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Topic (i): Sharing of software and components

Virtual teams: Wikis and other collaboration tools

Invited Paper

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I. INTRODUCTION

1. The purpose of this paper is to provide an overview of strengths and weaknesses of wikis as a tool for collaboration. First we introduce the concept of wikis. Next we provide a brief overview of technical characteristics of wikis. We compare wikis to other collaboration tools paying particular attention to points characteristic in wikis. We further provide the historical and social context of the emergence of wikis. Having drawn this picture of wikis and their context we deduce scenarios in which the application of wikis is particularly appropriate or respectively inappropriate. In conclusion it can be said that while wikis are a powerful concept they leave many questions open. Wikis are well suited in social environments with a flat hierarchical structure in which there is no single person or committee responsible for maintaining content.

A. What is a Wiki?

2. Wikis appeared on the Internet landscape in the mid 1990's. They were developed by Ward Cunningham [9] and named after the Hawaiian word for “quick”. Wikis can be used in different contexts mainly for developing written text not only WWW but also locally or Intranet. A wiki enables documents to be written collaboratively, in a simple markup language using only a Web browser. They do not require users to install additional software. Meaningful topic associations between different pages are created by making page links. This is almost intuitively easy and shows whether an intended target page exists or not.

3. Wikis are considered a Web 2.0 technology. In order to appreciate the implications of this categorization let us briefly review the characteristics of Web 2.0 applications. The term Web 2.0 refers to collaboration on the World Wide Web. Prominent examples for Web 2.0 applications are *flickr*, *facebook* or *del.ico.us*. The 2.0 version identifier plays at the fact that prior to Web 2.0 the web communicated with its users not in a dialogue but similarly to print media, in a monologue. Content was published by a single author and was not modifiable

by consumers. Interaction with the web site was rudimentary at best. Our personal opinion is that the name "Web 2.0" is misleading as it hints at a further development of the World Wide Web. Originally the web was intended to be an interactive collaboration platform [2] and the reason why it was not collaborative from the very beginning is that at the time the technological means were not sufficient for such a demanding task.

4. There is a wide discussion over the set of characteristics defining an application as being *Web 2.0*. One commonly accepted set of characteristics is:

- Participatory
- Decentralized
- Linked
- Emergent

5. Wikis fulfil all of these criteria. They are participatory, because every consumer can participate in the maintenance of the content. They are decentralized because they work best when they are managed not by a single person or committee but when the responsibility over the content is shared among the users of a wiki - this claim will be elaborated later in section *Best Practices*. They are linked because single pages in a wiki are often only meaningful in the larger context of the entire content of a wiki. They are emergent because wikis are a relatively new technology the flexibility and limitations of which are still being tested.

6. Judging by the purpose and functionality of wikis they can be categorized as a kind of content management system (CMS). Unlike traditional CMSs however wikis are unstructured. There is no imposed structure on content. While this means that a wiki navigation path can be shaped in any desired way, it also means that the content graph can become unwieldy and impractical if its growth is not being overlooked. Content is not the only part of wikis that is unstructured - wikis also lack user hierarchies. Although there are methods to restrict editing rights on wikis the intent is to grant write access to anyone who has access to the wiki. This has several social implications which will be discussed in more detail in section *Social Mechanisms*.

7. Wikis were designed upon the premise that content is never complete or error free. To allow for faster convergence towards optimal content wikis allow as many editors as possible and give them as much freedom as possible. As radical as this approach may appear at first it is actually the way the World Wide Web was envisioned in the early 1990s.

B. Technical Aspects

8. In this section we will cover some technical aspects characteristic for wiki software. Content is entered into wikis using a special markup language. The markup language provides syntax for simple formatting of text as well as inserting links to other documents as well as external content. Although the markup language is kept simple, it poses a significant entry barrier. Its advantage however is that it can be used on any web browser and on any device with web browsing support. Practically all current wiki software also supports WYSIWYG (What You See Is What You Get) content entry. The WYSIWYG editor makes all the features of the markup language accessible from a toolbar. Text entry using the toolbar may be slower because users will need to alternate between the keyboard and the mouse often. The WYSIWYG editor is also often only supported on the most common web browsers. Its main advantage however, a low entry barrier, makes its existence legitimate.

