

Hypertext Interaction Revisited

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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, 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, create a persistent record of a reading, 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 on top of 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* [4], 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 (in this case pages) 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

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Hypertext 2000, San Antonio, TX.

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collaboration between the two writers and the reader; instead, the participation is unintentional, unacknowledged, undefinable. 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." [1] 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. The ergodic level of electronic texts need not be limited in such a way.

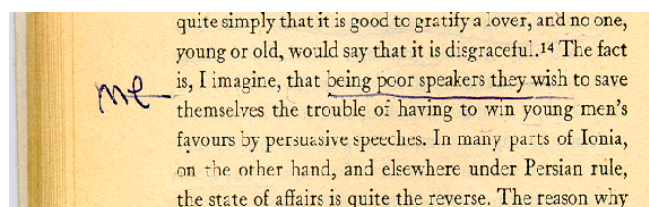


Figure 1. Interaction with a printed text, Plato's *Symposium*.

Even if we take a quick, ironic look at the most hide-bound codex, we find more interaction than that (see Figure 1). For in some sense, our texts have always been interactive, especially in ways no writer might anticipate. Interaction with texts may be fluid, playful, destructive, wry. Readers respond to texts in an unselfconscious way that is paradoxically highly individual and situated while it is also collective and part of a larger ecology [12]. In Figure 1, the reader has reacted to the text as a mirror; it is the awkward reflection of a college freshman that he sees there.

Thus the trick in designing interactive hypertexts is to renegotiate our relationships with our machines - to subvert the fixity of the link. How can we best do this? In the remainder of this paper, we propose an extended model of interactivity in hypertext. We use three different interfaces to Malloy and Marshall's collaborative hypertext *Forward Anywhere* as a foil for discussing how this model plays out in implementation. The design of the third interface, an annotation-based interface written on top of XLibris [20], 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 systems restrict the user to following fixed links; some vary the available links based on a user 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. The scenario section that follows will analyze our interface in terms of this model.

Waterworth and Chignell [21] described a model of information exploration that consisted of three dimensions: structural responsibility, target orientation, and interaction method. The interaction method dimension ranged from descriptive to referential: from typing in a query on one extreme to following a link on the other.

The advantage of almost a decade of interface innovation has afforded us many examples of systems that don't fit cleanly into Waterworth and Chignell's model framework. More precisely, that model does not distinguish among the variety of ways in which navigation is realized. Furthermore, the interaction method dimension confuses issues of interface with those of the underlying computational mechanisms. Finally, we believe that a theory of hypertext interaction must consider links as well as nodes to capture the diversity of interactive possibilities that go by the name hypertext.

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. It fails, however, to capture the nuance of hypertext interaction. If a system performs a calculation 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 [5]. In VOIR queries looked and acted like links. Similarly, XLibris [20] uses a reader's annotations to select terms for queries, but the navigation is accomplished by tapping on a link anchor. Other examples of query-mediated links have also been described (e.g., Phrasier [8], Paraphrase Search Assistant [2]). These examples suggest that although systems may be implemented in quite different ways, users may 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.

Navigational expressiveness can vary from simple page turning or clicking to sophisticated annotation and search interfaces on the other. 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?

Spatial expressiveness can range from requesting the display of a single node, to arranging lexia¹ spatially, to recombining sub-lexic units programmatically or manually, to creating new lexias (Table 2). This dimension represents some interesting possibilities: several lexias displayed at once [7], pieces of lexias recombined to produce new perspectives (e.g., **Lines** feature in *Web/Forward Anywhere*), lexias juxtaposed spatially to reflect new interpretations [15], 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 [3]. We use the term *recombinant hypertext* to describe this interaction style.

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, the 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* [4], and is certainly reflected in Malloy and Marshall's collaboration on *Forward Anywhere*.

¹ We use *lexia* to mean a discrete unit of text like a Web page or a node in a hypertext system [9].

