

Graphical History List with Multi-Window Support on a Mobile Web Browser

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Abstract— Rolling back to previously visited Web pages and opening multiple browser windows or tabs at the same time are common activities in a Web browsing session on a PC. When using a mobile device for Web browsing, these usage patterns have to be supported seamlessly in the mobile environment under the additional constraint of limited screen real estate. In this paper, we introduce a solution called Rolling History, a user interface targeted for mobile devices with 4-way navigation control and graphics acceleration hardware. We tested the usefulness of a Rolling History prototype in two small-scale user studies and the results indicate that Rolling History is a useful feature for Web history navigation and browser windows management. The Rolling History case demonstrates how to design a unique user interface for a mobile device without displacing the deep-seated use patterns that people have found useful on a PC.

Index Terms— Graphical user interfaces, Internet, User interface human factors

I. INTRODUCTION

WEB browsing on a mobile device has become an everyday habit for many users. As of today, mobile devices and wireless networks are capable of delivering the same Web content as their desktop counterpart. Usability and user experience are especially important in the case of mobile browsing because most Web pages are designed for PCs and getting them to work correctly on a mobile device requires a lot from the mobile browser. Many problems and issues have already been addressed, including visualization of large Web pages on the small screen of a mobile device [23]-[27].

Rolling back to previously visited Web pages or “back stepping” is an essential part of a Web browsing session. In addition to returning one step to the previous page in the Web history, the users often move multiple pages back in the history. Many different mechanisms, such as Back and Forward buttons, bookmarks, and history lists have been introduced to support this task and to enable the users to step back as efficiently as possible [1]-[3], [10]-[15].

On a mobile device, back stepping needs to be considered even more carefully than on a PC. Getting a previous page back on the screen of the mobile device may take a while due to the bandwidth and processing power and also consume precious device resources such as battery and memory. Furthermore, some Web pages require non-cacheable content from the Web so downloading content via a cellular

connection while back stepping may even add browsing expenses. It would be beneficial if the user did not have to load any other Web pages from the Web history except the one he/she desires. However, in most current mobile Web browsers, the back stepping functionality is implemented the same way as in PC browsers: by having a button or a command that steps through the previous pages in history one at a time.

When stepping back several pages and trying to locate a specific page from the Back history list, the Web page titles do not always tell much about the page content. This is one of the reasons why people often just click the Back button repeatedly and skim through the content of the previous pages until the desired page is found instead of simply selecting a page title from the history list. However, this approach does not fare well on a small screen where it may be hard to identify the page. Going through each page one by one is also a slow and laborious process especially if the cache is not big and the cellular connection does not provide a fast data rate.

In addition to back stepping, a popular Web browsing pattern on a PC is having multiple browser windows or tabs open at the same time. Multiple windows are useful, for example, when comparing information from a set of Web pages. Using multiple browser windows is one of the usage patterns imported from PC to mobile and consequently needs to be supported even if multiple windows would not be highly usable on a small screen [28]. Some Web sites even require support for multiple windows by providing essential information on popup windows which makes the support for this feature mandatory in mobile Web browsers. Mobile browsers typically capitalize the whole small screen for one window only. The mobile browser designers must pay special attention both to inform the user about popup windows and to allow easy switching between the windows. The current mobile browsers present windows either as a textual list or tabs.

In a Web browser, each window has its own history of pages opened in the window. When the user wants to go back to the previous pages, the Back button does not help if a new window was popped up from a Web page at some point of navigation. The user has to cancel the back stepping operation and find a way to move to another window. On a small screen mobile device where only one window is visible at a time, it may be hard for the user to understand that multiple windows

even exist. This results in getting “lost” in the Web browser, because the user does not understand that he/she has to change the window to return to the previous Web page.

In this paper, we introduce a solution called Rolling History that addresses the previously introduced problems in back stepping and window management on a mobile Web browser. The proposed user interface is targeted for mobile devices that provide 4-way navigation control and graphics acceleration hardware.

II. RELATED WORK

Rolling back to previously visited Web pages is one of the main activities for a Web browser as more than half of Web page visits are to pages previously visited by the user [7], [9], [18]. However, many users misunderstand the stack-based behavior of the Back button, even though they use it regularly.

Cockburn et al. [5] evaluated different behaviors of the Back button in a Web browser. The results showed that a Back menu of visited pages turned out to be more efficient than individual Back button presses for distant navigation tasks. Cockburn et al. observed that Web browsing could become more efficient if browsers encouraged users to make greater use of the Back menu instead of the Back button.

Although the Back button has major advantages – it requires no decision making and it is visually compact – there also exist many limitations [6], [17]. With the Back button, it is inefficient to retrieve Web pages from distant history. People visit many pages, resulting in large page histories. While the Back button is appropriate for returning to the previous page, it requires many clicks and page redispays to revisit prior distant pages. Furthermore, it is very hard for a user to understand the context when using the Back button, as only the current page is visible. This results in the user having the sense of orientation entirely dependent on the memory of previously visited pages and the contents of the current page. The reality is that most people just click Back until they see the desired page or until they give up. Cockburn et al. [8] suggest that interactive graphical tools have the potential to help in many of these problems of navigating through the page history; especially, thumbnails of Web pages can help users to identify the correct page in the history. Also other studies have confirmed that visual aids in history mechanisms are more powerful than using text or the Back button [4], [16], [29].