9. As outlined in the previous section one of the main characteristics of a wiki is that its content is dynamic. Wikis implement several mechanisms to ensure a high standard of the quality of content in spite of its fluidity. A complete revision history of every document is stored so that after an erroneous or malicious change the content can be easily reverted to a previous state. Users can opt to receive emails when the content of a document is changed. This may result in an Inbox full of notifications of typo corrections. To prevent this, editors can mark changes as minor. Minor changes are not sent to all users for review. Users can also subscribe to an RSS feed publishing major changes instead of requesting emails. The main advantage is that RSS infrastructure is better suited for this news flash style solicitation of information.

10. Wikis are available through wide variety of services and open-source software tools. Generally there are the following two categories of wikis:

- Wiki services or Wiki farms: the wiki pages are hosted at the service provider server or array of servers and require no local software installation and the service can be free or fee-based. A comparison of many Wiki farms can be found at http://en.wikipedia.org/wiki/Wiki_farm. Also very helpful, especially if one is looking for a very simple solution, is the following *blog* entry and the subsequent discussion: http://pascal.vanhecke.info/2005/10/30/.
- Self-hosted wikis: there exists a variety of open source wiki software like *MediaWiki* and *TWiki*. The advantage of self-hosting the wiki allows for maximum control over the access and security as well for fulfilment of specific requirements. A disadvantage is the necessity of own server and some technical and network experience which results in longer start-up time.

11. Choosing the right wiki can be based on answering some question regarding the key features of the wiki, the available resources and technical support:

- How many users?
- Are separate groups necessary?
- Is interaction between the groups necessary?
- How secure should be the pages?
- Public or private pages?
- How skilled are the participants (simple markup or WYSIWYG)?
- How important is the layout?

II. COMPARISON WITH SIMILAR TECHNOLOGIES

12. To present a profile of wikis we will compare them with other collaborative technology. We will compare wikis with emailing lists, forums and newsgroups, blogs and traditional content management systems.

13. **Mailing lists**. A simple and widely spread collaboration method are emailing lists. In a mailing list emails are sent to a designated email address. The receiver of that address is not a person but software, which broadcasts received emails to all subscribers. Although it is possible to send emails to all receivers in the first place, the automated method makes it simpler to administrate subscribers of the mailing list. The main difference between mailing lists and wikis is that mailing lists are private. The receivers are usually restricted and although there is some support for publishing mailing lists on the web the information circulated through mailing lists is usually not accessible from users who are not subscribed. It is interesting to note that although it may not be obvious at first sight, archived mailing lists provide functionality to achieve tasks similar to the ones accomplished with a wiki.

14. **Web forums.** Another comparable technology are newsgroups and their more modern counterpart, web forums. Although the difference between wikis and forums seems obvious, it is tricky to define precisely. Unlike mailing lists in forums users can change their own content after it has been posted. The archival of communication threads is intrinsic in the medium. The difference to wikis seems to be mainly in spirit: while wikis are more document centric newsgroups and forums are more communication centric. A forum with sufficient article persistency can be used in the same way like a wiki. However wikis provide better support for authoring, retrieval and interrelation of documents. For example URLs to documents in wikis are often self-explanatory. In forums on the other hand, URLs are identified by a numeric unique ID, which does not give any clues about the content at the location. The qualities of both systems are difficult to compare because their performance depends heavily on the culture and discipline of the community they are used in.

15. **Blogs.** Although blogs are not a collaboration tool in the strictest meaning, they are still covered here since they are a significant step up from the monologues Web 1.0. Blogs, short for web logs, are comparable to periodic columns in print media. The main difference is that they usually have an interactive comments section right beneath each article. The main articles are usually written by one or few authors. The comments however can be written anonymously. This policy may be a good trade-off between the strict access control in traditional content management systems and the liberal approach in wikis. The content in blogs is organized chronologically, hence the name web logs.

16. In Table 1 the main features of the three (blogs, web forums, wiki) technologies are summarized – see also [11].

Table 1: Comparison of different collaboration tools.

