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Semantic wiki
– collaboration, semantics & semi-structured knowledge

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English summary

Wikis are collaboration tools and characteristic examples of Web 2.0 utilisation of technology. Users participate to generate content and maintain the quality of information within the wiki. Information is contained in interlinked pages and organised and structured in categories.

Semantic wikis add more structure by the use of typed links, typed pages and annotations. Semantic technologies are utilized in order to achieve machine-readability, automatic reasoning, knowledge representation, and information integration. Semantic wikis contain semi-structured knowledge by combining user generated hypertext with the formal world of semantics.

User stories from the Zoran Sea Scenario illustrate military applications of semantic wikis. These include ontology making in Communities of Interests, wikis used in distributed planning and information integration and reuse.

Some organizational challenges related to planning and user participation, as well as usability and quality aspects, are discussed. The evolutionary and user centric nature of wikis necessitate a new paradigm in information management and control.

Sammendrag

Wiki'er er samhandlingsverktøy og karakteristiske eksempler på ny, sosial bruk av teknologi. Brukere deltar og samarbeider om å lage innhold og opprettholde kvalitet på informasjon som finnes i en wiki. Informasjon er lagret i sammenkjedete sider og organisert i kategorier.

Semantiske wiki'er har mer struktur i form av klassifiserende lenker og konsepter i tillegg til annotasjoner. Semantiske teknologier tas i bruk for å oppnå maskin-lesbarhet, støtte for automatisk resonnering, kunnskapsrepresentasjon og informasjonsintegrasjon. Semantiske wiki'er inneholder semi-strukturert informasjon som resultat av å kombinere brukergenerert hypertekst med formell semantikk.

Brukerhistorier fra Zoran Sea-scenariet illustrerer militære bruksområder for semantisk wiki. Blant annet vises ontologi-generering i 'Communities of Interest', distribuert planlegging ved hjelp av wiki og informasjonsintegrasjon og -gjenbruk.

Noen organisatoriske utfordringer, samt bruks- og kvalitetsaspekter, blir diskutert. Den evolusjonære og brukersentriske tilnærmingen ved bruk av wiki nødvendiggjør nye kontroll- og styringsmekanismer med tanke på informasjonsgenerering og informasjonsdeling.

Contents

1 Introduction

Wiki is both a technology and a collaboration model and is often mentioned as a characteristic example of Web 2.0. In its structure, a wiki is a simple online database with interlinked web-pages. A wiki is evolutionary in nature. To the user, the essence of wiki is that it invites all users to edit any page or to start a new page and that interlinking pages promotes associations between concepts.

In wikis, both content and structure may be edited by its users. For most collaboration technologies the structure is fixed and only the content is editable to the user. The user-editable structure is a unique feature of wikis. In a regular wiki, structure is limited to links between pages and collections through the concept of categories. However, the structure of a wiki is already editable, and it is therefore interesting to further enhance the structure part of wikis.

Semantic wiki is a step in this direction. A semantic wiki adds meaning – that is semantics – to the relations between the concepts defined in the wiki. By 'semantic' we understand structures and relations that are machine-readable. Semantic wikis belong to a middle ground between regular wikis and databases, containing a semi-structured representation of knowledge.

1.1 Goal

We want to demonstrate uses of wiki in a military context. This report also explains the value of adding semantics to a wiki, as well as utilizing a semantic wiki as a tool for collaborative ontology making, distributed planning and information integration. Another purpose of this report is to document the work done implementing a demonstrator – a semantic wiki containing background information and analysis from a NATO scenario. We will not evaluate actual usage of wiki in a military setting, but rather explore and demonstrate the potential we envision.

1.2 Motivation

User contribution and collaboration are important aspects for effective information management and exploitation. Wiki allows organizations to harness collective knowledge and efforts in creating and maintaining an information base for some given domain. Wikis are essentially hypermedia systems. Domains in which the concepts can be described textually and there are relations between these concepts, are suitable to be modelled and defined using a wiki.

Information sharing and integration are fundamental requirements for achieving the effects promised by NATO Network-enabled Capabilities (NEC) or Network-based Defence (NBD). Adding semantics yields two dimensions of enhancements to a wiki:

1. Adding a more formal structure to the wiki, increasing the possibility of more advanced searches and categorizations
2. Exporting, integrating and reusing information by using standard semantic technologies and data representations

Human information consumption and collaboration is the focus of a traditional wiki. Compared to a regular wiki, a semantic wiki allows for; adding formal structure and facts; searching the relations between concepts; querying and filtering of the information; exporting the knowledge for data integration; and the reuse of standard vocabularies.

Semantic technologies aim for machine-to-machine integration and reuse of data. A semantic wiki thus resembles the more structured and computer friendly domain of databases. Compared to a traditional database, a semantic wiki allows for; expanding the structure; letting the domain model emerge from actual usage; collaborative, distributed work flows and processes; and the reuse of standard vocabularies.

Semantic wiki thus seems to combine the best from two worlds: Structure, machine-readability from databases and expandability and collaboration from wiki systems.

1.3 Methods used

This report will begin with an analytical approach discussing the underlying technology and philosophy of wikis. Further, we will introduce semantic technologies before discussing the benefit of adding semantics to a wiki. Other related research will be presented. We continue with an exploratory method, using user stories combined with a background story from the Zoran Sea Scenario to exemplify and visualize possibilities of a semantic wiki. The background scenario is summarized in section 4.1. These examples are implemented in an actual semantic wiki demonstrator system and an intelligence analysis support tool demonstrator. Technical details about these two demonstrators are found in Appendix A.

1.3.1 User stories

A user story (XP, 1999) (Cohn, 2004) is a system requirement described in a non-technological language. Such a story should be short – two to three sentences – and focus on the business value to be implemented. User stories are used to create time estimates (Cohn, 2006) in agile software development methodologies (Fowler, 2000). Normally, user stories are written by the customers or the users of the system, and are used to create acceptance tests as well. We use user stories as short, descriptive entries describing what a semantic wiki may be used for. The stories in this report are not created by the users, but we use the stories to focus on business value rather than just discussing the technical aspects. We then expand the user stories with explanations, discussions and screenshots for more details about the possibilities.

1.4 Structure of Report

In section 2 we begin by presenting the background theory and philosophy of wiki and semantic technologies. We continue in section 3 by presenting semantic wiki as a concept, as well as related research. Section 4 contains the actual user stories and the more detailed description of how and why a semantic wiki may be useful. We discuss some challenges in section 5 before concluding in section 6.

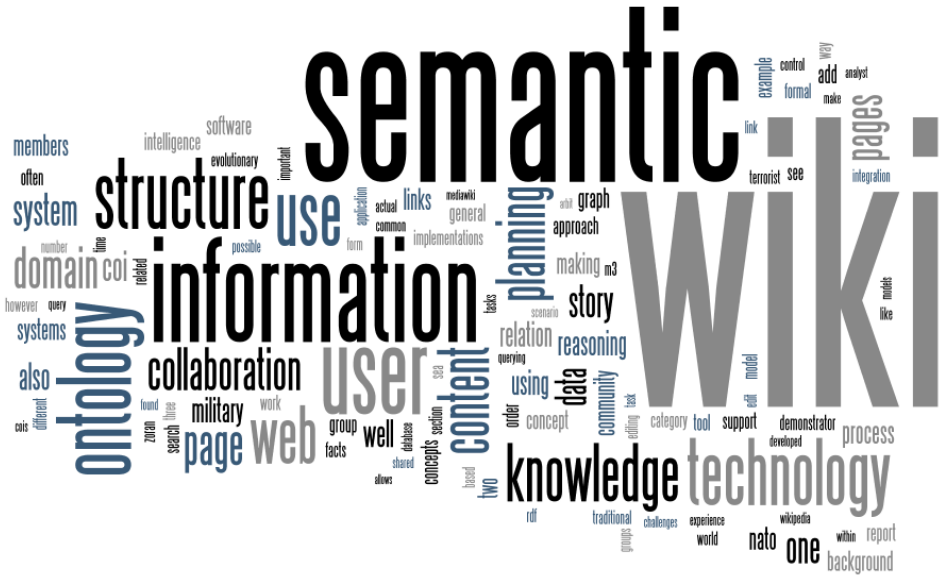

Figure 1.1: Word cloud for this report, generated by http://wordle.net

Figure 1.1 above shows a word cloud generated by the content of this report, giving some indication of the important terms and concepts covered in the following chapters.

2 Background

In this section we will present related research and background theory of wiki and semantic technologies respectively.

2.1 Wiki

The simplest online database that could possibly work,
Ward Cunningham (Leuf & Cunningham, 2001)

A wiki is a user edited web-site. Users can add pages, remove pages, and edit every page using only a web browser. The wiki technology belongs to the class of *discussion and collaboration servers*. In its structure, a wiki is a freely expandable simple online database of interlinked web-pages, documents or articles.

The collaboration model of a wiki is much like the one of a shared database. The database is a collection of articles or documents the users easily can edit using their web browsers (see Figure 2.1).

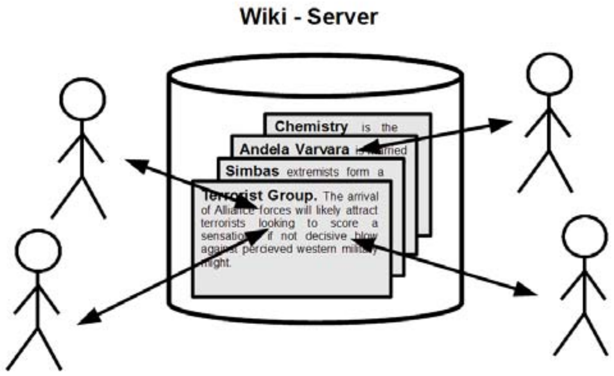

Figure 2.1: wiki, a shared collection of articles the users easily can edit

Leuf and Cunningham (2001) describe the essence of wiki with three points:

- A wiki invites all users to edit any page or to create new pages within the wiki Web site, using only a plain-vanilla Web browser without any extra add-ons.
- Wiki promotes meaningful topic associations between different pages by making page link creation almost intuitively easy and by showing whether an intended target page exists or not.
- A wiki is not a carefully crafted site for casual visitors. Instead, it seeks to involve the visitor in an ongoing process of creation and collaboration that constantly changes the Web site landscape.

