Structured Wikis – Application Oriented Use Cases

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ABSTRACT

Structured wikis combine the flexibility advantage of traditional wikis with the possibility of presenting structures and relationships in a partly automated fashion. Such wikis can, for example, map process structures and thus support complex processes. Taking the ICKEwiki as an example, this paper examines the differences between traditional and structured wikis by presenting four different real-life sample cases.

Categories and Subject Descriptors

H.4.3 [Information systems application]: Communications Applications - Information browsers, H.5.2 [Information Interfaces and Presentation]: User Interfaces, H.5.3 [Information Interfaces and Presentation]: Group and Organization Interfaces - Collaborative computing, H.5.4 [**Information Interfaces and Presentation**]: Hypertext/Hypermedia – *User issues.*

General Terms

Management, Documentation.

Keywords

Keywords are your own designated keywords.

1 LIMITS OF CONVENTIONAL WIKIS

Wikis are increasingly being implemented in enterprises for varying purposes (cf. [19], [20]), e.g. information storage, project management and cross-group communication, and in very different domains (cf. [23]), e.g. knowledge documentation and work or internal and external information exchange with suppliers, partners and customers (cf. [8], [5]). The term enterprise wiki or corporate wiki has established itself (cf. [20]).

Principles that function in Web 2.0 and for Wikis in particular cannot simply be transferred to enterprises, however (cf. [8], [1]). In Web 2.0, the collective editing of contents is self-organized and voluntary and without specified structures and central control. Predetermined structures – such as processes, organizational units and predefined categories (e.g. customer or product groups) – and responsibilities beyond voluntary action and self-organization exist in enterprises.

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Traditional wikis follow a document-oriented structure by using titles, headlines, paragraphs, lists, etc. (cf. [7]). Web 2.0 tools, like wikis and weblogs, support the generation, gathering and exchange of unstructured information in large, spatially distributed groups. The capability of wikis such as Wikipedia to support collaborative authoring of content is well documented (cf. [2], [4], [17]). A wiki's users collaboratively develop and link its content. While this simple principle is one of the success factors of conventional wikis, it is also their weakness. They operate without any predetermined structure (cf. [28]) since the structure is created only when individual pages are linked (cf. [23]). However, traditional wikis do not offer possibilities for the (semantic) representation of information.

Nowadays, there are different types of wikis, including semantic (cf. [26]), structured (cf. [28]) or hybrid (cf. [21]) wikis, enabling the users not only to manage unstructured information, but also to add structures to them (cf. [29]).

Based on the example of structured wikis, this article shows an alternative to conventional wikis. Chapter 2 features a distinction to similar approaches. Chapter 3 outlines the concept and the realization of the structured wiki by means of the example of the ICKEwiki, co-developed by the authors of this article. The practical examples[1] in chapter 4 comprise the main part of this work. Chapter 5 provides a conclusive overview of the advantages of structured wikis.

2 SEMANTIC, STRUCTURED OR HYBRID WIKIS?

Semantic web tools support the classification, structuring, and representation of large, unstructured stocks of information. In order to apply the flexibility of a standard wiki even to structured data, a semantic wiki supports meta-data in the form of semantic annotations to wiki pages and links between the pages (cf. [26]). By adding suitable structure to the pages semantic wikis enables further computation beyond the simple search, match and capture of text (cf. [7]).

Existing (semantic) wikis (e.g. SemanticMediaWiki [30], KiWi – or its ancestor IkeWiki [26] –, Kaukolu [16], SweetWiki [6], AceWiki) adress textual content – the semantic representation and structuring of information. In semantic wikis, an annotation is represented as a triple-relation of the wiki page, the attribute and the attribute value. Semantic wikis are less suited for the use in

[1] Readers should be advised, however, that the presented sample cases do not represent actual scientific case studies in the traditional meaning of the term.

companies, as in many cases, the users fail to understand the benefits of semantic annotations, which also required complex maintenance (cf. [21]). As the ontologies are often pre-configured by experts, semantic structures are difficult to customize (cf. [21]).

At the Technical University of Munich, a hybrid wiki based on the Tricia platform was developed in the course of a research project. In this wiki, descriptive attributes without pre-defined structures are attached to a wiki page (cf. [21]). However, the structures that can be displayed are not very complex in nature (e.g. no hierarchy of attributes), meaning that only basic filtering is possible, which does not include intricate filtering. (cf. [21])

A structured wiki – like the ICKEwiki (see below) – ought to be able to map enterprise structures so that employees are able to navigate and properly work with it. In addition to cross-linking unstructured information, structured wikis allow for the management of structured, database-like elements (cf. [28], [13]). These elements can always be used where they are needed, e.g. in overviews. Co-funded by the German Federal Ministry of Education and Research, such a structured enterprise wiki (ICKEwiki, see: www.ickewiki.de) was developed within the ICKE 2.0 research project. In this wiki, meta-data is logically linked with the wiki page using the wiki syntax. E.g. one page may be marked as a project page and classified with additional data if and as desired e.g. by allocating a project manager, a deadline or a status for a project. Once it has been linked to the wiki pages, the data can automatically be displayed even in other areas, e.g. in the form of a list showing all projects of a certain client. This approach ensures that complex information architectures may be pre-defined individually and created at the touch of a button. Users enter the structured data in forms. Then, the data is data is displayed in pre-defined templates. (cf. [29]) Other structured wikis are the TWiki and the Foswiki, which is a spin-off of the TWiki (cf. [21]). Even the Wikipedia seems to go a similar way with its Wikidata project, started in 2012 (cf. [3]).

