Hypertext Semiotics in the Commercialized Internet

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Abstract

Hypertext theory makes use of the same set of terms that have been explored in decades of semiotic investigation, such as sign, text, communication, code, metaphor, paradigm, syntax, etc. Building on approaches that have succeeded in applying semiotic principles and methodology to computer science, such as computer semiotics, computational semiotics, and semiotic interface engineering, this dissertation establishes a systematic account for those researchers who are ready to look at hypertext from a semiotic point of view. Rather than a new hypertext model, this work presents the prolegomena of a theory of hypertext semiotics, interlacing the existing models with the findings of semiotic research, on all levels of the textual, aural, visual, tactile and olfactory channels. A short history of hypertext, from its prehistory to today's state of the art systems and the current developments in the commercialized World Wide Web creates the context for this approach which should be seen as a fortification of the connection between the media semiotic approach and computer semiotics. While computer semioticians claim that the computer is a semiotic machine and Artificial Intelligence scientists underline the importance of semiotics for the construction of the next hypertext generation, this paper makes use of a much broader methodological basis. The range of subtopics include hypertext applications, paradigms, structure, navigation, Web design, and Web augmentation. The interdisciplinary spectrum of methodology also enables detailed analyses, e.g. of the Web browsers' pointing device, the @ sign, and emoticons. The "icon" (a small picture known from the GUI desktop and used in hypertext) is identified as a misnomer and replaced by a new generation of powerful "Graphical Link Markers". These findings are placed in the context of the commercialization of the Internet. Besides identifying the main challenges for eCommerce from the viewpoint of hypertext semiotics, the author concentrates on information goods and the current limitations for a new economy, such as restrictive intellectual property and copyright laws. These anachronistic regulations are based on the problematic assumption that – for information too – value is based on scarcity. A semiotic analysis of iMarketing techniques, such as banner ads, keywords, and link injection and two digressions on the Browser War, and the Toywar complete the dissertation.

Zusammenfassung

Die Hypertext Theorie verwendet die selbe Terminologie, welche seit Jahrzehnten in der semiotischen Forschung untersucht wird, wie z.B. Zeichen, Text, Kommunikation, Code, Metapher, Paradigma, Syntax, usw. Aufbauend auf jenen Ergebnissen, welche in der Anwendung semiotischer Prinzipien und Methoden auf die Informatik erfolgreich waren, wie etwa Computer Semiotics, Computational Semiotics und Semiotic Interface Engineering, legt diese Dissertation einen systematischen Ansatz für all jene Forscher dar, die bereit sind, Hypertext aus einer semiotischen Perspektive zu betrachten. Durch die Verknüpfung existierender Hypertext-Modelle mit den Resultaten aus der Semiotik auf allen Sinnesebenen der textuellen, auditiven, visuellen, taktilen und geruchlichen Wahrnehmung skizziert der Autor Prolegomena einer Hypertext-Semiotik-Theorie, anstatt ein völlig neues Hypertext-Modell zu präsentieren. Eine Einführung in die Geschichte der Hypertexte, von ihrer Vorgeschichte bis zum heutigen Entwicklungsstand und den gegenwärtigen Entwicklungen im kommerzialisierten World Wide Web bilden den Rahmen für diesen Ansatz, welcher als Fundierung des Brückenschlages zwischen Mediensemiotik und Computer-Semiotik angesehen werden darf. Während Computer-Semiotiker wissen, dass der Computer eine semiotische Maschine ist und Experten der künstlichen Intelligenz-Forschung die Rolle der Semiotik in der Entwicklung der nächsten Hypertext-Generation betonen, bedient sich diese Arbeit einer breiteren methodologischen Basis. Dementsprechend reichen die Teilgebiete von Hypertextanwendungen, -paradigmen, und -strukturen, über Navigation, Web Design und Web Augmentation zu einem interdisziplinären Spektrum detaillierter Analysen, z.B. des Zeigeinstrumentes der Web Browser, des Klammeraffen-Zeichens und der sogenannten Emoticons. Die Bezeichnung ”Icon” wird als unpassender Name für jene Bildchen, welche von der graphischen Benutzeroberfläche her bekannt sind und in Hypertexten eingesetzt werden, zurückgewiesen und diese Bildchen durch eine neue Generation mächtiger Graphic Link Markers ersetzt. Diese Ergebnisse werden im Kontext der Kommerzialisierung des Internet betrachtet. Neben der Identifizierung der Hauptprobleme des eCommerce aus der Perspektive der Hypertext Semiotik, widmet sich der Autor den Informationsgütern und den derzeitigen Hindernissen für die New Economy, wie etwa der restriktiven Gesetzeslage in Sachen Copyright und Intellectual Property. Diese anachronistischen Beschränkungen basieren auf der problematischen Annahme, dass auch der Informationswert durch die Knappheit bestimmt wird. Eine semiotische Analyse der iMarketing Techniken, wie z.B. Banner Werbung, Keywords und Link Injektion, sowie Exkurse über den Browser Krieg und den Toywar runden die Dissertation ab.

Preface

”Why is this a book?” is the first sentence of Jakob Nielsen’s seminal work on hypertext and hypermedia, [387]. The same question should be asked to the author of a doctoral thesis on hypertext semiotics. For Nielsen, there were still ”so many disadvantages connected with electronic publishing” that he decided to stay with paper a little longer. Many of these disadvantages seem to have disappeared with the rise of the WWW. Yet, a lot of technical and administrative factors still favor the dissemination of scientific works on paper *and* online. The strategy to deliver a printout of a Web project’s HTML pages to the library staff (as described in [65]) does not solve the problem. Thus, I opted for a hybrid form of electronic and paper publishing, the PDF format with embedded hyperlinks and a HTML version derived from it, cf. [196].[1]

The cross-references to other sections, figures or footnotes are active links that save the reader of the electronic text from leafing or scrolling around. The definiton links to the glossary, the ”backlinks” in the bibliographic section and the active hyperlinks to World Wide Web sites are especially useful in the online version.

Accordingly, the table of contents alone cannot fully represent the structure of this document. To get an overview over this work and for navigation purposes, the reader should also study figure 1, the graphical map of the dissertation.

This dissertation would not exist without the sustained efforts of many people. Allow me first and foremost to stress the depth of my obligation to my adviser, Veith Risak. In personal conversations and numerous e-mails, his insights and commentaries on this dissertation helped me discover what it was about. I am also thankful for the advise and contributions of several collegues, among them Wolfgang Panny and Andreas Geyer-Schulz at the Vienna University of Economics and Business Administration (WU Wien), Herbert Hrachovec and Klaus Hamberger at the University of Vienna (Uni Wien), Jeff Bernard at the Institute for Socio-Semiotic Studies (ISSS) in Vienna, Karin Wenz, Guido Ipsen and Joseph Wallmannsberger at the University of Kassel, Dagmar Schmauks at the TU Berlin, Linda Colet at the Museum of Modern Art (MoMA), Lauretta Jones at the Thomas J. Watson Research Center, Sigi Reich at the University of Linz, Frank Shipman at Texas A&M University, and Brian Proffitt at BrowserWatch. In my efforts to write this work, I was supported by Claudia Hundius (who also helped with the compilation of the glossary), my parents, my brother and my closest friends.

[1] This thesis is written with the text editor LyX on LaTeX, a document preparation system designed by Leslie Lamport in 1985. It, in turn, was built up from a typesetting language called TeX, created by Donald Knuth in 1984. The embedded hyperlinks use the package hyperref (developed by Sebastian Rahtz, Heiko Oberdiek and others). The PDF version was created with ps2pdf, the HTML version was generated using the LaTeX2HTML translator by Nikos Drakos. The online version of this dissertation can be found on my Home Page www.unet.univie.ac.at/~a9108095.

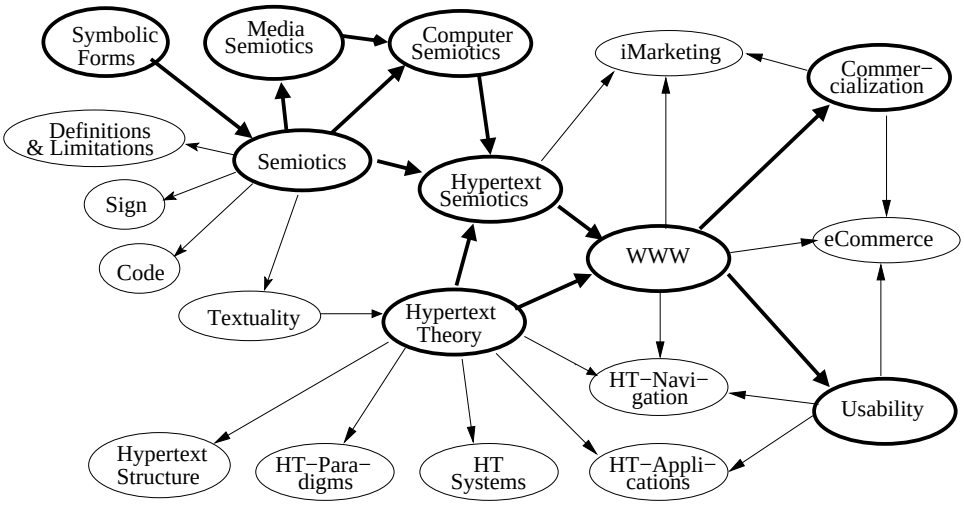

Figure 1: Graphical overview of this doctoral thesis.

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Chapter 1

Introduction

While many people think of hypertext in terms of the World Wide Web, hypertext was conceptualized in the mid-1940s by Vannevar Bush (cf. [80]) and practical research by Douglas Engelbart and Ted Nelson has been ongoing since the early 1960s, cf. [162, 379]. In 1965, Nelson coined the word ”hypertext” and defined it as ”a body of written or pictorial material interconnected in a complex way that it could not be conveniently represented on paper. It may contain summaries or maps of its contents and their interrelations; it may contain annotations, additions and footnotes from scholars who have examined it” [379].

Since the late 1980s, Hypertext Theory has established a new battle-field for literary studies, semiotics, linguistics, philosophy and media theory. Prima facie, there seems to be a vast discrepancy between this theoretical approach and the phenomenon of the commercialized WWW at the turn of the century: ”Discussion of hypertext from five or ten years ago now seems strangely idealistic. Although the possibilities identified by semioticians are still present, the implementation of hypertext within the Web closely resembles traditional print media. Indeed, the structure often imposed upon hyperlinks actively negates the radical, writerly, intertextual qualities previously envisaged,” [346]. Yet, that does not mean that academic research must adapt itself fully to the current standards of corporate Web design and electronic publishing, cf. [287]. On the contrary, it can critically analyze these developments and provide a theoretical and scientific basis for a public discussion that involves the industry and governments, the hypertext research community, the W3C and the Internet Engineering Task , cf. [266, 506].

Today, navigation tools and even the content of typical Web pages consist to a large extent of graphical information, whether we call them images, icons, buttons, or even animations. However, most hypertext theorists view the terms hypertext and hypermedia as synonymous and use them interchangeably with a preference to sticking to hypertext ”since there does not seem to be any reason to reserve a special term for text-only systems,” [387, p. 5]; cf. [62] . Concerning the difference between multimedia and hypermedia, it has been said that the difference between multimedia and hypermedia is similar to that between watching a travel film and being a tourist yourself, cf. [387, p. 10]. In the question whether hypermedia is a subset of hypertext or, hypertext a subset of hypermedia, I follow Schulmeister: ”A special subset of multimedia, then, is hypertext at the same time, and the decisive criterion is interactivity. If we collate both arguments, we arrive at the following definition: hypermedia is a subset of hypertext, and at the same time hypermedia is a subset of multimedia. It is probably better to view multimedia and hypertext as two independent entities with an intersection that might be called hypermedia” [476].

The importance of all our senses for understanding cannot be overestimated, yet there are no major hypertext systems that incorporate olfactory, gustatory, or haptic elements (neither

as nodes, nor as links). Video and audio clips can be found in many systems and are available widely on the WWW, but involve many questions, e.g. how to link *within*, *out of*, and *into* a sound[1] [320], [20], [215]. Nielsen points out that "even though many hypertext systems are in fact hypermedia systems and include many multimedia effects, the fact that a system is multimedia-based does not make it hypertext [...] Only when users interactively take control of a set of dynamic links among units of information does a system get to be hypertext," [387, p. 10]. Therefore, the main focus will be on the distinction between textual and graphic elements of hypertext systems, whether they are simply part of a node or whether they have linking functionality.

The semiotic approach has proved to be a suitable and most elaborate tool when working with both words and images. It has been adopted by art history and media theory and is nowadays a standard tool when analyzing the domain of images, cf. [66, 535, 141, 160]. "Computer Semiotics" is a term which has been gaining currency in recent years. Established by Peter Bøgh Andersen (cf. [9, 8, 10, 13]) it may be an emergent field of inquiry, but as of yet there is little academic consensus as to its scope. By elaborating the concept of *Hypertext Semiotics*, I intend to test the stability of the *Computer Semiotics* construct and its applicability of its methods on hypertext structures which has often been implied but not yet fully explored, cf. [8, 106, 382, 383, 478, 384, 128]. The validity of a semiotic approach to computer science has been emphatically underlined by Nadin:

> "Computation is about meaning, not electrons. Regardless of the type of computation, what interests computer users is not the electrons moving along sophisticated circuits, but the various bearers of meaningful information signs subjected to their programmed processing. Whether electron, light, quantum, or DNA-based, the computer is a medium for sign processes! Numbers turned into images, simulations, database operations, etc. are examples of how the signs of the object of our practical interest are processed according to our goals" [375].

Peirce's classic distinction between iconic, indexical and symbolic signs has been cited in connection with hypertext theory by Colón [107]. It has also been pointed out that some of the "icons" employed in GUIs, within the toolbar of Web browsers and on Web sites are in fact symbols, cf. [346]. However, many of these bridges between semiotics and hypertext theory are not quite theoretically founded. Besides a thorough consideration of classical semiotic approaches, I will draw on a broader theoretical framework of the symbol, including Cassirer, Langer and Lévi-Strauss on the one hand and Freud, Lacan and Derrida on the other.

The analysis of signs in hypertext systems can also profit from the latest advances in image theory, namely Elkins [160], who weds Wittgenstein's *Bildtheorie* with Goodman's criteria of notation. The visualization of hypertext architecture depends largely on graph theory, itself a notation system. Some readers might be surprised by the exemplary regresses on cultural and artistic phenomena to illustrate my points of view. Yet, considering that the average Web page designer (knowingly or not) seems to recur on the same concepts, memories and experiences of a common visual culture, this strategy will present itself as appropriate for the purpose.

The intention to make Web pages more appealing to users of different age and education from around the globe have pushed forward a wave of non-text media: Graphic and photographic elements of hypermedia design promise to ring in a Renaissance of the image while the semiotic limitations of picture languages have been long identified, cf. [163, 471, 473]. Keeping these limitations in mind, I will still try to make use of Otto Neurath's

[1] Hopefully, the insights gained from building non-visual hypermedia systems for blind users can soon be used for navigation in auditory hyperspace, cf. [367], [255].

International Picture Language to elaborate a basic scheme for a new generation of "icons", which I call Graphic Link Markers (GLM). I will also reflect on the future involvement of other human senses into hypermedia, even if they are still restricted by bandwidth[2] (such as moving images and sound) or other technological limitations (such as haptic, olfactory and gustatory inputs).

Hypertext theory has always been strongly linked to usability and human factors, epitomized by Jakob Nielsen who is commonly referred to as a Web design guru today. Important as Nielsen's usability studies are to understand the success or failure of corporate Web sites, online services and DotCom enterprises, they often lack a broader analytical basis. The discussion of the commercialization of the Internet has produced a large body of theoretical and practical work. The elaboration of my hypertext semiotic approach is placed in the framework of this sociological and economic research.

It is commonly agreed upon that eCommerce, the expansion of the Information Technology branch (sometimes called *Wintelism*, cf. [69]) and the increasing capital market orientation on *New Markets* have changed our economy, cf. [111, 331, 437, 481, 29, 30, 32, 214]. The New Economy phenomenon, if understood on a macroeconomic level, has promised higher non-inflationary economic growth due to increases in productivity caused by the digital revolution. Evidence put forward by mainstream protagonists of the New Economy suggests the end of the economic cycle and permanent stability of a finance-led regime of accumulation on the basis of the digital production paradigm. However, Scherrer [470] reasons that some basic causal relationships of such a regime, especially the connections between investment and profits; profits and wealth; and wealth and consumption seem too fragile for suggesting that a stable new regime of accumulation has emerged. Furthermore, the New Economy thesis suffers from serious problems in measuring productivity in the service industries and seems to be based on massive borrowing by both companies and households, whose debts now stand at a record high, cf. [165]. As the expansion of the late 1990s comes to an end, the vast inflows of financial capital from abroad are turning around and thus become a threat for the US economy. This paper will not analyze the recent market crash of the technology and information sector. Nevertheless, future research might well prove that my semiotic reflections on commercialized hypertexts tackle some of the problems that have led to the "DotCom-crisis" on a deeper level than current usability statistics and financial market models.

The Internet is a phenomenon that has inspired the literateness of many scholars, but the methods of each academic discipline facilitate certain ways of knowing and inhibit others. For instance, those which involve quantitative paradigms (such as Economics) involve the selection only of those aspects of experience which can be measured. Linguistic and Literary studies, on the other hand, concentrate on the purely academic and artistic use of the medium, and tend to ignore the rapid growth of its commercial use (advertising, public relations, eCommerce, etc.). While Computer Science is primarily concentrating of technical innovations and implementation, traditional methods of Business Administration encounter difficulties if applied to an environment that (at least in the future) deals primarily with *non-tangible* goods, agents and points of sale. Such selectivity has, of course, dramatically empowered "the scientific method", but it can do so only in limited domains. As Aldous Huxley wryly noted, "our universities possess no chair of synthesis" [242, p. 276]. As a matter of fact, the way of knowing favored in the broad arena of academia is specialization. The intention of this paper is to contribute to a broader discussion of theoretical and practical issues related to hypertext and the World Wide Web. It is also a wide-ranging exploration of the commercialization of the Internet and focuses on a variety of ways in which the development is framed. It highlights major steps in the history of the

[2] Nielsen's Law of Internet bandwidth states that "a high-end user's connection speed grows by 50% per year [but] you don't get to use this added bandwidth to make your Web pages larger until 2003". For him, average bandwidth increases slowly for three reasons: 1. Telecom companies are conservative, 2. Users are reluctant to spend much money on bandwidth, and 3. The user base is getting broader, cf. [390].

medium and its users, including the dynamic changes which have enabled the Internet to become a major marketplace of the 21st century. It involves a particular focus on its academic and corporate structures, although many references are also made to private users. I aim to give an account which will serve, by its generality and interdisciplinarity, to lift the scholars' heads from what sometimes seems to me too narrow a focus. The need for this kind of enterprise becomes apparent in the context of the recent "DotCom-crisis". The main challenges for online businesses that want to establish themselves on the market are, for consulter Helmut F. Meier, language and cultural problems: "Sprach- und Kulturbarrieren [sind] noch schwerer zu überwinden [als nationalstaatliche Grenzen]" [3]. To analyze these barriers, it seems favorable to employ methods of Ethnology, Information and Media Theory, Cultural Studies, Semiotics, Philosophy and Art History, hand in hand with an Economic approach. Of course, this multidisciplinary advance runs the risk of ignoring academic-bureaucratic structures but the point is not so much to dismantle disciplinary boundaries as to be able to move across them, cf. [152, p. 27].

> "Hypermedia is on the one hand multidisciplinary [...] on the other hand it is pervasive, with applications in many areas, instruction, information, entertainment, commerce, engineering. [...] Despite the recent upsurge of interest in the commercial applications of the WWW and e-commerce generally, many of the fundamental issues surrounding successful commercial exploitation of hypertext remain unsolved" [114, p. 40].

That line of thought makes it less surprising why this dissertation was handed in at a business school, not at another faculty or school that deals with Communication Science, Aesthetics, or Philosophy. Obviously, a primarily theoretical approach to communication networks and new media seems congruent with the current flow of research at these faculties. Furthermore, theoretical disciplines tend to face the commercialization of the Internet on a rather superficial and polemical level. Furthermore, the Vienna University of Economics and Business Administration (WU Wien) houses a variety of disciplines which have long been dealing with communication problems (such as Marketing, especially International Marketing and Advertising), and a Department of Information Business that is actively involved in hypertext research issues, cf. [427].

Working inter-, or transdisciplinary is more than the sum of the involved disciplines; it is the exploration of a common ground for researchers from different fields by contrasting established points of view. In the following sections, I will try to elaborate a theory of Hypertext Semiotics that adheres less strictly to literary theories and linguistics than comparable approaches (e.g. [265, 304, 448, 369, 247, 56, 539]). It will include a diachronic account of the historic and technological efforts to implement advanced hypertext functionalities. The insights and principles will then be applied to analyze the current state of the World Wide Web[3].

While the tidiness of academic texts often misleadingly suggests the enduring nature of the positions which they represent[4], I think to have left a lot of open ends and loose threads for critique and future research. The methodology and presentation of this dissertation have been chosen in accordance with the demands of the field of study to which it contributes, cf. [312]. While the paper version follows most technical conventions of a dissertation, the online version of this text is enhanced with hypertext functionalities[5]. Naturally, I hope that

[3] In semiotics, this strategy is called a synchronic analysis.

[4] "Seamlessness and sequential structures reinforce an impression of the ground having been covered, of all the questions having been answered, of nothing important having been left out. Though it is a lie, closure suggests mastery of the material through its control of form" [95, Syntagmatic Analysis].

[5] Besides the uncountable bibliography links, this dissertation includes more than 2500 handcrafted links to the glossary, to external Web sites and between sections.

the present work will be linked into rich relationships with other resources to disseminate my findings.

In Austrian academic terms, this dissertation should be regarded as part of the studies ”Handelswissenschaften” (Commerce) with a strong inclination towards an interdisciplinary approach of the subject, depending strongly on what is usually summarized in German as ”Geisteswissenschaften” (humanities). Accordingly, the glossary supplies key terminology and definitions of semiotics, as well as economic and technical terms (as certain definitions mean completely different things in the various disciplines). In British, or north American academic terms, the paper might be considered as a melding of Business Administration, Economics, Computer Science, *Communication Studies* (blending psychology, sociology, semiotics and linguistics), *Composition Research* (a slightly more focused hybrid of disciplines) and *Media Theory*. This paper was written in the English language for broader accessibility. Nevertheless, the author has employed the scientific principles and tradition of his native country, Austria.

Chapter 2

The Semiotic Approach

According to Andersen, a major contributor to the field of computer semiotics (see section 2.9), ”semiotics may be helpful in enhancing the interpretation of computer based signs and creating understandable interaction” [11]. Before presenting my prolegomena for a theory of hypertext semiotics, it will be necessary to describe the methods and practices, definitions and limitations of the semiotic approach. What Andersen says about semiotic interface engineering is basically true for the whole field of computer semiotics, including hypertext semiotics:

> ”Semiotics is an abstraction of individual disciplines such as linguistics, art theory, drama theory and film theory. Therefore it can serve as a common language for transferring insights from one domain to another in a systematical way. This is useful in designing computer interfaces, since computers are inherently multimedia where codes from these diverse fields meet and amalgamate in practice” [11].

For such a transfer to take place, there is a strong need to build a common base of departure which is furnished with a shared methodology and terminology. In this chapter, I will introduce the the basic semiotic principles and comment on their applicability on hypertext theory.

2.1 Introduction to Classic Semiotics

After speaking of language as a system of signs that express ideas (“un système de signes exprimant des idées”), the Swiss linguist Ferdinand de Saussure points out that language is only the most important of these systems and that a science that studies the life of signs within society is well conceivable: “On peut donc concevoir une science qui édudie la vie des signes au sein de la vie sociale” [468, p. 33]. This new science would be a part of social psychology and consequently of general psychology:

> “I shall call it semiology (from the Greek semeîon ’sign’). Semiology would show what constitutes signs, what laws govern them. Since the science does not yet exist, no one can say what it would be; but it has a right to existence, a place staked out in advance. Linguistics is only a part of the general science of semiology; the laws discovered by semiology will be applicable to

> linguistics, and the latter will circumscribe a well-defined area within the mass of anthropological facts."[1]

Ferdinand de Saussure sharply distinguished the diachronic from the synchronic study of language.[2] In order to make his synchronic studies persuasive, Saussure was forced to draw another sharp distinction. He argued for dividing language into three levels,

langage, by which he meant the human capacity to evolve structured communication systems,

langue, what we think of as a language, such as English or French, and

parole, any individual speaker's particular use of the language.

