Chapter

A Link-Click Lifecycle on the Screen

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Abstract

In some sense, links are the writer's clicks, while clicks are the reader's links. Links build a document structure, and act as browsing cues. Clicks build a browsing structure and force the browsing context to change. This contextual change affects the reader's prediction. To provide a comprehensive frame for the chained reactions around clicks and links, we propose a link-click lifecycle model, which consists of six stages: the fading-in, attracting, focusing, clicking, linking, and fading-out stages. To see the effectiveness of our lifecycle approach, we looked at the two popular Web browsers, Netscape and IE. They seem immature in managing the chained reactions by links and clicks.

Keywords: Link-click lifecycle, Browsing, Document interfaces, and WWW

1. Introduction

"Links are the writer's clicks, while clicks are the reader's links."

What we propose in this paper is a short lifecycle model to explain the chained reactions around clicks and links. Links and clicks are two sides of a coin. Structural negotiation between the author and the reader happens on the screen over links from the author and clicks from the reader. Browsers help this negotiation. The inter-reactions between clicks and links during browsing have to be defined well. However, these have not been investigated thoroughly.

Browsing Web documents is an iterative process. Neisser's Perceptual Cycle [8] is a useful conceptual model to understand the browsing and Norman's Cognitive Engineering Model [10] provides an engineering way for it. In addition, prediction seems an essential concept to understand the reader's cognitive transition resulting from the clicks on links. Shannon's uncertainty is a useful theory to mathematically express this. Based on these models and concepts, we built a link-click lifecycle model of six stages. We then looked at the two popular Web browsers, Netscape 4.0 and Internet Explorer 4.04, to see the effectiveness of our model. In the last section, we conclude our work so far and discuss future work.

2. Browsing Web documents

2.1 Browsing through links

Readers have their own reading models [2, 3, 4, 6]. They like to read the documents in the form of an inverted pyramid structure [2, 3, 7, 9]. Their components need to be small, concise, scannable, and objective [7]. These components are related by links in the Web, as Fig 1 shows. This role of links makes them act as browsing cues [1, 7, 9]. Therefore, the reader tends to browse Web documents through links.

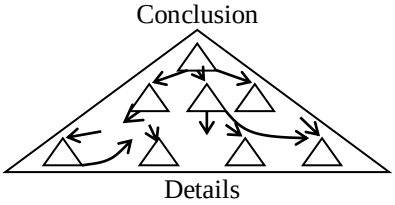

Fig 1: Inverted pyramid document structure

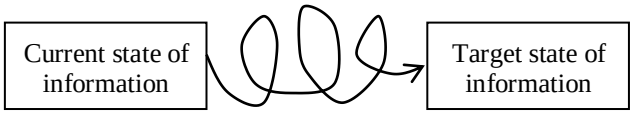

Fig 2: Cyclic journey of browsing

Cyclic journey of Web browsing

Browsing documents is an iterative and evolutionary process as Fig 2 shows. Browsing Web documents can be characterised by iterative navigation through the links and clicks on the screen. When you browse through Web documents, you see links on the screen, examine them, select one of them, and see new links. Interpreting this process from the viewpoint of links, a link appears on the screen, attracts the reader, wins the reader's click, and disappears from the screen.

2.2 Conceptual browsing cycle

Looking into the browsing cycle shown in Fig 2, there are three major objects acting in the journey. These are the reader, the browser, and information. Neisser's Complete Perceptual Model [8] is an integrated model of learning, perception, and activity, and is a good reference to understand the properties of browsing cycles. Fig 3 shows a conceptual browsing model of the chained reactions, which is derived from the model. Cycles repeat until a satisfiable level of information is reached.

