THE EFFECTS OF THE AJAX TECHNOLOGY ON WEB APPLICATION USABILITY

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Abstract: The Ajax technology is said to make the Internet faster, more interactive and user-friendly. It is spreading rapidly throughout the web. By allowing scripts being executed inside the user's browser to communicate with a remote server, it enables new forms of interaction for web-pages and -applications. In this paper we analyze Ajax usability, taking into account both advantages and imposed problems. Subsequently we present a user study with two typical scenarios in web-applications and compare Ajax-enabled and non-Ajax-enabled versions. This allows us to verify and quantify the assumed effects. As a result, we show that Ajax significantly enhances both user satisfaction and efficiency of use, at least in some scenarios.

1 AJAX INTRODUCTION

The term Ajax is an acronym for "Asynchronous JavaScript and XML" (Garrett, 2005) and describes a way to realize a HTTP communication from within a JavaScript program embedded into a web page.

The retrieval of information or the usage of an application in traditional websites consists of loading web pages page-by-page by clicking on links or submitting forms. Once a page has been loaded, the content remains mostly unchanged until a user action triggers loading of a completely new page.

In contrast to this, Ajax sites can dynamically load new data from and transmit data to the originating web server while the page stays in display. The Javascript application running inside the browser can update the content of the web page with no need to discard the whole page at every data transmission. Communication happens asynchronously in the background, the web application stays fully functional in the meantime. Figure 1 shows the control-flow of an Ajax site compared to a regular web application.

The communication with a webserver in an Ajax application is controlled by the so-called XMLHttpRequest object, which offers either synchronous or asynchronous retrieval of data. In the latter case, the application is notified via callbacks, when the retrieved data is available. The XMLHttpRequest object is an API being accessible from major scripting languages, like e.g. JavaScript. Its runtime environment is the Ajax engine being embedded into a standard web browser.

Using the available mechanisms, highly interactive web applications can be realized, like e.g. Google Maps (http://maps.google.com) where users can seamlessly navigate through maps or Gmail (http://www.gmail.com/) where the inbox can be updated or emails moved between folders, all without loading a new page.

So Ajax-enabled web applications seem to offer huge benefits in usability compared to traditional web applications. But studies trying to analyze this are very rare. So our goal is to provide some significant results that substantiate certain aspects of Ajax usability.

2 USABILITY ASPECTS

When used in web pages, Ajax enables new interaction modes with web pages, which imply effects on the usability of these. In this section we will analyze the improvements that an adequate use of Ajax can

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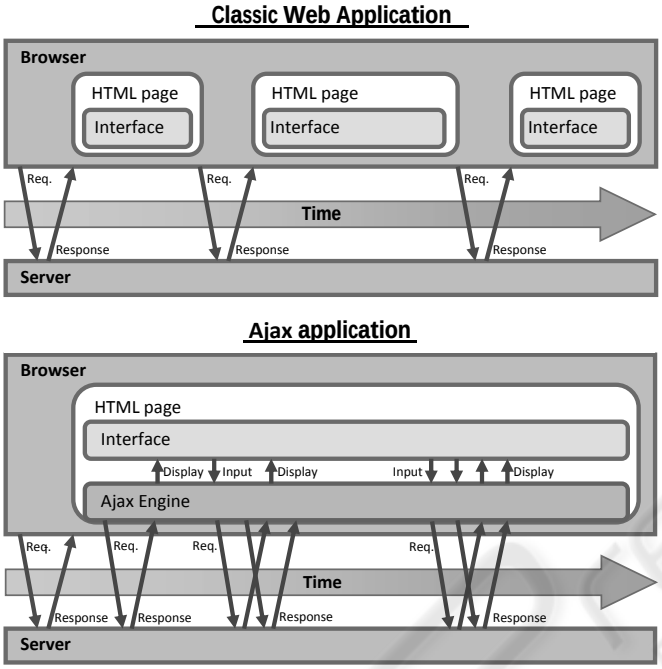

Figure 1: Comparison of classic web applications and ajax applications.

mean for websites; in the following section we will discuss the drawbacks of its usage.