Langue is, according to Saussure, a self-contained whole and thus appropriate object of synchronic study; it refers to the system of rules and conventions which is independent of, and pre-exists, individual users, cf. [102, p. 86], [95, Introduction]. Accordingly, Saussure was chiefly interested in langue as an a-historical phenomenon. Parole, however, refers to the use of this system in particular instances.

In contemporary semiotics, the distinction langue – parole has been generalized to a differentiation between the semiotic system and its usage in specific (con-)texts: "The distinction is one between between *code* and *message*, *structure* and *event* or *system* and *usage* (in specific texts or contexts)" [95, Introduction]. The system includes rules of use which constrain but do not determine usage (this is analogous to Chomsky's distinction between competence and performance, cf. [97]). To the traditional, Saussurean semiologist, what matters most are the underlying structures and rules of a semiotic system as a whole rather than specific performances or practices which are merely instances of its use, cf. [102, p. 86].

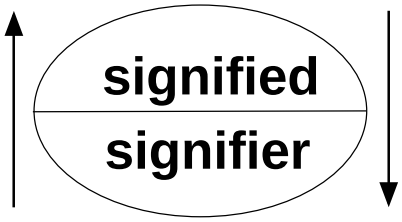


Figure 2.1: The Saussurean sign model. Source: [469, p. 78].

While the Saussurean definition of semiology may have inspired much semiotic research of this century, it falls short for many contemporary semioticians. For Saussure, the sign is a composition of the signifier, /dog/[3] and the signified (our concept of a dog), as shown in figure 2.1. The real animal (in semiotic terminology, the reference) does not interest him as

[1] [468]. English translation according to [246, p. 34-35] and [95].

[2] A diachronic investigation traces the development or evolution of language, whereas a synchronic inquiry examines language as a system, a network of relationships co-existing in the present. Saussure was reacting to the Neogrammarians of his own day, linguists who contended that the only valid approach to the study of language was a historical or diachronic approach. It is arguable that one extreme approach called forth the opposite extreme, for an exclusive concern with the history of language was displaced by a systematic denial of this history's relevance for an understanding of language, cf. [469, 102, 95, 154].

[3] It has become an academic convention among scholars of semiotics to use the forward-slash character to emphasize a referral to the signifier. Thus, /dog/ refers to the word formed by the letters d, o, and g, as opposed to the meaning of the word, "dog" and the actual animal (which is not taken into account by the Saussurean system), cf. [155, p. 30f.].

a linguist, cf. [155, p. 31].[4] In the context of natural language, Saussure stressed that there is no necessary, or inherent connection between the signifier and the signified – between the sound or shape of a word and the concept to which it refers. The relationship is purely conventional – dependent on social and cultural conventions. This is not to suggest that the form of a word is random, of course: While the words *fish* and *man* are unmotivated, composita like *fishermen* illustrate the relative arbitrariness of language: the intra-linguistic determination of grammar, cf. [401, p. 340].

Saussure emphasized the differences between signs. He argued that concepts are purely differential and defined not by their positive content but negatively by their relations with the other terms of the system: Their most precise characteristic is in being what the others are not, cf. [469, p. 128]. The Saussurean model, with its emphasis on internal structures within a sign system, can be seen as supporting the notion that language does not "reflect" reality but rather constructs it, cf. [545].

Peirce's semiotic triangle has become the counter-model to Saussure's dichotomy signified/ signifier. The American philosopher Charles Sanders Peirce (1839-1914), indeed, was the other key figure in the classic development of semiotics:

> "I am, as far as I know, a pioneer, or rather a backwoodsman, in the work of clearing and opening up what I call semeiotic, that is, the doctrine of the essential nature and fundamental varieties of possible semiosis…" [416, 5.488].

This semiosis is "an action, an influence, which is, or involves, a cooperation of three subjects, such as a sign [representamen, MN], its object, and its interpretant, this thrirelative influence not being in any way resolvable into action between pairs" [416, 5.484]. While Saussure's system needs an active sender of signals to make the semiotic process work, Peirce's semiosis-trias can be applied to phenomena that have no sender, such as natural symptoms of an illness that can be detected and interpreted by a medic.

Peirce was clearly fascinated by tripartite structures and made a phenomenological distinction in his three universal categories of firstness, secondness, and thirdness[5]: "Everything is something in itself; this Peirce calls firstness. We might call this initselfness. Everything either actually or potentially reacts against, or opposes itself, to other things; this he calls secondness (over-againstness). Everything is, in some measure, intelligible, if only because it can be related by me to something else" [102, p. 194]. Formally and abstractly defined, thirdness is betweenness or mediation.[6]

In contrast to Saussure's self-contained two-termed model of sign (sign as an arbitrary correlation between signifier and signified), Peirce offered a triadic relation between the representamen, the interpretant and the object. Nöth has substituted these terms for more intuitive terminology: the sign vehicle, the sense and the reference object.

The representamen (*sign vehicle*) is the broadest form in which the sign takes place. In Peircean terminology, "a sign, or representamen[7], is something which stands to somebody for something in some respect or capacity" [416, 2.228].

[4] Thus, many subcategories of today's semiotic studies (such as zoosemiotics, computer semiotics, and computational semiotics) would have to remain outside the semiologic building that Saussure sketches, cf. [469, 396].

[5] "Such unfamiliar terms are relatively modest examples of Peircean coinages, and the complexity of his terminology and style has been a factor in limiting the influence of a distinctively Peircean semiotics" [95, Signs].

[6] One of Peirce's own favorite examples of thirdness or mediation is an act of giving. For him, giving exhibits an irreducibly triadic structure or form – that is, any attempt to break it down into a simpler affair loses its meaning. In any act of giving, there is a giver, a recipient, and a gift. One half of this act is divestiture (the giver diverts herself of something she owns); the other half is appropriation (the recipient appropriates or comes to own something new). But, in giving, these two dyads (giver and gift-as-divested; recipient and gift-as-acquired) are integrally united. If the giver simply gets rid of her property and, a little while later, the recipient comes along and finds it, we have two accidentally related dyads but no act of giving, cf. [102, p. 195]

[7] He proposed this term because he believed that the English word "sign" and most, if not all, of its equivalents in English and other languages were too closely tied to a mentalist understanding of the sign.

The interpretant of a sign is the sense made of the sign. Apart from mental interpretants (for example a concept in the Saussurean sense), the Peircean pansemiotic view of the world also considers not-mental interpretants (for example, the plant turning towards the sun), cf. [102, p. 171]. The interpretant should not be confused with the interpreter: The interpretant is that in which a sign as such results, whereas the interpreter is a personal agent[8] who takes part in and presumably exerts control over a process of interpretation.[9]

The (reference) object is that to which the sign points. The difference between the rather conceptual sense of the sign and the concrete referent can be shown in an easy example: The reference *semiotician* includes the historic persons Charles S. Peirce, Ferdinand de Saussure, Charles Morris, Roland Barthes, and the like; these are some of the beings to whom this sign refers. In contrast, the meaning of *semiotician* is anyone who investigates, especially in a self-conscious way, the nature and properties of signs.[10]

What might seem like the same triad already offered by Platon and Aristoteles as semainon, semainomenon and pragma, is more complex. The triadic model of the sign and the concept of the semiosis was expanded by Umberto Eco to designate the process by which a culture produces signs and/or attributes meaning to signs. Eco and others criticize the simplified variants of Peirce's triad which keep reappearing under the name "semiotic triangle", cf. [368, 406]. While there seems to be a broad consensus on the triangular shape of the model, the names of the three poles are not only terminological differences: They represent different ways of seeing the process as a whole. Nadin calls this lack of consistent terminology the post-Morris[11] syndrome, "an intellectual disaster from which semiotics does not seem to recover. The consequences are obvious: the outcome of applied semiotics rarely justifies expectation", cf. [375].

Floyd Merrell thinks that the triangle shape, too, is a misinterpretation of Peirce's sign triad. According to him, the triangle has been chosen because it is pleasing to the eye:

> "Its shape is quite familiar to any elementary schooler who has studied a few geometrical figures, and it coincides nicely with our penchant for Euclideanizing the world. But it is not genuinly triadic. It consists of a set of three binary relations…" [353, p. 135]

Like Marty and Marty [341, p. 100] before, he proposes a model (figure 2.2) that ties each sign component to the other two, and, in addition, to the relation between them, cf. [401, p. 140].

It is important to note that Saussure's term, "semiology" is sometimes used to refer to the Saussurean tradition, whilst "semeiotic" (or "semeiotics") sometimes refers to the Peircean

[8] In computer semiotics, the interpreter can be a machine or a process, e.g. a compiler or, of course, an "interpreter" in the technical sense: "There are many interpreters at work in the design and use of computer systems. In fact, systems development mainly consists in writing and reading, so semiotics may not only shed light over the interface, but also inform technical concepts such as program verification, program specification, compilation, etc." [9, p. 11].

[9] The interpretant is not any result generated by a sign. Something functioning as a sign might produce effects unrelated to itself as a sign: "For example, a fire indicating the presence of survivors of an airplane crash might set a forest ablaze. The forest fire would be an incidental result and thus not an interpretant of the sign calling for help (or indicating the whereabouts of the survivors)" [102, p. 121].

[10] Imagine Saussure's neighbor in Geneva at the turn of the last century: Even if she did not know the meaning of the word *semiotician,* she would still know Monsieur Saussure. It is also possible for a sign to have a meaning but no reference: for example, the "unicorn" has no real animal to whom it points, cf. [155, p. 29].

[11] Besides presenting a simplified semiotic triangle model, Morris provided useful extensions to the Peircean theory. His division of semiotics into the following three branches has been widely accepted: semantics (the meaning of signs; the relationship of signs to what they stand for); syntactics or syntax (the structural relations between signs); and pragmatics (the ways in which signs are used and interpreted), cf. [368, p. 6-7]; [396, p. 50].

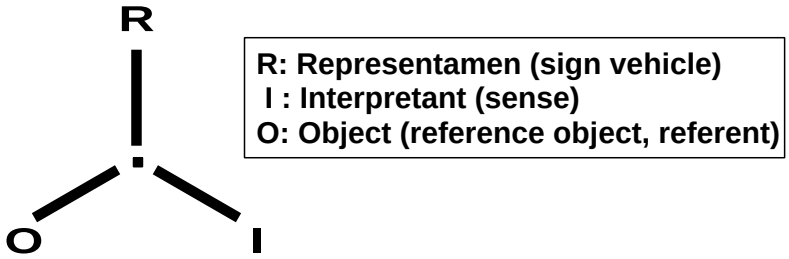


Figure 2.2: The Peircean sign model. Source: [353, p. 136].

tradition. Colapietro gives a most concise differentiation of the two classic semiotic approaches:

> "For Peirce, anything properly designated as a sign has an object; more over, this object is conceived in such a way that it can constrain or guide the process of semiosis or sign generation. In other words, whereas Saussure's view of language as a self-contained system of formal differences suggests something free-floating, Peirce's conception of semiosis suggests something firmly rooted in an objective world. In Saussure's semiology, the link between language and reality is severed or, at best, extremely attenuated; in Peirce's semiotic, the connection between signs and objects is commonsensically assumed" [102, p. 151].

While the *European* tradition of semiology evolved from the science of linguistics, the *American* tradition of semeiotic is seen as part of a much more comprehensive philosophical system. The work of Louis Hjelmslev, Roland Barthes, Claude Lévi-Strauss, Julia Kristeva, Christian Metz and Jean Baudrillard follows in the semiological tradition of Saussure whilst that of Charles W. Morris, Ivor A. Richards, Charles K. Ogden and Thomas Sebeok is in the semeiotic tradition of Peirce. Nöth complements these two traditions with a rich study of the history of concepts (Begriffsgeschichte) of the terms that derive from Greek σημεῖον and σῆμα, which have been used in philosophy and medicine since the late antiquity.

Many other leading semioticians (e.g. Umberto Eco) have also helped bridging these two traditions since the late 1960s. Today, the term semiotics is primarily used as an umbrella term to embrace the whole field, [401, p. 3], [95, Introduction]. The same is true for this dissertation.

2.2 From Symbolic Forms to (Post-)Structuralist Semiotics

Even if Ernst Cassirer has long been recognized as a semiotician *ante litteram* and a thinker worthy of the semiotic Olymp[12], his influence on today's semiotic viewpoints has been neglected, cf. [342]. There are only faint historical connections between Peirce and Cassirer[13], and "there is also no hint that Cassirer would have appreciated Peirce's philosophy

[12] As pointed out to me by Jeff Bernard, Institute for Socio-Semiotic Studies (ISSS), in a personal interview on July 19th, 2001.

[13] "One of the few relations that can be drawn between Cassirer and [American Pragmatism] is constituted by the Cassirer-disciple Edgar Wind [...] another link between Cassirer and Peircean philosophy can be seen in the work of Susanne K. Langer (1895-1985) who is often considered as deeply influenced by Cassirer" [342, p. 332-333].

even if he had known about it" [342, p. 333]. Yet, there is a consistent line of thought on Symbolic Forms from Cassirer to Langer and Lévi-Strauss that intersects with the semiotic path at several points.

Cassirer's definition of man as an *animal symbolicum* that lives in a *symbolic universe* is inherent in any discussion about human thinking, understanding, culture, and communciation, including telecommunication and hypertext (see section 3.5): "No longer in a merely physical universe, man lives in a symbolic universe. Language, myth, art and religion are parts of this universe. They are varied threads which weave the symbolic net, the tangled web of human experience" [90, p. 25]. Peter Marx insists that Cassirer cannot be clearly categorized into either the European or the American semiotic tradition, as his *symbolic forms* (which must not be confused with the Peircean definition of the symbol) relate to a broader cultural concept. Marx [342] also points out that Cassirer deals with two different questions:

> "On the one hand, the philosophy of symbolic forms is concerned with the questions of knowledge, it is concerned with the matter that is called Erkenntnistheorie [...] On the other hand, Cassirer tries to develop a new science of culture and this project is very close to the project of European structuralism" [342, p. 337].

Susanne Langer's work [306, 305] is based on the findings of Ernst Cassirer [89], and inherent in the work of Claude Lévi-Strauss [315, 316].[14]

Langer remarks that, in modern science, the object of study is no more the center of attention because it has been displaced by measuring and control technology, displays, visual representation material: Indices have taken the place of the cause, and observation has become almost entirely indirect: "The sense-data on which the propositions of modern science rest are, for the most part, little photographic spots and blurs, or inky curved lines on paper. The problem of observation is all but eclipsed by the problem of meaning.[15] And the triumph of empiricism in science is jeopardized by the surprising truth that our sense-data are primarily symbols" [306, p. 20-21]. Langer makes clear that mathematical constructions are symbols as well, as mathematics does not need to refer to an external world at all: its signifieds are indisputably concepts and mathematics is a system of relations. However, her investigations of the symbol do not draw upon that discipline's technical conventions, cf. [306, p. 18ff.]. These observations, of course, are based on Cassirer's statement that all truly strict and exact thought is sustained by the symbolics and semiotics on which it is based.[16]

The other great influence for Langer comes from Alfred North Whitehead's exposition of the two pure modes of perception [543], one of which is essentially perception in space, and the other in time. Whitehead designates them *presentational immediacy* and *causal efficacy*.[17] Presentational immediacy is perception of what is immediately present without

[14] The inspiration for this line of thought are owed to Klaus Hamberger's lecture on social structures and symbolic forms which included a thorough discussion of its epistemological sources (University of Vienna, summer term of 2001).

[15] In her longing to implement the concept of transformation (i.e. the theoretical basis for any virtual reality) into epistemology, Langer uses the term *analogy* in her theory of isomorphism. The concept of transformation between structures was also used by Lévi-Strauss, cf. [316]. Chandler's notion that "signifying systems impose digital order on what we often experience as a dynamic and seamless flux" [95, Signs] still draws on the Kantian evolution of cognition from "Mannigfaltigkeit", via "Synthesis", to "Einheit", cf. [267, B 102-104].

[16] "Every law of nature assumes for our thinking the form of a universal formula and a formula can be expressed only by a combination of universal and specific signs. Without the universal signs provided by arithmetic and algebra, no special relation in physics, no special law of nature would be expressible. It is, as it were, the fundamental principle of cognition that the universal can be perceived only in the particular, while the particular can be thought only in reference to the universal" [89, p. 86].

[17] It is important to note that these two modes rarely occur in their "pure" form. Neither pure mode in itself can be called consciousness as we know it, but these two pure modes together constitute symbolic reference.

reference to anything in the past or anything that may lie in the future (neither memory nor awareness of potentiality). Causal efficacy is the pure mode of inheritance of feeling from past data and the precondition for awareness of future potentialities. In accordance to Whitehead's dichotomy, Langer distinguishes between *rational discursive language* and *presentational language*. To begin with the discursive function of symbolism, we see a linear construction which is limited to sequencing. Its nature is very exacting and precise, as it is used in science.

> "Language in the strict sense is essentially discursive; it has permanent units of meaning which are combinable into larger units; it has fixed equivalences that make definition and translation possible [...] The meanings given through language are successively understood, and gathered into a whole by the process called discourse..." [306, p. 89].

Discursiveness in this context is similar to sequentiality: Words cannot be piled one upon the other, neither can they be arranged arbitrarily into a sentence (they have to follow a predefined grammar); it takes time to form (and listen to) each word of a sentence and only once you have heard the last word of a sentence you can be sure of its meaning. Langer thought that, even if they are nested, we have to string our ideas in order to communicate them to others in a language; like clothes that are draped around a body, but hanging out to dry on a clothes-line. You place one piece of language at a time into a straight line; at the end of the process the parts add up to a whole argument or proposition, cf. [307, p. 88]. The argument of hypertext is that ideas do not have to be arranged on an infinitely long clothes-line. In fact, hypertext represents variable structure that permits an interlinked presentation of ideas, as outlined in section 3.5. The act of navigation means a linearization of those nodes that the hypertext user chooses to read along a personal thread that is laid upon the network.

For Langer, denotation and connotation are central to discursive symbolism, cf. [306], see section 2.2. While denotation makes reference to a specific object or person, connotation brings up a concept of a name.[18] While denotation is intended, connotation is inferred. Therefore, Langer believes that denotation is the essence of language, because its use is deliberate, and directly relates the concept to the real thing. The syntax and grammar of discursive language tie together symbols into complex thoughts, allowing intricate ideas to be communicated.

In contrast with the rather strict discursive form, presentational symbolism is simultaneous in its nature and open to broad interpretations. Using art as an example, Langer writes, "visual forms – lines, colors, proportions, etc. – are just as capable of articulation, i.e., of complex combinations of words" [306, p. 93]. This is because the relationship that exists in a picture, between an object and image, is similar to the relation of a word to its object. They evoke a presence rather than defining a present fact.

With a basic understanding of the two functions of symbols, Langer presents her case as to their role in the origin of language. Although language is clearly one of the keys to human survival, it is not well explained as derived from such motivations. The psychogenetic theory of language contends that human language developed from the simple signs that animals use to communicate; in time, these mechanisms became more complex and developed into symbols. Langer rejects this theory and argues that human rationality is much too varied and distinct from that of animals to have developed from basic needs for survival. She believes that humans have had, since their earliest days, a peculiar need not

[18] One is reminded here of Wittgenstein's concept of names: "One name stands for one thing, and another for another thing, and they are connected together. And so the whole, like a living picture, presents the atomic fact [Sachverhalt, MN]" [548, 4.0311]. For an overlook of the use and reference of names in Wittgenstein's Tractatus, cf. [249].

found in other animals: to express their inner life. The mere expression of ideas seems to be a uniquely human exercise, as animals do not see any need for crying, laughing, superstition, rituals and scientific ingeniousness. Presentational language did not develop from a need for something in addition to self preservation; but rather, Langer believes that the need for *expression* gave birth to discursive language.[19]

Though language may be the most important natural outcome of this symbolic process, the other transformations of experience in the human mind have quite different overt endings and end in acts that are neither practical nor communicative, though they may be both effective and communal, e.g. rites and art, cf. [307, p. 49-51].

Signs (as symbols not as symptoms) help us to refer to objects *in absentia*. Rather than *aliquid pro aliquo*, symbols, for Langer, serve as vehicles for the *conceptions* of objects, cf. [307, p. 39 and 69]. Symbolization *precedes* the actual *act of thinking* (rather than being the act itself, as formulated by Ritchie [444, p. 238]). Thus, symbolic transformation of sensual information is an inherent necessity, just like eating, looking and moving. It is a fundamental, continuous process of the human mind, a fountain of ideas.[20] This is the point where Langer's theory coincides with structuralism, especially Lacan and Lévi-Strauss, who have employed Saussure's structural analysis with psychoanalysis and ethnology.

Structuralism drew heavily on linguistic concepts, partly because of the influence of Saussure and because linguistics was a more established discipline than the study of other sign systems, cf. [131]. Lévi-Strauss noted that "language is the semiotic system par excellence; it cannot but signify, and exists only through signification" [317, p. 48]. Accordingly, the structuralists adopted language as their model in exploring a much wider range of social phenomena: Lévi-Strauss for myth, kinship rules and totemism; Lacan for the unconscious; Foucault for disciplining systems of power; Barthes and Greimas for the "grammar" of narrative. Structuralism is an analytical method which has been employed by many semioticians and which is based on Saussure's linguistic model of binary oppositions.[21]

According to Saussure, meaning arises from two kinds of differences between signifiers: syntagmatic (concerning positioning) and paradigmatic (concerning substitution). Whilst syntagmatic relations are possibilities of combination (the dimension of "and"), paradigmatic relations are functional contrasts – they involve differentiation (the dimension of "or").

On the syntagmatic axis, a word is assigned meaning by the words surrounding it.[22] A

[19] Freud has shown that human behavior is not a mere strategy to provide food, but also a language, as every movement is, at the same time, a *gesture*, cf. [300, vol. 1, p. 115ff.], [307, p. 59]. Consequently, Jacques Lacan drew his famous conclusion that the unconscious itself is structured like a language (see section 3.5).

[20] "Language, in its literal capacity, is a stiff and conventional medium, un-adapted to the expression of genuinely new ideas, which usually have to break in upon the mind through some great and bewildering metaphor" [306, p. 45f.]. Metaphors are the next step in understanding the development of symbolic language. Metaphors expand the literal meanings of symbols. In this stretching of meaning, is the abstraction of presentational symbolism. Symbolic transformation is the process in which man transforms experience into new ideas. Metaphors are the means by which new abstractions of symbolism are born; metaphors are the key to symbolic transformation; they dictate the laws of language. Both the presentational and discursive functions of symbols are expanded through metaphorical means, cf. [371].

[21] "People have believed in the fundamental character of binary oppositions since at least classical times. [...] As for methodologies, Saussure's theories constituted a starting point for the development of various structuralist methodologies for analyzing texts and social practices. These have been very widely employed in the analysis of a host of cultural phenomena. [...] Semiotics is probably best-known as an approach to textual analysis, and in this form it is characterized by a concern with structural analysis." [95, Introduction]. As a metatheory, a theory about theories, "structuralism insists upon the necessity to conceive any object of inquiry as a structure" [102, p. 187]; cf. [289, p. 197f.].

[22] The syntagm "waxing hot" was used for a visual punch by the American artist Bruce Nauman: In the series *The Artist at Work*, he shows snapshot-like situations of the artist's activities, where the boundary between everyday doings and the practice of art is undefined. In the photograph *Waxing Hot*, his hands are seen at work, polishing 3 cast letters, *H*, *O* and *T*, which are standing on the floor. The pun is realized by means of visualization. The oscillation of the word *hot* between the role of an adverb in the syntagm *(*waxing *how? – hot!)* and an object (waxing *what*? – *H*, *O*, and *T*.) formulates a tension on the syntagmatic axis.

syntagm is an orderly combination of interacting signifiers which forms a meaningful whole within a text – sometimes, following Saussure, called a syntagmatic chain (see figure 2.3). Such combinations are made within a framework of syntactic rules and conventions

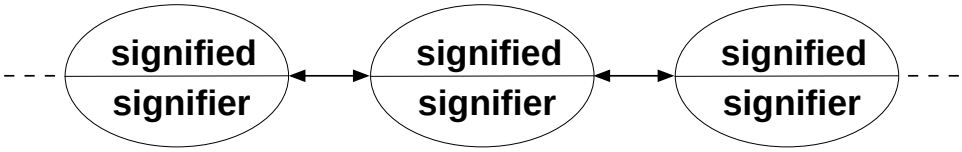


Figure 2.3: Syntagmatic chain. Source: [469, p. 137].

