AniAniWeb: A wiki approach to personal home pages

Conference or Workshop Item

AniAniWeb: A Wiki Approach to Personal Home Pages

Jochen Rick

College of Computing / GVU Center
Georgia Institute of Technology
Atlanta, GA 30332-0280
jochen.rick@cc.gatech.edu

Abstract

This article reports on my dissertation research on personal home pages. It focuses on the design of AniAniWeb, a server-based system for authoring personal home pages. AniAniWeb builds on a wiki foundation to address many of the limitations of static technologies used to author personal home pages. This article motivates the technical hypotheses behind AniAniWeb and reflects on these hypotheses, based on a two year study of adopters using AniAniWeb in academia, a prominent vocational setting where personal home pages are important. In particular, I reflect on two broad categories: 1) the usefulness of wiki features (wiki authoring, wiki mark-up, and interaction / collaboration) to authoring personal home pages; 2) the other features (structure, designing looks, and access control) needed to make a wiki approach to personal home pages viable.

Categories and Subject Descriptors H.5.4 [*Information Interfaces and Presentations*]: Hypertext / Hypermedia—architectures; H.4.3 [*Information Systems Applications*]: Communications Applications

Keywords personal home pages, AniAniWeb, access control, wiki design

General Terms Design, Human Factors

1. A Wiki Approach to Personal Home Pages

This article is based on my dissertation work [26] on personal home pages. Rather than study how personal home pages are currently used [25], I chose to advance the authoring technology to investigate the future of personal home pages. I designed the AniAniWeb system to move towards that future—when new technology allows the use and meaning of personal home pages to escape their static constraints. What will personal home pages look like once their use and meaning is determined by user needs, rather than current limitations? What practices do these personal home pages afford? What do the adopters get out of them?

This article reports on the design issues surrounding AniAniWeb. First, the origins of personal home pages are introduced. I argue that, to realize the potential of personal home pages, home-page technology needs to go beyond static pages. Second, I motivate the initial design of AniAniWeb. I show how wiki features can address the major limitations of static pages. Additionally, I motivate the additional features necessary to apply wiki technology to personal home pages. Third, I detail my study of AniAniWeb in academia, one professional setting where personal home pages are important. Fourth, I reflect on the usefulness of wiki features to personal home pages. Fifth, I reflect on the supplementary design features of AniAniWeb. One of the more complex and important design issues is access control: How can people usefully determine who has what access to their home page (or specific sections of their home page)? I show how AniAniWeb implements a usable and useful access-control system to a wiki foundation. Sixth, I conclude by discussing the findings of this research in a broader context.

2. Personal Home Pages

Personal home pages are hypertext pages on the World Wide Web that represent a specific person. *Hypertext* is text in which the reader can navigate the text by clicking on hyperlinks embedded within the text. The vision of hypertext goes back to Vannevar Bush's [7] article on Memex, a device for memory extension. The notion of hypertext was improved upon by Doug Engelbart (the first-realized hypertext system), Theodor Nelson (coining the term "hypertext"), among others [8]. With the arrival of the World Wide Web (initiated by Tim Berners-Lee at CERN), and its commercial explosion in the mid-1990s, the vision of having a hypertext presence that can be shared with others became a reality for many people. HTML (HyperText Mark-up Language) be-

WikiSym'07, October 21–23, 2007, Montréal, Québec, Canada.

came the *de facto* standard for distributing information on the WWW.

Personal home pages were one of the first uses of the WWW to reach the point of being a recognizable genre, with expected properties and standards [10]. In the mid-1990s, commercial sites such as Geocities offered users space to distribute their HTML personal home pages. Along with such avocational uses, personal home pages have become important in professional communities. At the forefront of this trend is academia.

2.1 In Academia

In academia, personal home pages are an important medium for communication. In research communities, there is a particularly strong need for members to construct and publish artifacts that present themselves. Identity is largely constructed and published through scholarly publication; academic reputations are made to a large extent by conference articles, journal articles, books, etc. [33].

Often, when I, as an academic, review or read an article, I find it useful to know more about the context of the article. Who is this author? What was her previous research? Which academic communities does she belong to? For established researchers, I tend to know the previous work and can thus better understand the current work. For relatively unknown researchers, such as graduate students, this requires a bit of work. My strategy is to perform a web search on the author. This usually leads me to their personal home page. If that home page is useful (and, in computing disciplines, it usually is at least somewhat useful), I can efficiently answer these questions to better understand the article.

Like the published article, the personal home page acts as a proxy. I could have answered these questions by engaging the author directly (for instance, through an e-mail exchange); instead, I engage the constructed artifact—the personal home page. Unlike direct engagement, the author is not aware that I have engaged their home page. Yet, it could have a real effect on my impression of the author as researcher. If I am acting as reviewer, it might even have a measurable effect on the author's academic reputation. Thus, though academics may not be aware of it, their personal home pages are important. In particular, they are important to graduate students who are still trying to construct their research identities. As Agre [1] advises graduate students, "your home page is a projection of your professional persona—a way for people to know who you are as a member of the profession."

At faculty hiring time, the use of personal home pages has become standard. Students are advised to have their professional home page prepared when applying for an academic position. Commonly, online faculty applications prompt the applicant for a home-page link. Before sending in applications, a candidate posts his research portfolio (curriculum vitae, research statement, teaching statement, publications, etc.) to his home page. Faculty candidates also visit the personal home pages of faculty members at the institutions they apply to. While it is common to do this even before applying, this use is critical when preparing for an interview. Candidates research the history of the interviewers and other faculty members they will meet on their visit.

Academics have a need to publish information to others, connect with their research community, connect with their local community, and collaborate with others. A good personal-home-page system for academia should allow its owner to engage each of these functions. To do that, home page technology has to go beyond its current limitations.

2.2 Limitations of Static Technology

Unfortunately, the current use of personal home pages is quite limited. Even when personal home pages are acknowledged and used [1, 10], they are seldom acknowledged and used for more than distributing contact information and making the research portfolio more available.

This limited use is partly a function of the limitations of current technology. The vast majority of academic personal home pages are static; adopters are limited by the affordances (or lack thereof) of the static technology (e.g., Microsoft FrontPage). As the Web matures, new technology will allow personal home pages, their use and meaning, to mature. New uses and techniques will become prominent and the character of personal home pages will change. For instance, personal home pages created using blogging technology tend to be different in character from static pages [17, 22].

With conventional technology, users construct their static personal home page on their home machine and then upload it to the server, where it can be accessed by others. While this technology allowed personal home pages to become prominent, these sites only partially fulfilled Berners-Lee's vision of the World Wide Web: "My vision was a system in which sharing what you knew or thought should be as easy as learning what someone else knew" [3, p. 33].

When Berners-Lee created the World Wide Web, he envisioned users seamlessly transitioning from viewing a page to editing it; however, he was unable to persuade the creators of Mosaic, the first viable graphical web browser, that seamless editing was essential to the Web. Creating a graphical HTML editor is difficult and the Mosaic team did not feel it was worth the effort. From an adoption perspective, they were right: Even without editing capability, Mosaic and its commercial twin, Netscape, introduced the world to the World Wide Web. Unfortunately, the vision of user editing was largely lost.

Aside from hit counters that show how many visitors had visited a site, there was little interaction between creators and viewers of the web artifact. One person built the artifact and others were able to view it; there was an impassible barrier between the creator and the viewers. This model of interaction was more a function of what the technology easily allowed, rather than the needs of its adopters. In terms of their use in academia, I found three major limitations of

static technology: 1) content creation is not emphasized; 2) publication is awkward; 3) interaction is not facilitated.

2.2.1 Content Creation is not Emphasized

Most conventional website-creation tools do not provide structural support for content creation. They are designed to be used for many different applications. An artist can create a gallery to display their work. A company can create their website to match their corporate image. A fan can create an homage to their favorite television show. A graduate student can create a site for potential employers to look at prior to a job talk. All of these users have different needs, but they all share the same website-creation tool. Such a general tool is not particularly well suited for any one of those purposes. Users are left with a large open canvas that can be so overwhelming that they never get beyond creating the looks of their site to focus on generating the useful content (i.e., text) that is important to academia.

Focusing users on content creation can be important. As an example, in wiki use in English composition classes, the teacher found that the content-focused wiki improved the quality of students' work [27]. For their final project, students were asked to create a website. In previous terms, students had designed their sites using conventional website-creation tools. Although the teacher had emphasized that she was primarily interested in *content*, students tended to focus on *appearance* to the detriment of content. When students started using a wiki, this changed. Wikis are designed to facilitate content creation, not creating a great-looking site [20]. If we want users to use websites to present themselves usefully to others, then their tools should support them in that task.

2.2.2 Publication is Awkward

For static home pages, the publication cycle is long and awkward. In order for a person to make changes to his home page, he needs to launch special website-creation software or a text editor. Next, he needs to find the file that needs changing. Then, he needs to change and save it. If the user is not on a machine that has direct access to the source files, two extra steps of downloading the original source file and uploading it back to the original server are required. In the community that I studied, an additional problem was discovered: Most home pages did not update publicly until the next day.

An awkward publication cycle can be a large barrier to quick changes and keeping a home page up to date. Ease of use and simplicity are good predictors for whether people will use a technology [36]. The longer it takes to access an application, the less likely a user will use it; for instance, PDA users often still resort to scrap paper to remember an appointment, as the retrieval time for the PDA is high [30]. The more difficult it is to update a personal home page, the more likely a student is to put off updating that home page. Ultimately, less content is made available on the home page for the community to engage with.

2.2.3 Interaction is not Facilitated

Static home pages do not facilitate interaction with others. This limits functionality, as collaboration is not even an option. For example, if a graduate student was scheduling a time for his thesis proposal, his home page might be a logical place for the committee to coordinate schedules. The home page can serve as a collaborative artifact that everyone can visit easily on their own time to view, add to, revise, etc. With conventional home-page software, this functionality is not even an option. Static personal home pages do not allow these types of useful practices to emerge.

Additionally, static pages limit the feedback that a user gets about his home page. Since awareness of an audience is a critical part of composition [2] and provides a motivation to construct an identity [4, 35], limiting that awareness hampers the composition process.

2.2.4 Beyond these Limitations

To investigate these technological limitations in practice, I conducted a survey of first-year graduate students [26]. This survey was administered before AniAniWeb was available to get a better understanding of the use of static home-page technology. Ph.D. students who had just completed their first year of coursework were asked to participate. Because the mandatory "Introduction to Graduate Studies" class requires students to create a personal home page, all had opportunity to use and adopt personal home pages. They were a homogeneous group, allowing me to investigate early issues of use and adoption in a cross-sectional quantitative manner.

