# Eyes of a Wiki: Automated Navigation Map

Hee-Seop Han and Hyeoncheol Kim

Korea University,
Dept. of Computer Science Education, College of Education,
Anam-dong Sungbuk-ku, Seoul 136-701, Korea
anemon@korea.com, hkim@comedu.korea.ac.kr

**Abstract.** There are many potential uses of a Wiki within a community-based digital library. Users share individual ideas to build up community knowledge by efficient and effective collaborative authoring and communications that a Wiki provides. In our study, we investigated how the community knowledge is organized into a knowledge structure that users can access and modify efficiently. Since a Wiki provides users with freedom of editing any pages, a Wiki site increases and changes dynamically. We also developed a tool that helps users to navigate easily in the dynamically changing link structure. In our experiment, it is shown that the navigation tool fosters Wiki users to figure out the complex site structure more easily and thus to build up more well-structured community knowledge base. We also show that a Wiki with the navigation tool improves collaborative learning in a web-based e-learning environment.

## 1 Introduction

There have been discussions on potential uses of a Wiki within a digital library, such as a knowledge base system, a web site content editing tool and a content management system [3]. The Wikipedia is a good example that shows how users can build up a community-based digital library efficiently and effectively[http://en.wikipedia.org/wiki/Wiki]. Wiki is a simple yet powerful web-based collaboration platform where users can edit any existing pages and add new pages[1][2]. Since it provides a transparent way for users to publish and exchange their ideas with others over the web and fosters information flows within an organization, it has been used for collaborative e-learning environment as well as collaborative works.

In this article, we address how a Wiki way of knowledge management approach fosters collaborative learning experience for learners on distributed e-learning environment. The first impression of Wiki to learners is, however, usually of chaos [6]. Since every participants in the wiki can edit pages and make new links asynchronously and independently, complexity of the hypertext structure increases and thus it might turn out to be chaos to learners. We developed an automated navigation tool embedded in the Wiki which lets you know where you are and recommends you where to go. The navigation map changes dynamically as you hop the hyper-linked pages. It would let you navigate the

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hyper-link forest with ease and fun, instead of being lost in the chaos. This paper describes architecture of the automated navigation embedded in Wiki and its effectiveness for collaborative learning. To evaluate the effectiveness, we experimented controlled tests between a Wiki with the navigation tool and a Wiki without it.

## 2 A Wiki-Based Community Knowledge Base

Mutual interaction among community users creates a community knowledge. A Wiki fosters a community knowledge construction by its two features: freedom to edit any existing pages and freedom to create new pages linked to existing pages. Therefore users can contribute their knowledge to a community knowledge construction in two different ways: by editing existing pages and by creating new pages linked to existing pages.

- Knowledge of a user *A* is represented in a page. By a user *B* editing the page, knowledge of user *A* and *B* is mixed and represented in the page. By a number of users editing the same page, their knowledge interacts each other resulting in a community knowledge agreed. Thus a Wiki's function of user editing of existing pages plays an important role in construction of a community knowledge.
- Users can contribute their knowledge by creating new pages. By linking the new pages to existing page structure, the user knowledge can be incorporated into a community knowledge structure.

In our previous studies, we investigated how community users interact their ideas with others in a Wiki page. In an experiment of a team-based foreign language translation project, it was shown that the knowledge of team members interacts heavily for agreement of translated terms and context [4]. Final output showed a well-translated article agreed by all users participated, which is a team knowledge. Another experiment of writing relay novel was performed to see how the interactivity in a Wiki improves individual user knowledge [5]. Range of imagination and vocabulary was enriched by the interactivity.

In this paper, we investigate how the creation of new pages contribute a community knowledge structure. In a Wiki, any users can create new pages by linking them to existing pages. It generates different level of knowledge interaction from editing pages. Users create a new page when they want to add their knowledge associated to an existing one. The linked structure of a Wiki site represents a community knowledge base. The link is made by individual users independently. In order to creating new pages, users need to figure out existing linked structure of community knowledge before he add new pages to it. However, the linked structure of a Wiki is very complex and changing dynamically. Thus, we developed an automated navigation tool embedded in a Wiki so that users can figure out the linked structure easily. In this paper, we experimented to see whether the Wiki with navigation tools encourages community users to build up community knowledge structure more effectively and efficiently.

