Back to Basics

Is a Better Understanding of the Internet a Precursor for Effective Use of the Web?

Louise Sheeran & M. Angela Sasse
Dept. Computer Science
University College London
Gower Street
London WC1E 6BT
UK
+44 20 7679 2000
L.Sheeran@cs.ucl.ac.uk

Jon Rimmer & Ian Wakeman
School of Cognitive and Computing Sciences
University of Sussex
Falmer
Brighton BN1 9QH
UK

ABSTRACT

Due to the rapid growth of the Internet over the past few years, the profile of Internet users has changed considerably, growing from a small group of professionals and experts to a large group of mostly novice and intermediate users. Since the Internet is a best-effort service, high levels of usage can lead to slowing down and occasional breakdown of service. However, networked applications such as Web browsers currently fail to take this into account. This paper reports on two studies, which found most users' models of networks to be patchy and inaccurate. Feedback provided by the Web browsers, such as error messages, did not help the users identify the appropriate action when they encountered problems. We suggest that designers of Web browsers and Web sites should provide users with appropriate models of network operations in their help systems and explanatory pages which helps users understand the underlying technology. This will allow users to appropriately diagnose and recover from breakdown situations. Additionally, this knowledge will give users the confidence to explore the possibilities of the Web further.

Keywords

Conceptual Design, Mental Models, User's Model, Internet, WWW, Web browsers

1 INTRODUCTION

Before the World Wide Web (Web) gained wider popularity, Internet users were regular and committed users with a good or expert knowledge of computing and networking. Since then, the number of Internet users continues to soar. With a best-effort service such as the one currently provided by the Internet, rapid growth in the number of users means that occasional bottlenecks and breakdowns are inevitable. Unfortunately, this is not taken into account by those who develop software applications for the Internet. Web browsers are often cited as one of the great success stories of user interface design; for instance, many users who could not cope with ftp in the past are now happily downloading files via the Web – until they encounter a problem. Designers' efforts to keep the interaction with the underlying network "transparent" has led to users receiving little or no feedback about underlying network operations. When problems occur – as they inevitably do – these users have little chance of diagnosing the cause of problems accurately, and identifying the appropriate action to be taken. Internet applications which do not support users appropriately, are costly in terms of human, network, and financial resources:

- Human resources: Users feel helpless and become frustrated because they do not understand the breakdown situations and how to recover from them.

- Network resources: Users often inadvertently take inappropriate recovery actions when they encounter a problem, and make the situation that caused the breakdown situation in the first place, even worse.

- Financial resources: Internet Service Providers (ISPs) spend large amounts on help desk services for their customers - a cost which is, of course, ultimately born by the customer.

And the consequences are likely to be even more far reaching. Users who do not feel in control, are likely to be less inclined to do tasks which are perceived to be "risky", like filling in on-line forms, and submitting credit card details on the Web. Much effort is being spent on improving Web usability with regard to site content and presentation, but without providing browser software and site contents which support users in *understanding* the cause of breakdown situations and the implications of submitting credit card details on-line, the impact of this effort is likely to be minimised.

This paper proposes that users' inability to correctly diagnose and recover from breakdown situations appropriately, and their apprehension regarding more "risky" Web applications may be linked to their having inappropriate or even wrong users' models of how the underlying network works when browsing the Web. A visit to the helpdesk call centre of one of the largest Internet Service Providers (ISP) in the UK showed that the staff there mainly held procedural knowledge of how the Internet works. They had been taught about the Internet, email and Web browsing using metaphors, but where this metaphor based procedural training enabled them to deal with the majority of calls, they expressed frustration over not really knowing what goes on when sending an email or downloading a Web page. They thought that holding structural knowledge of the Internet would greatly improve their job satisfaction and improve the help they could offer to customers. The fact that Internet help desk staff hold insufficient mental models of how the Internet works, spurred us onto investigating how "normal" Internet users who had not been specially trained to deal with breakdown situations fare. This was explored in two studies presented in this paper. The framework for carrying out the studies was conceptual design.