(both explicit and inexplicit). In written language, a sentence, for instance, is a syntagm of words; so too are paragraphs and chapters. Saussure himself noted that visual signifiers (he instanced nautical flags) can exploit more than one dimension simultaneously, while auditory signifiers are presented one after another on a time line, cf. [469, p. 82]. Chandler expands this concept of multiple syntagmatic dimensions:

> ”Syntagms are often defined as ’sequential’ (and thus temporal – as in speech and music), but they can represent spatial relationships. [...] Spatial syntagmatic relations are found in drawing, painting and photography. Many semiotic systems – such as drama, cinema, television and the world wide web – include both spatial and temporal syntagms” [95, Paradigms and Syntagms].

I will return to spatial syntagmatic relations in section 3.5 on hypertext semiotics.

Paradigmatic analysis involves comparing and contrasting each of the signifiers in a text with absent signifiers which in similar circumstances might have been chosen, and considering the significance of the choices made. Saussure had actually called the words on this axis ”associative” relations, cf. [469, p. 147ff.], but Roman Jakobson’s term is now used.[23] Paradigmatic analysis can be applied at any semiotic level, from the choice of a particular word, image or sound to the level of the choice of style, genre or medium. The use of one signifier rather than another from the same paradigm is based on factors such as technical constraints, code, convention, connotation, style, rhetorical purpose and the limitations of the individual’s own repertoire. Paradigmatic analysis has been used to trace binary oppositions in visual images.[24]

The distinction between the syntagmatic and the paradigmatic axes is a key one in structuralist semiotic analysis. The *value* of a sign is determined by both its paradigmatic and its syntagmatic relations (see figure 2.8). Syntagms and paradigms provide a structural context within which signs make sense; they are the structural forms through which signs are organized into codes. Roland Barthes [35] outlined the paradigmatic and syntagmatic

[23] ”Saussure’s notion of ’associative’ relations was broader and less formal than what is normally meant by ’paradigmatic’ relations. He referred to ’mental association’ and included perceived similarities in form (e.g. homophones) or meaning (e.g. synonyms)” [95, Paradigms and Syntagms]. Such similarities were diverse and ranged from strong to slight, and might refer to only part of a word (such as a shared prefix or suffix). He noted that there was no end (or commonly agreed order) to such associations. In the syntagm ”waxing hot”, introduced in footnote 22, the associative axis for the word ”waxing” might include:

waxing			
rewaxing	polishing	ordering	waxwing
dewaxing	applying wax	teaching	vaccine
waxer	augmentation	wearing	Maxim
waxed	crescendo	having	mixing
radical	*analogy*	*suffix*	*sound*

Saussure noted that there was no end (or commonly agreed order) to such associations, cf. [469, p. 150ff.]

[24] Jean-Marie Floch compares and contrasts the company logos of IBM and Apple, revealing their differences to be based on a series of associated binary oppositions, cf. [172].

elements of the ”garment system”.[25] Jonathan Culler analyzed Restaurant menus in similar terms.[26]

Chandler notes that formal semiotics is difficult to disentangle from structuralism [94, 95]. However, he also quotes Deborah Cameron who suggests that structuralism is merely “a method you can use” in semiotics, cf. [84, p. 25]. John Hartley describes structuralism as “an analytical or theoretical enterprise, dedicated to the systematic elaboration of the rules and constraints that work [...] to make the generation of meanings possible” [408, p. 302]. Teresa de Lauretis describes the movement away from structuralist semiotics which began in the 1970s.[27] Contemporary social semiotics has moved beyond the structuralist concern with the internal relations of parts within a self-contained system and is also sometimes allied with a Marxist approach which tends to stress the role of ideology, cf. [153, p. 168-179], [210]. The other emphasis in ”poststructuralist semiotic theory” is a semiotics focused on the subjective aspects of signification and strongly influenced by Lacanian psychoanalysis, where meaning is construed as a subject-effect (the subject being an effect of the signifier), cf. [126, p. 166-67].

2.3 Definitions and Limitations of Semiotics

Semiotics is not yet widely institutionalized as an academic discipline. It is still under discussion whether semiotics is a science, a discipline, or a field of study. Some commentators adopt Morris’s definition of semiotics (in the spirit of Saussure) as ”the science of signs” [368, p. 1-2] For others, the term *science* is misleading.[28]

Hodge/Kress think that ”semiotics offers the promise of a systematic, comprehensive and coherent study of communications phenomena as a whole, not just instances of it” [227, p. 1]. For John Fiske and John Hartley, the central concerns of semiotics are ”the relationship between a sign and its meaning; and the way signs are combined into codes” [170, p. 37].

One of the broadest definitions of semiotics is that of Umberto Eco, who states that ”semiotics is concerned with everything that can be taken as a sign” [154, p. 7]. Accordingly, semiotics is often criticized as ”imperialistic”, since some semioticians appear to regard it as concerned with, and applicable to, anything and everything, trespassing on almost every academic discipline, cf. [95]. David Sless sees semiotics as consolidating, rather than invading.[29]

[25] The paradigmatic elements are the items which cannot be worn at the same time on the same part of the body (such as hats, trousers, shoes). The syntagmatic dimension is the juxtaposition of different elements at the same time in a complete ensemble from hat to shoes, cf. [35].

[26] ”In the food system [...] one defines on the syntagmatic axis the combinations of courses which can make up meals of various sorts; and each course or slot can be filled by one of a number of dishes which are in paradigmatic contrast with one another (one wouldn’t combine roast beef and lamb chops in a single meal; they would be alternatives on any menu)” [113, p. 104].

[27] ”In the last decade or so, semiotics has undergone a shift of its theoretical gears: a shift away from the classification of sign systems - their basic units, their levels of structural organization - and towards the exploration of the modes of production of signs and meanings, the ways in which systems and codes are used, transformed or transgressed in social practice. While formerly the emphasis was on studying sign systems (language, literature, cinema, architecture, music, etc.), conceived of as mechanisms that generate messages, what is now being examined is the work performed through them. It is this work or activity which constitutes and/or transforms the codes, at the same time as it constitutes and transforms the individuals using the codes, performing the work; the individuals who are, therefore, the subjects of semiosis” [126, p. 166-67].

[28] ”Semiotics is not, never has been, and seems unlikely ever to be, an academic discipline in its own right. It is now widely regarded primarily as one mode of analysis amongst others rather than as a ’science’ of cultural forms” [95, Criticisms]. Yet, ”it is at least a focus of enquiry, with a central concern for meaning-making practices which conventional academic disciplines treat as peripheral” [95, Strenghts].

[29] ”We consult linguists to find out about language, art historians or critics to find out about paintings, and anthropologists to find out how people in different societies signal to each other through gesture, dress or decoration. But if we want to know what all these different things have in common then we need to find someone with a semiotic point of view, a vantage point from which to survey our world” [493, p. 1].

Semiotics involves the study not only of what we refer to as ”signs” in everyday speech, but of anything which ”stands for” something else – *aliquid stat pro aliquo*, such as words, images, sounds, gestures and objects. For the linguist Saussure, ”sémiologie” was a science which studies the role of signs as part of social life and linguistics was one of its branches; cf. [468], [469, p. 19]. For the philosopher Charles Peirce, ”semeiotic” was the formal doctrine of signs which was closely related to Logic. For him, ”a sign [. . .] is something which stands to somebody for something in some respect or capacity” [416, 2.227-8]. His pansemiotic view of the world led Peirce so far as to declare that ”every thought is a sign”; indeed he claimed that: ”The entire universe [. . .] is perfused with signs, if it is not composed exclusively of signs” [416, 5.448], cf. [102, p. 154]. Contemporary semioticians study signs not in isolation but as part of semiotic ”sign systems” (such as a medium or genre) and in relation to a code.

Semioticians do not always make explicit the limitations of their techniques, and semiotics is sometimes uncritically presented as a general-purpose tool: ”Saussurean semiotics is based on a linguistic model but not everyone agrees that it is productive to treat photography and film, for instance, as ’languages”’ [95]. While it cannot be the purpose of this paper to contribute to this discussion, it shall be noted that – according to my fields of expertise – I will make use of other approaches apart from semiotics to tackle the problems of hypermedia.

Today, Seboek’s Encyclopedia [477] and Nöth’s Handbook of Semiotics [396] have become the standard works for the history, and methodology of this field of study.

Danesi’s work [119] might achieve an equal status as an interdisciplinary approach to semiotics and the related fields of media studies and communication theory. Traditionally, communication theory has been seen as one of Semiotics’ major rivals in the struggle for truth finding: “Communication theorists generally focus more on the study of message-making as a process, whereas semioticians center their attention more on what a message means and on how it creates meaning” [118], quoted in [105]. Marcel Danesi implies that both communication science and semiotics are systematic studies of signs. These definitions and distinctions about communication science and semiotics seem to have captured the interest of Carlos Colón. In his article *Communication Science vs. Semiotics*, Colón goes back to the term information as their common destiny.[30] In defining communication “as the transfer of information from a source to a receiver” and keeping in mind Danesi’s statement that semiotics studies signification first and communication second, he arrives at a point where he sees “more a stitch than a line between communication science and semiotics” [105].

Insofar as semiotics tends to focus on synchronic rather than diachronic analysis (as it does in Saussurean semiotics), it underplays the dynamic nature of media conventions (for instance, television conventions change fairly rapidly compared to conventions for written English). It can also underplay dynamic changes in the cultural myths which signification both alludes to and helps to shape, cf. [95, Criticisms].

Besides a few ”full-time semioticians”, those involved in semiotics include linguists, philosophers, psychologists, sociologists, anthropologists, literary, aesthetic and media theorists, psychoanalysts, art historians and educationalists. Semiotics has changed over time, since semioticians have sought to remedy weaknesses in early semiotic approaches: Yet, it is only fair to note that much of the criticism of semiotics has taken the form of self-criticism by

[30] “Information is the core element of communication science and probably of semiotics as well. I consider information to be the raw material for message construction and the creation of meaning. Signs are a collection of bits and pieces of information. Information is what we decipher from signs. Notice that decoding has to be performed because some sort of coding is always a part of the ’creation’ of a sign. Even iconic signs which are ’a direct representation of a referent’ as defined by Danesi, have to be encoded in order to make them deliverable through any given medium” [105].

those within the field. Morris and Kristeva have both criticized the auto-reflexivity of semiotics: Morris describes semiotics as a discipline that wants to be science and meta-science the same time. For Kristeva, semiotics tries to be a meta-language (a science of text) while also being an object-language (a signification practice), cf. [401, p. XII]. Nöth [401] argues that this question depends mainly on the underlying scientific theory: And which concept of science could be more applicable than Peirce's? Thus, the *circulus vitiosus*, for him, has long become a *circulus virtuosus* of consequent semiotic self-reflection that establishes semiotics as a scientific activity.[31] The theoretical literature of semiotics reflects a constant attempt by many semioticians to grapple with the implications of new theories for their framing of the semiotic enterprise" [95, Criticisms]. This elaboration also showed its result in a transformation of terminology, which means that, even with the most basic semiotic terms, there are multiple definitions, cf. [154, 477, 396, 401, 95]. In this dissertation, I have tried to define most controversial terminology in the glossary of this dissertation.

Recent semiotic work in the commercial and economic context, especially papers submitted to the Vienna University of Economics and Business Administration (WU Wien) concentrate on the fields of Marketing, Advertising, and Business English [110, 123, 182, 314, 364, 508, 523].

2.4 Sign

While logical reasoning à la "cogito, ergo sum" seems to demand complex brain-work, the association of a signifier with its meaning (resp. of a sign vehicle with its sense) looks like a rather automatic process[32], cf. [154, 396, 401]. Many people will not even be aware of the fact that there is difference between the signifier /dog/ and its signified. Saussure takes this as reason enough to speak of the sign as their sum. From the experience that a child will automatically say "dog" whenever it sees a drawing of one, we can see that the process works in both directions, as depicted in figure 2.1. In the semiotic terminology, a sign is to be distinguished from what we often call a "sign" in colloquial language: the signal and the sign vehicle.[33]

As mentioned before, Saussure sees the signifier and signified as relata in the sign-relation. Unlike Peirce's triadic model of the sign (see fig. 2.2), Saussure's model excludes reference to an object in the world (the actual animal known as "dog"). Saussure's model includes only a mental concept and a "sound-image"[34]. His conception of meaning was purely structural – the meaning of signs was seen as lying in their (syntagmatic and paradigmatic) relation to each other.

[31] "Denn die konsequente Anwendung der Semiotik auf sich selbst läßt die Theorie von den Zeichenprozessen zu einer stets selbstkritischen wissenschaftlichen Tätigkeit werden, welche somit ihre dynamische Weiterentwicklung zu sichern in der Lage ist" [401, p. XII].

[32] "In signs, one sees an advantage for discovery that is greatest when they express the exact nature of a thing briefly and, as it were, picture it; indeed, the labor of thought is wonderfully diminished" Gottfried Wilhelm von Leibnitz, cited in [407].

[33] The failure to due so can lead to difficulties when working in the border-field of semiotics. Andreas Dieberger's dissertation "Navigation in Textual Virtual Environments using a City Metaphor" is one of many valuable approaches to the same problems that I intend to tackle with my "Hypertext Semiotics". Dieberger, Nielsen, Bieber and other authors will be heavily quoted in my reflections on hypertext navigation (I could not agree more to Lunefeld's charming assertion that "we love to correct those who treat closest to our own path, for who else would listen?" [325, p. xviii]). However, it should be noted that those approaches which ignore the key results of decades of semiotic investigations (whilst using the terms sign, text, communication, code, metaphors, etc.) are truly not state of the art user-centered research. Dieberger, for example, defines the sign as a general form of an information provider: "Signs can be read. They can be attached to facades or walls or can be located on their own in the environment. Some signs are well visible all day, others are unreadable in the dark. Signs can change their appearance repeatedly – these signs provide rapidly changing information, like departures in a train station" [142, p. 57].

[34] For the linguist Saussure, the "image acoustique" is a psychological imprint of the sound of the word.

Lacan was one of the main engineers in the conversion of the Saussurean sign model, appropriating Saussure through Jakobson to Freud: He related metaphor to Verdichtung (condensation) and metonymy to Verschiebung (displacement).[35] Saussure had stressed that the signifier and the signified were as inseparable as the two sides of a piece of paper (see figure 2.1), they were intimately linked in the mind by an associative link, and wholly interdependent, neither pre-existing the other, cf. [469, p. 77]. Lacan substituted Saussure's model of the sign in the form of the quasi-algebraic formula $\frac{S}{s}$ and a "variation" of the diagram that describes the relation between the signifier and the signified (figure 2.4). In the formula, the signifier (represented by a capital "S") is now placed *over* the signified (a lower case and italicized "s"), separated by a horizontal "bar". Lacan's diagram shows the doors of a public restroom, the crossroads which forcefully separate male from female necessities. What he means is that we think in categories that we have not chosen ourselves: While entering the symbolic order of language enables us to express ourselves, we have to subordinate under its rules of grammar and social habits, cf. [300]. The parlêtre, or "speaking-being" cannot brabble whatever he feels like without having to fear social consequences, e.g. when using rude or non-sense words. Barry notes that "symbols in the form of written language may be inaccessible to those outside the culture, yet each symbol within that culture of necessity carries a history of representation, association and relation" [34, p. 119].

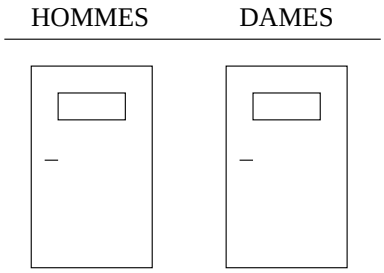


Figure 2.4: Lacan's signifier/signified model. Source: [300, vol. 2, p. 24].

Throughout his life, Peirce tried to construct a comprehensive and systematic classification of signs. Peirce reduced his ten trichotomies of signs, which would have sufficed to furnish us with $3^{10} = 59049$ sign classes, to sixty-six not completely independent classes of signs, cf. [416, vol. 2, p. 330]. These ten trichotomies are not to be confused with his ten not completely independent classes of signs described hereafter. The latter originate from only three trichotomies.

This threefold consideration "is at the center of what is perhaps his most successful attempt at such a classification" [102, p. 132]. It is based on the very nature of a sign, as defined by Peirce: anything (thus, something in itself) standing for some other (called its object) and giving rise to an interpretant. Accordingly, signs might be considered in themselves, or in relationship to their object, or finally in relationship to their interpretants. These three

[35] Simply put, his theory goes from the assumption of a fundamentally split subject and thus comes up with a model of subjectivity that grounds itself on a constitutive lack rather than wholeness. According to Lacan, the human being is entangled in three registers, which he calls the symbolic, the imaginary, and the real. Whereas the imaginary constitutes the (perceptual) realm of the ego, the register that accounts for a (however illusive) notion of wholeness and autonomy, the symbolic is the field of mediation that works according to a differential logic. Whereas the imaginary constantly tries to "heal" the lack-of-being of the subject, the symbolic accepts castration. The human subject is thus doubly split: on the imaginary level between the ego and its mirror image, while on the symbolic level it is language and the inscription into a specific socio-cultural reality and its rules that bars the subject from any unity. Thus, this forever lost unity belongs to the third register: the real, which is simply that which eludes any representation, imaginary or symbolic. Because of this lack, the subject, which, according to Lacan, is an effect of the signifier, aims at recreating that lost unity. The 'strategy' of desire emerges as a result of the subject's separation from the real and the "means" by which the subject tries to catch up with this real, lost unity again, cf. [300, 225, 239].

considerations yield three trichotomies: a sign considered in itself might be a quality and thus a qualisign, an individual thing or event, thus a sinsign, or a law, hence a legisign; the relation of a sign to its object can be an iconic or indexical or symbolical; the relation of the sign to its interpretant is a rheme or dicent or argument, cf. [102, p. 132]. This

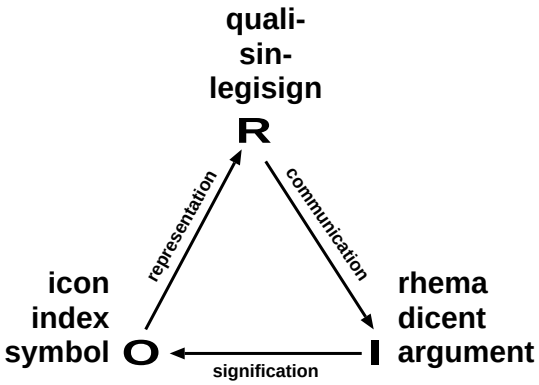


Figure 2.5: Peircean sign classes. Source: [375].

concept, of course, can be seen as going beyond Saussure's emphasis on the paradigmatic and syntagmatic value of a sign in its relation to other signs. To demonstrate the logics of the Peircean classification, Colapietro takes the example of a knock on the door:

> "If there is a knock on the door announcing the arrival of guests, this rap is a sinsign. More accurately, it is a dicent, indexical sinsign. It is a dicent (or dicisign) since it in effect performs the function of an asserted proposition ('The guests have arrived'). It is indexical since there is an actual, physical connection between the sign vehicle and its object (the knocking sound and the guests announcing their arrival by means of knocking). Finally, it is a sinsign because the knocks as they are occurring here and now – the sounds in their individuality – serve as the sign vehicle" [102, p. 132].

According to the Peircean pansemiotic view of the world, signs may be considered in themselves; that is, in terms of what the sign vehicle (in Peirce's terminology: representamen) is in itself, for different things play the role of signs. When a quality plays this role, we have a qualisign; when something general or law-like performs this function, we have a legisign; and when an individual or actual existent assumes the role of sign, we have a sinsign.[36] The trichotomy of qualisign, sinsign, and legisign is part of an intricate classification of signs devised by Peirce, for he also considers the sign in its relation to its object and in its relation to its interpretant.

The second trichotomy has been cited more than once in isolation from the two other trichotomies. In relation to its dynamic object, a sign may be either an icon, an index, or a symbol (see figure 2.5). An iconic relation is a mode in which the signifier physically or perceptually resembles or imitates the signified, recognizably looking or sounding like it – possessing some of its qualities (e.g. a portrait, a scale-model, onomatopoeia, the sound of a gun in a violent computer game, imitative gestures). Index is a usage established by Charles S. Peirce and widely adopted by contemporary semioticians to denote a specific type of sign or sign function in which a sign vehicle represents its object (of reference) by virtue of a causal or physical connection, cf. [102, p. 118]. This linkage can be observed or inferred (e.g. a weather vane to indicate the direction of the wind, smoke for fire,

[36] For example, a photograph of a woman may stand for some broad category such as *women* (legisign) or may more specifically represent only the particular woman (sinsign) who is depicted.

footprints for a path in use, fingerprints in biometrics, knock on door announcing a visit, medical symptoms for certain illnesses, greyed-out link marker for an inactive link, etc.). In a symbolic relation, the signifier does not resemble the signified but is arbitrary or purely conventional, like most words of our natural languages, road signs, exclamation marks that accompany error meassages, an arrow on a Web page or the browser tool bar that points to the left for ”back”, etc. Naturally, different cultures show very different conventions, e.g. the arrow to the left in Arabic or Hebrew means ”forward”; shaking the head does not mean ”no” in all cultures, etc.

It is important to note that these broadly cited modes are not mutually exclusive: a sign can be an icon, a symbol and an index, or any combination. “A map is [...] indexical (it indicates where places are) and iconic (it represents places in topographical relation to each other) and symbolic (its notational system must be learned)” [118, p. 77]. Furthermore, a signifier resembling that which it depicts is not necessarily *purely* iconic. As will be elaborated in section 2.7, photographs have iconic, as well as indexical and symbolic relations. hypermedia show all three types aswell, as will be shown in section 3.5. Whether a sign is symbolic, iconic or indexical depends primarily on the context in which the sign is used and the code it is embedded into, so the ”typical” examples chosen to illustrate the various modes can be misleading.

In relation to its interpretant, the sign may be either a rheme, a dicisign, or an argument (see figure 2.5). Peirce’s third trichotomy of signs is the most confusing one and can only be understood as a reflection to the traditional logic categories. That is, rheme, dicent, and argument more or less correspond to terms (concepts), propositions (statements), and arguments, respectively. A rheme (Greek ῥῆμα = word) represents a possible, not a concrete object; it can be every sign which is neither false nor true, such as nearly any word except ”yes” or ”no”, cf. [416, 2.309, 2.250].[37] A dicent is an informative sign which is slightly more defined in its relation to the interpretant: It is not an assertion, but a sign capable of being asserted, cf. [416, 8.337]. The difference to the rheme is that a dicent can either be true or false: For example, if a man on the street shouts ”apple”, it would be considered a rheme, while the street vendor’s promotion of ”fresh apples!” is a dicent[38]. An argument is a complex sign whose elements (rhemata and dicents) are governed by general rules, e.g. a sonnet, a syllogism, cf. [401, p. 66f.].

Peirce doesn’t stop here: He goes on to explore the possibilities of combining the specific types of sign or, perhaps better, sign functions identified in these three trichotomies. The ten resulting categories (not all 27, i.e. 3^3 combinations make sense) are listed with examples in [401, p. 67] and [353, p. 2].

Let us now turn back to the most fundamental taxonomies of the sign. Especially authors who are exploring the frontiers of the semiotic field, tend to maintain a classification that points to fields of studies such as zoosemiotics (animal communication) and endosemiotics (communication of the organs within the body); see figure 2.6.

Whereas Saussure had only considered non-verbal signs that explicitely function as such (military signals, etiquette, sign-language etc.), contemporary semiotics includes not only gestures but also objects. The function of an umbrella is to shelter against the rain. Thus, the umbrella has become a symbol for shelter, it becomes the exemplary of a model, or rite.[39]

The apparent secondary function of architecture as a communication system can sometimes even effect its primary function, or “functionality”, cf. [155, 43ff.]. The skirt of a balle-

[37] Peirce used rheme virtually synonymously with the way contemporary logicians used the term ”predicate”: The predicate ”x is red”, for example, is a sign which cannot be spoken of as being true or false (until a quantifier is added to tell which or how many xs we are talking about), cf. [416, 4.438ff.].