On the information visualization side, many graphical solutions have been introduced to assist user in stepping back several pages. A minimal effort for the visualization is done by SmartBack which collects some intelligence from the navigation trail and modifies the Back button in a Web browser to offer an access to key pages in the navigation history and also thumbnail views of the pages [14]. It does not offer thumbnails for all the pages, but only assists the user to find the key pages in the Web history.

Some of the systems form a tree-like layout of the Web pages the user visits during the browsing session:

- PadPrints dynamically builds a graphical history-map of visited Web pages, where pages are added as children of the current node in the hierarchy, and a

small thumbnail sketch of a Web page is displayed on each node in the hierarchy [3].

- WebView, an extension to a Web browser, uses the tree layout for the Web history view in addition to a temporally ordered list [10].
- Domain Tree Browser uses domain names to build a tree of visited pages [12].

These systems behave differently than the traditional stack-based Back button and may require extra effort from the user when he or she tries to select a page in the Web history. Even more work is probably required when using Browsing Icons [11] as it visualizes the Web history as a graph, or solutions presented by WebPath [13] and Yamaguchi et al. [2] which represent the Web history in a 3D space.

The History-Centric Browsing system takes a completely different approach and combines the tasks of Web browsing and the use of history, and allows users to browse previously visited pages in the same way as browsing pages in the Web [15]. This solution might help users a lot between different browsing sessions but a good tool for navigating in the Web history within one browsing session is still needed.

Closest to our solution in the scope of visualizing the Web history is presented by Ayers et al. [1]. They propose a two-dimensional view of the pages a user has visited in a session. By presenting titles, URLs, and thumbnail images of the pages a user has visited in a session, the Graphic History View allows a user to easily recognize a previously visited document.

Much less research work has been done in the area of visualization and usability of multiple windows on a Web browser even though users seem to encounter these features a lot either by opening them on purpose or as pop-ups [19]. Users also frequently move between windows on PCs when they browse the Web, but they do not necessarily remember which window the wanted page is in. To solve this problem on the PC side, Elastic Windows [20] and DeckScape [22] are both designed to help users to organize and interact with multiple Web browser windows. They visualize Web browser windows in the same view and enable the user to read and interact with the content in each window. The same kind of functionality is not possible on a mobile device as the screen size is not large enough. Comparative Web Browser [21] identifies the popular use case for multiple windows which is the comparison of content on different Web pages. It addresses the needs by enabling viewing of multiple windows at the same time and the interaction in one window is automatically replicated in another window. However, this solution does not apply to the general solution for visualizing multiple windows but just for comparing two windows.

III. ROLLING HISTORY

To improve navigation between pages in the history and pages that are concurrently available in different windows, we have modified the Back button and window management functions in the Nokia S60 open source Web browser. We named the solution Rolling History.

A key idea of Rolling History is that the user does not have

to remember if the wanted page is in the current window or in another one. Stepping back is via the same function in all cases, and the Web history provided in the same view as multiple windows. Since most users are familiar with browser windows (or tabs), we still handle windows as windows except that we do not try to provide only just one linear browsing history.

The use case of navigating in the Web history is more common than window handling; hence, more emphasis was put on the visualization of the Web history in terms of screen space. In addition, we wanted the basic interaction in Rolling History to be as simple as possible and targeted for a mobile device that does not have a pointer input device. All the prior graphical history and multiple window systems introduced by related work rely on a pointer as an input device. Their designs were not hardware agnostic while there was a clear goal on which sort of devices Rolling History should run on. While the target devices offered some new possibilities, they came with restrictions as well, especially with regards to input and output functionality.

In short, the design drivers for Rolling History were defined as follows:

1. Easy to step back and forward one or more pages from the current window
2. Intuitive way to step back to a page in another window (understanding the concept of a window is not required)
3. Efficient way to switch between windows
4. Clear indication of a new, opening window

To meet the abovementioned design principles, we defined Rolling History to consist of five parts that define the user interface (Figure 1) and interaction (Figure 2) for Rolling History:

1. A single view for Web history and windows
2. Graphical representation of the Web history of the current window
3. Graphical representation of the other open windows
4. 4-way moving between all the visited pages in all different windows
5. Animations between states

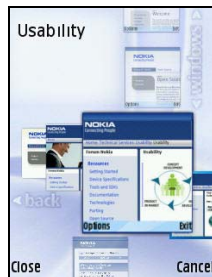


Figure 1: User interface of Rolling History.

