Never the Same Stream: netomat, XLink, and Metaphors of Web Documents

By: Colin Post, Patrick Golden, and Ryan Shaw

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Abstract:

Document engineering employs practices of modeling and representation. Enactment of these practices relies on shared metaphors. However, choices driven by metaphor often receive less attention than those driven by factors critical to developing working systems, such as performance and usability. One way to remedy this issue is to take a historical approach, studying cases without a guiding concern for their ongoing development and maintenance. In this paper, we compare two historical case studies of "failed" designs for hypertext on the Web. The first case is netomat (1999), a Web browser created by the artist Maciej Wisniewski, which responded to search queries with dynamic multimedia streams culled from across the Web and structured by a custom markup language. The second is the XML Linking Language (XLink), a W3C standard to express hypertext links within and between XML documents. Our analysis focuses on the relationship between the metaphors used to make sense of Web documents and the hypermedia structures they compose. The metaphors offered by netomat and XLink stand as alternatives to metaphors of the "page" or the "app." Our intent here is not to argue that any of these metaphors are superior, but to consider how designers' and engineers' metaphorical choices are situated within a complex of already existing factors shaping Web technology and practice. The results provide insight into underexplored interconnections between art and document engineering at a critical moment in the history of the Web, and demonstrate the value for designers and engineers of studying "paths not taken" during the history of the technologies we work on today.

Keywords: Hypertext | XLink | browsers | XML | digital art

Article:

1 Introduction

The metaphor of the printed page has been a prominent structuring principle of Web documents since the first browser, and indeed from the earliest implementations of hypertext. Although Nelson first defined hypertext in contrast to the printed page, as whatever “could not conveniently be presented or represented on paper” [29, page 96], many subsequent hypertext systems treated documents as metaphorical pages (or cards, which we might think of as small

pages). Although web browser interfaces still refer to documents as *pages*, there is a more complex relationship between the metaphors used to make sense of reading and writing hypertext and Web document structure. This relationship between metaphor and structure has varied over the history of the Web, and at different points in time, alternative metaphors and structures have influenced its ongoing development.

We provide historical case studies of two such efforts to explore other metaphors and structures for Web documents. One case is *netomat* (1999), both an artwork and functional browser developed by Maciej Wisniewski that structured documents according to the metaphor of the *stream*, pulling text, image, and audio from across the Web, and juxtaposing this heterogeneous content into a dynamic, flowing document. The other case is the XML Linking Language (XLink), a W3C standard to express hypertext links within and between XML documents. As described by DeRose, XML linking responds to perceived limitations of Web document structure, namely by expanding the functions of hyperlinks beyond one-directional anchors embedded within documents [11]. Both of these efforts were situated within the existing infrastructure of the Web, but imagined other ways of interacting with documents not afforded by mainstream browsers or existing HTML standards.

At the height of the "browser wars," and at a tumultuous moment in the development of HTML standards, Wisniewski's work echoed these contemporaneous debates about the role and function of XML for Web documents. In examining these two case studies, we aim for deeper historical understanding of how these systems both critiqued and contributed to the variable relationship between Web document structure and metaphor. More than just a technical issue, limitations of hyperlinking like the propensity for linkrot, or the inability for readers to forge their own links between documents, constrained individuals' abilities to more fully leverage the promised social functions of the Web as a technology to make wide and varied connections across and among rich corpora of information. Developing a more nuanced understanding of the complex relationship between document structure and metaphor can also enrich perspectives and vocabularies for current efforts to develop Web-based document technologies.

2 XML Linking and Artists' Browsers

XLink was part of the wave of standardization efforts around XML (eXtensible Markup Language) in the late 1990s. XML was an effort to create a well-defined subset of SGML (Standard General Markup Language) that would be more widely accessible to programmers and application developers, especially on the burgeoning World Wide Web. The Web had shown that a simple subset of SGML like HTML could be widely and successfully deployed, and XML was meant to pick up that work, creating a subset of SGML that was more expressive and extensible yet still compatible with SGML and HTML.

The W3C began publishing working drafts of the XML standard in 1996, and published XML as a Recommendation in early 1998. This standard tackled the syntactic features of XML: how parsers were meant to understand a string of characters as a valid document consisting of tags, attributes, and entities. The XML standard did not describe anything behavioral or interactive, such as how XML documents should be rendered, transformed, or linked with one another. Definitions of those sorts of behaviors were left to other working groups creating supplementary

standards meant to work on top of and in concert with the basic XML syntax, including DOM (Document Object Model), XSL (eXtensible Stylesheet Language), XLL (eXtensible Linking Language), XForms, and XHTML.

XLL was a standard to express connections within and between XML documents in a more sophisticated manner than HTML, which only allowed single direction links between documents. XLL consisted of two parts: XPointer (XML Pointer Language) and XLink. The former described a way to point to discrete sections within an XML document (e.g. "the second sibling of the third child of the first `<author>` tag"), and the latter described how to define hypertext links between documents and the elements within them. They respectively tackled two of the primary problems of networked hypertext systems: addressing and interlinking.

