

An Experience Using a Spatial Hypertext Wiki

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ABSTRACT

Most wikis do not allow users to collaboratively organize relations among wiki pages, nor ways to visualize them because such relations are hard to express using hyperlinks. The Spatial Hypertext Wiki (ShyWiki) is a wiki that uses Spatial Hypertext to represent visual and spatial implicit relations. This paper reports an experience about the use of ShyWiki features and its spatial hypertext model. Four groups, consisting of 3 members each, were asked to use ShyWiki for creating, sharing and brainstorming knowledge during the design and documentation of a software architecture. We present the evaluation of a questionnaire that users answered about their perceived usefulness and easiness of use of the spatial and visual properties of ShyWiki, and several of its features. We have also asked the users if they would find the visual and spatial properties useful in a wiki such as Wikipedia. In addition, we have analyzed the visual and spatial structures used in the wiki pages, and which features have been used.

Categories and Subject Descriptors

H.5.4 [Hypertext/Hypermedia]: Architectures
; H.5.3 [Group and Organization Interfaces]: Collaborative computing, Web-based interaction.

General Terms

Human Factors, Design

Keywords

wiki, spatial hypertext, ShyWiki, Knowledge Management

1. INTRODUCTION

Experiences with early hypertext systems such as Aquanet [13] and Notecards [9] have shown that people prefer to create hypertext using spatially organized text instead of articulating explicit relations between two objects, where users have to decide what is a concept and what is a relation. People are used to relate things spatially when using computer

environments or in real life [20]. A spatial organization of concepts permits to organize the navigation and the presentation of the content, as well as, to represent implicit relations that cannot be expressed using hyperlinks. For example, by using document centred hypertext one cannot express that a concept is near another, or that a concept is part of another [15].

Spatial hypertext [15] is based on using visual and spatial characteristics of hypertext elements for defining the relations among them. Spatial hypertext elements can be viewed as cards (or notes) that can hold hypermedia content (text, images, hyperlinks, etc.). In this way, it is possible to represent implicit hypertext structures, and interpret their implicit relations depending on the spatial and visual context of the notes [14]. Explicit relations used in the map based hypertext can be represented implicitly using visual and spatial characteristics. For example, the relations of elements in spatial hypertext can be represented in the following ways: The elements in the document can be positioned to form lists or stacks, or the elements can be near each other [22]. Also, elements of the same type can be represented by sharing the same visual and spatial characteristics: colour, borders, font types, adornments, layout, position, proximity, geometric relations, etc. The objects can be contained inside other objects to create collections. When information is organized in this way, it allows users to describe complex relations among the elements. Spatial hypertext systems have special facilities in their user interface [15]. For example, users can handle and move elements from one place to another in a hypertext document, or change the colour or size of an element.

Wikis are hypertext systems that allow users to collaboratively build knowledge by means of simple editing mechanisms which permit the fast evolution of the content. Tasks such as capturing, searching, and sharing knowledge can be performed in an open, collaborative and distributed way. Wikis are based on the principles of ease of use, continuous improvement through incremental content creation, open structure for editing and evolution, and self organized structure according to the needs of the community [4]. However, most wikis do not provide ways to organize and visualize the relations among concepts in a wiki. In addition, such organization has to be performed in a collaborative way. In most wikis, the kind of hypertext used is document centred hypertext, where the documents are explicitly connected using hyperlinks. Document centred hypertext presents several

problems: there is no other way than hyperlinks to express the relations among documents, and large networks can have the problem of “lost in the hyperspace” [2].

When spatial hypertext is used in wikis, users can express implicit relations, can organize spatially the information, and the impact of the “lost in the hyperspace” problem is reduced [21]. However, the collaborative use of spatial hypertext in the web, and in particular in wikis is not yet well understood.

ShyWiki is a wiki which uses spatial hypertext for representing its content. The basic functions of ShyWiki are introduced in [23, 24]. In this paper, we present an evaluation of its spatial hypertext model and some of the features of ShyWiki. We have asked four groups, each consisting of 3 members, to use ShyWiki in the software architecting process of a system. The group members had to collaboratively create, share and brainstorm knowledge involved in documenting and designing a software architecture. Later, the users were asked to answer a questionnaire about their perceived usefulness and easiness of use of the spatial and visual properties of ShyWiki, as well as other features. In addition, we have asked the users if they would find it useful to include the spatial hypertext features of ShyWiki in Wikipedia. We have also analyzed the wiki pages that were created by the users in order to classify the kinds of notes, and to identify the visual and spatial structures they built.

This paper is organized as follows: Section 2 gives an overview of the characteristics of the spatial hypertext wiki. Section 3 presents how we conducted the evaluation of ShyWiki. Section 4 gives the results of the evaluation of the questionnaire. Section 5 explains a classification of the notes that we have detected by analyzing the wiki pages defined by the users, and also summarizes the visual and spatial structures that they have created. Section 6 presents a discussion and an analysis of the results. Section 7 presents the related work. Finally, section 8 gives the conclusions and presents the future work.

2. SHYWIKI

ShyWiki is designed to support users in creating, storing, editing, and browsing knowledge structures, which are understood as interconnected networks of information. Each page is a hypermedia document that is identified by its name and is made up of an unordered set of named attributes called notes. The main function of notes is to define the attributes that characterize the concept represented by a wiki page.