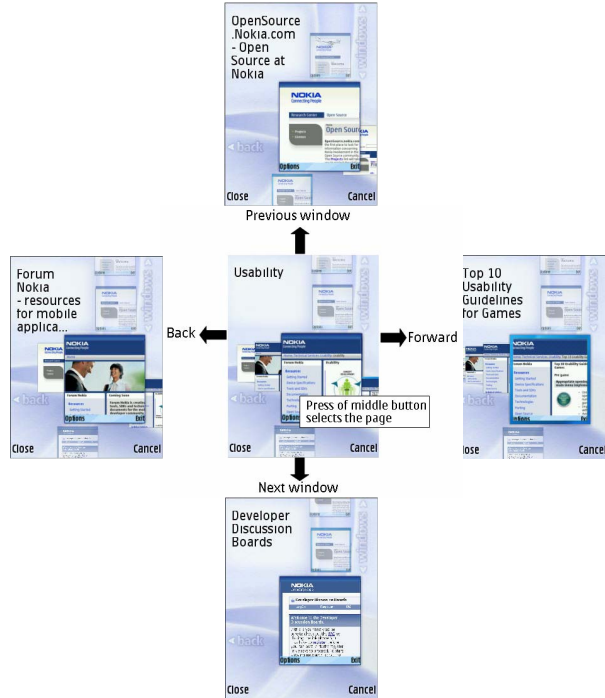


Figure 2: Interaction of Rolling History.

As concluded by related work [4], [5], [16], thumbnails improve the identification of a Web page in the Web history. Thus, we decided to use thumbnails as a basis for our design with the focus being optimizing the showing of the most important thumbnails.

The graphical representation of a Web history list consists of thumbnails, where each thumbnail presents a Web page that the user has visited during the browsing session in the same browser window. The thumbnails are aligned along a horizontal line, where the thumbnail of the currently selected page is shown as the largest one making the identification easier. Also, the title for the currently focused Web page is visible. Other pages in the Web history are placed on the right or left side of the currently selected page: the thumbnails on the left present the pages that the user visited before the currently focused page, while the thumbnails on the right present the pages that the user visited after it. The Web history is presented as a list indicating clearly that the Web pages in the list are related to each other and have an order. If the currently opened Web page in the browser exists in this window, it is clearly marked.

The graphical representation of a list of the other Web browser windows also includes thumbnails, where each thumbnail represents one window inside a Web browser. The thumbnail image illustrates the Web page that is currently opened in the window. The list of windows is laid out along a vertical line where the currently focused window is in the middle and its Web history list is visible in the horizontal direction. The window list should also indicate clearly that they form a group, but windows should not be mixed with the pages in the Web history. If the currently opened Web page in the browser exists in another window than in the selected one,

that window is clearly marked in the window list.

The user can navigate with a 4-way navigation control in the view containing the graphical representation of both the Web history list and the list of windows. The left and right movements of the control correspondingly change the focus of the horizontal Web history list elements while the up and down movements focus the elements in the vertical direction.

Animations are used to ease the adoption of Rolling History, as it is a new concept for users. Animations should give context for users when they activate Rolling History and interact with it, including where the currently open page in the Web browser is in Rolling History, how a new window appears in Rolling History, and how Rolling History changes when a window is closed. In addition, animations should help in making the distinction between pages in the Web history and Windows by animating the transitions differently. By considering these requirements, the following changes in states of Rolling History are animated:

- Opening a new window
- Activating the view
- Navigating in the view
- Closing a window
- Selecting a page

We implemented two versions of the Rolling History feature. First we did an initial version on Nokia 6600 and evaluated it in a usability test. The initial version did not include animations, as the hardware of the time was not optimal for running animations. Using the feedback from the test and with the help of additional hardware improvements, namely a graphics accelerator, we implemented an improved, “rolling” version of the feature including the animations on Nokia N95. Both implementations were done on Symbian S60 platform.

A. Initial version

The initial version of Rolling History was implemented as shown in Figure 3. After pressing the “Back” softkey in the browser, the Rolling History view took up the screen. The thumbnail of a Web page shown in the middle of the view was “in focus”. When the Rolling History view was opened, the focus was initially on the Web page that was loaded right before the current page, to ease one-step-back function. As defined earlier, the Web history for that window was presented in the horizontal direction, where the pages before and after the selected page were smaller in size and partially visible to fit more pages in the view and form a list-like presentation of related items.

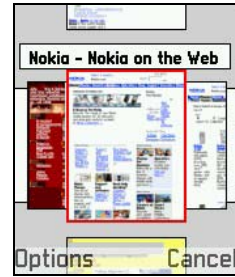


Figure 3: A screenshot of the initial version of Rolling History.

The currently open windows were visualized in the vertical direction. The partially visible thumbnail above the focused page indicated another concurrently open window that the user opened before the current window. The thumbnail below presented another concurrently open window that the user had opened after the current window. Their size was the same as the size of the selected page to indicate the relation between them (they are all windows). However, there was space between windows to separate them from the Web history list. If the currently open Web page in the browser belonged to the Web history list of the selected window, the thumbnail of the page was framed with a red rectangle; otherwise, the thumbnail of the window containing the currently open page was framed.

The user interacted with this view with a joystick. When the user wanted to move between pages in history, he/she pressed the joystick either to the left or right. This updated the view, and showed either the previous or next page in focus depending on the user’s action. If the user wanted to switch the window, he/she tilted the joystick either up or down. This action scrolled the window list up or down and put the next or previous window to the middle.

