Hypertext interactivity: From choice to participation

Abstract

Much of hypertext narrative relies on links to shape a reader's interaction with the text. But links may be too limited to express ambiguity, imprecision, and entropy, to allow appropriate control and access to information, or to admit new modes of participation short of full collaboration. We use an e-book form to explore the implications of freeform annotation-based interaction with hypertext narrative. Readers' marks on the text can be used to guide navigation, to create a persistent record of a reading, to enable fluid exploration and revisits, or to recombine textual elements as a means of creating a new narrative. In this paper, we describe how such an experimental capability was created with XLibris, a next generation e-book, using Forward Anywhere as the hypernarrative. We work through a scenario of interaction, and discuss the issues the work raises.

KEYWORDS: hypertext narrative, annotation, pen-based computing, e-books

INTRODUCTION

In If on a Winter's Night a Traveler (Calvino, 1981), Italo Calvino proposes a story idea in which two writers, one productive and one tormented, produce two separate novels, each appropriating the style of the other. Calvino goes on to enumerate different possible outcomes for the writings, all involving a young woman who is the reader. Among the many endings, he gives the following account:

"A gust of wind shuffles the two manuscripts. The reader tries to reassemble them. A single novel results, stupendous, which the critics are unable to attribute. It is the novel that both the productive writer and the tormented writer have always dreamed of writing." [p. 175]

The novel now has many hypertextual qualities: It is polyvocal, non-linear, and participatory. Lexias (discrete units of text such as Web pages or nodes in a hypertext system (Landow, 1992)) have been reassembled and recombined to make a new story. Despite the ultimately linear reading—the young woman forms the pages once again into a novel—the novel has become interactive. But what is the nature of this interactivity? It is not the point-and-click interactivity that is commonly associated with hypertext. Nor is there full collaboration between the two writers and the reader; instead, the participation is unintentional, unacknowledged, unanticipated. The reader's engagement with the text has been shaped by forces of nature (the wind), not by a thoughtfully designed user interface.
In this paper, we examine the qualities of hypertext interactivity beyond the navigational click. Is there something special about hypertext interactivity? Espen Aarseth makes a useful distinction between the interactivity that is central to computer games and interactivity as it is implemented in hypertexts. He proposes an adjective, *ergodic*, to describe a sequence of events that has been produced by "nontrivial efforts of one or more individuals or mechanisms." (Aarseth, 1997) He goes on to say:

"...we may conceptualize the difference between narratives, games, and hypertexts as follows. Narratives have two levels, description and narration. A game such as football has one level, the ergodic. A video game (e.g. Atari's Pac-Man) has description (the screen icons) and ergodics (the forced succession of events) but not narration (the game may be narrated in a number of ways, but like football, narration is not part of the game). A hypertext such as Afternoon has all three: description ("Her face was a mirror"), narration ("I call Lolly"), and ergodics (the reader's choices)." [p. 95]

In Aarseth's example, interaction with hypertexts is reduced to choice. But the notion of ergodics admits the possibility of other modes of interaction. In the transition from interaction with the physical world to interaction with the electronic, much of the ambiguity, imprecision, entropy, and indeed all the many ways in which we participate in events and the narration of events has been turned into binary choice, to click or not to click. Even when the link and its anchors are generated dynamically, the typical interaction is still the primitive click. The ergodic level of electronic texts need not be limited in such a way.

Thus designing interactive hypertexts should include a renegotiation of our relationships with our machines—subverting the fixity of the link and the monotonicity of the click. How can we best do this? In the remainder of this paper, we propose an extended model of interactivity in hypertext both in terms of navigation and spatial expressiveness. We focus on the nature and quality of the interaction, rather than on the larger organizational and systems aspects that typically dominate models of hypertext.

We use three different interfaces to Malloy and Marshall's collaborative hypernarrative *Forward Anywhere* (Malloy and Marshall, 1996) as a foil for discussing how this model plays out in implementation: a web-based interface (Web/Forward Anywhere), a proprietary hypertext reader (Eastgate/Forward Anywhere), and an e-book interface (XLibris/Forward Anywhere). The design of the third interface, based on XLibris (Schilit, Golovchinsky and Price, 1998), is presented in detail, and is used as a way of illustrating the model. We then discuss readers' impressions of this interface, and what it suggests for future work.

**A MODEL OF HYPertext INTERACTION**

Hypertext interfaces come in many forms. Some restrict the user to following fixed links; some adaptive hypertext systems vary the available links based on a user or data model; yet others provide more complex operations. In our attempts to explore the space of hypertext interactivity, we considered nodes and links as first-class citizens. In this section, we describe this model of hypertext interaction, and use it to compare several well-known hypertext interfaces. We capture the quality of interaction—what the reader does—rather than considering how the system implements that behavior.
Many theories of hypertext and information seeking have been described in the literature. While they have addressed various high-level issues such as the social and organizational contexts (Marchionini, 1995), representations of users’ cognitive states (Belkin, Oddy, and Brooks, 1982), and expertise (Borgman, 1986), these models either avoid issues of interaction, or assume straightforward queries or hypertext links.