Choice	Annotation	Search	Ad hoc Linking
Web	ThirdVoice ²	Google's "I Feel Lucky" ³	CREW ⁴

Table 1. Navigational expressiveness (links)

Lexic recombination	Sub-lexic recombination	Morphemic recombination	Authoring
VIKI [15]	Intergrams [18]	Cut-up [3]	Bad Information ⁵

Table 2. Spatial expressiveness (nodes)

FORWARD ANYWHERE—THE TEXT

Forward Anywhere is a collaborative hypertext written by Judy Malloy and Cathy Marshall. The hypertext, 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." [11]

The hypertext 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:

```
Date: Wed, 27 Oct 1993 19:27:11 -0700
From: Catherine Marshall <marshall>
To: Judy Malloy <jmalloy@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 <jmalloy@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.

² <http://www.thirdvoice.com/>

³ <http://www.google.com/>

⁴ <http://raven.ubalt.edu/features/crew/>

⁵ <http://www.well.com/user/jmalloy/bad.html>

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 hypertext. 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 lexias) 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.

FORWARD ANYWHERE—TWO INTERFACES

Given the authors' perspective on the hypertext—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*⁶, 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* [10]; 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.

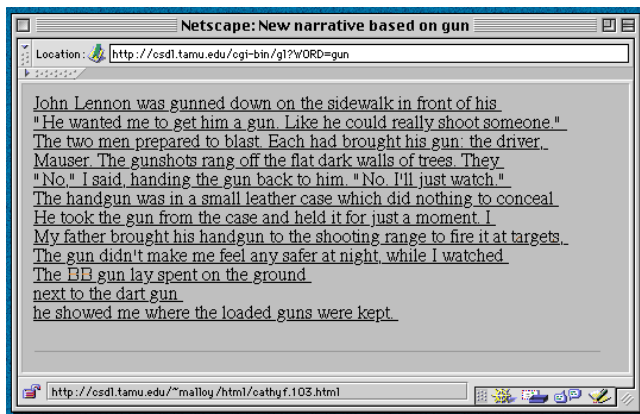
The third kind of interaction in the *Web/Forward Anywhere* invites participation, given the limitations and affordances of the Web. It also reflects the authors' original motivation to investigate the connections between the lives of researchers and artists. **Lines** entices a reader to gather together 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; a new screen is composed from lines of other screens that contain that word. Figure 2a, b, and c

⁶ We refer to the different interfaces to *Forward Anywhere* with the prefixes Web/, Eastgate/, and XLibris/.

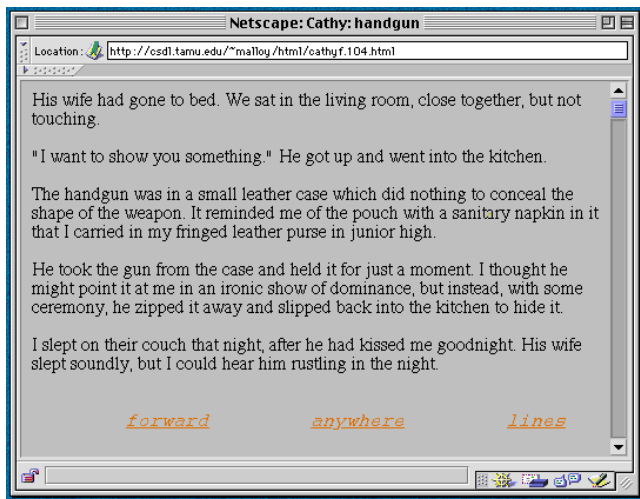
illustrate a sequence of Web pages from such an interaction. In Figure 2a, a reader has entered the word "gun"; Figure 2b shows the screen that results, a constructed set of links to other lexia in the work. Figure 2c shows one possible result of following one of these links.



(a)



(b)



(c)

Figure 2. A sequence of Web pages from Web/Forward Anywhere.

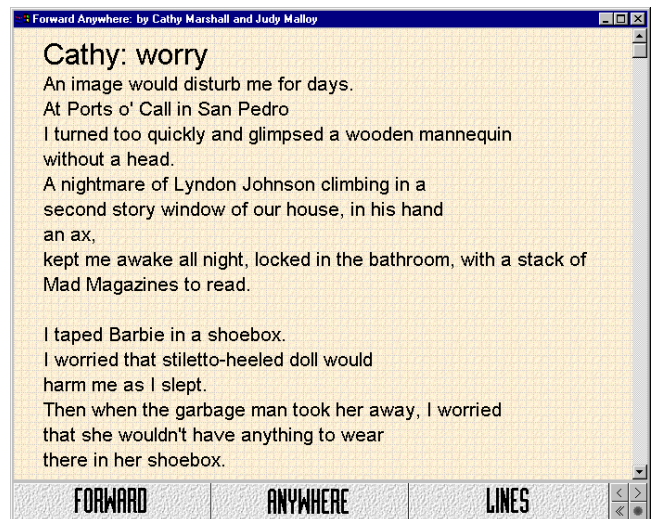


Figure 3. A screen from Eastgate/Forward Anywhere

Later, when the work was published by Eastgate Systems (see [11]), 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 3 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.⁷

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?

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 exploit them in a hypothetical reading scenario below.