After getting the desired page in focus in the Rolling History view, the user selected a page with a joystick click or using the “Options” menu. The possibility to give commands via the “Options” menu was added due to the platform user interface style. This dismissed the view, showed the normal Web page view and loaded the selected page from the cache or, if needed, from the Internet. The user could also dismiss the Rolling History view at any point by selecting “Cancel” from the right softkey.

Each window, unless there is only one left, could be closed through the “Options” menu in the Rolling History view. This deleted the window from the window list along with its Web history list. If the window was currently selected, the selection moved to the previous window if one existed; otherwise, the selection moved to the next window.

In addition to the Rolling History view, we offered access to a list of windows from the “Options” menu. This did not bring up the same view but only a textual presentation of the currently open windows.

The resolution of Nokia 6600 was 176x208 pixels. The thumbnails were 90x120 pixels in size. This size was used to show the page in focus in Rolling History, while other thumbnails in the Web history list were cropped to a smaller size to show only the top-left corner such that the next and

previous pages were 30x86 pixels in size. The thumbnails of the pages further away in the Web history were not drawn to save memory, but a placeholder (a white rectangle) was drawn in place. The thumbnails representing other windows were the same size as the page in focus, but only 20x90 pixels from the previous window and 30x90 from the next window fitted to the screen.

B. User Tests for Initial Version

To evaluate the initial version of Rolling History, we planned and arranged a user test. The test was a laboratory test where Rolling History was compared against a state-of-the-art solution. We implemented both solutions on top of the Nokia S60 open source Web browser so that the Rolling History was the only difference between the browsers.

1) Participants

Twelve subjects, six female and six male, participated in the laboratory evaluation. Four participants were 20-30 years old, five 31-40 years old, and three 41-60 years old. All participants were familiar with a Symbian S60 mobile device and half of them had previous experience with an earlier version of the tested Web browser.

2) Solution for Comparison

We tested Rolling History against a browser version that did not have any special view for Web history but pressing the right soft key labeled as “Back” took the user straight to the previous page in the history. Multiple windows were presented as tabs as shown in Figure 4, because tabs are a commonly implemented feature to present multiple windows in Web browsers both on PCs and on mobile devices. The tabs view was accessible via the Options menu. Otherwise the Web browser functionalities were the same.



Figure 4: A screenshot of the tab solution used for the comparison with the initial version.

3) Procedure

First, each participant filled out a background information form with questions about their mobile Web browsing experience and Internet knowledge. After completing the tasks, we asked the participants to fill out another form including questions about navigating in the Web history and window management. The form also had open questions, where the participants could list their comments and wishes.

Each participant executed a set of tasks with both browser versions. The set of tasks and their purpose are listed in Table 1. The reasoning for the tasks was that we wanted to include all the basic interaction that users experience when handling

TABLE I
THE SET OF TASKS USED FOR THE EVALUATION OF THE INITIAL VERSION OF ROLLING HISTORY.

Purpose	Task
Back stepping	Selecting a link from a main page of a Web site and returning back to the main page of the site.
Forward stepping	By using the “Forward” function of the Web browser, returning to the earlier viewed page on the Web site.
Opening a popup	Selecting a link from a main page of a Web site that automatically creates a pop-up window.
Closing a popup	Returning to the main page of the Web site after the pop-up window was created from that page.
Opening a new window and switching between windows	Comparing two Web pages that resulted from a Web search.

pages in the Web history and multiple windows. The focus for the handling of multiple windows was on pop-ups as they are the reason why users end up having many windows open at the same time during a browsing session without even necessarily wanting that. The tasks were grounded on a realistic task context that made the tasks more natural for the participants.

We counterbalanced the order of tested versions and checked that half of the users that had a previous experience on the tested browser tested Rolling History first, the other half last. Each participant performed exactly the same tasks with both of the versions.

4) Results and Discussion

After completing the tasks, we asked the participants to rate both of the solutions by function. The results are shown in Figure 5. We used a 7-point Likert scale, 3 meaning a strong disagreement or agreement and 0 meaning neutral.

The evaluation results showed that neither of the versions was a clear winner. The only noteworthy difference was when the users wanted to navigate multiple pages back or forward. Here, Rolling History was favored because according to the participants’ comments the graphical list made it quicker and easier.

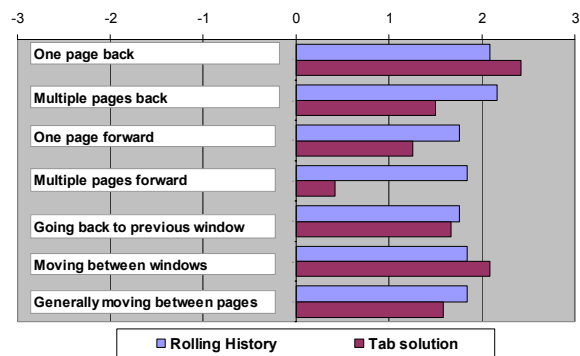


Figure 5 Results of all participants by function.

When we categorized participants into mobile browsing experts and non-experts, we saw a difference in results of

these two groups. In our categorization, the expert users had experience on using Web technologies, such as designing an HTML page, and they had used a mobile Web browser before. Non-expert users had previously done only basic Web browsing on PCs and had almost no experience on mobile Web browsing.

