

A Survey of Semantic Wikis for Requirements Engineering

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Abstract

Nowadays, semantic wikis are used in software development. In requirements engineering process, semantic wikis are used as lightweight and semantic/social-web based collaboration platforms. This paper first makes a survey on existing semantic wikis and their candidate features, which can be interesting in requirements engineering. Secondly, specific semantic wikis for requirements engineering are analyzed/compared based on the features identified in the first step. We conclude this paper with promising features which are provided by semantic wikis, and can be useful for requirements engineering.

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Contents

1	Introduction	3
2	Background	3
2.1	Wikis	3
2.2	Semantic Web	4
2.3	Semantic Wikis	5
3	RE and Semantic/Wiki Features	5
4	Existing Semantic Wikis	7
4.1	Implementations Comparison	7
4.2	Features Comparison	11
5	Using Semantic Wikis for RE Activities	13
5.1	Existing RE-specific Semantic Wikis	13
5.1.1	WikiReq	13
5.1.2	Software Organization Platform	13
5.1.3	SoftWiki	14
5.1.4	Summarization of RE-specific Semantic Wikis	14
5.2	Promising Features	14
5.2.1	Requirements Reasoning Support	14
5.2.2	Export to RE-tools	14
6	Conclusion	15

1 Introduction

Wikis have been used for 15 years for a wide variety of purposes, including: encyclopedia systems, software development, project knowledge management, personal knowledge management, and content management system (CMS) [14]. With the emerging techniques from semantic web, wikis are extended with functionality of the semantic web, resulting in semantic wikis. With the use of a semantic wiki it becomes possible to capture or identify further information about the pages stored in the wiki. This information includes relationships between pages and information gained from the metadata added to a page. In the process of requirements engineering (RE) diverse stakeholders participate in the process. Semantic wikis provide a flexible platform for collaborative support. The added semantics can model conflicts or dependencies between the requirements. In this paper, we focus on how semantic wikis can be used in RE. The paper is organized as follows. The background knowledge about wikis, semantic web, and semantic wikis are introduced in Section 2. Candidate features provided by wikis and semantic wikis to RE activities are discussed in Section 3. In Section 4 existing semantic wikis are described, with an implementation comparison and a feature comparison of the features which can be potentially used by RE. RE-specific semantic wikis are analyzed and compared in Section 5 with discussions on promising features desired by RE practitioners. We conclude our work with future directions in Section 6.

2 Background

2.1 Wikis

Bo Leuf and Ward Cunningham, define a wiki in their book, “The Wiki Way”[5], as follows:

A wiki is a freely expandable collection of interlinked Web "pages", a hypertext system for storing and modifying information - a database, where each page is editable by any user with a forms-capable Web browser client.

In short, this means an user is able to edit the content of a webpage online in a browser. There are a wide range of wikis available. Think, for example, at wikis used for corporate intranets [2], encyclopedia systems (e.g., Wikipedia), software development, and project knowledge management. Despite of the different goals of each wiki, most wikis share some common features as listed in Table 1.

Next to the different positive aspects of using a wiki, there are also problems with wikis to mention:

- **Unstructured Data.** A data model lacks or is not easily usable by an application.
- **Internally or Externally reuse of Knowledge.** Knowledge is limited to the page and the links between them. It is difficult to extract the knowledge from external websites or internal pages.

ID	Feature	Description
W1	Editing	The grain of the wiki philosophy is that users are allowed to edit content wherever they are and with only minimal technical requirements.
W2	Simplified syntax	Content is expressed in a simplified hypertext format.
W3	History	Modifications of any single page is saved, which results in a rollback function. Original content can be restored.
W4	Unrestricted access	Anyone can modify a page. Some wikis control access by using users and groups.
W5	Collaborative editing	With the above mentioned features, it can be concluded that everybody can contribute to a specific page.
W6	Linking	Each page can be linked to other pages using hyperlinks.
W7	Search functions	A full-text or title search is available for the wiki pages.
W8	SandBox/PlayGround	A wiki page that is used as a test environment. With the SandBox users can learn how to use wikis.
W9	Recent changes	Most recent changes are listed.
W10	Files upload	It is allowed to upload any types of content.
W11	Change tracking	All changes applied to wiki pages are tracked.
W12	Versioning	Assigning unique version names and/or numbers.

Table 1: Common features of wikis

- **Limited Search Functions.** Search functions are reduced to page title search. Sometimes free text searches are possible, but this is limited.