[38] I chose this example, of course, to demonstrate the relationship to Wittgenstein’s concept of *names* in relation to his *propositions* and his theory of the *Sprachspiel*, cf. [548, 549].

[39] This semiotic of the consumer good has inspired many authors, e.g. [154, 40].

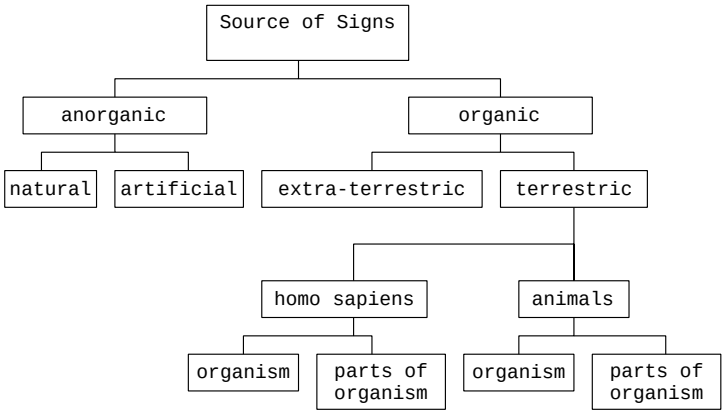


Figure 2.6: Classification of signs by their source. Source: [155, p. 37].

rina has very little, or even negative primary functions (it reveals more than it covers) and very dominant secondary functions. Thus, Eco proposes to replace Sebeok's classification (figure 2.6) by his own (figure 2.7).

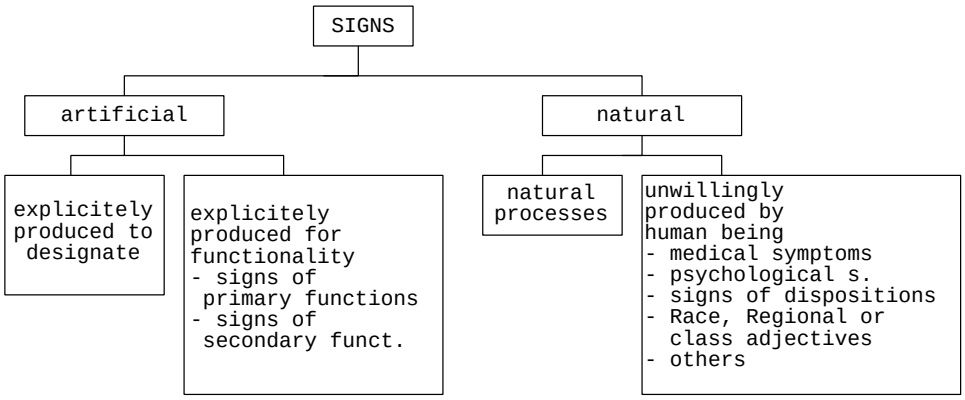


Figure 2.7: Classification of signs by their sign-functionality. Source: [155, p. 44].

Signs could also be classified according to the grade of consciousness and the intention of the sender, cf. [155, pp. 45-50]: Besides the *communicative* signs, that are sent out explicitely as tools to "get something across", every individual also sends along unwanted signals, or *expressive* signs. While the first kind of signs are consciously coded, signs of the second kind are intuitive. If a dancing partner has sweaty hands, or uses a certain perfume, that might reveal more than what the person wanted to say. Paralinguistics is a discipline that concentrates on the sound of the voice rather than the spoken words. Buyssens [82] uses the example of a fake descendant of the Platagenet family, who discloses his false play with his rude manners and inaccurate pronunciation while telling his stories. Whether a sign is sent/received intendedly or not, whether the receiver thinks it was intentional and finally whether the the sender wanted the receiver to think one or the other, creates a whole new "Semiotics of Dissimulation" [155, p. 49].

Another important classification of signs is that according to their physical channel of transmission (especially in the context of media semiotics). While really natural signs[40] can be carried by virtually every thinkable medium, or channel, the reception of signs is, com-

[40] *Natural* signs, according to Eco, are physical processes, such as thunder, starry nights, etc., cf. [155, pp. 45-50].

monly spoken, restricted to the five channels of human sensibility.

The question of arbitrariness vs. motivation of a sign has produced a large production of scholarly discourse: Although the signifier is treated by its users as "standing for" the signified, Saussure emphasized the arbitrariness of the sign: there is no intrinsic, direct or "transparent" relationship between the signifier and the signified. John Fiske comments that Saussure believed that the arbitrary nature of verbal language is the main reason for its complexity, subtlety and ability to perform a wide range of functions, cf. [168]. Each language involves different distinctions between one signifier and another (e.g. "tree" and "free") and between one signified and another (e.g. "tree" and "bush"). The arbitrariness of signs underlines the scope for their interpretation (and the importance of context). Signs have multiple rather than single meanings. Within a single language, one signifier may refer to many signifieds (e.g. puns draw on homonyms) and one signified may be referred to by many signifiers (synonyms). Eco shows that the signified does not only depend on the signifier, but also on the position within a system, for example the system of a language (Figure 2.8). In a triadic sign model, arbitrariness is given if the cognitive experience of the

Figure 2.8: Language systems. Source: [155], p. 86.

<table>
<tr><th>French</th><th>German</th><th>Danish</th><th>Italian</th><th>English</th></tr>
<tr><td>arbre</td><td>Baum</td><td rowspan="2">trae</td><td>albero</td><td>tree</td></tr>
<tr><td rowspan="2">bois</td><td>Holz</td><td rowspan="3">skov</td><td>legno</td><td>wood</td></tr>
<tr><td rowspan="2">Wald</td><td>bosco</td><td>woods</td></tr>
<tr><td>foret</td><td>foresta</td><td>forest</td></tr>
</table>

sign-user with the referent has no influence on the sign vehicle, cf. [401, p. 340]. Grades of arbitrariness, for Peirce are given by the iconic, indexical and symbolic types of object-relation, cf. [401, p. 341]. This system is especially helpful (and often cited) when defining the arbitrariness of visual signs (see section 2.7). Some semioticians, among them Fiske and Eco, maintain that convention is necessary to the understanding of *any* sign, however iconic or indexical it is. Guy Cook asks whether the iconic sign on the door of a public lavatory for men actually looks more like a man than like a woman (the two signs on the bottom left of figure 2.16). For a sign to be truly iconic, it would have to be transparent to someone who had never seen it before - and it seems unlikely that this is as much the case as is sometimes supposed. We see the resemblance when we already know the meaning, cf. [110]. This is especially true with onomatopoeia which supposedly imitate the sound of their referent. Onomatopoeic words like "to miaow", (Dutch: miauwen; French: miauler; German: miauen; Italian: miagolare; Spanish: maullar) were seen by Saussure as being no threat the arbitrary relationship of the signifier to the signified. The same is true for exclamations (English: ouch!, Spanish: ¡ay!, French: aïe!, German:au!, etc.), cf. [469, p. 78ff.]. Although Saussure's approach was a synchronic one, he was aware that the relationship between the signified and the signifier in language was subject to change over time. John Hartley notes that over time, what were once motivated signs can "become arbitrary and radically change their signified" [220, p. 31]. Many signs which in their original use could be seen to be motivated – to bear some discernible relationship to their referent – come to be used more metaphorically and may subsequently lose even their metaphorical association for their users.[41] Some of the letters in the Greek and Latin alphabets, of course, derive from iconic signs in Egyptian hieroglyphics (cf. [160, p. 132ff.]. The first three Arabic

[41]The word "miniature" derives from Latin word "minium", the red lead color that was used for medieval illumination of manuscripts. Therefore, the Latin word miniâre, soon became a synonym for producing small painting executed with great detail and the signified of /miniature/ shifted from "painted with lead color" to "being on a small or greatly reduced scale" [7].

numbers can be shown to derive from the same counting technique as the Latin numbers by a little trick: While the number one is obviously a scratch of the prehistoric accountant, the following two numbers have to be rotated to reveal graphein as their common root, see figure 2.9.

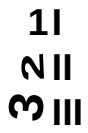


Figure 2.9: Graphein as the root of numbers.

Another important taxonomic distinction is that between analogical and digital signs: ”Analogical signs (such as visual images, gestures, textures, tastes and smells) involve graded relationships on a continuum. They can signify infinite subtleties which seem ’beyond words”’ [95, Signs]. As Guy Cook puts it: “one cannot specify the number of different smiles and [. . .] laughs available in one person’s repertoire” [110, p. 67].

Digital signs, on the other hand, involve discrete units such as words and numerals and depend on the categorization of what is signified. The appearance of the ”digital watch” in 1971 and the subsequent ”digital revolution” in audio- and video-recording have led us to associate the digital mode with electronic technologies, cf. [95, Signs]. Yet, digital codes (e.g. the Morse code) have existed before the invention of binary coding, cf. [401, p. 224]. In fact, ”digital codes have existed since the earliest forms of language – and writing is a ’digital technology”’ [95, Signs]; see section 2.4. Fiske notes that “turning nature into culture and thus making it understandable and communicable involves codifying it digitally”, [169, p. 313]. Digital differences are *either/or* while analog distinctions are *more-or-less*.

An example for an analog representation system is the speedometer on an automobile. The speeds of the vehicle are represented in a dense class of states of affairs (positions of the pointer) that can hold in the meter. The light on the dashboard that registers oil pressure affords a digital representation system because there are only two states of affairs (on and off) that indicate information (high and low) about the oil pressure. Both classes of indicating states of affairs and indicated states of affairs are discrete. Of course, a single representation system can be both analog and digital with respect to different subsets of information within its coverage, cf. [482, 105].

One may be tempted to use this distinction between analog and digital to draw a line between graphical systems and linguistic systems. Thus, it might be proposed that a linguistic system is digital with respect to the entire set of information it covers, while a graphical system is analog with respect to the entire set of information it covers [482]. However, Goodman has effectively cut this line of proposal.[42] Linguistic systems might be all digital, but the property of being digital is shared by some graphical systems, cf. [482, p. 106].

Umberto Eco has criticized the apparent equation of the terms “arbitrary”, “conventional” and “digital” by some commentators, cf. [154, p. 178-180]. He notes the way in which the following widespread pairings misleadingly suggest that the terms vertically aligned in figure 2.10 are synonymous. He observes, for instance, that a photograph may be both

[42]”Diagrams, whether they occur as the output of recording instruments or as adjuncts to expository texts or as operational guides, are often thought – because of their somewhat pictorial look and their contrast with their mathematical or verbal accompaniments – to be purely analog in type. Some such as scale drawings for machinery, are indeed analog; but some others, such as diagrams of carbohydrates, are digital; and still others, such as ordinary road maps, are mixed” [194, p. 68]. Since diagrams of carbohydrates are digital with respect to

digital	vs.	analog
arbitrary	vs.	motivated
conventional	vs.	natural

Figure 2.10: Misleading pairing of terminology. Source: [154, p. 190].

“motivated” and “digital”.

Based on Peirce’s views – especially the differentiation of sin-, quali-, and legisigns – Eco offers another distinction between sign vehicles, relating to the linguistic concept of tokens and types. In relation to words in a text, a count of the tokens would be a count of the total number of words used, whilst a count of the types would be a count of the different words used (regardless of repetition). Eco lists the following kinds of sign vehicles: signs in which there may be any number of tokens (replicas) of the same type (e.g. exactly the same model of car in the same color[43]); ”signs whose tokens, even though produced according to a type, possess a certain quality of material uniqueness” (e.g. a word spoken or handwritten by different people); and ”signs whose token is their type, or signs in which type and token are identical” (e.g. an original oil-painting), cf. [154, p. 178-180]; [95, 396, 44]. In the context of hypertext, nodes and link markers are typically signs of the first kind, or ”copies without originals” [95, Signs].

2.5 Semiosis

Semiosis, a term borrowed from Charles Sanders Peirce, is expanded by Eco to designate the process by which a culture produces signs and attributes meaning to signs. Umberto Eco coins the phrase ”unlimited semiosis” to refer to the way in which a series of successive Peircean interpretants lead to a (potentially) *ad infinitum* process, as any initial interpretation can be re-interpreted; cf. [416, 1.339, 2.303], [154, 396]. Merrell [353, p. 137] illustrates ”the ongoingness of this semio[t]ic process” as figure 2.11, an extension of his tripod model of the sign (figure 2.2).

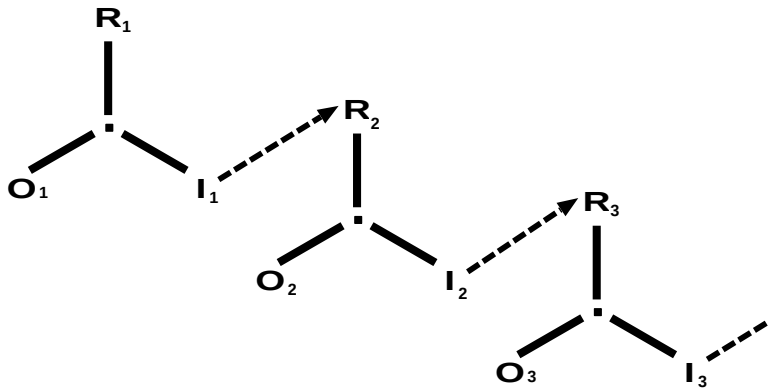


Figure 2.11: Unlimited semiosis. Source: [353, p. 137].

Chandler equates unlimited semiosis with the process of browsing a dictionary: ”That a signified can itself play the role of a signifier is familiar to anyone who uses a dictionary

the entire sets of information they cover, Goodman’s observation also precludes the suggestion that a graphical system is analog with respect to at least a part of the information set it covers, cf. [160, p. 13ff.].

[43] See footnote 36.

and finds themselves going beyond the original definition to look up yet another word which it employs" [95, Signs].[44] Bolter [68] and McGuire [346] expand the equation to hypertext navigation, as described in section 3.7.11.

The notion of the importance of sense-making[45] (which requires an interpreter – though Peirce doesn't feature that term in his triad) has had "a particular appeal for communication and media theorists who stress the importance of the active process of interpretation, and thus reject the equation of 'content' and meaning. Many of these theorists allude to semiotic triangles in which the interpreter (or 'user') of the sign features explicitly (in place of 'sense' or 'interpretant')" [95, Signs]. Nadin insists that "each time someone interprets a sign, that person becomes part of the sign and thus of the process of its interpretation" [375]. David Sless reminds us that statements about users, signs or referents can never be made in isolation from each other: "A statement about one always contains implications about the other two" [493, p. 6].

2.6 The Code

In information theory and computer science, codes play a major role in programming, data transmission, cryptography[46], etc. In semiotic texts, two meanings of code are encountered most frequently: In one sense, code means a set of rules prescribing how to act or how to do, and in another, a key (or set of instructions) for translating a message. Morse code is a key for correlating particular patterns of clicks and silences to letters of the alphabet. Codes as sets of rules are normative: They provide us the norms to judge whether we are acting appropriately. Judgments of mispronunciation are only possible in reference to the codification of sounds found in the alphabet. Of course, not all violations of a code signal ineptitude or incompetence; some result from deliberate or conscious decision: "For example, when a person desiring to shock people shows up on a formal occasion dressed in a bathing suit, thereby breaking the fashion code. This example suggests an important distinction: A code needs to be explicitly formulated. In fact, most codes might be sets of more or less implicit (or unstated) rules: They are acquired through imitative behavior and are followed, in a sense, unconsciously" [102, p. 64].

Eco points out that the semiotic field includes the traditional field of Aesthetics because every code (visual codes, cultural codes, natural languages, musical codes etc.) permits an aesthetic usage of its signs, cf. [153, p. 25]. Thus, even the non-semiotic aspects of aesthetics, such as the psychology of artistic creation, the analysis of the relation of art and society and the physio-psychological definition of aesthetic pleasure, could be directed from a semiotical point of view. Although many of these issues shall not be approached directly in this paper, they will permanently reappear on the horizon of the field of study.

In the semiotic context, however, codes are interpretive frameworks which are used by both producers and interpreters of texts and help to simplify phenomena in order to make it eas-

[44] This seems even more true for browsing an encyclopedia. The encyclopedia paradigm of hypertext will be described in section 3.3.

[45] "Although for Eco meaning production or semiosis is a social activity, he allows that subjective factors are involved in each individual act of semiosis. The notion then might be pertinent to the two main emphases of current, or post-structuralist, semiotic theory" [126, p. 167].

[46] Whilst the fascination of hidden messages (e.g. of Kabbalistic and alchemistic kinds) seems to be as old as language itself, the deciphering of the Egyptian hieroglyphs may be seen as the starting point of modern cryptography. Royal names were historically, along with the Rosetta stone, the key to the understanding of the Egyptian hieroglyphs: The Abbot Barthélémy had already suggested in the eighteen century that the cartouches enclosed royal names. Thus, after the Rosetta stone had been found, Akerblad and Young were able to read some Greek and Roman royal names. Jean Champollion, using his knowledge of the Coptic language, proved that the phonetic system wasn't only used for foreign names, thus getting the clue that allowed him to translate quite accurately many texts during the ten years that followed his discovery, cf. [450]. The importance of cryptography to ensure secure data exchange and authenticity on the Internet will be treated in section 4.7.3).

ier to communicate experiences, cf. [193, p. 35]. Yet, ”codes are not simply ’conventions’ of communication but rather procedural *systems* of related conventions which operate in certain domains. Codes organize signs into meaningful systems which correlate signifiers and signifieds” [95, Code]. Society itself depends on the existence of such signifying systems, or, as Stuart Hall puts it, ”there is no intelligible discourse without the operation of a code” [210, p. 131]. In accordance to Kristeva’s intertextuality thesis [291], codes transcend single texts, linking them together in an interpretative framework.

It has become the common way to start a semiotic account of the code by citing Ernst Gombrich’s commentary on the golden plaque aboard of Pioneer 10, an interstellar probe sent into deep space by the NASA in 1972, cf. [95, 458]. Gombrich explains why – even in that unlikely case that ”intelligent scientifically educated beings” (as expected by the NASA) had sense organs that responded to the same band of electromagnetic waves as our eyes – the aliens could not possibly *get* the message: ”Reading an image, like the reception of any other message, is dependent on prior knowledge of possibilities; we can only recognize what we know” [193, p. 151]. Accordingly, primal tribes experience initial difficulties in decoding photographs and film to the same degree that Westeners fail to understand Chinese writing or a Tibetian mandala, cf. [18, p. 11, 80].

Roman Jakobson emphasized that the production and interpretation of texts depends upon the existence of codes or conventions for communication, cf. [253, p. 570-79]. Since the meaning of a sign depends on the code within which it is situated, codes provide a framework within which signs make sense: ”Indeed, we cannot grant something the status of a sign if it does not function within a code” [95, Code]. According to the Gestalt psychologists [281, 280] there are certain universal features in human visual perception which in semiotic terms can be seen as constituting a perceptual code.[47] Perceptual constancy ensures that ”the variability of the everyday world becomes translated by reference to less variable codes. The environment becomes a text to be read like any other text” [386, p. 26]. Whilst these basic principles have to be observed in the design of any information system, it is impossible to base an intuitive hypertext interface on them alone: To the first-time computer user, the basic codes of Human-Computer Interaction (HCI) have to be learned first. Only thereafter will they soon be internalized, or ”naturalized” [210, p. 132], see section 3.6.

Unlike researchers that ignore the semiotic approach, semioticians have tried to capture the difference between code and language in verbal and non-verbal communication: With regard to photography (though one might say the same for film and television), Victor Burgin insists that: ”There is no ’language’ of photography, no single signifying system (as opposed to technical apparatus) upon which all photographs depend (in the sense in which all texts in English depend upon the English language); there is, rather, a heterogeneous complex of codes upon which photography may draw” [79, p. 143]. Jakobson observed that ”the image of language as a uniform and monolithic system is oversimplified. Language is a system of systems, an overall code which includes various subcodes” [254, p. 30]. However, ”the term *language* is often used by semioticians and others in a very general sense to mean any system of signs. It is also frequently used in a narrower sense to designate a system of verbal signs, talking *verbal* here to include both spoken (or auditory) and written signs. Third, *language* is used in a still narrower sense by some linguistics [. . .] and others to mean a system of auditory signs” [102, p. 128].

Semioticians have seeked to identify codes and the tacit rules and constraints which underlie the production and interpretation of meaning within each code. Different theorists have found it convenient to divide codes into groups, yet they favor different taxonomies.

[47] ”In addition to introducing the terms ’figure’ and ’ground’, the Gestalt psychologists outlined what seemed to be several fundamental and universal principles (sometimes even called ’laws’) of perceptual organization. The main ones are as follows (some of the terms vary a little): proximity, similarity, good continuation, closure, smallness, surroundedness, symmetry and prägnanz” [95, Code], cf. [57, 336, 384]. See figure 3.11.

The most widely mentioned in the context of media, communication and cultural studies are social, textual, and interpretative codes (and subcodes), cf. [95, Code]; [401, p. 216ff.]. As the various kinds of codes overlap, the semiotic analysis of any text or practice involves considering several codes and the relationships between them. The ”tightness” of semiotic codes themselves varies from the rule-bound closure of logical codes (such as codes in computer science) to the interpretative looseness of poetic codes.[48]

The deliberate intention to communicate tends to be dominant in digital codes, whilst communication in analog codes (through gesture, posture, facial expression, intonation and so on) takes place on a largely uncontrollable and unconscious level. Actors, politicians and managers are trained to control these analog codes to a certain extent. To the receiver, these codes unavoidably ”give us away”, revealing such things as our moods, attitudes, intentions and truthfulness (or otherwise), cf. [95, Signs].

2.7 Media Semiotics

Nöth sketches the relation of two neighboring research disciplines Semiotics and Media Studies[49] as appearing to be ”predestined to fruitful transdisciplinary cooperation” [399, p. 1].

Semiotics began to become a major approach to media theory in the late 1960s, partly as a result of the work of Roland Barthes. The translation into English of his popular essays in a collection entitled Mythologies (1957), followed in the 1970s and 1980s by many of his other writings, greatly increased scholarly awareness of this approach, cf. [401, p. 107-111]. Semioticians have been interested in the media both as an area of applied semiotic research and as an area of testing, questioning, or even revisiting its own theoretical premises. Consequently, there is a plurality of semiotic approaches to the media, cf. [399, p. 1f.].

The term ”medium” is used in a variety of ways by different theorists, and may include such broad categories as speech and writing or print and broadcasting or relate to specific technical forms within the mass media or the media of interpersonal communication, cf. [95, Introduction]. Chandler’s own definition of a medium ”is similar to the definition of a semiotic system as a symbolic system which serves to support the construction of reality” [94, p. 3]. Other theorists classify media according to the physical channels involved (visual, auditory, tactile, olfactory, gustatory[50]). Human experience is inherently multisensory, yet every representation of experience is subject to the constraints and affordances of the medium involved. Peirce’s consideration of the medium instead of signs has often been revisited, reminding us that the study of the sign just like the study of the media is the study of the process of mediation between ourselves and the world outside, cf. [399, p. 3]. Of course, every medium is constrained by the channels which it utilizes and an awareness of this phenomenon of transformation by media has often led media theorists to argue deterministically that our technical means and systems always and inevitably become ”ends in

[48] Nöth shows some exemplary transcodings, e.g. between the Latin alphabet, Morse code, Braille alphabet (for the blind) and the naval alphabet, cf. [401, p. 223]. Janko demonstrates en- and decoding the ASCII, the Huffman code, error correcting codes, etc., cf. [256, p. 16ff.].

[49] According to Daniel Chandler, media studies, or ”the study of the mass media” is an offshoot of communication studies, cf. [94, p. 2]. Media Theory, ”a term which has been gaining currency in recent years” is even less of an established discipline than semiotics or media studies: ”Many of the concerns of media theory are shared by scholars in a variety of disciplines, including the anthropologists, linguists and rhetoricians. [...] And a particular kind of media theory is also a concern of those involved in semiotics [...] The best-known ’theorist’ of media in the broadest sense, Marshall McLuhan (who enjoyed widespread popular attention in the 1960s and ’70s), can hardly be regarded as having developed a coherent theoretical framework for the study of media” [94, p. 3].