Regardless of use, students found the current publication cycle to be an impediment to their adoption of personal home pages. This suggests that an easier editing cycle could entice more graduate students to adopt personal home pages. The results were split for interaction. Lower-use adopters did not feel that support for interaction to be important for their home pages. Higher-use adopters, on the other hand, want to interact with others through their home pages. Thus, while interaction may not entice students to adopt, it can be a desired feature to realize the potential of personal home pages.

To realize the potential of personal home pages, these technological limitations are problematic. Because content creation is not emphasized, users have a hard time creating content-centric personal home pages. Because the publication process is awkward, individuals are less likely to adopt personal home pages. Because interaction is not facilitated, no important collaboration will be done. In this research, I seek to go beyond these limitations to create a better personal-home-page system. Fortunately, these three technological limitations can be addressed through an already established web technology—the WikiWikiWeb.

3. From WikiWikiWeb to AniAniWeb

While the standard web browser became popular without an emphasis on client editing, other web applications soon came along to realize collaborative editing. One of the most popular and simplest of these is the WikiWikiWeb,[1] created in 1995 by Ward Cunningham. Wiki takes a radical democratic view of interaction—everyone is a creator. Wiki invites all visitors to edit any page within the website, and add new pages using only a regular web browser. Any person visiting the site can simply click the "edit" button to edit the page. The text is edited in an HTML text area without special applets or plug-ins. While allowing anyone to edit the site may seem quite dangerous, it can also be powerful. For example, by adopting Wiki's open interaction model, Wikipedia has been able to grow and leverage its community of users to create one of the largest and most useful sites on the Internet [5].

3.1 Addressing the Static Limitations

Though use of and research on wikis has focused on purposes other than personal home pages, they can address many of the limitations of static technology. First, wikis focus users on creating textual content. It is easy to create new pages and link pages together through hyperlinks. Second, as a server-based system, the publication cycle is quick and effective. To edit a page, a user simply clicks on the "edit" button and the source of the page is available to edit. Third, wikis facilitate interaction, allowing even anonymous users to edit the site. Their use has demonstrated that a simple, trusting approach to access control can be effective with few instances of abuse [14, 20]. Wikis demonstrate a best-practice approach to facilitating powerful (going beyond accessing and addition to editing) interaction with a lightweight system. AniAniWeb extends a WikiWikiWeb approach to personal home pages, leading to the first technical hypothesis:

Thesis 1 Wiki features (quick authoring, interaction support, and collaboration support) can enhance the authoring of personal home pages over traditional (static) tools by better supporting established uses and by making new uses possible.

3.2 Additional Design Issues

While wikis address many of the problems of static pages, they bring up new ones. First, their aesthetics are different than those of personal home pages. A personal-home-page system needs to place more emphasis on looks than a wiki normally provides. Second, wikis are too democratic. A personal home page is about one person; it makes sense to give that person more power than others have. The owner of the site should be able to control the access that others have to the site. Third, since there will be an owner in charge, that person has a greater ability to structure the space effectively. To summarize, what follows is the second technical hypothesis informing the design of AniAniWeb:

Thesis 2 Wiki technologies need to be augmented with more access control, more structure, and more support for customizable looks to better support the authoring of personal home pages.

3.3 AniAniWeb

> Mirrors, literal and metaphorical, play an important role in human development. In literature, music, visual art, or computer programming, they allow us to see ourselves from the outside, and to objectify aspects of ourselves we had perceived only from within.
> —Sherry Turkle [34, p. 155]

Ward Cunningham named WikiWikiWeb after the Wiki Wiki Buses that shuttled people around the Honolulu airport [20]. "Wiki wiki" means quick in Hawaiian Creole. The quickest way to build a website is to invite anyone who visits the site to also contribute content. To honor its origins in WikiWikiWeb, the software was named AniAniWeb. "Ani-ani" means mirror in Hawaiian Creole.

If a static personal home page is like a photograph of an individual, AniAniWeb is more like a mirror. It is not as polished, but it is more alive. It is constantly changing and there are things happening in the background. Reflection is key. Through the process of writing hypertext, an AniAniWeb adopter should be able to reflect on his understanding of who he is.

Like most wikis, AniAniWeb is an entirely server-based system; all that is required to use AniAniWeb is a regular web browser. This makes it extremely accessible. It can be used in the office, at home, at a conference, at a kiosk, etc. All that is required is Internet access and a keyboard.

When first viewing an AniAniWeb, it looks like a regular home page. From a viewer perspective, it is a little bit better than a static site: It shows recent changes, it is searchable, and each page can be rendered for printing. But, from an observer's perspective, it is fundamentally a normal site. The difference is that there is a "sign-in" button. On that page, you can create an account using a valid e-mail address. Once you have an account, you can sign in. When you sign in, the site more closely resembles a wiki (Figure 1). You can upload documents. You can see the history of each page over time. Most importantly, you can press the "edit" button; from there, an HTML form allows you to edit the page using a simple mark-up language (Figure 2).

There are a few key differences between AniAniWeb and WikiWikiWeb. First and foremost, AniAniWeb grants extra power to the owner of the site. She is the only user who can change the site's appearance. She is the only user who can move or delete uploaded documents. She is the only user who can change the access control (Figure 2). The version of AniAniWeb used at the beginning of this research allowed

[1] The original Wiki is located at `http://c2.com/cgi-bin/wiki`.

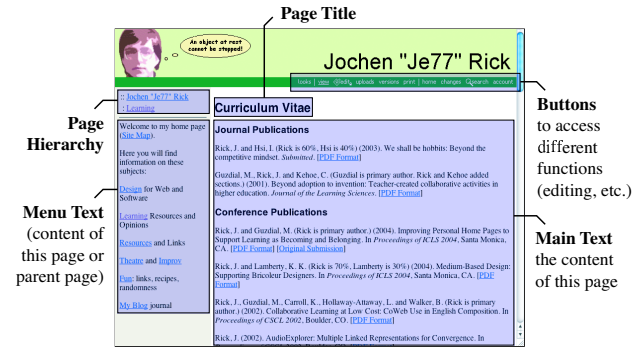


Figure 1. Anatomy of Viewing an AniAniWeb Page

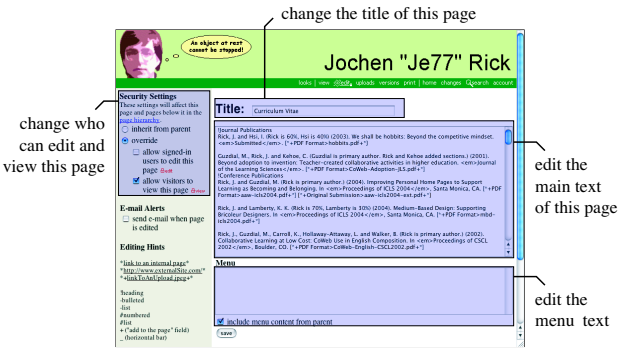


Figure 2. Anatomy of Editing an AniAniWeb Page

for fairly simple access control. I decided to start with a simple system. One of the key lessons of Wiki's success is that a simple system can trump a more sophisticated system [5]. Through this research, I was ultimately able to develop a more flexible system, largely driven by user needs. While the initial system proved to be less than ideal, it was sufficient to allow AniAniWeb adopters to reflect on their needs.

Second, AniAniWeb features a page hierarchy (Figure 1). When new pages are created, they automatically mark the page they were created from as their parent page. When viewing the new page, the page hierarchy shows a link to the parent page. This feature helps users navigating the website. It also allows pages to inherit appearance and access control from their parent. So, owners can change the appearance or access control of large sections of their home pages with minimal effort.

Third, AniAniWeb supports multiple columns. It has become standard for many professional sites (and personal home pages) to feature multiple columns. Typically, a smaller left column is used for site navigation and a larger right column shows the main content of a page. AniAniWeb dictates this format (Figure 1). As the navigation column, the "menu text" is set up so that it can be inherited from its parent page.

Finally, AniAniWeb puts more emphasis on customizable appearances. Most wikis will never be mistaken for a personal home pages. They are too uniform in appearance; visitors immediately recognize them as wikis. The appearance of a personal home page is more important. It represents someone's identity; aesthetics can be essential to conveying a good first impression [19]. An academic personal home page's aesthetics should positively reflect its owner. To better support aesthetics, AniAniWeb allows users to upload a few key graphics and modify the style sheets to easily change the appearance of all or part of their site (Figure 3).

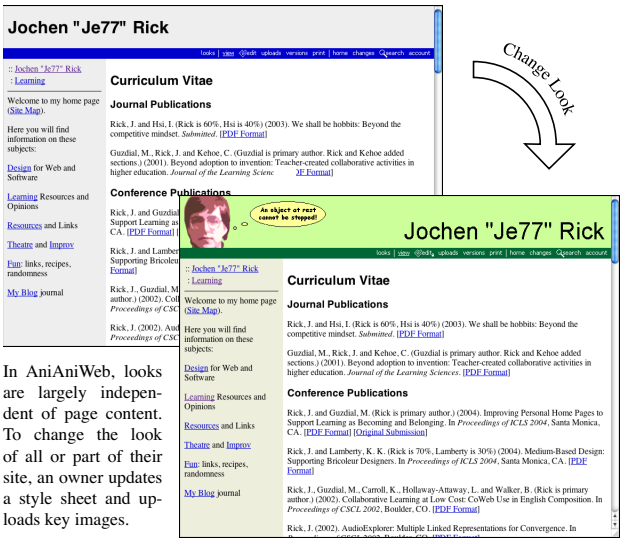


Figure 3. Customizing the Appearance of an AniAniWeb

Designing usable web applications is an art-form that relies heavily on rules of thumb and best practices. There are numerous websites dedicated to web design, including Jakob Nielsen's `useit.com`. Nielsen recommends focusing on content and presenting that content in a usable, standards-compliant manner. Conventional home-page tools are open ended; they allow users to create sites that are neither content focused, nor usable. In contrast, AniAniWeb adopts a Nielsen approach—supporting users in creating content focused, usable home pages.

4. Overview of the Study

AniAniWeb was introduced to the College of Computing at the beginning of the 2003–04 school year. Though they were not heavily recruited, Ph.D. students further along in the program were given the same opportunity. After a year of AniAniWeb use, several graduate students who adopted AniAniWeb were asked to participate in the research. Participants were purposefully chosen to reflect a variety of users, both in terms of their style of use and their progress towards a degree. Students were asked about their current home page, the evolution of their home page, how they view others' home pages, and specifics on their use and evaluation of AniAniWeb. This guide was augmented with questions arising from their home pages. The night before the interview, I closely examined the respective participant's entire web presence.