Wikipedia is the best known running wiki. The wiki concept, with the collection of articles, lends itself well to the encyclopaedia structure. Wikis may express more advanced structures and the areas of utilization of wikis are beyond that of encyclopaedias, dictionaries and simple collections. Wiki may be utilized as a collaboration tool about a certain topic, a tool for a community website (e.g. communities of interest), or as a component in a knowledge management system. It is a tool for collaborative editing of documents, books, reports, knowledge bases, or for documentation in general. Wiki may even be seen as a management philosophy that manages knowledge creation through evolution of norms and values rather than directives and incentives (Andersen, 2005). However, wiki is not a self contained content management system (CMS), but may be found as a module within a CMS.

2.1.1 The Wiki Concept

One of the best ways to understand the wiki concept is through the wiki design principles of Ward Cunningham, creator of the first wiki software, and originator of the wiki concept. These are the design principles he sought to satisfy with his first release of wiki (Wiki Design Principles, 2010):

- **Simple** - easier to use than abuse. A wiki that reinvents HTML markup[1] ([b]bold[/b], for example) has lost the path!
- **Open** - Should a page be found to be incomplete or poorly organized, any reader can edit it as they see fit.
- **Incremental** - Pages can cite other pages, including pages that have not been written yet.
- **Organic** - The structure and text content of the site are open to editing and evolution.
- **Mundane** - A small number of (irregular) text conventions will provide access to the most useful page markup.
- **Universal** - The mechanisms of editing and organizing are the same as those of writing, so that any writer is automatically an editor and organizer.
- **Overt** - The formatted (and printed) output will suggest the input required to reproduce it.
- **Unified** - Page names will be drawn from a flat space so that no additional context is required to interpret them.
- **Precise** - Pages will be titled with sufficient precision to avoid most name clashes, typically by forming noun phrases.

[1] Markup annotates a text to add presentational or structural specifications

- **Tolerant** - Interpretable (even if undesirable) behaviour is preferred to error messages.
- **Observable** - Activity within the site can be watched and reviewed by any other visitor to the site.
- **Convergent** - Duplication can be discouraged or removed by finding and citing similar or related content.

In the name "Wiki" there is also a statement about the wiki concept: *Wikiwiki* is a Hawaiian word often used in the context of "quick" or "informal". Cunningham's wiki software was developed because he wanted a quick way to collaboratively publish on the Web (Leuf & Cunningham, 2001).

2.1.2 Web 2.0

Web 2.0 is a term that is used to describe the changes seen in utilization of the World Wide Web. Wiki is often mentioned as a characteristic example of Web 2.0 technologies (Reitan & Hafnor, 2007). Its simplicity, using the Web as its platform, and the thorough focus on user contributions matches well the Web 2.0 concept as it is described by Tim O'Reilly (2005).

Wiki is also one of the technologies, or concepts, often referred when Web 2.0 ideas are brought into an Enterprise context (Bughin, Manyika, & Miller, 2008) – sometimes referred to as Enterprise 2.0. McAfee (2006) writes about Enterprise 2.0 and argues that the intranet platform shifts form being the creation of a few to being a constantly updated, interlinked work of many. He claims that most people have something to contribute, whether it is knowledge, insight, experience, a comment, a fact, an edit, or a link. He relates this claim to the intentions of Cunningham with his wiki software: To get to these contributions in a simple way.

2.1.3 User generated content and openness

One of the design principles mentioned earlier is: *Open - Should a page be found to be incomplete or poorly organized, any reader can edit it as they see fit*. This principle in action will enable the readers to become editors, they may do revisions, and they may do minor and major revisions.

A consequence of the "open" design principle is that the content of a wiki becomes evolutionary. Writing a good quality, comprehensive article implies much work. Therefore, since it is easier to correct a minor mistake, add a paragraph, rewrite a passage, move some content or link to existing content – in essence: build upon what is already in a wiki – the content is generated in an incremental and evolutionary way.

2.1.4 Linked content

Most wiki implementations make link creation close to effortless and will show whether an intended target page exists or not. A link between different pages in a wiki, like we are accustomed with from hyperlinks between web pages, promotes meaningful topic associations. Further, links between pages in a wiki will reveal structure; this is illustrated in Figure 2.2. Links – and as such the structure – are also evolutionary in nature. Cunningham states about the applicability of wiki: *Where there's not a natural structure that's known in advance to what you need to know* (Venners, 2003). The evolutionary nature supports structure generation as part of working with a wiki.

In a wiki, both content and structure may be edited by its users. For most collaboration technologies the structure is fixed and only the content is editable to the user. User editable structure is a unique feature of wikis. Very little structure is forced upon the users of wikis by the software itself.

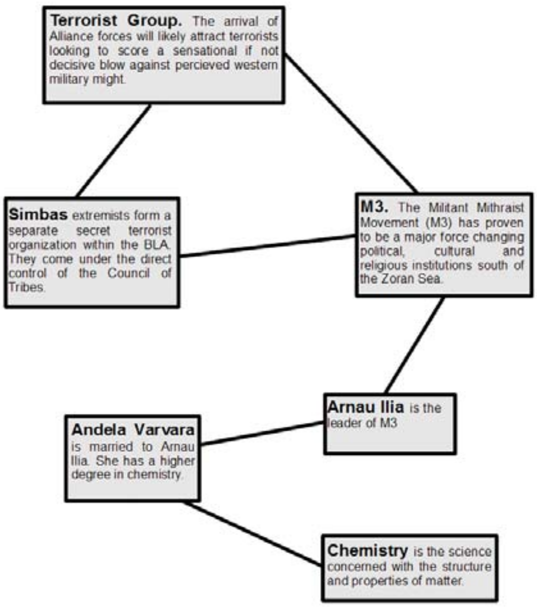

Figure 2.2: Links between pages in a wiki

2.1.5 Categorization and tags

Categorization, or organization, of content is similar in most wiki implementations, but may still differ slightly. Obviously, the structure being evolutionary, a strict classification scheme is rarely the method of choice for wikis. One way to categorize is, by convention, to put a link in a page that links to the wiki-page of the category. Some wiki implementations use more explicit tags that link to the pages of the concept or category. It is common to let a category have its own page in the wiki. Linking to this page in one way or another suggests a weak or undefined relation or associations to that category or concept (See Figure 2.3 and Figure 2.4). A visit to the category page, or tag page, will normally show the pages associated with that category.

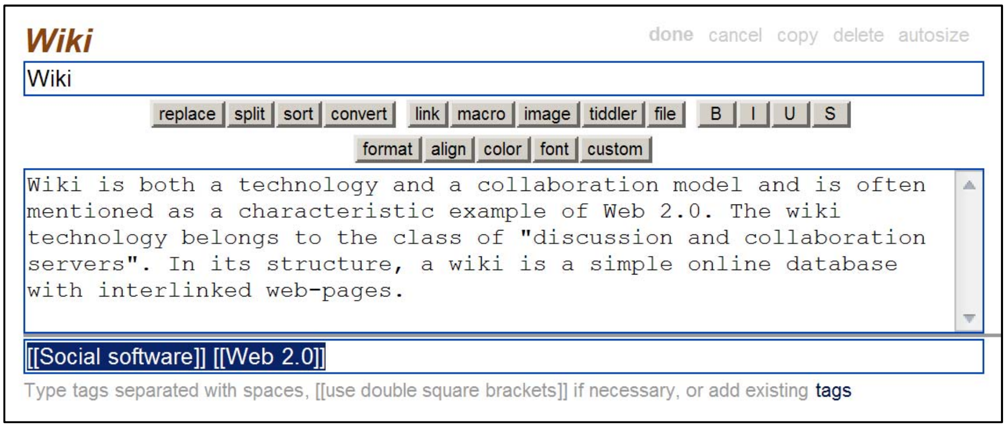

Figure 2.3: In TiddlyWiki there is a separate box for tags

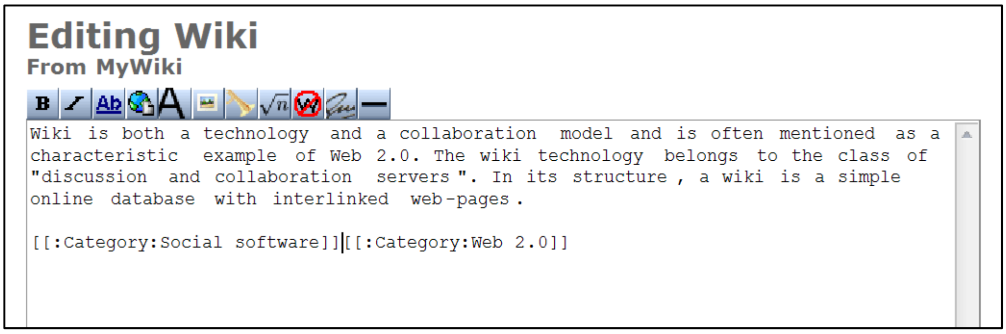

Figure 2.4: In MediaWiki, categories are tagged within the article with a special link

Use of categories in a wiki will add further aspects to the structure of the wiki, and the wiki may start to resemble an informal model of the domain of the wiki. The structure in a wiki is closely related to the concept of linking pages.

2.1.6 Wiki implementations

There are numerous wiki implementations available, many open-sources, with slightly different approaches to the wiki concept. Implementations exist as stand alone server software or as modules to larger content management software (CMS). Schaffert (2006) claims the following to be common properties of wiki systems:

- Editing via Browser
- Simplified Wiki Syntax
- Rollback Mechanism
- Unrestricted Access
- Collaborative Editing
- Strong Linking
- Search Function
- Uploading of Other Content

There is still room for improving the user experience of most wiki systems, and ease of use is often a parameter when choosing a wiki system. Unfortunately, ease of use is often at the expense of fundamental wiki principles and will quickly require additional client software or plug-ins.

The open-source MediaWiki[2] implementation is probably the best known. Wikipedia is one of the sites running MediaWiki software. For MediaWiki, and several of the other wiki implementations, many extensions exist. Extensions give the option of adding functionally to a wiki installation or configuring a wiki for special needs of the targeted domain. References to other wiki implementations may be found at *Wikimatrix*[3] or *Comparison of wiki software*[4] at Wikipedia

2.2 Semantic Technologies

Semantic technologies are information technologies utilizing formal models that define the vocabulary and problem-solving knowledge of the information domain at hand. This approach makes computers able to perform certain knowledge-intensive tasks and in general contribute to more intelligent, adaptive and flexible software.

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[2] http://www.mediawiki.org/

[3] http://www.wikimatrix.org/

[4] http://en.wikipedia.org/wiki/Comparison_of_wiki_software

Central to semantic technologies are formal models, where domain information is explicitly captured and defined. The semantics – the meaning – of the domain knowledge is separated from the data and the application code, and put into the formal models. These models are dynamic, and can be exchanged at runtime. Upon changes to the models the applications change behavior accordingly. As the models are formal and explicit, they are amenable for computer processing in terms of automatically inferring meaningful conclusions according to the defined semantics.