Waterworth and Chignell’s (1991) model of information exploration does touch on interaction. It describes a model of information exploration consisting of three dimensions: structural responsibility, target orientation, and interaction method. Structural responsibility specifies who—the person or the computer—is responsible for manipulating the structure of document (e.g., person follows links, computer manages full-text index). Target orientation represents the degree to which the person has a clear target (document) in mind prior to searching (e.g., looking for the New York Times article of September 7, 2000 titled “A New Gulf War Study Fails to Find the Cause of Illnesses”) or whether the target is open-ended (e.g., looking for information about the Gulf War Syndrome). Interaction method refers to the nature of interaction: does the user describe the desired information (e.g., by typing keywords), or refer to explicitly (e.g., by title). Two dimensions—interaction method and structural responsibility—merit closer attention.

The advantage of almost a decade of interface innovation has afforded us many examples of systems that do not fit cleanly into Waterworth and Chignell’s model framework. The interaction method dimension attempted to capture the quality of interaction: it postulated a continuum from the descriptive to the referential, from typing a query to following a link. The model’s power stems in part from this unification of two interaction techniques traditionally held to be unrelated. In both extremes, however, it treated the connections between nodes as second-class citizens: the reader either described a node or referred to it. Thus it failed to distinguish among the variety of ways in which navigation is realized and confused issues of interface with those of underlying computational mechanisms.

For this reason, the interaction method dimension appears to be confounded with the structural responsibility dimension. The structural responsibility dimension of Waterworth and Chignell’s model represents the extent to which the system or the user is responsible for carrying out search, for identifying the destination of navigation. It fails, however, to capture the nuance of hypertext interaction. If a system performs a calculation based on user activity to create links that the reader subsequently traverses, does structural responsibility lie with the system or with the user?

How different are links from queries really? VOIR created anchors on the fly, and used queries derived from the context of selected anchors to resolve the links (Golovchinsky, 1997). In VOIR queries looked and acted like links. Similarly, XLibris (21) uses a reader’s annotations to select terms for queries, but navigation is accomplished by tapping on a link anchor. Other examples of query-mediated links have also been described (e.g., Phrasier (Jones and Staveley, 1999), Paraphrase Search Assistant (Anick ad Tipirneni, 1999)). These examples suggest that although systems may be implemented in quite different ways, users need not always be aware of the differences. When modeling interaction, it seems more important to represent interfaces from the user’s perspective rather than from the software system’s.

From a hypertext perspective, it may be more useful to think of interaction in terms of two dimensions—how the reader expresses navigational intent, and how information is presented in response. These are analytical dimensions; real interfaces may combine aspects of both to produce interaction: click on an anchor, see a page; drag a node to position it with some others, etc. Roughly speaking, they correspond to the conventional hypertext notions of links and nodes, respectively. We discuss these dimensions in turn below.

Navigational expressiveness

Navigational expressiveness can vary from simple page turning or clicking to sophisticated annotation and search interfaces. This dimension (Table 1) is intended to capture the degree of control the reader has over what to see and read next. Can the reader...
merely select among predefined choices? Are selections always explicit, or can the system infer or adapt based on the reader’s behavior? Can the reader request specific information that is outside the context of the current display? Can the reader participate in the link creation process?

<table>
<thead>
<tr>
<th>Choice</th>
<th>Annotation</th>
<th>Search</th>
<th>Ad hoc Linking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Web</td>
<td>ThirdVoice1</td>
<td>Google's &quot;I Feel Lucky&quot;2</td>
<td>CREW3</td>
</tr>
</tbody>
</table>

Table 1. Navigational expressiveness (links)

Furthermore, navigational interaction can serve different purposes. For example, some navigation, such as page turning, supports reading. Other navigation, such as following a link from an index to a help file, supports information seeking. These hypertext interfaces are designed to support the retrieval or discovery of information. Often, however, people navigate not with the intent of reaching some potentially useful node, but rather with the intent of leaving a not useful (or no longer useful) one. This may be because they accidentally selected a wrong link, because it wasn’t clear from the anchor what the destination would be, or because they found what they were looking for and wish to return to some previous location. Furthermore, the user may desire to return to a place visited "long ago" rather than just recently.

These are qualitatively different kinds of navigation that require different interfaces. Typical web browsers provide a "back" button to step through the interaction history, serving both the short-term and more historical back-tracking purposes. Such implementations have significant usability problems due to the way long-term history is handled. As described in Beiber and Wan (1994), web browsers prune previous branches when a new anchor is selected following a backtracking episode. This pruning often causes confusion and frustration because recently-visited information may no longer be easily accessible.

