML, as shown in **Figure 1**.
- **Browse**: navigate through the graph of data retrieving fragments of manageable size and rendering them as interactive HTML, as shown in **Figure 2**.
- **Annotate**: provide new semantic metadata describing a resource, or edit existing one, using HTML forms that assist the user during this process.
- **Mashup**: mix two or more pieces of metadata about common resources, or resources similar in some sense, e.g. they all have geographical coordinates or are situated in time and can be placed together in a map or timeline respectively.
- **Map**: define simple mappings between concepts from different ontologies.
- **Share**: upload, update and delete pieces of content (HTML, images, videos, etc.).
- **Transact**: generically, this task includes any user action that change the state of a real-world entity or of a resource in a system outside Rhizomer.

5. Conclusions and Future Work

In order to make the Semantic Web reach "real world" end-users, special care must be placed in making Semantic Web applications more usable and accessible. It is possible to take profit from the experience accumulated by the Human-Computer Interaction community and apply User-Centred Design approaches.

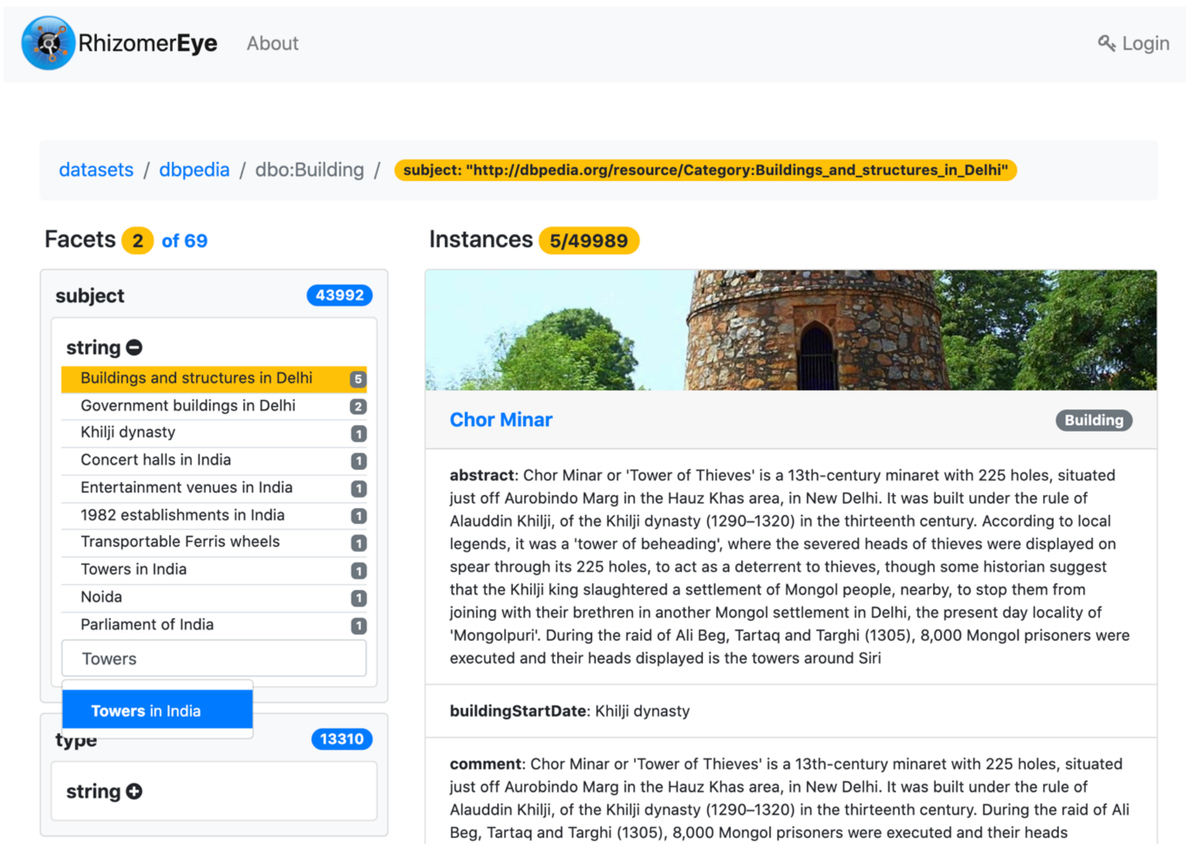

Figure 1. Rhizomer's faceted view featuring search

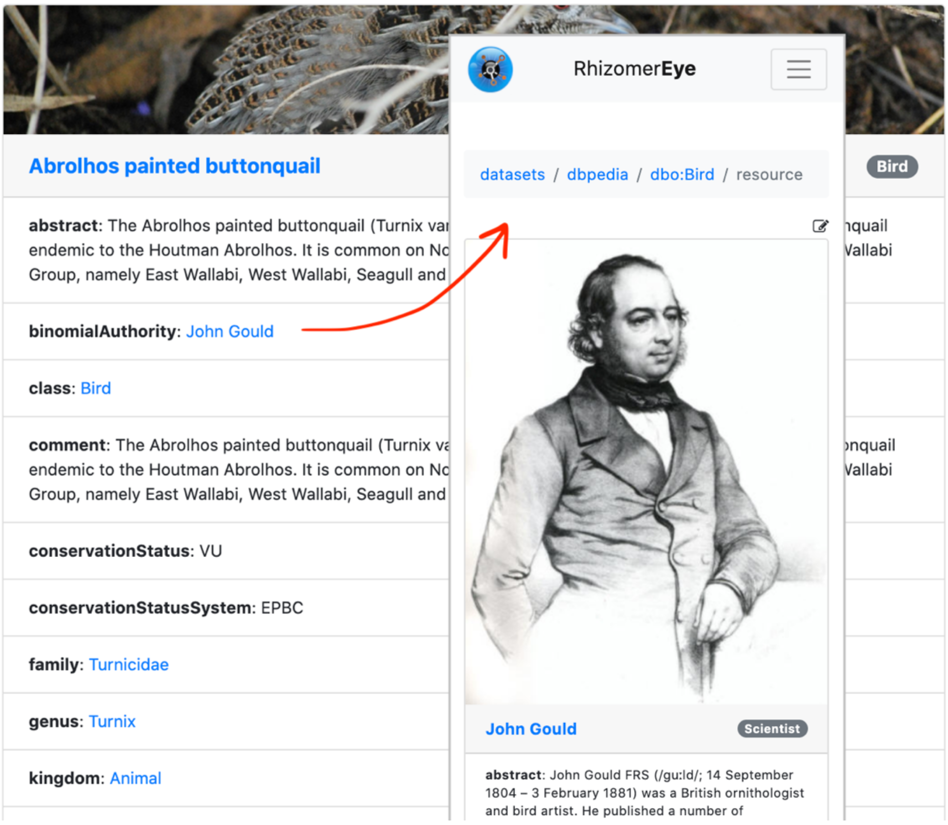

Figure 2. Rhizomer browsing Linked Data

This kind of approaches place the user at the centre of the development process and start by defining the user, its context and the tasks to be performed by them in order to meet their needs. These tasks are specific to a particular interactive application, but it very useful to define a set of common user tasks in the context of a particular domain, e.g. Web information systems, in order to establish UCD guidelines and common interaction patterns for that domain.

This is the main aim of this work, to identify a set of common user tasks for the Semantic Web. However, it is important to concretise the user profile, it is not enough to say that tasks are for any user. In this case, as the aim is to contribute to the widespread adoption of the Semantic Web, the target user is the end-user. This is a user with no or quite limited knowledge about the Semantic Web. The context is any online application based on Semantic Web technologies.

Once the user and the context are defined, it is time to determine the user tasks. In order to consider a broad range of user tasks, it is important to avoid constraining the analysis to the current Semantic Web. The set of Semantic Web end-user tasks proposed is based on the analysis of existing tasks inventories for the Web and even for online information systems in general.

