Toward Global User Models for Semantic Technologies: Emergent Perspectives

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Abstract. The Usability of Semantic Web Technologies is an area of research in need of better definition. This paper analyses the state of the art, identifies new 'emergent' perspectives, and suggests that ethnography and task analysis techniques are integrated into a methodology to support good practice in semantic technology usability. It concludes by proposing to the semantic Web community the collective development of a toolkit, and that usability should become a validation criteria for quality of semantic technology.

Keywords: Usability, Semantic Web, Ethnography, Task Analysis

1 Introduction

The Internet and the Web have evolved rapidly, changing the way people work, study, communicate. Much more powerful functionality can be delivered by the Web when 'reasoning capabilities' are going to be supported by underlying 'intelligent' technologies. Nobody can really tell what shape the 'semantic Web' will take, and what technologies will support it in the long term, however research points out that 'usability' should be considered earlier in the technology development lifecycle [1], and this inevitably also applies to semantic technologies

1.1 Definitions and acronyms

'Semantics' in the context of Web based technologies refers to 'representation of meaning'. Meanings are conveyed via symbols, using language, and depend on beliefs, axioms, relationships, context and mental constructs. While we generally identify “semantic technologies” with RDF/OWL syntax and SPARQL query language, because they are the current standards recommended by the W3 consortium, technologies capable of supporting any level of reasoning (from simple semantic associations to complex inferences) over the Web, can be said to have semantic capabilities. Therefore in our work we consider “semantic technology” any artifact capable of inferring context, meaning, logic, possibly reasoning, using the Web as a source of knowledge, irrespective of how such capabilities are achieved. Although literature often fails to identify a consistent standard definition for it, “usability” is a well defined factor in 'quality engineering', consisting of attributes and metrics. According to IEEE 1061 Usability can be defined by the following attributes: Understandability, Ease of Learning, Operability, Communicativeness. The slightly different ISO 9126 standard defines usability as understandability, learnability, operability. We do not restrict our definition of usability to any specific standard, however we point out that several models exist to help us find a definition of usability that fits our purpose. SWUI is the acronym used for the Semantic Web User Interfaces by the homonym workgroup at W3C, but SWU (semantic Web usability), and UST (usability of semantic technologies) are also used in this paper. SWA is the acronym for semantic Web applications.

1.2 Problem statement, proposed approach and contribution

When discussing the usability of Semantic Web Technologies, several 'problem areas' can be identified, that correspond to as many research questions. For example:

Defining of 'usability' in such a broad, emerging context such as the Semantic Web. Depending on users profiles, including their knowledge and skills, organizational constraints (time and budget) and the task to be accomplished, usability may be defined by different criteria. Usability is also 'usefulness', that is, the ability of a technology or tools to satisfy real user needs. So starting from established methodologies, we suggest that usability of Semantic Web is defined at least with reference to existing standards for quality engineering ISO/IEEE namely effectiveness, efficiency, satisfaction, learnability, understandability, memorabilty.

Developing methods and artifacts and good practices to support the analysis of usability requirements. In this paper we present the outline of an integrated method that relies on the combination of user profiling, ethnography and task analysis

Ensuring adoption of good practice by the developer community. Paradoxically, the usability of semantic Web technologies is still largely developed in research laboratories and under simulation condition. The current research environment for semantic technologies is often competitive and hardly promotes early collaboration and knowledge sharing. Usability should be considered very early the development lifecycle of products, and thus users, and or usability experts, should work in close collaboration with Semantic Web Application developers.

As a partial contribution toward the challenges and research questions above, this paper proposes:

a) the collaborative development of a 'Semantic Web Usability Toolkit', containing simple guidance steps to be recommended as reference at planning, analysis and design stage of semantic Web technologies
b) the development of a W3C semantic usability 'standard', and validation mechanism, to ensure that all recommended SWT satisfy at least to some extent, usability requirements.

This paper contributes to the existing SWU body of knowledge as follows: it discusses an innovative approach to some of the open research question, suggests a high level segmentation for SWU research supports task oriented approaches by suggesting task analysis and functional tasks analysis, suggests ethnographic methods are adopted in SWU based on empirical evidence and literature review outlines the requirement for a collaborative developed methodology for SWU, proposes a collaboratively developed SWU Toolkit, as well as industry wide measures such as a SWU recommended standard of practice.