The content of the wiki pages is spatially organized. Notes may be placed in different regions of the page, and can be moved around. Notes can have different sizes or colours. The notes can contain a mix of text, hyperlinks, or images. Composite notes can be created from simpler ones, allowing knowledge to be hierarchically organized. Figure 1 shows a ShyWiki page. It includes notes of different sizes and colours that are spatially organized.

In the edit mode, a user can perform the following actions to create or modify wiki pages:

- **Create wiki pages.** When a wiki link is navigated for the first time, a new wiki page in the ShyWiki web is created.
- **Create Notes.** The user can add new notes to the wiki page. The note types that can be added are content and transcluded notes.
- **Edit Notes.** The content, size and colour of notes can be changed anytime. The content of the notes is described using the ShyWiki mark-up language.
- **Move notes.** Notes can be moved freely in the interface by dragging and dropping them. In this way, a user can organize the information as she/he desires.
- **Group notes.** Users can group notes to create aggregations. In this way, a note can be dragged and dropped inside another note, and the note becomes part of the other one. Once notes are grouped, a user can manipulate a set of notes together.
- **Transclude notes.** Users can transclude a note inside another wiki page by indicating the source document and the note identifier. The position of the transcluded note can be changed, but the other properties can only be modified if the original note is edited.
- **Label hyperlinks.** Hyperlinks in ShyWiki can be typed. A label indicates the meaning or type of the association represented by a hyperlink.
- **Create a template.** This action allows the user to define a new template. A template defines a set of notes and the associations between a template and others. These characteristics are inherited by wiki pages created as instances of a template.
- **Instantiate a Template.** This operation is used to indicate that a wiki page is an instance of a template. As a result, the notes defined in a template are added to the current wiki page.

In the following subsections, we present how relations can be represented in ShyWiki, and explain the voting and versioning facilities. A detailed explanation of these can be found in [25].

2.1 Defining Relations

In ShyWiki, we can define implicit and explicit relations as follows.

2.1.1 Defining Implicit Relations

Logic and cardinality relations can be expressed using implicit relations [7]. Figure 1 gives examples of the different types of implicit relations that can be expressed in ShyWiki. The following logic relations can be graphically expressed: disjoint, intersection, part of, and connection. The disjoint relation indicates that two concepts do not have elements in common. For example, the notes representing books *Julio Cesar* and *Otello* are disjoint. The intersection indicates that two concepts have elements in common, e.g., the note representing the book *Hamlet* and the note *Readers Review*. This might indicate that the *Readers Review* note is associated with the *Hamlet* book, and are not about another book. The “part of relation” indicates that a concept is part of another, e.g., *Act 1* note is part of *Hamlet* book. The connection relation indicates that two concepts are disjoint, but

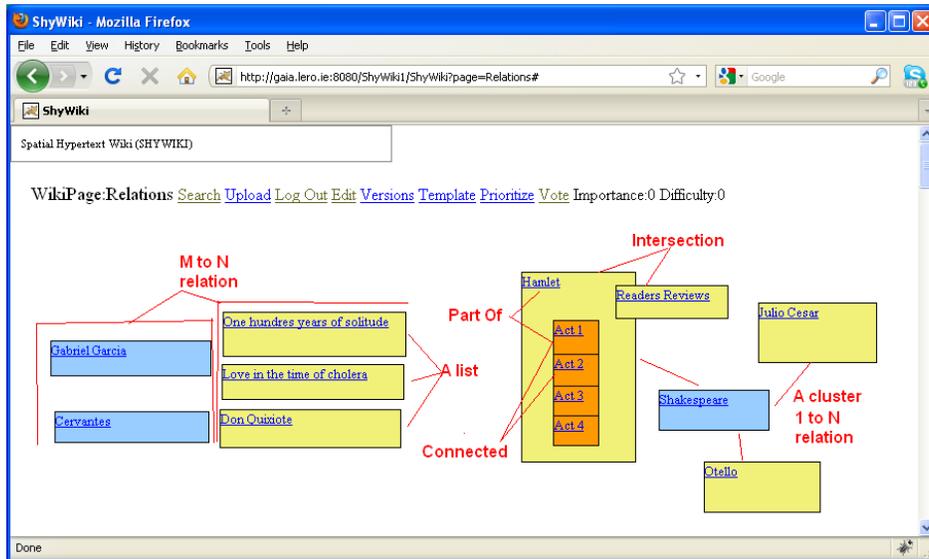


Figure 1: Implicit relations in ShyWiki

if they are close to each other, it might indicate a sequence. For example, *Act 1* has a connection relation with *Act 2*. When users are organizing the hypertext spatially, they do not have to explicitly think in terms of logic relations. As a result, users do not suffer from cognitive overhead.

In ShyWiki, a set or cluster is expressed by means of the proximity, visual properties, and alignment. A group of elements which are near each other can conform a cluster or set, e.g., there is a cluster around *Shakespeare* note. A visual colour shared by diverse elements indicates that they belong to the same set or type, e.g., the notes in blue are authors *Shakespeare*, *Cervantes*, and *Garcia Marquez*. The elements in a set can also form structures as lists or stacks. Also, the notes can be used to represent different cardinality relations: one to one, one to n, and m to n. For instance, *Shakespeare* is related to many notes, *Cervantes* has a one to one relation with *Don Quixote* note. In the left side of Figure 1, there is a cluster of books written in spanish, and there is a m to n relation between authors and books.