2.1 Application Speed

Web sites can use Ajax to load content requested by the user. Given a web page is already present at the users browser, subsequent loads can be truncated to the changes. This way the server can omit sending the code used for layout and unchanged parts of the page (like menus) and just transfer the new content. This can reduce the loading time of a page significantly.

The effect is most noticeable when only a relatively small part of a big page changes or is additionally loaded. Also when a form is submitted as a part of a page and the rest of the page is supposed to remain in display (e.g. the later examined message board with an additional message being added), the transfer via Ajax can save transmission time.

2.2 User Interface Smoothness and Interactivity

As the user can work within a page and the displayed page doesn't have to be discarded at each request of additional content, the interaction with the web page can be designed substantially more fluid than before. The interruption of the user's work process and the required adaption to a new workspace which happen when the page is changed disturb the workflow of the user. When content is sent or loaded via Ajax, the user interface remains continuously visible and unchanged apart of the new content elements.

A good user interface interacts with the user and reacts instantaneously to his actions. Lowry et al. compared in a study variants of web applications with different grades of interactivity and found out that the satisfaction of the user increases with higher interactivity. (Lowry et al., 2006)

Regarding the interactivity, web applications were always in an inferior position compared to desktop software. Classic web applications can only directly react to user actions as far as the required information had been delivered to the browser with the page. In any other case a new page has to be loaded. This limits potential reactions to predictable user input. In case the reaction of the application is based on a big amount of data it is neither useful nor wanted to transmit all data to the user. Using Ajax the application can access server side data from inside the page and react to user input dynamically. Thus only these parts of data which are relevant to handle the current user input have to be loaded.

2.3 Data Transfer Transparency

We have already mentioned that Ajax can reduce the actual time the user has to wait for new content to appear. Often the subjective impression of waiting depends not so much on the actual time it takes to load and display the content but on the way the user interface presents it. Culwin and Faulkner (Culwin and Faulkner, 2001) found out that users preferred an interface keeping them informed regarding the total loading progress over an interface with a regular browser loading indicator.

With Ajax, the technical means now exist for web applications to provide custom loading indicators to the user. By being able to control the user interface without interruption, the application can keep the user informed about when loading occurs, what is being loaded and what the current progress is. In contrast to this, regular web browser UIs only display a loading animation and a rough estimation of the loading progress.

2.4 New Interactions

Ajax can not only replace regular loading of content and speed up applications by this, but also enables new interactions with a web page. For example an input field which offers completion suggestions for the typed characters can hardly be realized without Ajax. Neither a reload of the whole page after each typed character nor preloading all possibly needed data (like the train stops in the later mentioned travel planner) together with the web page would be very useful.

3 PROBLEMS

As we have seen, the use of Ajax can improve website usability in several modes. Unfortunately, by changing the way the web applications work, problems arise as well. In this section we discuss the drawbacks of Ajax in the fields of accessibility and the disturbance of web browser navigation tools.

3.1 Accessibility

As Ajax applications rely completely on JavaScript, they are not accessible to users of browsers, which do not support this language. Text browsers such as Lynx and browsers for mobile devices but also screenreaders for visually impaired are part of this group.

As the different web browsers vary in extent and implementation of Javascript support, the risk is high that Ajax applications do not work as expected with some browser versions. To reach a broad compatibility, strong efforts are necessary.

Possible solutions to the accessibility problem include the delivery of normal HTML pages, which are subsequently enriched with Ajax functionality. To realize this, a non-Ajax-based version of the page is loaded and subsequently modified by a JavaScript programme, if Ajax support has been detected.

3.2 Browser Navigation and Bookmarks

In normal web applications, users navigate between pages and can use the browser's "back" and "forward" buttons to return to recently visited items. Typically pages can also be bookmarked and re-visited later.

As with Ajax the change of page content is controlled by scripts, the browser cannot simply go "back" any more. Clicking the navigation buttons might lead to undesirable consequences.

Also, when content is loaded via Ajax, the URI of the page does not change, which renders the bookmark function of web browses useless. Accessing a bookmark of an Ajax page thus loads the initial screen only.