To a certain extent, we can think of navigational expressiveness as the temporal dimension of hypertext. Not only does time extend into the future by way of navigational choice or path following, but also into the past by way of path-tracking or history mechanisms (e.g., Trigg, Suchman and Halasz, 1986). The temporal dimension need not be maintained strictly on the basis of nodes visited (and revisited) and links followed, but rather it may reflect other levels of reader activity.

In a redesign of XLibris, we implemented three kinds of temporal navigation related to backtracking: the conventional back button, a short-term history, and an immediate navigational “undo.” The conventional back button is familiar to web browser users. Although it was absent in the standard XLibris interface, we introduced it in XLibris/Forward Anywhere to retain familiar functionality. Based on usability problems of two designs for backtracking, we chose to make it easier to re-specify a location visited long ago than to back up to it. In certain cases it seemed easier to move to the future rather than to the past.

The short-term history is the second kind of temporal navigation in XLibris. It reflects visited document pages, and also other views onto the reader’s workspace. Figure 2 shows such a history. From this view (arranged left to right in order of appearance), the reader can ascertain that she was looking at a document, a list of documents, a search result, a set of annotations, and a notebook page, since the views are each visually distinctive. Views are "recycled" in this history: if the reader revisits a view that is already in the history, the existing item is emphasized with a dark border (as shown in Figure 2), but no new item is added. This history is not strictly chronological; rather it provides a visual memory of recently-viewed information. We preferred spatial stability to temporal consistency to reinforce the visual nature of the interface and to minimize the potential confusion among similar-looking views: if the thumbnail images in the overview were ordered strictly chronologically, switching to a prior view would require us to reorder the thumbnails. But readers could be confused by the change in spatial position when some of the views look alike. Thus we chose to combine the

\[1\] http://www.thirdvoice.com/
\[2\] http://www.google.com/
\[3\] http://raven.ubalt.edu/features/crew/
spatial and the temporal aspects of this navigational control to minimize visual confusion while still providing an overview of the recently-visited locations.

Finally, we introduced a new immediate backtracking button, labeled “Back,” placed near the destination of a link after the link has been traversed. This button serves two purposes: it identifies the target visually, and it provides an obvious way for “undoing” the navigation. The design encourages the user to treat the back button not as a static widget, but as an "undo" operation. In a way, it is similar to the back button found in Web browsers; it differs, however, in its location and in its scope. The button is placed near the target of the forward link to underscore its temporary nature (Figure 3), and persists only while the reader remains in the target view. If the reader jumps to a recent view (via the history mechanism, for example) or to another view via a view selection button, the back button is removed as it probably won’t be meaningful to the reader when that view is revisited in the future.

Spatial expressiveness

Spatial expressiveness can range from requesting the display of a single node, to arranging lexias spatially, to recombining sub-lexical units programatically or manually, to creating new lexias (Table 2). This dimension represents some interesting possibilities: several lexias displayed at once (Halasz, 1987), pieces of lexias recombined to produce new perspectives (e.g., Lines feature in Web/Forward Anywhere), lexias juxtaposed spatially to reflect new interpretations (Marshall, Shipman and Coombs, 1994), and even perhaps the faintly Borgesian idea of a multitude of novels formed from the same set of words, or Burroughs’ notion of cut-up narratives, in which words are realigned in arbitrary ways to form new meanings. (Burroughs, 1973) We use the term recombinant hypertext to describe this interaction style.

<table>
<thead>
<tr>
<th>Lexic recombination</th>
<th>Sub-lexical recombination</th>
<th>Morphemic recombination</th>
<th>Authoring</th>
</tr>
</thead>
</table>

It is interesting to note that the logical extreme of both kinds of expressiveness is the creation of new structure or content. In the extreme case of navigational expressiveness, a reader’s choices become integral to the work. This spirit is captured in a manner by the intimate relationship between the narrator and the Reader in If on a Winter’s Night a Traveler, and is certainly reflected in Malloy and Marshall’s collaboration on Forward Anywhere. Co-authoring need not be synchronous or even collaborative: space plays an important role in the layers of commentary and annotation that are the Talmud.

FORWARD ANYWHERE—THE TEXT

Forward Anywhere is a collaborative hypnarrative written by Judy Malloy and Cathy Marshall. The hypnarrative, begun as a bridge between art and research, is the result of a two-and-a-half year effort in which the two authors exchanged stories from their lives. Over time, it became "a single hallucinatory vision made up of two pasts.” (Malloy and Marshall, 1996)

The hypnarrative was created via email through an accretion of several hundred exchanged episodes. Each memory formed a lexia that was used as a stimulus for evoking others. Thus, while the project was in progress, the authors received each other’s writings as email. For example, a message such as this one:

From: Catherine Marshall <marshall>
To: Judy Malloy
<jm@well.sf.ca.us>
Subject: western king
We had a western king sized bed:
That's 7 feet by 7 feet, 49 square feet of dense
green, fire-retardant foam rubber.
We weren't speaking, I guess.
He wasn't speaking to me anyway.
He slept with his head at the foot of the bed
and his feet even with my face, but very far away.
We had separate blankets so I couldn't steal the covers during the night.
evoked this response:

Date: Thu, 28 Oct 1993 21:13:21 -0700
From: Judy Malloy
<jm@well.sf.ca.us>
To: marshall@parc.xerox.com
Subject: blue bed
We had a waterbed. It was blue --
blue plastic --
translucent so that after several years you could see the mold growing inside.
I hated the way it rolled around when we moved.
I like beds to be solid
under my body -- like floors.