# 3 Navigation Map in a Wiki

## 3.1 Link Structure and Page Types

Front page is the entry point in a Wiki that users access. From the front page, pages are created non-linearly by hyperlinks. Users access any page to modify knowledge or create new linked pages from the page. Since all the users are free to create and modify the linked pages, the structure gets more complex and users have difficulty to access or organize the knowledge structure. From the

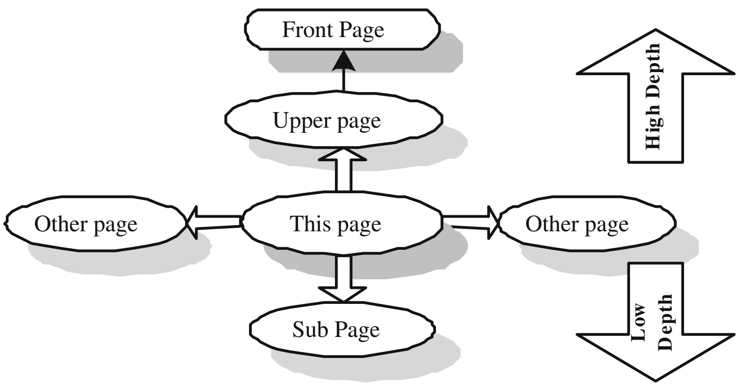


**Fig. 1.** Three types of browsing

current page that users work on, we defined three types of Wiki pages: *Upper, This& Others* and *Sub*. Users at *This* page can move to one of the three directions as illustrated in Figure 1. *Upper* pages contain more general (i.e., super) topic associated to current page topic, and *This& Others* page are associated to the same super topic, but contain different information. *Sub* pages provide more detailed information on current page topic. Navigation interface is shown in Figure 2 where Wiki pages belong to one of the three types. The number next to page name represents its relevance value to current page, which plays as a clue for users to decide where to navigate. We call it as a relevance score. Figure 3 illustrates an example of linked structure. A Line with arrow represents hyperlink with two types: a dotted line and a solid line. The solid lines are related to three page types: *UpperPage*, *This&OtherPage* and *SubPage*. *Upper* pages are the pages with links to *This* page like the black circle number 1 and 2. *Other* pages are the pages with links from the *Upper* pages like the number 5 and 6. Both *This* page and *Other* page have links from same *Upper* pages. The sub pages of *Other* page like the number 7 and 8 are not shown in our navigation map, but they are used to calculate the relevance score of *Other* page. *Sub* pages are just pages that are connected from *ThisPage* like the number 3. The links like number 4 are used to calculate the relevance score of *Sub* page.

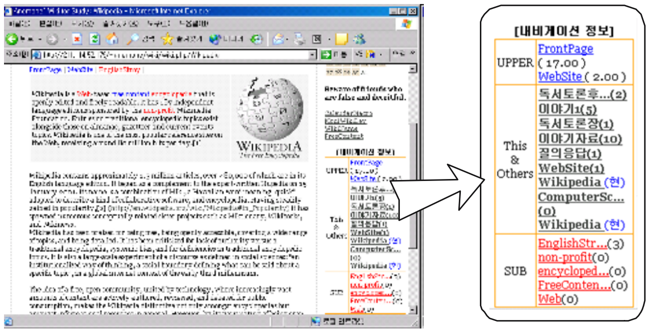


**Fig. 2.** Navigation Interface in Wiki Page

### 3.2 Relevance Scores

Our navigation map provides the three types of pages in separate boxes as in Figure 2. For each type, pages in the type are listed descending order according to their relevance scores. The idea of relevance score is based on the assumption that users want to move to the pages with more information related to the current page. Users navigate *Upper* pages to find different information but similar topic category. Notice that all the *Upper* pages have links to current page. Any *Upper* page with more linked-pages might provide users with more information related to current page. Users want to navigate to *Other* pages to find more information related to current page or new information with same depth level. In the similar manner, Users want to find more detailed information from *Sub* pages. Thus, we give more score to the pages with more links among the pages of a same type. From a viewpoint of a current page $c$ in the browser, $Score(p_k)$, relevance score of a page $p_k$, is defined as follows:

$$Score(p_k) = \begin{cases} \dfrac{\sum_{i=1}^{Size(Upper(c))} Npage(p_i)}{Depth(p_k)} + Npage(p_k), & \text{if } p_{i,k} \in Upper(c), \\[2ex] \dfrac{Nlink(p_k)}{\sum_{i=1}^{Size(ThisOther(c))} Nlink(p_i)}, & \text{if } p_{i,k} \in ThisOther(c), \\[2ex] \dfrac{Nlink(p_k)}{\sum_{i=1}^{Size(Sub(c))} Nlink(p_i)}, & \text{if } p_{i,k} \in Sub(c). \end{cases}$$

The terms used in the equation are defined in Table 1.

## 4 Observation and Result

### 4.1 Experiment Design

We expected the navigation map to assist students to figure out complex structure of wiki-based site and to organize their collaborative knowledge better. In our experiments, hypertext structures of a Wiki that students had worked on were analyzed.

**Table 1.** Terms and definitions used in $Score(p)$

| Terms | Definitions |
|---|---|
| $Depth(p)$ | depth of page $p$ |
| $Upper(p)$ | a set of pages that have links to the page $p$ |
| $ThisOther(p)$ | a set of pages that have links from $Upper(p)$ |
| $Sub(p)$ | a set of pages that have links from page $p$ |
| $Npage(p)$ | the number of pages that have links from page $p$ |
| $Nlink(p)$ | the number of links in page $p$ |
| $Size(A)$ | the number of elements in a set $A$ |

Two groups of undergraduate students participated in our experiments. Group I of 37 students (male:12, female:25) used the Wiki with navigation map, and group II of 38 students (male:13, female:25) used the normal Wiki. A team-based activity was assigned to each team composed of three or four students. Goal of the activity is to develop a team-based Wiki site (i.e., a group knowledge base) on computer science subjects. Participants had never learned the topic before. The activity consists of two tasks as follows:

1. Each student collects related contents from internet and publish three or more pages in a Wiki.
2. They construct a knowledge map of the collected materials in just one public page.

Process of the activity is illustrated in Figure 4.

The activity lasted three weeks and we tracked all the navigation pathes of every participants to observe knowledge changes and user navigation patterns. We estimated participants' comprehension of knowledge map by letting them draw the map individually.

### 4.2 Experimental Results

As a result of the activities, group I and II generated 214 pages and 254 pages, respectively. The difference is actually not meaningful because it comes from just typing of related URL or uploading of related files instead of creating new pages. Results of tracking participants' event-reading, modification and creation were stored 15308 rows for group I, and 15331 rows for group II into DB. Which tells that participation degree is very similar each other. We also investigated the participation degree of each individual student and the individual participation was good enough. However, the two groups shows differences in several factors as shown in Table 2. We summarize the experimental results with two viewpoints as follows:

**Complexity of the Group Knowledge Structure.** Even though the number of pages are similar, a normal Wiki has simpler structure than the one with a navigation map. For example, depth of the linked structure in normal Wiki is 3 while it is 6 in the Wiki with a navigation map. It is because normal Wiki