The initial development of XLink took place in 1997 privately within the W3C's XML Linking Working Group, with public drafts published in April and July of that year. Two of the principal authors of the standard were Steve DeRose and Eve Maler, both of whom had been active in the SGML community and the initial XML standardization effort. In 1998, another draft was released in which XPointer and XLink were separated into separate documents. Additional drafts were released through 1999 and 2000, with the publication of a final Recommendation in June 2001[1]. The working group also published a "requirements" document describing the background, design principles, and general use cases of XLink[2].

Links in XLink are descriptions of how elements in XML documents are interlinked with one another. In HTML documents, inserting a link involves inserting one of a few different tags (especially `<a>` and `<form>`) within the normal flow of a document, pointing to a single target using the HTML href attribute. With XLink, however, links are able to be defined on arbitrary elements, can point to multiple targets, and can appear out of the normal top-to-bottom flow of documents. Further, links between elements can be defined without those elements appearing in the same document as the links themselves. This means that links can be made even without control over the document containing the elements to be linked. Links between external resources were referred to as "out-of-line links," collections of which were called "linkbases."

XLink has enjoyed success in several domain-specific markup languages derived from XML, including XBRL (eXtensible Business Reporting Language, for describing business reports), SVG (Scalable Vector Graphics, a vector image format expressed in XML)[3], and DocBook (for technical documentation). In all three, XLink was used to define hyperlinks within and between documents. However, as a generic way to express linking on the Web, XLink had much less success. Opera and early versions of Mozilla Firefox both developed minimal implementations for "simple" links, but never worked with anything more complex that the standard afforded, such as "extended links" or linkbases. In effect, they recreated "anchor" (`<a>`) links from HTML.

In the following examples, a sentence is marked up with links to external resources. In Fig. 1, simple, one-directional links are defined between the XML standard, the W3C, and their

[1] https://www.w3.org/standards/history/xlink
[2] https://www.w3.org/TR/1999/NOTE-xlink-req-19990224/
[3] The use of XLink for defining hyperlinks is slated to be removed in SVG2. See http://www.w3.org/TR/2016/CR-SVG2-20160915/linking.html#XLinkRefAttrs

respective homepages. This is functionally similar to an HTML <a> link, but defined on an arbitrary tag. In Fig. 2, the `<entity>` tag representing XML is associated with multiple external resources in an "extended" link. Such multi- directional links are not able to be formally expressed in HTML. An arbitrary number of elements with `xlink:type` "resource" and "locator" are able to be connected using elements with the `xlink:type` "arc." Note that none of `<entity>`, `<reference>`, or `<link>` are specific to XLink. They are arbitrary tags whose link semantics are defined by their various `xlink:` attributes.

```
<text xmlns:xlink="http://www.w3.org/1999/xlink">
   The
   <entity xlink:type="simple"
         xlink:href="http://w3.org/XML/">
      XML standard
   </entity>
   is maintained by the
   <entity xlink:type="simple"
         xlink:href="http://w3.org">
   World Wide Web Consortium
   </entity>
</text>
```

Figure 1. A "simple link

```
<sentence xmlns:xlink="http://www.w3.org/1999/xlink"
         xlink:type="extended">
   <text>
      The
      <entity xlink:type="resource" xlink:label="xml">
         XML standard
      </entity>
      is maintained by the
      <entity xlink:type="resource" xlink:label="w3c">
         World Wide Web Consortium
      </entity>
   </text>
   <reference xlink:type="locator"
            xlink:label="xml-home"
            xlink:href="http://w3.org/XML"
            xlink:title="XML Homepage" />
   <reference xlink:type="locator"
            xlink:label="xml-std"
            xlink:href="https://www.w3.org/TR/xml/"
            xlink:title="Current XML Standard" />
   <reference xlink:type="locator"
            xlink:label="w3c-home"
            xlink:href="http://w3.org"
            xlink:title="W3C homepage" />
   <link xlink:type="arc" from="xml" to="xml-home" />
   <link xlink:type="arc" from="xml" to="xml-std" />
   <link xlink:type="arc" from="w3c" to="w3c-home" />
</sentence>
```

Figure 2. An "extended" link

While the extended hyperlink model of XLink did not have much uptake in mainstream Web browsers, other “artists’ browsers" did experiment much more with different forms of hypertext. The first of these artists’ browsers was *The Web Stalker* (1997) by Matthew Fuller, Colin Green, and Simon Pope under the collective name I/O/D. This browser offers users many alternative views onto webpages, notably a hub-and-spoke diagram of the pages and links that make up the overall website [15]. Mark Napier created several browsers, including *Shredder* (1998), which runs a Perl script filter from within a mainstream browser to reconstitute webpages as opaque collages of hyperlinks, HTML tags, pixelated images, and color swatches—directly dramatizing the limits of the metaphor of the Web as a print publication [28]. First exhibited at Postmasters in June 1999 and later featured in the “Data Dynamics” (2001) show at the Whitney Museum, *netomat* built on these earlier artists’ browsers, developing another alternative interface to the Web.