1.1 Conceptual Design

Norman (1986) proposed the notion of conceptual design in order to ensure that users develop appropriate users' models of systems: The designer creates a *design model*, which is implemented as the *system image*. The user interacts with the system image and forms a *user's model* of the system. If this transfer is successful, the user's model will match the design model closely, and interaction with the system will be effective, and hopefully enjoyable as well (see Figure 1).

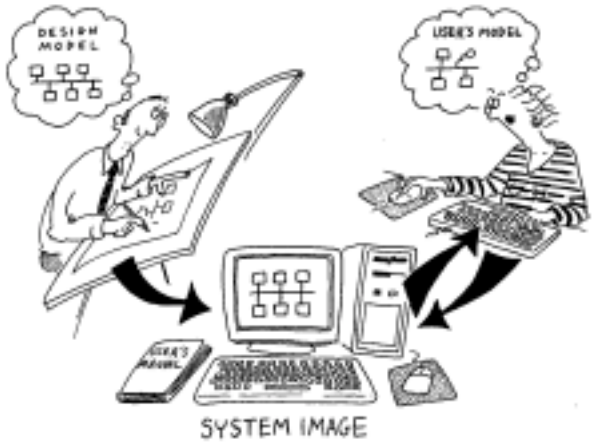

Figure 1: Conceptual Design (after Norman, 1986).

The *design model* is the designer's view of how system should be presented to the user. The design model is therefore not necessarily a model of what the underlying system actually looks like, but a model of how it should be presented to the user. The design model can successfully be based on a metaphor, but only if due care is taken to ensure that the chosen metaphor does not restrict the functionality of the system or that it does not suggest additional functionality which is not present in the system.

The *system image* is the implementation of the design model, and consists of all the aspects of the system that the user can interact with, i.e. the actual user interface, any manuals and documentation and online help, training courses, error messages etc. The design model should be implemented consistently across all elements of the system image.

The *user's model* is the user's mental model of the system. Since users' models are influenced by users' existing knowledge and experience, each user's model is unique. For instance, a user familiar with Netscape Communicator who uses Internet Explorer for the first time is going to be guided by his/her user's model of Netscape Communicator and his/her expectations of Internet Explorer. When constructing the design model, it is therefore important that the designer takes the intended user group's previous knowledge and experience into account.

A previous study by the authors (Clark and Sasse, 1997) demonstrated how effectively this method can be used in practice. A small Internet application was redesigned, based on a design model which incorporated a metaphor well known to the user population. The re-designed version caused users to develop users' models which reflected the design model. Furthermore, their understanding of the application's functionality was far better than experienced users' understanding of the original application.

However, the application of conceptual design is severely hampered by the lack of tools available for practitioners for carrying out conceptual design. Establishing users' previous knowledge and experience, designing a suitable design model, and implementing it in the system image are all non-trivial tasks. In addition, the tools for eliciting and describing users' models are also severely limited (for a recent detailed literature review and discussion of conceptual design in HCI, see Sasse, 1997). A good starting point for practitioners interested in using conceptual design is Newman and Lamming (1995). which has two whole chapters dedicated to conceptual design.

The studies described in the remainder of this paper examines users' existing background knowledge and experience of Web browsing – the first step in conceptual design. This knowledge allows us to develop design models for Web browsing which ensure that users develop appropriate users' models of Web browsing.

2 USERS' MODELS OF THE INTERNET

To date, there has been very little research on users' models of the Internet. Thatcher and Greyling (Thatcher and Greyling, 1998b, Thatcher and Greyling, 1998a, Greyling and Thatcher, 1997) conducted a series of studies looking at users' models of the Internet. Their approach involved asking Internet users to *draw* how they thought the Internet works. By analysing the drawings, they devised 8 categories based on the sophistication of the drawings. The drawings were then compared to the subjects' computer and Internet experience, and the categories were ordered hierarchically. The categories, in order of sophistication, are: interface, telephone analogy, central database, simple connectivity, users to the world, simple modularity, cloud, and modularity & networking. All categories, apart from the modularity & networking category, which is a rich representation of the Internet, showing different types of links and indications of transmission media and protocols, are extremely simple representations of people or computers linked up. From a methodological point of view, the task of drawing may well have proved a stumbling block for many adults. This may, in turn, have caused the representations to be much simpler than they would otherwise have been. However, the results do indicate that users' models of the Internet are indeed naïve to a point where recovering from breakdown situations and making informed decisions about whether to trust a secure connection or not are severely disadvantaged.