The interviews were conducted it an open-ended clinical style [29], to explore the adopter's relation to personal home pages. The purpose of these interviews was largely *ideographic*—focusing on understanding the individual participants in depth rather than as examples of a user archetype. This depth approach is necessary as many of the important issues of identity construction can only be realized with detailed qualitative data [11, 35]. The subjects were chosen based on their high use of AniAniWeb. Their usage is not meant to be representative of average use. Instead, it aims to be representative of the potential and variety of personal home pages once further adoption of the medium is a given. The subjects were purposefully sampled to be extreme adopters of personal home pages, as studying extremes is a useful for understanding the meaning of new media [35].

To supplement the student perspective, faculty members were interviewed. Faculty members are core members of and gatekeepers to the academic community of practice. These interviews sought to understand how faculty members perceive and interact with personal home pages of graduate students. Participants were asked about their home page and how they viewed other personal home pages. Particular emphasis was placed on the role of personal home pages during faculty hiring.

The major purpose of this research was to understand the (potential) use and meaning of personal home pages in academia. To investigate the important individual, social, and technological aspect of this medium in practice, I analyzed the research data using three analytical perspectives: core identity theory [11], communities of practice [37], and media theory [21]. Going into detail on these findings is beyond the scope of this article. Instead, I concentrate on the findings informing the design of AniAniWeb. Section 5 reflects on applying wiki technology to personal home pages (i.e., Thesis 1). Section 6 reflects on the supplemental design features necessary to make wiki technology applicable for personal home pages (i.e., Thesis 2).

5. Applying Wiki

Wikis have proven to be useful for content creation and facilitating collaboration in several settings; however, they are generally used for purposes other than personal home pages. This work applies the essential features of wikis to this new domain. This section reflects on the importance of wiki features to the use of AniAniWeb. It reflects on both the advantages and limitations of using wiki features. Furthermore, it suggests how and why a more-sophisticated interface could address these limitations. This section is split into three subsections, detailing important wiki design elements to personal home pages: wiki authoring, wiki mark-up, and interaction / collaboration.

5.1 Wiki Authoring

> "I've probably updated my AniAniWeb webpage more than I ever updated all my other pages combined... maybe not... it just feels like it." —Participant C

As the above quote attests, the research participants authored more content with AniAniWeb than with other technologies they had used.[2] Furthermore, compared to the static-homepage users, AniAniWeb adopters created more content.

To usefully compare these groups, I examined their respective home pages. I had downloaded the home pages of survey participants, shortly after they completed the survey. At that time, they had been at the College of Computing for one year. As a comparison, I reconstructed the home pages of AniAniWeb research participants one year after their AniAniWebs were created. Because AniAniWeb research participants were recruited based on their high usage, I only considered the static sites of the nine survey respondents who reported spending more than one hour per month on their home pages. Comparing these two groups, the static home pages averaged under 12 HTML pages, while the AniAniWebs averaged almost 39 pages—more than three times as many pages.[3]

This direct comparison has several problems. First, the populations are slightly different. All the static-home-page users were first-year doctoral students, while many of the AniAniWeb adopters were not. Since the need for and usage of personal home pages is influenced by the position in the community, this might bias the numbers towards AniAniWeb, as senior students have a greater need for a professional home page. On the other hand, all first-year students had to author several pages for the "Introduction to Graduate Studies" class, thereby biasing the results towards static technology. Second, a hand-authored HTML page and an AniAniWeb page are not exactly the same. An AniAniWeb page can serve purposes, such as interaction, that static-home-page users would have to use other technology (e.g., `evite.com`) for. Third, only the AniAniWeb portion of the web presence for research participants was counted, since I could not reconstruct the static sites for the appropriate times. Even given these defects, the large difference in the quantity of pages suggests that home-page adopters created far more content with AniAniWeb than with traditional HTML tools. Why?

In terms of creating content, the primary advantage of AniAniWeb over static tools is the quick editing cycle, enabled by wiki technology. For quickly and easily authoring content, AniAniWeb proved to be a big improvement over traditional HTML tools. To better understand the role of wiki

[2] While this characteristic was true for all research participants, it is not too surprising, as the research participants were recruited based on their high use of AniAniWeb.

[3] While the sample sizes were small, the comparison still achieved significance of $p < 0.05$ on a single-headed t-test.

editing, I examined the number of contributions adopters made to their sites during active use of AniAniWeb. I calculated the time of active use for a site as the period from the inception of that site to the last time the site was used; the ending limit was needed as many research participants stopped using their Georgia Tech AniAniWebs after leaving Georgia Tech. Examining those figures, two distinct groups emerged: 1) those that used their sites primarily as a professional web presence; 2) those that used their sites primarily for self use. The latter group edited much more, averaging about 37 edits a month and about 25 edit cycles per page; the former group edited less, averaging about 10 edits a month and about 9 edit cycles per page. Self use, such as maintaining a "to do" list, inspired large amounts of edits. The greater number of edit cycles per page for the self-use group was a consequence of these self uses; a "to do" page naturally lends itself to more edit cycles than a project description page.

Another significant advantage of AniAniWeb over static tools for creating content is that AniAniWeb largely separates content creation from designing the look. This allows AniAniWeb adopters to concentrate on creating content. By examining the static home pages of survey participants, it was obvious that several concentrated on visual aesthetics, rather than content; for the time that they claimed to invest in their sites, the amount of content was minimal. In addition, it was easier to maintain and update the look of an AniAniWeb. Like on a wiki, adopters can add a new page without having to replicate the structure and visual feel of the site; instead, the look is inherited from the parent page. When an AniAniWeb adopter does want to change the look of the site, he can change a few central files and have the changes automatically apply to the other pages. Several participants reported that updating the look of multiple HTML pages was much more tedious. For quickly and easily authoring content, AniAniWeb proved to be a big improvement over traditional HTML tools.

5.2 Wiki Mark-Up

AniAniWeb uses a wiki mark-up language, which is edited in an HTML text area. Specifically, AniAniWeb inherits CoWeb's mark-up language. CoWeb is a wiki designed for use in Georgia Tech classes [14]. Since many Georgia Tech users are familiar with HTML, it allows users to write HTML, in addition to the mark-up conventions. For users switching from a static site to AniAniWeb, this simplified moving their static HTML content. Building on CoWeb's mark-up language had an additional benefit for this research: As many College of Computing members were already familiar with CoWeb, the transition to AniAniWeb was easy.

Wiki editing was an important feature to research participants. One participant adopted AniAniWeb largely for this feature; he had "hijacked" a part of a public wiki before then to serve as his home page. Another found the wiki editing so useful that she eventually moved her extensive static page to AniAniWeb; this made maintaining the content easier. To further support reorganizing content, AniAniWeb, unlike some wikis, allows users to change the name of a page; every research participant used this feature.

Like other wiki mark-up languages, the syntax particularly supports users in authoring hypertext content: It is optimized for integrating formatted text and links, either internal or external. Users reported that they enjoyed the conciseness of the mark-up language. It was significantly more convenient to author than the verbose HTML of static pages; however, the language does not fully cover all HTML functionality. Occasionally, users had to resort to HTML to create sophisticated structures, such as complex tables and embedded applications. This often became fairly messy. For instance, editing HTML table code by hand can be difficult. Creating a convenient and expressive syntax for generating tables is a difficult task that was never satisfactorily solved.[4]

While users enjoyed using the mark-up language, it was not trivial for them to learn all its features. A few common mark-up conventions are displayed in the form of a crib sheet on the editing page; more sophisticated features had to be learned from the help page; the vast majority of that extensive page is dedicated to explaining the features of the mark-up language. While that page is easily accessible, most computer users do not like checking external documentation.

One oft-suggested remedy for the deficiencies of the mark-up language is to move editing from plain text to a graphical user interface, such as word processors use. It is foreseeable that the view and the edit mode could even be merged (or, at least, more tightly integrated); this would relieve the inconvenience of users having to find the text they want to edit again when switching to edit mode. A more sophisticated editing interface could also feature spell checking, WYSIWYG table support, better support for embedding external content, etc.

While hypertext is the most relevant content for personal home pages, a good system needs to support other media. Many research participants used their websites to distribute pictures. Initially, the support for this activity in AniAniWeb was minimal: Users had to use complex HTML to create their picture gallery. To address this, a gallery feature was created to support a simple picture gallery. While that feature is a substantial improvement to authoring the gallery by hand, it cannot compete with the flexibility and sophistication of commercial sites set up to explicitly support photo sharing. Like tables, the gallery suffers from being forced into the mark-up language; the generated mark up is verbose and hard to browse (Figure 4).

[4] A table is organized along two dimensions: rows and columns. While it is possible to linearize this two-dimensional space, the results are always a bit awkward to author. In addition, there are many table features to integrate into the syntax: header rows, borders, alignment, cell spacing, column spanning, etc. Naturally, linearized tables tend to be verbose and obfuscated, even in standard mark-up languages like HTML and LaTeX.

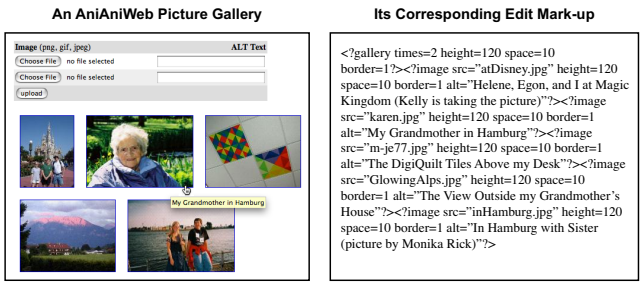


Figure 4. Embedding a Picture Gallery into an AniAniWeb Page

While pictures were the most sought after non-hypertext media, specific users had other needs. One participant wanted to construct a textual database that he could query. For graphics researchers, support for video content is important, as they often distribute a video reel with their portfolio. Also, interactive media, like voting systems, are important. While AniAniWeb supported simple polls, they were somewhat difficult to create and users often abused them by voting more than once. Again, the textual interface proved awkward for this task. An elegant graphical user interface, that integrates well with the average browser, would solve many of the existing problems in authoring content.

5.3 Interaction / Collaboration

Another large difference between AniAniWeb and static tools is that AniAniWeb allows for interaction and collaboration. Through various features, the owner can open their site to contributions from visitors. This section reports on the successes and failures of AniAniWeb adopters to foster interaction. While AniAniWeb builds on a wiki platform, the amount of interaction was far less than on a typical wiki, with most adopters only achieving a small amount of interaction. This section examines the important technological and social barriers to interaction. It also shows how interaction and collaboration can be usefully facilitated. Lightweight tools can help adopters set up a successful interactive space. Private areas can enable deeper collaboration. Even if the amount of interaction was small compared to a typical wiki, it was still an important element for most research participants.

Normally, the communication between the owner of a home page and its visitors is unidirectional: The owner authors content that the visitors consume. This principle even applies to home pages created with newer technologies, such as blogs and AniAniWeb, that allow visitors to contribute content. The average personal blog has far fewer comments than posts [22]. AniAniWeb users too found that visitors only occasionally contributed to their home page. While wikis normally have many different authors posting significant content [9, 27], the same does not hold true for AniAniWeb, a similar technology.