⁷ 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 [16]. He could have searched freely there.

had resulted in spontaneous combustion.

Actually, my brother, *4 my sister*
whose chemistry set dominated that area of the basement,
had lit the newspapers on fire
just to see what would happen.

Figure 4. A reader's response to the "Judy: basements" screen (fragment).

Figure 4 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 5). 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 6).

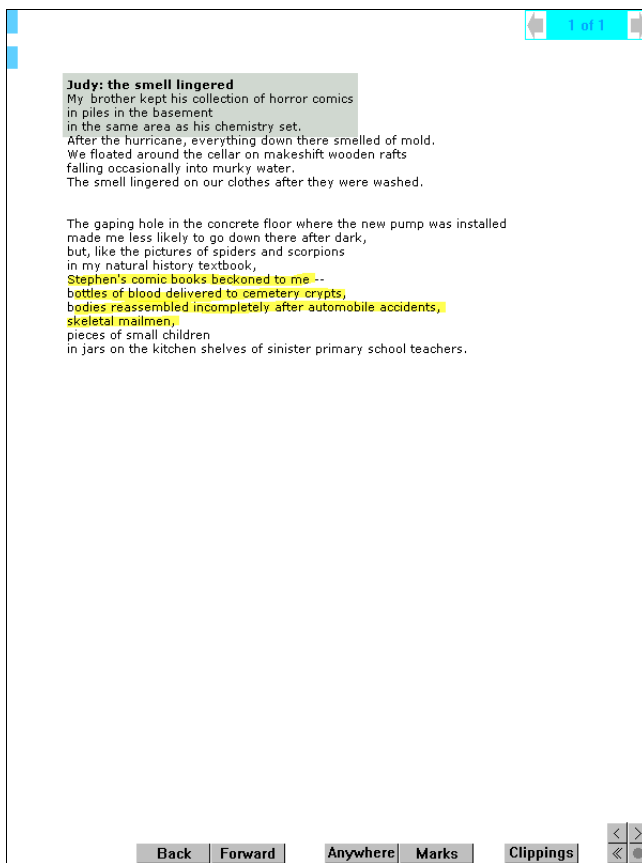


Figure 5. Result of "Marks" navigation

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

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 7). 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.

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.

This synthesis echoes the Lines interface in the Web version, but, in addition to showing the marks, it selects text on a sentence level, preserving enough semantics to allow the reader to create new interpretations in a natural way.

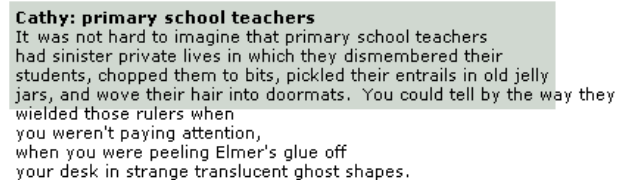


Figure 6. An unexpected connection (fragment of "Cathy: primary school teachers")

Freeform digital ink annotation is designed to draw on the familiar work practice of marking as you read. People annotate for a variety of reasons, often unselfconsciously, and such marks do not always have explicit meaning [13]. 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. 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. [20] 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 7). 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 8). The **clip** button associated with each clipping can be used to preserve these recombined sequences from the vagaries of subsequent inking.

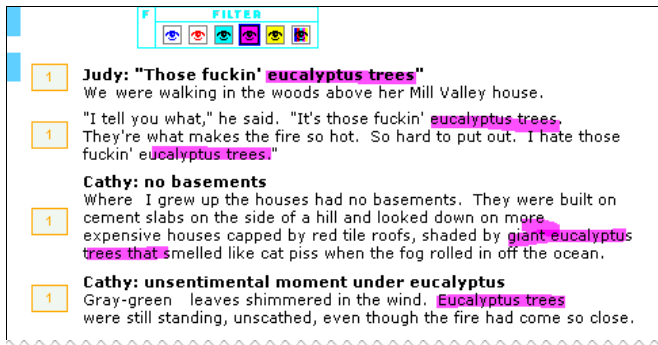


Figure 7. Clippings of the eucalyptus theme.

INTERACTION IN XLIBRIS/FORWARD ANYWHERE

XLibris/*Forward Anywhere* retains much of the paper document metaphor introduced in XLibris [20]. 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*.

Changes to the interface included adding several buttons that controlled navigation between lexias, and in the appearance of some controls. The ever-present 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 7, for example, hide the ink palate and the menu items. Figure 9 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.

Clippings

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, the clippings view for filtering annotations, the notebook for taking notes (rather than annotating), and a further reading list.⁸ We simplified the interface by retaining only the document and the clippings views. Furthermore, the clippings view was redesigned in several important ways.

Clippings (annotations with the corresponding passage)

⁸ An early version of XLibris [20] also included a separate view for showing all pages of a document; subsequent redesign replaced that view with an overlay.