2.2 Semantic Web

The Semantic Web is a collaborative effort led by the World Wide Web Consortium (W3C). On their website the following explanation of the Semantic Web is given:

The Semantic Web provides a common framework that allows data to be shared and reused across application, enterprise, and community boundaries.

Broadly, this means that the data on the Web should be understandable for people as well machines. However, a formal definition of semantic web does not exist. As mentioned by Thomas B. Passin in his book, "Explorer's Guide to the Semantic Web" [11], the Semantic Web is not a technology but a vision. Passin talks about an evolving, informally defined concept. There are a wide range of visions, but roughly they can be

concluded in the following: The semantic web is a web of entities, instead of a web of documents, as is the case with the current web. The entities and their relations are available on the entire internet.

To realize a semantic web, semantics are added to the current web by ontologies in metadata. With the use of semantics it is possible to automatically relate different entities to each other. As mentioned, these entities can be available on the entire internet and is not restricted to a single application or website. In contrary, with the traditional web, the user needs to gather the information from the internet and relate the different entities to each other.

Technologies used in the semantic web can also be applied to a traditional wiki. Adding semantic technologies to a traditional wiki can make the inherent structure of a wiki accessible to machines.

2.3 Semantic Wikis

As described in the previous section, Section 2.2, wiki properties can be combined with Semantic Web technologies[15]. Annotations are added to wiki pages and stored in a knowledge base. It is possible to connect those annotations with background ontologies. Consequently, the inherent structure of a wiki becomes accessible for machines.

With the addition of semantics to a wiki, the wiki becomes more sophisticated than normal wikis. Data in a wiki page can be captured or identified and can be related to data in other wiki pages. Consequently, the navigation, search, retrieval, and presentation can be improved. Another point of interest is the better means to support interoperability. With semantic wikis the interoperability among each other or with external services is increased.

Next to the features provided by a traditional wiki, there are some extra features that become available with the use of a semantic wiki. The common features of a semantic wiki are listed in Table 2 [14, 4, 10].

3 RE and Semantic/Wiki Features

Wikis and semantic wikis can be used within software development life cycle with the features presented in the previous section. This paper focuses on the applications of semantic wikis in RE. Zave defines RE as follows [16]: *Requirements engineering is the branch of software engineering concerned with the real-world goals for, functions of, and constraints on software systems. It is also concerned with the relationship of these factors to precise specifications of software behavior, and to their evolution over time and across software families.*

The core activities of RE are [9]:

- **Eliciting Requirements.** Collecting a complete set of requirements of a system.
- **Modelling and analyzing Requirements.** Construction of abstract descriptions, which provides the opportunity for analysing.

ID	Feature	Description
SW1	Adaptive content presentation	The content presentation of pages can change based on semantic annotations. Pages can be enriched with the display of semantically related pages in a separate box or information can be displayed, which is derived from the underlying knowledge base.
SW2	Enhanced search	New search possibilities are added to a wiki, due to the query languages used. Full-text search is also a feature provided by almost every semantic wiki.
SW3	Enhanced navigation	A semantic wiki can offer extra information about the relation a link describes. Furthermore, a semantic wiki can provide context-aware navigation.
SW4	Reasoning support	With reasoning support, conclusions can be derived from formal symbolic knowledge. The knowledge is derived from the semantic content of the semantic wiki.
SW5	Typing of annotation	Links and text (requirements artifact) can be annotated by giving them certain types.
SW6	(Semi)automatic extraction of metadata	Metadata can be extracted from wiki articles to simplify the annotation process.
SW7	Ontology import/export	Existing Ontologies can be reused by importing/exporting OWL/RDF data.
SW8	Changing underlying model	A semantic wiki contains an underlying model of the knowledge. Users are able to change this underlying model.

Table 2: Common features of semantic wikis

- **Communicating Requirements.** Facilitating effective communication of requirements among stakeholders.
- **Negotiating Requirements.** Agreeing on requirements with stakeholders and validating the requirements.
- **Evolving Requirements.** Managing change of requirements.

In projects with high uncertainty, a greater user participation improves the quality of requirement products [12]. Consequently, a large number of diverse stakeholders should effectively and efficiently collaborate to improve the quality of the requirements. However, stakeholders can have different backgrounds, objectives, abilities, involvements, and perspectives.