The tab solution was preferred by the non-expert users. In this short evaluation session, non-experts did not see Rolling History intuitive enough and had to spend some time to learn the difference between windows and pages in the Rolling History view. They also preferred using “Options” menu to joystick key, although the Rolling History design depends on 4-way navigation with the joystick.

Rolling History was preferred by the participants who had used a mobile Web browser at least a few times. These participants were very familiar with using multiple windows and appreciated Rolling History for making the use of them easier. Also, the Web history function created a “Wow” effect for them and was useful when they wanted to step multiple pages back.

The tests revealed many improvement ideas for Rolling History. The navigation between windows and pages should be more intuitive: Not all users recognized readily how to move inside the view, as the view did not include any guidance on how to interact with it and move between windows or pages. The graphical design did not invite users to use the four-way joystick navigation. Furthermore, the view did not indicate the difference between windows and pages clearly enough for a first-time user.

When a new window is opened, a notification (Figure 6) with a beep sound was shown to make it clearer that there are now multiple windows open. In the evaluation, the beep was regarded as an alarming sound and unnecessary. We learned that audio notification is not the best solution to notify about opening of a new window. On the other hand, showing a dialog alone was not enough either. The users did not pay much attention to dialogs in general and did not realize that they had to switch window to go back to the previous page.



Figure 6: Dialog for notification of new window.

C. Second Version

As concluded in the previous chapter, the initial version of Rolling History was not a big success. We believed, however, that Rolling History could provide an efficient and easy way to move back to pages both in the current and other windows, if we could make it more intuitive. Once double resolution and

graphics accelerator hardware were installed to an S60 mobile device, we implemented an enhanced version of Rolling History.

The second version of Rolling History is presented in Figure 1. In this version, each entry in the vertical window curve contained its own history list, which was visible on the horizontal curve when the window was in focus. Compared to the initial version, more windows and pages fitted to the same view. Partly, this was related to better display resolution but also to the new layout. The new layout also aimed to show the Web history as a timeline, where the older pages go further off in the space. The page in focus was slightly moved to the right and down, as usually there are more pages in the Web history before than after the current page. Added benefit was that the layout became more visually appealing.

We paid special attention to the details that would make the separation of the Web history of this window and other windows more intuitive. Windows were framed with a platform look&feel -styled frame, while page thumbnails within one window did not contain the platform header & footer, but moved inside the frame. A text box was drawn in the top right corner to indicate the user’s current action and the currently selected window/page was highlighted. If the user was inactive for 1.5 seconds after opening the view, help texts (“windows” and “back”) appeared into the background to indicate what the items on the curves were presenting. The currently open Web page in the browser was marked with a blue rectangle the same way as in the initial version.

The Web history list was always presented with no transparency, while the window curve had 50% transparency. The reason was that we aimed to highlight the Web history list, which was the main use of Rolling History.

We were now able to use animations to communicate transitions more efficiently. With the help of hardware acceleration, the animations performed well and looked smooth. The animations were implemented as follows:

- *Opening a new window.* When a new window was opened, the Rolling History view was activated. An animation showed the new window being created under the current window (Figure 7). The animation was needed on the grounds of the evaluation of the initial version: Users needed a clear indication when a new window was opened and a connection of that to the view. As soon as the animation was played and the new page started to load, the Rolling History view disappeared. The animation consisted of three parts: minimizing the current page (1 sec), the creation of a new window (0.5 sec), and enlarging the new window (0.7 sec).
- *Activating the view.* When the Rolling History view was activated, the currently open Web page shrank to its right place in Rolling History: typically to the right of the focused page. This animation lasted 0.7 sec.
- *Navigating in the view.* All transitions in the view were smooth, i.e. animated. The navigation is visualized in Figure 2. The transitions of moving in the Web history lasted 0.4 sec, while the transition of moving between

windows lasted 0.8 sec. The difference was due to the goal of making clear distinction between the pages in the Web history and windows. Also, during this timeframe the selected windows animated the opening and closing of their history lists to better communicate the functionality to the user.

- *Closing a window.* When the user closed a window in the Rolling History view, the window shrank until it disappeared and the other windows repositioned to fill the empty place. The animation of the shrinking window took 0.5 sec.
- *Selecting a page.* When the page in focus was selected with a joystick click, the thumbnail of the page was zoomed in until it covered the whole screen. This animation took one second, and the time was optimized by starting to load the selected Web page in the background.

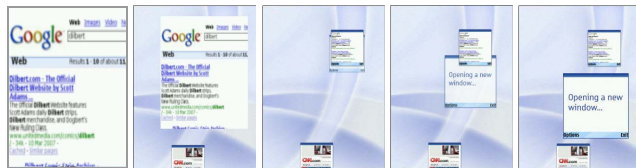


Figure 7: Animation of opening a new window.

In the new version, the view was activated when the user pressed the Back button or selected “Switch window” from the “Options” menu. Both of these actions brought up the same view. This was implemented differently in the initial version, where the Options menu offered a textual presentation of the open windows. We anticipated that consistent functionality would offer better usability.