These artists’ browsers were discussed together in the arts press at the time as a genre of digital art, with shared concerns and aesthetic strategies. As described by Mirapaul, these artworks examine the influence exerted by browsers as interfaces to Web documents, and highlight the conventions that inform the display of Web content [25]. Although these artists’ browsers were exhibited in arts institutions and discussed in arts publications, they featured equally as much in Web technology discourses. These artworks were also functional hypertext systems, garnering upwards of a million users, and receiving attention from the popular press.

Throughout the history of computing, artists have frequently been early adopters of digital technologies, plumbing both the technical possibilities as well as the broader social, cultural, and aesthetic significance of these systems. Artists have often pursued this experimentation by actively engaging with engineers and contributing directly to information science discourses. *9 Evenings* (1966), a series of collaborations between artists like John Cage and Robert Rauschenberg and engineers at Bell Laboratories, is one prominent example [26]. As the Web grew in popularity, artists investigated the technical and social dimensions of various Internet protocols and technologies, from artists’ mailing lists like Nettime to standalone webpages-as-artworks like *My Boyfriend Came Back from the War* (1997) by Olia Lialina [16]. Artists’ browsers like *netomat* need to be seen as part of this longer lineage of artists actively engaging with digital technologies as both technical and cultural systems.

3 Hypertext Structures and Metaphors

We analyze both *netomat* and XLink in terms of the intimate relationship between structure and metaphor, as this theoretical framework sheds light on how these systems were understood, developed, and made meaningful as part of the global hypertext infrastructure of the Web.

The structure of hypertext documents and the metaphors used to describe reading and writing in hypertext are mutually informative. Hypermedia is derived from prior reading and writing technology, yet affords novel, distinct interactions not previously available, and the language of hypermedia research and development is peppered with metaphorical terms which make sense of this novelty through the example of already-existing understandings of reading and writing. These metaphors in turn influence the ways in which hypertext documents themselves are structured. Such a formative role of metaphor is not unique to hypertext: new technologies are

often discussed in terms that call back to earlier ones. As Mak observes, language of form and architecture has shaped our understanding of the "page" across manuscript, print, and digital writing [21]. Formative metaphors for earlier writing technologies continue to shape our understanding of digital writing, even as these metaphors are reworked and transformed.

Many of the metaphors used in the language around hypertext derive from the genres of scholarly and technical communication, which feature documents that are conventionally structured into parts and have standardized references to other documents. Scholars and technical professionals structure their documents in accordance with or as a challenge to dominant conventions in order to achieve their rhetorical ends. They also position their documents in relation to other scholars' documents, via citations to earlier work, and via the act of publishing, which provides an anchor for later scholars to cite. Taken as a whole, these scholarly or technical documents form a complex system, a "literature." Metaphors of scholarly writing featured prominently in SGML designers' vision of hypermedia. As set forth in the 1994 treatise on HyTime, *Making Hypermedia Work*, the authors state that "hypertext is a technology for writing and display," presenting reproductions from a 1647 edition of Clement's Epistle and a 1661 edition of Euclid's *Elements* as examples of hyperdocuments [12, page 14].

Metaphors of physical space also feature prominently in visions of hypertext and hypermedia, filtered through the language of computer programming. Computer programmers, concerned with the management and use of computer memory, turned to spatial metaphors: the parts of memory became *locations*, with *addresses*, which could be used elsewhere to *point* to those locations.[4] Hypermedia researchers in turn borrowed these terms to conceptualize another kind of space, a space not of *memory* but of *information*. In this space, addresses could be used to build links. A link, like a telephone line or the arc of a bridge, does not simply point, it connects. The connection a link makes can be followed or traversed, taking you from one location to another. These interlinked locations constitute a complex whole similar to a "literature" of scholarly communication, except that this complex whole is presented in explicitly spatial terms, a domain that can be explored and navigated.

Bolter, one of the developers of the literary system Storyspace, describes hypertext in topographical terms, characterizing documents as *spaces*, and reading and writing as peripatetic practices [6]. This metaphor informs the document structure for Storyspace works, as nodes are "writing spaces" that readers move between by clicking links. Authors of Storyspace works experimented with this underlying topographic metaphor, most notably Shelley Jackson in *Patchwork Girl*, in which the text is structured as a Frankenstein-like body [19]. This text is still topographic, but the body is transposed into a territory to be explored. However, it is important to note that the topographic metaphor is not unique to hypertext. Bolter and Joyce point to the work of Jorge Luis Borges, who wrote stories about maps that extended over the whole of territories and gardens of forking paths, as a precursor [7]. The metaphor of the text as a space can be traced back even further; for instance, medieval monks thought of reading as exploring a "vineyard of the text" [18]. This adaptation of document metaphors highlights that hypertext is not easily separated from earlier information technologies, and indeed often depends on

[4] These terms were less metaphorical in the early days of computing, when memory consisted of large arrays of vacuum tubes.

references back to previous modes of understanding reading and writing in order to familiarize users with a potentially strange and novel system.