O'Day et al. (1999) have taken a very different approach to investigating users' models of the Internet. They conducted an ethnographic study, analysing the questions asked on introductory courses to the Internet offered by SeniorNet, an organisation which helps seniors use computers. By looking at the questions asked by the seniors, they were able to point to the areas where novice users' previous knowledge and experience failed to help them understand the Internet world. The questions that the seniors asked, showed how difficult it is to come to grips with the concept of the Internet. The study provides important background information for understanding the users' models of users who are very new to the Internet, but it does not tell us how the large bulk of intermediate Web users fare.

3 STUDY 1

The aim of this study was to investigate primarily intermediate users' models of a series of common Web situations. The study investigated users' perception of 10 relatively common Web scenarios. This paper looks at 3 of the scenarios, all of which were breakdown situations. Breakdown situations are particularly interesting with regard to distributed systems because the "location" of the breakdown determines whether there is any action the user can take to recover, and if so, what this action is. By location we mean the point in the connection where the breakdown has occurred, i.e. whether the problem is:

- local, e.g. the user has made a typo when typing in a Web address;
- remote, e.g. the remote site has been reorganised and the page the user is trying to access no longer exists on that address;
- "in between", e.g. the user's ISP's server is too busy for the user to log on and gain access to the Internet.

This particular study is described in greater detail in Sheeran et al. (2000).

3.1 Method

35 participants took part in the study, which consisted of a simulated Web browsing environment. A series of Web pages had been designed to incorporate the 10 scenarios. The following three are analysed here:

1. A link containing a spelling mistake in the filename (error 404).
2. A link to a page on a server, but invalid port number specified (wrong port number).
3. A link to a page on a non-existent server (non-existent server).

All three types of errors are very common when browsing the Web (non-existent file, server not contactable, and server non-existent). However, they are fundamentally different, and require different recovery actions. The actual scenario for "server not contactable", i.e. wrong port number, is not a common error, but it is similar to trying to contact a server which is down or busy, which is very common when browsing the Web.

The scenarios were incorporated in an overall task. Each participant was asked to follow a prescribed route through the web pages while "thinking aloud". Either Netscape Communicator 4.6 (Netscape) or Microsoft Internet Explorer 4 (IE) was used, depending on the participants' normal choice of Web browser. The study took approximately 30 minutes per participant.

3.2 Results

The results confirm what we anticipated based on Thatcher and Greyling's studies (see section 2), that only very experienced Internet users have users' models sophisticated enough to distinguish between the 3 breakdown scenarios. Only the expert users in the study were able to correctly diagnose and recover from the breakdown situations. The explanations from the novice and intermediate users revealed a reluctance or inability to pin down the exact cause of each of the breakdown situations. Novices would attribute a problem to something being wrong with the Web address, but would fail to distinguish between the first part of the address, which represents the server, and the second part, which represents the directory/file.

The three scenarios represent three different problems. In the first, the server exists, a connection can be established, but the page which is attempted accessed, is not there. In the second scenario the server exists, but the port number is invalid, so no connection can be established. In the third scenario the server does not exist, and is not contacted at all. The distinction between scenarios 1 and 2-3 is that the first has to do with the file structure on the server (it is not necessarily the page that does not exist, but it could be any of the directories listed in front of the page which is inaccessible). Scenarios 2 and 3 relate to the actual server. A problem with the page is therefore only related to the second part of the Web address. Likewise, a problem with the server is only related to the first part of the Web address.

This division is fundamental to understanding the structure of Web browsing, but 8 out of 28 participants who were asked if they knew which part of the Web address represented the server name, did not know, revealing a fundamental gap in their users' models. This could also be linked to the fact that they were not too sure what a server is, e.g.