The two authors thus experienced the work as an unraveling mystery. Each new episode was not only a response to messages that had passed back and forth before, but also an invitation, a veiled question. Each episode was also an opportunity for unexpected congruence as newly introduced topics became shared.

After the authors had amassed a significant amount of material, the question then became how to convey to the reader a sense of what it felt like to participate in creating the hypernarrative. What shape should the interaction take? The authors did not experience the work as ambiguity-free and potentially linear as the reader would if the text were presented within a conventional hypertext framework of anchored links. Furthermore, the authors themselves were not always certain of what lexia (or lexiyas) provoked a particular response; pinning a link anchor to particular words would be over-precise and would not give the reader a good sense of the process.

Would spatial structure be sufficiently expressive to convey the writers' joint sense of the work? Moreover, what shape should the reader's interaction with the work take? Figure 4 shows a portion of a structural diagram Marshall attempted to draw to show her perception of the relationships among the lexia. It quickly became apparent that a standard link map was not capturing the spirit of the work, let alone its structure. Even with a very constrained notion of topical influence, the diagram does little to elucidate the complex, elusive, and oftentimes ambiguous relationships among hundreds of nodes.

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Figure 4. Marshall’s preliminary experiment that explores a structure for Forward Anywhere. The diagram shows a fragment of a conventional network-based link mapping technique done by hand.
Experimentation with spatial structure in VIKI proved similarly frustrating. Figure 5 shows a portion of this structure. Because it is possible to juxtapose the lexia, and to create multiple references to the same lexia, a spatial structure is closer to expressing the structure of the work. Yet it does little to reveal the process.

**FORWARD ANYWHERE—TWO INTERFACES**

Given the authors’ perspective on the hypernarrative—that the work should reveal the process by which it was created; that it should reflect the vagaries of association and memory; that it should invite participation beyond clicking—they arrived at an initial design for the work, one that could be implemented on the Web, as well as in other hypertext delivery mechanisms.

In Web/Forward Anywhere, there are three kinds of controls. The first control is called **Forward**. Forward re-creates the chronology of the work's creation; it is a literal record of Malloy and Marshall's process. A screen is linked to the next screen that appeared in email, in the order they either first wrote or read it. This allows the reader to experience the same mysteries that the authors experienced: surprising intersections, dead-ends, and the organic, unpredictable introduction of new topics. This chronological pathway through the work is, in fact, an essential mode of reader interaction.

The second way interaction is realized in Web/Forward Anywhere is through an **Anywhere** control. It uses a random number generator to bring the reader to a new place in the work. Judy Malloy used this technique in *its name was Penelope* (Malloy, 1991) it very much conveys the quirkiness of human memory. It is also very effective in simulating the effect of dense interconnections: if every screen in Forward Anywhere builds in some way on what the authors have written and read before, shouldn't all the screens be implicitly related and equally likely destinations? Note that while this mode of reading is very different than Forward interaction, they fall into the same slot in our taxonomy of interaction.

The third kind of interaction in the Web/Forward Anywhere invites participation, given the limitations and affordances of the Web. It also reflects the authors’ original motivation to investigate the connections between the lives of researchers and artists. **Lines** entices a reader to gather together screens related by a single thread, and thus moves the reader along the interaction continuum to the search-and-lexical recombination types of interaction shown in Table 1 and Table 2. Lines works by allowing a reader to simply type in a word, and uses that word as a keyword in context: a new screen is composed from lines of other screens that contain that word. Figure 6a, b, and c illustrate a
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sequence of Web pages from such an interaction. In Figure 6a, a reader has entered the word "gun"; Figure 6b shows the screen that results, a constructed set of links to other lexia in the work. Figure 6c shows one possible result of following one of these links.

Later, when the work was published by Eastgate Systems (Malloy and Marshall, 1996), the three modes of interaction were reinterpreted and re-implemented by Mark Bernstein, with an eye toward distributing it as a stand-alone publication, which presented him with a different set of constraints than the Web implementation. Figure 7 shows the Eastgate interface. The first two interaction modes, Forward and Anywhere, are preserved, but although Lines is preserved as an interaction mode, and the navigational result is similar (a reader clicks on a word and the word is used as navigational input), the interactivity feels substantially different. It is transformed from search (unconstrained term input) back to choice (see Table 1); the reader can no longer gather together themes invisible on the current screen, or explore off the beaten path. Of course, the clever reader can always circumvent the implementer's interaction constraints. Stuart Moulthrop, in his reading of Forward Anywhere browsed the sequential data file (Moulthrop, 1997). He could have searched freely there.