Another benefit of semantic technologies is their ability to effectively utilize large amounts of heterogeneous datasets. This, together with the ability to deduce implicit knowledge, provides means to automate certain knowledge-intensive tasks in order to assist human users. Examples of knowledge-intensive tasks include classification, monitoring, prediction, and planning (Schreiber, et al., 1999).

2.2.1 Ontologies

In computer science, an ontology is a formal explicit model of the concepts and relations in a domain. The assumptions in the domain in question are made explicit, making them computer-processable. Ontologies also facilitate reuse of domain knowledge.

Ontologies are the core components in any system utilizing semantic technologies. Making the necessary ontologies is a modeling task. It is often resource intensive and represents the biggest challenge in order to make semantic technologies work. Ontologies are formal and computer-processable and this makes them amenable for automated reasoning. Furthermore, ontologies are inter-linkable and suited to be developed in an incremental fashion.

Ontologies are often arranged into upper ontologies, general domain ontologies, and application ontologies according to their generality. The upper ontologies define the most general concepts, like for example PhysicalObject, HumanBeing, and TemporalObject. General domain ontologies define concepts in general domains that are common to many applications, for example the time domain, the geography domain, and the command and control (C2) domain.

The application ontologies are the most specific ontologies, being designed to serve a specific application or a family of applications. Application ontologies have to be created manually or semi-automatically, but should reuse existing ontologies, both upper ontologies, general domain ontologies, and other application ontologies, when appropriate.

Note that there is no requirement to use all the three types of ontologies when utilizing semantic technologies. In particular, it will often be the case that the use of an upper ontology is not necessary.

2.2.2 The Semantic Web

The Semantic Web is a vision originally developed by Sir Tim Berners-Lee, the inventor of the World Wide Web. The vision was presented to the world in Berners-Lee et al. (2001). In essence, the vision of the Semantic Web describes an enhancement to the current World Wide Web (WWW), making the contents of the Web accessible to computers as well as to humans.

The Semantic Web is often referred to as representing a shift from today's Web of Documents, where the links are between documents, to a Web of Data where the links are between information elements. This is illustrated in Figure 2.5.

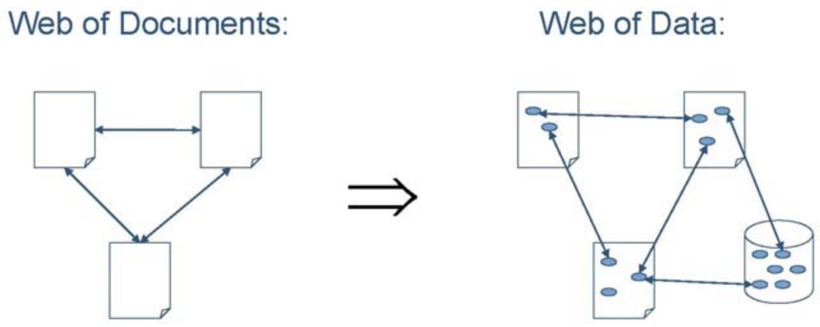

Figure 2.5: From a Web of Documents to a Web of Data

Although the Semantic Web vision focused on the World Wide Web, the associated technologies themselves have also shown to be useful in closed internal enterprise systems.

2.2.3 The Semantic Web Technology Stack

The recommended specifications developed by the World Wide Web Consortium (W3C) in connection with their effort to realize the Semantic Web, can be considered as an important toolkit when implementing solutions utilizing semantic technologies.

Figure 2.6 shows the Semantic Web Layer Cake, which summarizes the technologies and standards needed to implement the Semantic Web. In the following, the Semantic Web standards particularly relevant to this report are presented.

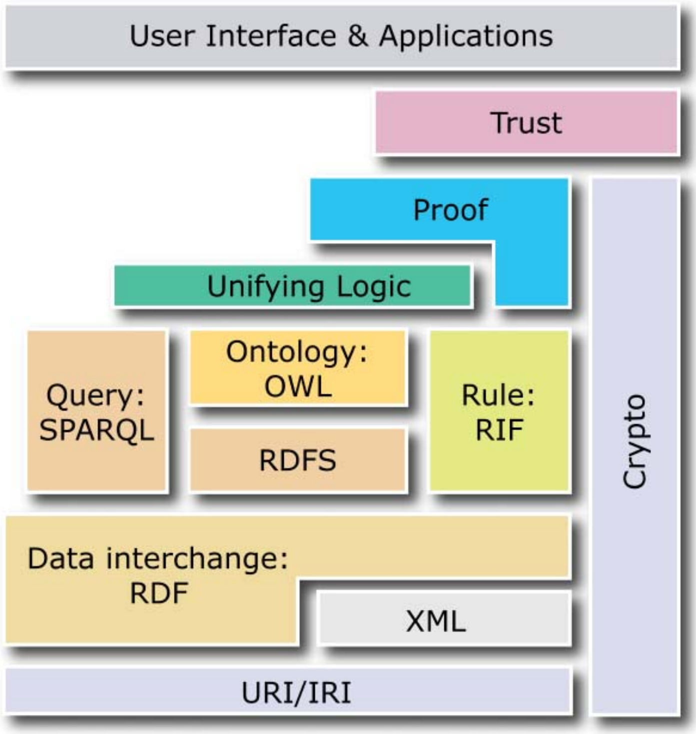

Figure 2.6: Semantic Web technologies and standards. From http://www.w3.org

2.2.4 Resource Description Framework - RDF

The Resource Description Framework (RDF) (W3C, 2004a) is a formal language for representing structured information in a graph. By a graph we understand a general representation of a set of vertices (nodes, points or concepts) connected by edges (lines, links or relations). An information set represented in RDF consists of triples - subject-predicate-object tuples. Subjects are information items identified by a Uniform Resource Identifier (URI); objects can either be an information item or a literal value, while predicates are the relations between the subjects and the objects. A set of triples constitutes a graph, as illustrated in Figure 2.7.

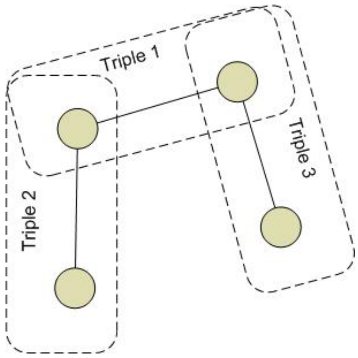

Figure 2.7: An RDF graph consisting of three RDF triples

RDF has several serialization formats, the most widely used being RDF/XML (W3C, 2004b), Notation3 (Berners-Lee, 2000), and Turtle (Beckett & Berners-Lee, 2008).

SPARQL Protocol and RDF Query Language (SPARQL) (W3C, 2008) is the W3C query language designed to allow querying on RDF graphs, much like SQL is used to query relational databases. Using SPARQL, a user specifies a graph pattern which is matched with the RDF graph in question. SPARQL includes a capability to specify remote RDF graphs for querying. This makes SPARQL interesting as a tool to perform federated querying, i.e. the issuing of one query to a number of sources and receiving a single answer.

2.2.5 Web Ontology Language - OWL

The Web Ontology Language (OWL) (W3C, 2000) is a formally defined language for representing ontologies on the Web. It is based on Description Logics (DL) (Nardi & Brachman, 2003), a family of logic-based knowledge representation (KR) formalisms for which there exists complete and tractable algorithms. OWL allows for modeling ontologies with definitions of and restrictions on classes, roles and individuals, and allows the derivation of implicit knowledge through the use of a reasoner. It is a W3C recommended standard with substantial uptake and popularity. It has taken a reasonable balance between expressivity and efficiency with regards to reasoning (Hitzler, Krötzsch, & Rudolph, 2009).

3 Semantic Wiki

> *"A semantic wiki is a system that allows collaborative authoring, editing and linking of pages, but also the authoring and adding semantics to the data on the wiki itself"*
>
> (Kousetti, 2008)

In the previous section we have discussed the properties of wikis and semantic technologies respectively. In this section we will describe how to enhance the functionality of a wiki by semantifying it.

Völkel et al. (2006) use Wikipedia to exemplify how semantics enhance a traditional wiki system. For example, Wikipedia has a page about *London*. This page contains text about the city and links to other pages. The page will belong to some categories like *European Capitals.* The text itself says that *London* is the capital of *United Kingdom* and has a link to this page as well. However, using this information requires that a user actually reads these articles and click on the links to navigate in the hypertext structure.

The goal of semantic wikis is to extend wikis to also contain machine-readable content and structure. This will enhance the possibilities for 1) internal organization, querying, aggregating and question answering as well as 2) exporting and reusing the knowledge and integrate the information with other systems. Völkel et al. (2006) list a number of requirements for semantic wikis:

- **Usability.** A wiki always relies on a community of users; the semantic additions must therefore be easy to use for non-technical users.
- **Expressiveness.** One must balance the wish for having as much information in a machine-readable form with the requirements for usability and performance.
- **Flexibility.** It should be possible to use a semantic wiki for a wide range of tasks, and users should be able to unrestrictedly adjust the form and content.
- **Scalability.** The content in a wiki can become quite extensive and will usually grow over time.
- **Interchange and compatibility.** The actual machine-to-machine interfaces need to be compatible with current tools and standards.

The added meaning and machine-readable structure would allow Wikipedia to answer queries such as*; what is the capital of England*; *find all capitals in Europe* ; *find all* *cities in Europe with more than two million citizens*. Traditional wikis already has some inherent structure in the form of categories, but semantic wikis adds structure in the form of typed pages, typed links and annotations.

Typed links express a relation between two pages or concepts. Links on the web and in traditional wikis have no types. From the example above, a typed link could be *capital of* relating London to United Kingdom. Following the wiki spirit and philosophy, users are free to add new types on the fly. Attributes provides more database-like way to enter machine-readable data and facts can be expressed using values such as numbers, dates and coordinates.