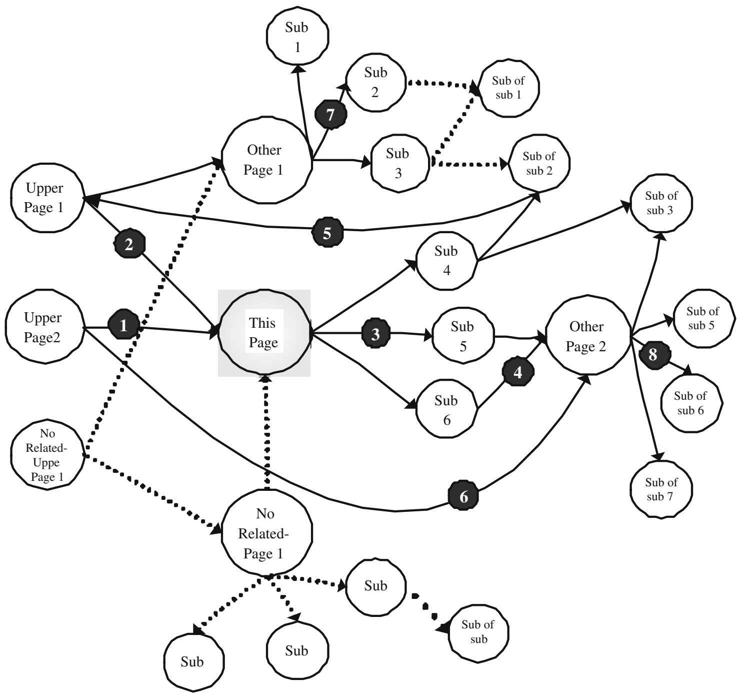


**Fig. 3.** Example of Linked Structure

users feel uncomfortable to construct a more complex structure. They also tried to gather links in just one page whenever it is possible, and therefore they tend to express the structure of knowledge not by links, but by paragraph in one page. The number of crosslinks in the Wiki with a navigation map is obviously larger than the one in the normal Wiki. Thus, similar number of pages are organized quite differently with different complexity of linked structures. We can conclude that the group knowledge structure with the navigation map is more well organized with necessary complexity.

**Understandability of the Group Knowledge Structure.** Crosslink can be another clue that shows how well users understand the linked structure of their Wiki site. In a normal Wiki, most of the crosslinks are just simple links

**Table 2.** Summary of experimental results

| Factors | Wiki with navigation map | Normal Wiki |
|---|---|---|
| Depth starting from Front Page | 6 | 3 |
| The Number of Cross-Links | A lot(74/328) | Little(7/296) |
| User Response | Interesting | Difficulty(path finding) |

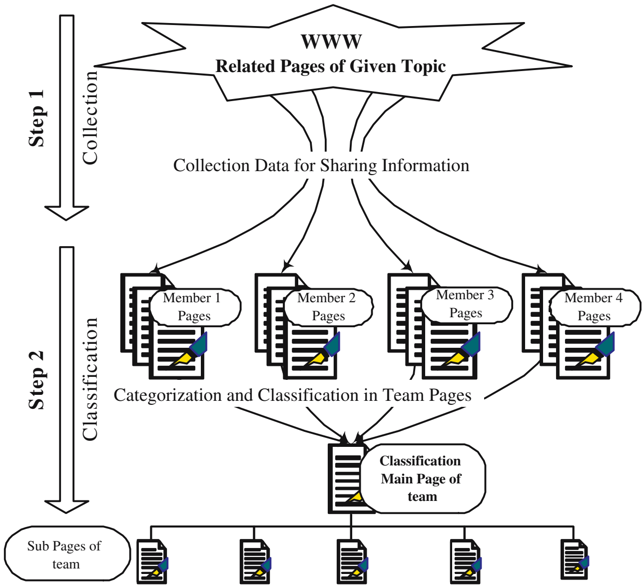


**Fig. 4.** Experimental activities. Four students in a team collect contents and construct a team Wiki site.

to the front pages or members' pages where users visit frequently. In a Wiki with navigation map, however, many meaningful crosslinks between inner pages have been found, which indicates that users in the Wiki have good understanding about the pages in the whole linked structure. From the difference of the number of crosslinks in Table 2, it is obvious that navigation map helps users to grasp the linked structure with ease. Responses from normal Wiki users tell that it was difficult for them to find pathes and to navigate in the complex unlinear link structure, while navigation map users tells that the tool was very useful during the team-based activity.

## 5 Conclusion

A Wiki has great potential for collaborative learning in distributed environment. Community knowledge linked in non-linear hypertext is changed as anyone can create, edit and modify the knowledge and links. To make the Wiki to be a more effective learning tool, we developed the navigation map which guides learners not to get lost in the Wiki's structural chaos. The navigation map shows learners where they are and where they can find more information associated to the current page in the complex structure of a Wiki. Experimental results show that it helped learners to understand linked structures of pages, and thus to access pages more easily and to organize group knowledge more efficiently. Wiki with the automated navigation map makes wiki-based collaborative learning more easy and effective for learners. The wiki site implemented with the experimental navigation map is open at http://ini.korea.ac.kr/∼anemone/wiki01/wiki.php.

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