In this cycle, the reader modifies her/his own plan as predicting the result of a new plan. The plan as a reader's intention directs the browser to explore its own information resources. This direction is implemented by a set of clicks on the screen. Clicks implement the reader's plan for exploration. This relationship is shown well in Shneiderman's Object/Action Interface (OAI) Model [14]. OAI can be a good conceptual model for the implementation of document interfaces, even if it does not provide any details on how to identify tasks and interfaces. The wrong plan based on a wrong prediction produces useless clicks and useless context changes, which introduces new cognitive load. Therefore, saving clicks is important. There are two ways to do this.

- One way is by supporting the reader not to make a wrong prediction to avoid useless clicks.
- The other is by providing click-efficient interfaces according to task purposes.

Prediction with user interfaces

Information reduces uncertainty in prediction. The deviated prediction makes the disorientation worse. To reduce the chances of deviated prediction, user interfaces should have sound structure and sound procedure (see below). Shannon's uncertainty measure, $H = - \Sigma P \log_2 P$ [13], shows that reader's prediction is governed by the number of information items and their probabilistic distribution on the user interfaces. Attributistic Information Theory also claims that the structure of interfaces affects the information [5]. This effect is likely to be from the gap between the information structure and the user interface structure. On the Web media, non-sequential relationships between information items can be implemented unlike paper-like documents. In addition, Dillon's experiment [3] shows that readers have their own reading processes. This also affects the reader's prediction.

Sound coupling

Sound coupling is a necessary condition for a sound document structure and smooth browsing through links. To be semantically sound, a link should have a message that is semantically the same as the topic of its destination. If a page has any semantically unsound links, the reader may meet the wide gulf of evaluation after clicking them by impairing the reader's prediction. To be syntactically sound, a link should reach an encapsulated unit of a page. Web pages evolve over time so that a link to somewhere within a page is unstable in keeping the link message and its contents consistent. Syntactically unstable links are easy to transform to the semantically unsound links, which induce a high potential uncertainty. Modularity has an important role, again.

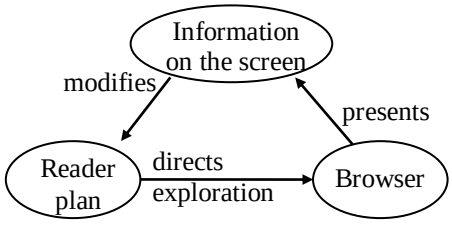

Fig 3: Conceptual browsing cycle

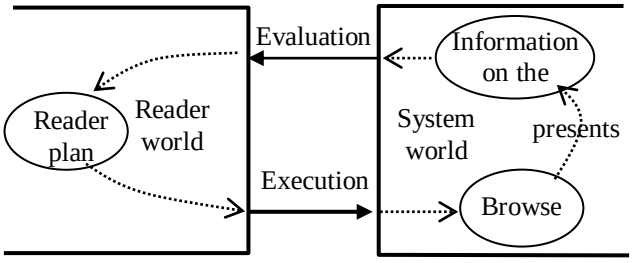

Fig 4: Cognitive engineering model for browsing

2.3 Cognitive engineering model for browsing

The conceptual browsing cycle model shown in Fig 3 can be transformed into a cognitive system model by referring to Norman's Cognitive Engineering Model [10]. Fig 3 shows the model. To select a link while browsing, you may follow the following algorithm for the evaluation in Fig 4:

1. Syntactically perceive a link on the screen.
2. Semantically examine it.
3. If the link is interesting, then focus on it for more information; otherwise, go to step 1.
4. If the link is worth following, then select it; otherwise go to step 1.

As the result of the evaluation, a click is made and then the browser may perform the following procedure:

1. Accept a click as a reader's command to the browser.
2. Perform the functions corresponding to the click.
3. Remove old interfaces from the screen.

This procedure does not exactly represent the execution in Fig 4, because the execution of Norman's model is just clicks on the Web interfaces. We redefine the execution as the cognitive process until the first responding information appears on the screen. This is because the waiting time is not related to the reader's browsing goal. These procedures of evaluation and execution during browsing can be regarded as a kind of lifecycle, which is built by links and clicks on the screen.