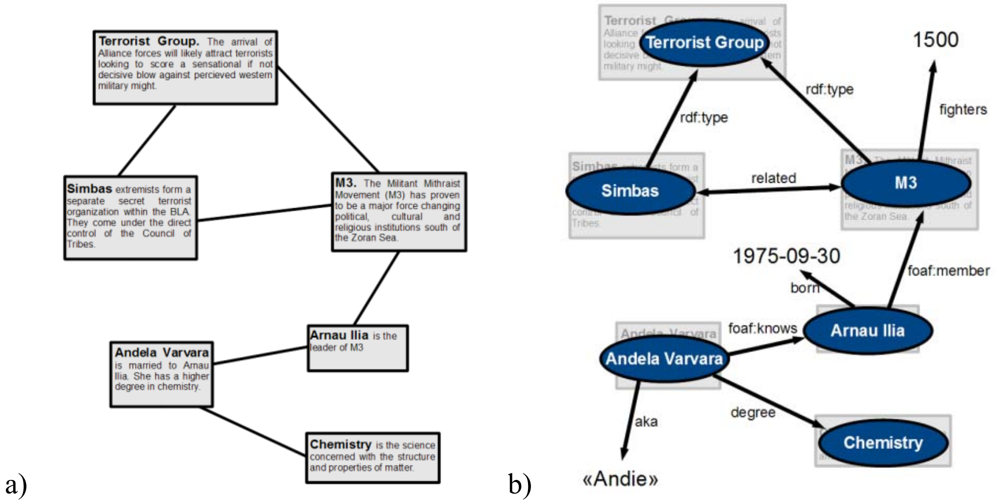

Figure 3.1: A semantic wiki adds structure and meaning to the relations between concepts

The semantics is a typed graph overlaid the conventional wiki content (Tolksdorf & Simperl, 2006). Figure 3.1 a) above shows conventional content composed of wiki pages related with un-typed links. Figure 3.1 b) shows the corresponding semantic graph with typed links – such as *foaf:knows, born, aka* and *fighters* – and annotations such as *1975-09-30, 1500* and *"Andie"*. This semantic graph is the machine-readable and exportable part of a semantic wiki, and onto which advanced queries may be asked and answered.

Wikipedia is just one use case for semantic wiki. Schaffert (2006) lists a number of other scenarios for semantic wiki:

- **Ontology engineering**, in which domain experts and knowledge engineers working together can be supported by a semantic wiki. The experts will have an easy way to enter knowledge, they can all collaborate on working on the ontology and the knowledge can be evolutionary formalized.
- **Knowledge management** systems must combine content creation and easy authoring with structuring knowledge in order to retrieve related information. Traditional wikis may be used for the first aspect, while semantic wikis adds support for the latter.
- **Educational environments** can be supported by semantic wiki by acting as a "learning content pool" where content can be created, edited and related to relevant learning material. Further, the structured and interlinked content in a semantic wiki can support self-directed learning.

We will discuss ontology engineering further in subsection 3.2 below, and in section 4 we will demonstrate military use cases for semantic wikis.

3.1 Semi-structured Knowledge

The added structure and the possibility to annotate pages with facts place semantic wikis somewhere between conventional wikis and traditional databases (see Figure 3.2). A semantic wiki will be more structured than a regular hypertext wiki, but at the same time the structure is dynamic and extendible. It will normally be difficult to change the structure (the table layout) in traditional database systems.

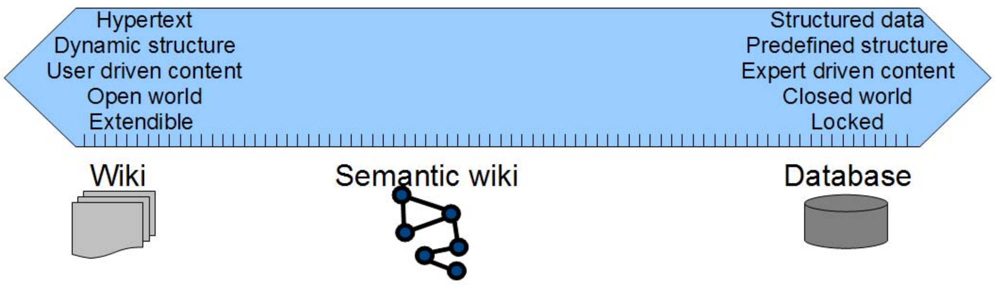

Figure 3.2: semantic wikis belong to a middle ground between hypertext wikis and structured databases

In a semantic wiki the knowledge will be semi-structured, keeping the good features and characteristics from each side. The process of generating the structure itself is also different. In database systems the domain modelling is usually done by a few domain experts; in semantic wikis this is a collaborative, dynamic and evolutionary process. We will discuss this further in the next subsection.

3.2 Collaborative Ontology Making

A semantic wiki merges the 'Wiki way' with the more formal world of ontologies. Klein, Hoecht, and Decker (2005) denote this combination *Wikitology,* where one concept in the ontology corresponds to one page in the wiki and vice versa.

Ontologies and ontology making are often thought to be tasks and responsibilities of domain experts and knowledge engineers. Braun, Schmidt, and Walter (2007) argue that in most real-world settings, maintaining ontologies affects ordinary users as well. Ontologies are *"shared understandings of a particular domain that have to be constructed within social processes among stakeholders"* (Braun, Schmidt, & Walter, 2007). Their work emphasises the simplicity and collaborative nature of the Web 2.0 paradigm, and that ontology making is a process of continuous evolution. They present a model for ontology development or *ontology maturing* (see Figure 3.3 below).

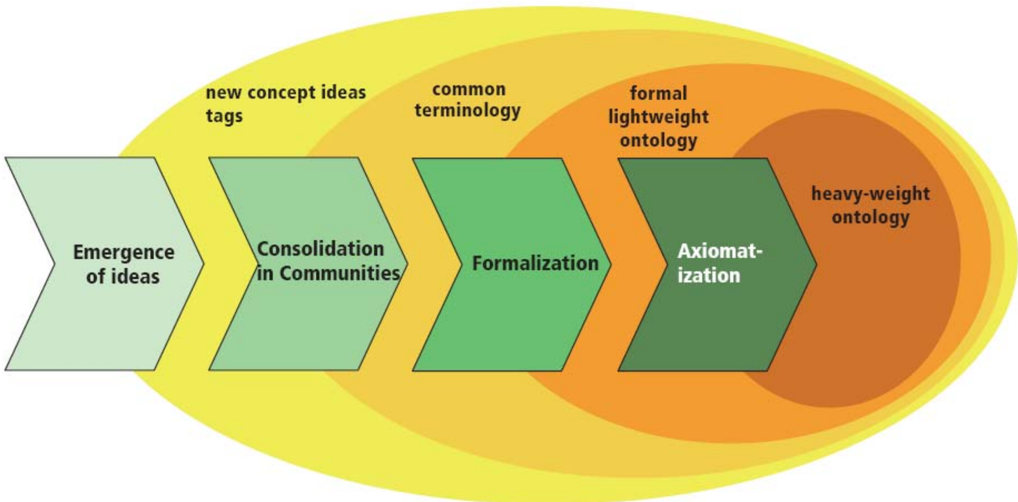

Figure 3.3: Ontology Maturing Process. From (Braun, Schmidt, & Walter, 2007)

This model describes four steps in a collaborative ontology making process. The steps from *Emerging of ideas* to *Formalization* are done by users, whereas the last step requires skills in logical formalism and usually needs to be carried out by a knowledge engineer or domain expert.

We will argue that semantic wiki may be used as a tool for collaborative ontology making – that is defining ontologies from actual usage by a community, developed over time. This is supported by Kousetti, Millard, and Howard (2008), who claim that a user community using a semantic wiki can generate large amounts of semantic annotated information. Such an approach would be faster and require less effort than a small group of knowledge engineers solving the same task. Bry and Kotowski (2010) also contrast the rigor of traditional approaches to knowledge representation with the emergence of semantically rich structures when combining user collaboration with proper tools.

3.3 Reasoning

In addition to knowledge representation and sharing, automated reasoning is another aspect of semantic technologies. Krötzsch, Schaffert, and Vrandečić (2007) list four areas in which such reasoning may help wiki users:

- Browsing and displaying content
- Querying the knowledge
- Editing support
- Validating formalized knowledge

Reasoning support is possible because of the formal structure semantics adds to the wiki. However, the reasoning mechanisms that are available internally in most semantic wiki systems are often restricted and limited in their functionality. The second benefit of adding semantics – that knowledge may be represented, exported and reused in a standardized way – means that other semantic systems may be able to exploit the knowledge to do more advanced reasoning. The demonstrator system described in this report exports the structure and content using OWL/RDF from the Semantic Web stack of technologies.

Reasoning over OWL ontologies commits to the Open World Assumption (OWA), which means that it is implicitly assumed that a knowledge base may always be incomplete (Hitzler, Krötzsch, & Rudolph, 2009). One example (Hansen, Halvorsen, Kristiansen, Rasmussen, Rustad, & Sletten, 2010) is discovering whether Karen is a

Swedish citizen based on the asserted knowledge that Karen is a Norwegian citizen. Reasoning under the Closed World Assumption (CWA) would conclude that Karen is not Swedish. However, under the OWA, a reasoner would not be able to conclude either true or false as there is no knowledge that asserts that a person cannot be the citizen of two countries (Karen could for example have dual citizenship).

There are methods that can be used to close the world in systems where that is needed. 'Closing the world' means forcing the system to regard its information set as complete. This is common practice in traditional databases, where facts not explicitly present are considered to be false.

Automated reasoning over formal models like ontologies is not a new paradigm in computing. This approach, based on deductive, logic-based methods, focuses upon users telling the system what it needs to know (i.e. description of domain vocabulary, domain facts, and problem-solving know-how), then letting the computer find an answer using deductive inference. More details on reasoning in relation to semantic technologies can be found in Hansen et al. (2010, s. Section 3).

3.4 Information Integration

Wikis and semantic wikis being based on hypertext and web technologies, there are more straight forward ways of integrating information. Fidjeland and Reitan (2009) present Web-oriented Architecture, an emerging approach for information integration making use of the proven technologies and principles of the World Wide Web. Information in a wiki fits well with this approach, as each page in a wiki is an information resource identified by an URI (Masinter, Fielding, & Berners-Lee, 2005) (Mealling & Denenberg, 2002) and available using the HTTP GET method (Fielding, et al., 1999).

4 Military User Stories

In this section we present a number of military user stories for semantic wiki. They will focus on practical applications of wiki technology and philosophy. Most will take place within the Zoran Sea Scenario (explained in the next subsection), whereas some will be more general in nature. The user stories are not meant as a technical handbook for how to write wiki pages, but rather show what functionality is available in a wiki or semantic wiki.

4.1 The Zoran Sea Scenario

The content of the semantic wiki described in this report is taken from the Zoran Sea scenario (see Figure 4.1 below).