[50] Buyssens [82] calls these categories “semies”.

themselves" [95, Introduction].[51].

The same is true, of course, for hypermedia nodes. While aural and visual signs seem to be privileged in current hypertext systems, other channels are helpful for the reception of expressive signs. In media theory, the use of a certain channel, or "medium" can be as important as the message itself. In his account on "the computer, hypertext and the history of writing", Jay David Bolter argues that "signs are always anchored in a medium. Signs may be more or less dependent upon the characteristics of one medium – they may transfer more or less well to other media – but there is no such thing as a sign without a medium" [68, 195f.]. Chandler points to the fact that it would be more precise to say that the sign vehicle cannot be without a medium, cf. [95, Signs]; [551, p. 17]. Hodge and Tripp note that, "fundamental to all semiotic analysis is the fact that any system of signs (semiotic code) is carried by a material medium which has its own principles of structure" [228, p. 17]. The medium is not "neutral"; each medium has its own constraints and, as Umberto Eco notes, each is already "charged with cultural signification" [154, p. 267]. John Fiske insists that "each medium is capable of transmitting codes along a channel or channels" [408, p. 176] and that "the physical characteristics of the channel limit the medium and codes that it can carry". For Schmauks, media differ from each other in their ability to illustrate abstract objects and concepts[52]. Such differences lead Emile Benveniste to argue that the "first principle" of semiotic systems is that they are not synonymous: "We are not able to say 'the same thing' in systems based on different units" [47, p. 235]. This assumption seems even more striking in the consciousness that the general scheme of the communication process is always the same (see figure 2.12).

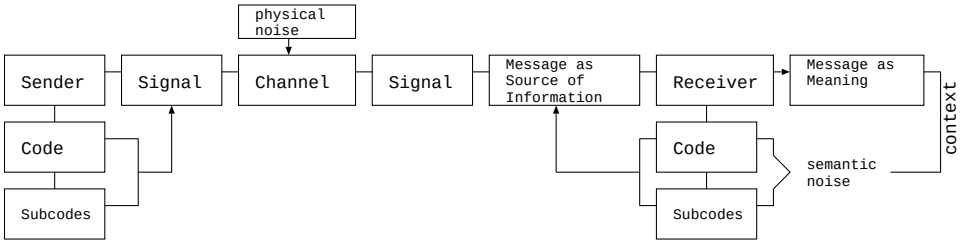


Figure 2.12: Communication process. Source: [153, p. 139].

As an approach to communication which focuses on meaning and interpretation, semiotics challenges the reductive transmission model [480] which equates "meaning" with "message" (or content), cf. [102, 442, 399]. Meaning is not 'transmitted' to us – we actively create it according to a complex interplay of codes or conventions of which we are normally unaware. Becoming aware of such codes is both inherently fascinating and intellectually empowering. We learn from semiotics that we live in a world of signs and we have no way of understanding anything except through signs and the codes into which they are organized. Signs do not just "convey" meanings, but constitute an environment in which meanings are constructed. Generalizing the findings of those urban semioticians who have highlighted the limitations of the Lynchian and cognitive perspective (cf. [198]), one could say that meaning gets "conceived", not "perceived" (see section 3.7.11). Semiotics helps

[51] This is a common interpretation of Marshall McLuhan's famous aphorism, "the medium is the message" [350, 351], and has even led some to present media as wholly autonomous entities with "purposes" (as opposed to functions) of their own. "However, one need not adopt such extreme stances in acknowledging the transformations involved in processes of mediation. When we use a medium for any purpose, its use becomes part of that purpose. Traveling is an unavoidable part of getting somewhere; it may even become a primary goal" [95, Introduction]. These reflections are important in the consideration of hypertext navigation, see section 3.7.

[52] "Medien unterscheiden sich unter anderem darin, inwieweit sie abstrakte Objekte darstellen können. Die Sprache ist außerordentlich flexibel [...]. Bilder hingegen können abstrakte Objekte nur auf "semiotischen Umwegen" darstellen" [473].

us to realize that meaning is not passively absorbed but arises only in the active process of interpretation, cf. [63, 399].

Lacanian psychoanalysis has been successfully applied to media theory, e.g. the relation of the spectator to the cinema in general, cf. [225]. Christian Metz, in his seminal study of cinema as *The Imaginary Signifier*, has tackled the problem of the position of the spectator with respect to a film from within a Lacanian framework. His analysis starts off from the notion of perception – "The cinema's signifier is perceptual (visual and auditory)" [355, p. 42] – and goes on to distinguish the cinema from other arts inscribed into the perceptual register (such as painting, sculpture etc.) by stating that the cinema is "more perceptional" [355, p. 43] by involving more perceptional axes.[53]

Semiotics will have to play a major role in the successful introduction of gustatory, olfactory and tactile data into (hyper-)media systems. Merrell makes clear that the specifica of those senses make them extremely interesting for the human understanding, learning and interpreting of data: for example, "odors, and even tastes [...] hardly know more than long-term memory" and "touch is sort of at the crossroads regarding sensory modes" [353, p. 151, 157]. As the technological means for their integration are not yet available, most researchers concentrate on audio-visual inputs:

> "Images, language and writing are what's meant when I talk of media in the narrow sense. They have been at the centre of many philosophical discussions in the twentieth century which were mostly concerned with identifying one or more of these media as being a binding base structure for human understanding of reality altogether, or – at the very least – as the foundation of the world-picture characteristic of Western culture" [465].[54]

The transformation of the WWW from hypertext to hypermedia and the evolution of interfaces from symbolic to iconic (in Brown's sense [77]), echoes the transition from a society of text to a society of the (moving) image. At this point the Web is primarily a static visual medium, but higher access speeds and the convergence with other media, such as TV and radio will bring more time-based hypermedia soon, cf. [388, 393].

As pointed out by Risak, optical presentation of home pages can communicate a lot of messages to the user, cf. [442, 443]. Screen designs that resemble glossy magazines and brochures rely of the eye-catching quality of the image, and also on an immediate (and easy) understanding of its meaning. In other words, that what Langer calls presentational immediacy[55]. The investigation of popular cultures is the realm of cultural studies and semiotics alike. Some ask if the intrusion of the image catapults us back into an age when most people were educated by narration and murals on church or cave walls and only few were able to read and write. Others face this development by tearing down the wavering distinctions between "art" and "nonart," "expressive" and "inexpressive" that have been

[53] Bignell argues that "the whole of our social world is pervaded by messages which contain visual as well as linguistic signs, or which are exclusively visual. Gestures, dress codes, traffic signs advertising images, newspapers, television programmes and so on are all kinds of media which use visual signs. The same principles underlie the semiotic study of visual signs and linguistic signs. In each case, there is a material signifier, which expresses the sign and a mental concept, a signified, which immediately accompanies it" [63, p. 14].

[54] "The spectrum reaches from analytic philosophy's 'linguistic turn' and the diverse misunderstandings triggered by Derrida's early concept of a philosophical 'grammatology' in the realm of postmodern thinking, through to contemporary proclamations of a 'pictorial turn"' [465].

[55] In Philosophy in a New Key, Langer writes, "Visual forms are not discursive. They do not present their constituents successively, but simultaneously, so the relations determining a visual structure are grasped by one act of vision" [306], see section 2.2. Mircea Eliade puts it this way in *Images and Symbols*: "Images by their very structure are multivalent. If the mind makes use of images to grasp the ultimate reality of things, it is just because reality manifests itself in contradictory ways and therefore cannot be expressed in concepts. [...] It is therefore the image as such, as a whole bundle of meanings, that is true, and not any one of its meanings, nor one alone of its many frames of reference" [159, p. 15].

obstructing the way to a wider panorama on visual codes, cf. [160, p. 31f.]. Of course, this question falls far beyond the borders of this dissertation. Yet, a short disquisition on the state of art in image theory may clarify the potential of graphics and photos in hypermedia.

Elkins breaks with the tradition of art history that concentrates on fine art images leaving non-art, or "informational images"[56] to other disciplines, such as archaeology, cognitive psychology, mathematics, philosophy of science. As "art history is centrally positioned in the emerging field of image studies because it possesses the most exact and developed language for the interpretation of images", existing art-historical methods "can embrace images of any kind, from graphs to ideographic writing" [160, p. 6]. He takes a sonar chart used for fishing (similar to figure 2.13) as an example of "a composite of very different

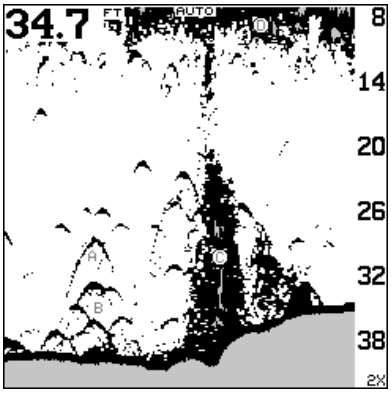


Figure 2.13: Sonar chart of the water beneath a fishing boat. Source: Eagle Electronics.

routes of reference: It is an x-y graph, a naturalistic scene, and a collection of symbols for the motion of fish. It needs to be read, seen, and deciphered, and a viewer must switch between modes of interpretation in order to comprehend it" [160, p. 36]. Recurring on Nelson Goodman's terminology of "routes of reference" ([195, p. 55-70]), Elkins finds *mixed* routes of reference not only in sonar charts for fishing, but also "on ancient artifacts, and on contemporary images such as computer screens (which are partly naturalistic pictures and partly notations)" [160, p. 36].

According to Elkins, nonart images could be called notations, "if it were not that the word has been coopted by Nelson Goodman to describe especially systematic images such as printed music and Labanotation[57]" [160, p. 54].

In the context of hypertext, Goodman's notational criteria[58] concern the presentation layer

[56]"In general, art history tests its boundaries by working with popular, medieval, and non-Western images. But the domain of images is substantially larger. In particular there is another group of images that seems to have neither religious nor artistic purpose, and that is images principally intended – in the dry language of communication theory – to convey information. There is no good name for such images, which include graphs, charts, maps, geometric configurations, notations, plans, official documents, some money, bonds, patents, seals and stamps, astronomical and astrological charts, technical and engineering drawings, scientific images of all sorts, schemata, and pictographic or ideographic elements in writing: in other words, the sum total of visual images, both Western and non-Western, that are not obviously either artworks, popular images, or religious artifacts. In general, art history has not studied such images..." [160, p. 4]. Thus, "it makes sense to use "informational images as convenient labels rather than as definitions, because they say less about pictures than about the disciplines that study them" [160, p. 5].

[57]Labanotation is a standardized system for analyzing and recording any human motion. Mainly it is used at theaters to archive ballets. The original inventor is the (Austrian-) Hungarian Rudolf von Laban (1879-1958).

[58]Goodman lists five criteria of notation, of which two are syntactic and three semantic. It is crucial that a mathematic symbol is *syntactically disjoint*, that is, that a mark cannot be assigned to two characters. The notational system itself must also be *syntactically finitely differentiated* or *articulate*, i.e. different symbols must not be mistaken for one another. Furthermore, a notation must be *semantically unambiguous*, *semantically disjoint*, and *semantically finitely differentiated*, or *dense*, cf. [194]. Veith Risak has drawn my attention on the parallels between the syntactic rules of notation and the scope rules in computer programming.

(the ”run-time layer”) and the within-component layer of the Dexter Reference Model (see section 3.4), as link markers must be clearly defined for the user and lead to the right link target. In order to display node contents, these notation criteria are relevant for design questions, such as typography and computer fonts, questionnaires, etc. For Elkins, Goodman’s system becomes interesting at the point of breakdown.[59]

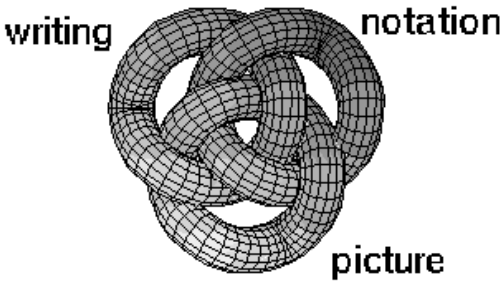


Figure 2.14: Borromean rings. Source: based on [160, p. 86] and [101].

After several attempts to formalize the relation between writing, picture and notation, he recurs on Lacan’s idea of interlocking the registers Symbolic, Imaginary and Real with Borromean rings:

> ”For Lacan, Borromean rings are a suggestive image of the state of the psyche, formed of encircled emptiness rather than bounded psychic ’registers’. The same could be said of the triad of writing, picture and notation. Interlocked rings do justice to the commonsense belief that all images are somehow related: A page of text might fall on the circumference of the ’writing ring’ at a point diametrically opposed to the unnamed center, but even there will be intimately connected with the other rings” [160, p. 86].

Elkins distinguishes seven kinds of images on the way from writing via picture to notation[60], cf. [160, p. 95ff.]. Of course, he is well aware that there are overlappings and hybrid forms in the categories (writing, notation, picture) just as well as in the image taxonomy (allography, semasiography, pseudowriting, subgraphemics, hypographemics, emblemata, schemata), cf. [160].

Wittgenstein’s *Bildtheorie*[61] (picture theory) is, according to Elkins ”the strongest and most consistent form of the desire to have pictures make determinate sense” [160, p. 56]. Elkins claims that Wittgenstein wants to demand of pictures what Goodman demands of notations. While any further commentary reaches beyond the limits of this dissertation, I do agree to Elkin’s claim that ”there might be good reason to reconsider the ’picture theory’ and Wittgenstein’s *Tractatus logico-philosophicus* in light of contemporary visual theory” [160, p. 58].

Apart from his picture theory, Wittgenstein, especially in the *Philosophische Untersuchungen* [549] was interested in natural language and its use. Wittgenstein, Bertrand Russell,

[59] Kaplan/Moulthrop take a similar position towards the breakdown of the graph model for hypertext, cf. [268].

[60] This way could be called a logocentric sequence, the ostensive progression from a pure picture to the alphabet, cf. [160, p. 86]

[61] The idea for a theory of the *Bild* (he could have tried *Darstellung* or *Vorstellung*, with their echoes of Hegel and Schopenhauer) probably came from Gottlob Frege who writes ”It would be desirable to have a special term for signs having only sense – if we name them, say pictures [Bilder], the words of an actor on the stage would be pictures; indeed the actor himself would be a picture” [178], cited in [160, p. 64]. For different viewpoints on Wittgenstein’s Bildtheorie, cf. [236, 250, 87].

Karl Kraus, Fritz Mauthner and the Vienna Circle were all working on different models for a critique of language[62] whilst Otto Neurath challenged the image: Neurath was of the opinion that the times of linguistic dominance were once and for all over and that the image would soon take that place to solve epistemological confusions, cf. [163, p. 17]. For him, images have two major advantages: They are not dominated by the systematic fallacies of natural language and they can transgress cultural and language barriers.[63] Of course, his "Bildstatistik nach der Wiener Methode" and especially his International Picture Language, a true "renaissance of the hieroglyph"[64] faces problems quite similar to Wittgenstein's attempt to formalize language in the *Tractatus*, cf. [548, 549, 88].

As a picture says more than a 1000 words[65], many contemporary cultural theorists have remarked on the growth of the importance of visual media compared with linguistic media in contemporary society and the associated shifts in the communicative functions of such media: In an increasingly visual age, an important contribution of semiotics from Roland Barthes onwards has been a concern with imagistic as well as linguistic signs, particularly in the context of advertising, photography and audio-visual media, cf. [95, Introduction, Strenghts].

Figure 2.15: Counting technique.

Language can describe complicated relationships easily, e.g. "your chance of winning is one to a thousand", as compared to a depiction of a sign for "you win" beside a thousand signs of "you loose", cf. [306]. We can only count a restricted number of visual inputs at the moment of seeing them, like the numbers on a dice. This is also reflected by a counting technique that crosses out every fifth element, see figure 2.15. A basic psychological rule (that is often quoted in Web design classes) says that the maximum we can grasp at a time is 7 elements, cf. [144, 359]. Mathematical notation is explicitely tailored to show relationships such as $p = \frac{1}{1000}$. But when the formulae become too complicated and too many factors get involved, visualization is needed again: The endeavor to design better charts, maps and diagrams has lead to Neurath's "Wiener Methode der Bildstatistik", and also to Bertin's semiology of graphics, cf. [385, 57]. Apart from methods for quantitative data representation, Otto Neurath worked on an International Picture Language that became known as ISOTYPE. The idea for a picture language is based on the assumption that images can hold the same or even additional information as text in a compressed and intuitive form, cf. [50]. In his thorough formulation of a semiotic critique of Neurath's

[62] "All philosophy is 'Critique of language' (but not at all in Mauthner's sense)", [548, 4.0031].

[63] When I read about "The Multicultural Promise of Multimedia" at the Institute of Afro-American Research at Harvard University, I expected an account of the potential of the image to cross cultural borders in a classic ethnological sense. In fact, the staff of that institution, by "doing things without words", is hoping to bridge the "ever-widening chasm between the hyper-specialized world of the Academy, and the generation of students accustomed to the depth, pace and production values of MTV and Nintendo" [453, p. 62]! The renaissance of the image in hypermedia is thus not only bound to globalization and the bridging of language barriers. The visualization of information is also a *perpetuum mobile* within our own languages and cultures. Ulrich describes the timeless power of the image (or rather the gramma): "Die Zeit steht still [...] Keine Übersetzung ist notwendig. Bild kennt keine fremden Sprachen. Unbeschadet der babylonischen Sprachverwirrung spricht [...] das Bild aus vorbabylonischer Zeit" [522, p. 108].

[64] As Neurath was personally impressed and influenced by hieroglyph and all other kinds of picture languages, he did not hesitate to call his work on the ISOTYPE system as a renaissance of the hieroglyph, [385, p. 642].

[65] This is true for all non-verbal sensations, which belong to a certain kind of "archaic" thinking, as formulated in psychoanalystic terms by Ulrich: "Am Bild (wie am Ton, Geruch, Geschmack, den taktilen Sensationen, dem Gleichgewichtssinn) arbeitet die Sprache sich ab und erreicht es nie ganz" [522, p. 104].

picture language, Eschbach points to a number of questionable assumptions, or ”myths”, above all the myth of the visible, talking sign, cf. [163, p. 17]. As outlined in section 2.4, semiotics defines the sign not as a tangible object, but as an invisible relationship between the sign vehicle, the sense and the referent. Eschbach concludes that there can be no talking signs, as it is us who make them talk. He introduces seven criteria that differenciate language from picture (Bild), most of them based on already cited reflections, cf. [306, 173, 416, 368, 154, 548]. These considerations will be crucial when describing the renaissance of the image in the World Wide Web (see section 4.5).

Images can never be separated from vision and subjectivity. Images are part of a mental process, the result of an interaction between photographs and viewing subjects. Images are products of perception and thought, of semiosis. The power of the image, or, more precisely the iconic sign, lies in its similarity to the object: Never can a description of a face be more precise than a photograph. Due to its presentational form, the image lacks translational ability. While a sentence in French can be translated into a sentence in English, there is no way to translate a painting into a sculpture, cf. [306, 371] For Eliade, to translate an image into a concrete terminology by restricting it to any one of its frames of reference is to do worse than mutilate it – it is to annihilate, to annul it as an instrument of cognition, cf. [159, p. 15].

As the term ”picture” has been used synonymously to ”image”, Elkins recurs (like Derrida, but for a distinctive reason) on the Greek term gramma. The gramma inevitably plays into questions of a technical process of inscribing (graphein), by means of a physical process, or with the help of an apparatus and a chemical/electronic process. Grammata are always related to questions of verification and truth, cf. [160].

Grammata on the computer screen can be classified into photographic and graphic pictures in digital form. The first category consists of direct digital photographs and scans, the second includes all kinds of computer-generated pictures (”synthetic or infographic images” [466, p. 121] *created* on, or by the computer), such as CAD pictures, diagrams, bullets, arrows, graphs, etc. Yet, for the viewers, these two categories are blurring to a degree that they cannot decide anymore whether a picture is ”authentic” of not. This ”authenticity”, in semiotical terms, is expressed as indexicality. Furthermore, digital pictures are infinitely reproducible by anybody, as there is no (need for any) original, negative or mould, cf. [140]. This total absence of any ”aura of the original” certainly goes beyond the reproductive techniques known to Walter Benjamin, cf. [44]. The same is true for digital video and audio clips (see section 3.4.4), and for future olfactory, gustatory, and haptic (hyper-)media[66] (see section 3.7.10).

Photography has always been an important demonstration model and catalyst for semiotic studies as ”the very idea of a science of signs, of semiotic discourse, relies on the ’photography effect’. [...] It is hard to imagine a science of signs, especially Peircean semiotics, developing in a pre-photographic age” [325, p. 57, 61]. In the early days of photography, few perceived that, like any image or word, the photograph was inherently symbolic, possessed of meaning, and subject to interpretation. What appealed initially to scientists and artists alike was photography’s factual nature, its precision and objectivity, cf. [181, p. 11ff.]

> ”Semiotically, the correspondence of the photographic signifier with the object it depicts is grounded in what Peirce described as the indexical and the iconic nature of photography” [397, p. 135].

[66] Olfactory and gustatory sign vehicles have a strong indexical relation to the referent, which will influence future use in hypermedia environments: e.g., in our everyday experience, we can identify certain odors, even if their source has long left the place. These media will strongly enhance our comprehension, as we understand through the body, cf. [302, 353]; see section 4.3.2.

Photographs correspond to the depicted world by their iconic nature because, as Peirce [416, 2.281], puts it, ”we know that they are in certain respects exactly like the objects they represent.” In addition to this correspondence by similarity, photographs also correspond to reality by their contiguity with the depicted object at the moment of their production. He argues that there is a ”physical connection” between the signifier and its referential object since ”photographs have been produced under such circumstances that they were physically forced to correspond point by point to nature” [416, 2.281]. By this relation of productive causality, ”the photographic picture is defined as an indexical sign” [397, p. 135]. Barthes takes up this debate by asserting that photography ”always carries its referent with itself” and (drawing on Sartre) that ”it is not possible to perceive the photographic signifier, but requires a secondary action of knowledge or of reflection” [39, p. 5]. The dissociation of consciousness and identity, as in ”this picture is not really *me*!”, leads to a certain discomfort when we see ourselves on photographs.[67]

It is primarily because of this indexical signature that we tend to see in the photographic signifier an affirmation of the existence of the depicted object, ”an emanation of past reality” [39, p. 88]. As bare fact, the photograph contains uninterpreted analog data. Once that data is interpreted, the photograph takes on meaning, becomes a symbol for a past or future moment in the space-time continuum which may be either remembered or imagined. As symbol, the photographic image unites the perception of time and space in a single locus. Time, in this loop, does not rely on the movement of a clock but is instead located in the physical periodicity of the photograph. Barthes’ example is a photograph of Lewis Payne who had tried to assassinate the American secretary of state in 1865, and was given the death sentence. Alexander Gardner photographed him in his cell, where he was waiting to be hanged. Looking at the photo, the viewer utters: ”he is going to die. . . ”[68]

Family photos, which remind us of real situations lived in the past, press photos, which document a historical event, or scientific photos are typical Web content. They all show a real world object in all its details, they are typical examples of indexical photographic reference and iconic correspondence between the photographic signifier and its object which testify to the truth potential of the photograph, cf. [397, p. 135].

On the very last pages of *camera lucida*, Barthes states that today’s omnipresence of banal images has lead to a loss of their authenticity. What he did not know was that two years after his book came out, photography entered a new stage of authenticity, or the lack threrof. In a photograph for the National Geographic magazine, the pyramids at Giza were digitally moved closer together to fit the layout of the February 1982 issue front cover. The status of the photographic document as evidence is thus called into doubt. While manual falsification of photography is nearly as old as the medium itself[69], laying hands on an original (authenteô – to have full power or authority over sth.) has entered a new stage with the arrival of ”postphotography”: ”Digital technologies put into doubt the nature and function of the photograph-image as representation. The essence of digital information is that it is inherently malleable. [. . .] Through techniques of electronic montage and manipulation,

[67] It also leads Bathes to reformulate the important question of who owns the photograph: the subject or the operator of the camera? The ”visual trace”, according to Barthes, belongs to its subject more than any rendering or interpretation (i.e. painting, drawing), an interesting assumption in times of increasing battles for intellectual rights over everything, including ”electronic traces” called hyperlinks. For copyright issues on the WWW, see section 4.7.3.