The scope of this paper is to provide an overview of open issues and to discuss possible approaches. Future work will provide additional focus to drill down individual aspects of this area of work only briefly referenced here.

1.3 Theoretical Foundations

The lack of usability is an important issue especially when it comes to technology adoption, one of the problems of semantic technologies today. Lack of Usability represents an underestimated cost, an unquantifiable 'risk' factor. 'Usability' has theoretical roots in the social, cognitive and learning theories, it is studied mainly as an HCI (Human Computer Interaction) discipline. Usability engineering is becoming increasingly integrated with Software Development methodologies, and is the main focus of User Centered Design. “Cognitive Engineering”, the main theoretical framework for our research, is interdisciplinary and draws directly from related fields that determine the context for the this work: "Cognitive Engineering is an interdisciplinary approach to designing computerized systems intended to support human performance It encompasses the fields of human factors, human-computer interaction, cognitive psychology, computer science, artificial intelligence and other related fields” [2].

2. State of the Art

There is a growing body of knowledge in this field, however the state of the art in Usability of Semantic Technologies is not easily captured, given the high degree of scatter of initiatives, the multidisciplinary angle, and the dynamic pace at which things happen. The “official” SWUI (semantic Web user interfaces) mailing list for the W3C and Wiki [3] promotes regular activities, discussions and research, and we thank members for essential contributions to this section of this paper. Semantic Web founders and early proponents have been publicly advocating and supporting the cry for more usability for years [4] .Workshops on SWUI are co-hosted regularly at the ACM CHI conferences, knowledge about this topic however is also to be found indirectly in literature related to broader HCI (human computer interaction) and ancillary disciplines, as well as in unstructured, somehow tacit field work and direct observation of mailing lists and workgroups. Despite the availability of research and ongoing activities, and increasing awareness, there is little measurable improvement in this area of practice. Usability of Semantic Web Technologies is obviously not about “reinventing the wheel”. There is no indication to date that existing usability methodologies as applied to other areas of IT, are suitable for semantic technologies. SWU is about devising suitable methods to improve the ease of use, as well as the “usefulness” of the most exciting and powerful knowledge based environment ever existed, the Web, and make sure that such methods are adopted in the early stages of technology development. This can be achieved by leveraging existing know how as it emerges from various IT practices, but it is likely to consist, at least to some extent, of novel approaches. In a recent exchange [5], Duane Degler, who usefully points to a wealth of literature, asks: "what problems might the Semanic Web solve that existing technologies and methods struggle to solve - what's unique?". The Web is unique, in its knowledge aggregation/dissemination capacity and reach. Technologies capable of exploiting the semantic relationships between information objects on the Web, are uniquely powerful. However, different techniques and approaches can be used to leverage the semantic power of meaning and association on the Web, RDFization being possibly one of them, and the current W3 standard, but not necessarily the only way that semantic capabilities can be achieved. Working closely with users, and building systems designed around user goals, is one way of avoiding getting out of touch with the “real world” A question asked during an informal BOF (birds of a feather) meeting at ISWC in Busan Korean, November 2007, [6] was “How is usability of semantic technologies different from the usability of the Web as we know it so far?” A possible way of answering the question is that usability requirements should be considered from a functional viewpoint: in the same way that usability requirements (such as ergonomics) of handheld pens are radically different from the usability requirements of typing text using keyboards. SWT can be distinguished by other kinds of software/Web based usability mainly in the functionalities that they offer, as they are designed to fulfill functional tasks not supported by other technologies, and that's where our usability research should start from**.**

2.1. SWU Research segmentation

The complexity of this area of research suggests that advancement depends on practitioners' ability to target the various different and highly interdependent facets of the SWU question from the appropriate theoretical and methodological perspective. Following partial analysis of the state of the art, we suggest that identifying an appropriate level of segmentation for SWU research would help researchers and practitioners to find and keep the focus and identify priorities, depending on the scope of their work, perspective and interest. The research questions outlined in literature so far, such as in the early paper "The Usability Imperative Inherent in the Semantic Web" (2004), [7] , remain relevant to date, and are largely still unanswered. It is not in the scope of this paper to address such questions individually, however the long list of diverse open questions indicates the need for further segmentation into higher level (more abstract) areas of interest Below a possible outline of segmentation, which is not intended to be definitive at this stage, and it is proposed solely for the purpose of discussion