3. Link-click lifecycle

Browsing Web documents is an iterative navigation through links by clicks as shown in Fig 1 to 4. Links and clicks are the major interaction components so that the chained reactions around links and clicks need to be considered from that viewpoint. Links stand for the author's structural intention. Meanwhile, clicks stand for the reader's structural intention. These two intentions interactively negotiate on the screen through the links and the clicks. Fig 5 shows the negotiation process as a short but iterative lifecycle on the screen. The procedures of evaluation and execution of the cognitive engineering model for browsing Web documents is translated into the six stages of this lifecycle.

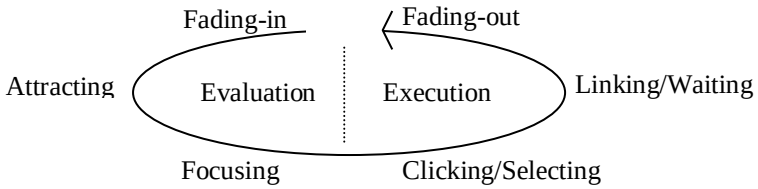

Fig 5: One cycle of link-click reactions on the screen

Fading-in: Some of the built-in links in the document fade in on the screen by manipulation such as scrolling, simple swapping, and linking. This stage is a gate for new information so that abstracted conclusive information instead of fully new information is more favourable to the reader according to the experiments [3, 4] and [7]. It helps the reader's smooth topical transition to the full new information. In the case that interfaces transit at once, visual promptness is important to the reader [11]. Transitions over time should be considered because networking is usually time-consuming. Time delay allows the reader to lose her/his concentration on a topic as time goes on. The order of fading-in also affects the reader's choice of a link. Browsing the Web document falls in this case.

Attracting: The faded-in links are seen as browsing cues. For the reader, links are opportunities for more information [9], clues for the credibility of documents [7], and chances to improve task performance [1]. They compete to get a focus. In the quantitative view, the more links mean the higher choice uncertainty. The uniform distribution of the links on the screen will produce the highest uncertainty, according to Shannon's uncertainty [13]. This clearly explains why the front pages of newspapers are composed as they are. In these pages, the number of news items are much smaller than that of the other pages and the items are different in their location, shape, and colour, which control the probability distribution of the items. Another important characteristic on the front pages is the directness in information representation, which makes the fast

information extraction possible. Selection of a news item on the pages depends on how much it is relatively attractive to the reader. Those attracting methods in the newspaper paradigm seem to suit the Web documents as well. Besides those static methods, dynamic methods can also be useful.

Focusing: This is the stage for the reader to actually express her/his interest in a link on the screen. The most attractive link gets into the focusing stage by locating the indicator on it. The indicator changes its shape to show the stage has changed as the Guide system does. Internet Explorer adds a border box around the link boundary. Besides these progress indication methods, some other prediction aids are needed to decrease the uncertainty about what is to come up next. Helping prediction can be done by showing link intention or the overview of the connecting page. Those aids help the reader to deal with their predictions well.

Clicking/Selecting: This is the implementation stage of the reader's interest in a link. A link is hard-selected after being soft-selected at the focusing stage. This stage usually quickly moves to the linking/waiting stage. The indicator changes again to show the changed stage. At this stage, the information such as the destination profile, the network speed at that time, and the estimated transmission time helps the prediction to the next stage. Based on this information, the reader makes one's last decision considering physical condition. So, one's late decision of cancellation should be supported to minimise useless navigation and time spent.

Linking/Waiting: The roles of the links on the screen are suspended at this stage. The browsing task is also suspended, as the new page has not been up yet. In browsing Web documents, the waiting usually depends on the network and processing performance at that time. The current links on the screen are ready to fade out. Real progress information will help the reader to accept the situation. Time management is required to avoid getting bored or losing information so that the reader can keep the current uncertainty level at least. Some lubricant information for the coming page such as its profile and overview at the previous stages will be helpful. In addition, the navigation thread will help the reader to know their navigation direction.