2.1.2 Defining Explicit Relations (Templates)

Templates allow users to define reusable explicit relations among wiki pages. A ShyWiki template is an abstraction which represents a set of concepts that share common properties and relations. A template has an identifier, which is a unique template name. In ShyWiki, properties and relations are defined by using named notes. A note's name defines the name of a property, and its content is the default value in the instances. Templates permit the definition of 1 to 1 and 1 to N relations. The user has to define a named note, the note's name defines the name of the relation. Then, the associated concept is selected from the template list. The content of the note shows the definition of the relation: a labelled hyperlink to a concept instance, which is labelled with the name of the note, followed by an *N* if the cardinality is 1 to N. Users do not have to deal with the definition of the labelled hyperlink because the editor writes the defi-

inition for them. They only have to indicate the cardinality, and select the associated concept.

2.2 Voting

ShyWiki allows users to vote about their perceived importance and difficulty of an idea. Users can assign a value from 1 to 10 to them, being 1 unimportant and difficult, and 10 very important and easy. After the prioritization of the ideas, the tool allows users to observe a summary of which ideas are important and easy to accomplish, which are important and hard, which are easy to do but without importance, and which ideas are difficult and without importance. If the importance or difficulty is greater than 5, then they are shown in green colour. Otherwise, they are shown in red.

In the current version of ShyWiki, users have to assign a note type when they add a note to a wiki page in order to vote. This means that a created template type is assigned to a note. A typed note represents an idea that can be voted (in the wiki page it represents). In ShyWiki, any wiki page has an option for viewing the priority of the typed notes that it contains. As a result, a wiki page shows the list of notes ordered by importance and difficulty, and grouping the notes by type (For example see Figure 3).

2.3 Versioning

The versioning facility allows users to look at previous versions of the wiki pages, which are read only. A new version is created when a user commits a set of changes which includes the creating, editing, moving, and grouping notes, and the instantiation of templates. Privileged users can replace the current version of a wiki page with an older one.

3. SHYWIKI EVALUATION

In this section, we describe the study that was conducted to explore the perceived usefulness and easiness of use of ShyWiki, and the way users worked with ShyWiki.

3.1 Research Questions

The research questions that this study wants to answer are:

RQ1 Is ShyWiki perceived as useful, and is it easy to be used?

RQ2 Which are the spatial hypertext properties and note kinds that are used?

For answering the first research question, the hypotheses to be contrasted are:

Hypothesis1 ShyWiki spatial hypertext model is perceived as useful.

Hypothesis2 Non Spatial Hypertext features (templates, voting and versioning) are perceived as useful.

Hypothesis3 Users believe that ShyWiki’s visual and spatial properties are useful for Wikipedia.

Hypothesis4 ShyWiki is perceived as easy to be used.

Hypothesis5 Non spatial hypertext features (templates, voting and versioning) are perceived as easy to be used.

3.2 Experiment Design and Study Variables

The design of this study is a non-experimental design as we did not randomly assign groups nor did we control groups or use multiple measures [12, 18]. All the participants of the experiment were treated equally and variables were not manipulated. We also can consider part of our study a survey design because we developed a survey to reflect our first research question.

The questionnaire is composed of five sets of questions (items) in order to measure four dimensions (variables). The first group of questions (see Table 1) is about the usefulness of ShyWiki spatial hypertext model. The second group of questions ask if the non spatial hypertext facilities, which are templates, voting, and versioning are perceived as useful (see Table 2). The third group of questions (see Table 3) are about if ShyWiki’s visual and spatial features are useful to be included in Wikipedia. All users were familiar with Wikipedia. The fourth dimension (see Table 4) was about the ease of use of ShyWiki. With these questions we explored if our tool was perceived as easy to be used. The last set of questions asked if non spatial hypertext (templates, voting and versioning) are perceived as easy to be used (see Table 5).

The questionnaire consists of 21 questions using a 7-point (1-7) Likert scale (1, extremely unlikely; 2, quite unlikely; 3 slightly unlikely; 4, neither; 5, slightly likely; 6, quite likely; 7, extremely likely). In this study, we deal with Likert scale as ordinal data. This is because the answers to the questions can be meaningfully ordered from lowest to highest but the intervals between the scoring are not equal psychological intervals [11].

For answering our second research question, the wiki pages created in ShyWiki are analyzed, looking into the variables represented by the visual and spatial properties of the notes (spatial organization, spatial and visual relations) and the

Table 1: Questions about the usefulness of ShyWiki spatial hypertext model

Code	Question
SHM1	I believe that using notes for structuring information in wiki pages is useful
SHM2	I believe that using spatial and visual properties in wikis is useful
SHM3	I believe that the free movement of notes is useful
SHM4	I believe that grouping notes is useful
SHM5	I find that the localization of a note has a meaning
SHM6	I find that the colour of a note has a meaning

Table 2: Questions about usefulness of non spatial hypertext features.

Code	Question
OF1	I find the templates to be useful
OF2	I find the voting facility to be useful
OF3	I find the versioning facility to be useful

kind of notes, which are defined by the goals of usage of the notes.