First impression is that a semantic wiki provides an interesting platform for RE. The collaboration between the different stakeholders can be improved by using a wiki. With the use of a wiki, non-technical stakeholders can also easily participate. Next to collaboration support, semantic relations can model conflicts or dependencies between the requirements. Functionalities provided by existing requirement management tools can also be supported by semantic wikis. For example, at requirements versioning and baselining. Versioning is provided by a feature called permalink. Permalinks are created by a link harvester, which provides a list of all links on a certain page. These links are placed on a page representing a release and are frozen.[3] Furthermore, a semantic wiki can interoperate with an Integrated Development Engineering (IDE) platform. Requirements can be exported from a semantic wiki to the Eclipse IDE. Consequently, the rendering of organizational business processes and system artifacts from the requirements description, can be partially automated [1, 3, 13].

Table 3 lists activities in the RE process which can be supported by semantic wiki/wiki features.

4 Existing Semantic Wikis

Different semantic wikis are on the market with their own characteristics. In the section, the implementations and features of the semantic wikis are compared with each other. However, the comparisons come with a caveat: most of the semantic wikis are still under development, so their features and implementations can change.

4.1 Implementations Comparison

Table 4 compares general information for a number of wiki software packages. Not all listed semantic wikis are active. However, features provided by inactive semantic wikis can be useful for activities in the field of RE. For each semantic wiki entry in Table 4, the last column lists if the concerning semantic wiki is active or defunct. Empty fields mean that the available information is not trusted.

Core Activity	Sub-Activity	W Feature	SW Feature
Eliciting Requirements	Identify System Boundaries	W1,W2,W4,W5,W8	
	Identifying Stakeholders	W1,W2,W4,W5,W8	
	Eliciting Goals	W1,W2,W4,W5,W8	
	Use Cases	W1,W2,W4,W5,W8	
Modelling and Analysing Requirements	Modelling Goals		SW4,SW7
	Automated Reasoning		SW4
	Consistency Checking		SW1,SW4,SW5
	Validation and Verification		SW4,SW5
Communicating Requirements	Requirements Management		SW1,SW6,SW5
	Requirements Traceability		SW2,SW3,SW5
Agreeing Requirements	Requirements Validation	W6	SW6
	Requirement Negotiation	W1,W2,W4,W5	
Evolving Requirements	Configuration Management		SW1
	Requirement Version Management		SW1
	Fixing Errors in Requirements	W1	W11
	Change Impact Management	W3	SW3,W11

Table 3: Wiki and semantic wiki features for RE activities

Semantic Wiki	Affiliation	Last Release Date	Data Backend	Programming Language	License	Status	Active/Defunct
COW			KAON	Java			D
IkeWiki	Salzburg Research	2.0 (Mar 5, 2008)	Jena store	Java	GPL	Inactive	D
Kaukolu		revision 737 (Oct 30, 2007)	Sesame2	Java			
Makna			MySQL, PostgreSQL and Oracle	Java			D
OntoWiki	University Leipzig	0.8.6 (Sept 8, 2008)	MySQL	PHP			A
OpenRecord				JavaScript, PHP	BSD		A
Platypus Wiki				Java			D
Rhizome				Python			D
Semantic MediaWiki	SMW Project	1.4.2 (Feb 11, 2009)	MySQL	JavaScript, PHP	GPL	Stable	A
SemperWiki	DERI Galway			Ruby			D
SweetWiki				Java			D
WikSAR			PostgreSQL, Jena Store	PERL	GPL	Alpha	D
KendraBase			PostgreSQL	Python			D
AceWiki	University of Zurich	0.2.13 (May 28, 2009)		Java	LGPL	Alpha	A

Semantic Wiki	Affiliation	Last Release Date	Data Backend	Programming Language	License	Status	Active/Defunct
BOWiki	Max Planck Institute For Evolutionary Anthropology	0.14 (Jun 23, 2008)			GPL	Stable	A
Hypertext Knowledge Workbench	FZI	0.2.0		Java, GWT	BSD		A
KiWi	KiWi Project			Java EE	Sun CDDL	Under Development	A
Knoodl				Java	Free, publicly hosted		A
KnowWE	University of W?zburg	2.0 (Oct, 2008)		Java	LGPL	Beta	A
Subleme		r18 (Apr 23, 2009)			GPL		A
SWiM	Jacobs University Bremen	0.2.1 (Jun 17, 2008)		Java, XSLT	GPL	Alpha	A
Swirrl	Swirrl IT Limited	(Sept 25, 2008)			Hosted web application	Stable	A
TaOPis	Faculty of Organization and Informatics		PostgreSQL	FLORA-2, Python, PostgreSQL, PHP	GPL	Prototype	A
Wikidsmard	zAgile	1.0.0 (March 17, 2009)		Java	AGPL	Stable	A