	Web forum	Blog	Wiki
Speed of publication	Yes	Yes	Yes
Ease of publication	Yes	Yes	Yes
Knowledge representation	Chronological organization	Chronological organization	Topical organization as well as chronology of changes
Team support	Open or closed set of members; moderators	Individual publishing but some tools offer team support	Inherently open to public but can be restricted to close groups
Security	Yes	Yes	Yes
Version management	Not provided	Not provided	Versions and history changes are provided; rollback possible

17. **Content management systems.** As mentioned above wikis are a subgroup of content management systems (CMS). Nevertheless wikis have some peculiarities, which make them stand out from what is commonly understood under the concept of a CMS. While the features and functionalities are the same, a different emphasis is placed on the same features in a CMS and in a wiki. Generally a wiki is more open for authorship. The support for authorization and authentication is less sophisticated than in a content management system. Because of the open authoring policy wikis implement elaborate inter personal conflict resolution mechanisms, which are usually not found in a CMS. Another difference, which is more a guideline than a rule, is that wikis can be implemented efficiently relying solely on free open source products while traditional content management systems are often expensive, proprietary solutions (with some exceptions like *Joomla*, see also http://www.cmsmatrix.org/). The last major difference is the organization of content: in a CMS content is organized in hierarchies while the organization structure of wikis is flat.

18. **Microsoft SharePoint.** A completely different platform for collaboration on the web is provided by Microsoft SharePoint products and technologies. SharePoint web sites and pages are commonly used to build intranet and extranet portals and team sites, as well as public Internet sites. It shows maturity in terms of user interface, database design, and workflow and communication features. SharePoint includes two platforms: Windows SharePoint Services (WSS) and Microsoft Office SharePoint Server (MOSS). WSS is more basic and is used to create web sites for team collaboration on a common project. It can serve small companies and individual departments. It comes as a free extension to the Microsoft Windows Server 2003 and higher. MOSS builds on WSS and provides capabilities for portal publishing, enterprise search, enterprise content management (ECM), and many more. MOSS targets the management and control of a company's diverse knowledge assets. It is available in Standard and Enterprize Editions. Both WSS and MOSS are .NET 2.0 applications with XML web service interaction layers and ASP.NET presentation layers.

19. SharePoint is highly integrated with MS Office and thus very strong when type specific documents (Word, PowerPoint, Excel) are concerned. It integrates also nicely with MS SQL Server. But SharePoint ultimately turns into just a file share. Another disadvantage is the required maintenance of the user access rights. SharePoint 2007 includes a wiki but it is very low profile when it comes to be benchmarked with other wiki engines, not to consider its price. In summary, it is not necessary to compare SharePoint to wikis because they have completely different purposes (complexity vs. simplicity, expensive vs. free) but rather SharePoint has to be compared to other Content Management Systems like *Joomla, Alfresco, drupal* and others.

20. **Lotus Notes/Lotus Domino 7.0.** Lotus is one of the original players in the collaboration and messaging market and has made a name with business users and IT specialists. Basically there are two products - a Lotus Domino Server that provides the back-end services and Lotus Notes serving as a client application. The tool

Lotus Notes Designer helps for developing collaborative applications but it requires specialized skills. Lotus Notes has good interoperability with DB2, JSP and XML but poor third party support. Similarly as for SharePoint, there is some integration possible between wikis and Notes but different communities draw the dividing line between Notes content and wiki content differently, depending on what suits the preferences and "culture" of the particular community. However, Lotus Notes tends to be preferred for hosting large reference documents, or more formal documents, within the Intranet.

III. PURPOSE STRENGTHS AND LIMITS

21. Wikis are a collaboration tool. In the context of this paper we treat wikis as a means for collaborative knowledge management. To understand better the tradeoffs involved in wiki collaboration we present a historical background of wikis, a treatment of the social mechanisms at work in communities using wikis and finally we present some best practices for the successful implementation of wikis.

C. Historical Implications

22. To understand the social context and original intent of wikis it is necessary to look at the history of their development. Wikis were made famous by the open source community. They were used as a simple documentation tool for projects. Since documentation is often written by the people who wrote the software, the documentation tool needed to cater to the organization structure of open source projects. The structure of open source projects is covered in great detail by Eric Raymond [10]. This kind of projects have several characteristics usually not found in commercial projects. The hierarchical structure of the contributors is flat. The release cycle is very short, Raymond goes as far as phrasing the mantra “publish soon, publish often”. Every user is a potential contributor. The schedule of the project needs to be flexible - in many large open source projects there is non-stop development because there is always a time zone with contributors currently working on the project. It is easy to see how wikis fulfil all these requirements.

23. Eric Raymond explains the motivation driving open source software as the need to scratch an itch. In this metaphor contribution to open source software is treated as the solution to a minor annoyance. Although there is no monetary return, the effort required to solve a minor annoyance is low. Writing documentation however does not add to the solution of the annoyance, it just makes the solution viable for other people than the contributor at an added effort. To make open source contributors document their software at all they must be able to do this in a simple and quick manner. What makes the documentation complete is the sum of small contributions of all programmers. To make the process of documentation even simpler, the need for categorization of information is removed all together.