The main difference between traditional, semantic and structured wikis can be seen in the following: Traditional wikis focus only on unstructured information. Semantic wikis add extra structural (semantic) information between the single pages to explain their interdependencies. Structured wikis focus on creating and maintaining structured information, they are adding structure in different ways to the wiki as will be explained in the following chapter.

3 Concept and Implementation

The following sections illustrate the conceptual consideration and their implementation. As a solution, a qualitative analysis of the wiki users' requirements with three piloting SME and a quantitative empirical study conducted by the authors (cf. [11]) resulted in the two main requirements: 1) support primary business operations and 2) giving structures in the wiki [29]. Employees need structures in which they work in the Web 2.0 environment, orient themselves and compile information as needed, and collectively develop knowledge and access past experiences.

Davenport distinguishes between free-access and structured-provisioning approaches to support knowledge work. Each approach has different implication on productivity, depending on the type of knowledge work. Davenport sets up a matrix: complexity of work (routine or interpretation/judgment) on x-axis and level of interdependence (individual actors or collaborative groups) on y-axis. Individual actors doing routine work should thus be supported with structured-provisioning tools. Collaborative groups focusing on interpretation based knowledge work need free-access tools. For the other two fields of the matrix hybrid approaches using free-access tools with structured provision in some areas are suitable. (cf. [9]) Traditional wikis can be sorted into the "free-access" cell of the matrix. Structured wikis combine the free-access and structured-provisioning approach in one. Structure is provided where needed, e.g. to support predefined processes within an enterprise. Structured wikis can thus cover all the four cells of the matrix.

The initial question in the run-op of the development of a concept for a structured Enterprise wiki was which structures to take into consideration, which preceded the question how to implement them. Research has shown that important structures to be taken into account include the following:

- Topical structures: The topics covered by the wiki
- Document structure: The structure of a given page
- Enterprise structures: Pre-defined procedures to be followed and logically connected pieces of information found on different pages

To orient oneself within a wiki it is useful to see the **topical structure** at a glance: Which topics are covered within the wiki? This helps to see, what is in there for the user and how to navigate through the information base.

What we see as important on an overall level is similar on a page level. Again it is important to orient oneself very quickly on a page. Therefor the **document structure**, represented through headlines plays an important role. The top level headline (page title) is often aggregated on a higher level when introducing a topic it is useful to present the most important pages. If a wiki page is linked within the DokuWiki and no link text is given, the first headline will be used instead. Thus the document structure on the lower level can be found within the topical structure too.

What is meant with enterprise structures can be explained best with an example. Within enterprises employees are used to work with different structures that have to be matched to information objects within the IT landscape within the company. Enterprise Resource Planning (ERP) systems, as an example, often focus on processes, customers, produced products, suppliers and employees. ERP systems handle the data regarding these enterprise structures. Within a wiki we do not want to handle pure data, but information and knowledge too. Thus the main enterprise structures have to be found in a wiki too, to make clear the interrelation in between. In a wiki the user does not want to find, what amount of products is ordered when by a customer. Instead the user is interested in

- how the product was developed,
- which colleague was responsible for the design,
- which components did fail in testing the product,
- which similar products were successfully developed,
- how the product has to be assembled or
- who has experience with maintaining the product.

Additionally the operational (processes) and organizational (departments) structure of an enterprise play an important role to orient oneself within the company. These enterprise structures have to be integrated adequately within the wiki. The implemented ICKEwiki is based on the successful DokuWiki (see

www.dokuwiki.org), meaning that the core of the wiki was modified where needed and new as well as existing plugins were developed/improved.

3.1 Topical Structures for Navigation

3.1.1 Conceptual Considerations

In large public wikis such as Wikipedia, topical structures are created evolutionary, meaning that subject areas in which many new articles are published are continuously growing and given a certain structures by linking them to each other (cf. [22]). However, this structure is unsystematic and high-maintenance, as the links have to be placed manually. Enterprise wikis, however, always serve a specific objective (see chapter 1) and are supposed to cover different topics, depending on the desired objective, which clearly distinguishes them from the global Wikipedia. These topics should be identified through demand analysis [14] and further differentiated. Ideally, even the content level for the different topics is pre-defined once the objective has been identified. This approach ensures that the progress can be measured after a certain time [10]. As these topical structures are predefined to meet business needs, it would be useful for the management to know the "fill level" for each topic.

This being said, traditional wikis lack a good access to the basic topical structures: There is no quick overview and no quick access to guided navigation. Therefore, the structured wiki should implement a central navigation based on the basic topical structure – a requirement setting it apart from the Wikipedia, which, being an encyclopedia primarily relies on the search function, using sub-links as a secondary structural feature only.

The underlying DokuWiki is a plain text wiki, storing the wiki pages in text files on the server. These text files can hierarchically be organized within so called namespaces (file folders). To access different pages the namespaces are part of the URL, divided by a slash ("/"). This hierarchical namespace tree can be used for topical structuring the wiki content.

The navigation can be facilitated by means of relevant and unambiguous icons, with one navigational item represented one main topic (namespace) of the wiki, which in return may contain a sub-hierarchy. In order to be able to quickly understand what content may be found under a given subject area, it makes sense to enable quick access to the sub-structure.

