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A Critical Assessment of Hypertext Systems

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General Overview

Over forty years ago, Vannevar Bush articulated his vision of a "Memex" machine: *"associative indexing, ... whereby any item may be caused at will to select immediately and automatically another"* [Bush 45]. In the sixties, Engelbart [Engelbart, English 68] built collaborative systems to provide idea structuring and sharing. Nelson [Nelson 81] coined "hypertext" and proposed world-wide networks for publishing, linking, annotating and indexing multiple versions of documents. With increasing numbers of research projects, papers, panels and conferences, and commercially available systems (e.g. Notecards by Xerox, Guide by Owl and HyperCard by Apple) in recent years, hypertext may be an idea whose time has finally come -- or at least a phenomenon not to be ignored.

The goal of this panel is *not* to define hypertext or hypermedia (at its simplest: non-linearly arranged and accessed information), debate its uniqueness, explain implementation issues, or survey the many applications and contributions in the field (see [Conklin 87] for an excellent survey of Hypertext, and the Proceedings of Hypertext '87 Workshop at University of North Carolina, Chapel Hill). Rather, we intend to approach it from the perspective of the information user: reader, searcher, author. The panel will address the following issues:

- Are the processes of authoring and understanding helped or hindered by the non-linear structure of hypertext, for which kinds of tasks and users? What is the difference between a hypertext writer and a knowledge engineer? In searching for information, what is the difference between browsing and querying?

- What experiments need to be done? What tools, environment or interfaces can improve the process of information creation and access? Can the overhead of creating or interpreting structure be reduced?

- When will hypertext replace paper, or should it? How do functions of author and reader co-evolve? Could this revolutionize society like the printing press? Why didn't the panelists create a multi-versioned, highly crossreferenced online entry for the proceedings? Is hypertext a technology in search of a problem?

Gerhard Fischer

In a current research project (jointly with Walter Kintsch), we are exploring problems in user-centered system design with an emphasis to build a personal intelligent information system. A workshop in January 1987 brought together researchers working on different aspects of Hypertext systems [Fischer, Nieper 87]. The role of *structure* emerged as a critical challenge in system design during the workshop. The discussion centered around the question "Is structure desirable: yes or no?" Users do not like to be forced to generate structures. In early problem solving stages the enforcement of structure may get in the way. In addition there is the pragmatic decision: Are the advantages of

structure for retrieving and using information worth the effort to generate the structure? The following issues have to be considered:

- If we have no structure, then there is no need for restructuring.

- If we impose a structure, which form should it take: hierarchies, inheritance networks, associations, ...? Are fileboxes (e.g., in NOTECARDS), which impose a hierarchical structure, compatible with the more associative structure of ideas represented in a Hypertext system?

- Is a structure statically given or generated on demand?

- Do Hypertext systems encourage their users towards premature organization of information?

- As our understanding of a domain increases, can we incrementally impose more structure and can we represent more information formally (e.g. in a knowledge representation language) allowing the interpretation of information by computer systems?

To be able to cope with large Hyperknowledge systems, structuring principles play an important role. For many interesting areas, a structure is not given a priori but evolves dynamically. Because little is known at the beginning, there is an almost constant need for *restructuring*. Despite the fact that in many cases users could think of better structures, they stick to inadequate structures, because the effort to change existing structures is too large.

Another research effort related to Hypertext systems is based on the assumption that information and knowledge embedded in computers can be represented and used in *qualitatively* different ways than on paper. Paper is passive and can only serve as a repository for information, whereas computer systems can be active and assist us in searching, understanding, and creating knowledge in the course of cooperative problem solving processes. We have explored this general idea in the context of building a variety of *intelligent support systems* for high-functionality computer systems emphasizing the following specific issues:

- representation of programs as knowledge networks where the code, the documentation, and visual representations are external representations generated from the same complex internal knowledge structure,

- user-definable filters that give users control which parts they would like to see,

- constraint mechanisms to maintain consistency between internal and external representations,

- different browsing and retrieval systems to explore Hypertext spaces,

- design environments to advise, guide and critique users of Hyperknowledge systems [Fischer 87].

William P. Jones

Jones has developed a *Memory Extender* (ME) personal filing system [Jones 86]following an approach that assumes important similarities between task considerations facing human memory and those facing computer-based information retrieval systems (the ME system adopts a network approach and actively models the user's own memory for the files of a personal directory.) He is currently exploring neural network processes that may give hypertext systems an ability to make better use of information in human-computer interaction. Events of the recent past may help the computer to anticipate (i.e., "given that the user has selected these units what units will the user next most likely need to see?") and to adapt ("how can the hypertext network of interconnections be modified to increase the ease with which a user accesses this unit (just selected) in contexts similar to this one in the future?")