Several workarounds for these problems are known. A promising approach to the navigation problem is the implementation of custom functions for the handling of the "back" and "forward" buttons, which is supported by the current releases of Mozilla Firefox and Microsoft Internet Explorer browsers. The bookmark problem can be solved by coding the current page-state into the in-page link anchor marker "#" either by providing a link to the current state or by automatically jumping to a new virtual anchor on each page update.

4 EMPIRICAL SURVEY

To support our theoretical findings from the last sections, we conducted a user testing in which we measured the differences in selected usability aspects between Ajax and non-Ajax-versions of two web applications. This chapter describes the configuration of the study and its results.

4.1 Subjects and Measures

We decided to examine two different usages of Ajax: On the one hand we choose a form field autocomplete widget as a very typical example for applications that become possible when using Ajax. The auto-complete widget is used in a public transit trip planner, where the fields for the start and destination

station suggest completions for the typed characters, based on a database of all train stations in Germany.

In our second example, Ajax is used to send the content of a form to the server in order to save it to a database while the user can continue to use the application. This is implemented in a discussion forum application where the user can add a comment which is submitted to the server via Ajax and directly inserted into the tree-like message board. In the meantime, the user can continue reading or posting to the forum without interruption.

While in the first example the expected advantage consists in the support of the user through the auto-complete suggestions, the main issues in the second example are the reduced transfer time and the increased smoothness of the user interface.

For the study we implemented both web applications in a version with and a version without Ajax usage. As measures we choose two sub-aspects of usability: satisfaction and efficiency (Nielsen, 1993). We select satisfaction, as it is a subjective impression and summarizes the whole experience of the user with the application. In contrast, efficiency is chosen as an objectively measurable criterion.

Satisfaction was measured with a 12 item questionnaire based on the IBM Usability Satisfaction Questionnaire (Lewis, 1995) with statements like "Overall, I am satisfied with how easy it is to use this system"Each item has to be rated on a scale with five possible gradings between "strongly disagree" and "strongly agree". Efficiency was quantified by the time the users needed for the completion of given, characteristical tasks.

4.2 Hypotheses

According to the chosen subjects and measurements, four hypotheses are tested:
H1: The user satisfaction with the trip planner with auto-completion of input fields is higher than without auto-completion.
H2: The efficiency of using the trip planner with auto-completion of input fields is higher than without auto-completion.
H3: The user satisfaction with the message board with transmission of new comments via Ajax is higher than with regular comment transmission.
H4: The efficiency of using the message board with transmission of new comments via Ajax is higher than with regular comment transmission.

4.3 Methodology

The study was conducted via Internet. The participants were asked to complete a set of tasks for each application. Each user worked with both the Ajax and the non-Ajax version of the two applications, so they had to complete four sequences altogether.

The order of the applications and the Ajax and non-Ajax version was randomized to eliminate succession effects. Two different variants of the tasks were created for the two versions of the applications, the assignment of the task variants to the application versions was randomized, too.

After each version the participant was requested to fill out a satisfaction questionnaire. At the end of the survey statistical data (age, gender, experience with computers and the Internet) was gathered and a text field for transmitting feedback was offered.

4.4 Results

The survey has been completed by 123 participants successfully. Participants were between 14 and 68 years old with an elevated concentration between 20 and 30. There was a slight dominance of males with a rather high experience with computers and the internet. Figure 2 shows the age and gender distribution. A small number of participants (exceeding the 123) experienced technical problems, mainly browser compatibility issues, and have not been included in the analysis.

The results show different extents of improvement on satisfaction and efficiency in the two applications. For the statistical validation of the results we applied an analysis of variance for a repeated measures design. Using this method, three of the four hypotheses can be confirmed while the fourth cannot be validated statistically.

Figure 3 gives an overview over the results. Figure 4 shows a histogramm of the time required to complete the given tasks, which is taken as the inverse of efficiency.

The satisfaction with the trip planner improves from 3.7 to 4.37 (on a scale from 1 to 5) when introducing the Ajax-enable auto-complete widget. The corresponding hypothesis H1 can be proven with high significance ($p < 0.01$).