The implementation and representation of the topical structure of the first and second levels can be based on Miller's Law. "Miller concluded that seven represents an upper limit on the human capacity for processing information, and claims of the number seven that there is 'some pattern governing its appearance'." [24] Hence, a maximum of seven structural elements should make it easier for the user to quickly understand the structure.

Additionally to these predefined topical structures we wanted to give users the opportunity to build up their own view on the topical structure. Therefore it seems to be useful to annotate wiki pages with own keywords. The social tagging concept seems to fit for this purpose.

3.1.2 Implementation

First off, a new template was created for the ICKEwiki (see: http://www.ickewiki.de/dokumentation/template), breaking up the text-heavy structure of most DokuWiki templates.

Since, in keeping with the "whiteboard approach", wikis often lack a main structure/navigation, a main navigation system presents the most important topics of the ICKEwiki by means of customizable icons. Mouseovers also directly display substructures (Figure 1). Following the principle of the flexible wiki, the substructures are customizable rather than set. Two icons are used in the standard settings: The dashboard and the tool list. The dashboard contains user-specific access to information, and/or the enterprise structures described under 3.2 (e.g. my projects, clients, tasks). The tool list contains recent changes as well as a tree of the entire page index of the wiki.

The sub-structure of the main navigation (a pop-up) is generated form a link list within a wiki page called "quick" in the namespace. A mouse-over over the navigation icon will read the page content and return it in a pop-up. This mechanism allows for any user (provided that they have access rights) to modify the second-level structure.

Moreover, the main navigation items were integrated in the search feature, meaning that the search may be limited to the different topics (namespaces). This feature was implemented using the Fancysearch plugin (see http://www.ickewiki.de/dokumentation/fancysearch). A drop-down menu next to the text gadget contains the same icons as the main navigation (see Figure 1).

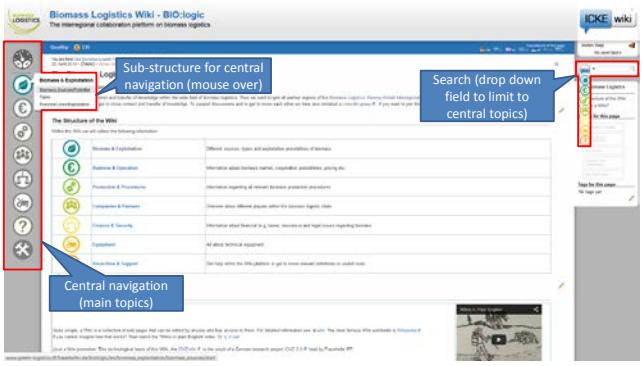

Figure 1. Topical structures within the ICKEwiki

To measure the fill level of the topical structure, the existing WikiStatistics Plugin (see: https://www.dokuwiki.org/plugin:stats) can be used. The following syntax can be used to display the numbers of pages within a namespace (=topical structure on top level):

{{wikistatistics>type=pages ns=NAMESPACE}}

To provide annotation mechanisms in the wiki, the Tagging plugin (see: http://www.ickewiki.de/dokumentation/tagging) was developed. This plugin enables the user to annotate a wiki page with own keywords. These tags are integrated in the search function as well, so pages tagged with search phrase items can be found. The tagging section is integrated within the ICKE-template. To build up user or namespace specific tag clouds, the following syntax can be used on every wiki page:

{{tagging::user>USERNAME}}

{{tagging::ns>NAMESPACE}}

Figure 2. Tagging section within the ICKE-template

3.2 Enterprise Structures

3.2.1 Conceptual Considerations

3.2.1.1 Enterprise Structures in general

Within conventional wikis, enterprise structures cannot be mapped properly or can be kept up-to-date only with difficulty. Naturally, product, project or client pages can also be created in conventional wikis and linked. Overviews of all pages can also be created, which must be maintained manually. Structuring is additionally subject to the individual users with their differing views and ideas. The problem can be seen very clearly if you look at the following examples:

- Connected sites of a project process (e.g. phases and milestones) are only connected through the linking of single sides, an overview of the phases of the project including their state has to be done manually
- In general automatic listings of all projects with restrictions to one customer are not supported.
- Process description with common structure following the guidelines of quality management as well as the hierarchical and chronological relations (e.g. sub process, succeeding process) are produced with high manual effort or require specialized wikis
- The listing of all projects, products, customers etc. belonging to one wiki-user on the profile page has to be taken care of through the particular employee instead of the automated readout of information given in the wiki (e.g. on the project-, product- or customer page)

If we want to integrate business objects from the real world (e.g. products, customers, processes or projects) into a wiki, we have to transform them into information objects that can be described and found within the wiki. These information objects represent the enterprise structure (e.g. customer groups, individual processes, product families). Each information object (e.g. a project) can be grouped of different single information (e.g. characteristics as starting date, project manager). The corresponding data has to be integrated within the wiki syntax as a single data entry (see chapter 3.2.2.1) that can consist of even more data. These data are grouped together to a data entry. The following adopted figure summarizes these thoughts.