- *The Enthusiast:* Hypertext provides the writer with more direct ways to represent information (ideas, arguments). It allows an expression more closely aligned with the writer's way of thinking.

   The Skeptic: Few writers will tolerate the overhead of hypertext, its obtrusive and premature imposition of structure.

- *The Enthusiast:* Hypertext allows the reader to customize interactions with a body of information, focusing on those pieces of information that most closely match individual needs and interests.

   The Skeptic: Hypertext presents the reader with a confusing web of alternatives that hides relevant information; the reader will pursue links of no relevance and arrive at relevant information without having first viewed prerequisite, supporting information.

Similar and contradictory arguments can be advanced in the assessment of hypertext's use in programming and information management. Each situation contains actions of information sending (i.e., writing, programming, storage) and reception (i.e., reading, program use or modification, retrieval). In each situation, a case can be made that hypertext helps or hinders the sender and, correspondingly, that it helps or hinders the recipient.

Is it possible that hypertext enthusiasts and skeptics are talking about two different systems? Certainly enthusiasts may sometimes have in mind systems that are many years away from realization, while skeptics may

sometimes maintain viewpoints that are overly influenced by the constraints of more conventional, "linear" channels of communication. But it may also be true that the specification of the basic hypertext system allows the formation of a variety of contradictory arguments depending upon assumptions, implicitly made, regarding who is doing what to bridge the communication gap between sender and recipient.

Hypertext, in its current form, is a scheme of representation critically short of supporting processes. As a consequence, the work needed to take advantage of its representational features must be expended by its users, through some division of labor between sender and recipient. Where is the computer in all of this? We must develop processes whereby the computer can assume a larger role in transforming the information of the sender into forms that are usable by intended recipients. These processes may come from a variety of sources including AI work on knowledge bases and expert systems, work on information retrieval systems, and neural network research.

Alan Kay

Kay has created and inspired many innovations in the personal computing and object-oriented programming areas at Xerox PARC, Atari, and Apple [Kay 77; Kay 84]. The Dynabook computer was to be more than a portable computer or an online book; together with a language like Smalltalk, it was envisioned as a "personal dynamic medium" for learning and expression. Hypertext is a new communication medium; as with all new media, how will it change our writing and understanding? Will the experience be like television? Will carefully crafted essays fit this genre? Will fragmentation or connection dominate?

Kay is currently investigating what it would be like for people to create their own computer agents -- semi-intelligent processes that can act as alter egos, carry out tasks, find resources, advise, coach, and more. The Vivarium project involves children observing and designing environments for animal and plants and populating these environments with creatures that sense and interpret it. Analogously, they might create "information ecologies" that could serve as a framework for representing and exploring the world's knowledge.

Walter Kintsch

Kintsch is trying to relate Hypertext to the the study of discourse comprehension and production. One can argue that Hypertext is an old story (the "variorum" editions of classical authors in the 15th century), a new vision (Bush's essay in 1945), and a modern technology in search of an application.

Its goal is to make reading, writing and knowledge transfer easier by transcending the limitations of linear text. Conventional distinctions between reading and writing are blurred. The essential action becomes one of making the appropriate connection between a new piece of information and a large and growing body of existing knowledge. In the context of Hypertext, readers may frequently switch into writing modes.

Hypertext seems a vision worth pursuing, so let's see what is involved. What might be the relevance of text comprehension and writing research to this goal? Comprehension as well as writing is limited by (a) properties of the medium, e.g. need for linearization, and (b) constraints of human information processing. We can change (a), but must respect and understand the limits set by (b).

Reading and writing. These are not just opposites, but the strategies involved are different; what makes them difficult is different. In general, what support people need depends on what they are trying to do - even if we consider only writing, what is needed for the idea generation phase is irrelevant for the translation (editing, organization) phase. A system, therefore, must be task specific, adapted to the demands of various writing stages, reading modes (e.g. SUPERBOOK) and learning modes.

Reading. A textbase is the mental representation of the content and structure of a text that a reader constructs; it is useful to distinguish a micro- and a macrostructure [Dijk, Kintsch 83]. The textproperties that affect the difficulty of comprehension at the micro-level are reasonably well explored: e.g., the discourse cues that indicate how to form a coherent microstructure, or how the organization of information via the given, new strategy facilitates understanding. The relevant text properties at the macro-level have also been studied extensively. Chunking is seen as a major process by means of which the mind deals with complexity. In all studies with regular text, a good macrostructure appears to be a prerequisite for comprehension, learning, and memory (e.g., the "composite nodes" in NOTECARDS are an attempt to deal with chunking). One may ask the question: how much of this can the hypertext reader do without? Reading the kind of text discussed here is a resource consuming task; we cannot make it much harder than it usually is (by giving no cues, requiring the reader to make decisions about the selection of alternatives, etc.). On the other hand, there is an optimal level of difficulty - college students actually write worse summaries when a text is too well-organized, while 6th grade students need that structure in order to do well.