In many cases, hypertext systems are explicitly described in terms of the "electronic book." Yankelovich, Meyrowitz, and van Dam evaluate hypertext systems developed at Brown University over the 1970s and 1980s in comparison to analog books, elaborating the relative advantages made possible for books in the digital medium, such as the ability to easily search for specific strings [35]. Moulthrop takes issue with this analytical frame, urging engineers, designers, and theorists to think beyond a rhetoric of the "electronic book," as this persistent reference to the earlier information technology of the printed page puts unnecessary constraints on the imagined potential and utility of hypertext systems [27]. His concern was that instead of leveraging the unique capabilities of hypertext, "electronic book" systems would get bogged down in porting the features of books, and would be judged according to the criteria of this disparate information technology. Airing similar grievances, Bernstein et al. advances a plan for "volatile hypertext" systems, which "emphasize a continual process of construction, deconstruction, and reconstruction" [5, page 243]. These volatile systems address Moulthrop's concern by eluding any one structure, proposing that the truly unique feature of hypertext is its potential to exist in a continual process of structural reinvention.

Other hypertext systems pursued metaphors and structures related to the page, albeit to quite different ends. Walker compares the hypertext interpretation of technical manuals offered by the Symbolics Document Examiner with NoteCards, a more unstructured system that enables users to manipulate blocks of text like notecards on a desk [33, 17]. Each system strives for different reading and writing experiences, and so each fashions distinctive document structures, and presents these to users through quite different metaphorical frameworks. In a review of the hypertext discourse, Michalak and Coney expand on this point: although discussed as a monolith, various engineers and theorists use "hypertext" to refer to quite different conceptions of textuality, ranging from postmodern literary theoretical ideas of a polyvocal text actively constructed by both readers and writers to positivist ideas of hypertext as a pragmatic utility for quickly discovering information [23]. Often, these differences manifest in the document structure and the mechanisms afforded to readers and writers for manipulating and making sense of the text.

Metaphors of the book, page, and space all influenced the development of the Web. In 1980, Tim Berners-Lee famously built a hypertext system for managing documentation at CERN, which he named ENQUIRE, after a 19th-century British reference book. Entitled *Enquire Within Upon Everything*, this book is organized as a sequence of numbered paragraphs, preceded by an alphabetical index of topics, each pointing to a single paragraph. ENQUIRE's interface, with its lists of numbered nodes, owes a clear debt to the organization of *Enquire Within Upon Everything*. Yet when Berners-Lee described the "musty old book" in 1999, he did not mention its structure or indexing apparatus at all; instead he wrote that "the book served as a portal to a world of information" [4, page 1]. With ENQUIRE, Berners-Lee had successfully programmed his computer to emulate the organization of his beloved childhood reference book, but he still found it lacking. Reflecting on his experience, Berners-Lee imagined doing better: "Suppose I could program my computer to create a space in which anything could be linked to anything … There would be a single, global information space" [4, page 4].

To build this single, global information space, Berners-Lee sought funding from CERN, writing proposals in March 1989 and November 1990. In these proposals, the portal to a world of information is no longer a musty book but a *browser*, a "program which provides access to the hypertext world" [3]. In his first proposal, Berners-Lee imagined how exploration of this hypertext world might enable insight into organizational structure: "imagine making a large three-dimensional model, with people represented by little spheres, and strings between people who have something in common at work. Now imagine picking up the structure and shaking it, until you make some sense of the tangle: perhaps, you see tightly knit groups in some places, and in some places weak areas of communication spanned by only a few people" [2].

Berners-Lee was not imagining a 3D visualization—elsewhere in the same proposal he states that "addition of graphics would be an optional extra" [2]. Rather he was emphasizing the importance of treating the hypertext system not as just a method for documents to point to other documents, but as a single navigable space: "the wood" and not merely "the trees" [2]. Concurrent to the early Web, others were developing spatial hypertext systems that did seek to introduce linking capabilities into 3D worlds, such as the Hyper-G system and Harmony browser, released to the public in 1994 [13]. Harmony offered a number of interface views, including a Local Map detailing the link structure of documents, and an "interactive information Landscape … a kind of networked virtual reality" [13, page 38]. In both the experimentation with alternative interfaces, and the centrality of spatial metaphors, Hyper-G anticipated key aspects of XLink and *netomat* discussed below.

Although browsers initially presented documents primarily as pages, Berners-Lee imagined webpages as having structural robustness, semantic richness, and the capacity to readily write and edit documents as integral to browsing [4]. Mainstream browsers like Netscape Navigator and Internet Explorer rendered Web documents more akin to magazine pages, privileging the display of media content over structural depth. Rallying against the growing influence of these commercial browser developers, Flynn articulated a trenchant claim for the need to return to the question of Web document structure: "if the Web is to succeed in the long-term as an information system, the robustness of a formal means of modeling structure must outweigh the short-term gain of making pages look cute or clever" [14, page 617]. Both XLink and *netomat* address these limitations by attending to the relationship between Web document structure and metaphor.

4 Method: Historical Case Studies

To advance our argument about the relationship between the metaphor and structure of Web documents at a critical moment in the history of the Web, we use the method of comparing two case studies. Both XLink and *netomat* were developed contemporaneously and were motivated by similar concerns about the state of the Web as a global hypertext system. Each technology also trafficked in quite different worlds: XLink in the realms of XML development and W3C standards, and *netomat* in contemporary art scenes. Comparing these two different case studies, however, provides insight into both the arts and technology contexts. Nor are these contexts wholly distinct or hermetic—our analysis demonstrates the relations between arts and technology

discourses and shows the importance of bringing art objects into computer and information science, and likewise bringing computer and information science into art history.