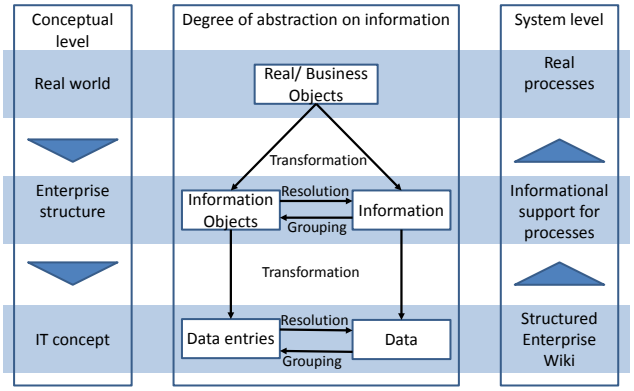

Figure 3. Conceptual level and degree of abstraction (in dependence on [18])

The ICKEwiki should connect enterprise structures (e.g. products, projects, clients, employees, processes) with the wiki:

- A wiki page is uniquely identifiable via its uniform resource identifier (URI), thus it would be ideal to link the structure directly to the corresponding wiki page.
- The enterprise structure will be realized as attributes with user specific values using the wiki syntax. The advantage of the wiki syntax is to make the structure editable for every user with appropriative rights.
- To be flexible enough to match every possible structure, we suggest using different and even user configurable data types. Therefor a data type administration interface is needed.
- An attribute thus has a name, a value, and an optional special data type, e.g. links to other wiki pages with the name stored in the attribute.
- Based on the data linked to a different wiki pages, automated listings (sorted lists or tables) should be made possible on every other and even on the same wiki page. These listings should allow filtering and sorting the data based on user specification.
- Wiki syntax is not easy to understand for each user, especially when using it for complex structures. Thus a template and form based mechanism is needed to create wiki pages to realize enterprise structures (e.g. to create a new project page with predefined structure via a form to hand over the main data for the structure).

To sum it up, the wiki's syntax logically links meta-data with a page directly in the wiki pages. A page can thus be noted as a client or project page, for instance. What is more, it can be classified with any other data. For instance, a project manager, period or status can be assigned to a project.

3.2.1.2 Procedural Structures in particular

Many enterprises are process-oriented, working according to pre-defined and audited quality standards. As wikis have frequently been used by companies to support specific business processes, a structured enterprise wiki should also be able to reflect core elements of procedural structures. A process contains of a range of activities generating a defined work result (output) from a defined input (cf. [27], p. 45). Business processes consist of the cross-functional chaining of value-adding activities, generating specific services and results expected by the client, the results of which are of strategic importance to the company. These business

processes may involve external activities such as client, supplier or even competitor processes. (cf. [27], p. 40)

This definition illustrated the key benefit of supporting structured enterprise wikis: a process is cross-functional, i.e. staff from different departments is involved. A wiki can make the status of a supported process transparent and collaboratively enable the development and/or description of the output.

Processes follow a pre-defined structure; a pre-defined procedure normally enshrined in the quality management handbook of the company. If certain data is to be documented within an individual procedural step, it is possible to do so on a separate wiki page. This also means that the steps that belong together should be linked up, i.e. the user, who may have used the search to start navigating the wiki, should be able to understand that these steps belong together. Moreover, it makes sense to be given a status update in order to enable quick overview.

The procedural operations normally contain role-based tasks, e.g. that proposals are to be prepared by the sales representative. Thus, the presentation of tasks within the structured wiki seems to be an important feature to adequately display processes.

Another key element are the branches resulting from decisions. The power of decision in a company is not necessarily in line with the wiki philosophy, under which any user is welcome to edit the contents. Therefore, the pilot-stage users requested a feature that clearly identified decisions taken by superiors.

3.2.2 Implementation

3.2.2.1 Enterprise Structures in general

The enterprise structures (connected information objects) are linked using the wiki syntax from the data plugin (see https://www.dokuwiki.org/plugin:data).

As the underlying DokuWiki is build up using plain text files to store the wiki page syntax, we cannot use a built-in database to realize the enterprise structures. For the purpose building a lightweight and fast mechanism, the helper plugin sqlite (see: https://www.dokuwiki.org/plugin:sqlite) was developed to access SQLite databases.

The data plugin enables the user to define a single data entry on every wiki page, logically linked to this specific wiki page. A data entry consists of a class name (used for later filtering only certain classes of entries, e.g. project pages) and attribute-value combinations. Each attribute can have a certain predefined or customized data type. Data entries can be made by using the following syntax:

```
----dataentry CLASSNAME ----
ATTRIBUTNAME_DATATYPE: VALUE
----
```

Thus, a set of data can be defined in a data entry on any page, as shown in the following wiki syntax example (from Figure 3):

```
---- dataentry process ----
biomass_bios: hebaceous_plants, other_plants
sequence_hidden: 1
----
```

Once they have been linked with the wiki pages, these data can also be displayed automatically in others areas, e.g. as client overviews or as a list of all of one particular client's projects (ideally on the client page of the same name). Automatic listings are thus the counterpart of a data entry. Each listing can be configured via a set of attributes (defined in the corresponding data entry) to be displayed. Filter and sorting mechanisms are also added. These listings may be used on any page, e.g. in the form of tables or lists, as shown in the following wiki syntax example (table from Figure 3).

```
---- datatable equipment ----
cols: %pageid%, biomass_bios, category_category
filter: %class%=equipment
filter: process_proces=cultivation
----
```

Complex information architecture (e.g. projects or processes) can be predefined individually and created by users at the push of a button. Users enter such structured data in forms. Afterwards, they are displayed in predefined templates.

This mechanism is realized in the bureaucracy plugin (see https://www.dokuwiki.org/plugin:bureaucracy). The plugin allows the user to define forms that gather data from other users and copy it into place holders within a new page based on predefined templates. Thus the normal user does not have to use the complex syntax shown above (cf. Figure 2).