The design space around annotations is large, and we have only begun to consider certain aspects. Yet our own readings and re-readings of Forward Anywhere have suggested some promising directions. We explore them in a hypothetical reading scenario below.

Backtracking and pressing Marks again, the reader is confronted with a damp basement kitchen (“Judy: underground places”); a new thread presents itself. Figure 8 shows an annotated passage: the reader has jotted down her reaction to the text. She then flips to the next page, reads that node, and, getting a sense for the theme (brothers, basements, what else?), decides to explore it further. Backtracking to the first screen, she hits the Marks button, that brings up another related (and previously unvisited) node (Figure 9). She reads and annotates it, pursuing the sibling thread. The system, however, matches the teachers and jars theme, and associates it with Cathy’s impression of primary school teachers (Figure 10).

Actually, my brother, whose chemistry set dominated that area of the basement, had lit the newspapers on fire just to see what would happen.

// Backtracking and pressing Marks again, the reader is confronted with a damp basement kitchen (“Judy: underground places”); a new thread presents itself.

Figure 8. A reader’s response to the “Judy: basements” screen (fragment).

SCENARIO

Forward Anywhere is both an experimental text and an experimental interface. Its history, described above, is as much a history of interaction as of interpretation. When our XLibris-inspired thoughts turned to hypertext fiction, they naturally turned to Forward Anywhere. We could easily imagine annotating text, but what would the interface and interaction be like? How would the literary context differ from the research or legal ones we had considered before? Finally, where would these interactions fit into our model?

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Some time later, the reader discovers the eucalyptus tree topic. Intrigued by its recurrence, she marks the passages as she encounters them. Finally, tapping on the Clippings button, she combines the parts into something like a new lexia (Figure 11). This recombined text consists of sentences from four different lexias that form an interesting dialog: trees to fire to trees and back to fire again. The passages are gathered in the order they were read and annotated rather than in the order they were written; the dialog emerges independently of the authors’ intentions.

This scenario reveals several forms of interaction on the link and node level. The Forward, Back, and Anywhere buttons, borrowed from Web/Forward Anywhere, are implemented as traditional hypertext links (choice in Table 1); freeform digital ink marks are used to implement an annotation style of link traversal: the passage selected by the reader’s marks is used to retrieve some other, related lexia. Similarly, annotation marks are used by the Clippings function to select candidate passages. These are pieced together (an instance of sub-lexic recombination) to create a new node. It is important to note that the reader’s marks are not commands to the computer; intrinsically, they are unconscious responses to the text. They may become a source of investigation in their own right as the reader attempts to figure out how they work, but they need not be thought of as interactors. They also allow greater freedom of expression to the reader, expression constrained computationally only by the cleverness of the programmer of the hypertext.

This recombinant synthesis echoes the Lines interface in the Web version, but, in addition to showing the marks, it selects text on a sentence level, often preserving enough semantics to allow the reader to create new interpretations in a natural way, as illustrated by the eucalyptus example (Figure 11). The keywords that caused the new passage to be retrieved are not emphasized; we decided not to emphasize the source of the connections between passages to encourage a diversity of interpretations on the part of our readers. In an informational hypertext, the nature of the connections could be made more explicit by emphasizing the keywords that caused the match.

Freeform digital ink annotation is designed to draw on the familiar practice of marking as you read. People annotate for a variety of reasons, often unconsciously, and such marks do not always have explicit meaning (Marshall et al., 1999). This ambiguity is reflected in the way XLibris/Forward Anywhere interprets annotations for navigational purposes. Whereas good design dictates that link anchors in an informational hypertext should reflect their destination, this constraint is not necessary (and may not always be desirable) in a literary hypertext. The constraint may not be necessary in informational hypertexts either, if annotations are used as a mechanism for eliciting relevance feedback (Golovchinsky, Price, and Schilit, 1999). What works as ambiguity in literary hypertexts may also work as serendipity and ease of use in informational ones.
Previous incarnations of Forward Anywhere captured ambiguity with the Anywhere and Lines buttons, and with the ability to click on arbitrary words to initiate a search. In the XLibris version, we kept Anywhere and used queries based on freeform digital ink as a new way of making unpredictable connections. Borrowing from the Anywhere feature of prior interfaces, the Marks navigational technique does not revisit nodes: matching nodes previously seen by the reader are excluded from consideration. Thus, repeated invocations of Marks from a particular screen will take the reader to a sequence of different, but related, locations. A difference between Anywhere and Marks, then, is that Marks respects the reader’s annotations, whereas Anywhere does not.