D. Social Mechanisms

24. Wikis are a tool for the externalisation of knowledge. As such knowledge is transferred and synthesized along several vectors in a wiki community. To externalise knowledge an individual writes or changes a wiki article. However, the process of externalisation can lead to individual learning processes in the contributor because in order to write something down a clear understanding of the matter is required. Knowledge in wikis also flows in the opposite direction. When users read articles, they internalise the knowledge in the wiki corpus, this leads to expansion of the individual's knowledge on a topic. The crucial flow of information in wikis however is the synthesis of knowledge, which was previously neither present in the wiki nor in the individual. When newly acquired knowledge interacts with previous knowledge the so-called emergent knowledge is created. Emergent knowledge is a direct result of collaboration; it is more than the mere sharing of knowledge. Within this theoretical structure an attempt can be made to explain what motivates the contribution of knowledge to a wiki. Cress et al. [5] propose the theory that what drives people to edit wikis is an incongruence between the knowledge in the wiki and the internal knowledge of the contributor. One such incongruence could be information which is missing in the wiki but present in the internal knowledge. Another incongruence is conflicting information - when the wiki contains information, which is contradictory to internal knowledge a reader is prompted to edit the article. Cress et al. [5] model the motivation for contribution as a function of the size of incongruity and the importance (valence) of the topic to the contributor. Curiously dealing with the

resolution of contradiction conflicts between different users and the corpus in the wiki is also the largest challenge in running a wiki. Failure to deal with such conflicts leads to the inevitable failure of a wiki.

25. As mentioned above, wikis emerged as a documentation tool for software projects. When writing documentation usually all programmers document their own modules. The subtle implication of this setting is that there are hardly ever inter-personal conflicts about the content. Such conflicts are possibly the most obvious reason not to use a wiki. Although most wiki software implements elaborate conflict resolution mechanisms, all of them fail without a fair and clear policy as well as the willingness of the community to adhere to such a policy. Some of the conflict resolution mechanisms are discussion forums, moderation or user authentication. Authentication is targeted specifically at conveying a sense of responsibility to users and thus preventing vandalism. A possible policy to deal with controversy is to assure that all aspects of a controversial topic are covered in an article - this is the modus operandi in the online encyclopaedia *Wikipedia*.

E. Best Practices

26. The historical roots of wikis have strong implications on their applicability in environments outside of the open source community. For wikis to be useful a large user base is needed. Wikis work best when the organization structure of the users is flat. In commercial environments with a strict hierarchy wikis often do not work well. In a hierarchy subordinates often do not carry the initiative attitude required for the productive implementation of a wiki. For a wiki to work its users need the confidence that they take on responsibility for parts of the content without intervention of superiors. In hierarchical contexts often information is power. When this is the case, participators are usually unwilling to give away information, for example by entering it in a wiki, and thus forfeit power. A related problem frequently found in strict organizations is the fear that due credit will not be attributed for contribution to a wiki. The users worry that they will not receive credit for their good ideas and hard work and thus refuse to participate. This problem can be greatly alleviated by using the change monitoring mechanisms described in section *Technical Aspects* in combination with an administrator who makes sure that deserved credit is given for good work.

27. In open source projects there is most often a flat hierarchy of contributors led by a so called benevolent dictator who makes sure that there is a common vision and who steers the project towards it. This is the setting in which wikis work best. The content of successful wikis is monitored by the community, not by a single person. In the case of irresolvable problems the issue is escalated to a higher authority. This approach works well for two reasons. On the one hand, the information stored in wikis is often too overwhelming for a single person or a small team to overlook in sufficient detail so that they can identify problems. On the other hand bearing responsibility and custodianship for the content of an article is an additional authoring incentive.

28. The smooth working of such a culture is best supplemented with conduct guidelines. These guidelines should state what kind of information should be entered in the wiki, it should specify conflict resolution procedures, it should settle a guideline for copyright issues and so on. A good example for successful guidelines are the five pillars of Wikipedia - see http://en.wikipedia.org/wiki/Wikipedia:Five_pillars. Often the presence of a clear policy in combination with technical conflict resolution support will prevent conflicts from appearing in the first place. Anecdotal studies have shown that when relying on community monitoring vandalism has practically no negative impact on the integrity of wikis.