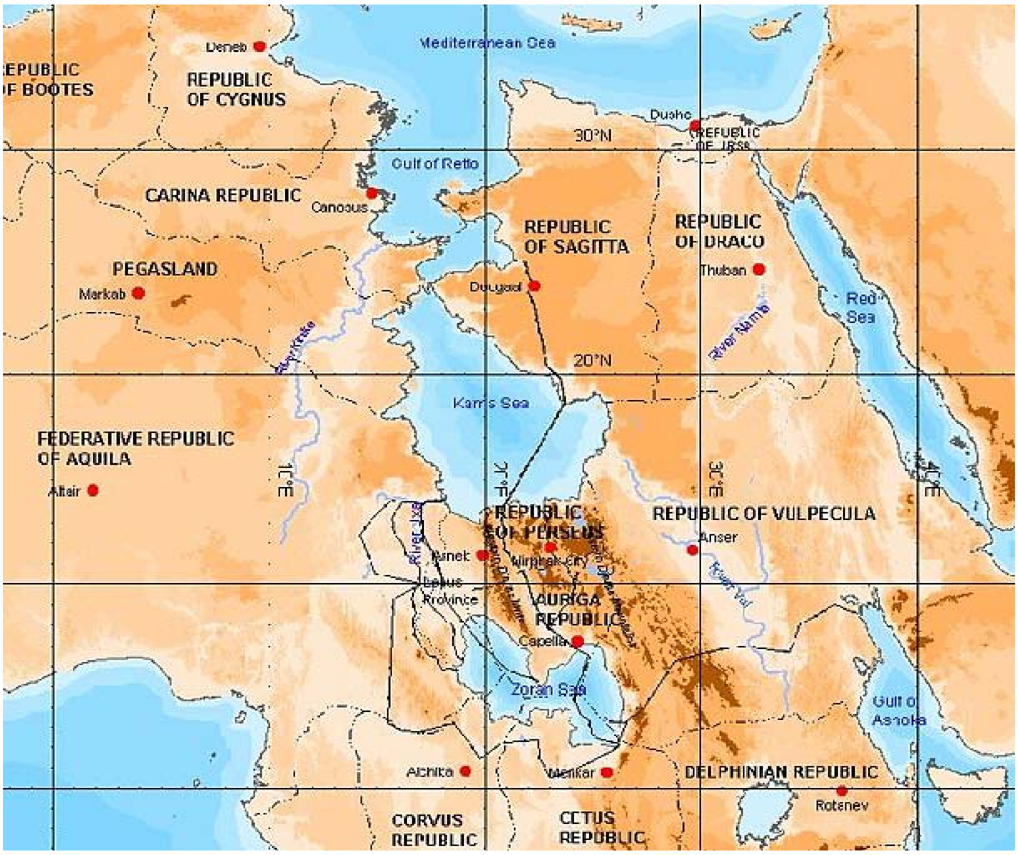

Figure 4.1: Map of the fictitious Zoran Sea region

The Zoran Sea Region is a remote area in central Constellatia, ridden with a patchwork of different cultures, religions and ethnicities and has been a historical battlefield of empires. The region's geo-strategic importance has increased since the discovery and exploitation of natural gas and oil reserves.

There are two regional powers, Aquila and Vulpecula. Aquila is a former part of a larger federation, and is now a stable state playing a constructive role in international and regional diplomacy and politics. Auriga and Perseus are other previous members of the federation, and are now independent states. These countries have a large ethnic Batari minority. Especially in Auriga the Batari are seeking greater independence. Large areas of Auriga are under de facto control of BLA – the Batari Liberation Army – an insurgency group.

The overall strategy of BLA is the establishment of an autonomous and ethnically pure Batari homeland. BLA strongly oppose NATO involvement in the conflict, and are supported by Vulpecula (both direct military support as well as safe havens in Vulpeculan territory). The most extreme elements of BLA resort to tactics such as terrorist attacks and ethnic cleansing. Auriga is burdened by a large number of internally displaced people because of the conflict, and is seeking international support for humanitarian assistance and maintaining internal security and integrity.

Vulpecula itself is a regional power with regional ambitions. It is an authoritarian, totalitarian and strongly anti-western oligarchy. It supports the Batari insurgency in neighbouring Auriga, as well as opposing international involvement in the region.

Other countries of interest are the Republic of Sagitta, a NATO alliance member, and the Delphinian Republic. The Delphinian Republic is another nearly failed state after decades of civil war. International criminal groups as well as terrorist groups such as the Militant Mithraist Movement (M3) operate from safe havens in the republic. The terrorist groups have attacked civilian targets on European soil.

4.2 User story 1 – Communities of Interests Ontology Making

A cross-functional Community of Interests collaborate to maintain high quality and updated background information and analyses of the Zoran Sea Region. Concepts and relations in this domain are modelled by the community as a whole, emerging from the actual usage.

The NATO NEC (Network-enabled Capabilities) net-centric data vision is to eventually make it possible to move beyond traditional Communities of Interests (COIs), such as Command and Control or Intelligence, to full cross-functional information exchange across the battle space.

One of the conceptual ideas in the approved Data Strategy approach in NATO NEC (NATO C3 Board, 2005) is to foster high performance in collaboration and exchanging information across organizational and technological domains. In short; the idea of creating various forms of "Community of Interest" (COIs), as a virtual collaboration construct, is 1) to promote increased net-based collaboration and information exchange across domains, and 2) to handle vast and more complex information flows (i.e. net-centric approach to information management).

The COI concept is very broad, and covers a large number of potential groups of every kind and size. In general a "Community of Interest" (COI) is a community of people who are all interested in "something common" and need to share information, and who therefore must have shared definitions, formats and other common attributes for the information they exchange. Any element, e.g., domain, organization, task force, project team or group who must exchange information may be considered a "COI". For example, every task-oriented workgroup can be a COI. Any collection of people with a declared interest (e.g. in Biological Warfare or Logistics) can also be a COI. A COI can assume a diverse range of characteristics depending on the community's mission or objectives (Hafnor, 2006). COI members may include various data owners and producers (e.g. subject matter experts, developers, program managers, users, etc.) that need to share the same knowledge. A COI has a so-called "self organizing mandate" since there is no "special process" for designating or establishing a COI, nor any specific criteria for qualifying as a COI.

A cross-functional COI shares and contributes to information about a wider topic, such as the Zoran Sea region as a whole. The Zoran Sea Scenario contains information about a number of subjects and categories. Each subject has its own page, which are editable by all members of the community. These pages contain links to related subjects, so that users reading about the Militant Mithraist Movement can browse forward to the page about, say, the Delphinian Republic, then read or update an analysis of the current situation in Delphinia or search for suitable air or sea ports of debarkation (APODs or SPODs) in the country.

There are a number of features to facilitate the collaboration of creating and maintaining the information on each page. The most important is the fact that anyone can edit or add pages in the wiki. The editing is done in the same web interface used for reading. It is possible to discuss the content and the process of information management on each page. There is a separate discussion available for each page or subject.

Semantic wikis can be used as an alternative or complementary solution to address some of the complexity in the COI efforts to develop shared understanding involving shared vocabularies and taxonomies that promote the semantic and syntactic understanding of data assets. Chapter 3 in this report describes that semantic wiki can be used as a tool for collaborative ontology making - defining ontologies from actual usage by a community, developed over time. A COI using a semantic wiki can generate large amounts of semantically annotated information faster and require less effort than a small group of knowledge engineers solving the same task. By creating a semantic wiki as a COI domain model – that is describing the community domain – ontologies can automatically be generated from that model and put to use. One of the advantages gained is that semantic wiki is a user-friendly and user-centric technology that provides an evolutionary approach to ontology-making in contrast to the expert regime required in the meta-data strategy (NATO C3 Board, 2005).

4.3 User story 2 – Group membership

Before commencing on a foot patrol, a scoutmaster search for all members of the Militant Mithraist Movement (M3). The search is stored inline in the page about M3 itself so that users do not need to replicate and maintain facts in several places.

Semantic queries are searches on the relations, facts, and implicit knowledge contained in the semantic graph (see Figure 3.1b above). The Militant Mithraist Movement (M3) has only two known members; *Andela Maia Varvara* and *Arnau Ilia*. These facts are stored in the page about each person respectively, with a relation like `[[member::Militant_Mithraist_Movement]]` stated in the source.

In the page about the M3, there is a list of all members in this organization (see Figure 4.2). This list is **not** a replication of the facts that Andela and Arnau are members, but an inline search of all pages in the wiki that are related to M3 through the relation *member*. Inline searches are stored in the page source. They are editable in the same way as the remaining page content. One of the main features of inline searches is that the actual facts are only stored one place (in this case in the pages about each person). This eases the maintenance of the wiki as information is not repeated and copied throughout the wiki.

Figure 4.2: Inline semantic search of members of the M3

4.4 User story 3 – Implicit knowledge

An intelligence analyst searches for all members of the category of Irregular groups. The memberships of this category are not stated explicitly, but are implicit in the structure of groups, subgroups and memberships.

The semantic wiki has a special page for semantic searches, with syntax similar to inline searches and the general wiki markup. Figure 4.3 shows the semantic query input along with the search result at the bottom.

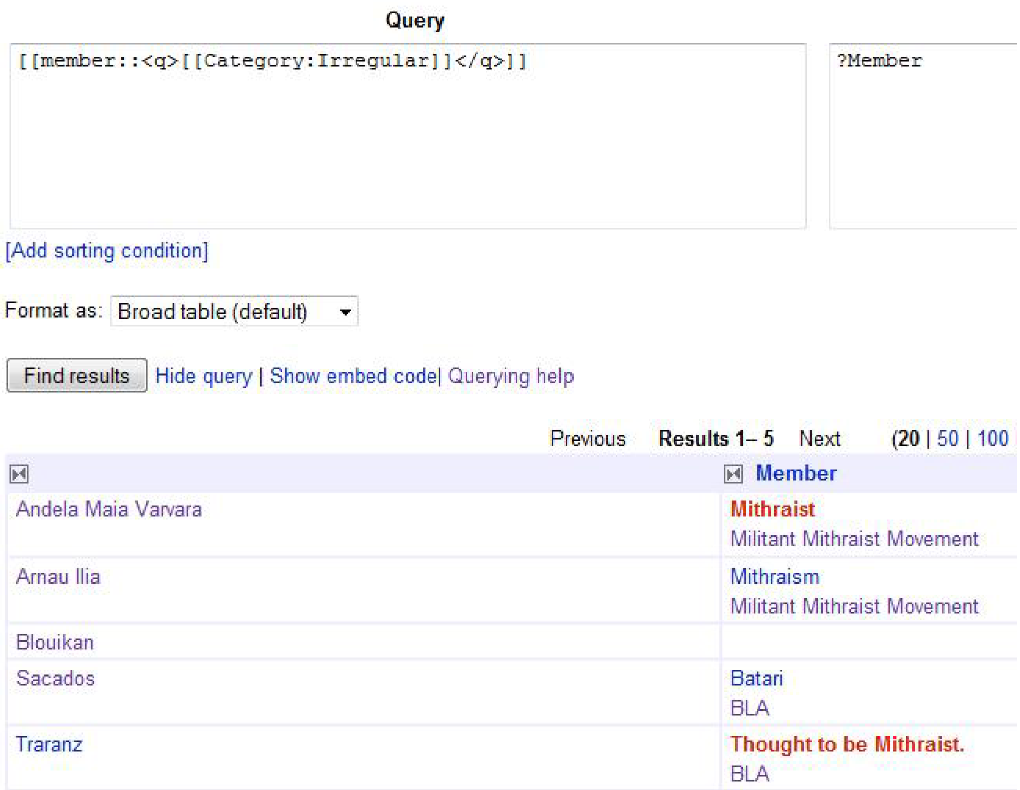

Figure 4.3: Semantic search with reasoning to find all members of the Irregular *class. Members are listed to the left, the organizations they are members of to the right.*

This is an example of a more advanced compound query. The result is a list of all members of any organization that belongs to the irregular category or any subcategory. Figure 4.4 shows part of the relevant taxonomy from the wiki content. The *Irregular* category has two sub-categories or sub-classes, below these there are three actual instances of groups – *BLA, Simbas, Milites Oppressorum* and *M3*. The query will find members of any of these four organizations.