3.3 Participants and training

We have used availability (or convenience sampling) [18], where the participants were graduate students of the Software Architecture module of the software engineering master programme of the University of Limerick. Four teams of 3 members were formed, and membership to each team was determined voluntarily by team members. Each of the teams had to design and document a software architecture of a university library web portal. The teams were asked to follow the Attribute Driven Design method (ADD) [29] which is a method for designing software architectures basing on the quality attributes that an architecture must fulfill.

The subjects were also asked to use ShyWiki as a collaboration tool for brainstorming, sharing and communicating knowledge involved during the design and documentation process of the software architecture. The subjects received 30 minutes training on ShyWiki consisting of a 15 minutes presentation, by which the main characteristics of ShyWiki

Table 3: Questions about usefulness of visual and spatial properties in Wikipedia

Code	Question
WP1	I believe that the visual and spatial properties would be useful in Wikipedia
WP2	I believe that the visual and spatial properties would be useful to write annotations in Wikipedia
WP3	I believe that Wikipedia would be better if they had visual and spatial properties

Table 4: Questions about ease of use of ShyWiki

Code	Question
EU1	Learning to use ShyWiki is easy for me
EU2	It will be impossible to use ShyWiki without expert help
EU3	It is easy for me to become skilful at using ShyWiki
EU4	Interacting with ShyWiki will not require a lot of my mental effort
EU5	It is easy to remember how to perform tasks using ShyWiki
EU6	I find ShyWiki easy to use

Table 5: Questions about ease of use of non spatial hypertext features.

Code	Question
FU1	I find the templates easy to use
FU2	I find the voting facility easy to use
FU3	I find the versioning facility easy to use

were explained, and 15 minutes of a tool demo. The presentation slides were handed as a manual of the tool. They did not receive further assistance while they were using the wiki.

3.4 Data Collection

After a month and two weeks, the teams finished their software architecture design and documentation as spatial hypertext documents. After that moment, the questionnaire was distributed to the subjects in order to gather appropriate data from the participants. The participants were asked to respond to each statement in terms of their own degree of agreement or disagreement. The questionnaire was filled in anonymously. In addition to the questionnaire analysis, we also accessed their wikipages and analyzed how users have used the notes. In particular, we analyzed which kind of information structures they have built and for what purpose.

3.5 Threats to Validity

Since our research design is non-experimental and we cannot make cause-effect statements, internal validity is not contemplated [18]. Survey designs have specific ways to deal with the following validity threats: face, content, criterion, and construct [12]. In addition, survey designs have to take into account conclusion validity, external validity, and ethical validity. In the following, we explain how we dealt with these validity threats.

- **Face validity.** Face validity concerns superficial and subjective review of questions. The questions were shown to two researchers that are not involved in this research.
- **Content validity.** Threats concerning content validity concern the completeness, appropriateness and subjectiveness of the questions. The items in dimension “usefulness of ShyWiki spatial hypertext model” and “ease of use of ShyWiki” are similar to the questions

used in several studies which have followed Technology Acceptance Model(TAM) [5]. However, we did not do a TAM study about ShyWiki.

- **Construct validity.** It is related to the internal consistency, and convergent and divergent validity of the questionnaire. The internal consistency of the questions was verified by using the Cronbach’s α which is over 0.7 for all dimensions instead for one, which is higher >0.6 and that is valid for exploratory studies (see subsection 4.1).
- **Conclusion validity.** This threat is about the sampling procedure followed and the use of the appropriate statistical tests. The main threat is the small sample used. However, to have more meaningful results we have used non-parametric tests. In addition, the choice of non-parametric tests is re-enforced because we have dealt with the likert data as ordinal. In respect to the random heterogeneity of subjects, the participants have received the same training about ShyWiki.
- **External validity.** This threat deals with the generalization of the results to other participants and settings. The results can be generalized to other people that received the same training about ShyWiki and have experience using other wikis such as Wikipedia.
- **Ethical validity.** This threat is about the ethical issues related to perform the study. The questionnaire questions and the study method were approved by The Research Ethics Committee of the University of Limerick.

4. QUESTIONNAIRE RESULTS

In this section, the questionnaire results are presented, which includes questionnaire reliability, descriptive statistics, and hypotheses test.

4.1 Questionnaire Reliability

To measure the reliability of the questionnaire, we calculated the Cronbach’s α index for each set of questions. Cronbach’s α is a reliability index which indicates the degree in which a set of questions (items) measures a dimension (variable). Cronbach’s alpha value ranges from 0 to 1. The higher the value, the more reliable is the scale. When Cronbach’s α value is above 0.70, it is an acceptable value, although in exploratory studies a threshold of 0.60 is also acceptable [8]. Table 6 indicates that all the dimensions were reliable, the less reliable one is dimension “Ease of use of non spatial hypertext features”.

4.2 Descriptive Statistics

According to Stevens [27], means and standard deviations cannot be used to describe ordinal data. Instead, medians, modes and percentile measures may be applied to rank-ordered data. Jamieson points out that the median or mode should be employed as a measure of central tendency and percentages/frequencies to describe ordinal data [11].