29. When introducing wikis into social contexts without prior wiki experience there are some common misunderstandings. Often expectations are too high, users need to be made aware that not everything will work from the beginning. Wikis are not a solution for every collaboration difficulty. Although wikis are simple, they need to be introduced. A tutorial or workshop in which technical as well as social aspects of wikis are explained ensures that they are used as intended. Usually it needs to be made explicitly clear that wikis are never finished and that they require constant commitment. Another way to reduce the entry barrier for new users is to have some content present at the time the wiki is introduced.

IV. EXAMPLE SCENARIOS

30. To draft a picture of possible applications of wikis we present several fictional (and real) scenarios.

F. Building collaboratively a knowledge base (in a given domain)

31. This is may be the most common usage of a wiki with *Wikipedia* being the most famous example. The content is created by the community and used by the community and the size of this community can vary from a small team to potentially the whole world in *Wikipedia*. Several examples of particular knowledge base wikis are in order.

METIS Wiki

32. **URL:** http://www1.unece.org/stat/platform/display/metis/About+this+wiki. The METIS wiki is part of the effort to help experts in statistical agencies develop metadata management systems and processes. The meetings of metadata experts from statistical offices are held every 1-2 years, with the purpose of sharing experiences and developing a Common Metadata Framework (CMF). Published on-line, the framework is available at http://www.unece.org/stats/cmf. Each part of the CMF concentrates on different practical and theoretical aspects of statistical metadata systems. Part D focuses on the experiences of national statistical offices that have recently implemented or re-engineered their statistical metainformation systems. Statistical organizations are describing their approach to metadata management in a series of case studies, which are published on the METIS-wiki, a platform where contributors can keep their own material up-to-date as their metadata projects progress. The wiki engine behind is the enterprise wiki *Confluence* - see http://www.unece.org/stats/cmf hosted by UNECE. The content is structured around "case study" entries at several levels and only authorized users (i.e. the contributors of the respective case studies) can add or edit content. The case studies follow a predefined template (available also as a MS Word template) containing general information about the organization, six topics (which could slightly vary from organization to organization) and the complete case study as a PDF document. If the case study was created as a MS Word document it can be easily uploaded to the wiki using the import capability provided by the engine. The front page of the wiki contains information about the common metadata framework, about the wiki and the available editing tools as well as further contact information.

R Wiki

33. **URL:** http://wiki.r-project.org/rwiki/doku.php. As described by the R-core development team on its web page, R is "a system for statistical computation and graphics. It provides, among other things, a programming language, high-level graphics, interfaces to other languages and debugging facilities." R is a free software and is developed and distributed under the GNU license and enjoys a very large community of users and developers. R comes with several official manuals and a general collection of useful information for users on all platforms (Linux, Mac, Unix, Windows) can be found in R FAQ. Additionally there are two platform-specific FAQs for Windows and MacOS. The main location for general questions about R is the R-Help mailing list. It is useful (if you dare ask a question) but very busy and quite unfriendly. May be this was the reason to launch an R Wiki as an easier platform to search, find and contribute information all around R. There existed other R Wikis before, but they did not gain much success due mainly to the lack of publicity and the use of a too simplistic wiki engine which did not provide R-specific features like code-highlighting, direct links to documentation for R functions and packages, etc. The new R Wiki launched in 2006 [6], uses the *DokuWiki* engine, targeted to software documentation and extended with R-specific plugins to make it more suitable for creating R documentation. The main principle for structuring the content is to distinguish between large guides or books and short tips. It seems that the first category is not quite relevant since its content did not go further than importing a small part of the book *Statistics with R* by Vincent Zoonekynd and several short tutorials.

Ubuntu Users

34. **URL:** http://wiki.ubuntuusers.de/Startseite. *Ubuntuusers* is a portal (in German) providing everything necessary about *Ubuntu* and its derivatives. It is the single entry point to a web forum where one can ask questions, a wiki where one can read (or write) guides and explanations and a blog which publishes news from *Ububtuusers*. The wiki has a clean structure build on a small number of top level categories like download, installation, drivers, security, programming and so on, which can be further expanded.