Fading-out: All the links on the screen fade out after completing their roles to switch the reader to a new document. This transition can happen either at once or over time like that at the fading-in stage, but the time is fully manageable. The reader's working memory also moves to a new state.

4. Case study

4.1 Lifecycle management in two Web browsers

The data on Table 1 have been collected by examining the two systems, so they may not be their whole features related to this lifecycle model.

Both systems seem to be modelled in three stages such as the before-selection, selection, and after-selection stages instead of six stages, which emphasise the focusing, clicking stages. In time management, they have not considered the time well as a critical design factor. The useless time delays at the fading-in, fading-out, and linking stages happen. These unmanaged delays may accelerate the reader's forgetting or getting bored, so the prediction is critically damaged. In vision management, they seem to well manage the vision with the cursor shape, the link colour, and the pop-ups. However, pop-up methods are not well utilised for the prediction as they have the pop-ups only for image links, but none for text links and the pop-up duration is fixed regardless of the pop-up length. Visibility seems to have not been well considered. In summary, these two popular systems do not effectively support the reader's prediction for the smooth lifecycle transition. Hence, you have to build them onto your documents if you wish to provide prediction aids on these systems.

4.2 Suggestions

Some methods for the browser implementation of this model are suggested. However, these are not suited for all browsing tasks. For example, browsing Web news is different from browsing Web mails.

- Fading-in: Management of time and presentation order
  - Short abstract of the coming document should be provided before main document comes up.
  - The first screen should be displayed as soon as possible to avoid the reader’s getting boring.

Table 1: Link-click lifecycle management in two Web browsers

Stages	Netscape 4.04			IE 4.0		
-	**Link**	**Pointer**	**Others**	**Link**	**Pointer**	**Others**
Fading-in	Not managed fading-in over time	Arrow	-	No tmanaged fading-in over time	Arrow	If arrived in 5 secs, the pop-up overlaps for the rest of time duration.
Attracting	Blue for the not-visited Magenta for the visited	-	-	Blue for the not visited(Always) Blue for the not visited(Hover) Magenta for the visited (Always) Magenta for the visited (Hover)	-	-
Focusing	-	Hand indicator for links I-shape cursor for normal text	One long-line pop-ups for image links: ~0.5 sec wait and ~2 secs stay No pop-up for text links	Blue(Hover) Magenta (Hover)	Hand indicator for links I-shape cursor for normal text	Multi-line pop-ups for image links: ~0.5 sec wait and ~5 secs stay No pop-up for text links
Clicking / Selecting	Red after btn-down No change for image links Reversed blue when cancelled	No basic change but back- slash-in-a-circle cursor for cancellation	Pop-up disappears if btn-down within ~2 secs	Blue for the not visited in a box after btn-down Magenta for the visited in a box after btn-down Image in a box after btn-down	No basic change but back-slash-in-a-circle cursor for cancellation	The pop-up disappears if btn-down within ~5 secs.
Linking / Waiting	Blue for the not visited Magenta for the visited	Sand clock	Not managed waiting till the 1st screen presentation ready	Red in a box	Sand clock with an arrow	The same pop-up re-appears & stays ~5 secs Not managed waiting until the 1st screen is ready
Fading-out	Fading-out at once	-	-	Fading-out at once	-	-

  - If the fading-in document is in the browsing thread, the fact should be notified to the reader.
  - The spring-out of new document from its source link clearly refreshes the relationship.
  - In the case of back or forward fading-in, the previous screen context should be kept
- Attracting: Differentiation of links by the browser
  - Link usage log needs to be visualised on the link by gradual change of colour.
  - All the links pointing to the visited pages need to be notified. The visited links need to differentiate from the links that are not visited but point to the visited pages.
  - Visualisation of the link normalisation based on the hit rates to the destinations can be helpful.
  - Visualisation of the freshness of the destination document can be helpful [12].
  - Removing link properties on the screen can be helpful for sequential reading.
- Focusing: Provision of link intentions or summaries
  - Link intentions need to be delivered to the reader as pop-ups.
- Clicking/Selecting: Provision of profile
  - Destination profiles and time prediction will be helpful for the reader's last decision.
- Linking/Waiting: Time utilisation
  - The shorter, the better. Progress should be continuously reported based on time.
  - Current navigation thread of links will be helpful to know the browsing direction.
- Fading-out: Fade-out at once or animated fade-out
  - Fading-out by spring-out of a document from a link refreshes the connection.