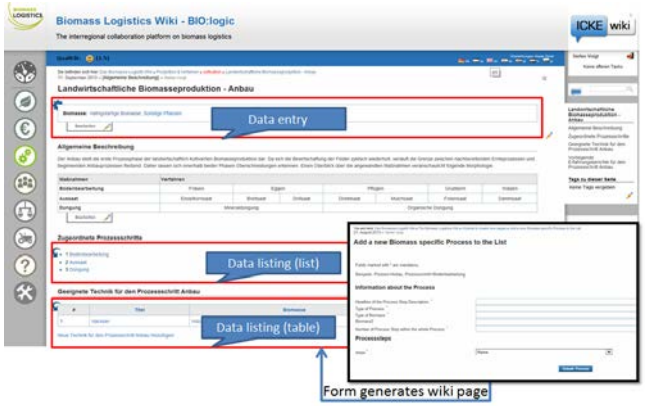

Figure 4. Linking unstructured data with structured data

Within a form different fields (textboxes, checkboxes, dropdown lists etc.) can be defined to gather data from the user. The name of each field has to be the same as the placeholder within the template. A form defines the target namespace and the name of the wiki page that will be created on a named template. When submitting the form, the wiki will generate a new page (with the specified name) in the given namespace using the template and replacing all placeholders with the gathered data. There are a lot of customization options for the generated forms, all of them are explained in detail on the plugin webpage.

3.2.2.2 Limits of the Approach

Due to the complexity of the data and bureaucracy plugin it is difficult to define complex enterprise structures for normal users. We see the implementation of a conceptual enterprise structure as a task for special users, as an administrator for instance. For further development it would be useful to realize more intuitive user interface to generate data entries/listings and forms/templates. Thus enterprise structures could be developed even more evolutionary by the users of the wiki. To keep the enterprise structure up to date, synchronization mechanisms are needed to: When the structure is updated, the already existing pages (based on old structure) have to be updated too. It should at least identify old pages that deviate from the new structure and suggest these pages to be updated through the user.

3.2.2.3 *Procedural Structures in particular*

The procedural relationship representation process is implemented twofold: First, the templates are used for the compilation of the process-supporting pages, which means that each of the procedural steps defined in the quality management handbook contains a separate page with a pre-defined name and page structure. Second, the sub-navigation mechanism (see section 3.1.2) is also used here. If a page with the name "steps" is within a certain namespace, this page is read and returned in the right side-bar. Thus, all the pages belonging to the process are shown from the very first to the very last step. The mechanism described in section 3.2.2.1 is used to show the status. The procedural step page updates the status, which is displayed using an automatically generated list containing the links to the procedural steps and the current status on the "steps" page.

Figure 5. Procedural structures for an example project page

The pilot users identified customized product development as a case of application. It was important to concretely adopt milestones and stages of the process as important structural elements. Whenever new product development is initiated by a wizard, templates generate namespace and site structures. These structures can be configured easily using wiki syntax.

As there is no space to describe every detail, the implementation of the task featuring in the Do plugin (see https://www.dokuwiki.org/plugin:do) and the signature feature in the Signature plugin (see http://www.ickewiki.de/dokumentation/cryptsign) are not outlined here.

3.3 Document Structure

3.3.1 *Conceptual Considerations*

Every wiki page has its own structures, which is created by headings, for example. A wiki document is structured by user based on their individual preferences and knowledge, meaning that not all pages are structured to the same extent. Therefore, the user should be given a tool to improve the structure of a given page. Content structure analysis is used to identify documents (wiki pages) that fall short of the requirements or recommendations (guidelines), and they are recommended for correction. A number of criteria can be identified for the content structure analysis. Also, criteria for source text formatting (which can be found in programming guidelines and automatically checked by StyleChecker (cf. [15]) can be applied to wikis. Criteria enabling the definition of values for the content structure analysis include the length of the document, the ratio of amount of text to number of headings as well as the number of links.

What follows is an example based on the use of headings as a criterion for the content structure analysis of wiki documents: Wiki documents normally are structured by means of HTML header elements (H1, H2,..., H6). The headers give the document a structure and contain the titles of the content following them. H-tags may be freely used in the DokuWiki. However, there are recommendations as to how to use them, which can be used as criteria for analysis: Only one H1 tag (header) is to be used; several H2 tags (contents of page) are to be used; all headers should be followed by text (non-empty H-tags); texts that are too long should be structured using sub-structures (balanced amounts of text).

3.3.2 *Implementation*

ICKEwiki provides users support when they are structuring individual pages by assessing and giving users feedback on the quality of the wiki pages' structure. Thus a quality check plugin (QC plugin, see http://www.ickewiki.de/dokumentation/qc) was implemented in the ICKEwiki. Every time a page is selected, an analysis based on predefined criteria (e.g. ratio of heading to text, links to the page, number of authors) is performed in the background (cf. [12]).

The QC plugin uses a renderer to analyze page structure and stores the results for later use. The implementation of a general renderer enables DokuWiki syntax plugins to supply additional quality check tests to the QC plugin. This makes the plugin easily adjustable to the special DokuWiki set-ups in different companies. Since rendering and analysis can be time consuming, they were decoupled from the normal page display by integrating the results as an image.

Users are notified of the results of the analysis: red, yellow and green smileys identify "structural irregularities" for which points were deducted. The plugin supplies users additional support that enables them to improve quality concretely: If required, users receive suggestions for improvement in order to support continuous improvement of the wiki pages (see Figure 3).