G. Collaborative software development

35. This scenario entails a small team of software developers working on a mid-range project. The team uses a wiki in their development process. The content of the wiki will not be a part of the product developed by the team, it is rather part of the supporting infrastructure, similarly to a version control system. It is used to document peculiarities of the development cycle, to share know-how about third party software, to collect information about how problems are tackled by competing products or perhaps to store meeting minutes and to-do lists. The wiki is probably an inappropriate medium for a technical documentation of the source code. For such a task a wiki is far too informal. One of the advantages of using a wiki in this scenario is that common tasks, which are not performed frequently enough for the team members to remember the exact steps, can be documented. In these cases the developers will have a guideline for solving a specific problem and will not have to sift through the same documentation over and over. An example for such a task is the build process. Suppose that the developers are employing unit test techniques. Infrequently it is necessary to build the project although some of the tests are failing. The wiki could store the command line options required to ignore failed tests and produce a project build. The wiki corpus would also be advantageous to developers newly introduced into the project. On the one hand new developers can be referred to the wiki on trivial issues. On the other hand, these new developers will probably discover several minor mistakes in the wiki and will thus contribute to a better corpus.

H. Wiki for education, teaching and training

36. Modern education theory states that meaningful learning cannot be accomplished solely by performing passive activities like reading or listening. Rather students should be engaged in the learning process. Following this logic a teacher is not one who provides content but one who provides context for learning. If passive learning were effective, students would read a book on a topic and become experts. Since this is not the case, the job of a teacher or instructor is to provide a context in which effective learning can take place.

37. Wikis can serve as a tool, which inherently requires students to actively contribute to the learning process. When applying wikis in an educational context similar problems as well as best practices apply like in other scenarios - see section *Best Practices*. One major difference is that unlike in traditional wikis, in educational settings the contributors to a wiki meet frequently in person. In a classroom setting resolving issues is much easier than when the contributors to a wiki are scattered around the world.

38. Several applications have been identified for wikis in education [12]. They can be used for knowledge construction. Students will compile an information corpus on a subject, field or discipline in order to gain a deeper understanding of the matter by being forced to write down their thoughts. Another application of wikis is to hone critical thinking. Although critical thinking is a skill mainly promoted in academical settings, its goals, namely the analysis and evaluation of a subject, are also applicable outside universities. A third application of wikis in a classroom is to provide contextual application. Contextual application is the practicably application of newly acquired knowledge with the purpose of reinforcing the grasp on the material. In this case wikis can be used to coordinate and organize the implementation of a practical project.

I. Collaborative Authoring

39. In this scenario we consider a small team, say of up to 10 members (possibly distributed geographically and organizationally) with the task of creating one or more documents (known as collaborative writing or collaborative authoring). Editing of the document can be done either in real-time or asynchronously. There exist software tools and technologies that facilitate the editing and reviewing of a text document by multiple individuals which can vary a great deal and can range from the simplicity of wiki system to more advanced systems. The collaborative writing tools are characterized by several key features: supported file formats, text chat or conferencing, tracking changes and support of revisions, support for RSS feeds, email updates, support of private and public sessions, real time co editing, possibility to add comments, spell checker. A useful guide to online collaborative writing tools based on these criteria can be found at http://www.kolabora.com/news/2007/03/01/collaborative_writing_tools_and_technology.htm. We illustrate this scenario with a recent, very successful example of application of wiki by a cross organizational working group -

the MSIS Task Force on Software Sharing. The task force was launched during the 2008 MSIS meeting and was asked to prepare a report on possible future work on sharing statistical software and components. The working group had 10 members (representing five national statistical offices and five international organizations) and no face-to-face meeting was envisaged. The work started by conventional mail exchange, than for a short time was introduced a web forum and finally the group settled on a wiki generously hosted by ISTAT. Some initial structure was proposed and it turned out to be sufficient. The editing was performed both asynchronously (adding and editing the bulk of the text and writing comments) or in real time, during a teleconference (hosted by UNECE). The asynchronous mode demonstrates how wikis allow both discussion of content, i.e. comments, that do not directly change the base content and evolution of the content itself. The real-time mode is even more impressive when compared to alternative methods like email discussion or web forum. Of course this could be achieved through "heavy duty" on line collaboration tools, but wikis are free and provide the simplest means - no need to download specialized software, no problems with the organizational "borders" (no organization could host the group easily in its *SharePoint* or *LotusNotes* environment).

J. Intranet Wikis

40. Most Intranets follow the model of *browsing already authored texts* and the content is created by a small number of employees assigned to this task and supported by the IT department. It is considered that the publication process is too complicated and has to be done by specialists. Recently several large companies like Google, Nokia, Motorola presented their internal web organization based around wiki [9, 4]. Within an Intranet, wikis are a good means for the quick and uncomplicated collecting of information. This creates a knowledge base as well as a platform for communication that is always available to the participating employees. At the TWiki web page http://twiki.org/cgi-bin/view/Blog/2008-03-17-wiki-intranet one can read the top ten reasons why should be a wiki in every Intranet.