Writing. [Bereiter, Scardamalia 87] have analyzed the knowledge telling versus the knowledge transformation strategies in writing. It is easy to support the former, but the latter is what is difficult. Writing is social: we write for someone. Correctly gaging their audience is one of the strongest characteristics of expert writers. Not only the content, but also discourse aspects need to be considered, e.g. for questions of

convincingness and believability.

Another characteristic of good writers is their ability to reorganize: NOTECARDS forces you to label and link right away, which may promote premature organization. What is needed are tools for restructuring. At this point, the usually passive computer in hypertext systems might have to take on a more active role, recombine ideas, and make suggestions to the writer as to new organizations and perspectives.

Knowledge acquisition and transmission. Remembering a text is (often) not the goal; rather, what we want is "truly integrated knowledge". Cognitive theory is still weak here. We know that memory for text is not the same as learning from that text. Conditions that optimize the former may produce little integrated knowledge (e.g. [Mannes, Kintsch 87]). There are still many open research questions concerning these problems.

Knowledge organization and structure. What is needed here is above all flexibility. In theories of human knowledge representation, structures such as frames, scripts, and schemata are used to guide knowledge use. However, these structures are not fixed properties of the memory system, but are generated on demand in some particular task context. Only in this way is it possible to account for the context sensitivity of the human information processing system. We need to study such emergent structures, and learn from them how to design knowledge bases for hypertext systems.

Some of the questions based on this research are: Is our theory limited to sequentially organized systems or is it independent of the representational medium? What is the impact of non-linear text on theories of discourse and current cognitive theories of text processing? Hypertext gives us a "GOTO" -- should we have more structured constructs?

Randall H. Trigg

Trigg combined hierarchical and network organizations, "paths" and link types in a single framework in his TEXTNET system [Trigg, Weiser 86]. For the last four years, he has been working at Xerox PARC where he was one of the developers of the NOTECARDS system [Halasz, Moran, Trigg 87]. His research into hypertext/hypermedia-related issues has focused on: user interfaces including graphical browsers over hypertext networks; user-tailorability [Trigg, Moran, Halasz 87]; hypertext support for collaborative research and writing [Trigg, Suchman, Halasz 86]; and studies of hypertext user communities [Trigg, Irish 87]. Currently, he is working with P. Irish on a semi-automated facility "History cards", used to keep records of work in a collaboratively maintained hypertext project notebook. Most recently he has implemented a graph-based "guided tour" facility to support authors building online presentations of their

NOTECARDS networks.

How can we support the gradual emergence of structure over the lifetime of a hypertext network? In writing a paper, for example, this involves moving from loose sketches and outlines through note-taking and organizing/linking materials to the generation of linear drafts. What special problems arise when the network is collaboratively constructed?

How should a hypertext network support discussion about itself? How should guided tours, record keeping, and other forms of self-documentation be embedded in the hypertext?

How can a hypertext system be both tailorable and suitable? Can we create a layered system that extends from a pure hypertext substrate towards progressively more customized application-specific systems?

Is it worth pursuing the elusive primitive set of link types for applications like critiquing, or are link types hopelessly user- and context-dependent?

Stephen A. Weyer

Weyer developed Smalltalk information retrieval tools, browsing interfaces and applications for the office, library and school while at Xerox PARC. For his dissertation work [Weyer 82], he designed an online world history book and evaluated its use by eighth-grade students to answer questions. This dynamic book had many hypertext qualities: subject and content bookmarks, search path highlighting, hierarchical subject links, and hierarchical text. In contrast to this emphasis on text structure and search techniques, [Weyer, Borning 85] explored issues related to dynamic information in a prototype electronic encyclopedia, that included active objects (measurements, abbreviations, crossreferences), videodisc images and simulations (e.g., abacus, spring).

His current interests are in applying artificial intelligence techniques to representing and presenting knowledge. Can authoring tools be created that can suggest or infer the appropriate structure? Can intelligent guides help learners navigate this information space -- in addition to helping us find "the answer" more efficiently, could a guide help in creating questions? In addition to helping to better ask "What?," can we make more explicit such questions as "When is it appropriate?" "Why is it important?" "From whom did it come?" and "With what effect?" How can we preserve context if information is reduced to digestible chunks ("Knowledge McNuggets")? If we are successful, how do we promote online literacy, or will the distance between "have nets" and "have nots" increase further?

Rather than thinking of the system as containing information, think of it as an environment for descriptions

and programs. Rather than thinking of the system as a passive entity on which the author performs neural surgery to add new components and connections, think of it as an active partner -- a hyperknowledge assistant. What besides browsing can we do with a hypermedia system -- can it provide support for all of a user's activities?

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