For both case studies, we draw on several historical sources. In the case of *netomat*, we conducted an extensive interview with Wisniewski, who also shared the *netomat* technical specifications.[5] In addition to these primary sources, we looked at contemporaneous coverage of *netomat* in both arts and technology publications, information from the gallery and museum exhibitions featuring the work, as well as materials from Web archives. Our analysis of XLink centers around the monograph *XPath, XLink, XPointer, and XML: A Practical Guide to Web Hyperlinking and Transclusion* (subsequently referred to as *XXXX*), as this work builds on the foundational work on XLink to explicitly express a summary statement of how XLink functions and the value that XLink can bring to the Web [34]. This analysis is supplemented by the W3C XLink standard and other papers describing XLink implementations.

In many ways, both XLink and *netomat* are "failed" technologies, and it seems strange to continue to devote attention to them. However, bringing a historical perspective to bear on earlier Web technologies is of the utmost importance, not only to make sense of how past decisions continue to impact current Web technologies, but also to uncover a richer imaginary of how Web documents might be structured and understood. By delving into the historical context of these technologies, we also demonstrate the particularity and complexity of "the Web" at any given moment, as true of the late 90s as today. The Web is a complicated assemblage of systems and protocols, as well as people and organizations. XLink and *netomat* articulated alternative possibilities for how Web documents might be configured, written, and read, but necessarily did so within this broader infrastructure. As with many "failed" technologies, ideas presented by XLink and *netomat* might still be attractive and could be beneficially implemented in the Web of today, but a historical perspective is needed to translate these ideas across time.

5 Results

In this section, we develop three main metaphors from our analyses of *netomat* and XLink, discussing how these influenced the structure of documents in these systems.

5.1 Navigable Information Space

A major motivation behind both XLink and *netomat* was to create navigable information spaces. More than a collection of interlinked documents, XLink and *netomat* both utilize spatial metaphors of hypertext, conceiving of the Web as a space that users can explore. Although each pursues different kinds of spaces, both implement mechanisms to provide users with more comprehensive overviews of information on the Web than the single page of a standard browser.

Published shortly after XLink 1.0 became a W3C Recommendation in 2001—and well after the Web became a global phenomenon—*XXXX* compares the extant Web with "the Web we want." Many of the authors' concerns echo Berners-Lee's desire for a way to understand the *whole* of an information space, and not simply its parts. They argue that effective use of resources, such as

[5] Unless otherwise noted, information about *netomat* and Wisniewski is drawn from the interview or technical specification.

documents or data, requires not only access to those resources, but an understanding of how different resources are related to one another. Wilde and Lowe go further to claim that understanding of these relationships is best facilitated through interaction with a *representation* of them. This representation, they argue, is what makes the Web not "just an extremely large collection of … distributed information" but "a single complex system" [34, page xxvi]. In this complexly structured information space, moreover, one creates value not by just adding more resources to the collection, but by enriching the space itself, improving its structure for better navigability and freer exploration.

Wisniewski developed *netomat* precisely to provide an alternative visualization of the massive amounts of information on the Web. One significant social function promised by the Web was the low barrier to entry for users to post their own webpages and add their perspectives to potentially global conversations. However, Wisniewski felt that mainstream browsers failed to leverage this diversity and complexity of information: "the network—with all of our thoughts and work going into it—was presented in this flattened way." Even though webpages can be linked together, browsers typically render pages as discrete and contained entities. In contrast to this, *netomat* zooms out from the individual page to visualize the interconnected information on the Web as stream, with text, image, and audio from different pages flowing together.

Although XLink and *netomat* are functional hypertext technologies, both also advocate for an imagined future for the Web. This perspective can be useful for understanding some corollaries of the spatial metaphors employed by both systems. One of these corollaries is a concern for freedom of exploration, the ability to freely move through an information space. Surveying definitions of hypertext, Wilde and Lowe cite the W3C's 1995 definition of it as "text which is not constrained to be linear" [31]. But hypertext's nonlinearity is important, they assert, not because the *text* is less constrained but because *people* are: nonlinearity "means that the user has a range of options… a network of potential or possible paths through the information" [34, page 24]. The autonomy granted in a hypertextual space is what allows people to explore it in "complex but flexible patterns," simultaneously making sense of those patterns and the resources visited [34, page 24]. The sense-making potential of these explorations is undermined, however, when people cannot make good choices, either because the required links cannot be made, or because they exist but are insufficiently contextualized. In other words, freedom of movement alone is insufficient: the information space must be designed and maintained in such a way that people can fully exercise their capability to explore.

Both of these technologies imagine improved means for users to navigate the Web as an information space, but the major difference is in how XLink and *netomat* figure movement through this space. XLink developers and proponents talk in terms of trails and paths, while Wisniewski uses the metaphor of the stream. Although both are motivated by perceived limitations in the Web document structure manifest in HTML standards and mainstream browsers, these different metaphors result in quite distinctive possible solutions.