41. Here we will consider the example of the UNIDO Intranet. UNIDO launched a wiki as an Intranet platform in 2006 as a successor of the previous conventional HTML web site. The adopted engine is Mediawiki with many optional modules. The Intranet wiki is accessible in the Headquarter in Vienna as well as in all in all field offices throughout the world (directly or indirectly). Currently there are about 20000 pages in the database which includes "talk" pages, pages about UNIDO Intranet, minimal "stub" pages, redirects, and others that probably don't qualify as content pages. Excluding those, there are 8000 pages that are probably legitimate content pages. There are 650 registered users and about 200 of them contribute actively content. The rest are simply using the available in the wiki services (may be without even knowing that they are working with wiki software) like calendar of events, room reservations or access the library. Recently was installed a Semantic MediaWiki (SMW) extension that helps to search, organize, tag, browse, evaluate, and share the wiki's content (see section *Semantic Wikis*).

K. A lobbying group wiki

42. The next scenario describes lobbying group with a small core team and a number of freelances. In this scenario a wiki can be used to sketch a common argumentation strategy of the group. It would be used to structure excerpts of publications of directly or indirectly involved parties in such a way that an optimal strategy can be devised. For example if the group lobbies for cyclists in urban environments it would contain references to road traffic regulations, excerpts of health advisories supportive of bicycling or studies demonstrating how bicycles are a lot more environmentally friendly than fossil fuelled vehicles. While the wiki is probably too unstructured for a contact list of government representatives responsible for road traffic, it can be used to document an escalation plan along government instances in case of a specific issue. If the lobby publishes a newsletter, the wiki can be used to store and collaboratively proofread articles.

V. WIKI ENGINES

43. Without going into details - comparing and choosing a wiki or a wiki engine is a topic of itself - we will briefly present several of the most well-known wiki engines. The majority of engines are open source/free software, often available under the GNU General Public License (GPL). It is hard to determine which wiki engines are the most popular, although a list of lead candidates include *TWiki*, *MoinMoin*, *PmWiki*, *XWiki*,

DokuWiki and *MediaWiki*. Some engines include many non-wiki features (news articles, blogs, etc.) like those in *TikiWiki* CMS/Groupware and can be considered a wiki-Content Management System hybrid. An excellent resource for choosing a wiki is the site Wikimatrix: http://www.wikimatrix.org/.

L. Mediawiki

44. MediaWiki is the most popular wiki software powering Wikipedia and other projects of the non-profit WikiMedia Foundation, as well as many other wikis. MediaWiki supports many languages, web site user styles, multimedia and extension features, index of content items, edit tracking, talk pages and a lot more. MediaWiki is suitable for personal and education use. MediaWiki is a free software package licensed under the GNU General Public License (GPL).

M. TikiWiki

45. TikiWiki http://tikiwiki.org/ - is a powerful open-source "groupware" tool as well as a Content Management System, written in PHP. TikiWiki can be used to create web sites on the Internet and Intranet. It offers great resources as a collaboration tool. One can use TikiWiki for forums, chat rooms, poll taking, blog, file and image gallery, FAQ, calendar, and even more.

N. DokuWiki

DokuWiki http://www.dokuwiki.org/dokuwiki - is an easy to use and standards-compliant wiki system. DokuWiki is the best choice if you need to write a documentation of a small or medium size. It eases the creation of structured content, it has a powerful syntax, and data files can be read outside the wiki. DokuWiki helps teams and workgroups interact much easier while working on a project. All data are stored in plain text files and no database is required. DokuWiki (as well as MediaWiki and TikiWiki) is written in PHP.

VI. INFORMATION RETRIEVAL IN WIKIS

46. One common critique on wikis is that it is hard to find information when you are unfamiliar with the specific wiki. Since the content structure is loose there is often no other feasible way than a full text search to find a specific article in a wiki. There are several strategies to deal with the unstructured information graph. Two of the approaches are discussed in the following, structured wikis and semantic wikis.