While it is possible for a visitor to an AniAniWeb to contribute content, most do not feel compelled to do so. The vast majority of the content is authored by the owner of the home page. Research participants knew that others regularly visited their site, but visitors only occasionally posted content when visiting. For most participants, it was more common for a website to be mentioned through other channels (e-mail, conversation, etc.) than the site itself.

For most research participants, visitor content contributions were minimal. One participant intentionally locked down his site, preventing any interaction. While the other participants left their sites open to external contributions, they did not receive many. Excluding Participant A, only 6% of content contributions came from people other than the home page owner.[5] Furthermore, most of those contributions were fairly minimal: fixing a spelling mistake, adding a short greeting message, adding a movie night preference, etc.

Participant A's site presented a noticeable exception to this trend. Using the same metric, about 44% of the content contributions to her extensive site came from others. She succeeded in getting others to contribute to her site, where others generally failed. To succeed, she did a good job of navigating both the technological and social barriers to interaction.

One explanation for the small amount of interaction is technological: AniAniWeb has a higher barrier to editing than WikiWikiWeb. In order to edit an AniAniWeb page, a visitor needs an AniAniWeb account. While anyone with a valid e-mail address can create an account, this requires some effort. To create an account, a visitor goes to the sign-in page. There, he enters his preferred user name and his e-mail address in the appropriate HTML form. An e-mail is sent to that address with a preliminary password. Using that password, he can sign in. This prerequisite adds a degree of accountability to content contribution. At minimum, the owner of the site has an e-mail address to associate with any abuse to their site. This technological barrier also prevented spam-bots from trashing sites, as has become an increasing problem on wikis. While this level of protection was desirable for preventing abuse, it made it more difficult for legitimate visitors to interact.

Another explanation for the small amount of interaction is social: There are no established practices for editing someone else's home page. In a wiki, collaborative practices are well established. In addition, there are often guidelines on a wiki that usefully guide use. For instance, Wikipedia has guidelines about writing in a neutral voice and citing claims

[5] To calculate this percentage, the relevant HTTP requests to the site where categorized by whether they came from the owner of that site or from someone else (including anonymous IP addresses). Both edit and "add to the page" request where counted, as both could be used to contribute content to the site. The individual ratios of visitor contributions to total contributions were calculated. 6% is the average of these ratios, which ranged from 2% to 8%.

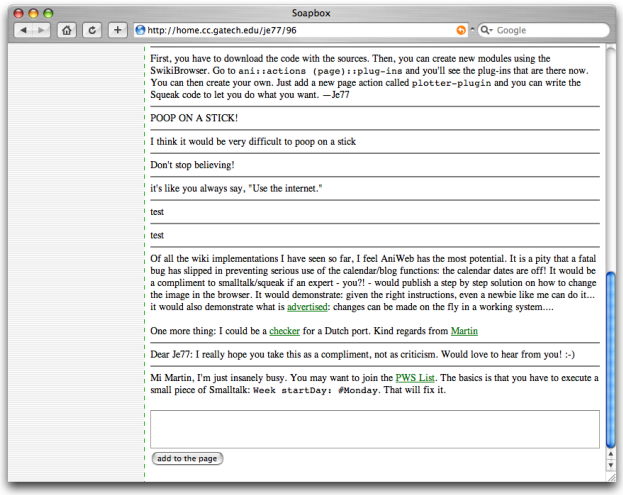


Figure 5. My Comments Page

that usefully guide the authoring [5]. In contrast, a visitor does not have a model of how to appropriately edit the home page of another. For example, one participant added a statement on his home page, inviting anyone to edit the page; however, the amount of editing by others has been minimal. One reason that visitors may hesitate to edit his site is that it is not clear how they should contribute; this user does not have a specific page for external contributions. So, when a stranger, who was willing to create an account to add content, added content, he simply erased it, judging the content to not fit his professional home page.

Overall, incidental or unplanned interactions were rare on AniAniWeb. Several adopters reported that an old friend who stumbled onto the site might leave a comment. Practically, to overcome these barriers, owners must explicitly set up the interaction, providing both a setting and a purpose for the interaction. When given explicit directions, visitors did contribute.

One technological feature that facilitated interaction was the "add to the page" box. By beginning a new line of page's text with a plus sign, an HTML text box is created at that spot when viewing the page. By entering text into that box, a visitor can contribute content (without creating an account). The new content is inserted before the plus sign. This feature was first created for CoWeb, to support external reviewers who were not familiar with wiki technology [14]. Since external reviewers did not have enough invested to learn about wikis, this provided them a simple interface to add comments. The same simple interface proved useful in allowing anonymous visitors to add content to AniAniWebs.

On my site, I use this feature to implement a "Soapbox" page (Figure 5). The page invites visitors to add a message to the bottom of the page, using the "add to the page" box located there. Every few months, I receive a message on this page; considering that this page is an Easter egg for my site, that is fairly successful. This page succeeds, because it addresses both the social and technological barriers. I make it explicit that people are welcome to add (almost any) content and provide them a lightweight tool for doing so.

Participant A uses a similar page successfully on her site. She too receives a comment in this manner every few months. These comments are small and friendly. An old acquaintance might announce that she stumbled across the site. A fellow researcher might note that he finds her research interesting. A friend might leave a remark that only makes sense to her.

These comments pages demonstrate that the appropriate technology and the appropriate setting can encourage interaction. These pages are similar to the popular "walls" feature in Facebook in both the process of the interaction (add content directly to a prominent part of a person's home page) and the nature of the typical content added (short, friendly, informal, etc.). One difference between the two technologies is that AniAniWeb contributions are anonymous unless the person has an account, whereas all Facebook posts are associated with an identifiable Facebook user.[6] So, it is easier for Facebook users to reply to the message. To compensate for this, anonymous contributors often leave an e-mail address for replies. Like me (e.g., Figure 5), Participant A will occasionally reply to new posts by posting a message to her own interactive forum.

Another research participant used the same "add to the page" boxes as a convenient method for adding content to her page. Occasionally, she would receive similar notes from anonymous visitors, although she had not intended for these boxes to be used in this way. This suggests that visitors are willing to add content to a home page as long as the process for doing so is simple.

Another lightweight interaction opportunity arose through polls. Polls could be set up through editing a page and then be used by anyone simply viewing the page. All it takes is a button press to vote. Several adopters used polls. Polls helped several adopter chose movies for movie nights. For Participant A, the poll helped her name her research project. Another participant created a poll to better understand how people felt about some computer science topics. While polls take a while for home-page owners to set up, they only require visitors to press a button. As a consequence, visitors are willing to participate on polls. Polls proved to be a useful form of light interaction.

While it is useful to support the occasional visitor who wants to leave a small comment, there is also a need to support more sophisticated interaction (i.e., collaboration). Participant B's initial reason for adopting AniAniWeb was for collaborating on a class project. Participant C was able to use one page to collaborate on a software project and another

[6] At the time of this writing, Facebook pages can only be viewed by Facebook members. Facebook has a large user-base, so this is not a huge barrier. AniAniWeb's user-base is much smaller; therefore, requiring that visitors create an account to edit a page is a much larger barrier to interaction.

to collaborate on a research publication. Another participant created a page for reference letter writers to communicate. Participant A had several close friends and colleagues who would regularly contribute to her home page. Even in cases where the interaction never became highly bi-directional, the possibility of collaboration helped make the technology appropriate for the task. One participant created a repository for a class project; while he was the only one to edit this page, this was a result of his role in the project, rather than the disinclination of his fellow group members to contribute.

One technology that could better facilitate collaboration is support for private areas, which are open only to the collaborators. Participant B did not use AniAniWeb for her class project as the early version of AniAniWeb did not support private areas. Participant C felt vulnerable that the drafts of an article were available on her site. AniAniWeb's new access-control system enables such private areas.

While entering a password or creating an account can be significant barriers, serious collaborators are more willing to overcome these barriers than casual visitors. Collaborators typically have strong ties to each other [16]. Even for Participant A, who had hundreds of contributions from others to her site, those contributions all came from eight people that she knows well. Thus, different technologies are necessary for supporting interaction and for supporting collaboration. Lightweight tools, such as "add to the page" boxes and polls support interaction, since the visitor does not need to invest much effort to use them. In contrast, serious collaborators are willing to overcome hurdles, such as creating an account, and are willing to learn more complicated skills, such as properly using the wiki syntax. To support these collaborators, access control can be important as the collaborative efforts of people with strong ties often are not open to the general public.

While interaction and collaboration did not occur as often or as pervasively as on a typical wiki, it was still important to adopters. Most felt positive about others contributing to their site and were disappointed that it did not occur more often. Only one studied user locked his AniAniWeb to prevent contributions from visitors. The other adopters left their sites open for the most part. They trusted visitors to use their abilities appropriately. One participant specifically commented that she would leave her site open until she gets abuse; then, she might reconsider it. Many adopters were familiar with CoWebs. CoWeb has few access restrictions, yet the sites are seldom abused [14]. AniAniWeb users may have adopted a similarly open attitude, believing social protocols can keep their site from being abused. Besides the occasional attack of spam-bots, reports of abuse were non-existent throughout this study (from either research participants or other AniAniWeb adopters).

6. Beyond Wiki

While wiki technologies were useful to AniAniWeb adopters, AniAniWeb is more than a wiki. Specific features were added to compensate for several weaknesses of a wiki approach to personal home pages. This section reflects on the three major differences between AniAniWeb and a typical wiki. First, I reflect on the use of the page hierarchy and the menu area to usefully structure a home page. Second, I chronicle the evolution of the looks system for designing the appearance of a site. AniAniWeb takes the approach of separating looks from content; the utility of this approach is discussed. Third, issues of access control are detailed. The design of the new access-control system is both motivated and detailed. Personal home pages tend to integrate different audiences into the same virtual space; however, people also have a need to separate. Access control is the vehicle for achieving a useful balance between these two opposing needs. As access control is so core to the design of a personal-home-page system, this is the longest and most detailed section.

6.1 Adding Structure

Unlike most wikis, AniAniWeb is structured through a page hierarchy. When a new page is created, it automatically becomes the child of the page it was created from. When viewing a page, links to the pages above it in the hierarchy are automatically embedded (e.g., Figure 1 on page 5). This helps visitors navigate the site and encourages an owner to clearly organize his site. Through the edit interface, owners can change the parent of a page, thereby easily reorganizing the site. Adopters reported that this feature was useful and easy to use.