In addition to mediating jumps to related passages, freeform digital ink was used to create clippings. Clippings in XLibris/Forward Anywhere can serve several purposes. In their basic form, they provide a visual history of interaction. Each annotated passage is shown with its marks and with links to the full text (Figure 11). The clever reader can, however, take advantage of the different pens and ink color to create sub-sequences, to collect themes, to recombine lexia (cf., Figure 12). The clip button associated with each clipping can be used to preserve these recombined sequences from the vagaries of subsequent inking. The annotated passage is copied to a notebook page in which it may be positioned relative to clippings from other parts of the work. Once clipped, the text may be annotated further; the marks are reflected to the original pages and to subsequently-created annotations views.

INTERACTION IN XLIBRIS/ FORWARD ANYWHERE

XLibris/Forward Anywhere retains much of the paper document metaphor introduced in XLibris (Schilit, Golovchinsky, and Price, 1998). Paginated layout, freeform digital ink annotation, and ink manipulation and search algorithms are all based on the corresponding features of XLibris. Not all features were incorporated without change, however. Reading hypertext fiction differs from reading work-related documents; we tried to capture these differences in the redesigned interface and functionality of XLibris/Forward Anywhere.

We implemented several buttons (borrowed from other interfaces to Forward Anywhere) that controlled navigation between lexias, and added some new controls. The ever-present XLibris ink and navigation controls on the bottom of each page have been replaced by semi-transparent overlays that the user can hide or reveal. The shaded rectangles in the top left of Figure 11, for example, hide the ink palate and the menu items. Figure 13 shows the palette extended in the top-left corner to reveal the ink and highlighter choices. Finer differences were introduced into the way computation was used to augment reading. These will be discussed in turn in the sections that follow.

Annotations

In addition to using the paper document metaphor to structure interaction, XLibris was based on the notion of multiple views. These views included the workspace for viewing and managing all documents, a view for filtering annotations, the notebook for collecting clippings and taking notes (rather than annotating), and a "further reading" list. We made the document view the primary means of interacting with the text, and relegated annotation and search results views to secondary status: they were accessible only from document views, rather than from any view as originally implemented in XLibris. Furthermore, the annotations view was redesigned in several important ways.

Annotations (with the corresponding passage) were displayed in XLibris in a paginated vertical list in which each item corresponded to some annotated
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passage. Items were separated visually with shading, and included some metadata that described the corresponding documents. This design was based roughly on conventional search results displays that provide sufficient residue to allow the reader to decide whether a link is worth following or not.

To foster the sense of recombinant text, we changed the presentation in several subtle ways, as shown in Figure 12. Shading and background were removed, metadata identifying source documents were not shown, and clippings were arranged to fit the page in a manner resembling normal Forward Anywhere lexia.

Whereas in XLibris the reader was encouraged to distinguish the different views, in XLibris/Forward Anywhere we tried to mask the differences. Although it is still easy to tell the views apart (the left margin in the annotations view holds anchors to the lexias), the reader is encouraged to treat the different views similarly. We did not want the interface to interfere with the ability to construct new lexias, with the possibility of creating new texts.

Finally, XLibris/Forward Anywhere annotations differ slightly from XLibris clippings in the way that the bounding area was computed. XLibris calculated the bounding box of each stroke, expanded it to the nearest line height (to create legible passages), and merged overlapping clippings. XLibris/Forward Anywhere extended this algorithm by clipping text at sentence boundaries rather than at line breaks. This change made it possible to combine strands from different lexias in a simple way that did not necessarily destroy the illusion of coherence. The literary style of Forward Anywhere lent itself to these sorts of programmatic manipulations, but it is possible to apply this algorithm to informational hypertexts as well, although documents with particularly long sentences (e.g., legal texts) may need to be handled differently to avoid overly-long passages. As the size of the passage increases, the effectiveness of this technique for summarization purposes decreases; a balance that accommodates the two constraints of succinctness and comprehensibility must be sought.

Notebook
The notebook in XLibris allowed the reader to save arbitrary parts of pages for future use (see Figure 13). Although we had not redesigned this feature explicitly for XLibris/Forward Anywhere, it was available in the interface through the clip buttons in the annotations view. Our reader (see the following section) discovered the feature on her own, and took some advantage of it to reconstruct narrative threads and to speculate about characters.

Marks
After a reader annotated a document in XLibris, he could request additional documents that were similar (that contained similar terms) to the annotated passages. The reader pressed a button, XLibris extracted terms from annotated passages, formed a query, retrieved matching documents (see Golovchinsky, Price, and Schilit.1998) for a description and evaluation of the algorithm), and presented the top few matching passages to the reader for selection. A link corresponding to each
match took the reader to the corresponding matching page.