[68] ”. . . I read at the same time: This will be and this has been; I observe with horror an anterior future of which death is at stake. By giving me the absolute past of the pose the photograph tells me death in the future. What pricks me is the discovery of this equivalence” [39]. Olivieri Toscani’s Death row campaign for Benetton plays on the same effect.

[69] ”Everyone knows that photographic correspondence can be manipulated. [. . .] This deceptive potential of the medium was recognized early in the history of photography and made use of in techniques, such as retouch, color filtering, solarization, double exposure”, cf. [397, p. 135]. Empress Elisabeth ”Sissi” of Austria had her portrait of 1863 retouched into a family portrait of 1875, to quote only one case. The same is true for the relationship between scripture and falsification of written documents, which was highly common in the Middle Ages, see section 4.7.3 on authenticity in the WWW.

what we once trusted as pictures of reality can now be edited and altered seamlessly and undetectably" [446], cf. [238, 237]. Digital imaging tools have opened whole new vistas for the manufacture of fakes, fabrications and misinformation which have grown into the hypertextual information corpus of the WWW. In 1980, Barthes described how the chemical process keeps the ghostly trace of past moment, photography's connection to death, its mortality through fading (the reversion of the chemical process that has produced the phantasma) and the image's loss of authenticity. Only two years later, the relationship between the photographic image and its referent has been subverted, "leaving the entire problematic concept of representation pulverized [...] and destabilizing the bond the image has with time, memory or history". What it "represents is a fundamental transformation in the epistemological structure of our visual culture" [150, p. 37].

One might argue that the postphotographic construction of meaning is only a technically potentialized questioning centered on whether or not the truth is present.[70] Yet, "synthetic or infographic images" [466, p. 121] are no more the trace of a light beam emitted by a pre-existing object, captured and fixed by a device that is either chemically photosensitive (photography, film) or electronic (video, digital camera), cf. [39, 397, 85]. By means of Computer Aided Design (CAD), it is feasible to reverse the process and to produce an image *ex nihilo*. The computer not only simulates an imaginary piece of film (the image memory), but also an imaginary camera – and a rich phantasmagoria of computed chimera just waiting to be photographed. The computer-generated – as opposed to computer-inflected, cf. [325, p. xviii] – gramma disinherits photography from its legacy of truth and severs its umbilical chord to the body of past reality, cf. [446, 19, 149]. The fact that many still trust these test-tube pictures makes the issue an even more ticklish one: "... whilst digital imaging techniques are increasingly eroding the indexical of photographic images, it is arguable that it is the indexicality still routinely attributed to the medium which is primarily responsible for interpreters treating them as 'objective' records of 'reality"' [95, Signs].

Lunenfeld notes that "the development of electronic imaging technologies, of which digital photography is but one part, has posed a challenge to both the conception of semiotics and the discipline of art history" [325, p. 57]:

> "In this, the digital photograph must now be treated as having the same value (or lack thereof) as a written text. We have thus returned, in some sense to the aesthetic of the pre-photographic era..." [325, p. 61].

For Santaella, "the postphotographic paradigm is the universe of the fugitive, the universe of pure time, thus reversible and capable of being restarted at any time" [466, p. 131]. From the semiotics of the "dubitative image", it is only a small step to the "camera rasa" [325]: The door to virtual reality (VR) stands wide open[71] while the door to authenticity has to be resealed with ever new passwords and encryption techniques[72].

Besides general semiotic interest, these issues become important in connection with the construction of, and navigation in hypermedia: Content Based Retrieval (CBR) and Content Based Navigation (CBN). More precisely, linking (parts of) a picture to related pictures, be it by hand or automatically, draw on the same syntactic dimensions as the question "Can pictures lie?":

> "In language, only sentences, and not individual words, can be true or false. The statement *The cat is on the mat* may be true or false, but not the

[70] "The more recent developments in computer graphics, with the new possibilities of shape blending, distortion, simulation, and other modes of digital image manipulation have greatly increased this deceptive potential of the medium", cf. [397, p. 135].

[71] The question if hypertext should be represented by or integrated into virtual reality interfaces has been widely discussed, as will be pointed out in sections 3.4, 3.4.3 and 4.4.

[72] The indexical attributes of the password are treated in sections 3.6 and 3.5.

> individual words *cat* and *mat*. Truth values can only be derived from sentences or propositions in which a subject or argument is in a syntactic relation to a predicate. Is it possible to discover similar syntactic conjunctions of visual signs in pictures?" [397, p. 137].

Since there are no words nor verbal propositions in pictures, Nöth proposes Peirce's more general semiotic terminology: rheme, as the more general semiotic equivalent of words, and dicent, as the general equivalent of propositions (see section 2.4). The question is then, "can pictures function as autonomous dicentic signs, or do they only consist of rhematic signs? Do pictures only represent objects, or can they represent objects together with predications about these objects?" [397, p. 137]. Nöth tries to invalidate the logocentric arguments for a negative answer to these questions, as they are contextual incompleteness, non-segmentability, and dicentic vagueness.

The first logocentric argument, contextual incompleteness, was first exposed by Gombrich [192] and reformulated by Muckenhaupt [370]. It implies that only when a picture is accompanied by a caption or label can the resulting text-picture message convey a true or false proposition.[73] The caption below figure 3.6 (on page 84) could serve as an example for this argument. Landow's rule that "linked graphic materials must appear with appended texts that enable the user to establish a relation between file of departure and that of arrival" touches this issue, but does not solve the theoretical problem [303, p. 99]). Against this "logocentric thesis of the dicentic incompleteness of pictures", Nöth argues that "the function of pictures in text-picture combinations says nothing about the semiotic potential of pictures seen without labels or captions".

> "The thesis that pictorial messages can only be completed by their verbal anchorage is rather an indicator of the logocentric bias to be found in the current theory of pictorial representation. In fact, although pictures without verbal anchorage may have become rare in our age of multimedia communication, such pictorial messages are by no means uncommon. In pictorial genres such a paintings, family photos, or touristic slides, the lack of verbal anchorage is even the rule" [397, p. 138].

The second argument against pictures as autonomous dicentic signs, non-segmentability, is developed in Jerry A. Fodor's paper "Imagistic Representation" [173]. Fodor concludes that no pictorial language could exist because the linearization of arguments and predicates would prevent such pictorial words from being interpreted as a propositional whole.[74] Nöth's counter-argument is that "Fodor commits the error of projecting the linearity of verbal language onto the visual domain where simultaneity is the structural principle relating the rhematic elements in question" [397, p. 139].[75] Here, of course, Nöth is in line with Langer's dichotomy of discursive linearity vs. presentational immediacy (see section 2.2).

[73] While in the early Middle Ages, the function of scribe and artist were often united in one person, in the late fourteenth century, it will have become less common for lay illuminators to be scribes as well, though not entirely unknown, cf. [7, p. 16]. In scientific and news publications, figures within the text may have been elaborated by the author himself or borrowed from others. This holds true for photographic reproductions as well as for diagrams and other graphical illustrations, cf. [94, p. 190ff.]. The foliage and carpet-like texture in medieval manuscripts and the drolleries often blur with calligraphy: The marginal drawings of Dürer's Book of Prayers for Emperor Maximilian show cases where the frontiers between ornament and content seem to vanish, cf. [22]. The same is true for illustrated initials.

[74] Fodor's example is: "Suppose that, in Iconic English, the word 'John' is replaced by a picture of John and the word 'green' is replaced by a green patch. Then the sentence 'John is green' comes out as (say) a picture of John followed by a green picture. But that doesn't look like John's being green; it doesn't much look like anything" [173, p. 65].

[75] "Would not the photo of our green John testify to his unusual colour in an even much more convincing way than the verbal statement 'John is green'? We claim that the argument 'John' and the predicate 'is green' must thus be sought in pictorial simultaneity and not in contiguity" [397, p. 139].

For his International Picture Language, Neurath has mastered this problem with the ”invention” of compound signs: The pictograph for ”worker” combined with the pictograph for ”miner’s hammer” generates the ”miner”, cf. [163, p. 20]. Yet, Eschbach’s semiotic analysis has shown other frontiers of the picture language, cf. [163].

The third syntactic argument against the possibility of assigning truth values to pictures is the argument of dicentic vagueness: ”This argument claims that pictorial messages are so ambiguous, vague, and polysemous that they cannot serve to prove any truth or falseness” [397, p. 141]. Both Gombrich and Fodor have defended the point of view that we cannot express pictorially whether we mean ’the’ cat (an individual) or ’a cat’ (a member of a class). Nöth claims that this argument, which crucial for CBR/N, ”is clearly logocentric”:

> ”It does not ask whether pictures can convey statements, but asks whether it can convey the same statement as a given sentence. The answer would be different if the picture were the point of departure in the comparison with verbal statements. A particular photograph of a cat on a mat, being an indexical sign, is certainly in the first place about an individual cat and not about a member of a class. [. . .] The individuality of the cat and the mat an be easily identified in many details” [397, p. 141].

Against Gombrich’s and Fodor’s view that pictorial polysemy prevents pictures from being vehicles of truth, Nöth argues that a message which conveys a plurality of facts about the world must not therefore be less true than a message that conveys only a single true statement: ”Neither polysemy nor ambiguity can thus be accepted as general arguments against the truth potential of pictures” [397, p. 142].

Verbal language must serve as a meta-language for visual signs because there is no meta-image to describe or analyze another image. Sign languages, such as the sign language for deaf people or the Braille notation for the blind, have to be learned just like verbal language and share its arbitrary character. Pictograms do not share this arbitrariness, and they can show abstract concepts only on ”semiotic detours” [473], e.g. taking advantage of metonymic relations.

While Eschbach [163] has performed a semiotic analysis of Neurath’s International Picture Language (IPL), Schmauks has analyzed the same set of questions in connection with picture dictionaries, e.g. Graf’s ”point it” [200] and Langenscheidt’s infamous OhneWörterBuch [1], cf. [471, 472, 473]. Schmauks follows Baldinger [27] in stating that dictionaries follow a semasiologic order (they list words alphabetically), while picture dictionaries follow an onomasiologic strategy: They arrange the world in clusters (such as the OhneWörterBuch’s section ”case of emergency”, see figure 2.16) or time-lines, cf. [27, 471, 472]. The same is true for hypermedia systems that are based on graphic navigation. Yet, in hypermedia interconnected subjects and structures do not have to be flattened out into a sequential order, see section 3.5.

A symbol (especially in the strict sense of Peirce’s terminology) should have as little connotations as possible in order to function as a sign.[76] But most ”natural” symbols (such as animals, colors, etc.) are homonymous in different contexts and cultures. Think of or the color white as the symbol of joy (in Western cultures) vs. grief (in certain Asian cultures), cf. [442]. Or, the eagle as a symbol for freedom, strength, speed (figure 2.17a), but also as an emblem for institutions and countries (figure 2.17c). In the form of a spread eagle, the eagle appears as a heraldic emblem on flags and seals (figure 2.17b, d).

[76] Langer claimed similar restrictions for the appeal of the ”symbol” (in Langer’s general sense of the term), as signifiers that become too appealing distract our attention from their signified: If a real, ripe and juicy pear were to be used as the symbol for opulence, only few of us could concentrate on its semantic value: ”The power of the symbol lies in its scarcity and indifference” [307, p. 83].

Figure 2.16: Langenscheidt's OhneWörterBuch. Source: [1, p. 28].

(a) The "Bald Eagle, Symbol of Freedom series". Source: www.frankmillerfineart.com

(b) Official German flag. Source: www.fotw.ca/flags/de.html

(c) Seal of the US Department of Justice. Source:www.usdoj.gov

Figure 2.17: Depictions of eagles.

Symbols for non-visual concepts tend to be *gestalts* that can be recognized at first sight (think of company logos and road signs), while pictures that trigger the verediction mechanism invite the eye to travel through the picture space[77]:

> "Visual communication, when it does not consist of the representation of signals from a preestablished code that was originally nonvisual (road signs, for example), takes place in the continuous and yet, in the continuous of the variants we can define those few marks of verediction used to establish a constant correlation between the content and that of expression" [85, p. 149].

When compared to the emblem of the German flag (2.17b), the print of the "Bald Eagle, Symbol of Freedom series" which shows "majestic Bald Eagles poised above four of America's most spectacular waterfalls" (figure 2.17a) demonstrates this longing for expression:

[77] Ulrich sees a parallel between this visual exploration of a picture and the discursive linearity of the parole: "…das Umherwandern des Blicks im gemalten, gerahmten imaginären Raum – erweist sich, kaum dass wir uns des Sehens bewusst werden, als von inneren Redeströmen begleitet" [522, p. 101].

The heroic print is rich in narrative details, it ”triggers a mechanism of verediction of the representation” [85, p. 148].[78]

The journey (or, navigation) through this kind of pictures is led by the composition of the picture, but always influenced by the direction of reading, i.e. left-to-right[79] in the Latin-based languages:

> Das Auge wird belegt von der Schrift [...] Auf der Bildfläche schreibt sich die Leserichtung ein. [...] Möglicherweise können wir Bilder aus Schriftkulturn mit anderer Leserichtung deshalb gar nicht 'richtig' lesen” [522, p. 101].

These issues relate to the theoretical problem of human and artificial interpretation of visual information (see section 3.7.10) and the implementation into hypermedia, such as Content Based Navigation (CBN), and Retrieval (CBR). In this case, the picture *indicates* the hyperlink behind it, see section 4.6. In other words, besides their denotations, these images and words on the screen point to content that is connected to them via links. It has been argued that following links equates the process of (unlimited) semiosis, cf. [95, 346]; see section 2.5 on unlimited semiosis and 3.5 on hypertext semiotics.

Messaris claims that ”with regard to images, most people in most societies are mostly confined to the role of spectator of other people's productions” [354, p. 121]. Even if the arrival of (post-)photography has changed the situation significantly, most people feel unable to draw or paint. For Chandler, this is a legacy of an educational system which still focuses almost exclusively on the acquisition of one kind of symbolic literacy (that of verbal language) at the expense of most other semiotic modes (in particular the iconic mode):

> ”This institutional bias disempowers people not only by excluding many from engaging in those representational practices which are not purely linguistic but by handicapping them as critical readers of the majority of texts to which they are routinely exposed throughout their lives. A working understanding of key concepts in semiotics – including their practical application – can be seen as essential for everyone who wants to understand the complex and dynamic communication ecologies within which we live. Those who cannot understand such environments are in the greatest danger of being manipulated by those who can” [95, Strenghts].

Chandler shares his moderately pansemiotic view with Bill Nichols, who puts it, ”As long as signs are produced, we will be obliged to understand them. This is a matter of nothing less than survival” [386, p. 8].

Potentially, semiotics could help us to realize differences as well as similarities between various media. It could help us to avoid the routine privileging of one semiotic mode over another, such as the spoken over the written or the verbal over the non-verbal, cf. [95, Strenghts].

[78] Caneparo/Caprettini mean by *verediction* – in accordance to Greimas – that the image points outwards ”towards a certain reality, or rather, a certain concept of reality” [85, p. 148]. The design of the German flag follows the traditional heraldic notation for flags and emblems. Therefore, it can be described precisely in a specialized vocabulary which mostly derives from mediaeval or Norman French. The seal of the US Department of Justice is a mixture of modes: It depicts heraldic elements in a illusionistic manner.

[79] ”The horizontal and vertical axes are not neutral dimensions of pictorial representation. Since writing and reading in European cultures proceed primarily along a horizontal axis from left to right (as in English but unlike, for instance, Arabic, Hebrew and Chinese), the 'default' for reading a picture within such reading/writing cultures (unless attention is diverted by some salient features) is likely to be generally in the same direction. This is especially likely where pictures are embedded in written text, as in the case of magazines and newspapers. There is thus a potential sequential significance in the left-hand and right-hand elements of a visual image – a sense of 'before' and 'after'.” [95, Syntagmatic Analysis]; cf. [18].

2.8 Textuality

Language and writing are, for Saussure, two distinct systems of signs and the second exists for the sole purpose of representing the first, cf. [469, p. 28]. Hence, language in the broadest sense noted above (section 2.6) is as much an instrument of thought as it is one of communication.[80] Colapietro underlines "the importance (perhaps even paramount importance) of spoken and written language; the variety of irreducible different sign systems used by human beings; and the likelihood, if not inevitable, of interplay among these sign systems in any actual process of human thinking" [102, p. 129].

The phonocentrism[81] which was allied with Saussure's suppression of the materiality of the linguistic sign was challenged by Jacques Derrida [136], who attacked the linguists' privileging of speech over writing.[82] Whilst Barthes also sought to revalorize the role of the signifier in the act of writing, cf. [37,94], Derrida's grammatology, "a science of writing before and in speech," was designated to challenge the phonocentric bias of semiotic investigation. For Derrida, writing "signifies inscription and especially the durable institution of a sign" [136, p. 44]. So understood, writing (often called arche-writing) becomes nothing less than an equivalent of semiosis, or sign action, cf. [102, p. 206] Derrida uses the Greek word gramma to break with the view that our (Latin) alphabet can describe every meaningful linguistic unit (morpheme) by means of a sound phoneme — arguing that différance, but also hyphens, commas, periods, quotes etc. prove the prevalence of writing over spoken language. An interesting example in the Internet age is the metaphoric description of the @ sign in many languages, ranging from animals (snail, worm, little dog, horse) to body parts (elephant's trunk, monkey's tail, cat's foot, pig's ear) to food (rollmops herring, strudel, cinnamon roll, pretzel); cf. [224], see section 4.5.

trace is another term occupying an important place in Jacques Derrida's grammatology. trace has the place in Derrida's grammatology that the sign has in Ferdinand de Saussure's semiology and in Charles S. Peirce's semiotic.[83] In some ways, Derrida's theories seem too close to traditional semiotics as to be de(con)structive, cf. [534]. As in the case of spacing and difference: "Without space or spacing, semiosis would be also impossible: If none of the words on this page were spaced apart, there would be a blot of ink, but no words (or graphic signs)" [102, p. 197]. However, writing one letter after the other without any spacing at the word-boundry is still legible (but not always non-ambiguous). This is proved by medieval manuscripts on the one hand and the Turing machine on the other.[84]

Textuality is used today in a very broad sense to cover not only verbal but also other forms of communication. Here it should perhaps be noted that a "text" can exist in any medium and may be verbal, non-verbal, or both, despite the logocentric bias of this distinction. The term text usually refers to a message which has been recorded in some way (e.g. writing, audio- and video-recording) so that it is physically independent of its sender or receiver. This assemblage of signs (such as words, images, sounds and/or gestures) is

[80] "This observation brings up the important question of whether there can be thought apart from language taken in the narrower senses (specifically, as a system of verbal signs or, even more narrowly, a system of spoken signs). [...] For Charles Peirce, all thought is in signs though not necessarily in words" [102, p. 129].

[81] "Language is here conceived as a formal system of auditory signs. This view of language has been recently characterized as phonocentric (from Greek *phonema*, speech), since it focuses primarily or exclusively on linguistic signs as sound images or aural forms" [102, p. 206].

[82] From Plato to Lévi-Strauss, the spoken word had held a privileged position in the Western world-view, being regarded as intimately involved in our sense of self and constituting a sign of truth and authenticity. Writing had traditionally been relegated to a secondary position. In seeking to establish Grammatology [136], or the study of textuality, Derrida championed the primacy of the material word, cf. [95, Signs].

[83] "If a thing never left a *trace* of itself it could never be known, nor could it serve as a sign of anything else. Thus, without visible or tangible or, in some other way, perceptible marks or traces, semiosis (or sign action) would be impossible" [102, p. 197].

[84] For medieval manuscripts, cf. [7]; for the Turing machine, e.g. [256, p. 339ff.]. I owe this insight to Veith Risak.

constructed (and interpreted) with reference to the conventions associated with a genre and in a particular medium of communication.

A distinctive feature of this newly emerged use of *text* is that the derivation of this word from the Latin *texture* (”to weave”) and *textum* (”web”; ”texture”) appears to inform this use. The text is something woven; but now readers join authors or writers as the weavers of texts. That is, the emphasis is on the text as an open and perhaps even unfinished process. The logical extension ot this argument is, of course, hypertext. Hartmann claims that ”the act of writing” [94] has lost value in this system to the notions of ”media” and ”information”:

> ”Die Schrift erfüllt nicht länger die ihr angestammte Rolle der sozialen Regulation. Diese übernimmt jetzt der Informationsbegriff” [221, p. 47].

Intertextuality is a term introduced by Julia Kristeva and widely adopted by literary theorists to designate the complex ways in which a given text is related to other texts, cf. [102, p. 123]. Just as there is no sign apart from other signs, there are no texts apart from other texts. In Kristeva’s words, ”every text is constructed as a mosaic of other texts, every text is an absorption and transformation of other texts.[85] The notion of intertextuality comes to replace that of intersubjectivity” [291, p. 146]. Intertextuality has been applied to hypertext by various authors, cf. [68, 304, 538, 346]; see section 3.5. In the context of semiotic textanalysis, ”syntagmatic relations refer intratextually to other signifiers co-present within the text, whilst paradigmatic relations refer intertextually to signifiers which are absent from the text” [95], cf. [469, p. 147ff.].

2.9 Computer Semiotics

While some authors still try to fix the basement of the semiotic building, others already use it as a platform for further explorations. Even fields of studies that have long ignored the semiotic approach have now integrated this way of thinking into their sciences.[86]

> ”We have to realize that computer-based signs have their own characteristics that are different from texts, pictures or movies. However, semiotics can serve as a channel for transferring insights created in [the] older medium to the new emergent one” [11].

At the interface of Semiotics and Computer Science, it is important to distinguish between ”Computer Semiotics” and ”Computational Semiotics”: the former being typical of P. B. Andersen’s work which uses semiotics to analyze and design systems for use, the latter tries to ground out semiotics in cognitive/computational principles. Andersen [8, 10, 9] defines the use of semiotics in computer science as follows:

> ”The core of [traditional] semiotics is the sign that integrates a physical (the signifier) and a psychic side (the signified). Therefore, semiotics can talk

[85] Hypertext has evoked textile metaphors, cf. [217] but Schneider/Berz have shown that the weaving metaphor breaks down when taken literally, cf. [475]. This will be shortly exposed in section 4.1 on the WWW metaphor.

[86] Jonathan Alexander describes the difference between his lectures of Bibliography in 1983 and the publication he turned them into as a result of these tendencies: “At the same time, meaning can no longer be thought of as closed, unvarying or static, as in earlier iconographic studies. Here the influence is apparent of semiology, the study of signs, as well as of currents which can be broadly characterised as structuralist and post-structuralist. These approaches, especially influential in literary studies, are now at last beginning to affect our studies too” [7, p. 2].

> about representations (the algorithms and data structures) as well as the user's interpretation of these representations, but it does so with a particular focus, namely the sign. Thus, only those parts of the computational processes that influence interpretation, and only those parts of the interpretation that are influenced by the computation, can be analyzed by semiotic methods" [11].

For Andersen, the important difference between the system model and the user's simply signifies two interpretations of the same sign-complex produced two groups that access different parts of it (designer and user). Thus, computer semiotics sometimes enforces a reinterpretation of technical issues, e.g. many processes which computer science sees as data storage and retrieval are really communicative processes from a semiotic point of view, cf. [9, 11].

Computational Semiotics attempts to implement features of semiotic systems, as outlined section 3.7.10. Burghard Rieger's work presents a fuzzy linguistic approach in Computational Semiotics and Semiotic Cognitive Information Processing (SCIP) systems. His computational semiotic models in cognitive linguistics (combining the semiotic with the cognitive paradigm) aim at simulating the constitution of meanings and the interpretation of signs without their predicative and propositional representations which dominate traditional research formats in syntax and semantics so far, cf. [435, 436].

Other studies in computer semiotics (partly included in Andersen's updated bibliography, cf. [9, 7ff., 433ff.]; [12]) have been contributed by Figge [167], Wallmannsberger [531], Zemanek [555], Nadin [372, 374], Souza [127] and collected in [399, 402, 33, 128].

> "Semiotics provides us with a potentially unifying conceptual framework and a set of methods and terms for use across the full range of signifying practices, which include gesture, posture, dress, writing, speech, photography, film, television and radio" [95, Strenghts].

Andersen has widened this spectrum with his computer semiotics approach. In this dissertation I intend to prove the semiotic approach's applicability on hypertext and hypermedia. Hypermedia combines different semiotic channels with an interactivity and the construction of meaning by concrete linkage. Thus, hypertext semiotics should be seen as a fortification of the connection between the media semiotic approach and computer semiotics, cf. [399, 13, 63, 9].