Table 1. SWUI Research High Level Segmentation

METHODS: How is SWU different from other kinds of usability? What method can be recommended to ensure
PERSPECTIVES: How do different people (with different knowledge and skills) respond/perceive SWT? What are the problems that they face?
PRACTICE: How can the SWU community influence the way SW developers conceive and design their products?
IMPACT: How can the outcomes of research and good practice recommendations make the SWT more efficient?
INTERDISCIPLINARITY: How can we leverage and transfer the know how of related disciplines into SWU?

Battle [8] and Schrafel and Karger [9], identify the importance of developing usability for Semantic Web strictly around user tasks, to ensure the desired level of functional usability. Later in this paper we discuss the application of Task Analysis , as well as the role of 'ethnographic' methods to achieve better understanding of how different classes of users actually use, or would like to use, SWT.

2.2 Emergent user perspectives

Current work in the area of 'usability' of the semantic Web, tends to be geared towards 'using the semantic Web' from an *end user* view point, whose primary task is 'looking for information'. Here the user is primarily a 'consumer'. In a study of user interfaces carried out at the University of Zurich [10] for example, the emphasis of usability is on search/query tools that can help users make sense of data stored in structured (RDF/OWL) knowledge bases. While this information about a 'consumer' perspective is obviously very important, there is at least one more perspective on usability, that is, the usability of technologies to produce, modify and manipulate semantic data. In the early days of the Web, usability research mainly addressed the usability of Websites, but little work was available on the usability of Website development tools. This we can call the ‘content producer” perspective. 'Weblogs' became increasingly popular, and powerful in terms of social impact, when blogging tools developed intuitive user interfaces that allowed users not only to navigate and access easily information on Websites, but also to 'make' Websites as easily, thus 'interacting' with the Web. At the time when the Web sector was largely concerned with making the Web 'usable' for people who navigated it, we wrote a paper called 'The usability of Content Management Systems', where we discussed ways of making usable the Web making interfaces. We feel that we are in a similar stage with semantic technologies: in addition to using semantic Web data, users should also be able to produce semantic Web data... We therefore distinguish two perspectives, and an emergent dimension:

1. Usability of Semantic Technologies for Information Consumers
2. Usability of semantic Technologies for Information Producers

The “emergent” dimension that results from the two perspectives above, is a natural behavior on the Web: the information consumer becomes information producer by adding additional context, and by providing annotation to the resources. So ultimately the usability of semantic technologies should distinguish and address both perspectives, and leverage the synergy between the two.

3. Cultural Context, Usability and Semantic Web

There is a wealth of literature in anthropology, and more recently, in HCI (Human Computer Interaction) demonstrating a direct relationship between the cultural context of individuals, and their cognitive behavior, their perceptions and mental constructs. What meanings people associate to what symbols depends on many variables, including their language, education, professional and other circumstances. It is important to realize that “culture” is not only the anthropological context of users, but also their sociological context. So within the same ethnic culture, for example, there are different sociological clusters, differentiated by income, education, upbringing, beliefs, etc. According to Geert Hofstede, [11] who developed a five layers model of culture, “Culture is the collective programming of the mind which distinguishes the members of one group or category of people from another". In his thesis "The influence of culture on Usability” [12], Thomas Vohriger Kuhnt undertakes a systematic analysis and shows preliminary results indicating consistent differences in perception of Website usability based on a study of IBM Website. *Cultural Usability* [13] is an international project that studies precisely the impact of culture on usability practice "The production and use of technologically advanced information and communication applications are no longer restricted to the Western world, and there are indications that usability testing procedures developed for use in Europe or the US do not give reliable results in countries such as India, China or Malaysia." says their Website, which also contains pointers to related studies and projects, and again, says "We need to understand and accept that there are significant differences in how people with different cultural backgrounds respond to directions and test methodologies. From the lab of the very large IT companies in Beijing to the design departments at India's finest institutions of higher education, there is a call for adequate methods and techniques for designing human-computer interaction" .In the paper "Culture and International Usability Testing: The Effects of Culture in Structured Interviews" [14], the authors provide extensive literature review in this space and study not only the impact of culture on usability, but on usability testing methods. The findings and considerations that emerge from the wealth of literature only partially mentioned above, motivates and justifies the approach to SWU proposed in this paper.