As before, the user could interact with the view using the joystick the same way as in the initial version. The “Options” menu in the view itself was not used this time, but a command “Close” was offered directly in the left softkey. This was done to simplify the interaction in the view by not offering same functionalities in many places.

This implementation was also done with a later Symbian S60 version than was used for the initial version. The device also was a new model including a bigger display, and a better resolution (320x240 pixels). The software for the Web browser was also more stable. In addition, the platform included hardware acceleration with OpenGL ES. It provided tools for creating fast animations, image manipulations, etc. Thumbnails used in Rolling History were 128x128 pixels in size. The thumbnail indicating the selected page was shown in the original size but others were scaled down i.e. the thumbnails presenting the windows were 64x64 pixels and the size of a thumbnail in the Web history list was calculated accordingly:

$$\text{width} = \text{height} = 128 \text{ pixels} * 0.6 * (8 - |n|) / 8$$
, where n was the position of the page compared to the selected page.

D. User Tests for Second Version

Just like the previous version, we designed and arranged a

usability evaluation for the second version of Rolling History. This was again a laboratory test, where Rolling History was compared against the default browser in the N95 device.

1) Solution for Comparison

The second version of Rolling History was compared against the default N95 Web browser that visualized multiple windows as tabs, which was also used in the initial evaluation. The difference with the initial evaluation was that both of the browser versions presented the Web history graphically.

When the user pressed the Back button while viewing a Web page, the Web history view was opened. It included the page history for this window. The user could interact with this view with the left and right arrows to change the page, and use a softkey or the middle press of the joystick to select the page. After the selection or when the user decided the cancel the view, the normal Web page view is returned with the actual page retrieved from the cache if needed.

For switching windows, the user selected the “Switch window” option from the “Windows” submenu of the “Options” menu. This command activated the tab view. The user interacted with the tab view with the left and right arrows to switch between windows and with the middle button of the joystick to select a window. The menu offered functions for selecting window, closing window or closing all but the current window. The tab solution used for the comparison is presented in Figure 10.

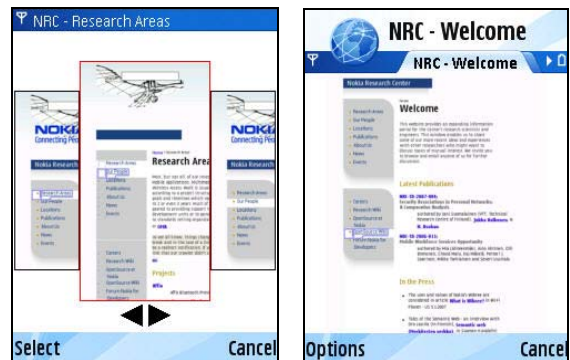


Figure 8: Tab-based solution used for the comparison with the second version. The Web history view is presented on the left and the tab view for multiple windows on the right.

When the user selected a link and a new window opened, a note “Opening new window” appeared on top of the Web page and disappeared automatically.

2) Participants

The evaluation of the second version was done with eight participants, of which six were female and two male. Their ages were 27, 30, 36, 41, 42, 47, 49, and 50 years, with an average of 40 years. All the users had experience on a S60 mobile device and on WAP/Internet browsing with a mobile device. None of the users participated in the evaluation of the initial version.

From the earlier evaluation we knew that expert users preferred Rolling History, while non-experts did not. We wanted to create a solution that would please non-expert participants as well. We selected six participants with no or

little experience with mobile browsers, and only two expert level participants. Again, we counterbalanced the order in which the participants from different groups tested the application versions.

3) Procedure

The tests were done as laboratory tests where each participant had three hours to complete a set of tasks. In the beginning, we asked the participants to fill out a background information form, and after completing the tasks, an evaluation form including questions about navigating in the Web history and window management. Half of the participants used Rolling History first and half started with the tab solution.

As before, each participant performed exactly the same tasks with both of the versions. We generated a new task context for the second evaluation, but used similar tasks as in the first evaluation. Again, the target was to define tasks that naturally make users to go back in Web history or have a browsing session with multiple windows (a new window is popped up after selecting a link without their knowing it beforehand).

4) Results and Discussion

The user preference between the two versions of the Web history and multiple windows visualization is presented in Figure 9. It indicates the number of users that preferred either Rolling History or the tab solution for the different functions. The results show that Rolling History was preferred by most users across all functions. The participants commented that Rolling History was pleasant to use and it was convenient to see the Web history and multiple windows in the same view. Please note that the results are from eight participants only.

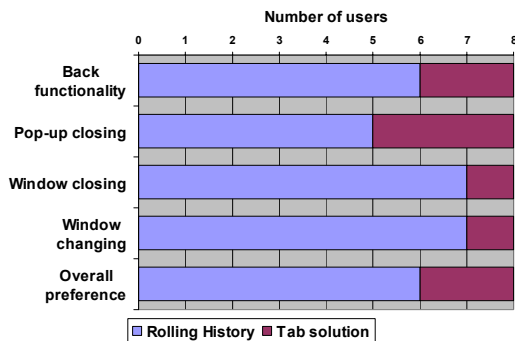


Figure 9: Preference by users.