FIGURE 3 IS OMITTED FROM THIS FORMATTED DOCUMENT
Figure 3. *netomat* interface, © Maciej Wisniewski

5.2 Trails, Paths, and Tours

An interlinked "space" is how *XXXX* figuratively describes the actual or imagined Web; in a section on the history of hypermedia, Wilde and Lowe approvingly cite Nelson's more specific spatial metaphor: "whole new gardens of interconnected text and graphics for the user to explore … making choices, browsing, exploring" [30, cited in 34, page 23]. Though they do not use the term themselves, Wilde and Lowe often discuss the information space of the Web as if it were a garden, in need of constant tending and maintenance by gardeners. Spaces that facilitate autonomous exploration do not simply arise; they must be designed and maintained. Concerns about design and maintenance lie at the heart of many of the "shortcomings" of linking as implemented in the actual Web. *XXXX* presents these shortcomings as technical issues related to the linking model, but to illustrate why these technical issues matter, they sketch scenarios that highlight the need for (re-)design and ongoing maintenance.

The Web that *XXXX* wants is a Web where anyone can create "trails" through the wood for others to follow, regardless of whether they happen to own any of the trees in the wood. In this imagined Web, the fact that anything can be linked to anything else by anyone ensures a kind of public space, "outside" the resources being linked to and from. *XXXX* criticizes the actual Web for lacking this public space, not only because this lack constrains the choices available to Web explorers, but because it curtails the creative potential of Web designers. In the actual Web, it is difficult to create experiences that blend and present others' resources in an open-ended way—a "guided tour"—unless those others agree to make those resources available to you as "data"—often for a fee. For Wilde and Lowe, this is a flaw because the interests of resource owners may be far removed from the interests of explorers, and local "guides" are likely to be more familiar with explorers' needs and interests. Empowering local customization and design is thus a strategy for ensuring that freedom of exploration cannot be encumbered by resource owners.

Bry and Eckert similarly use spatial language to describe the potential of XLink to augment the "open world" linking model of the Web, thus granting readers greater control over resources [8]. The Web already supports a great deal of free movement, where any resource can be linked to any other resource, and where resources can continually be added to the information space; but as links are embedded in the content of the document, readers can only follow the paths already laid out. Linkbases address this limitation by enabling readers to create or follow sequences of out-of-line links. This is put into practice by the XLinkProxy system, which uses a proxy to connect local linkbases to networked Web documents [9].

The guided tours made possible by linkbases not only provide greater means for self-directed navigation, but also represent a way to recompose and reconfigure documents, structuring altogether new contexts and meanings of documents by altering the arrangements of links. As Miles demonstrates, links have more than a merely grammatical function, possessing also a lyrical excess, a "semantic promiscuity" [24, page 66]. The exploratory, trailblazing metaphors used to describe XLink suggest the creative power that this expanded linking model promises to Web readers: users might forge their own paths, and in doing so effect wholly new documents of their passage. Navigation through the information space of the Web becomes a kind of writing.

Supporting better navigability on a local level is not Wilde and Lowe's only concern. They argue that "the global issue of overall information structure is just as important" [34, page 18]. One key

facet of this global issue is *maintainability*. The authors praise the pragmatic design choices that allowed the Web to quickly grow and flourish, but again and again express concern that these same choices will eventually lead to intractable maintenance issues. For example, though it is difficult to create Web experiences that blend and present others' resources in an open-ended way without their explicit permission, it is not impossible—designers find workarounds. But workarounds are difficult to maintain, so they will likely break sooner rather than later. For instance, Ciancarini et al. make note of the fragility of the external links in their proxy system, which will fail to work if the linked document changes in some way [9, page 59].

One need not agree with Wilde and Lowe that the use of XLink would have improved maintainability to see that the Web they want is one that facilitates maintenance over time—something that the actual Web has never done especially well. XLink and other XML linking technologies may aid in making and following paths at a local level, but Wilde and Lowe observe that these technologies will only be effective if the long-term maintenance of links can be scaled up to the Web as a whole. As an add-on to a Web where links cannot be consistently resolved over time, XLink can only marginally help users in their navigation and exploration.

5.3 Streams

In a certain sense, *netomat* concedes the basically unruly nature of the Web. As the terrain of Web resources expands and shifts at a breathtaking rate, the task for a system to maintain previously forged trails is daunting—and perhaps even undesirable. With new documents coming online, and old documents frequently changing, users may find that their existing paths either run into abrupt dead ends or must be updated to account for an altered geography. Instead of maintaining paths through a dense and unpredictable information space, *netomat* opts to open up dynamic streams, which flexibly follow the contours of Web documents as they exist at that moment. Accounts of *netomat* at the time of its release in 1999 emphasize the lack of clicking, the absence of forward and home buttons [22]; instead, users enter a query, and *netomat* gathers diffuse text, images, and audio into a single flowing meta-document.