Table 7 summarizes the results of the median and mode of the questions about the usefulness of the spatial hypertext model of ShyWiki. The median and mode for all the questions is 5. There is a positive trend, where the subjects

Table 6: Questionnaire Cronbach’s α

Dimension	Cronbach’s α
Usefulness of ShyWiki spatial hypertext model	0.725
Usefulness of non spatial hypertext features	0.798
Usefulness of visual and spatial properties in Wikipedia	0.968
Ease of use of ShyWiki	0.741
Ease of use of non spatial hypertext features	0.658

Table 7: Questions about usefulness of the spatial hypertext model of ShyWiki

Question	Median	Mode	Interquartile range
SHM1	5.0	5	3
SHM2	5.0	5	1
SHM3	5.0	5	2
SHM4	5.0	5	2
SHM5	5.0	5 and 4	1
SHM6	5.0	5	2

have considered that the ShyWiki spatial hypertext model is slightly useful.

Table 8 gives the median and mode for the questions about the usefulness of non spatial hypertext features. Subjects do not have a clear decision about the usefulness of templates (OF1) and the versioning facility (OF3). The subjects slightly disagreed that the voting facility is useful (OF2).

Table 8: Questions about usefulness of non spatial hypertext features

Question	Median	Mode	Interquartile range
OF1	4.5	5	2
OF2	3.0	3	2
OF3	4.5	2	4

Table 9 presents the median and mode for the questions about the usefulness of the visual and spatial properties in Wikipedia. The three questions have a median and mode of 5. Again, there is a positive trend and subjects indicated that they would be slightly useful.

Table 10 summarizes the median and mode of the questions about ease of use of ShyWiki. EU1 indicates that the subjects did not “find it easy to learn how to use ShyWiki” (EU1). They are undecided about “it is impossible to use ShyWiki without expert help” (EU2), and “interacting with ShyWiki will require a lot of my mental effort” (EU4) with medians of 4.0 and 4.5. They have indicated that it has been slightly difficult to become skilful (EU3). The subjects slightly agree with “it is easy to remember how to perform the tasks” (EU5), and “ShyWiki is easy to be used” (EU6).

Table 9: Questions about usefulness of ShyWiki visual and spatial properties in Wikipedia

Question	Median	Mode	Interquartile range
WP1	5.0	5.0	2
WP2	5.0	5.0	1
WP3	5.0	5.0	2

Table 10: Questions about ease of use of ShyWiki

Question	Median	Mode	Interquartile range
EU1	2.5	2	4
EU2	4.0	4	2
EU3	3.5	3	1
EU4	4.5	5	2
EU5	5.0	5	2
EU6	3.0	5 and 2	2

Table 11 presents the median and mode about the questions related to ease of use of non spatial hypertext features. Users slightly disagreed that “templates are easy to be used” (FU1), and that “the voting facility is easy to be used” (FU2), and are undecided about “the versioning facility is easy to be used” (FU3).

Table 11: Questions about ease of use of non spatial hypertext features

Question	Median	Mode	Interquartile range
FU1	3.5	2	2
FU2	5.0	5	3
FU3	4.0	2	3

4.3 Hypotheses tests

In statistical terms, H1 is defined as the median of usefulness of ShyWiki spatial hypertext model is greater than 24 (which is the sum of 6 answers in the Likert scale with a value of 4), H2 the median of usefulness of non spatial hypertext features is greater than 12, H3 is defined as the median of usefulness of ShyWiki’s properties for Wikipedia is greater than 12, H4 as the median of ease of use of ShyWiki is greater than 24, and H5 the median of ease of use of non spatial hypertext features is greater than 12. All the hypotheses can be checked with a one-tailed Wilcoxon signed rank test, which allows comparing if the median of a sample is greater than a value. In the one tailed Wilcoxon signed rank test, the alternative hypothesis is that the median is greater than a given value, and the null hypothesis is that the median is equal to a given value. All the hypotheses are the alternative hypothesis in the Wilcoxon tests.

The test results are shown in Table 12. For a one-tailed test, the null hypothesis is rejected if $|Z|$ is higher than 1.64 or $p - value < 0.05$. Therefore, H1 and H3 are accepted, and H2, H4, and H5 are rejected.

5. USAGE OF SHYWIKI

Table 12: Results of the Wilcoxon signed rank test

	H1	H2	H3	H4	H5
Z	-2.94	-0.59	-1.52	-0.629	-0.709
One tailed p-value	0.003	0.555	0.031	0.529	0.478

We have analyzed the wiki pages that were created by the users and the ways they used the notes. The users created 76 wiki pages and 367 notes. Examples of wiki pages that were developed by users are shown in Figure 2 and Figure 3. We have classified the notes in the following types according to their usage goal:

- **Content Notes.** Content notes are the ones used to describe a wiki page content. They depend on the name of the wiki page in which they are placed in, and on the goal of the wiki. In this case, the wiki was used for documenting software architectures. Therefore, we observe that the wiki pages were used to document uses cases, scenarios, stakeholders, technical concepts, brainstormings, etc. Content notes in this case are software architecture design notes.
- **Coordination Notes.** They explain the work that is being performed or is planned to be done by a member of the team. In addition, coordination notes were used to schedule face to face and virtual meetings. Users usually include the creation date and time of the note, and the name of the user that has to perform the task. Examples of these notes are: *Meeting at csis on Monday 22nd at 14:30* or *Jeff, please complete the security scenarios*. Coordination notes were frequently derived from observations users have about their designs. For example, noting an incomplete design and that a task is still to be performed as the comment on this note: *Need to include fault detection and firewall security*.
- **Annotation Notes.** These notes are used to explain, comment or clarify the content of another note. Annotation notes were usually included near or overlapping the content they were explaining. For example, *The team is using the template in Bass 2003 for defining scenarios*, which is an explanation of why the scenario described in a page had a particular structure. In addition, it included a hyperlink to an external web page describing that book. Another example is *I have created this illustration to get us thinking about the architecture of the portal application*. When the annotation notes were added on top of the annotated content, users created a group of notes that could be manipulated together.
- **Task Notes.** These notes describe a piece of work and its state. The state of a work was, in several cases, represented using a colour. For example a green note is included with the content: *Team completed the prioritization of scenarios*, while a red note is included with the content: *The usability scenarios are undefined* in red.
- **Comment Notes.** These notes are used to put general comments about the content. In these notes, users were expressing their impression about the content

that they were creating, or about the quality of content created by others. For example, there were notes with the following texts: *Looks good*, *This is interesting*.

- **Navigation Notes.** These notes are used to organize the navigation in the wiki. Users created indexes of hyperlinks to other wiki pages, and to external resources. Some users organized their wiki pages in a structure similar to a tree, where there is a root wiki page, wiki page branches, and wiki page leaves. These users created back navigation hyperlinks in a way similar to bread crumbs navigation aid. Some users also created menus in their entry wiki page.
- **Group notes.** A group note provides a common context to the set of notes it contains.
- **Figure notes.** These notes were used to display images. They were mainly content notes that displayed diagrams and illustrations. They were also used as navigation notes, because some of them had image based hyperlinks.
- **Combined Notes.** This kind of notes, do not have a clear specific type. For example, it can be an annotation explaining the activities that will be performed in a meeting which is scheduled using a coordination note that is part of a content note. In this case, the note is an annotation, but the goal is to coordinate people. The annotation gives more information about the meeting.

We have also analyzed the way the visual and spatial properties of ShyWiki were used to create wiki pages. In the following, we describe how these properties were used:

- **Colours.** Colours were used to classify notes. Notes sharing the same colour belonged to the same category or were displaying related information. For example in a page representing the tasks performed by the users, each note represented a task, and each colour a different state of the task (e.g., green = done, red = pending, etc.).
- **Spatial Organization.** Users organized notes spatially in different structures such as vertical or horizontal lists (For example, they created lists of scenarios and users), clusters, and composite notes with partially included notes (intersection) and with totally included notes inside others (part of). Notes belong to a cluster or a set if they were near each other.
- **Complex organizations.** Spatial organization and colours were used together. For example, in the case where notes represented tasks, the notes were organized in several lists, and a list corresponded to one participant. Another example is: An annotation was included over a note, and another annotation with the same colour of the original one was included near it.

We have also observed how other features of ShyWiki have been used:

- **Templates.** Users defined templates in order to avoid repetitive definitions. They created templates to de-

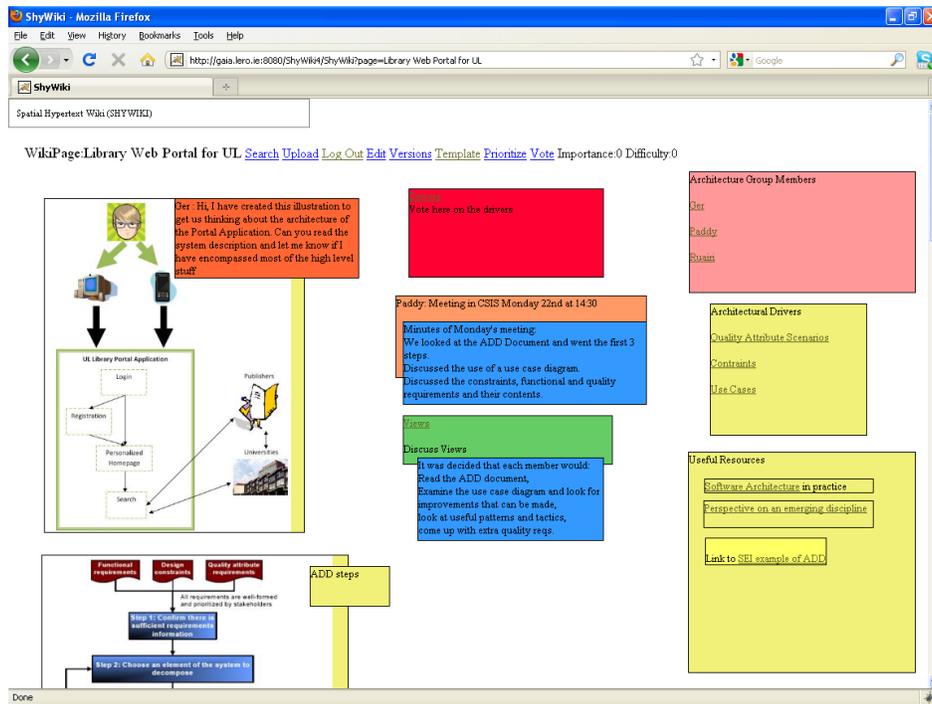


Figure 2: A Software Architecture Documented in ShyWiki

scribe the contact information of team members, scenarios, requirements, and uses cases, etc.