Semantic Wiki	Affiliation	Last Release Date	Data Backend	Programming Language	License	Status	Active/Defunct
SWOOKI	Nancy University	0.9 (May 22 2008)		Java	GPL	Alpha	D

Table 4: Comparison of Semantic wiki implementations

4.2 Features Comparison

Table 5 compares the features provided by the semantic wikis listed in Table 4. The features which are adopted in Table 5 are features, which can be potentially applied in the field of RE. Features that are supported by a semantic wiki are indicated by an "X". Absence of an "X" means that the feature is not supported or the available information about the feature is not trusted.

Semantic Wiki	Editing Paradigm	SW1:Adaption Content Presentation	SW2:Semantic Search	SW3:Context-aware Navigation	SW4:Reasoning Support	SW5:Typing Annotating of Text	SW6:(semi)automatic metadata extraction	SW7:Ontology Export	SW7:Ontology Import	SW8: Changing Underlying Model
COW	Forms	X		X				X		X
IkeWiki	Wiki-syntax	X		X	X	X				X
Kaukolu								X	X	
Makna	Wiki-syntax			X				X	X	
OntoWiki	WYSIWYG	X	X	X		X				X

Semantic Wiki	Editing Paradigm	SW1:Adaption	SW2:Semantic Search	SW3:Context-aware Navigation	SW4:Reasoning Support	SW5:Typing Annotating of Text	SW6:(semi)automatic metadata extraction	SW7:Ontology Export	SW7:Ontology Import	SW8: Changing Underlying Model
OpenRecord										
Platypus Wiki	Separate text area			X						
Rhizome		X				X	X	X	X	
Semantic MediaWiki	Wiki-syntax, Forms, Point and click	X	X	X	X	X		X	X	
SemperWiki	Wiki-syntax	X		X				X	X	
SweetWiki	Wiki-syntax, WYSI-WYG, Tagging			X						X
WikSAR	MarkDown			X				X		
KendraBase	Forms									
AceWiki	Predictive editor	X			X					
BOWiki			X		X					X
Hypertext Knowledge Workbench	Wiki-syntax							X	X	
KiWi					X					
Knoodl								X	X	X
KnowWE	Wiki-syntax	X		X	X	X		X	X	X
Subleme	WYSIWYG									
SWiM	WYSIWYG	X							X	
Swirrl										
TaOPis	Wiki-syntax, Tagging		X	X	X			X		X
SWOOKI	Wiki-syntax							X		

Table 5: Comparison of semantic wiki features

5 Using Semantic Wikis for RE Activities

For the application of semantic wikis, as substitute or complementary tool for existing RE tools, it is important that a semantic wiki can support/improve features a RE tool can support. The features that several RE-specific semantic wikis supports are discussed and outlined in the first part of this section. The second part presents some promising features for RE, which can be provided by semantic wikis.

5.1 Existing RE-specific Semantic Wikis

A semantic wiki is already proven to be a useful platform for the elicitation and documentation of requirements [3, 1]. The semantic wikis SOP-Wiki and WikiReq proof the usefulness of semantic wikis in the distributed requirements elicitation and documentation phase of the RE process. Both semantic wikis are based on the Semantic Mediawiki platform. There is also another cooperative research project going on, Soft-Wiki, which focuses on semantic collaboration in particular with respect to software requirements.[7]. The three RE-specific wikis are discussed in the following sections.

5.1.1 WikiReq

WikiReq, exploits the Semantic Mediawiki to manage system and organizational requirements [1]. In combination with the Si* goal oriented language the wiki provides some specific features. First of all, requirements can be acquired by means of a set of pre-defined forms. Furthermore, semantic relationships among the Si* main concepts can be automatically defined. Another feature is the possibility to debate about requirements in a specific tab page. Finally, to support interoperability with an Integrated Development Platform semantically annotated requirements can be transformed in another instance, Eclipse Modeling Framework (EMF).