The importance of semiotics for the construction of the next hypertext generation, the Semiotic Web, has been pointed out by John F. Sowa, cf. [502, 499, 500, 501]. In his lecture on signs and processes as the foundations for ontology at the Vienna University of Economics and Business Administration (WU Wien), Sowa proclaimed Wittgenstein, Whitehead and Peirce as the foundations for his research on Artificial Intelligence and the Semantic Web.

In his seminal work on computer semiotics, Andersen adapts and extends the structuralist methods: "Since the birth of structuralism, a recurrent question has been to what degree is our praxis as human beings governed by underlying 'systems' and 'structures'? Are humans just media through which structures are manifested? – or as Lévi-Strauss has it: humans do not think in myths, myths think in humans, and without their knowledge" [9, p. 134]. Andersen names the growth of bureaucracy and the spread of computers as having furnished some of the material motivation for structures and systems:

> "... the life of the ordinary wage earner is governed by large, unintelligible structures such as state and the company that make decisions behind his back, decisions over which he has very little influence [...] We receive letters untouched by human hand, decisions about our financial affairs are made by

> computers in the tax department [...] The computer is seen as the incarnation of the impersonal system that functions without human intervention" [9, p. 135-135].

Ruhs speaks of computers as "transitional subjects", or *appareillages sosies* in reference to Winnicott's transitional object, cf. [456]. The area described by Winnicott as being between the thumb and the teddy bear, between oral erotism and true object relationship is part of a conceptualization of the area of transitional space and transitional objects. This concept can link and be a bridge between the inner and outer worlds, a place where the two interact uninterrupted with the help of the first "not-me" possession, as perceived by the infant, the third area of experience, cf. [546, p. 89]. Put simply, a transitional object is a baby's favorite "toy", such as a piece of cloth that is treated as if it were still a part of the baby's body, an object affectionately cuddled as well as excitedly loved, hated and mutilated by the infant. Linus's "security blanket" has become the popular embodiment of the transitional object since the first time Charles Schulz used it in his comic strips "The Peanuts", on June 1, 1954 (according to the United Media Website, see figure 2.18): Charlie Brown asks "Why does Linus hold his blanket like that?", Lucy answers "I'm not sure... I think maybe it gives him a feeling of security". When Charlie Brown tries out the "security blanket", however, it does not work and he feels "like an idiot".

Figure 2.18: Linus' "security blanket". Source: www.unitedmedia.com.

Besides computers, robots and other machines with artificial intelligence, the transitional subjects of our times include models, stars, zombies, aliens, viruses, genes, embryos, etc.; cf. [456]. Ruhs puts special attention on homunculi and golems, in other words, on *intelligent* as well as *spiritual* machines, cf. [296], [297]. When computers will have exceeded human intelligence[87], they will cease to be seen as mere "assemblage[s] of parts that transmit forces, motion, and energy one to another in a predetermined manner" (Merriam-Webster's Encyclopedia). When and if machines become intelligent, computers themselves could construct new computers, causing a massive acceleration in technological progress. In Artificial Intelligence research, this phenomenon is called Singularity.[88]

But let us return from the mythology of singularity to the reality of doubleness: For the human mind, computers – just like the transitional subjects of mythic times, such as angels, puppets, apes, heroes, gods, ghosts, dwarfs and giants – have always been uncanny (in the sense of Freud's *Unheimliches*) and animate machines. Participating themselves in the production of subjectivity, these machines – be they real or imaginary – signify for us the epitomization of the subjects:

[87] Kurzweil has shown that the doubling period of the speed of computers is diminishing, i.e. it used to take us three years to double the speed and memory capacity of computers in the beginning of the 20th century, and now the same kind of progress is achieved in only one year. He claims that these trends will continue, and that computers will be able to emulate human brains in the year 2020, cf. [296], [297], and the March 2001 issue of the CACM which is entirely dedicated to "The Next 1,000 Years" of computing.

[88] Singularity is the postulated point or short period in our future when our self-guided evolutionary development accelerates enormously (powered by nanotechnology, neuroscience, AI, etc.) so that nothing beyond that time can reliably be conceived. This hypothetical event is commonly attributed to Vernor Vinge and his sci-fi novel *True Names and Other Dangers* or, to John von Neumann due to a 1950s quotation on the ever accelerating progress of technology, cf. [298].

> ”Autrement dit, il s’agit de constructions réeles ou imaginaires d’appareillages ou de machines appartenant á ce domain particulier où ils nous ont depuis toujours paru signifier la chosification de sujets, participant en même temps à la production de subjectivité” [456, p. 18].

Bahr comments Marx’s notion of the machine as dead, reified labor insinuating that what seems dead can always reappear as a ghost: ”Marx selbst nannte die Maschine *tote, vergegenständlichte Arbeit*. Also ein Tod, der noch geistert. Und es ist auch wahr, daß alle Diskurse über die Maschine mehr oder weniger offen von ihrer *Unheimlichkeit* überzeugt waren” [24, p. 33] (his emphasis). These machine-discourses have gone to great lengths in order to underline the *deadness* of an apparatus that is characterized by its *activity*, cf. [24, p. 32-34]. G. J. Verdam, a Dutch engineer of the 19th century, sees the machine as a ”Zwischentheil”, an inter-part between the applied force and the achieved effect:

> ”Eine Maschine muß betrachtet werden als ein Mittel, welches dazu dient, das Vermögen einer bewegenden Kraft zur Leistung eines bestimmten Effektes zu modifizieren. Die Maschine ist deshalb nur ein Zwischentheil, welcher erfordert wird, um die von der Kraft mitgetheilte Bewegung auf denjenigen Theil zu übertragen, durch welchen der Effekt geleistet werden soll” [526, p. 589].

The machine has to have an interface in order to connect with a living entity (its user) rather than cutting a dead body away, as indicated by the German ”Schnittstelle”.[89] The machine as *appareillage sosie* is an animate vis-à-vis: ”Wie Gott Adam das Leben einhauchte und der Teufel Sinnlichkeit, Erkenntnis, Bosheit, so scheint die Maschine vom gott- oder satansähnlichen Demiurgen Lebendigkeit eingehaucht oder doch nur verliehen bekommen zu haben” [24, p. 33]. If they are not on *strike*, (or *go nuts*), our computers *work*, until they fall into a *sleeping mode*, but they always *wake up* when we need them (maybe because they do not dream... yet). We treat the machine as a kind of counterpart[90] and the interface, in analogy to the mucous membrane of the baby mouth that sucks on the blanket, connects us to this transitional subject.

In her discussion of information gluttony (see section 4.3.2), Umiker-Sebeok asks herself what the embodied experiences involved in using a computer really are: ”Until current computer inter*faces* are replaced by the inter*bodies* now under development, for the most part, human-computer interaction involves repetitive, ritual movements of the eyes, hands and arms while the rest of the body remains largely immobile” [524]. As we ”understand through the body”, the integration of olfactory, gustatory, or haptic elements will make our understanding richer because human thinking ”is not something done by a computational engine but rather by the whole body, through the semiotic swarm of distributed intelligence where the ’neurotransmitters and regulatory hormones are not confined to the brain, but are scattered throughout the body, in the intestines, the lungs, even the sex organs’ (neurologist Richard Restak)” [524].

A user centered approach, such as Hypertext Semiotics, must not focus its attention solely on the rational part of the human brain: ”The body image schemas described by Lakoff and Johnson, among others, are fundamental to thought, and to think that we can divorce ’information’ from emotion (cf. [117]) and bodily experience leads us down a slippery cognitive slope” [524], cf. [302]:

[89] Thus, it seems clear that the German translation of *computer interface* should be *Verbindungsstelle* instead of *Schnittstelle,* as in the Dutch *verbinding.* Translating ”interface” to the German ”Zwischengesicht” sounds somewhat awkward, even if many other languages follow this rule, such as the Spanish *interfaz del ordenador* and the Italian *interfaccia del calcolatore,* etc.

[90] ”Unser Umgang mit Maschinen geht nicht nur mit ihnen gemeinsam durch sie hindurch auf anderes, sondern ebenso auf sie zu” [24, p. 11]; cf. [237].

> ”So heben uns die Maschinen von unserer leiblichen Struktur ab und übersetzen sie in eine ’kontemplative’ Struktur. Man spricht angesichts der Erscheinungen immer weniger von Er-fahrungen, immer mehr von ’Daten’, weil sie uns weniger in Bewegung bringen als vielmehr über Bewegung informieren” [24, p. 28].

Machines raise our receptive sensuality to a superhuman levels (e.g. they enable us to explore the surface of the Mars without even having to be there) but depriving us of our natural sensuality: ”So steigern die Maschinen die Sinnlichkeit, die sie uns zugleich vom Leibe [halten]” [24, p. 28].

Mihai Nadin claims that the computer is a semiotic machine (cf. [375]): ”Semioticians without knowing it, Norbert Wiener, Herbert Simon, Vannevar Bush, and Marvin Minsky gave computers an underlying semiotic structure. Bush, for instance, made us aware of the semiotic associative path of non-linear structures” [375]. As will be proved in the subsequent sections on hypertext semiotics, Web design and eCommerce, ”the issues involved are not just philosophical, but have practical implications in management and computer science” [9, p. 135].

Chapter 3

Hypertext Theory

The days when enthusiasts euphorically celebrated the liberating qualities of hypertext, its positive social and democratic impacts, its immense educational potential, the end of all linear reading, the death of the printed book, etc., these days are over. On the other hand, hypertext theorists have been alarmed by the death of many good hypertext systems and the — sometimes confusing — consequences of the vast commercialization of the WWW.

Landow [303] asserts that hypertext requires a new rhetoric and stylistics as both the way texts exist and the way we read them have changed. The necessity for these techniques, he says, is that they ”will enable the reader to process the information presented by this new technology” [303, p. 81]. For McHoul/Roe [347], establishing these conventions (the famous 19 rules for hypermedia authors), is a matter of securing merely the efficient distribution and dissemination of quite traditional information, ”rather than engaging with a reconceptualization of reading, writing, texts and meanings”. Furthermore, he thinks that Landow’s reading of Barthes is ”a terrible category mistake” and his ”claims of convergences between reader and writer, and between hypertext and contemporary critical theory, are based on a praxis of misreading” [347].

Even if one does not intend to overthrow the whole building of hypertext theory, some of the omnipresent claims seem to be worth revisiting: First, there is the assertion that ”hypertext parallels human cognition and facilitates exploration” [25], or, that the hypertext structure ”represents knowledge in a form relatively close to the cognitive organizational structures that people use [and therefore] hypermedia supports understanding” [62, p. 35]. Another theory that, from my point of view, will gain from a contextualization in the framework of this dissertation is the pronouncement that reading and/or authoring hypertext can enhance our mind to think in network structures, rather than in accordance with the principle of cause and effect: ”Die intensive Beschäftigung mit Hypertext erweitert unser Denken vom Ursache/Wirkung-Denken zum Denken in Netzen” [439].

There remains a lot to be said about the prehistory of hypertext which, in some accounts, has been curtailed or misinterpreted. The importance of ancient literature (such as the Talmud, the Indian Ramayana and Mahabharata stories, and Homer’s Odyssey), the production of medieval manuscripts, Juan de Celaya’s geometry of the mind (published 1525), and Diderot’s Encyclopedia have often be underlined. Yet, these works do not stand isolated in the cultural production of their time, and only profound analysis from different angles (e.g. a structural, semiotic, cultural studies approach) can proof if they should be labeled ”hypertext prototypes”. Furthermore, I will introduce two new candidates for this group of works: Marcel Duchamp’s Box of 1914, and the even more famous Green Box, published 1934 that contain loose reproductions of notes on his projects, cf. [377, p. 56, 112]; [138, p. 271, 303].

Having said all this, one can follow hypertext theory at a more modest pace. At this point, it seems adequate to introduce a definition: "We can define Hypertext as the use of the computer to transcend linear, bounded and fixed qualities of the traditional written text. Unlike the static form of a book, a hypertext can be composed, and read, non-sequentially; it is a variable structure, composed of blocks of text (or what Roland Barthes terms lexia) and the electronic links that join them" [129, p. 3], cf. [37]. In classic hypertext theory, these blocks of text are also referred to as nodes. Hypermedia takes the user even closer to the complex interrelatedness of everyday consciousness: It "extends hypertext by re-integrating our visual and auditory facilities into textual experience, linking graphic images, sound and video to verbal signs. Hypermedia seeks to approximate the way our waking minds always make a synthesis of information received from all five senses" [129, p. 7]. Therefore, integrating (or re-integrating) touch, taste and smell seems the inevitable consummation of the hypermedia concept. Yet, before olfactory, gustatory or haptic impulses can be easily implemented into hypermedia systems, there is still a lot of conceptual, as well as technical work to be done. Leaving the technical issues of producing odors, tactile impulses and tastes aside[1], there remain various questions concerning the linkability of such material.

Similar problems have to be solved when video and audio clips are to be integrated into hypertext environments. Even if audio-visual material is nowadays found in many systems and vastly available on the WWW, most clips can only be played from start to end. Accordingly, Nielsen points out that "the fact that a system is multimedia-based does not make it hypertext. [...] Only when users interactively take control of a set of dynamic links among units of information does a system get to be hypertext," [387, p. 10]. Furthermore, the interaction with the system must make sense and bring benefits to the user, or in other words, "linking by itself is not enough" [303, p. 81]. Figure 3.1[2] shows the influence of time in multimedia and hypermedia browsing. In order to integrate dynamic information into the Dexter Hypertext Model, Hardman et al. [216] formulated the Amsterdam Hypertext Model (AHM).

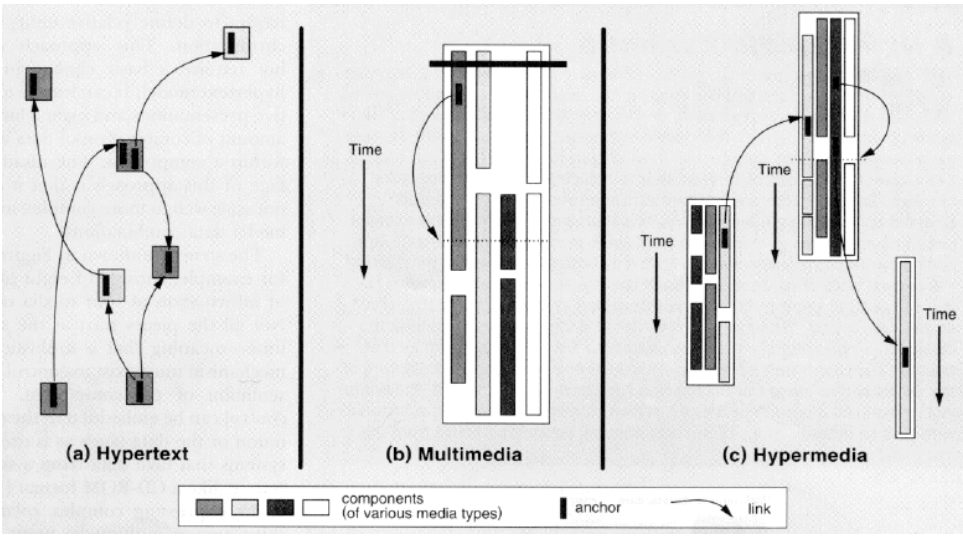


Figure 3.1: Hypertext, multimedia and hypermedia. Source: [216, p. 53].

From fig. 3.1, it might seem that any hypertext that contains multimedia must be labled hypermedia, really. In fact, most hypertext researchers view the terms hypertext and hypermedia

[1] Hiroshi Ishii, the director of the Tangible Media Group at MIT is working on various projects in this direction, cf. [251].

[2] Note that in part (a) of the figure, the hypertext graph, there is a node with two links departing from one anchor. This is called a multiple link. The concept of multiple linking shall be explained further in section 3.4.

as synonymous and use them interchangeably, with a preference to sticking to hypertext ”since there does not seem to be any reason to reserve a special term for text-only systems” [387, p. 5].[3] This is also true for the context of this dissertation, where I will make use of the term hypermedia almost exclusively in names (such as ”Open Hypermedia System”) or to put special emphasis on multimedia content of a hypertext system.

Hypertext theory (and practice) have always been strongly linked to usability and human factors, epitomized by Jakob Nielsen, who is commonly referred to as a Web design guru today. Important as these considerations and studies may be, they cannot supersede research of a more fundamental character. A fine example to illustrate these two poles are Jim Rosenberg’s vs. Jakob Nielsen’s remarks on the scroll-bar:

Rosenberg: ”Does linear reading inside the lexia contain / consist of actemes? Should we consider reading a lexia a single unitary acteme? Should perusing the lexia be considered the "null acteme"? [...] Whether the lexia must be linear is controversial [...] A lexia can contain numerous user interface devices (e.g. scroll-bars). Behaviorally, operating a scroll-bar is as complicated as following a link. However, a link is an explicitly *structural* device in a way that the within-component scroll-bar is not...” [449].

Nielsen: ”In early studies, I found that only 10% of Web users would scroll a navigation page to see any links that were not visible in the initial display. The vast majority of users would make their selection from those links they could see without scrolling. [...] In more recent studies, we have seen that most users have started scrolling when they visit a long home page or a long navigation screen. [...] The change from 1994 is that scrolling is no longer a usability disaster for navigation pages. [...] Pages that can be markedly improved with a scrolling design may be made as long as necessary, though it should be a rare exception to go beyond three screenfulls on an average monitor” [389].

For now, I follow Bieber et al. [62] in categorizing roles — not users — into hypertext *readers* and *authors*, in order to analyze if (and how) each interacts differently with a hypertext system. In fact, the current state of art of the WWW even supports this dichotomy (see section 4.2.3), while in other – more writerly – hypertext systems, these roles are argued to blur. Of course, one must distinguish the author role from the *system developers* who develops browsing software and other hypermedia environments. Further roles that have been suggested are *lectors* (reviewers) and *administrators* (e.g. librarians, webmasters). In some cases, the authoring process is divided into more roles: First, the *content author* who is only responsible for content, second, the designer of the logical structure (DTD), and third, the *designer* of the text-layout (CSS, XSL, etc.).

Readers, on the other hand, traverse links during the act of browsing. A central claim among hypertext theorists is that hypertext enables a democratization of the authoring/reading process. One reason for this is that groupware facilitates an oscillation between the author/reader roles in a cycle of writing, reading, and annotating documents to the point where the established roles finally blur. The other reason is that, in a hypertext environment, the reader has the (relatively) free choice of transversal through the text, which is seen as readerly, rather than *writerly*, ”with this distinction based very loosely on that of Roland Barthes” [347]. Risak sees a parallel between the transition from manuscripts to printed books and the transition from linear text to hypertext, as both processes have enhanced the capacities of the reader *and* the author: ”Ähnlich wie beim Übergang von handgeschriebenen zu gedruckten Büchern erweitert der Übergang vom linearen gedruckten oder interaktiv lesbaren Text zum nichtlinearen interaktiven Hypertext die Möglichkeiten von Autor und Leser entscheidend” [439]. This argument will be fully explored in section 3.7.11.

[3] This point has already been mentioned in the introduction (section 1).

3.1 History of Hypertext

In this section, I want to draft a short history of hypertext, including its prehistory. At the beginning of this chapter, hypertext was defined as the use of the *computer* to produce and transcend non-sequential nodes (or lexia) joined by electronic links. Thus, pre-computer text structures that would comply with common hypertext definitions, constitute the prehistory of hypertext. Especially technically oriented authors who decide to give overall accounts of the hypertext research field, tend to step short in writing a subtly differenciated history of hypertext:

> ”The concept of hypertext has been around for a long time. The dictionary and the encyclopedia are very old forms of hypertext. These can be viewed as a network of textual nodes joined by referential links. The Talmud, with its heavy use of annotations and nested commentary, and Indian epics such as Ramayana and Mahabharata (stories branching off to other stories) are ancient prototypes of hypertext representation,” [25].

As shall be discussed in the next section, the encyclopedia is only 250 years old, while the Talmud’s history reaches back several thousand years, and the Indian epics are believed to be even older. Furthermore, the reasons for (and grades of) their deviation from a linear, fixed structure are very different.

The ”invention”, or rather the formalization of hypertext is commonly assigned to Vannevar Bush in the 1940s[4], while the first implementations were done by Ted Nelson and Douglas Engelbart in the early 1960s. Afterwards, the chronology of my historical account is sometimes rather loose, due to overlapping and cross-dependencies of systems and inventions.

3.1.1 Prehistory

The compilation of Jewish Oral Law with its rabbinical commentaries (*Talmud* originally means ”learning”), Indian epics and Greek mythology have often been named as the first hypertextual constructions. It is important to note that epics are collections of myths that are not merely supposed to be entertaining or to ”go together well”: The purpose of myths is to explain natural phenomena (such as thunderstorms, spots on the moon, etc.), laws and social practice (ban of inbreeding, agriculture) or to legitimate a social order (e.g. castes) by constructing a mythic history of the ancestors.[5] If the myths are arranged diachronically to form an epic, their protagonists and plots have to be ”linked” together. Thus, the effect of stories branching off to other stories.

The standard printed Talmud page (spanning many centuries of Jewish religious scholarship) consists of the core texts, commentaries by various authors (most important Rashi’s Commentary), navigational aids (such as page number, tractate name, chapter number, chapter name) and glosses. Most of these glosses are emendations to the text, while others contain useful (or cryptic) cross-references. Often these comments were copied from the

[4] Using citation indexes, Linda C. Smith has classified mentions of Bush into five categories:”1) historical perspective; 2) hardware; 3) information store; 4) association and selection; [and] 5) personal information system” [405, p. 263]. She points out that many who have cited Bush and the memex have done so on account of his trendiness and often with little understanding, or even knowledge, of what he had proposed.

[5] In his article ”The Structural Study of Myth,” Lévi-Strauss is interested in explaining why myths from different cultures from all over the world seem so similar. He answers this question by looking at the structure of myths, rather than at their content. While the content, the specific characters and events of myths may differ widely, Lévi-Strauss argues that their similarities are based on their structural sameness. To make this argument about the structure of myth, Lévi-Strauss insists that myth is language, because myth has to be told in order to exist. As a language, it shares the same structures that Saussure described belonging to any language (see sections 2.1, 2.6).

handwritten annotations that the authors inscribed in the margins of their personal copies of the Talmud.

The radial, cross-linked model of hypertext theory seems to be anachronistically illustrated by a 16th century woodcut of the geometry of the mind, published by Juan de Celaya [92] (reproduced on the cover of [129]). The attraction of this model for literary theory is linked to the fact that it seems to provide a technological analogue for Kristevas's and Derrida's ideas about intertextuality and de-centering, cf. [338, 291, 135].

The *Encyclopédie ou Dictionnaire raisonné des sciences, des arts et des métiers, par une Société de Gens de lettres* was published under the direction of Diderot, with 17 volumes of text and 11 volumes of plates between 1751 and 1772. Contributors included the most prominent *philosophes*: Voltaire, Rousseau, d'Alembert, Marmontel, d'Holbach and Turgot, to name only a few. These great minds collaborated in the goal of assembling and disseminating in clear, accessible prose the fruits of accumulated knowledge and learning. Containing 72,000 articles written by more than 140 contributors, the *Encyclopédie* was a massive reference work for the arts and sciences, as well as a *machine de guerre* which served to propagate enlightened ideas.[6]

In 1914, a year before Marcel Duchamp physically began working on his famous *Large Glass*, he decided to take photographs of sixteen notes on the project (made during the course of the two previous years), print them in five separate sets and publish them in boxes. Actually these notes were only a fracture of the notes on the *Large Glass* project that was finished no earlier than 1923.

> "Initially, he wanted these notes to be gathered and made available to viewers in the form of a sales catalog that would be attached to the work itself [...] At one point, he speculated that this book might be circular in format, so that it could be opened at any point at random. 'Make it a round book without a beginning or end, he wrote,' either with the pages unbound or ordered by having the last word of the page repeated on the following page[7]" [377, p. 56].