Figure 6. Quality Feedback based on Document Structure

4 SAMPLE USAGES OF THE STRUCTURED ICKEWIKI

A wide variety of application scenarios are conceivable in the ICKEwiki. Some actual examples are presented below:

- Product development support in SMEs
- Shortening the orientation period in research projects
- Exchanging information on faults and solutions in maintenance
- Open, multilingual knowledge platform for biomass logistics

The different sample applications are described based on the structure presented in Table 1. The sample applications mainly differ in terms of focus, accessibility, and structure, as well as in objective. The wikis are either used to specifically support a selected process or to exchange and share knowledge (focus of use). The presented projects are both internal (and thus restricted

in access) projects or open, freely accessible applications. “Miller's Law” was used to describe the structure. Normally, humans are able to memorize up to seven elements. Thus, seven (plus or minus two) structure elements (information objects) that are logically linked in the wiki describe an average (medium) structure. One to four elements stand for low structure, while more than nine elements represent a highly-structured wiki. The lower extreme is zero (no structure), which is used for conventional wikis. The applicable characteristic for each sample is represented in bold.

Table 1. Descriptive Grid for Sample

Objective	Description of objective			
Focus of use	Process support		Knowledge transfer	
Accessibility	Internal		Open/free	
Structure	None	Low	Medium	High
Linked information objects	List of linked information objects (structure)			

4.1 Product Development Support in SMEs

The product development process in a medium-sized enterprise is the first example: the SME manufactures customized electronics in mass charges and covers the complete product life cycle in the process, beginning with product development. Above all, the wiki was supposed to link information from product development projects and thus preserve experience. The QM system’s established process specifications thus constituted the foundation for the wiki.

Table 2. Descriptive Grid for Product Development Case

Objective	To support the product development process by linking up all relevant information connected to the product to be developed.			
Focus of use	**Process support**		Knowledge transfer	
Accessibility	**Internal**		Open/free	
Structure	None	Low	**Medium**	High
Linked information objects	Staff, development project, project to be developed, client, production processes			

Every product development project includes the phases of design planning, design, testing, redesign and transfer to production. A kick-off meeting and a design review are mandatory additional milestones. When starting a new project, a collection of pages belonging together is compiled in the wiki based on the templates. A project’s master data (client, team, period and the like) are thus presented on its homepage (Figure 4, top). Other pages, which are automatically linked with the project homepage, exist for every phase of a project. Essential information is compiled, problems are discussed and solutions developed on the subpages. Individual phases, including status, are linked in the automatically displayed sub-navigation (Figure 4, bottom right).

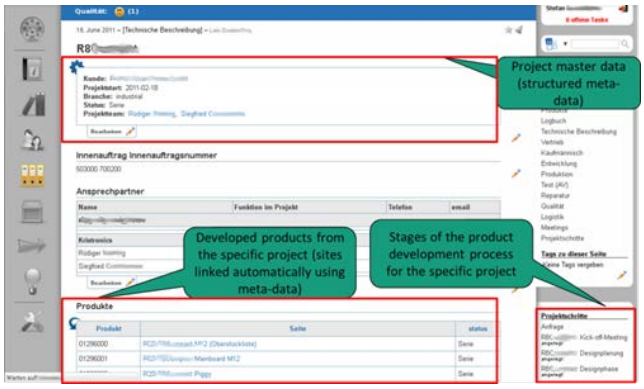

Figure 7. Implementing the product development process in a structured wiki

Projects are the focus of this wiki: Projects are correlated with staff profile pages that link every project, product and client worked on or with. Every client also has a page in the wiki, which automatically lists all associated products and projects. Only distinctive features or news are saved. Master data remain in the ERP and CRM system. In every project, products are developed (Figure 3, bottom). Products have their own pages, which document their life cycles, e.g. manufacturing defects.

Manufacturing entails standard manufacturing processes (e.g. cold or heat soldering), which are specified in the wiki too. Special products necessitate deviations from the standard manufacturing processes. Such deviations are specified on a particular page in the wiki, which is automatically linked with the given product and the standard manufacturing process. A list of all products that deviate from the standard exists on the page with the standard manufacturing process.

4.2 Shortening the Orientation Period in Research Projects

The Fraunhofer IFF is a research institute with a full-time staff of around 150 researchers and just as many students (interns, assistants and theses and dissertation advisees). Students play an important role in research projects, supporting the full-time researchers. Most students’ employment at the institute is over before the period of the research projects and new students have to be briefed.

Table 3. Descriptive Grid for Staff Training Case

Objective	Shorter initial training periods for student assistants participating in research projects			
Focus of use	Process support		**Knowledge transfer**	
Accessibility	**Internal**		Open/free	
Structure	None	**Low**	Medium	High
Linked information objects	Staff, research projects, dissertations			

In addition to general procedures, instructions or FAQs, research projects, academic papers and (student) colleagues are especially relevant for their daily work. These three “entities” are linked in the structured wiki. Researchers advise student assistants and degree candidates and manage research projects. Students provide support in research projects and are responsible for their seminar

papers or Bachelor's or Master's theses, which are usually directly related to a research project.

The logical linking of this information in the internal wiki's structured area not only facilitates automatic "Yellow Pages" but also project overviews and lists of already written academic papers (see Figure 4). Profile pages are created directly the first time the wiki is logged onto and can be supplemented with personal data.