The time needed to complete the given tasks with the trip planner decreases in average from 92.5 s to 71.5 s with Ajax auto-completion which shows a clear gain in efficiency. Hypothesis H2 can thus be corroborated also with high significance ($p < 0.01$).

In the message forum application, the satisfaction of the users improve from 3.84 to 4.22 when the com-

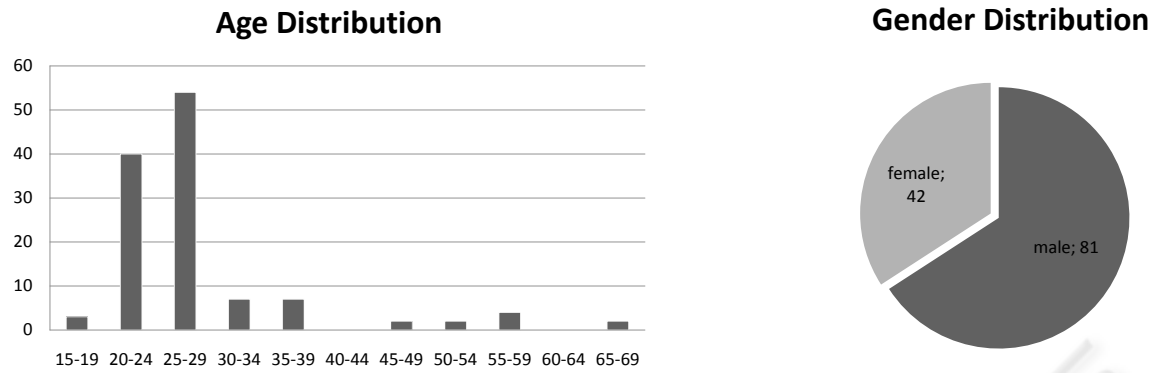

Figure 2: Age and gender distribution of the participants.

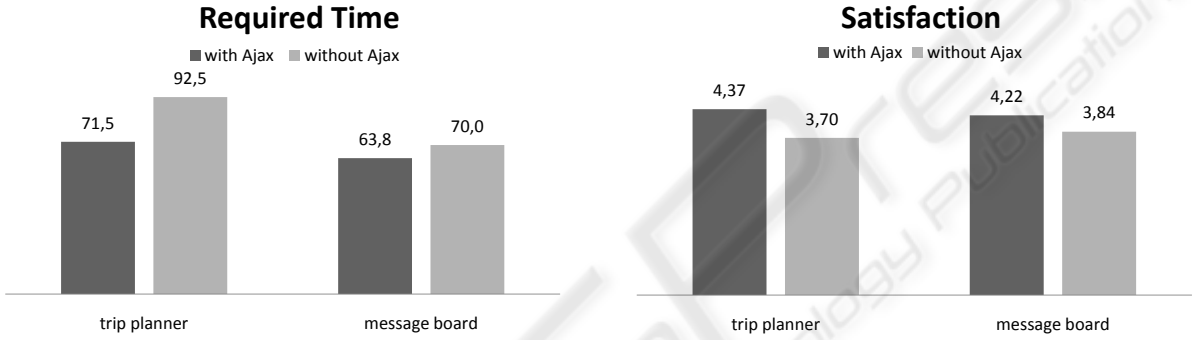

Figure 3: Results of the study: Measured Satisfaction for the Ajax and the non Ajax version of the two evaluated applications (higher value = better) and time in seconds needed to complete the given tasks (lower value = better).

ments are transmitted via Ajax. Hypothesis H3 can also be confirmed with high significance ($p < 0.01$).

The efficiency also increases when using of Ajax, reducing the average time needed for the tasks from 70 s to 63.8 s. However, the statistical test cannot confirm the corresponding hypothesis H4 ($p = 0.067$).

Summed up the employment of Ajax leads to a satisfaction gain in both cases, whereas the efficiency benefits can only be confirmed in one case. These results will be discussed and interpreted next.

4.5 Interpretation of Results

The results show that the introduction of Ajax leads to improvements of different extents in terms of satisfaction and efficiency of use of web applications.