Given that *Arnau Ilia* is member of *M3,* he is also implicitly a member of a *Terrorist Group* as well as a member of the *Irregular* category. The facts that are explicitly stated in the wiki is his membership of the *M3*, that *M3* is an instance of a *Terrorist Group,* and that *Terrorist Group* is a subclass of the category *Irregular.*

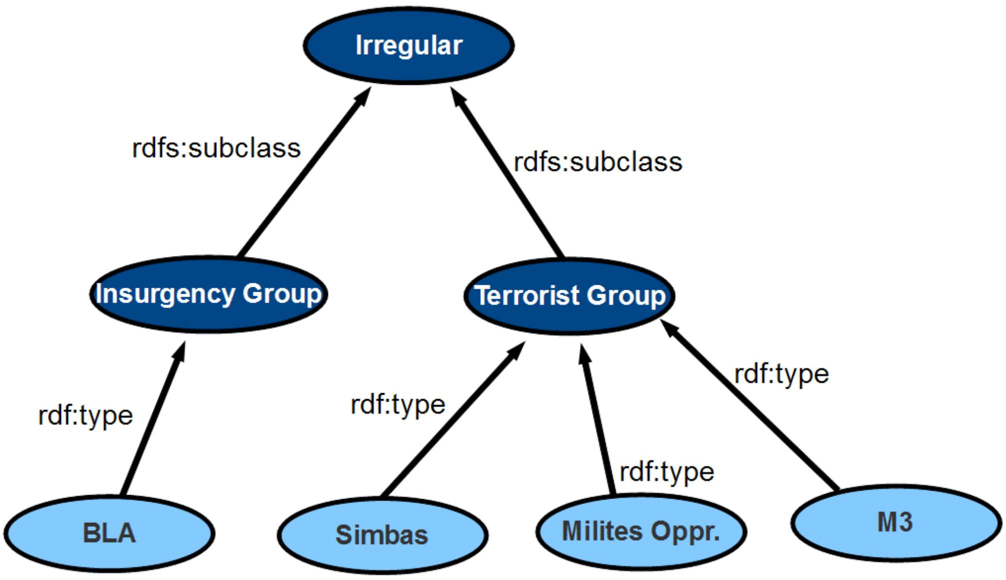

Figure 4.4: Part of the taxonomy with classes/categories and instances

This is an example of reasoning mechanisms provided by semantic technologies, in this case making implicit knowledge explicit. Internal searches like this only support basic reasoning mechanisms. The structured knowledge in the wiki can be exported as an ontology and be reused in more advanced systems.

4.5 User story 4 – Map overlay

The J3 cell adds geo-tagged information from the wiki as a map overlay in an operational picture.

Pages about countries, groups and peoples are tagged with a geographical location. By exporting[5] the wiki content in the standard KML format (OGC, 2008), this information can be viewed in a map along with other relevant information such as positions and observations. The place marks are organized in the same categories as in the wiki itself – the taxonomy left in Figure 4.5 is the same as the one in Figure 4.4. Place marks in the map links directly to the corresponding wiki pages.

Figure 4.5: Content in semantic wiki as map overlay. The taxonomy is the same as the semantic wiki content itself

[5] KML Export Extension, http://www.mediawiki.org/wiki/Extension:KML_Export

4.6 User story 5 – Information Integration and federated queries

Information about the M3 and its members from the semantic wiki is integrat ed with other hetero geneous information sources, helping an intelligence analyst detect a possible TST target.

A patrol from the NATO force in Delphinia observes two trucks near a storage building suspected to be controlled by the Militant Mithraist Movement (M3). The observation is inspected and analysed using the Automatic Reasoning-based Intelligence Tool (ARBIT) (see Appendix A for more details). The intelligence analyst first uses the system to fetch more information about the two trucks. ARBIT and the functionality is also described in (Hansen et al., 2010).

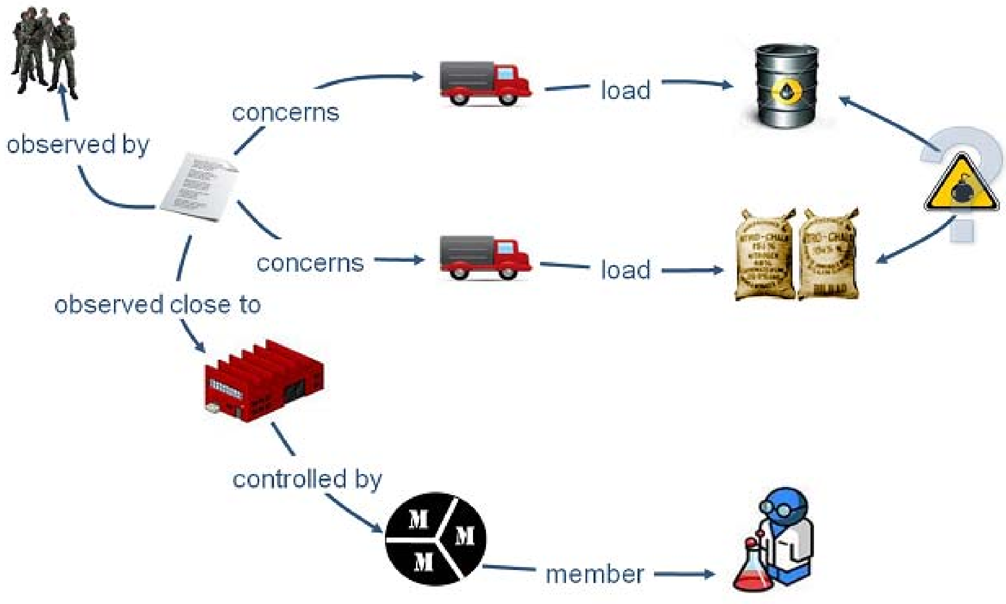

Figure 4.6: Conceptual graph of story. From (Hansen et al., 2010)

In the background, a federated query is performed. Based on the initial query, the information retrieved from the different sources is integrated together as a single answer in the form of a graph. The conceptual graph of all relevant information is shown in Figure 4.6. Information regarding what the trucks are carrying has been retrieved; ammonium nitrate and fuel oil. The system then uses background knowledge regarding chemistry and bomb making (defined in ontologies and rules) in order to identify that the co-location of these two trucks might indicate a possible bomb as the load that the trucks carry together are major components of an ammonium-nitrate fuel-oil bomb. Furthermore, the system notices that if this is a bomb, then it also partially matches a valid Time-Sensitive Target (TST) that according to military doctrine should be taken out immediately. Yet, this still might be coincidental co-location, so the analyst continues to drill down.

The next branch that the analyst focuses on is the storage building. Further drill-down indicates that this building is controlled by a known terrorist organisation. Drilling down on the organisation itself shows that it has a member that has bomb-making expertise. The system now classifies this organisation as a terrorist organisation with bomb-making expertise. Furthermore, this completely satisfies the rule for classifying a specific time-sensitive target, and the analyst is appropriately warned. The warning is then delegated to decision makers in order to decide on appropriate actions.

Two of the information sources used are wiki-related. First of all, the system utilise data from DBPedia[6] (Auer, Bizer, Kobilarov, Lehmann, Cyganiak, & Ives, 2008) which is a data-dump of Wikipedia facts formatted as RDF triples. The other source used is the intelligence content of the semantic wiki in the form of information regarding terrorist groups and their members.

For the part of the analysis, the system provides functionality to import a variety of different expert background knowledge about domains based on user needs. This background knowledge is in terms of ontologies and rules that form executable models of domains. Thus, these models can be run on the dataset and used to infer conclusions from it (e.g. classify objects, infer relations between objects, enforce constraints, etc.). Concrete examples include determining if a dataset indicates a potential bomb and/or a time-sensitive target, classifying an object as a certain type of vehicle, etc.

In the case outlined above, the semantic wiki played the role as a knowledge source containing information about terrorist groups and their known members. One could also envision that a semantic wiki could be used as a tool for developing and maintaining the ontologies and rules that make up the background knowledge. Furthermore, the inferred knowledge that comes from the reasoning process done in ARBIT could be fed back into the wiki, thereby enhancing it.

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[6] http://dbpedia.org

4.7 User Story 6 – Wiki-based planning

Wiki technology is used as a vehicle for distributed parallel collaborative operational planning. A task is given to a military force, with the units of the force distributed in different locations. All the planning is made on a wiki platform.

The planning will start with a preliminary formulation of the commander's intention. On this basis sub units at all levels may start their planning. All the units participating may, at any time, see and possibly comment the current version of the plan in development by all the other units, without much delay. This will enable each unit to dynamically adjust their plan to fit the plans of the other units. Included in the procedure are revisions of the commander's intent. The procedure also opens the possibility of including contributions from other units into own plans or intention statements, increasing the degree of collaboration in the process.

The objective of planning is formulated in various ways in the vast literature on the subject. In short the objective of planning as described here is to increase the probability for a successful outcome of an action or operation. Successful outcome without planning would be ideal. Hence planning is not an aim itself, and ideally as little as possible of time and resources should be spent on planning. Experience has shown however, that good plans and in particular good planning processes are very important for the success of an operation.

Military planning in the western countries may be characterized as commander centred, hierarchical, structured, controlled processes. This leads to relatively strict control of information flow, unit interactions and decision rights. The hierarchical structure of the planning where the commander formulates his intent on how to solve his mission (achieve the End state), the subordinates plan their missions and send their plans in for approval by the commander, with a subsequent approval, leads to a relatively sequential process.