3.1 Semantic Capabilities

It is difficult to figure out a functional approach to semantic technologies, because there is virtually no limit to what Semantic Technologies can do in scope and range of application: from autorecognition of topics and concepts, to discovery of associations and relationships between information objects, and information and meaning extraction and categorization. To study further Semantic Technologies in relation to Usability we use a summary of grouping [Appendix 1], extracted from a Briefing by Top Quadrant [25]. Any other taxonomy of semantic technologies, or functional categorization or grouping, can also be used. Once the semantic technology tool main class of functionality is identified, task analysis can be carried out using use cases, personas, scenarios, or other appropriate usability artifact.

4. Emergent Method Outline

A methodology consists of a set of steps, and a detailed prescription of how to achieve a certain goal. In complex development projects, methodologies are sometimes used with flexibility as framework of reference to provide guidance through the intricacies of the scenarios, and to avoid getting lost in the maze of variables and dependencies that can easily derail from the achieving the goals of any given activity. A methodological framework in SWU should be flexible but '*imperative*' (a must), and developed collaboratively to include diverse stakeholders, such as technology developers and different kinds of users. Below a sketched outline of a methodology, that emerged from ideas shared during discussion with peers. The provisional name 'emergent method' is inspired from 'emergence' as a property of dynamic complex systems, as well as 'emergence' to indicate something that is 'coming up'.

Our proposed method (outline) consists of:

1 Identify cognitive characteristics of users (user profiling approach)

2 Define the tasks that users have to carry out (task analysis) based on their 'semantic capabilities'

3 Evaluate user behaviour during task execution (ethnography)

4 Derive a user requirement/specification, that must be complied with during development (if the system does not comply with the user requirement, is does not meet an essential quality criteria)

5 Have a validation mechanism to ensure compliance of the technology/application with the target usability requirement

6. Future work: Semantic Web Usability Toolkit and a compliance validation

As part of the methodological outline above - the refinement and criticism of which we place upon the collective Semantic Web Community – we propose the collaborative development of a *'Semantic Technology Usability Toolkit'* (STUT) [26] as a technical, adaptive instrument containing easy to follow guidelines and templates for the elicitation of user requirements to be used during the early stages of analysis and development. STUT aims to provide guidelines not only for interfaces, but for functional design as well. Finally, a word about validation. Semantic Web Technologies are not going to become usable, until good practice in this area is demanded, and “expected”. While the validation of syntax as found in XML and RDF validators is relatively straightforward, the validation of usability compliance cannot be easily parsed, because it is not based on code. However the conformance to standards and good practices can be codified and tested, as in the ISO compliance, and even to some extent certified. Although such compliance methods have their limitations, at least they guarantee that attention is paid to recommendations and quality expectations during development. User confidence can be increased should a tool be 'certified as conformant to users needs'. Although this may seem far fetched, it may be the only option to promote progress in this area and avoid wasting additional precious resources and efforts in producing semantic technologies that nobody wants - nor understands how - to use.