Figure 10 presents more details on why users preferred each solution. We used a 5-point Likert scale, 1 meaning that a user totally disagrees with the statement and 5 that he or she totally agrees. The results show two benefits of Rolling History compared to the tab solution: “New window opening was easy to notice” and “Pop-up window closing was easy”.

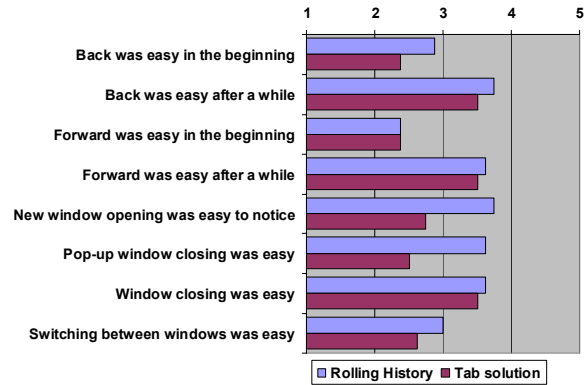


Figure 10: Results by function.

One challenge with the tab solution was that the users needed to understand that they had to activate a separate view for changing or closing windows instead of the Web history view. This required the user to notice that a new window was opened and to look for a separate function to switch a window. In Rolling History, the Back button offered access to both Web history and windows so there was no need to look for a special function.

Another problem with the tab view emerged if the user had opened many windows from the same Web site since the thumbnails in tabs looked very similar and hard to differentiate. With the Rolling History feature, it was easier to see which window is the right one, as the user was able to see the history for each window.

IV. CONCLUSIONS

In this paper, we discussed the need of supporting the same usage patterns on a mobile device as on a PC by providing a novel mobile user interface to handle the equivalent functions. We also showed how animations may help intuitiveness of our user interface solutions.

Our target use case was about Web browsing, more specifically about back stepping and opening multiple windows in a mobile browser. We saw that back stepping user interface on a PC is not optimal, and it is even worse on a small screen device. We wanted to provide a graphical representation of the visited Web pages, as many researchers had found thumbnails improve back stepping performance. We also saw that moving to pages in different browser windows (or tabs) is not that different from moving to pages in the Web history of the current window. For example, the back function should take the user to the previous window when the user is on the first page of this window. We wanted to create a new kind of user interface that combines Web History and multiple windows into one view. This user interface, called Rolling History, suits well on a mobile device with a small screen and 4-way navigation and supports the usage patterns of multiple windows and easy back stepping.

When introducing a new user interface for frequently used functions, it is important to test if users can understand and react positively to the new solution. We conducted two rounds

of usability and user experience evaluations with 12 and 8 participants, respectively. We wanted to find a solution that both expert and non-expert users would prefer. The first attempt at the solution was not intuitive enough, as non-expert participants were confused with pages and windows shown in the same view. We analyzed the problem being the graphical design. With the aid of higher resolution and a graphics accelerator, we improved our first solution by adding animations to better illustrate state changes in Rolling History.

The results of the second evaluation round showed that most participants preferred Rolling History solution to the current state-of-the-art tab approach. This indicates promising results as most of the participants were not experts in mobile browsing to begin with and the evaluation was conducted in a short session where participants used the system for the first time only. A field study where participants would have more time to adjust to the proposed new user interface might further justify the value of Rolling History. Also, a field study would provide more data on personalization, the performance, and usage of resources of Rolling History. We believe that Rolling History is paving the way for mobile interaction design: copy the good, deep-seated use patterns from the PC, but design the user interface uniquely for mobile.