were displayed in XLibris in a paginated vertical list in which each item corresponded to some annotation passage. Items were separated visually with shading, and included some metadata that described the corresponding documents.

To foster the sense of recombinant text, we changed the presentation in several subtle ways, as shown in Figure 8. Shading and background were removed, metadata identifying source documents was not shown, and clippings were arranged to fit the page in a manner resembling a 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 clippings 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, the possibility of creating new texts.

Finally, XLibris/*Forward Anywhere* clippings 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 destroy the illusion of coherence.

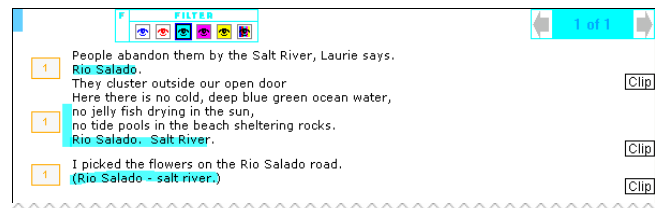


Figure 8. Portion of a clippings view showing annotations filtered by one color.

Notebook

The notebook in XLibris allowed the reader to save arbitrary parts of pages for future use (see Figure 9). Although we had not redesigned this feature explicitly for XLibris/*Forward Anywhere*, it was available in the interface through the clip buttons in the clippings view. Our reader (see the following section) discovered the feature on her own, and took some advantage of this feature.

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 [6] 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. In general, the Marks method of navigation will never take 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.

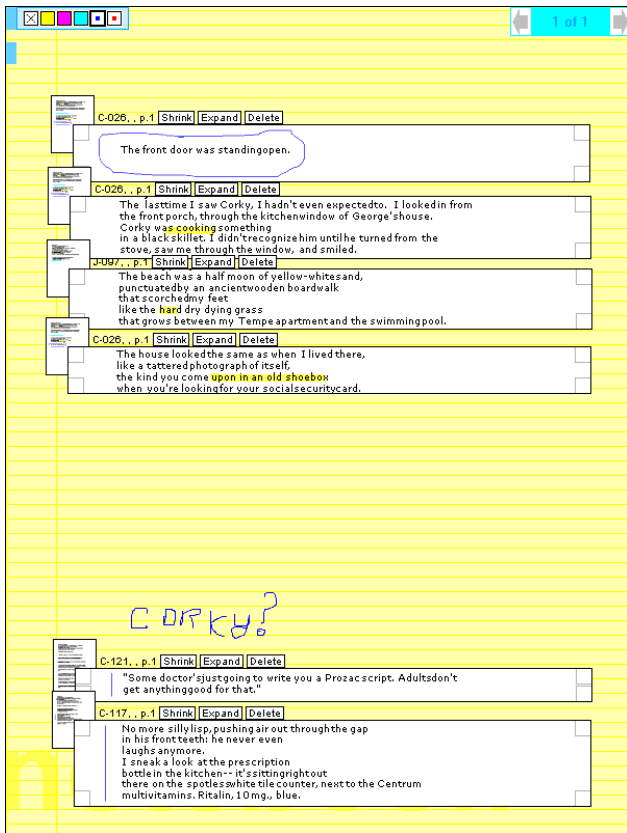


Figure 9. Some clippings as a spatial hypertext, complete with annotations.

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."

She commented on the random and interlaced 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 5) 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 interaction log that she spent a considerable amount of time manipulating the clippings in the notebook.

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 passages themselves [14]. Collaboration in reading hypertext 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 hypertext.

The possibility of managing clippings spatially (Figure 9) suggests that a spatial hypertext similar to VIKI [15] can co-exist with (and within) the page-oriented *XLibris* interface.

The current version of XLibris already provides a spatial interface for managing documents; VIKI would bring additional interactive possibilities to this interface. We expect to revisit these issues in a subsequent redesign episode to update not only the visual appearance (to make it more consistent with the rest of XLibris/*Forward Anywhere*) but also the spatial manipulations. Bringing clippings together, for example, should combine the corresponding lexias in a coherent display.