In XLibris/Forward Anywhere, we retained the basic algorithm, but changed the interface to make the interaction more like exploratory browsing and less like an explicit search. Rather than presenting a list of the matching passages, the best match is displayed immediately when the Marks button is pressed. The Back button returns the reader to the previous screen, but hitting Marks again causes the next-best match to be shown. The Marks method of navigation never takes the reader to a previously-visited screen; if no other matching nodes are available, no new screen is displayed. Early feedback from users indicates that we may need to make the reason for non-traversal more explicit. Another possibility is to make Marks revert to Anywhere once its supply of related lexia is exhausted.

**Lines**

The Marks interface echoed some of the serendipity of the Lines interface of Web/Forward Anywhere, but was also qualitatively different because the reader had only a vague sense of what theme would cause related lexia to be displayed. Annotations, on the other hand, had a similar feel in terms of layout—fragments of lexia pieced into apparent wholes—but lacked the trailblazing aspect of Lines. We decided, therefore, to introduce Lines back into XLibris/Forward Anywhere, and to compare the interface visually with the annotations view (compare the text in Figure 11 and Figure 14).

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4 The differences in controls are due to screenshots made from slightly different versions of the interface.

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A READER'S IMPRESSIONS

Through the course of developing the ideas and the software, as we gave demonstrations and played around ourselves, we developed a sense for how to use XLibris/Forward Anywhere to read. But we knew too much: the text, the interface, the underlying algorithms all became predictable and familiar after a while. We were following well-trodden paths.

But how would an outsider—a reader—react to the work? Would people want to interact with the text, or would they merely (merrily) flip through the screens in chronological order? Would the text and the interface hold their attention? Would the navigation controls be meaningful or confusing?

We asked a colleague to take XLibris/Forward Anywhere for a test-read, and to record her thoughts and impressions. Her comments, mirroring the interconnectedness of the text and the interface, reflect on both simultaneously: "The reading experience was of course enhanced by the writing experience—on this device they are inextricably linked." This is very much the feeling of flow described by Douglas (2000).

She commented on the random and interfaced aspects of the interface and the text: "The Anywhere button is like picking my *Sudden Fiction* up and jumping about from story to story," and she "liked the way threads seem to follow through, from one piece to another."
Navigation was also an important part of her reading, and several comments address this issue. Initially, she wanted an overview of the text ("a kind of map, like reading the contents table of a book"), and later subverted annotations as an approximation ("at one point I decided to use marks and clippings to get some overview of which pieces I had read in which order—that was very neat").

Several comments addressed issues of usability. The semantics of the Forward control were ambiguous, but she guessed correctly that it presented lexia in chronological order. The Back button was more problematic: did it take her "through some logical sequence … or back through what I had seen in reverse order"? Again, her guess—the latter—was correct. She was also confused by a redundant set of controls in the bottom-right corner of the display (see Figure 9) that we had copied from the Eastgate interface.

But there were positive comments: she liked clippings in general, and also commented on the way clippings in the notebook could be resized. It was clear from the log file that she spent a considerable amount of time manipulating the clippings in the notebook. The novelty of the interface seemed to appeal to her; her ergodic explorations added a new dimension to the text.

Aside from some comments about the physical device (that it was too heavy for prolonged use and that the pen was not well-suited for detailed notes), she enjoyed reading on XLibris/Forward Anywhere. Her comments suggest that the medium is sufficiently engaging to become an integral part of the work.

**FUTURE WORK**

Our experiences with XLibris/Forward Anywhere suggested several potentially interesting design changes and additions. Much may be done with collaborative use of freeform digital ink annotations. It is possible to share the annotations themselves, or, for a variety of reasons, just the annotated passages (Marshall et al., 1999). Collaboration in reading hyperfiction introduces an interesting tension between individual discovery and collective understanding. Following someone else's path through a hypertext may be as revealing of the reader's interpretation of the work as it is of the author's. We are exploring the possibilities that collaborating on a reading brings to hypernarrative.

The possibility of managing clippings spatially (Figure 13) suggests that a spatial hypertext similar to VIKI (Marshall, Shipman, and Coombs, 1994) can co-exist with (and within) the page-oriented XLibris interface. The current version of XLibris already provides a spatial interface for managing documents and clippings; VIKI would bring additional interactive and interpretive possibilities to this interface. We expect to revisit these issues in a subsequent redesign episode to update not only the visual appearance (to make the clippings notebook more consistent with the rest of XLibris/Forward Anywhere) but also the spatial manipulations. Bringing clippings together could, for example, combine the corresponding sub-lexic units into a new lexia.

Our implementation of Lines uses annotations from the current node to guide search term selection. Rather than relying on annotations on a single lexia, we may, following VOIR (Golovchinsky, 1997), take terms from the last few lexias when deciding where to go next. This sensitivity to prior interaction should echo the ambiguity and unpredictability of destination already found in Anywhere and in Marks, but can also make it possible to establish threads rooted in several lexias. Several strategies for selecting lexia from which terms are drawn suggest themselves: Annotated passages brought together in a page of an annotation view, annotations from recently visited or revisited nodes, or nodes with heavy or varied annotations may be used to seed the search.