The auto-completion function has clearly proven its advantages in terms of satisfaction as well as efficiency. The so improved trip planner received many positive comments from the users, which requested to have this function available in real trip planner applications.

In the second application, which uses Ajax to transmit the content of a form, the advantages are not as big as with the auto-completion. Regarding efficiency there was no significant gain at all. A possible explanation is the fact that the internet connection speeds in the tests were so fast, that the time advantage reached through the transmission via Ajax was hardly noticeable for the majority of the users.

Another reason for the failure to significantly prove the efficiency gain is the high variance in time needed by the participants to complete the tasks. Though being instructed to quickly scan the forum and write just anything, many participants read the comments thoroughly and tried hard to write meaningful contributions. A similar trial should be possibly conducted using a different application scenario. Anyhow the Ajax-based version did not perform worse than the non-Ajax one.

5 CONCLUSION

In this paper we presented many advantages when using Ajax in web applications but also considered some drawbacks. The main advantages in the field of usability affect user satisfaction and response time

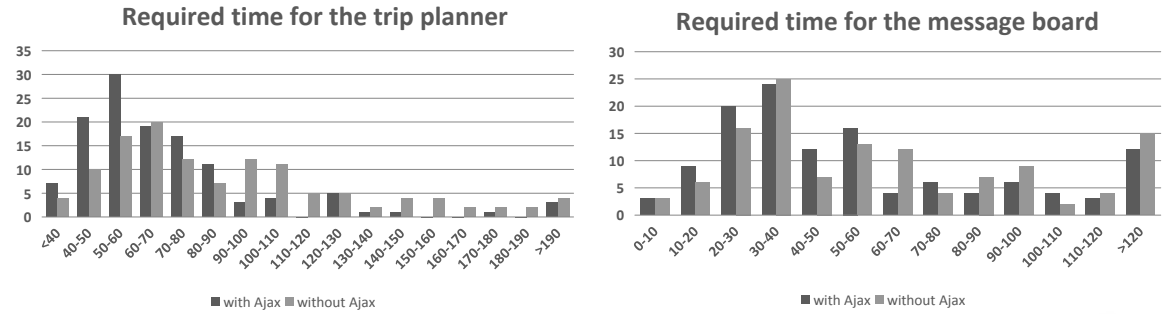

Figure 4: Histogramm of the time required to complete the given tasks with the two applications, comparing the Ajax and non Ajax version each. A lower value indicates a higher efficiency.

which influence the efficiency with which the application can be used. Besides this, new functions enhancing user comfort can be created. Some new kinds of applications are only possible through the use of Ajax.

On the other hand problems may arise because the browser loses some control over the HTTP traffic and its functions for navigation may not work as expected. However, with some effort developers can realize working browser navigation functions for most scenarios.

A more fundamental problem comes up when a user cannot use an Ajax application at all because her browser is incompatible with Javascript and/or Ajax. This is also an aspect of usability and maybe the most severe usability problem: The non-usability. When designing an application developers have to take into consideration the target group: will it be able to use the application or is partial non-accessibility viable.

Unquestionably Ajax makes sense when creating comfort functions like the auto-completion described previously. They are attached to existing applications and do not replace any regular HTTP transfer but only add visual support and convenience. Thus, they can easily be omitted if the browser does not support Ajax. Then, Ajax can be used without any of the disadvantages being mentioned.

For the group of applications that cannot be realized without Ajax, the situation is different. They may not be accessible for some groups of Internet users, but compared to the former non-existence of this application class, it is still an improvement.

5.1 Future Work

While we looked at the benefits of Ajax not only theoretically but also empirically in our study, we analyzed the drawbacks only in theory. In a future work it could be attempted to formalize and quantify the mentioned problems of the Ajax technology. Other future research could deal with a more comprehensive evaluation of other possible applications and include other usability aspects.

Ajax spread rapidly the last years and will continue to do so. Our paper showed that Ajax is no magic bullet as it can bring up new problems. However we could also show that the employment of Ajax brings a noticeable gain of efficiency and satisfaction in certain fields. Wisely used, Ajax can clearly improve the usability of web applications that way.

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