Averaging across all the AniAniWebs of research participants, 2.2% of all pages were at the top of the page hierarchy (i.e., the front page). 24.4% of all pages were one level down in the hierarchy. 43.0% of all pages were two levels down in the hierarchy. 21.1% of all pages were three levels down in the hierarchy. 9.3% of all pages were four levels down in the hierarchy. All research participants created pages at those five levels; no participant created a page at five levels down or more. Considering that even large personal home pages have only about 100 pages, it is not too surprising that the plurality of pages are two levels down. Typically, the front page links to several section pages and those link to the specific content pages.

In addition to supporting organization, the page hierarchy proved to be a useful tool for implementing other important features. When defining a new look or changing the access control, users often want those changes to apply to many pages at once. While it makes sense to have a central look to the site, some sections might deserve a distinct look. The page hierarchy defines such sections. So, I designed AniAniWeb so that both the look of a page and its access-control settings are automatically inherited. Thus, when a

user changes one of these settings for one page, all the pages in that section inherit that change. Another use for the page hierarchy was in defining the menu area for a page.

Each page includes a menu area, separate from the main content area (Figure 1 on page 5). By default, the menu content for a page is inherited from that page's parent. From there, adopters can choose to keep it as is, add to it, or override it. The menu area was used by most adopters to help visitors navigate the site. Since the menu is inherited by default, it was easy to change its content for the entire site or for an entire section of the site. Thus, the menu content of a parent page could serve as the navigation area for itself and its child pages; visitors could use that navigation to move between pages in the same section, without having to backtrack.

6.2 Designing Looks

One of the major challenges in designing a personal-homepage system is creating a looks system. AniAniWeb differs from most wikis, because it places more emphasis on adjusting the look of the site. Most wiki engines, such as Wikipedia's MediaWiki or CoWeb, have an easily-identifiable distinct look. While these looks may be aesthetically pleasing and professional, they also convey an immediate impression of being a wiki, with prominent edit buttons, etc. That is not the impression that an owner wants visitors to take away from her personal home page. Instead, the personal home page should primarily convey an impression of who its owner is. Visual aesthetics are important for conveying a first impression [19]; that impression is formed before the visitor has time to read any text. So, a home-page owner needs support for changing the looks.

The looks of personal home pages, even within academia, vary quite a bit; however, there are some fairly common practices that can be observed by just browsing a few sites. AniAniWeb implements these conventions. It contains a navigation column on the left, a main content area on the right, and a purely aesthetic banner at the top of the page (Figure 1 on page 5). This has become fairly standard way for websites, and particularly home pages, to organize content. AniAniWeb additionally adds a button bar between the banner area and the content area that allows users to access AniAniWeb-specific features, such as editing, search, creating an account, etc. This layout is core to AniAniWeb and cannot be changed by the user; however, users can tweak the look of their site based on this core layout. Through a web interface, users can add a few key graphics and edit the CSS text to change the look of their site. Through these means, the banner, the backgrounds, the fonts, and the colors used can be changed. This allows for different AniAniWebs to have distinct looks.

For many users, the core layout proved successful. For example, one participant wanted a site arranged in that manner before AniAniWeb was even made public. Another also used the same style of layout for her site before adopting AniAniWeb. A third participant liked the look of the site enough that when she had to create a static site, she used her AniAniWeb as a template. For creating a competent professional academic home page, AniAniWeb succeeded. While the looks system worked well as a standard template, a few adopters wanted something more flexible. For instance, one person wanted to erase the navigation column. This challenged the entire notion of the looks system. The system tries to separate looks from functionality; however, looks and functionality are not entirely separable. Removing the navigation column would change the look, but it would also remove functionality (e.g., the page hierarchy would be removed); therefore, this possibility was not envisioned by the initial design. Yet, some adopters may want to tweak both looks and functionality. For those wanting more control and flexibility, the looks system could be improved.

In the initial version, the size of both the navigation column and the main column were fixed. This was done intentionally, because it is often easier for people to read text in a smaller column than the full width of the screen. For this reason, it is common practice for news websites (e.g., *The New York Times* Online) to limit the size of their column width. While this configuration worked in most cases, it failed occasionally. Users would add graphics wider than the column width. The original version of the software tried to compensate for this by scaling pictures so that they would fit. While this allowed the column to stay limited in size, users complained that they wanted the full picture to be shown. Also, when one user embedded a web application, it could not be scaled. So, this initial design sometimes failed to satisfy the users' needs. A new look was introduced that scaled to the full size of the screen. This fixed the deficiencies of the old look and even allowed the site to work better for different screen resolutions.

There were also mixed results of building on CSS to change the looks. CSS (Cascading Style Sheets) are designed to separate the looks (CSS) from the content (HTML).[7] So, it seemed like a natural fit for AniAniWeb's looks system. By editing the CSS, a user has the power to flexibly customize his site. For a few adopters, this worked well as changing the CSS text in the browser was easier and faster than pre-planning the design with Photoshop. For others, that solution was frustrating. CSS is not the *lingua franca* that HTML is in the College of Computing; most research participants did not know how to take full advantage of CSS. For instance, it was possible to do quite sophisticated things in the banner area using CSS, but it required a good understanding of CSS. I had to help a few adopters make the CSS reflect their vision. For many adopters, a simple wizard system that hid the CSS would have been more useful. Such a

[7] The HTML file specifies the content and the class of that content. Then, the CSS file specifies the style of that class. For example, an HTML file might contain the following paragraph: A sample paragraph. ; the CSS file can then determine the style of this paragraph: p.bodytext {color: red; align: center}.

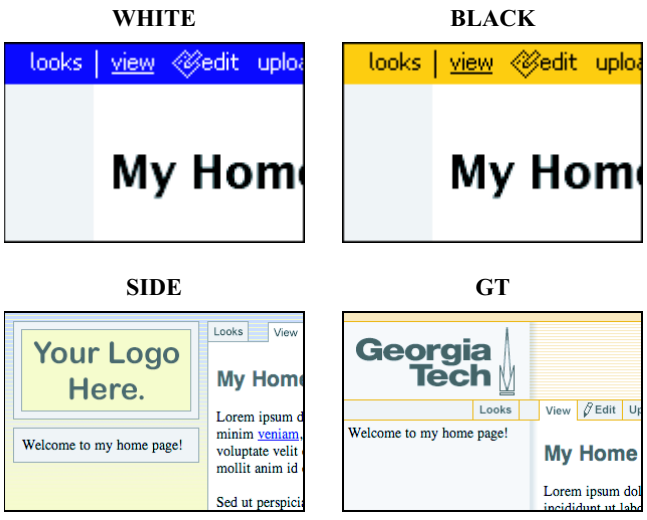


Figure 6. The Color Scheme Choices

system would constrain the choices that a user has, but many adopters would prefer this approach's ease of use over the flexibility of manually editing the CSS. On the other hand, for one adopter, the extent to which CSS was supported within the generated HTML was not enough; he wanted even more control. When designing the system, I had hesitated from using CSS too pervasively as several browsers still had problems with supporting CSS and I wanted the site to be backwards compatible. As browser technology has advanced, CSS support has improved and it is now possible to rely more on it.

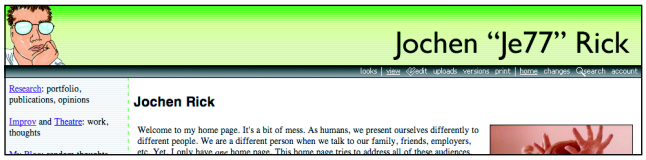
In the first version of AniAniWeb, I intentionally made the initial look of a new site boring and unattractive (see Figure 3 on page 5). I had hoped that this would be a useful incentive for new adopters to use the looks system. For a few adopters, the incentive worked; however, for most people, it failed: They never altered the look of their site. For many of the early adopters from the "Introduction to Graduate Studies" class, this design decision had an unintended negative consequence: Because their site did not look good, they abandoned the technology early on. To address this problem, I created a new default color scheme, GT (Figure 6), that looked good to begin with. That color scheme was specifically designed to be aesthetically similar to the Georgia Tech home page. Adopters could therefore quickly create a good-looking site that associated them with Georgia Tech. Initially, they could focus on creating the useful content of their site. Over time, they would have a more natural incentive to create a customized look. For the few later adopters, this strategy proved effective.

One difficulty in designing a looks system is that personal-home-page adopters vary widely in both their experience and aesthetic preferences. Some are happy with a standard looking site; others want complete control. Some adopt a new technology as their first foray into authoring web content; others have years of experience with HTML and CSS. Because of this variety, it is difficult to create one system that serves all users. A good looks system needs to provide multiple alternatives that meet the needs of different user groups. AniAniWeb tries to address this by having different color schemes to choose from (Figure 6). For complete novices, a good-looking standard template, such as GT, can be most useful. While it is difficult to customize, it allows adopters to work on the content, before investing effort into the looks. Blogger, a popular blogging engine, implements this template strategy successfully. For experienced adopters, BLACK and WHITE offer a simple look that can be easily customized to have its own aesthetic. SIDE was specifically designed to take full advantage of CSS. It no longer uses HTML tables to align content, instead relying on divisions that can be more flexibly controlled with CSS. Using that color scheme, an adopter could erase the navigation column.

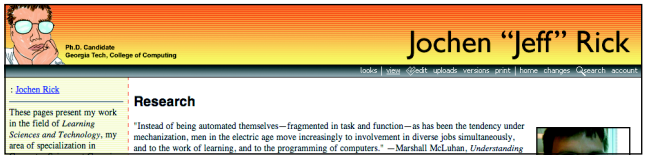
One AniAniWeb feature that proved successful for adopters was its support for multiple looks on the same site. Like access control, the look of a page is determined by its position in the page hierarchy. By default, a page inherits the look of its parent page (the page it was created from). From there, the owner of the site can customize it. This allows users to easily change the looks of an entire section of their site. The user simply changes the look of the top page in that section and all the other pages inherit it. Figure 7 demonstrates why it is useful for different sections to have a different look. The top excerpt is the default look of my current home page. Because I have two more substantial areas of interest to visitors (research and improv), I created a modified version of that look for those two sections (the second and third excerpts in Figure 7 respectively). Thus, a visitor can visually identify which part of the site he is in, but still feel that he is on the same site. All three looks contain my sketched image in the upper left hand corner, a gradient on the banner, and the same shoelace separation between the menu area and the main area. They differ by their accent color. The front page is green. The research page is orange. The improv page is purple. The improv page, one level down from the front page, overrides the look of the front page. Thus, all pages in that section of the site have the same look by default. The *Eggshell #1* page (bottom of Figure 7), one level down from the improv page and two levels down from the front page, looks different from the improv page. *Eggshell #1* is a theatrical play that I helped write using improv methods. While it belongs in the improv section, it deserves its own look.