5.1 Ethnography

Ethnography is a research approach used in anthropology and sociology, consisting of a method or set of methods including literature review, direct observation, and collection and analysis of data relating to the behavior of the subjects while ‘at work’, to systematically study individuals and communities in their context to determine common cultural understanding in relation to what is being researched. It is not in the scope of this paper to discuss nor analyse ethnography in detail, but to point to published sources of knowledge such as 15, 16, 17. According to Union Institute & University page on ethnography. "Early ethnography fieldworkers, and many of their contemporary successors, focused largely on so-called "primitive" people, often in places where European countries had established colonies. In the present, however, anthropologists increasingly study western cultural groups and people in urban settings” possible analogy with the current semantic developer and user population, which in perspective is just coming out of the cave. Johnson [18] defines ethnography as "a descriptive account of social life and culture in a particular social system based on detailed observations of what people actually do." The role and importance of ethnographic methods in IT development have already been established in literature, including Ethnographic Field Methods and Their Relation to Design [19]. Hughes et al [20] discuss ethnography as an alternative methodological approach to task analysis, while in this paper we propose that the two can used in nested formation, in a complementary way. In their general approach to ethnographic analysis for systems design [21] authors propose a schematic representation of the correspondence between ethnographic analysis and systems design activities. Ethnographic methods are said to be time consuming and laborious, and would be difficult to align the time frame for a serious study with the relatively fast development cycles of new tools, often coded without much planning nor design. Rapid ethnography has been devised with this constraint in mind, and is discussed in relation to rapid prototyping and deployments in the paper Rapid Ethnography: Time Deepening Strategies for HCI [22]. In addition to its 'anthropological' use, to understand different socio-cultural behaviors in different cultures and regions for the world, and the cultural variables impact perception and behavior, ethnography is also used to identify patterns of behaviors within the same ethnic/geographical/linguistic background which may depend on other factors, such as profession, interests, education . This application of ethnography is particularly useful to study user behavior when users come from different professional and educational backgrounds, and are approaching semantic technologies to extend the intelligent capabilities of their systems, and their usage thereof. Ethnography shows a particular interest in 'symbols' (semiotic), and therefore their meanings. In order to identify 'cultural patterns' ethnography makes use of 'conceptual maps', one of the fundamental artifacts of semantic Web paradigms (ontologies).

5.2 User Profiling

An established set of tools and methods to gather information about users, User Profiling techniques use surveys, questionnaires and focus groups, The primary outcome of user profiling is a set of demographic data, complemented by qualitative data and information about behavior, perception and can include feedback on certain products and services. A wealth of interesting research is been done in this area [23], but somehow the results of these studies are not adopted for application by developers of semantic Web technologies.

5.3 Task Analysis

A consolidated method to design functional, effective interfaces that are modeled to support the tasks. It uses 'task decomposition', the breaking down of the functional operations that a user must carry out into 'sub-tasks', at an appropriate level of functionality. It also analyses what skills, knowledge, resources and tools a user requires to carry out each task/subtask. The result is then mapped onto a 'task flow diagram' that guides the development of the interface, that can be used as input to design functionalities into the system in a logical, coherent way, that relates user behavior and facilitates the fulfillment of the task by supporting the task workflow, and making the required resources available. [24]

Our proposed method outline, to be developed in detail after consultation with peers, will help to produce 'user models' to guide the development of all stages of technology.

6. Conclusion

Usability as an essential requirement for quality of software tools is just sinking in the IT sector, and semantic Web is just, allegedly, in its infancy, although it's already been in the works for some years. The Web, scrambled and messy as it is, has been usable, in its own way, from day one, and since then has been delivering tangible benefits across all sectors. The semantic Web, by contrast, clever and carefully engineered, has been in the works for over a decade, still hardly delivers tangible benefits for the 'casual user'. It will never be early enough for a concerted effort involving all practitioners, researchers, academics, industry and users to find ways of crossing the usability threshold. In this paper we hope to have made a contribution towards that.

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ANNEX I Semantic Technologies Capabilities (Source: 25)

Answer Engine: To provide a direct reply to a search questions as opposed to returning a list of relevant documents. It interprets a question asked in a natural language, checks multiple data sources to collect knowledge nuggets required for answering the question and may even create an answer on the fly by combining relevant knowledge nuggets. Interpretation of questions using domain knowledge. Aggregation and composition of the answer.

Automated Content Tagging: To provide semantic tags that allows a document or other work-product to be "better known" by one or more systems so that search, integration or invocation of other applications becomes more effective. Tags are automatically inserted based on the computer analysis of the information, typically using natural language analysis techniques. A predefined taxonomy or ontology of terms and concepts is used to drive the analysis. Machine learning approaches based on statistical algorithms such as Bayesian networks.