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REFERENCES

- [1] Ayers, E. Z., and Stasko, J. T. Using graphic history in browsing the World Wide Web. Proceedings of the Fourth International World Wide Web Conference. 1995.
- [2] Yamaguchi, T., Hattori, H., Ito, T., Shintani, T. On a Web browsing support system with 3D visualization. Proceedings of the 13th international World Wide Web conference on Alternate track papers & posters, May 19-21, 2004, New York, NY, USA.
- [3] Hightower, R., Ring, L., Helfman, J., Bederson, B., Hollan, J. Graphical multiscale Web histories: a study of Padprints. Proceedings of the ninth ACM conference on Hypertext and hypermedia, p.58-65, June 20-24, 1998, Pittsburgh, Pennsylvania, USA.
- [4] Woodruff, A., Rosenholtz, R., Morrison, J., Faulring, A., Pirolli, P. A comparison of the use of text summaries, plain thumbnails, and enhanced thumbnails for Web search tasks. Journal of the American Society for Information Science and Technology, v.53 n.2, p.172-185, January 15, 2002.
- [5] Cockburn, A., McKenzie, B., Smith, M. Pushing back: evaluating a new behaviour for the back and forward buttons in Web browsers. International Journal of Human-Computer Studies, v.57 n.5, p.397-414, November 2002.
- [6] Greenberg, S. and Cockburn, A. Getting Back to Back: Alternate Behaviors for a Web Browser's Back Button. Proceedings of the 5th Annual Human Factors and the Web Conference, NIST, Gaithersburg, Maryland, USA, June 1999.
- [7] McKenzie, B., Cockburn, A. An Empirical Analysis of Web Page Revisitation. Proceedings of the 34th Annual Hawaii International Conference on System Sciences, Volume 5, p.5019, January 03-06, 2001.
- [8] Cockburn, A., Greenberg, S. Issues of Page Representation and Organisation in Web Browser's Revisitation Tools. Australian Journal of Information Systems (AJIS), 7(2), 120-127, May. 2000.
- [9] Tauscher, L., Greenberg, S. How people revisit Web pages: empirical findings and implications for the design of history systems. International Journal of Human-Computer Studies, v.47 n.1, p.97-137, July 1997.
- [10] Cockburn, A., Greenberg, S., McKenzie, B., Jasonsmith, M., and Kaasten, S., WebView, A Graphical Aid for Revisiting Web pages. Proceedings of the OZCHI'99 Australian Conference on Human Computer Interaction. 1999.
- [11] Mayer, M. and Bederson, B. B., Browsing Icons: A Task-Based Approach for Visual Web History. HCIL Technical Report. 2001.
- [12] Gandhi, R., Kumar, G., Bederson, B. B., Shneiderman, B. Domain Name Based Visualization of Web Histories in a Zoomable User Interface. Proceedings of Eleventh International Workshop on Database and Expert Systems Applications – Second International Workshop on Web-Based Information Visualization, p. 591-598. 2000.
- [13] Frécon, E., Smith, G. WebPath - A Three-Dimensional Web History. Proceedings of the 1998 IEEE Symposium on Information Visualization, p.3-10, October 19-20, 1998, North Carolina.
- [14] Milic-Frayling, N., Jones, R., Rodden, K., Smyth, G., Blackwell, A., Sommerer, R. Smartback: supporting users in back navigation. Proceedings of the 13th international conference on World Wide Web, May 17-20, 2004, New York, NY, USA.
- [15] Shirai, Y., Yamamoto, Y., Nakakoji, K. A history-centric approach for enhancing web browsing experiences. CHI '06 extended abstracts on Human factors in computing systems, April 22-27, 2006, Montréal, Québec, Canada
- [16] Nadeem, T., Killam, B. A Study of Three Browser History Mechanisms for Web Navigation. Proceedings of the Fifth International Conference on Information Visualisation, p.13, July 25-27, 2001.
- [17] Cockburn, A., Greenberg, S., Jones, S. McKenzie, B. and Moyle, M. Improving web page revisitation: Analysis, design and evaluation. IT & Society, 1, 3 (2003), 159-183.
- [18] Tauscher, L., Greenberg, S. Revisitation patterns in World Wide Web navigation. Proceedings of the SIGCHI conference on Human factors in computing systems, p.399-406, March 22-27, 1997, Atlanta, Georgia, United States.
- [19] Hawkey, K., Inkpen, K. Web browsing today: the impact of changing contexts on user activity. CHI '05 extended abstracts on Human factors in computing systems, April 02-07, 2005, Portland, OR, USA
- [20] Kandogan, E., Shneiderman, B. Elastic Windows: a hierarchical multi-window World-Wide Web browser. Proceedings of the 10th annual ACM symposium on User interface software and technology, p.169-177, October 14-17, 1997, Banff, Alberta, Canada.
- [21] Nadamoto, A., Tanaka, K. A comparative web browser (CWB) for browsing and comparing web pages, Proceedings of the 12th international conference on World Wide Web, May 20-24, 2003, Budapest, Hungary.
- [22] Brown, M., Shillner, R. The DeckScape web browser, Conference companion on Human factors in computing systems: common ground, p.418-419, April 13-18, 1996, Vancouver, British Columbia, Canada.
- [23] Roto, V., Popescu, A., Koivisto, A., Vartiainen, E. MinimAP: A Web Page Visualization on Mobile Phones. Proceedings of the SIGCHI conference on Human Factors in computing systems. 2006.
- [24] Buyukkokten O., Garcia-Molina H., Paepcke A., Winograd T.: Power Browser: Efficient Web Browsing for PDAs. Proc. ACM CHI 2000.
- [25] de Bruijn O., Spence R., Chong M. Y.: RSVP Browser: Web Browsing on Small Screen Devices. Personal and Ubiquitous Computing (2002) 6:245–252.
- [26] Baudisch P., Xie X., Wang C., Ma W.: Collapse-to-Zoom: Viewing Web Pages on Small Screen Devices by Interactively Removing Irrelevant Content. Proc. ACM UIST 2004.
- [27] Lam H., Baudisch P.: Summary Thumbnails: Readable Overviews for Small Screen Web Browsers. Proc. ACM CHI 2005, p. 681-690.
- [28] Roto, V. Web Browsing on Mobile Phones – Characteristics of User Experience, p. 43. Doctoral dissertation, TKK Dissertations 49, Helsinki University of Technology, Finland, 2006. http://research.nokia.com/people/virpi_roto/dissertation.html
- [29] Kaasten, S., Greenberg, S., and Edwards, C. How people recognize previously seen WWW pages from titles, URLs and thumbnails. In X. Faulkner, J. Finlay and F. Detienne (Eds.) Proc. of Human Computer Interaction 2002, BCS Conference Series, 247--265.