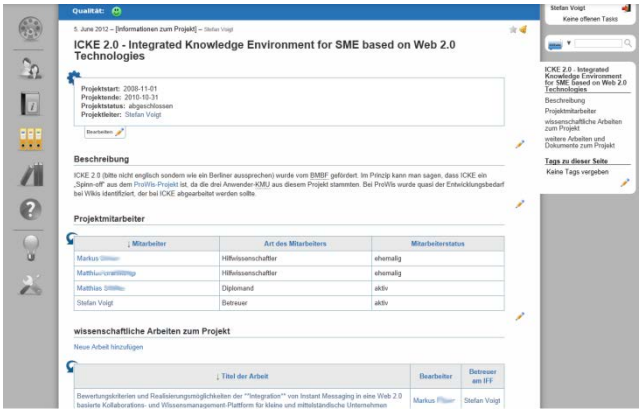

Figure 8. Linking projects, staff and academic papers

4.3 Exchanging Information on Faults and Solutions in Maintenance

Demographic change is also influencing maintenance processes in machinery and plant manufacturing, which are very much governed by personal experience. It is essential for companies to secure and process such empirical knowledge and reintegrate it in work processes. (cf. [25]). The ICKEwiki links both written specifications and features of machinery components with one another. The correlations between plants, the interconnected machinery and equipment inside a complex plant and their components can be established in the ICKEwiki. Afterward, using forms, faults that occur, including standardized descriptions and potential causes, can be added to these components. In turn, appropriate solutions can be described for each fault.

Table 4. Descriptive Grid for Maintenance Case

Objective	Documentation of error-solution combinations in order to be able to resolve future maintenance errors more efficiently (faster)			
Focus of use	**Process support**		**Knowledge transfer**	
Accessibility	**Internal**		Open/free	
Structure	None	Low	**Medium**	High
Linked information objects	Client, facility, machine, component, error, solution, staff			

The descriptions and solutions are unstructured information, which is integrated in a logical hierarchical structure of plants, machinery and components. This is where the structured wiki reveals its strength. Combinations of faults and solutions can be found through both the navigation structure and a search (see Figure 5). A full text search can be both restricted to main information categories (in this case: plants, machinery, components, faults and solutions) and applied to tags, i.e. keywords assigned by users. Thus, different types of users find the information they are seeking in the way suitable to them.

Figure 9. Linking clients, plants, machinery, components, faults and solutions for maintenance in a structured wiki

4.4 Multi Language support for interregional knowledge exchange

4.4.1 Description of the Example

The Fraunhofer IFF's research efforts revealed that there is great demand for practical information and guidance for all actors of the biomass value chain. Both the Internet and technical literature contain a wealth of experience. However, these sources are not linked up or bundled. Therefore, the Interregional Biomass Logistics II project gathers information about biomass logistics. This information is collected and edited in the 'BIO:logic' knowledge platform in the form of an ICKEwiki.

Figure 10. Linking partners, project and experience reports in a Multilanguage biomass logistics wiki

The Fraunhofer IFF believes that a holistic logistical analysis is a crucial success factor. To this end, a suitable clientele should be identified in the run-up. Additionally, it is strongly advisable to take into account the impact of the usable/available equipment on economic and cultivation- or harvesting-relevant aspects as well as how a given decision influences the quality and thus obtainable prices. Thus the wiki focuses on identifying and finding answers to urgent questions and challenges that the practical actors are confronted with. The demand for information does not only include a general collection of information, but also to intelligently interconnect this information: What equipment is suitable for what location? What other processes can this equipment be used for? What experience did others have when dealing with certain tree species, site characteristics or equipment? The realized wiki structures allow for the representation and interconnection of the answers to these questions. The wiki unites and edits the current state of research into the domain of biomass, making this information available for practical use. Experience reports of researchers and practical experts complement the collected findings. This also includes

experience from other European regions (Estonia, Latvia, Poland, Spain, Czech Republic and the UK).

Table 5. Descriptive Grid for Interregional Knowledge Platform Case

Objective	Enable inter-regional exchange of expertise and experience in the domain of biomass logistics			
Focus of use	Process support		**Knowledge transfer**	
Accessibility	Internal		**Open/free**	
Structure	None	Low	Medium	**High**
Linked information objects	Type of biomass, technology (harvesting, transportation, etc.), process (harvesting, care, etc.), experience reports (e.g. on technology), partners of the supply chain, research projects, applicable legislation, terms/definitions in each covered language (!)			

In the course of different workshops the following basic wiki structure was developed in a joint effort with practical actors of the biomass sector. This structure is currently in the process of being fed with numerous content and guidance:

- Biomass & Exploitation: Information on sources, types and exploitation
- Business & Operations: Biomass market, cooperation models and price calculations
- Production & Processes: Information about biomass production processes
- Companies & Partners: Overview of partner structures in biomass logistics
- Finance & Security: Financial and legal framework
- Equipment: Information on cultivation, care, harvesting and transport equipment
- Tools & Knowledge: Tools such as IT tools, checklists and a glossary.

4.4.2 Conceptual Considerations and Implementation of Multilanguage Support

To enable experts from other European regions to document their experience within the wiki, it has to have multi language support. The DokuWiki – on which the ICKEwiki sets up – provides basic multi language support via a special translation plugin. This translation plugin (https://www.dokuwiki.org/plugin:translation) shows a list of available translations for a certain page. Therefore the plugin looks up for a page with the same name in a language namespace (e.g. “en” or “de” set up in the configuration file). This approach works very well and can be seen on the DokuWiki page itself (see www.dokuwiki.org). But this was not compatible with the structured ICKEwiki template and with the data entries on single pages.