5.1.2 Software Organization Platform

Software Organization Platform (SOP) wiki is the successor of RISE, a project in which a wiki is used to elicit requirements, develop an initial architecture, and assign development tasks based on these requirements [3]. Different challenges that occur when applying RE wikis in RISE projects can be solved by the SOP wiki system. First of all, it has the ability to harvest links and freeze them. This makes it possible to easily establish links to a certain version of a page. Another feature concerning versioning is version tagging. With version tagging, the user can select wiki pages to assign a version tag. Furthermore, the SOP wiki provides the ability to export wiki content (e.g., requirements) to individual documents (Open Office documents). As with each semantic wiki, the SOP wiki makes it also possible to add semantic information to pages. Users can add properties to pages and define typed links between pages. With this feature relations between documents can be expressed. Finally, there is the feature of classification and reclassification of multiple pages.

RE-specific SWs	SW features
SOP Wiki	SW1,SW3,SW5,SW7
WikiReq	SW2,SW3,SW5,SW7
SoftWiki	SW1,SW3,SW5,SW7

Table 6: Features of RE-specific wikis

5.1.3 SoftWiki

SoftWiki focuses on semantic collaboration in software development in particular with respect to software requirements activities [7]. The aim is to let large and distributed stakeholders be able to collect, semantically enrich, classify and aggregate software requirements. The core concepts and interrelation of RE are defined in the SoftWiki Ontology for RE (SWORE). Among other things, frequent relation types are defined by SWORE. The relation types describe the requirements interdependencies. This way, all requirements are linked to each other. Another typical feature of semantic wikis (SW7) is also exploited by SWORE, the linkage to external resources (e.g., publicly available domain knowledge, company specific policies). In the future it is possible to import requirements into other requirements management tools. To make the import possible, the requirements are automatically transformed into RIF format.

5.1.4 Summarization of RE-specific Semantic Wikis

The semantic wiki features provided by the RE-specific semantic wikis are listed in Table 6.

Table 7 outlines the RE activities that are covered by the three semantic wikis. Only the information that can be derived from [3, 1, 7] is adopted in the table.

5.2 Promising Features

Besides the features provided by existing RE-specific semantic wikis, there are also some features that are not fully exploited yet in semantic wikis. The subsection discusses some promising features.

5.2.1 Requirements Reasoning Support

One of the promising features is reasoning support. Analysing existing work of using semantic wiki in RE concluded in the notion that reasoning support has not been fully explored yet [6]. Reasoning support can support requirements consistency, requirements completeness, and requirements correctness checking.

5.2.2 Export to RE-tools

Stakeholders with experience in RE are familiar to specific RE-tools. To become acquainted with a new tool (e.g., a RE-specific semantic wiki) costs time and effort.

Core Activity	Sub-Activity	SOP wiki	WikiReq	SoftWiki
Eliciting Requirements	Identify System Boundaries		X	
	Identifying Stakeholders		X	
	Eliciting Goals		X	
	Use Cases			
Modelling and Analysing Requirements	Modelling Goals			
	Automated Reasoning			
	Consistency Checking	X		
	Validation and Verification		X	
Communicating Requirements	Requirements Management		X	X
	Requirements Traceability		X	X
Agreeing Requirements	Requirements Validation		X	
	Requirement Negotiation		X	
Evolving Requirements	Configuration Management	X	X	
	Requirement Version Management	X	X	
	Fixing errors in Requirements		X	X
	Change Impact Management	X	X	X

Table 7: RE activities covered by RE-specific wikis

Therefore, to make a semantic wiki interesting for RE practitioners, it is sensible to require that the wiki should be compatible with the current RE-tools. Another reason for compatibility with RE-tools is that semantic wiki cannot provide all the functionalities for the RE process. A solution would be an export function to the existing RE-tools. Obviously, this also includes an import function from RE-tools to the semantic wiki. So, realized work in the RE-tools can be imported in the semantic wikis.

6 Conclusion

It is already proven that a wiki is a useful platform in RE activities (e.g., wiki-based requirements documentation), particularly when the concerning stakeholders are distributed. However, traditional wikis are insufficient to perform some RE activities, such as automatic requirements analysis. Different RE-specific semantic wiki projects are going on at the moment. Table 7 shows that every phase in the RE process can be supported by semantic wikis. However, there are some common semantic wiki features that are not fully exploited yet by the RE-specific wikis.

RE-tools are evaluated with evaluation frameworks for RE-tools [8]. This framework can also be used to evaluate existing RE-tools with RE-specific semantic wikis in order to understand their capability and usability.

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