This is not to say that Wisniewski welcomes the inherent messiness of the Web. As with Wilde and Lowe, Wisniewski expresses dissatisfaction with the state of the Web in the late 1990s. As Wisniewski said in our interview, *netomat* was motivated by a "Web that could be edited, a Web that you could write back." On top of limited means for users to creatively interact with Web content, Wisniewski grew frustrated by the conventions of the Web page. As navigation on the Web turned increasingly toward search engines, users were constrained by the ways in which these systems returned results as discrete pages ranked by an opaque algorithm—an issue even more prevalent today. These systems provide a necessarily delimited range of potential paths through the information on the Web. For Wisniewski, the technical issues involved in searching the Web cannot be separated from philosophical or political dimensions: "the interface to information is not neutral … you only get information from one source, usually one of the top ten sources. That's a problem."

Similar to how Wilde and Lowe describe XLink, Wisniewski presents *netomat* as a tool for exploration in an occasionally bewildering information space: "you can also find some of the forgotten parts of the Internet. When I was crawling the Web, a lot of information I would get

would never appear in a search engine, at least not in any of the top results." By introducing the stream metaphor, Wisniewski also worked toward a new kind of Web document structure that might address some of the limitations he saw in mainstream browsers. Although *netomat* itself functions akin to a search engine, the stream brings together information from diverse sources into a single document. Instead of distinct ranks, Wisniewski talks about the variable "velocity" of information on the network: as users wade through the stream, they encounter pieces of information meeting and separating at different speeds, often representing contrasting or dissimilar views on the queried topic; users can move the mouse up or down to change the speed, and left or right to change the direction of the flow, but this also alters the constitution of the document's content as crawlers continually bring in different pieces of information.

The metaphor and structure of the stream breaks with the vision behind XLink in some important ways. Unlike the path or guided tour in XLink, the intent of *netomat* is not to create clearly defined and reproducible paths that both present and later users can consistently follow. Indeed, *netomat*'s streams shift even in the process of a single browsing session. While XLink adds to the capabilities of links and increases the importance of the link as a navigational tool, *netomat* dissolves the page and the link altogether. In a way, links only implicitly persist beneath the surface of the stream, with fragments of content pointing obliquely back to their originating sites.

Netomat does not generate persistent navigational resources, but the system does afford users other means for active exploration of the Web. The main such utility is the users' ability to tune the search for and presentation of information via the netomatic markup language (NML), an XML dialect Wisniewski wrote to structure *netomat* documents. Users could double-click on the search bar in *netomat*, calling up a menu to tweak various NML parameters, and thus refine how the browser searched for information and how these fragments of information got presented in the stream. A primary use of this was to search over a delimited part of the Internet: "You could restrict it to a domain; you could restrict it to a subdomain. You could even run it on a Local Area Network. The reason I did that was so that you could actually direct your browser." Though *netomat* generates dynamic documents that resist charting a stable course, this feature does make possible exploration that maps the metaphorical information space to the real geography of the network.

Contemporaneous accounts of *netomat* remark on this feature as giving users great creative power. An article in *Computing Canada* attests that "with NML, users can create their own browsers which can search a network or the Internet for text, graphics, and multimedia files" [22, page 21]. For *Wired*, Jana compares using *netomat* to a DJ scratching and sampling tracks, adding that "in essence, data … is loosened from Web sites and viewed in a context the user determines" [20]. Given the flexibility and modularity of the system, Jana goes on to assert that it might be "more accurate to describe *netomat* as a means for spawning an infinite number of new browser interfaces rather than as a browser itself" [20]. As described at the time, even entering a query into *netomat* constituted a constructive act—a mode of browsing that joined both reading and writing, as with the creation of XLink paths, tours, and linkbases. The creative potential of the system was only augmented by the customizability of the underlying NML.

The metaphor of the stream or the feed has become dominant in today's Web, characterizing the never-ending flow of content presented to users of any given social media service. In fact,

Wisniewski went on to develop *netomat* into a company specializing in social Web applications.[6] However, these later applications continued in the vein of the *netomat* browser, all with an aim to give individuals greater agency over their explorations in the information space of the Web.

6 Discussion

In a number of ways, both XLink and *netomat* intentionally broke with the global hypertext system of the Web as it was manifested at the time in HTML 4 and mainstream browsers like Netscape Navigator and Internet Explorer. Wisniewski and XLink developers like Wilde and Lowe were motivated to address many perceived limitations of the existing system, striving toward "the Web we want." DeRose summarizes the motivations for many of the imagined possibilities carried forward by XLink and *netomat* in his overview of the suite of XML linking technologies [11]. DeRose points to three main areas for improvement: limits in addressing on the Web, such as the fragility of URLs and difficulties in linking to specific parts of complex resources; limits of closed tag sets with fixed semantics, which are likely insufficient for a wide variety of documents on the Web; and the limited behavior of links on the Web. As DeRose argues in an earlier paper, hypermedia systems can and should support a variety of kinds of links, although this will require sophisticated linked models [10].

Many of these concerns still resonate today, and many current Web development efforts continue to address these same issues. The Resource Description Framework (RDF) is another W3C recommendation, developed around the same time as XLink, that advances some of the same improvements to the Web, namely mechanisms for enriching the semantic structure of webpages as distinct from the content. While XLink has largely been abandoned, an active community continues to leverage RDF for Semantic Web and Linked Open Data efforts.