Concept-based Search: To provide precise and concept-aware search capabilities specific to an area of interest using knowledge representations across multiple knowledge sources both structured and un-structured. Knowledge model provides a way to map translation of queries to knowledge resources.

Connection and Pattern Explorer : Discover relevant information in disparate but related sources of knowledge, by filtering on different combinations of connections or by exploring patterns in the types of connections present in the data. Inferences over models to identify patterns using the principles of semantic distance.

Content Annotation: Provide a way for people to add annotations to electronic content. By annotations we mean comments, notes, explanations and semantic tags. Knowledge model is used to assist people in providing consistent attribution of artifacts.

Context-Aware Retriever: To retrieve knowledge from one or more systems that is highly relevant to an immediate context, through an action taken within a specific setting -- typically in a user interface. A user no longer needs to leave the application they are in to find the right information. Knowledge model is used to represent context. This "profile" is then used to constrain a concept-based search.

Dynamic User Interface: To dynamically determine and present information on the Web page according to user's context. This may include related links, available resources, advertisements and announcements. Context is determined based on user's search queries, Web page navigation or other interactions she has been having with the system. A model of context and a memory of activities are used to control UI generation.

Enhanced Search Query: To enhance, extend and disambiguate user submitted key word searches by adding domain and context specific information. For example, depending on the context a search query "jaguar" could be enhanced to become "jaguar, car, automobile", "jaguar, USS, Star Trek", "jaguar, cat, animal" or "jaguar, software, Schrödinger". Knowledge models are used to express the vocabulary of a domain.

Expert Locator: To provide users with convenient access to experts in a given area who can help with problems, answer questions, locate and interpret specific documents, and collaborate on specific tasks. Knowing who is an expert in what can be difficult in an organization with a large workforce of experts. Expert Locator could also identify experts across organizational barriers. The profiles of experts are expressed in a knowledge model. This can then be used to match concepts in queries to locate experts.

Generative Documentation: Maintain a single source point for information about a system, process, product, etc., but deliver that content in a variety of forms, each tailored to a specific use. The format of the document, and the information it contains, is automatically presented as required by each particular audience. Knowledge model is used to represent formatting and layout. Semantic matching is a key component of the solution.

Interest-based Information Delivery: Filter information for people needing to monitor and assess large volumes of data for relevance, volatility or required response. The volume of targeted information is reduced based on its relevance according to a role or interest of the end user. Sensitive information is filtered according to the "need to know". A profile of each user's interests is expressed in a knowledge model. This is then be used to provide "smart" filtering of information that is either attributed with meta-data or has knowledge surrogates.

Navigational Search; Use topical directories, or taxonomies, to help people narrow in on the general neighborhood of the information they seek. A Taxonomy that takes into account user profiles, user goals and typical tasks performed is used to drive a search engine. To optimize information access by different stakeholders, multiple interrelated taxonomies are needed.

Product Design Assistant: To support the innovative product development and design process, by bringing engineering knowledge from manydisparate sources to bear at the appropriate point in the process. Possible enhancements to the design process that result include rapid evaluation, increased adherence to best practices and more systematic treatment of design constraints.

Semantic Data Integrator: Systems developed in different work practice settings have different semantic structures for their data. Time-critical access to data is made difficult by these differences. Semantic Data Integration allows data to be shared and understood across a variety of settings. A common knowledge model is used to provide one or more unified views of enterprise data. Typically this is done by using mapping. Rules are executed to resolve conflicts, provide transformations and build new objects from data elements.

Semantic Form Generator and Results Classifier: To improve the data collection process and data input analysis by providing knowledge driven dynamic forms. A knowledge model is used to intelligently guide the user through data capture. The results are automatically classified and analyzed according to the model

Semantic Service Discovery and Choreography: Service Oriented Architectures enable increased reuse of existing services and the dynamic automation of processes through service composition and choreography. Knowledge models are used to enhance the functionality of service directories. Invocation methods, terminology and semantic description allow the dynamic discovery of services by machines.

Virtual Consultant: Offer a way for customers to define their individual goals and objectives, and then show them what products and services can help them meet those goals. Understanding customer's goals and requirements through a questionnaire or dialog establishes a profile that helps you communicate effectively with them now and in the future.