The advantages of an approach like the one sketched above are a higher degree of parallelism and collaboration in the planning process. In turn, this should result in reduced planning time and a high degree of shared understanding of how the task will be solved. A plan being based on more accurate topical information is another benefit.

5 Challenges

Implementing wiki-based solutions will not be easy. Cultural and organizational barriers have to be overcome, competence requirements have to be met, security issues have to be solved, and trust established. Effective use of wikis can only be reached through an evolutionary process with a combination of experimentation and experience from practical use. In this section we will discuss some of the challenges of introducing wikis and semantic wikis with regard to some of the user stories described above.

5.1 Organization

The openness necessary for wikis to work is difficult for some people and especially for certain organizations. Cunningham is commenting on this aspect in an interview:

> *"In addition, wikis work best in environments where you're comfortable delegating control to the users of the system. There isn't a lot of logic in wiki about who can do what when, because wiki doesn't really understand what you're doing. It's just holding pages for you. Lot's of conventions are established for what is or isn't an appropriate use, but they're all in the minds of the users not in the business logic of the application. That works well if you have a trusting community that isn't looking for the computer to enforce some behaviour. I've been asked sometimes whether wiki would fit in a corporate environment, for example. I think there are corporations that are together enough to have this trust of their own employees, and there are certainly corporations that aren't. Corporations that wouldn't trust their own employees to be able to maintain a web site need something other than wiki."*

(Venners, 2003)

Organizational inertia curtails the effectiveness of Communities of Interests (COIs) as well. The experience gained over the last few years is that COIs have a tendency to operate independently and have not been providing the "information sharing ability" that was initially expected, even when individual COIs are proclaimed successful (Winters & Tolk, 2009). One explanation for this independency is that there is no overall conceptual, technical, or governance framework to refer to, and this has resulted in multiple independent representations for the same data, making it very difficult to share data and services across COIs. Even if data may be visible, accessible and understandable within each COI, they are not necessarily understandable outside of the COI, nor interoperable across COIs. Another explanation proposed from our side is that it also may be that the bureaucracy related to establishing and managing COIs seems to heavily increase in such a way that it at the end may produce unintended side effects (e.g. bureaucracy that works like a firewall), or that the proposed meta-data strategy for making common understanding of the semantics of data is to complex or too ambitious. One resent proposed COI Information Sharing Solution from the NATO community (NATO C3 Board, 2009) requires the involvement of COIs that cut across organizations to create standard-based vocabularies to enable interoperability. This can be a good thing, but the danger of creating a COI regime that is being too complex or bureaucratic is still there.

A COI must be able to share and exchange information with other COIs in order to foster high performance in ad hoc cross domain teams. Thus, a crucial role of a COI is to make COI data visible, accessible, trusted and understandable *across* the network enabled enterprise. The Semantic Web has a global scope. Every ontology has its own unique URI identifying it and defining its namespace. The Semantic Web is also distributed, designed to create a web of data, or a web of concepts, where ontologies and vocabularies can be reused, combined or referred to from other ontologies. Ontologies from a semantic wiki will be available in RDF/OWL, ready to be used by other systems and integrated with other information. The semantic wiki technology characteristics also seem to harmonize better with the distributed self organizing characteristics of the COI concept as a virtual organizational construct. This can potentially contribute to solve some of the semantic problems in the cross-COI problem mentioned earlier.

With regard to ontology making, semantic wiki is a promising technology for collaborative ontology making within a COI. Semantic wikis may be especially geared towards the three first steps in the Ontology Maturing Process described in section 3.2 above.

5.2 Distributed Planning Processes

The military in general emphasize planning as a very important part of the decision-making process. Through a long tradition of theory and experience, the military planning process is highly developed. The opportunities created through modern communication and information technology together with the challenges created by the complexity of the tasks and operational environments in today’s operations, suggest adjustments to the military command and control process and hence the planning process.

Three factors are particularly important for the discussion of planning in relation to wiki technology:

- **Distribution of forces and headquarters**. With modern communication, forces may be more distributed and headquarters may be located far from the operational theatre. Operation Anaconda is a well documented operation that may give a good example of current network enabled operations and at the same time many of the challenges such operations face (Naylor, 2005).
- **Complexity of the command and control environment**. Missions may for several reasons, often be accomplished by coalitions with contributions from different NATO nations as well as non-NATO nations, international organisations, non-governmental organisations (NGOs) etc. This heterogeneous make-up may imply that no single element is in charge, violating the important unity of command principle, fundamental in military thinking on command and control (C2).
- **Complexity of tasks**. The tasks given to military forces are often difficult to define. A few examples of such difficulties are that the objective ("End State") of the task may be difficult to formulate in a sufficiently precise way, the enemy may be hard to define, operations are severely restricted by political and civil considerations, etc.

Modern thoughts on command and control (C2) suggest that in order to cope with the complex operations of today and expected in the future, more agile C2 approaches will be necessary. This means fewer restrictions on information exchange and interactions, and more distribution of decision rights (NATO RTO SAS-065). Figure 5.1 illustrates the requirements for increase in C2 agility.

The philosophy behind use of the wiki technology is very much in line with these ideas. This suggests wiki to be a promising technology to support more agile C2. In the planning context, wikis may potentially be used in three ways:

- As a vehicle for development and documentation of planning doctrines
- Source of information pertinent to a given operation
- Vehicle for distributed parallel collaborative operational planning

C2 Approach	Allocation of Decision Rights to the Collective	Patterns of Interaction Among Participating Entities	Distribution of Information (Entity Information Positions)
Edge C2	Not Explicit, Self Allocated (Emergent, Tailored, and Dynamic), one continuous adapted living plan	Unlimited As Required	All Available and Relevant Information Accessible
Collaborative C2	Collaborative Process and Shared Plan	Significant Broad	Additional Information Across Collaborative Areas/Functions
Coordinated C2	Coordination Process and Linked Plans	Limited and Focused	Additional Information About Coordinated Areas/Functions
De-Conflicted C2	Establish Constraints	Very Limited Sharply Focused	Additional Information About Constraints and Seams
Conflicted C2	None	None	Organic Information

Figure 5.1: Definition of the C2 approach types of the NATO NEC Maturity Model, from (NATO RTO SAS-065)

It is highly probable that the doctrinal structured approach to military planning will remain in the future. The planning doctrine is now documented in series of documents (e.g. AJP documents in NATO). The potential advantages of using a wiki, as the format for describing the planning doctrine and the vehicle for developing the doctrine, should be obvious. All the contributors to the doctrine may almost in parallel make their contributions. Changes are easily traced and previous versions restored if necessary. Most wiki-platforms allow for discussions on controversial subjects. It will be easy for the user to access the information requested.

Wiki-based planning has the potential of producing better plans and more agile response to changes in the situation. In case the task is given to a coalition, wiki-based planning may be even more advantageous. Coalitions with no single element in charge lend themselves to parallel collaborative planning. The relatively simple and open source software of most wiki-platforms may more easily be shared by the different participating organizations.

5.3 Quality and Authority

The information found in a system based on user generated content, like in a wiki or semantic wiki, will show different characteristics than content engineered by experts. With user generated content, every person will have his or her personal style and the content will reflect these personal approaches. Systems based on user generated content will sacrifice perfection at the micro scale for optimization at the macro scale; there is a trade-off between coverage and up-to-date information on one side and authority on the other. For example, Wikipedia is a system with much user generated content; Encyclopedia Britannica may be the equivalent authoritative source. They are both encyclopedias, but where Wikipedia excel in coverage and up to date information, it has little authority. Britannica is shallow in some categories and out of date in many others, but it is still a more authoritative source (Anderson, 2005).

Peer-based modification is likely to gradually improve the quality of information in a semantic wiki. Also, other measures may be taken to improve on quality and consistency throughout a semantic wiki, but in general, one is likely to face less consistent information and greater variation in quality. In Table 5.1 we list some factors illustrating the trade-offs one is facing if choosing between a semantic-wiki (user generated content) and a system with expert engineered content.

	Expert engineered content	**User generated content**
Cost/effort	High	Low
Authority	High	Low
Quality	Reliable	Variable
Information generated	Less	More
Best fit for	Critical decisions	Overview, understanding

Table 5.1: Differences between expert engineered and user generated content

A semantic wiki may, at a low cost and effort, give coverage and up to date information, but its quality may be variable. Expert engineered content may yield a more comfortable quality on the information, but at a higher cost.

5.4 Usability

Wikis are evolutionary in nature. As users add more content and improve upon the quality, the structure and semantic relations will emerge. Millard et al. (2008) argue that there is a danger that no consistent semantic graph will emerge, but that this can be mitigated by starting with a "seeded" wiki with some pre-filled content.

Simplicity is one of the design principles of wikis. Semantic wikis have been extended to ease the adding of semantics as well. Users have found the MOCA extension[7] very useful (Kousetti, 2008). It is also likely that some patterns of structure will establish themselves as being more mature and stable. In the demonstrator system we have a set of profiles of suspected terrorists and BLA commanders. These profiles all follow a template with relations such as *name, birthday, rel igion, group membership,* and so on.

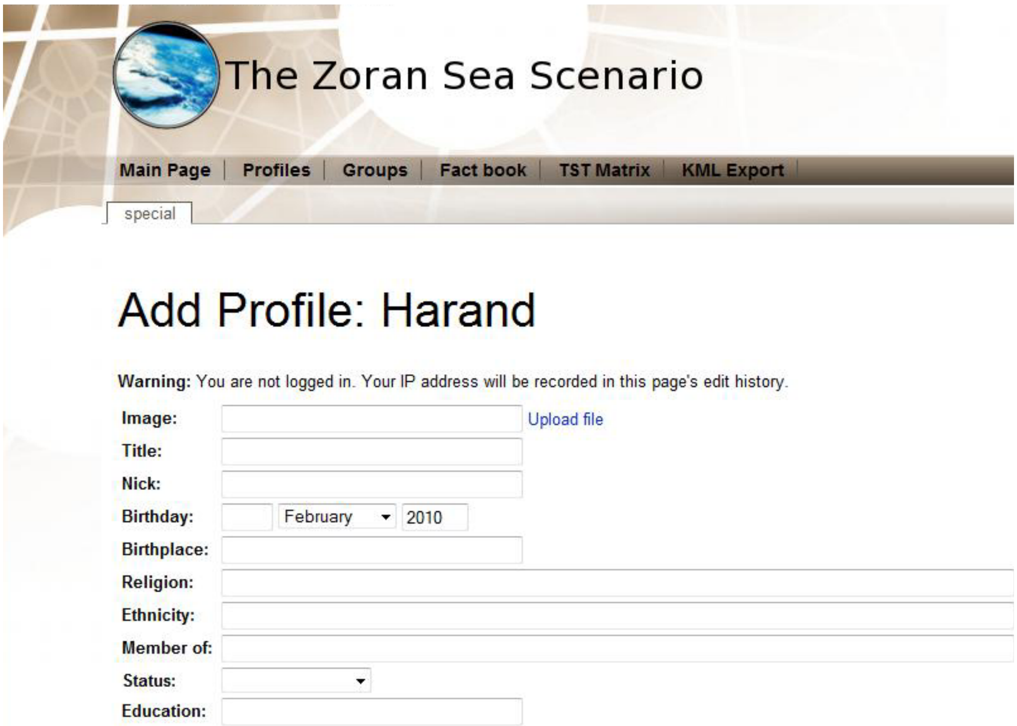

Figure 5.2: Semantics hidden behind a semantic form

[7] http://www.mediawiki.org/wiki/Extension:MOCA

Such templates can be created in the wiki. They work by hiding the semantic notations behind a simple form like the one shown in Figure 5.2. This makes it easy for users to add new and edit existing profiles – all they need to do is filling in simple input boxes.