The purpose of this paper is not to resurrect XML linking technologies, nor to suggest that new browsers be developed in the mold of *netomat*. Though these technologies both contain engaging ideas, and though many of the difficulties addressed still persist, the Web of today is quite different from the Web of the late 1990s. Even if many of the same general issues continue to be relevant to current projects—like linkrot, semantic richness, and expanded linking—the technical, social, and economic aspects of the Web today are markedly distinct in the particulars.

A lesson that we can still learn from historical technologies like XLink and *netomat*, though, is precisely how these systems were deployed on the Web as it existed, contingent upon protocols, network infrastructure, HTML standards, and browser specifications. XLink and *netomat* both critiqued key aspects of HTML, browsers, and the Web at large, but did so within the existing sociotechnical infrastructure of the Web at that time. XLink applications had to integrate into existing browsers and network protocols, as in the example of XLinkProxy [9]. Likewise, *netomat* crawlers functioned within the protocol suite of the Internet and the Web, and Wisniewski used XML standards to create his own special-purpose markup language. XLink and *netomat* represent critiques of the Web as it was, and offered visions of what the Web might be, but necessarily operated through the very technologies they sought to improve. This is to say that XLink and *netomat* staged immanent critiques, demonstrating limitations of the Web from inside the infrastructure of the Web itself. The necessity of fitting within this existing infrastructure is

[6] https://www.netomat.net/

part of the reason why neither of these systems work all that well today, but they remain instructive cases of how Web development needs to advance on the grounds of existing technologies, even as new projects might seek to introduce ideas or capabilities that are not yet wholly supported.

Our results demonstrate that metaphor is one of the essential ways in which this immanent critique is staged. Discussants of both XLink and *netomat* connect the innovations and critiques of these systems back into the complex ecology of existing and historical technologies through metaphorical language of spaces, paths, and streams. These metaphors hearken back to a hypertext imaginary that predates the Web, as many of the earliest hypertext theorists, engineers, and users developed spatial metaphors to describe the new and potential capacities of electronic reading and writing systems. As Barnet reminds us, the Web as it currently exists is only one example from a rich and varied history of hypertext [1, page xxi]. Describing XLink in terms of paths uncovers desired applications and intentions from older hypertext systems. In discussing NoteCards, for instance, Halasz points to the need for visual structures to help users navigate frequently changing information spaces [17, page 357]—an issue directly taken up by linkbases. In deconstructing the page metaphor as the overriding means for presenting Web documents, Wisniewski tapped into a long-running debate about the relationship between hypertext and printed media [6, 27]. Attending to these metaphors illuminates how these technologies were understood not only at the time of their development, but in relation to both the past and future of hypertext.

7 Conclusion

Metaphors form bridges across time, connecting current issues back to earlier instances of similar challenges, and positioning previously imagined possibilities within the technological landscape presently at hand. We have discussed the metaphors employed by two hypertext technologies, XLink and *netomat*, detailing how these metaphors situated these technologies in relation to both contemporaneous and historical hypertext discourses. However, the information space, the path, and the stream are just a few metaphors that populate discussions of hypertext, hypermedia, and the Web.

One metaphor for the Web that is conspicuously absent from the late 1990s discourse examined here is the *platform*. A platform is a surface on which things can be placed, and by the 1990s, it was already being used in a metaphorical sense to refer to a standardized system architecture or operating system, a base upon which things could be built. A canonical example of a computing platform is a video game console such as the Sony PlayStation, which simultaneously establishes both a common foundation for building video games and market for selling them. The Web, too, is a base upon which things can be built, and yet the phrase “Web platform” did not gain currency until around 2012, when Apple, Facebook, Google, Microsoft and a number of other tech corporations launched the WebPlatform project in an attempt to characterize the Web as a viable alternative to other platforms such as Android and iOS [32]. This effort came after several years of work on overhauling the HTML standard to make it easier to build “apps” for the Web—JavaScript applications that run in the browser and provide an experience more like working with a software application and less like reading a page.

The platform metaphor contrasts strikingly with the older metaphors discussed above. While a platform may allow "switching" between apps to allow multi-tasking, there is no attempt to create a navigable space. "Links" exist in only the most attenuated form, as means to initiate a switch from one app to another. At its most extreme, the platform metaphor leads to apps like Facebook or WeChat—platforms in their own right—where active exploration is replaced by passive consumption of "feeds" of content. These feeds, unlike the *netomat* stream, are not under the active control of the user but are carefully optimized by unseen platform managers. Users may offer contributions to the feeds of others—which the managers may accept or ignore as they see fit—but in no way are they empowered to guide others or to collaboratively maintain anything. Their only choice is to uninstall the app, or change platforms entirely.

Analyzing these metaphors in depth helps to make clear how the designers conceive of and envision these systems. Such analysis can also shed light on the social and political implications of a given hypertext system. The kinds of social interactions intended on a "platform" differ markedly from the navigable information spaces of a tended path or a directed stream. As we continue to develop the global hypertext system of the Web, we might take up the question posed by Wilde and Lowe: what is the "the Web we want?" Paying attention to the metaphors used to make sense of the Web can help to answer this question.

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