The template has to detect whether the translation plugin is installed or not. The language toggle had to be integrated into the ICKEwiki template and activated automatically if translation is enabled. The templates main navigation bar displays sub navigation read-out of a wiki page called “quick”, which mostly contains a list of links. This quick navigation has to change automatically with the language switch, because the whole user interface switches the language too (see 3.1.2).

Within the ICKEwiki distribution built-in “fancy” search (see https://www.dokuwiki.org/plugin:fancysearch) enables the wiki to focus the search on one of the main navigation namespaces (see 3.1.2). This does not work when switching the language from the German to English language and thus switch from the “de” namespace into the “en” namespace. The language namespace had to hand over to the search plugin as well.

The handling of structured data is realized via two main plugins (for details see section 3.2.2.1). The bureaucracy plugin (see https://www.dokuwiki.org/plugin:bureaucracy) provides the possibility to easily create HTML forms via wiki syntax and use it to create new pages (based on templates). The data will replace the place holder within the template. Within the new page structured data entries or data lists/tables can be realized via the data plugin (see https://www.dokuwiki.org/plugin:data). Data entries will be identified via the unique page id: all data entered in a data entry is tied to the page.

To build up complex structures a lot of templates and forms have to be created. For every new language these have to be translated too. It makes sense to separate the structure from the language to reduce the complexity for administration. The idea was to realize the structure in a master language (preferred English) and to only translate the surrounding information within the template. The template can thus be translated by a user without deep understanding of the syntax to build up the structure. The structure will be maintained by the administrator.

For every key within a data entry, data list or data table there will be language files, comparable to the language files to localize user interface (e.g. in every plugin). These language files will be administered by translators. The wiki crossfades the data entries or aggregations with the local translation while rendering the wiki page. Internally the wiki works with the original keys.

To use the same form within different language name spaces the include plugin (see https://www.dokuwiki.org/plugin:include) is used. The bureaucracy plugin will be adjusted that the target namespace (for the new created page) will work with relative paths (to be independent from language namespace). The form will also give a reference to a translation page of the form. Within this translation page the labels can be translated for each individual language. The current language will be cross faded. To fill in the data into the new created pages, a new language variable will be defined to set the current language.

4.4.3 Used Structure within the Wiki

In the case of the current BIO:logic wiki, it is not only important to know the different technologies for biomass production, but also to link the data in an intelligent manner: What type of equipment can be used for what type of biomass? What processes are supported by this equipment? What previous experience exists for a given type of equipment? Thanks to the structures implemented in the wiki, the answers to these questions can be linked up and presented logically. The following pages have been realized in the form of linked up structures and with corresponding lists:

- Type of biomass: Different production process and different types of equipment should be used for woody and herbaceous biomass.
- Equipment: The type of equipment to be preferred depends on the process as well as on the type of biomass can. The identification of the "right" type of equipment can be facilitated by linking up experience reports.
- Process: A farmer is interested in cultivation short-rotation plantations (fast-growing tree species) in the near future. To be able to do this, he should understand

the differences between the somewhat similar processes, as well as to what extent he can use the equipment that he already has.

- (Research) Project: Research projects produce new findings regarding types of biomass and often result in the development of new technologies or processes. The transfer into practical use can be facilitating by linking up the findings and results with the practical domains (process, biomass, equipment).
- Experience: Specific experience made when using different processes, types of biomass or equipment is a valuable source for other users. They have to be linked up correctly in order to be easy to find.
- Partners: Research institutes, contractors or associations are important partners for direct experience exchange. These partners are linked to the experience reports or projects.

In addition to this information, which is highly structured and linked, the wiki also contains considerable experience with economic, fiscal and legal aspects of biomass exploitation and production. The initial feedback of practical partners – who are involved in the initial stage of the creation process – is very promising.

5 BENEFITS OF STRUCTURED WIKIS

How do structured wikis support knowledge work? They supply a base of comprehensive information. Users can tag information with their own keywords and thus develop information relevant to them themselves. Personal dashboards provide all users the information relevant to them (e.g. completed projects, clients or products worked with and on). A full text search also incorporates tags and can be restricted to individual areas of information (e.g. projects), thus facilitating rapid access to the information sought.

The ICKEwiki was implemented operationally and evaluated at three pilot users' facilities. All in all, test users felt that use of the ICKEwiki improved documentation practices, including the documentation of solutions and approaches, information tracking throughout a project's history, communication of a project's history to third parties and documentation of agreements and decisions. The additional functionalities of the ICKEwiki were evaluated very positively (cf. [29]).

The ICKEwiki gives most employees a value added (better exchange, faster information search and process completion). In return, the employees are also willing to accept documentation that entails somewhat more work. Since the majority of test users were first-time wiki users, they will presumably see the additional work they perceived in the test phase differently as they accumulate user experience.

The wiki's process-oriented structure in the shown examples guides employees in their work, without sacrificing the creative latitude that wikis per se allow. Thus, structured wikis guide users stronger, simplifying and expediting knowledge work in the process. Teamwork is supported optimally. The wiki principle assures this by its very nature: Everyone is allowed to make improvements and refinements.

The ICKEwiki is based on the open source DokuWiki and thus follows the same open source license. ICKEwiki is available online as a downloadable preconfigured demo system – showing an imaginative SME – for the general public (www.ickewiki.de). Screencasts on the website briefly introduce how to use the ICKEwiki.

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