> *"Is the server not the kind of people responsible for putting the Internet out to the university or something like that – and email, the computer…"(Participant12, novice)*

Of the ten participants who were asked to define "server", only two came up with convincing explanations. The others had a vague idea of what a server does, but as to what a server actually is, the following were the explanations: the main connection…, the bit …, the hub …, the people …, the thing …, the page …, the computer …, the information …

The transcripts reveal that novice and intermediate users are aware of files and servers, and that servers can be down. But as to what a server is and its exact role in web browsing, or indeed which part of the Web address is the server, they are not sure. One reason could be that the Web address is displayed in Web browsers as one long string, and so does not facilitate breaking it down into its individual components. Another reason could be that the error messages were not very helpful (bearing in mind that this did not mean that the expert users could not diagnose the breakdown situations).

3.3 Summary

The data showed that novice and intermediate users did not have users' models appropriate for coping with 3 common breakdown situations relating to Web browsing. The explanations given by the novice and intermediate users were on a higher level (a problem with the address as opposed to a problem with the server

part of the address) than those given by the experts, indicating that their users' models were too vague to confidently provide detail. However, it could be argued that less confident users' attempts at diagnosing the cause of the breakdown situations were hampered by poorly worded error messages.

The study was followed up by another study in order to investigate intermediate users' models of Web browsing independently from the breakdown situations in order to investigate if the novice and intermediate users' inability to correctly diagnose the breakdown situations was purely due to poorly phrased error messages.

4 STUDY 2

This study consisted of 5 in-depth interviews with (self-assessed) intermediate Web users. In the in-depth interviews it was possible to pursue the participants' statements in order to gain a better understanding of their users' models. Pursuing users' explanations in Study 1 in a similar manner would have been disrupting to the overall task of the experiment.

4.1 Method

The interviews were semi-structured and contained questions regarding error messages, vocabulary and how the Web works. Each interview lasted approximately 45 minutes. The interviews were recorded on audio tapes and transcribed.

4.2 Results

The results confirmed the results from Study 1. The in-depth interviews showed that intermediate users have patchy users' models of how Web browsing works, and in particular about the role of servers and about how the Web address relates to the server name and file name.

4.2.1 Web vs. Internet

The participants were asked if there is a difference between the Web and the Internet, and if so, to describe the difference. The distinction is fundamental to understanding the different problems which can occur in connection with different Internet applications.

The distinction between the Internet and the Web was by no means clear to the participants, although only one participant had a wrong perception. She believed that the Web is *local*, e.g. university library information, and that the Internet is *global*. The others were unsure about the difference between the Internet and the Web:

> *"I think there is a difference, but I'm not exactly sure what it is." (Participant3)*
>
> *"I think, I mean they are very similar. I think… you would initially say that they are the same thing." (Participants4)*

But despite this, they had the notion that somehow the Web is part of the Internet. Their perceptions were patchy rather than wrong, and their confidence in their users' models was very low.

4.2.2 Word Definitions

In this part of the interview, the participants were asked to define a number of words:

Host, Host name, IP address, Server, Server name, Router, Domain (name), Web address, Web site, Web page, URL, http://

As an aid, they were given a sheet of paper with the following Web address printed on it:

http://www.cs.ucl.ac.uk/staff/l.clark/testpage.html

The participants were not able to divide the Web address up into its individual components. None of the interviewees could correctly identify which part of the Web address constituted the *server name* and *host name*. Both words are often used in both Netscape Communicator and Internet Explorer's error messages and status bars. And none of them could identify *domain name* either – 3 of them suggested that it was "staff" or that it was the entire address up till and including "staff". In current browser design, identifying the server name and the file name and path is essential in order to distinguish between and recover from errors which relate to the Web server and errors which relate to the Web page.