6. Conclusions

Web browsing is an iterative and interactive negotiation process between the author and the reader, which happens on the screen. Documents represent the author's intention, the browser presents the documents as user interfaces, and the reader navigates the documents through the interfaces on the screen with the browser. Links and clicks are essential when browsing through Web documents.

We proposed an iterative link-click lifecycle model, which consists of the six stages: the fading-in, attracting, focusing, clicking/selecting, linking/waiting, and fading-out stages. Through these stages, the interfaces, information on them, and the reader's mental status change. As a case study, the two popular Web browsers, Netscape 4.04 and IE 4.0, have been analysed from the viewpoint of our link-click lifecycle model. These two systems are a little different in managing the link-click lifecycle and seem immature. We suggested some methods for improvement.

Different browsing tasks are performed by different browsing patterns. If the patterns can be identified, the corresponding document patterns seems to be able to be defined. Then, the link-click lifecycle can be specialised to browsing tasks. Our next step will be on this issue.

References

[1] Baron, L, Tague-Sutcliffe, J, Kinnucan M, and Carey, T, Labelled, Typed Links as Cues when Reading Hypertext Documents, Journal of the American Society for Information Science, 47(12), 1996, 896-908.

[2] Dillon, A., Richardson, J., and McKnight, C, The Human Factors of Journal Usage and the Design of Electronic Text, Interacting with Computers, 1(2), 1989, 183-189.

[3] Dillon, A., New Technology and the Reading Process, Computers in Library, June 1991, 23-26.

[4] Dillon, A., Readers' models of text structures: the case of academic articles, International Journal of Man-Machine Studies, 35, 1991, 913-925.

[5] Dubrau, G, The Attributistical Understanding of Information, SIGCHI Bulletin, 28(4), 1996, 79-84.

[6] McNamara, T., hardy, J., Hirtle, S, Subjective Hierarchies in Spatial Memory, Journal of Experimental Psychology: Learning, Memory and Cognition, 15(2), 1989, 211-227.

[7] Morkes, J., and Nielsen, J., Concise, SCANNABLE, and Objective: How to Write for the Web, Sun Microsystems, 1997, At URL: http://www.useit.com/papers/webwriting/writing.html.

[8] Neisser, U., *Cognition and reality*. San Francisco: Freeman, 1976.

Nielsen, J., Inverted Pyramid in Cyberspace, Alertbox, Sun Microsystems, 1996, At URL: http:// www.useit.com/alertbox/9606.html.

[9] Norman, D.A., Cognitive engineering. In User Centered System Design (Norman D. and Draper S. Eds), Hillsdale, NJ: Lawrence Erlbaum Associates, 1986, 31-61.

[10] Robertson, C.K., McCracken, D., and Newell, A., The ZOG approach to man-machine communication, Intl. Journal of Man-Machine Studies, 14, 1981, 461-488.

[11] Sakagami, H., Kamba, T., Sugiura, A., and Koseki, Y., Effective personalization of push-type systems – visualizing information freshness, WWW7, 1998, At URL: http://www7.conf.au/programme/fullpapers/ 1871/com1871.htm

[12] Shannon C.E., A Mathematical Theory of Communication, The Bell System Tech J., 379-423, 1948.

[13] Shneiderman B., Designing Information-Abundant Websites: Issues and Recommendations, 1997, At URL:http://www.cs.umd.edu/projects/hcil/ijhcs-copy/ijhcs.html