The analysis is complemented with the experience gained implementing a Semantic Web platform and a Semantic Web application based on that platform. Additionally, a list of Semantic Web capabilities has been used in order to complement the process of checking the consistency and coverage of proposed set of end-user tasks.

The set of tasks includes Search, Browse, Annotate, Mashup, Map, Share, Communicate and Transact. Each of these tasks has been described avoiding technological considerations and then presented from the point of view of the Semantic Web. They are also related to the tasks proposed in the literature under consideration.

Finally, the set of tasks has been put into practice and the Rhizomer platform in order to detect if they give support to these end-user tasks and that not additional ones are required. This analysis also allows, in the case of the Rhizomer platform, presenting how these tasks are materialised in the context of the platform as different interaction patterns.

Additionally, it is shown how, as it might be anticipated, the platform user tasks are the basic ones while for the application build on top of Rhizomer, the more complex user tasks can be decomposed into basic user tasks from the proposed set.

Future work concentrates now on the next natural step when following a UCD approach. Once the user tasks have been identified, it is really useful to have an inventory of interaction patterns that give support to these user tasks as a guideline. There are many lists of interaction patterns, though most of them focus on Web systems or other interactive systems without particularising their proposal in the context of Semantic Web applications and Semantic Web user tasks.

Our aim is to build an inventory of Semantic Web interaction patterns starting from existing inventories, e.g. Tidwell's [25], van Welie's [26], Toxboe's [27] or Crumlish & Malone's [28]. Some of them are structured in part using user tasks as the way of classifying the patterns, making it possible to use them as a reference when implementing the interaction that support a user tasks, once decomposed into its basic components.

For instance, Welie proposes patterns for Browsing or Searching. The objective is to build on top of these pattern libraries and classify them considering the proposed Semantic Web end-user tasks. Many of them might be mapped directly from the Web domain to the Semantic Web, like Welie's patterns for Search and Browse, two tasks near clear equivalents in the Semantic Web. In any case, they must be studied in detail, new opportunities should be detected and there is also room for novel interaction patterns that the Semantic Web might make possible. On the other hand, our analysis against related work specific for Web information systems shows that the user tasks where the contribution of Semantic Web technologies might be more important, because they a less consider or not considered at all, are Annotate, Mashup and Map.

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