It is possible to mimic some of the functionality provided by the Lines features in *Web/Forward Anywhere* by recasting the "Further Reading" list in XLibris [20]. We may show matching passages in a manner analogous to the clippings view (e.g., Figure 7). Rather than relying on annotations on a single lexia, we may, following VOIR [5], 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*.

Lines, an important feature present in *Web/Forward Anywhere*, was missing from our new design. Although search based on annotated passages is available, there is no way for the reader to enter arbitrary search terms. We imagine two possible designs to re-introduce this functionality to XLibris/*Forward Anywhere*. Perhaps the more obvious one, a solution that mimics the web interface, is to allow the reader to type in the desired term. It's easy enough to overlay onto the screen a software keyboard, and to use the pen to type out text.

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.⁹ 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 Figure 4, 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.

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 fully illustrate the workings of the model, we include the original interface, email, to capture the initial interaction between the co-authors of *Forward Anywhere* as they collaborated on the work.

⁹ 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.

Choice	Annotation	Search	Ad hoc Linking
Forward, Anywhere	XLibris/Marks	Web/Lines	email/association

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

Lexic recombination	Sub-lexic recombination	Morphemic recombination	Authoring
XLibris/Clippings, VIKI	XLibris/Clippings, XLibris/Notebook		email/writing

Table 4. Spatial 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.

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'd 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-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 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 suggests that the reader might become a programmer if offered full programmability within the interface [19]. Might the reader also become a designer or an architect?

In some sense, hypertext fiction affords greater experimentation, a greater variety of 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.

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.

ACKNOWLEDGEMENTS

We would like to thank Judy Malloy not only for her role as co-author of *Forward Anywhere*, but also for her comments on the XLibris version. Much thanks is due Elizabeth Churchill for her reading of XLibris/*Forward Anywhere*. Finally, we thank Morgan Price for his help in navigating through the intricacies of the XLibris user interface code.

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