Associating the look of a page with the page hierarchy has been an effective solution. In my example, I can tweak all the pages for the play by just changing the look of that one page. Though no other adopter used the looks system as extensively as I did, others have found it convenient to change sections of their site. People tend to organize their information into meaningful sections. Giving these sections

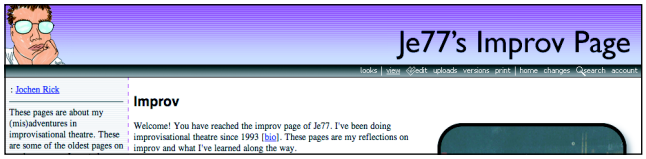
Front Page



Research Page (one level down)



Improv Page (one level down)



Eggshell #1 **Page** (t wo levels down)

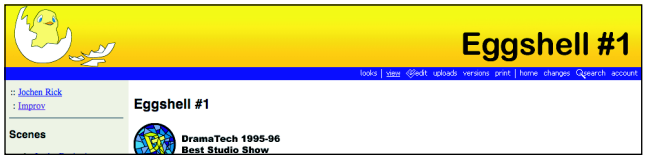


Figure 7. Four Page Excerpts Demonstrating Different Looks

a different look can help visitors distinguish them from one another. I gave my research section a distinct look so that vocational visitors could immediately know what I am professional about. As it is common for academics to separate professional and non-professional concerns, this way of changing the look fits well with people's needs. Participant A, for instance, also aesthetically separates professional and personal sections using the same strategy—variations on a central theme.

6.3 Access Control

Designing an access-control system for personal home pages is a daunting task. The system must address two complex and intertwined problems: 1) How can the same home page address multiple audiences? 2) How can the home page go beyond simple publication to enable interaction and collaboration?

Different audiences visit the same home page. As each of these audience has different expectations and interests, it is difficult for the owner to author one home page that serves them all. This problem is compounded by an advanced authoring system, like AniAniWeb. In comparison to static-home-page users, AniAniWeb adopters created more content and often authored content that is primarily intended for themselves. An access-control system should allow the owner to restrict sensitive content (e.g., a "to do" list) to the appropriate audience. While restricting viewing access is important, extending access beyond viewing is also important. AniAniWeb adopters wanted to use the software to interact and collaborate with others and found such interactions to be motivating. So, a good access-control system has to go beyond limiting view access to granting further access (i.e., adding and editing content).

In face-to-face conversation, people behave differently depending on the context—time, place, and audience [12]. Many electronic communications media, such as television, remove the context of communication [21]. The U.S. President cannot make a speech to a specific audience and not expect his words to be broadcast to a much wider audience. As a public figure, he has little control over the access that others have to that content. Personal home pages tend to also erase the context. Traditional static personal home pages contain the same content no matter who is accessing the page. Personal home pages can reinstate context into electronic communication through an access-control system.

Context is important to communication; at minimum, we are used to relying on it in face-to-face conversation. Communication in a specific context can be tailored towards that context, adhering to its practices, values, and standards. It can contain content that might be considered inappropriate in other contexts. Since the audience is confined, there is a degree of privacy that assures that the content of the communication will not be abused. Since the audience is typically trustworthy, interaction and collaboration becomes less dangerous.

While context is important for collaboration, it is not well supported by the Web. Unfortunately, the Web often evolved based on what was the easiest to implement, rather than what would address difficult problems [3]. So, support for context and collaboration on the Web has trailed behind. People have had to invent *ad hoc* solutions to these problems, relying on pseudonyms and multiple sites on different servers to achieve a sense of context. While web technology has been less supportive of authoring and collaboration than its originator, Tim Berners-Lee, intended, it is possible to create innovative systems of access control in the local confines of a server [6, 31, for example].

When I designed the first version of AniAniWeb in 2000, I felt that a personal-home-page system would require a fairly sophisticated access-control system. I designed the first access-control system to correspond roughly to Unix file permissions.[8] While I tinkered with the system off-and-on for some time, I could not arrive at a satisfying solution. Eventually, I gave up, abandoning the system. In 2003, I resurrected the system for this dissertation research. I arrived at a solution for the access-control problem: I would ini-

[8] On a Unix system, every file has an owner and a group. It also has a set of permission flags which specify read, write and execute permissions for the owner, group, and world (everyone else).

tially implement a simple access-control system. Wikis have demonstrated that even a simple access model (i.e., everyone can edit) can be useful [13, 20]. As adopters experimented with the simple system, I could discover the needs that they had for access control. With a better understanding of these needs, I could better design a more sophisticated system.

The simple version of access control was limited. The owner of the site could determine two properties for each page: 1) whether anonymous visitors could view it; 2) whether signed-in users could edit it. Anonymous visitors were not allowed to edit any pages. Signed-in users were allowed to view all pages. Implementing this system was easy and solved many of the problems that had doomed previous attempts. While this implementation was limited, it was flexible enough that users could adopt it to support a variety of activities. Furthermore, adopters were able to reflect on the system to suggest features for a more sophisticated system.

What follows is my findings on access control, based on observed usage and adopter interviews. These observations are split into three parts: access to content, prominence of content, and avoiding abuse. The central problem that adopters have had is controlling who has access to what content. While strict measures to limit access are necessary for some uses, often simply changing the prominence of content can work well enough. Since offering access to content can be dangerous, a central problem of access control is avoiding abuse. After these user needs are detailed, I introduce the new access-control system that I designed to address them.

6.3.1 Access to Content

Personal home pages tend to integrate multiple audiences into the same virtual space. Visitors can fall into a number of categories: friends, family, research collaborators, colleagues, professional visitors, possible employers, etc. To complicate matters, these audiences frequently overlap, as professional and personal connections often do in academia [15, 23]. Each audience has different expectations and needs. Content that may be appropriate for one audience might be unsuitable for another. For instance, a faculty research participant preferred to limit the distribution of baby pictures to family and close friends.

Protection is also sometimes required by law. Academics often distribute research articles on the Web. Unfortunately, many of these articles cannot be posted to a public forum without violating copyright agreements. Posting the articles in a password-protected forum solves this problem. Another example of usefully restricting content to a specific audience occurs on Facebook, a social-networking site for university communities. Facebook profiles are made available only to friends and, depending on the preferences of the user, others at the university. When surveyed, Facebook users reported that they felt most comfortable sharing their profiles with friends and least comfortable sharing them with strangers; family and classmates fell between these two groups [32]. As Facebook's user-base expanded, many early adopters voiced their concerns about the dangers of new audiences accessing their profiles.

In addition to simply publishing content to others, research participants sometimes wanted to collaborate, allowing visitors to author content. Wikis have proven themselves useful as a collaborative space; their simple open-to-everyone pages offer a chance for quick collaboration that could be useful for activities such as organizing a potluck dinner or scheduling participants for a research project. The initial version of AniAniWeb required users to create an account to edit content. This proved to be a huge hurdle for these uses; it was too inconvenient for an external visitor to create an account just for this purpose. This impeded the amount of interaction and collaboration. In addition to opening content for anyone to edit, supporting collaboration between specific people or user groups would be useful. A research article might need to be kept from the outside world until it is ready to be published. While such participants might be more likely to create an account, it would be more convenient if they only had to know a password.

While the personal home page is generally considered an instrument for publishing content to others, it can be useful for keeping private content, such as AniAniWeb adopters authored: bookmarks, financial records, an appointment calendar, access information for other sites, personal writings, a "to do" list, etc. Access to this content should be restricted to the owner of the site. Such self use was quite common among AniAniWeb adopters. Given AniAniWeb's convenient accessibility and short authoring cycle, it usefully supported posting such private content.

In summary, the accessibility of content might usefully vary from open pages (like a wiki) to completely private pages. In addition, the access control of a page might need to change throughout its lifetime. Private writings might mature to the point where they can be published to a wider audience. An open collaborative page might be restricted once it has served its collaborative purpose. New members might be added to a project group and need access to the site.

6.3.2 Prominence of Content

Ultimately, visitors assess a site based on the content they browse, rather than all the content on the site. Since people tend to browse websites by following only the information they are interested in [18], one of the most practical ways to limit the access that visitors have to some content is to reduce its prominence. While it would still be possible for visitors to reach obscure content, the vast majority of visitors will neither seek it out nor stumble upon it.

Interviewed faculty members felt that an academic personal home page should primarily convey a professional image. Goofy personal content, such as party pictures or gossipy blog entries, detract from that image. Faculty members had no problems with people distributing this kind of content, but it should be kept away from professional visitors.

Since academic visitors are often only interested in professional content, it has become standard to separate professional and personal content into separate sections. As long as professional visitors can quickly find the professional content, most are not likely to browse the other (more personal) content. Thus, clearly separating professional and personal concerns can largely satisfy the professional-image guideline. Whether this prominence-based solution to the multiple audience problem suffices is up to each adopter.

Some adopters prefer a more secure solution. For these adopters, access control, separate sites, and pseudonyms can further reduce the chances that visitors encounter inappropriate content. Access control can make sure that visitors cannot access some of the more controversial content on a site. Creating entirely separate sites can further ensure that visitors to the prominent professional site will not visit the more-obscure personal site. Pseudonyms are commonly employed to effectively hide such sites from search engines.

For other adopters, the prominence-based solution is adequate. Adopter A, for example, keeps impolite content on her site. Since it is separated from her professional content, she does not feel this to be a problem. If a professional visitor decides to browse through obviously non-professional content and discovers such impolite content, she believes that the visitor should be okay with it. After all, he or she actively looked for it.

6.3.3 Avoiding Abuse

One of the dangers of creating a public, interactive space is that the *content* or the *technology* could be used in ways not agreeable to the owner of the site. The content available could be accessed by unwanted parties and the information misappropriated. Bots can harvest e-mail addresses that will be used for spam e-mails. Given the ample information that people are willing to reveal online, someone could use that information for identity theft [32]. Stalkers could find such information equally convenient. For academics, publicly releasing preliminary research, such as a thesis proposal, could make them vulnerable to scooping.

A good access-control system should stop visitors from accessing content through the normal channels; however, there are other ways to access the information. A hacker could exploit vulnerabilities in the access-control system, the server software, the server itself, or the network. For instance, since HTTP is not encrypted, any node along the communication path has access to the transmitted content. Additionally, the content on the server can be accessed by the service provider and the relevant governing bodies. Fortunately, these kind of accesses are rare and not usually threatening to users.

While it is important to protect certain content from being viewed, there is also the danger of content being added, edited, or erased. While an interactive space has its benefits, it also has its dangers. There is little stopping someone from creating an account on AniAniWeb and editing the site of any of the majority of adopters that leave their site somewhat open. In particular, just as bots can harvest e-mail addresses, some bots can spam interactive websites directly. Due to the popularity of interactive sites, such as wikis and blogs, spam-bots have become quite common. These take advantage of the open nature of these sites to post unwanted content. This content usually serves one of two purposes. First, it can provide free advertisement. Second, it can help nefarious sites raise their page ranking on search engines.