One problem could be that the concept of a *server* is a difficult to understand. There are many different kinds of servers, but they are not always distinguished from one another. Users in larger organisations will, apart from Web servers, encounter email server, file servers and ISP access servers, which all help to confuse the concept. These were some of the definitions put forward:

- Gateway to Internet
- More than just a computer – it's the whole system, links and all
- A hard disk containing the Web pages
- A node on the Internet, things come in and things go out, and connecting local things to global things

4.2.3 Web scenario

The concept of servers was further explored when participants were asked to explain what happens from when a Web address is typed into the browser till the page appears on the screen.

It emerged that the participants had a notion of a "local" Web server. Users do not perceive their own computers to be on the Internet, but that they connect to a "local" Web server, an intermediate which takes care of their Internet business. Requesting a Web page will therefore automatically involve the local server, which forwards the request to the remote Web server. This "local" server was perceived to be either the University Web server or the Internet Service Provider's Web server. And if the "local" *Web* server was down, they would not be able to access the Internet. The reason for this mis-conception could be the array of servers that users come into contact with, as mentioned above, and not quite knowing what a server is, they are all lumped together into Web servers and email servers. Another reason could be that they know that email goes through a local email server, and this idea is then transferred to Web servers.

4.3 Summary

This study confirmed the results from Study 1, which showed that users are not entirely sure of how Web browsing happens. They have vague ideas which show that their users' models are patchy rather than wrong. They are not quite sure of what the Web is as opposed to the Internet, nor are they sure of what a server is. The different components of a Web address are muddled, and so diagnosing and recovering from the breakdown scenarios in Study 1 would be adversely affected by this lack of knowledge.

5 CONCLUSIONS

The studies presented in this paper showed that novice and intermediate users have too patchy users' models of the processes of Web browsing to allow them to diagnose and recover effectively from even the most common breakdown situations.

In order for users to make the most of the Web, they need more confidence, and in order to gain confidence, their users' models of the Web need to be more sophisticated. This will allow them, not only to correctly diagnose and recover from the more common breakdown situations, but also feel more confident in making assessments of potential risks of filling out and submitting forms and credit card details on the Web.

We anticipate that basing designs, both browser design and content design, when applicable, on a design model depicting a simple model of Web browsing, would greatly increase users' ability to diagnose and recover from breakdown situations, and boost their confidence in using on-line facilities. It is not anticipated that users' need very sophisticated users' models of the Web browsing in order to use the Web effectively, but nevertheless a model which depicts the key elements of Web browsing accurately. Metaphors are often used to form the basis of design models, but no suitable metaphor could be found to cover all the key aspects of Web browsing in a suitable way (see Anderson et al., 1994 for a method of evaluating the suitability of interface metaphors). This does not preclude using metaphors for explaining how the individual components of the model works.

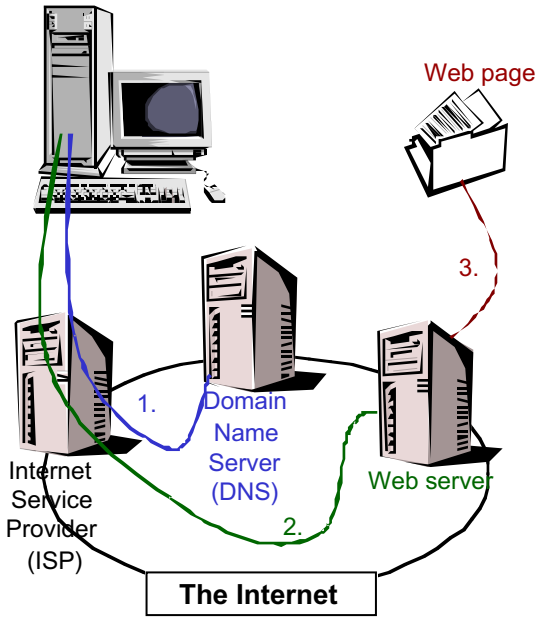

Figure 2: Suggested Design Model for Web Browsing

The model proposed (see Figure 2), which is specific to Web browsing, is very simple, and should be seen as a high level model. The model can then be expanded further if and when it is needed. The model has not been validated at the time of writing, but it has been incorporated into the error messages of a Web browser, which will be used in an experiment comparing them to the "friendly HTTP error messages" of Internet Explorer 5.

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