People profiles, group memberships and social network are naturally modelled by Semantic Web technologies (Golbeck, Mannes, & Hendler, 2005) (Mannes & Golbeck, 2005) (Mannes, Golbeck, & Hendler, 2005). Semantic wiki can provide a user friendly interface to the Semantic Web and ontology making.

6 Conclusion

A semantic wiki will contain semi-structured knowledge – that is somewhere between hypertext wikis and structured databases. Semantifying a wiki gives it more structure; both helping users organizing and browsing information as well as allowing machine-to-machine integration and prepare for external reasoning mechanisms.

We have seen several diverse military user stories for semantic wiki. Wiki is a general-purpose technology for organizing pieces of information that are linked to other pieces of information. These resources may be abstract concepts, ideas, classes, background information, analyses, person profiles, and so on. Further, these resources are uniquely and globally identifiable and locatable by the use of URIs.

Wikis are especially useful when a group of users or a community of interest work collaboratively for creating and maintaining information. Semantic wikis also offer a positional easy and user friendly way for Communities of Interests to collaboratively construct and maintain their ontologies and vocabularies.

We will conclude this report with a quote summarizing an actual effort of taking a semantic wiki in use:

> *"Moving from a KB-driven web site to a semantic wiki means a crucial change in thinking; one must release control of the structuring ontology, and place one's faith in the wisdom of the user community. It is however a liberating experience and the potential advantages are many: a familiar wiki editing paradigm, co-ownership of content, and evolution rather than stagnation of structures and terms"*

(Millard, et al., 2008)

Appendix A Demonstrator systems

Two demonstrator systems have been implemented; a Semantic Wiki containing background information from the Zoran Sea Scenario and ARBIT, the Automatic Reasoning-based Intelligence Tool.

These were developed for and demonstrated at the Demo2010, a one day conference at Norwegian Defence Research Establishment (FFI) presenting technological possibilities and network-based collaboration within a future NATO NEC. The technologies shown were based on results from the FFI projects SecSOA, SINETT and Semantini, in cooperation with NC3A.

Figure A.1: Demo2010. Photos by FFI/Infoenheten.

The event revolved around the Zoran Sea scenario involving NATO forces working in Delphinia, involving terrorist activities from the Militant Mithraist Movement. The semantic wiki was presented as a tool used in the planning process. ARBIT was showcased under the story of an intelligence analyst working on an observation report received from the battlefield. Both were demonstrated at the stand and poster area

A.1 Semantic wiki demonstrator

The SINETT project implemented a demonstrator Semantic Wiki using the open-source, freely available *MediaWiki*[8] software. This is the same software used for powering Wikipedia. The semantic functionalities are available as an extension called *Semantic MediaWiki*[9]. Figure A.2 shows a screenshot of the demonstrator system.

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[8] http://www.mediawiki.org

[9] http://semantic-mediawiki.org

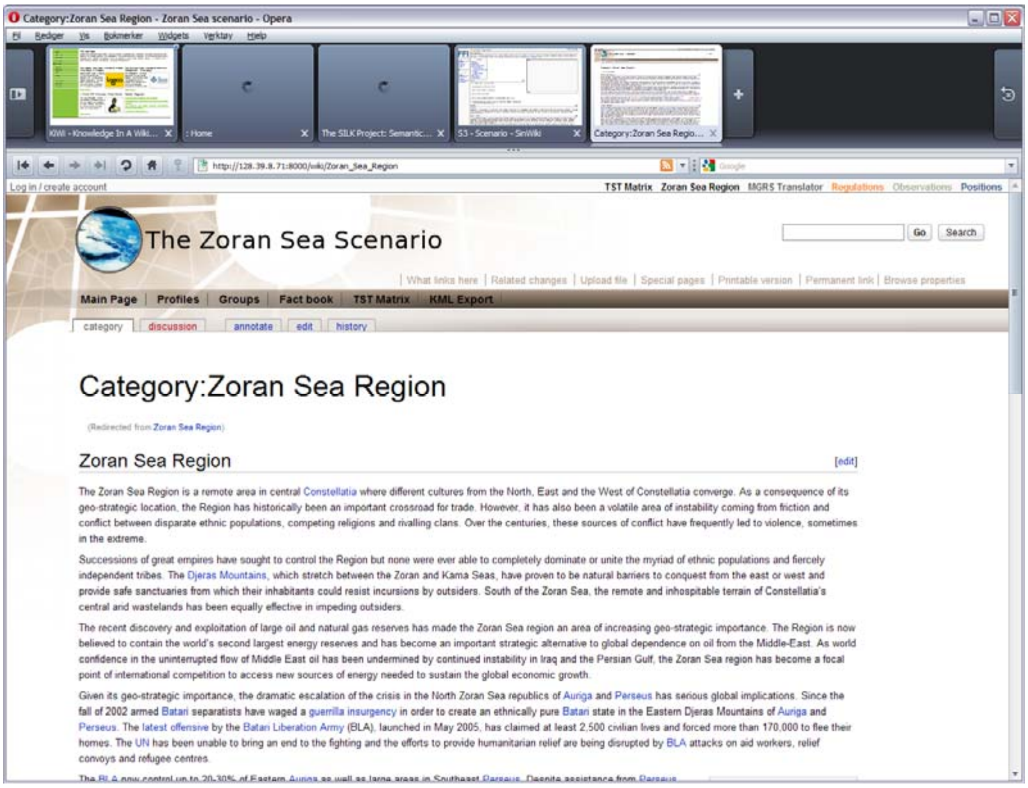

Figure A.2: The implemented Semantic Wiki viewed in a web browser

There are a multiple of Wiki implementations, the MediaWiki and the Semantic MediaWiki being some of the more popular and mature implementations. A commercial version[10] is available from the German semantic technology company Ontoprise. Other software implementations include IkeWiki[11] (Schaffert, 2006) and AceWiki[12] (Kuhn, 2008). Millard et al. (2008) compares various implementations of Semantic Wiki with regard to a list of given characteristics.

The content in the demonstrator semantic wiki is mostly taken from background information handed out at the command-post exercise "Joint Effort" at the Norwegian Defence Staff Collage (FSTS) (Fidjeland & Gulichsen, 2009) (Sendstad, 2008) (Marthinussen, 2007). In this exercise a Joint Operational Planning Group in an allied operational level headquarters plan for a NATO operation to deploy into the Zoran

[10] http://www.ontoprise.de/en/home/products/semantic-mediawiki/

[11] http://ikewiki.salzburgresearch.at/

[12] http://attempto.ifi.uzh.ch/acewiki/

Sea region in order to support the Aurigan government and counter the influence of the insurgency group BLA.

A.2 ARBIT demonstrator

One possible usage for semantic technologies in the military domain is in decision support systems. This includes systems dealing with C2/3/4, early warning and surveillance, intelligence analysis, etc. In order to explore this application area, the Semantini project developed ARBIT, a demonstration decision support system for the intelligence domain put to work in a fictitious intelligence setting (see Hansen et. al. 2010 for a more detailed description). The system works as an aid for intelligence analysis in terms of acquiring relevant information from unanticipated information sources (one of them being the semantic wiki described previously), and automating knowledge-intensive tasks such as classifying and deducing conclusions from datasets.

The ARBIT system provides functionality for graph navigation, information integration, federated querying, ontology- and rule-based reasoning as well as partial matching of rules. From the analyst's perspective, this should address both fetching relevant information and automatically drawing meaningful conclusions.

First of all, ARBIT provides the ability to drill-down on information (fetching additional information). This is done by performing federated querying and information integration based upon user guidance (point-and-click on nodes in the graph to find and fill in more information). Thus, the system provides human-guided querying of various unanticipated heterogeneous information sources and returning the results as a single unified answer.

In addition to executing/firing rules as the conditions are satisfied, the system performs partial rule matching (aka. relaxing the rules) in order to help the analyst drive the data drilling forward. This will hopefully aid the user to reach an answer to the question at hand. E.g. if a rule indicating a time-sensitive target is matched partially, the system will indicate what is missing and indicate where to find more information in order to confirm a suspicion. The tool is semi-automated, as a fully automated approach would result in a combinatorial explosion with a growth in number of sources. Thus humans guide the search space. This technique is common in automated reasoning applications such as mathematical theorem proving, where the search space is unbound (infinite). Early indications show that this approach is suitable for our task as well.

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Abbreviations

APOD – Air Port of Debarkation
ARBIT – Automatic Reasoning-based Intelligence Tool
BLA – Batari Liberation Army
C2 – Command and Control
C3 – Command, Control and Communications
C4 – Command, Control, Communications and Computers
CMS – Content Management System
COI – Community of Interest
CWA – Closed World Assumption
DL – Description Logics
HTML – Hypertext Markup Language
HTTP – Hypertext Transfer Protocol
INI – Information Infrastructure
KB – Knowledge-based
KR – Knowledge Representation
M3 – Militant Mithraist Movement
NATO – North Atlantic Treaty Organization
NEC – Network-enabled Capabilities
NBD – Network-based Defence
NGO – Non-governmental Organisations
OGC – Open Geospatial Consortium
OWA – Open World Assumption
OWL – Web Ontology Language
RDF – Resource Description Framework
SPARQL – SPARQL Protocol and RDF Query Language
SPOD – Sea Port of Debarkation
TST – Time-sensitive Targeting
URI - Uniform Resource Identifier
W3C – The World Wide Web Consortium
WOA – Web-oriented Architecture
WWW – World Wide Web
XML – Extensible Markup Language