While there is great potential for abuse, the gap between that potential and the actual amount of abuse is wide. Wikis, for example, demonstrate that even an open environment that allows anonymous strangers to edit can be used appropriately by visitors. People tend to behave in ways that are socially acceptable (i.e., befitting the nature of the forum). Wikis are predominately used as collaborative spaces; consequently, their practices are quite different than the predominately individual practices of personal home pages. Because wikis are communal property, rather than individual property, the vulnerability of any particular person is less. In addition, the larger user-base of a wiki can assure that attacks are combated quickly. Wikipedia is famous for thwarting attacks on its content quickly; however, Wikipedia is unique: It is by far the largest wiki on the Web and has a large, dedicated, and active user-base.

To account for the differences in vulnerability, a layer of safety was added to the version of AniAniWeb used at the beginning of this study: Anybody who wanted to edit content had to create an account. This provided a barrier to entry that made adopters feel more secure in leaving their sites (partially) open. In addition, any edits could be traced back to the e-mail address of the person. This provided a greater level of accountability than seen with anonymous wiki editing. The system has worked well: Except for spam-bot attacks, there have been no reports of malicious editing. Another feature that has made people feel more secure from abuse is that certain pages can be more protected. So, software-download pages[9] and curricula vitae can be secured from editing. Which pages need to be protected and which can be left open for potential abuse is up to each adopter. Different adopters will have different preferences, depending on their experience, position, and inclination.

Abuse does occasionally happen. In AniAniWeb, the biggest problem so far has been controlling spam-bots from posting content. To deal with these attacks, several features are useful. First, several AniAniWeb features allow owners to realize quickly when their site has been attacked. Registered users can sign-up to receive e-mail alerts when a page has been edited by someone else. Some adopters embedded a listing of recent changes on their top page; since they visited that page frequently, they could see if anyone had made

[9] One participant used his AniAniWeb to distribute software. To prevent hackers from replacing his valid software with a corrupted copy, he locked the page. Unfortunately, such attacks are not unheard of.

changes. Second, since spam-bots tend to attack the entire server, it is practical for the attack to be dealt with at the server level. AniAniWeb provides tools for the server administrator to roll back changes made by a specific user (as identified by their IP address).

6.3.4 The New Access Control

Based on the findings of this research reported in the previous sections, a new access-control system was implemented to better serve users' needs. Implementing an access-control system is a complex task, as it must satisfy two opposing criteria: flexibility and usability. The system needs to be flexible enough to enable a variety of uses; however, it needs to be simple enough that adopters can easily use the system and incrementally learn its extended features.

One characteristic of personal home pages that complicates matters is that most external visitors to a site have little invested in their visit. They are unlikely to be willing to learn how to use a complicated system. To support external visitors in CoWeb, "add to the page" boxes were added [14]; these required little to no instruction to use. To support these low-investment visitors, the visitor interface for AniAniWeb must be simple and intuitive. As owners of the site are more invested in the technology, their interface for controlling access control can be more complex; however, even there, the system needs to be simple enough that novice adopters can feel comfortable using it.

Another obstacle for creating a good access-control interface is that HTML was not designed for creating sophisticated interfaces. To assure that the interface would function on all browsers, the system was built using plain HTML and simple Javascript. This limited interface elements to drop-down lists, check boxes, radio buttons, and text input. Since some people disable Javascript in their browser, the interface also had to function adequately without Javascript. To make access control visible to owners, it was critical that the interface was compact enough that it could conveniently fit on the edit page; thus, the owner of the site could set the access control for a page at the same time as authoring the content. While it is not strictly necessary to combine editing and managing access control, the previous work on CoWeb had demonstrated the utility of this approach.

Satisfying all of these design criteria is inherently complex. Designing a suitable solution is not a straightforward task. It takes a while to work-out a potential solution far enough that it can be judged by the design criteria. Thus, the reflection cycle, so important to design [28], is costly time-wise. Additionally, a good solution should both be usable and full-featured. Since usable and full-featured are often at odds, designing products for people is inherently a difficult enterprise [24].

I started by sketching out various approaches on paper, judging each design by how well it satisfied the user needs and the implementation constraints. In particular, I wanted to ensure that the system could support the uses (open pages, hidden pages, private pages, gaining access through a password, etc.) envisioned by my research participants. Some potential solutions were rejected because their interface would be too complicated for users or too complicated to be implemented in HTML. Other potential solutions did not match the identified needs well. I felt it was essential to actually implement a solution to demonstrate that an adequate solution is even possible.

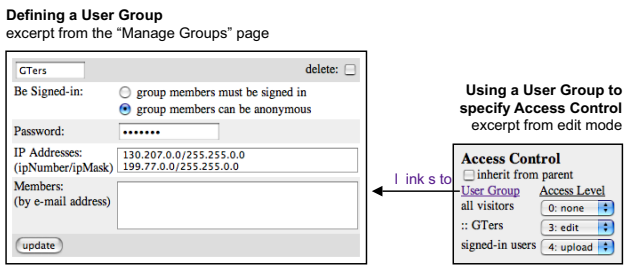


Figure 8. Specifying Access Control, based on User Groups

I finally chose one paper-based design and implemented it over several weeks. After implementing it, I was dissatisfied with the results: It was neither as capable nor as usable as I had hoped. I ended up abandoning that code and implementing a completely new system. Luckily, I am satisfied with the results of this second attempt. The system is more sophisticated than other access-control systems I have seen, such as those employed by LiveJournal and Facebook. Yet, the interface for controlling it is fairly simple.

Access control, in the new system, is defined by user groups (Figure 8). The old system already defined two of these groups: those with an account and those without an account. In the new system, those groups are still present as "all visitors" and "signed-in users" respectively.[10] These two groups are created automatically when the site is created. From there, the user can define new groups. Figure 8 shows one such user group, GTers. I created this group for Georgia Tech visitors. Anyone accessing my site from a campus machine (i.e., within the IP ranges specified), automatically is part of this group, whether they realize it or not. People from off-campus could also join the group if they knew the appropriate password. Membership in a group can be determined by either password, IP address, or by manually adding AniAniWeb members. Each user group is either a subgroup of anonymous visitors or a subgroup of signed-in users. Once the group is created, a slot for defining its access level for a page is added to the access control part of editing a page. In Figure 8, the GTers group is listed under "all visitors," because group members do not need to be signed-in users.

The access-control settings for a page can then be specified using these groups. By default, the access control for

[10] Not only did these groups make sense, the inclusion of these groups allowed me to convert the existing sites to the new access control without a change in the access levels they had specified.

Table 1. Group Access Levels, from Least to Greatest

Level	Description
0: none	The visitor has no access to the page.
1: hidden	The visitor can view the page, but the page is hidden. Would-be-links to the page appear to the visitor as plain text. The page is also excluded from search results and recent changes.
2: view	The visitor can view the page.
3: edit	Additionally, the visitor can edit the page.
4: upload	Additionally, the visitor can upload files to the page.

a page is inherited from its parent page. Using inheritance, the user can easily change the access control for an entire section of the site; the user simply changes the access control for the top page in that section and all the other pages inherit the change. When the access control is inherited, the interface is still visible, but disabled through Javascript. To override the access control, the user simply clears the check box next to "inherit from parent." From there, the user can use the drop-down lists next to the names of the user groups to specify their respective access level.

Table 1 details the five access levels. The access levels are cumulative, so an access level of "4: upload" allows group members to view the page, edit the page, and upload files. The access level that a visitor has to a page is determined by the maximum access level of all of the user groups he belongs to. In the example given in Figure 8, the page is inaccessible to anonymous visitors, but can be edited by Georgia Tech visitors. It can also be fully accessed by signed-in users. If a visitor fits into both user groups (GTers and signed-in users), their access level is "4: upload," since that is the higher access level of the two groups. Because the access that a user has is based on the maximum access level of his user groups, it does not make sense to allow owners to specify an access level for a group lower than its general category (all visitors, signed-in users). To enforce this, the edit interface removes all the choices that would be illogical from the drop-down lists.

The above covers how the access control is set by the owner of the site. The second, perhaps lesser, challenge in creating an access-control system is the visibility of the access control as users browse the site. The access control needs to be sufficiently visible to be usable, but sufficiently lightweight to not impede normal use. Visibility can be broken down into two parts: 1) how does the page reflect its accessibility; 2) how does a link to a page reflect the accessibility of that page. Both of these affect the owner, who determines accessibility, and external visitors differently.

As the owner of the site can access any page on the site, the access-control indicators were designed to simply remind the owner what access others have to a page. Small lock graphics on the view and edit buttons indicate that the page is respectively locked from viewing by anonymous visitors and editing by signed-in users. The links to pages are

Table 2. How Links Appear to the Owner

Appearance	Meaning
Page Name	This page is private: Visitors not belonging to a user group cannot access it. If visitors can gain access by joining some user group, the tool-tip for the lock image reads "Inaccessible to Visitors." If not, the tool-tip reads "Inaccessible to All."
Page Name	This page is hidden: Visitors not belonging to a user group do not see a link to it. If the page is hidden to all visitors, the tool-tip reads "Hidden to All." If the link is visible to some user group, the tool-tip reads "Hidden to Visitors."
Page Name	This page is visible: Any visitor can view it.

decorated to indicate their accessibility (Table 2). Initially, more-detailed link decorations were implemented; however, these proved to be overbearing and complex. Eventually, the solution of only indicating whether visitors could view a page was implemented. Since the primary relationship that visitors have to another's site is as viewers, this simplification works.[11] Owners can quickly see that a page is private or hidden.

For visitors, the decorations indicate the access level that the user has. Small lock graphics are added to the edit and upload buttons of a page to indicate when these features are restricted. If the user can gain access with a password, the link still functions, but leads users to a page to enter the password. Once the password is confirmed, the user can proceed to edit the page or upload files. If the user cannot gain access through a password, the button is made inactive. When possible, the page specific buttons (view, edit, upload, and history) are still hidden from anonymous visitors. This allows the site to still look more like a traditional static home page than a wiki. The links to pages are decorated according to the access level that the user has (Table 3). Again, the decorations are simplified to only indicate whether the user has viewing privileges for that page.

This system addressed many of the reported needs of research participants. By setting the access level to "0: none," a completely private page is created. By setting the access level of all visitors to "4: upload," a completely open page is created. This page would function like a wiki page. Given the affordances of wikis for collaboration, homepage adopters could use them to collaborate with others. Of course, these pages would also be subject to the same problems as wiki pages, such as spam-bots. By setting the access level of all visitors to "1: hidden," the page is effectively hidden from search engines and visitors that stumbled

[11] In the original access-control scheme, the indicators showed both whether a page was locked from viewing and locked from editing. This worked well for most adopters, who only occasionally locked a page from editing; however, it was awkward for one user, who locked his entire site from editing. All his links had an edit-lock decoration. With the new scheme, the decorations are visibly less obtrusive.