Another, more interesting possibility, is to apply handwriting recognition to the reader’s marginalia, and to augment scribbles with links to instances of the recognized words in the text. In fact, this was one of the first strategies the work’s co-author tried when she first saw the interface. It was also a common question in demonstrations. This approach not only eliminates an extra interface mode, but also makes the link creation act more idiosyncratic, more
expressive. Thus in the example of Backtracking and pressing Marks again, the reader is confronted with a damp basement kitchen (“Judy: underground places”); a new thread presents itself. Figure 8, the scribbled annotation would afford two interaction possibilities: in addition to searching based on the annotated text, the system could match the word “Sister” to other passages. In this manner, a reader’s annotations can augment an existing lexia both visually and textually, multiplying the possible avenues of recombination, of exploration. We may also use ink shape matching rather than full handwriting recognition to identify similar annotations and to combine corresponding passages (Price, Golovchinsky, and Schilit, 1998). The reader should be able to identify a theme or a thread, mark occurrences with a particular symbol, and cause the system to display just those items. Subsequent invocation of the Marks feature might then retrieve additional passages related to the selected theme.

**REVISITING HYPERTEXT INTERACTION**

Having described the three different interfaces to *Forward Anywhere*, including XLibris/Forward Anywhere, we now review our model to see where the various interactions in the different versions are classified. Instantiating the model will allow us not only to compare the different interfaces, but also to look for opportunities. We revisit Table 1 and Table 2 in Table 3 and Table 4 below. To illustrate the workings of the model more completely, we include the original interface, email, to capture the initial interaction between the co-authors of *Forward Anywhere* as they collaborated on the work.

<table>
<thead>
<tr>
<th>Choice</th>
<th>Annotation</th>
<th>Search</th>
<th>Ad hoc Linking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward and Anywhere controls</td>
<td>Marks in XLibris/Forward Anywhere</td>
<td>Lines in Web/Forward Anywhere</td>
<td>Associative creation of the work through email</td>
</tr>
</tbody>
</table>

Table 3. Navigational expressiveness in *Forward Anywhere*. email represents the creation process.

With the exception of morphemic recombination, the various *Forward Anywhere* interfaces fill the tables. How might morphemic recombination be realized? Is it even desirable? One mode of morphemic recombination that essentially falls out of existing XLibris functionality is to give the reader access to the full text index maintained by the search engine. The reorganization of words—and a sense of their relative frequency—may provide a new window onto the work. Such “back of the book” index displays may be quite useful in informational hypertexts as well. They can serve as browsing interfaces and as sources of terms for query expansion. Finally, it is possible to create clippings of highlighted passages that consist solely of the annotated text with little or no surrounding context. The reader could then construct new passages from these word-level building blocks.

It is also interesting to note how the reader’s use of the interface can transcend the notions of interactivity as they have been implemented. Originally, the clippings in XLibris were conceived as a means for readers to perform sub-lexic recombination, to juxtapose passages from different lexias to construct new interpretations. Our reader used them instead to get an overview of reading progress, to see where she had been and in what order. These different purposes account for the double classification of clippings as lexic and sub-lexic recombination.

**CONCLUSIONS**

Hypertext is about interacting with text. Much interaction with text, however, does not fit the traditional click-on-an-anchor, follow-a-link concept, as ample evidence from the hypertext community suggests. We have attempted to capture some of this richness in our model of hypertext interaction that
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treats nodes and links as equal partners, rather than allowing one to dominate the other. As the hypertext creation process becomes more complex, this model might be enriched by opening up the dimensions of what we are referring to as full collaboration. For example, Rosenberg (1998) suggests that the reader might become a programmer if offered full programmability within the interface. Might the reader also become a designer or an architect? Did Marshall and Malloy’s collaboration realize Rosenberg’s suggestion? Did ours? Is the first author’s bending of the XLibris code to the will of Forward Anywhere a reading of the text, as Rosenberg suggests? Or does the creation of a new interface lie beyond the realm of reading?

In some sense, hypertext fiction affords greater experimentation, a greater variety of novel interface decisions, than informational hypertexts. Thus we chose Forward Anywhere, a literary hypertext, as a foil for our model. We examined previously-existing interfaces, and described a new interface for reading hypertext, an interface based on freeform digital ink. The unconstrained and idiosyncratic nature of this interaction technique seems like a natural match for freeform and open-ended readings of hypertext. Yet our conclusions and insights could often be interpreted profitably in the context of an informational hypertext.

Our design is an initial exploration. As we continue to gather experience with such interfaces, we expect to expand the set of tools and techniques. Innovation may take different shapes (handwriting recognition, spatial hypertext, collaborative reading, etc.), but the common goal remains the same: to explore and to understand how to bring various kinds of interactivity to hypertext.

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