O. Structuring the Wiki

47. The wiki is by definition an informal database with free-form entries and no specific structure is imposed. Nevertheless often useful structures are created (evolving over time) by the user. The structure can be also viewed from administrative point of view - a particular structure can be created, suggested and in some cases enforced. There are different ways to structure the content of a wiki and all are supported by the underlying hyperlink mechanism. In order to support both contributors and users of a wiki, most wiki implementations, like MediaWiki, TWiki, or PmWiki, offer structuring elements such as namespaces, subpages, categories, different types of links (internal and external), keyword or full-text search, templates, or skins.

48. To impose or not a structure on a wiki depends very much on its purpose and content. Wikis used for education and training need much more structure than general discussion wikis. A focused team consisting of people used to working with wiki usually needs only a very rudimentary structure. One way to "improve" the structure of a wiki is to periodically set up or renew the main topic content [9] by selecting "core pages" including

- A page explaining the topic and its scope, which will be the top page
- Pages setting the major entry points (first-level pages)
- A page explaining the "Find" capabilities
- Pages explaining how to use the editing capabilities

49. Much more insight in the structuring issues of a wiki can be gained by investigating particular case studies [see 9, page 363].

P. Structured Wikis

50. Structured wikis combine the benefits of plain wikis and database systems, although these two seem to belong to contradicting worlds. The result of such a combination is a collaborative database environment where knowledge can be shared freely, and where structure can be added as needed. In a structured wiki, users can create applications that are very specific to their needs, such as *call center status boards*, *to-do lists*, *inventory systems*, *bug trackers*, *calendar of events* and more. A wiki can become a structured wiki thanks to a combination of a number of features like templating system, formatted search - see [1] for details. There are several wiki engines, which support structured wikis – *Twiki, TikiWiki, PmWiki* and others.

Q. Semantic Wikis

51. Semantic wikis follow the idea of the semantic web as envisioned by Tim Berners-Lee [3]. The main idea behind the semantic web is to enrich information on the World Wide Web with machine processable information. When information is stored in a machine processable format, the retrieval, evaluation and combination of search results can be automated. A common example is one of a person looking for a doctor's appointment. In the today's web the person would search for doctors in the vicinity, look through their opening times and match these against their existing appointments - all by hand. Suppose that the address of the doctors' offices and their opening times were not only presented in a human readable format on their web sites but are also contained in some meta data which is hidden from human users. An agent software could then sift through the meta data and automatically combine the opening times with the calendar of the human user. Effectively a semantic web would not be restricted to full text searches, as is the case even with today's most sophisticated search engines, but would be able to produce meaningful results based on the meaning of information.

52. Adding semantic metadata to wikis relies on the fact that hyperlinks are the main method for structuring information in a wiki. When analysing the relationship between articles and links one can only tell how much links are leading into or out of an article. Such an analysis would give a measure of the importance of an article. In fact, this measure is called the page rank and is used by Google.com to index the web. The importance of an article however only provides a useful way to sort matches to full text queries. The deficiency here is that although it is possible to enumerate links and articles and produce a graph of the information in a wiki, there is no feasible method to tell a computer the meaning of a link or what kind of articles it is connecting. To alleviate this problem such information is simply added to the wiki content. Each hyperlink is treated as a subject, predicate, object triple. Let us look at a concrete example. Suppose you are looking for all movies staring Great Actor in a wiki containing movie information. In such a wiki articles on movies would belong to the class \ *movies*, actors would belong to the class *actors*. Links would serve as predicates so there would be a predicated called *playsIn*. If articles and links are enriched with these respective data, it is easy to ask a machine for all movies which have an incoming link of the type *playsIn* from a specific actor.

53. For further information on semantic wikis the interested reader is referred to the seminal paper on semantic wikis [8]. Semantic wiki implementations are currently mainly a research topic and there are so far none known to the authors, which work well with large amounts of information. An example implementation is the MediaWiki extension SMW (Semantic MediaWiki) that allows users to add "semantic annotations" to the wiki - http://semantic-mediawiki.org/wiki/Semantic_MediaWiki.

VII. CONCLUSIONS

54. In this paper the concept of wikis as collaboration tools was introduced and their strengths and weaknesses as compared to other collaboration tools were considered in a number of scenarios. Wikis have the advantage of being simple and inexpensive (if not completely free) which promotes widespread application with moderate resources. A small group of people working intensively on related material is the ideal scenario for applying the wiki technology. A moderately sized company or organization could successfully utilize wikis for building

Intranet but we do not know how well this architecture would scale. A potential hindrance for the adoption of wiki as a knowledge management platform is the possible mismatch with the organization culture.

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