Table 3. How Links Appear to Visitors

Appearance	Meaning
Page Name	This page is either hidden or only viewable by the owner. What would normally appear as a link remains plain text, effectively hiding the existence of the page.
Page Name	This page is locked. When the visitor follows the link, the server prompts him to authenticate that he is part of a user group that can view the page. The tool- tip for the red lock reads "Locked."
Page Name	This page is normally locked, but the visitor belongs to a user group that has access. Following the link brings the visitor to the page. The tooltip for the green lock reads "Unlocked."

onto the site. Yet, the URL could still be e-mailed out to others. For example, a home-page adopter might be hosting a party at his house and want to distribute directions. By using hidden pages, he can mail out the URL for a directions page without worrying that the information will be accessible to strangers (who might abuse it). The owner of the site can also create user groups to give others, who are more trusted, more access. Participant C would be able to create a private page that she and her collaborator could use to work on their article, without having the products of that collaboration viewable to outsiders. Participant B could create a private section to support sensitive group work—her original motive for adopting AniAniWeb. While the system addresses the discovered user needs and allows for a variety of uses, it does have some drawbacks.

First, limiting the access of subset user groups is not possible, since access is based on the highest access level. In Figure 8, I could not specify that GTers have less access to a section than anonymous visitors. While it is difficult to imagine a situation when this would be appropriate, such a situation could exist. For instance, when planning a surprise birthday party, an appropriate access model might grant access to all friends except for the guest of honor.

Second, the access levels (Table 1) are simplified for usability. The abilities to see the link to a page, edit a page, and upload files do not have to be cumulative. Some owner might want a page that is hidden, but can be edited when someone visits it. Another owner might want a page that allows visitors to upload files, but not edit content. Since these scenarios were not mentioned by research participants, I deemed it safe to make these simplifications. Such approximations are necessary when creating a system that is simple enough to use. Another such approximation is employed for "add to the page" boxes. Currently, anyone who can view the page can use its existent "add to the page" boxes. While it is possible to differentiate adding content from viewing in the access levels, this would further complicate the system. In CoWeb's access-control system, these two actions are separated; this granularity has proven useful for combating spam-bots.

Third, the inheritance model of access control does not always function cleanly. One participant wanted an access-control scheme where her top page was locked from editing, but the other pages could be edited. Since the top page is so prominent, she did not want others to be able to edit it. To implement this scheme, she would have to override the top-page's access control for all its children. While this is inconvenient from an interface standpoint, she would still be able to execute this scheme fairly quickly.

7. Discussion

AniAniWeb is an advanced system for authoring personal home pages that was designed to meet the needs of its adopters. For many adopters, it proved to be a useful, usable, and stable system for the task. The concrete design embodies many technical improvements for supporting personal home pages in academia. Going into the research, I had two technical hypotheses. First, wiki features (quick authoring, interaction support, and collaboration support) could benefit the authoring of personal home pages. Second, that other features (access control, more structure, and customizable looks) would be needed to convert a wiki into a suitable personal-home-page system.

All of these features proved important to adopters and to evolving the meaning of personal home pages. As AniAniWeb shortened the editing cycle, adopters published more information. As AniAniWeb provided interaction and access control, adopters began using the technology for new collaborative and self uses. AniAniWeb proved to be a flexible medium, allowing people to adopt it in different ways.

Personal home pages are still evolving. New technologies will enable simpler authoring, new forms of media, and new opportunities for interaction. As technology matures, adopters will adopt new practices that fit both their needs and the new affordances of that technology. New innovations in the design space, such as a prominent social network and GUI editing, will continue to shape the meaning of personal home pages. This work is an attempt to understand that design space and realize the potential of the new medium. AniAniWeb is a concrete instantiation of the features that future technologies for authoring personal home pages might enable.

While AniAniWeb was designed to author personal home pages, some of its design features are applicable to other wiki systems. For instance, one of the more popular uses of AniAniWeb has been for the home pages of academic research groups. While it was not designed for that purpose, AniAniWeb's features enabled this use. Wiki authoring allowed researcher to collaboratively author content. The looks system allowed one person to design and maintain the site's aesthetics, independent of the content. The access-control system allowed the creation of private areas for managing internal issues, such as organizing laboratory meetings. By discussing the major design decisions that informed

AniAniWeb, I hope that other wiki developers can learn from them and apply them for their purposes.

References

[1] P. Agre. Networking on the network: A guide to professional skills for Ph.D. students. `http://polaris.gseis.ucla.edu/pagre/network.html`, August 14 2005. Accessed December 2006.

[2] C. Bereiter and M. Scardamalia. *The Psychology of Written Composititon*. Lawrence Erlbaum Associates, Hillsdale, NJ, 1987.

[3] T. Berners-Lee. *Weaving the Web: The Original Design and Ultimate Destiny of the World Wide Web by its Inventor*. Harper, San Francisco, 1999.

[4] M. U. Bers. Identity construction environments: Developing personal and moral values through the design of a virtual city. *The Journal of the Learning Sciences*, 10(4):365–415, 2001.

[5] S. L. Bryant, A. Forte, and A. Bruckman. Becoming Wikipedian: Transformation of participating in a collaborative online encyclopedia. In *GROUP'05: Proceedings of the 2005 international ACM SIGGROUP conference on Supporting group work*, pages 1–10, New York, 2005. ACM Press.

[6] A. L. Burrow. Negotiating access within wiki: A system to construct and maintain a taxonomy of access rules. In *Proceeding of Hypertext'04*, pages 77–86, New York, 2004. ACM Press.

[7] V. Bush. As we may think. *The Atlantic Monthly*, July 1945.

[8] D. Connolly. A little history of the World Wide Web. *http://www.w3.org/History.html*, 2000. Accessed December 2006.

[9] D. Craig, S. ul Haq, S. Khan, C. Zimring, C. Kehoe, J. Rick, and M. Guzdial. Using an unstructured collaboration tool to support peer interaction in large college classes. In B. J. Fishman and S. F. O'Conner-Divelbiss, editors, *Proceedings of ICLS 2000*, pages 178–184. Lawrence Erlbaum Associates, 2000.

[10] A. Dillon and B. Gushrowski. Genres and the Web: Is the personal home page the first uniquely digital genre? *Journal of the American Society for Information Science*, 51(2):202–205, 2000.

[11] E. H. Erikson. *Identity and the Life Cycle*. Norton, New York, 1980.

[12] E. Goffman. *The Presentation of Self in Everyday Life*. Anchor, New York, 1959.

[13] M. Guzdial, J. Rick, and C. Kehoe. Beyond adoption to invention: Teacher-created collaborative activities in higher education. *The Journal of the Learning Sciences*, 10(3):265–279, 2001.

[14] M. Guzdial, J. Rick, and B. Kerimbaev. Recognizing and supporting roles in CSCW. In *Proceedings of CSCW 2000*, pages 261–268, New York, 2000. ACM Press.

[15] C. Haythornthwaite. Work, friendship, and media use for information exchange in a networked organization. *Journal of the American Society for Information Science*, 49(12):1101–1114, 1998.

[16] C. Haythornthwaite. Strong, weak, and latent ties and the impact of new media. *The Information Society*, 18:385–401, 2002.

[17] S. Herring, L. Scheidt, S. Bonus, and E. Wright. Weblogs as a bridging genre. *Information, Technology, & People*, 18(2):142–171, 2005.

[18] B. A. Huberman, P. L. T. Pirolli, J. E. Pitkow, and R. M. Lukose. Strong regularities in World Wide Web surfing. *Science*, 280:95–97, 1998.

[19] G. Kress and T. Van Leeuwen. *Multimodal Discourse: The Modes and Media of Contemporary Communication*. Arnold, London, 2001.

[20] B. Leuf and W. Cunningham. *The Wiki Way: Quick Collaboration on the Web*. Addison-Wesley, Boston, 2001.

[21] J. Meyrowitz. *No Sense of Place: The Impact of Electronic Media on Social Behavior*. Oxford University Press, New York, 1985.

[22] B. A. Nardi, D. J. Schiano, and M. Gumbrecht. Blogging as social activity, or, would you let 900 million people read your diary? In *Proceedings of CSCW 2004*, pages 222–231, New York, 2004. ACM Press.

[23] C. E. Nippert-Eng. *Home and Work*. The University of Chicago Press, Chicago, 1996.

[24] D. A. Norman. *The Psychology of Everyday Things*. Basic, New York, 1988.

[25] Z. Papacharissi. The self online: The utility of personal home pages. *Journal of Broadcasting & Eletronic Media*, 46(3):346–368, 2002.

[26] J. Rick. *Personal Home Pages in Academia: The Medium, its Adopters, and their Practices*. PhD thesis, Georgia Institute of Technology, Atlanta, GA, May 2007.

[27] J. Rick, M. Guzdial, K. Carroll, L. Holloway-Attaway, and B. Walker. Collaborative learning at low cost: CoWeb use in English composition. In G. Stahl, editor, *Proceedings of CSCL 2002*, pages 435–442, Hillsdale, NJ, 2002. Lawrence Erlbaum Associates.

[28] D. A. Schön. *Educating the Reflective Practitioner*. Jossey-Bass, San Francisco, 1987.

[29] I. Seidman. *Interviewing as Qualitative Research: A Guide for Researchers in Education and Social Sciences*. Teachers College Press, New York, second edition, 1998.

[30] T. E. Starner, C. M. Snoeck, B. A. Wong, and M. McGuire. Use of mobile appointment scheduling devices. In *Proceeding of the ACM Conference on Human Factors in Computing Systems (CHI 2004)*, pages 1501–1504, New York, 2004. ACM Press.

[31] G. Stevens and V. Wulf. A new dimension in access control: Studying maintenance engineering across organizational boundaries. In *Proceedings of CSCW'02*, pages 196–205, New York, 2002. ACM Press.

[32] F. Stutzman. An evaluation of identity-sharing behavior in

social network communities. In *Online Proceedings of the 2006 iDMAa and IMS Code Conference*, Oxford, OH, 2006. Miami University.

[33] T. Sumner. Promoting scholarship through design. In W. H. Dutton and B. D. Loader, editors, *Digital Academe: The new media and institutions of higher education and learning*, pages 135–151. Routledge, London and New York, 2002.

[34] S. Turkle. *The Second Self: Computers and the Human Spirit*. Simon & Schuster, New York, 1984.

[35] S. Turkle. *Life on the Screen: Identity in the Age of the Internet*. Simon & Schuster, New York, 1995.

[36] V. Venkatesh, M. G. Morris, G. B. Davis, and F. D. Davis. User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 27(3):425–478, 2003.

[37] E. Wenger. *Communities of Practice: Learning, Meaning, and Identity*. Cambridge University Press, Cambridge, UK, 1998.