- **Brainstorming.** The brainstorming facilities of ShyWiki were used to capture the brainstorming sessions performed to define quality scenarios. In addition, these scenarios were prioritized in order to define their importance for the team. Teams used the *voting mechanism* of ShyWiki to take that decision (see Figure 3).
- **Images Upload.** Users uploaded images and photos from design sessions performed in whiteboards, as well as, images developed using other tools.

6. DISCUSSION

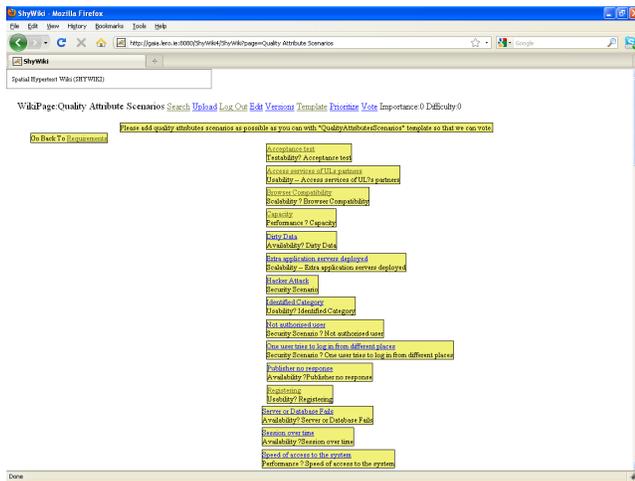
The median in all the questions related to the usefulness of ShyWiki spatial hypertext model was 5.0, which indicates that most users agree that the spatial hypertext model is slightly useful. We believe that this is a positive result considering that users are not familiar with this kind of wiki and hypertext model. Hypothesis “H1: ShyWiki spatial hypertext model is perceived as useful” is accepted because the p-value is 0.003, and is in concordant with the medians in this dimension.

In the dimension about the usefulness of using the visual and spatial properties in Wikipedia, the median for all the questions was 5.0. As a result, users believe that visual and spatial properties are slightly useful for Wikipedia. These three questions also confirm the findings in the dimension of ShyWiki’s spatial and hypertext model usefulness. Hypothesis “H3: Users believe that ShyWiki’s visual and spatial properties are useful for Wikipedia” is accepted because it has a p-value of 0.031.

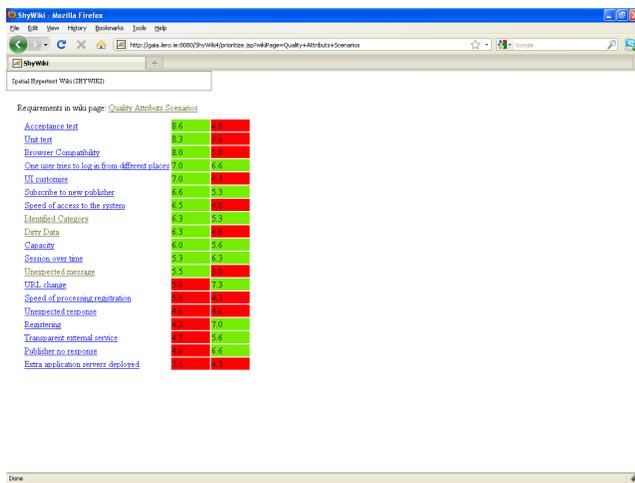
In the experience presented in the paper, the subjects have used the spatial and visual properties for annotating the content, coordinating tasks using annotations, clarifying the content, or adding navigational aids, etc. We believe that the use of annotations and notes that are included over content make spatial hypertext attractive for users. This also confirms the study presented in [26] where users stated that they would like to perform spatial annotations in wikis.

In the ease of use dimension, EU1 is the question with the worst median (2.5). EU1 indicates that the subjects did not find it easy to learn how to use ShyWiki. On the other hand, it seems that once they have learnt they would not need expert help (EU2). It has to be taken into account that the training which the users received was only 30 minutes and that they were not given any extra support while they were using ShyWiki. In addition, the subjects have indicated that it has been slightly difficult to become skilful (EU3). According to EU5, once they learnt how to use ShyWiki, it was slightly easy to remember how to perform a task. Users found ShyWiki slightly hard to use, the median of question EU6 is 3.0. Hypothesis “H4: ShyWiki is perceived as easy to use” is rejected due to that its p-value is 0.529. Users do not find the current version of ShyWiki easy to use. We are aware that ShyWiki needs improvements in its usability and is still a prototype with some bugs, and we expected this result. In addition, the overall ease of use results are impacted negatively by the easiness of use of the non spatial hypertext features.

Subjects are undecided about the usefulness of templates. They have a median of 4.5. Templates are perceived as not easy to be used. They have a median of 3.5. Users can only define templates if they have an accurate definition of the



(a) Scenarios List



(b) Scenarios Priority

Figure 3: Scenario Prioritization

objects they want to create. The difficulty of having a clear definition of an object type, as well as the usability of the templates made them not easy to be used. We believe that the usefulness of templates is limited due to the fact that they need expert users.

Subjects are also undecided about the usefulness of the versioning, which has a median of 4.5. A factor that might reduce the usefulness of the versioning facility is that it does not provide ways to compare the different versions of wiki pages. The versioning facility has a median of 4 in the ease of use. In addition, with the versioning facility it is easy to look at previous versions but it is hard to observe the changes from one version to another. The versioning facility needs to be improved with a functional and an easy to use version comparison.

The usefulness of the voting feature has a median of 3.0. Therefore, users do not find it useful. It can indicate that the voting facility is only used in specific tasks as prioritizing ideas. The technique provided by ShyWiki might be useful

when there are many ideas, there is no consensus, and it is difficult to have a face to face meeting with all the group members. The voting was slightly easy to use and has a median of 5.0. We believe that several users had difficulties with the voting feature due to the fact that the voting facility depends on creating a template. In the near future, we believe we should make independent the voting facility and the template one.

The hypotheses H2: “Non spatial hypertext features (templates, voting and versioning) are perceived as useful” is rejected because it has a p-value of 0.555; and H5: “Non spatial hypertext features are perceived as easy to be used” is rejected because it has a p-value of 0.478.

In relation to the usage of ShyWiki, we have observed that ShyWiki can be used to spatially organize collections of text and graphical information related to a project. ShyWiki provided an extensible way for adding and interconnecting information. The information can be interconnected by means of hyperlinks or by using implicit visual and spatial relations. Users have created several ways to visually and spatially organize the information. Users were able to use the spatial context to represent implicit relations. In addition, this experience has shown that ShyWiki can be used as a collaborative tool to build spatial hypertext documents, or as an idea processing system where users can perform brainstormings for taking design decisions.

Another important factor about the usage of ShyWiki is that users have used annotations for everything. We think this experience is a kind of Annotative Collaboration Process [28] similar to the collaboration supported by Notecards, where annotations are used collaboratively for deciding how the content of a document must evolve. In this experience, it is an Annotative Design Process.

7. RELATED WORK

There are several spatial hypertext systems that provide interfaces which allow the information to be spatially organized. In the following, we provide an overview of several of them.

Notecards [9] introduced the use of cards for representing hypertext documents. However, the cards were not independently movable. Aquanet [13] is a hypertext tool for structuring knowledge, which provided node types and allows users to organize the information spatially. These systems were extensively evaluated and have shown that spatial hypertext was suitable for information management and for idea processing. In addition, their developers also observed that they needed to be improved for collaborative work.

VIKI [16] and its descendant VKB [19] focused on the emergent structure of the documents because the concepts and relations in Aquanet were hard to articulate, and users preferred to use implicit relations. They allow users to freely organize the notes in the interface. Since then, it has been observed that spatial hypertext interfaces could be used in the “casual collaboration” that happens in the web.

One of first spatial hypertext systems for the web is WARP [6] which is based on applets and JavaScript, and has an

interactive interface. TinderBox [1] is a personal content assistant for visualizing, analyzing, and sharing notes. TinderBox is a standalone application that can generate HTML documents for the Web. Emberlight [17] is a tool for publishing spatial hypertext to the web, and provides basic versioning and collaboration facilities.

There are studies that have shown that spatial hypertext can be used for information seeking and structuring in digital libraries, e.g., the Garnet interface [3]. Spatial hypertext has been also used for knowledge management and was combined with zooming visual interfaces as in the iMapping interface [10]. However, none of the mentioned systems allow collaborative work in the web by using the wiki way, and spatial hypertext has not been evaluated in such context.

8. CONCLUSIONS

This paper has presented an evaluation of spatial hypertext wiki. We have evaluated the perceived usefulness and easiness of use of ShyWiki. The subjects have found ShyWiki spatial hypertext model useful. In addition, they have also indicated that the spatial and visual information could be useful in Wikipedia. The features with more potential are the spatial organization, and the annotation of content. Space and colours were meaningful for the users. They were able to create spatial hypertext documents and to represent implicit relations among wiki pages.

On the other hand, users had some difficulties using ShyWiki because ShyWiki is a prototype tool that still needs improvement in its usability. The harder task was the creation of templates (wiki page types), which was difficult because the articulation of object types and their relations is not an easy task, and the steps for creating a template are not easy to follow.

ShyWiki provides two ways for representing relations: the spatial hypertext features which allow users to represent implicit relations, and the templates are used to define object types by using explicit relations. Users were able to represent implicit relations using visual and spatial features. On the other hand, they did not perceive the usefulness of the explicit relations, and they found them difficult to be used. Users prefer to define implicit relations instead of explicit ones.

We have also presented a classification of the kinds of notes defined by the users, as well as, the spatial structures they have built. This allowed us to understand what spatial and visual properties users prefer to use. For example, they created spatial patterns such as lists, clusters, overlapping notes, and they often combined these patterns with notes of different colours. Users included notes to represent information such as task coordination, commenting the quality of the content, representing the state of tasks, etc. Users made annotations over their content and designs. Spatial hypertext is suitable for annotative collaboration activities, and organizing the content in the wiki.

One advantage of this evaluation is that we have detected improvements to be made to ShyWiki, specifically the ones related to improve the usability of ShyWiki. In the future versions of ShyWiki, we will also separate the depen-

dency between the voting feature from the template creation. Other research directions we would like to consider is to have a deeper study of the kinds of annotations used in Annotative Collaborative Design, and to perform other studies of collaborative work in different areas where ShyWiki can be used such as requirements engineering.

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