In the end, Duchamp decided to publish the 16 notes unordered in a box to underline the ephemeral quality of the originals. Twenty years later, he published 93 more manuscript notes and drawings in an edition of 300 as the famous Green Box, cf. [138, p. 271, 303]. "Duchamp placed the collotype[8] notes into each box in an intentionally random sequence which, for anyone who wanted to read the notes and relate them to the Large Glass, made any attempt of their organization the responsibility of individual readers" [377, p. 116]. The lack of organization of the material therefore forces unsequential reading. Curiously enough, there are two more artworks by Duchamp that somehow relate to hypertext metaphors: First, a *Sculpture for Traveling* made of rubber bathing caps that he cut into pieces and stretched from various corners of his studio which made "a sort of multicolored cobweb" (Letter to Jean Crotti, 1918, cited in [377, p. 76]). Second, the installation of about one mile of string that he laced throughout the exhibition space of Peggy Guggenheim's Surrealism show in 1943. It is said that "the resulting weblike pattern resembled the cracks in the *Large Glass*," [377, p. 151].

[6] An online version is being prepared and available at www.lib.uchicago.edu. The encyclopedia paradigm will be described in section 3.3.

[7] Veith Risak reminded me that this technique cannot only be used to connect two loose pages, but furthermore to bridge a temporal gap: In large religious service books, such as graduals, repeating the last word (and its musical notation) of the recto page on its verso (or backside) was common practice to give the monks enough time to turn pages. Beside the standard literature on medieval book design, such as [7], there has been recent focus on the art of books-making and illumination. An excellent account on *l'aventure des écritures* is hosted by the Bibliotheque Nationale in Paris. Other valuable online resources include the Getty Museum's site and the Papyri Pages.

[8] The collotype (or phototype) process is a reproductive technique using a gelatine matrix that captures a photographic projection. Patented in 1855, this printing process could be called a predecessor of high quality Xeroxing.

3.1.2 Memex

Vannevar Bush (1890-1974), President Roosevelt's science adviser during World War II, is "considered the 'grandfather' of hypertext. He proposed a system called the 'memex' as long ago as 1945. [...] Apart from the conventional form of indexing, Bush proposed 'associative indexing'..." [25]. Ted Nelson insists that Bush "rejected indexing and discussed instead new forms of interwoven documents" [405, p. 245]. Yet, in Bush's vision of the memex (memory extender), "links primarily embodied, not relationships between node and node, but meaningful sequences", as Randall H. Trigg points out, [405, p. 353]. For Bush, the memex was only one example of a variety of devices to enhance scientific development by taking over repetitive thought processes: "For mature thought there is no mechanical substitute. But creative thought and essentially repetitive thought are very different things. For the latter there are, and may be, powerful mechanical aids," [80].

As Director of the Office of Scientific Research and Development, Bush coordinated the activities of some six thousand leading American scientists in the application of science to warfare, cf. [554]. He was a practical engineer and scientific administrator who had some very impractical visions of the ways we may think and work.

It is worthwhile noting that Bush had conceived the memex almost a decade and a half before he published "As We May Think", cf. [405, p. 122]. His famous article begins with a tribute to war research, which enabled scientists who, having buried their old professional competition in the demand of a common cause, "have shared greatly and learned much". This applied especially to the physicists who had left academic pursuits for the making of "strange destructive gadgets", devising new methods for their unanticipated assignments:

> "They have done their part on the devices that made it possible to turn back the enemy. They have worked in combined effort with the physicists of our allies. They have felt within themselves the stir of achievement. They have been part of a great team. Now, as peace approaches, one asks where they will find objectives worthy of their best" [80].

Bush was concerned about the explosion of scientific literature which made it impossible even for specialists to follow developments in a field and feared that truly significant attainments become lost in the mass of the inconsequential. He envisioned techniques that closely resemble today's digital photography, voice recognition, digital libraries to make scientific research easier.[9]

All these functionalities would be integrated into the memex, a device that would integrate – what we call today – hypermedia, as well as CSCW, and eLearning to "implement the ways in which man produces, stores, and consults the record of the race" [80].

The memex would store information, both personal and common, on microfilm which would be kept on the user's desk. The data – stored on microfilm – could be projected onto the desk, and several projectors would enable the user to view more than one document at the same time. The memex would have a scanner for user input of new material and it would also allow users to make handwritten marginal notes and comments. Apart

[9] "A scene itself can be just as well looked over line by line by the photocell in this way as can a photograph of the scene. [...] [There will be] a machine which types when talked to. [...] The Encyclopedia Britannica could be reduced to the volume of a matchbox." It is especially interesting to note that Bush does not suggest digital information, but optical storage. At first glance, one might just think that Bush was not able to foresee storage on hard disks, floppies and CD-ROMs and therefore concentrated his extrapolations on microphotography. However, it has been pointed out by various authors that magnetic data is very unstable and as technology races on, it becomes increasingly difficult to retrieve older material, cf. [441], [479]. To counter these concerns, the Long Now Foundation uses as their storage technology small micro-etched nickel disks that records analog text and images at densities up to 350,000 pages per disk, with a life expectancy of 2,000-10,000 years. That way, too, "a library of a million volumes could be compressed into one end of a desk" [80].

from the conventional form of indexing, Bush proposed ”associative indexing, the basic idea of which is a provision whereby any item may be caused at will to select immediately and automatically another. This is the essential feature of memex. The process of tying two items together is the important thing” [80]. Associative indexing would help to overcome our ineptitude in getting at a certain record which ”is largely caused by the artificiality of systems of indexing. When data of any sort are placed in storage, they are filed alphabetically or numerically, and information is found (when it is) by tracing it down from subclass to subclass. [. . .] The human mind does not work that way. It operates by association.”

In the years before the publication, Bush had developed of his conceptions of the memex from a *memory extender* to an *intellectual symbiote*, cf. [405, p. 122]. As a scholar, he worked with linked and annotated material on a daily basis, as ”linkage and inclusion are not new in inquiry; the library is full of links and quotations” [283, p. 32]. What he wanted to contribute was

- a new density of links, cf. [81], with ”miscegenational[10] linkage and full-scale mutual inclusion that crosses borders” [283, p. 32];
- a new tempo of writing and connection (be it on microfilm or hard disks), and the ability to include any number of self-representations and self-commentaries in different dimensions; and
- a new way to bring these to bear with a single link back, despite the distance one may have traveled.

I want to spend one more paragraph on Bush’s conception of the famous trails, as they have been re-discovered by several authors, cf. [405], but play a marginal role on today’s conception of hypermedia (and even less in the WWW).

Bush conceives trails as a basic function of the human mind: ”With one item in its grasp, [the mind] snaps instantly to the next that is suggested by the association of thoughts, in accordance with some intricate web of *trails* carried by the cells of the brain. [my emphasis, MN] [. . .] Man cannot hope fully to duplicate this mental process artificially, but he certainly ought to be able to learn from it” [80]. In the memex, numerous items can be linked together to form a trail, and ”then be reviewed in turn, rapidly or slowly, by deflecting a lever like that used for turning the pages of a book. It is exactly as though the physical items had been gathered together to form a new book. It is more than this, for any item can be joined into numerous trails.” But trails can also be produced by what we today call *surfing*, or ”linking as trailblazing” [405, p. 353]. This means that valuable information can be added to the system, not by writing new nodes that contain links, but rather by the linking process alone. Instead of hordes of Web designers, Bush envisioned ”a new profession of trail blazers, those who find delight in the task of establishing useful trails through the enormous mass of the common record.”[11]

3.1.3 Xanadu

About 1962, nearly 20 years after Bush’s famous article, the word ”hypertext” was coined by Nelson, cf. [379, 28]. Ted Nelson’s Xanadu was designed to be an online repository for everything that anybody has ever written, a truly universal hypertext. Since then, Nelson has been working on his vision of a ”docuverse” (document universe) where ”everything

[10] Note the metaphorical use of miscegenational, which literally means interracial.

[11] Bush’s trail blazer is loosely related to today’s knowledge engineer, a person who gathers knowledge and incorporates it into computer programs such as expert systems, natural-language processing systems and hypertext systems.

should be available to everyone. Any user should be able to follow origins and links of material across boundaries of documents, servers, networks, and individual implementations. There should be a unified environment available to everyone providing access to this whole space." [378]. The system has no concept of deletion: Once something is published, it is for the entire world to see forever. As links are created by users, the original document remains the same except for the fact that a newer version is created which would have references to the original version(s).

For Nelson then, hypertext was first conceived as a literary tool that enables the author of a text to extend his or her text to the multiple and successive versions of it, in order to compare them. It is a fundamental tool because "any piece of writing evolves to the very end of its creation. And the real issue is how can we hold partially organized materials for inter-comparison" (Nelson, personal interview, cited in [28]).

This feature of Xanadu could be used for version management (e.g. for software development). Since conventional file systems are not adequate to implement such a system, Xanadu has focused much of its attention on the re-design and re-implementation of file systems. The information would be stored either on local or on back end databases. If a requested document could not be found in the local database, it would be transparently retrieved from the back end repository via the network. In addition, documents can be virtually included in multiple contexts without being physically copied. The system would enable the authors to get royalties depending on the number of bytes seen by each reader, even if his document or parts of it are included in other documents. At the time of writing, Ted Nelson gave a technical briefing of his system at the Hypertext 2001 (Twelfth ACM Conference on Hypertext and Hypermedia, August 14-18, 2001, University of Aarhus, Århus, Denmark).

3.1.4 Augment/NLS

At the same time that Ted Nelson coined the term hypertext, Douglas Engelbart was beginning to implement his framework for the Augmentation of Human Intellect at Stanford Research Institute (SRI, in Menlo Park, CA). Although his framework itself did not directly mention hypertext, the core of Douglas Engelbart's vision was based on a very similar premise, cf. [28]. As part of the Augment Project, primarily designed for office automation, Engelbart developed a system called NLS (online system) which had hypertext-like features. In contrast to the memex, Augment was actually implemented and was successfully demonstrated in 1968. This system was used to store all research papers, memos, and reports in a shared workspace that could be cross-referenced with each other, cf. [162]. In 1972, Augment lost its research support, and Engelbart had to stop developing his project. His original augmentation ideas were based on the premise that computers should be able to perform as a powerful auxiliary to human communication and collaboration if they were to manipulate the symbols that human beings manipulate, cf. [388]. For such augmentation to take place, a co-evolution of the computer and the human being was necessary – as in the biological notion of symbiotic association, where both entities co-evolve for an ever better fit: The computer should learn to manipulate the human language, and the human being should learn to use the computer, cf. [28]. In developing the mouse and the chord keyset in 1964, Engelbart and his group at SRI made a quantum leap in human-computer interaction: The introduction of the body as whole, as a set of connected basic sensorimotor capabilities. The experimentations that the group conducted was not limited to the hands and the eye, but involved many other parts of the body (the knee, the back, the head) as potential sensorimotor ways to control a pointer on the screen, cf. [162].

3.1.5 KMS

KMS (Knowledge Management System) was developed at Carnegie Mellon University and has been a commercial product since 1983. It runs on UNIX workstations and was designed to manage fairly large hypertext networks across local area networks. KMS is based on the basic unit called the frame. A frame can contain text, graphics, or images. Frames are connected to other frames via links. Links are of two types: tree items to represent hierarchical relationships and annotation items to represent referential relationships. In KMS, there is no distinction between browsing and authoring modes. Users can make changes to a frame or create links at any time and these changes are saved automatically, cf. [25]. KMS supports features such as aggregation, keyword searching, tailorability, collaboration, concurrency control, data integrity and security. It has been used for collaborative work, electronic publishing, project management, technical manuals and e-mail.

3.1.6 Intermedia

Intermedia, developed at Brown University from 1985 to 1991, was probably the most promising educational hypertext system. Unfortunately, it was only implemented for Apple's version of the UNIX operating system, and in 1991, when funding was discontinued, the system died, cf. [388, p. 33], [420]. The applications which existed within the Intermedia framework included a text editor (InterText), a graphics editor (InterDraw), a scanned image viewer (InterPix), a three-dimensional object viewer (InterSpect), and a time-line editor (InterVal). The hypertext functionality of the system was integrated into each application so that the creation and traversal of links could be intermixed with the creation and editing of documents. The system provided consistent, modeless, direct-manipulation applications. Strict conformance to user interface standards throughout the system made it easy for the user to interact with all the applications in a similar manner. Intermedia supported the concept of webs, composite entities that have many nodes and links between them. A link could belong to one or more webs. It provided three types of navigation tools: paths, maps, and scope lines. Links in Intermedia were bi-directional, which provided link consistency even when a document was deleted. Links were stored in a separate database, which made it possible to add new links without changing the original document. A link destination did not necessarily have to be a whole node, like in other systems, but could also be a destination anchor, in other words a string within a document. If such a link was selected, the browser would scroll the document, after loading it, until the destination anchor was visible. As this important functionality (which follows the text paradigm) has been implemented into the WWW, it seems almost natural.

Intermedia supported shared and concurrent access to documents based on a system of access permissions. The system provided special educational features and was used in presenting two courses online at the University – English literature and biology. It supported shared and concurrent access to documents based on a system of access permissions. It allowed users to add new links to documents or to annotate documents. The new links were then added to the user's web to build individual semantic maps. Intermedia also provided different maps. To overcome the problems related to displaying all links and nodes of a document in a single view, a simplified overview map could be created by the author of the hypertext. Furthermore, the Intermedia Web View combined a record of the user's path with a map of the currently available links. The web view consisted of three components: the path, the map and the scope line, cf. [191, section 11.1]; [25].

3.1.7 NoteCards

NoteCards is a hypermedia system for designers, authors, and researchers to analyze information, construct models, formulate arguments, and process ideas, cf. [207], [25]. Its basic framework is a semantic network composed of note cards connected by typed links. It provides users with tools for displaying, modifying, manipulating, and navigating through the network. NoteCards contains four basic constructs: note cards, links, browsers, and file boxes. Note cards contain information embedded in text, graphics, images, voice or other media. Links represent bidirectional relationships between cards. Browsers display node-link diagrams of portions of the network. *Fileboxes* provide a mechanism to organize cards into topics or categories. NoteCards can be integrated with other systems such as mail systems, databases, and expert systems.

3.1.8 HyperCard

Bill Atkinson originally designed HyperCard as a graphic programming environment for the Apple Macintosh and many of its applications have nothing to do with hypertext, cf. [388]. Nevertheless, it caused a real breakthrough for hypermedia in 1987, probably because it was launched free and still is. The program uses the card paradigm and a collection of cards is called stack. HyperCard is a frame-based system like KMS with the major drawback that link anchors are not strings, but physical positions on a document (card). Hence, you cannot edit a document without redesigning the areas of the links. Links do not have to be hardwired but can also be programmed in HyperTalk, HyperCard's scripting language. The popularity of HyperCard resulted in the birth of many followers like SuperCard, Plus, MetaCard, Toolbook, Authorware Professional, and HM-Card, cf. [420].

3.1.9 HyperTies

HyperTies started as TIES (The Interactive Encyclopedia System) under the direction of Ben Shneiderman at the University of Maryland's Human-Computer Interaction Laboratory. It provides authoring and browsing tools. According to the encyclopedia paradigm, a node may contain an entire article that may consist of several pages, but only the beginning of the node can be used as the link destination. Links are represented by highlighted words or embedded menus which can be activated using the keyboard, the mouse or a touch screen. Readers can preview links before actually traversing them. The user interface is relatively simple due to the original emphasis on museum information systems or kiosks. The commercial version was being used for a much wider spectrum of applications such as diagnostic problem solving, self-help manuals, browsers for libraries, and on-line help, but taken off the market[12]; cf. [488, 439], [387, p. 35].

3.1.10 Guide

Guide was developed by Peter Brown as a research project at the University of Canterbury, U.K. Guide was the first popular commercial hypertext system when it was released for the Macintosh in 1986. After the release for the PC and for quite some time, it was the only hypertext that was available for both platforms. Text and graphics are integrated together in articles or documents. Guide supports four different kinds of links, which – according to their link markers, or buttons – are called replacement buttons, note buttons, reference buttons, and command buttons, cf. [387, p. 91]. Navigation through the replacement buttons

[12] Probably because of the advent of HTML, as Veith Risak suggests.

initially provides a summary of the information and the degree of detail can be changed by the reader. Guide has an author and a browser mode, which cannot be distinguished on a quick glance due to an enhanced WYSIWYG design. Therefore, it has been argued that the roles between the author and the reader are rather blurred in this system, cf. [76]. Yet, texts can also be released for browsing-only. The different types of hypertext action in Guide are revealed to the user by changing the shape of the cursor. Nielsen/Lyngbæk [392] showed empirically that users had no problems distinguishing among those signs. In the author mode, the replacement buttons are a good tool to build hierarchical structures.

3.1.11 Writing Environment

Researchers at the University of North Carolina at Chapel Hill developed the Writing Environment (WE), a hypertext system based on a cognitive model of the communication process and designed to support the process of writing cf. [25]. It contains two major view windows, one graphical and another hierarchical, along with commands. The graphical window allows the user to loosely structure their ideas in terms of nodes. As some conceptual structure begins to emerge, the writer can transfer the nodes into the hierarchy window which has specialized commands for tree operations. WE uses a relational database for the storage of nodes and links in the network. There are three other windows: an editor window, a query window, and a window to control system modes and the current working set of nodes. WE can be used both as a hypertext system as well as an authoring system with advanced graphical, direct manipulation structure editing capabilities, cf. [108].

3.1.12 gIBIS

The gIBIS system (graphical Issue-Based Information System) by MCC (Microelectronics and Computer Technology Corporation, Austin, Texas) supports argumentation dialogues among a team of software designers, including transcriptions of design decisions and design rationale. gIBIS was developed to support software design on Sun computers. gIBIS supports cooperating groups of software designers in the construction of diagrams, to which hypertext can be added. Nielsen describes the further development of gIBIS into the icon-oriented planning instrument CM/1, designed by the Meta Software Corporation (1987), cf. [388, p. 73]. gIBIS' conceptual model focuses on the articulation of the key *issues* in the design process. Each issue can have many *positions*, where a position is a statement or assertion that resolves it. Each position, in turn, may have one or more *arguments* that either support it or object to it, cf. [62, p. 37], [109]. As will be treated in detail in section 3.4.1, gIBIS was the first system that had a consistent and concept of typed links.

3.1.13 The Aspen Movie Map

The Aspen Movie Map was probably the first hypermedia system. It was implemented on a set of videodisks containing photographs of all the streets of the city of Aspen, Colorado.

> "Filming was done by mounting four cameras aimed at 90° intervals on a truck that was driven through all the city streets, each camera taking a frame every ten feet (three meters). The hypermedia aspects of the system come from accessing these pictures not as a traditional database ('show me 149 Main Street') but as a linked set of information" [387, p. 36].

The user can select the time of the year for the drive by a season knob, since the entire town was recorded in both fall and winter. Nielsen argues that the season knob is probably

easier to understand for users than the temporal scrolling in the Xanadu system because "it relates directly to a well-known concept from the real world even though it provides a functionality that would be impossible in the real world" [387, p. 37]. So-called *magic features* will be described in section 3.6 on usability. Even if the Aspen system itself was not really an application in the sense that it actually helped anybody accomplish anything, Nielsen concludes that it was "far ahead of its time and of great historical significance in showing the way for future applications" [387, p. 37].

3.1.14 Storyspace

Storyspace is a hypertext system that was specifically designed for writers of literary hypertexts. Created by Jay David Bolter, John B. Smith, and Michael Joyce and programmed for Riverrun Inc., Storyspace is currently being developed at Eastgate Systems, under the supervision of Mark Bernstein. Storyspace follows Bolter's terminology in calling nodes writing spaces. These are displayed as scrollable windows on a desktop which includes the pull-down menus and a toolbar. Writing spaces may contain text, graphics, sound, or video. They can also act as containers for other writing spaces; in this way, clusters are supported. Storyspace supports global maps, lists of node names, and a horizontal flow chart. A magnification tool allows one to zoom in on an area of particular interest. Navigation is as easy as point and click. Basic links may be made by drawing a line between two nodes and typing a label. Boxes around the link anchor serve as link markers which may be made visible momentarily through a simple key combination, cf. [265, 273].

3.1.15 Spatial Hypertext

While the spatialization of hypertext in the broadest sense will be treated in section 3.4.3, spatial hypertext in the narrower sense is a project that is gaining importance in the hypertext research community. At the time of writing, this approach is being institutionalized by the First Workshop on Spatial Hypertext at the Hypertext 2001 (Twelfth ACM Conference on Hypertext and Hypermedia, August 14-18, 2001, University of Aarhus, Århus, Denmark). Spatial hypertext has its origins in browser-based approaches in which the emerging hypertext network is portrayed graphically. In overview maps (see section 3.7 on navigation), authors create new nodes and links from within this structural map. In browser-based hypertext, boxes generally symbolize nodes; lines represent the links among them. In a completely spatial view of hypertext, the lines – links – may be removed from the picture, and the nodes may move about freely against their spatial backdrop. This means that nodes may appear in different contexts through multiple references to the same underlying content.

Their survey [335] of the types of spatial structures people created in three different hypertext systems (NoteCards, the Virtual Notebook System, and Aquanet) provided Marshall/Shipman with a basis for designing VIKI. Since then, spatial hypertext has been an important hypertext research topic and a number of other spatial hypertext systems have appeared: Web Squirrel, CAOS, and VKB among others, cf. [336], [337], [486].

As we have seen, the seventies, eighties, and early nineties saw the creation of many monolithic hypertext systems. Apart from the ones just presented, other notable systems include: Hypertext Editing System (HES) and File Retrieval and Editing System (FRESS) from Brown University, Thoth-II, MUCH, and Sepia. While individually impressive, monolithic systems did not become as widespread as they might. One of the obstacles to widespread acceptance was the lack of support of the editors (such as word processors, spreadsheets etc.) already in widespread use: According to Nielsen, many users rely on standardized tools, such as word processors, databases, spreadsheets, CAD

systems, etc., and unless the payoff is high, they are understandably hesitant to migrate to other tools. The major problem was the lack of portability as monolithic hypertext systems could only provide hypertext functionality to their own editors and file formats. Meyrowitz suggested that the correct course was to embrace the third-party applications and to offer full hypertext functionality for them, ideally to the degree where linking, annotation and navigation was as ubiquitous as copy and paste, cf. [356, p. 118], [70, p. 19]. Two developments in hypertext research have partly fulfilled these expectations – yet in completly different ways – OHS and the WWW.

3.1.16 Open Hypermedia Systems

The OHS approach is the augmentation of third-party applications with hypertext functionalities. Traditional monolithic hypertext systems typically functioned within a context of one file system. An Open Hypermedia System (OHS) may well contain documents residing on other, possibly remote, file systems. Integrating third-party applications allows people to create relationships between documents handled by different programs, that would otherwise be non-integrated. Thus, dissimilar applications are ”knitted together” by the OHS. The Microcosm Link Service from Southampton University was the first OHS that is still in development and use. Other current open hypermedia systems are (as listed in Bouvin [70, p. 19]):

- Chimera (University of Colorado, Boulder, USA)
- Construct (University of Aarhus and Aalborg University Esbjerg, both Denmark)
- HOSS (Texas A&M University, USA)
- HyperDisco (Aalborg University, Denmark)
- Webvise (University of Aarhus and Mjølner Informatics, Denmark)

All of these are represented in the Open Hypermedia Systems Working Group (OHSWG). The OHSWG was founded at the Second Workshop on Open Hypermedia Systems held in conjunction with the 1996 ACM Hypertext Conference[13], cf. [432, p. 1]. Among the original goals of the OHSWG were interoperability between OHSs and third-party application integrations. The work of OHSWG has over the years evolved into the Open Hypermedia Protocol (OHP), a data model and protocol for collaborative, open hypermedia, cf. [124]. The model attempts to be as inclusive as possible in the sense that it is capable of representing the link models assumed by most existing hypertext systems. However, it does not attempt to model the systems that have particular features such as transclusions in Xanadu or spatial hypertext systems. Today, OHP encompasses a growing number of protocols that covers hypermedia, such as navigational, compositional, and spatial collaboration support, subscriptions, naming and location of hypermedia services, caching, document retrieval, and Web integration, cf. [122, 432], [211, p. 6], [70, p. 19].

The OHS approach is a promising attempt to integrate hypertext functionality to standard applications and thus making hypertext concepts more popular. The real revolution, of course, came with the rise of the World Wide Web (WWW).

[13] Not in 1994, as reported in [70, p. 31].

3.1.17 Brief History of the World Wide Web

It is interesting to note on reflection that the WWW approach did not come from the hypertext research community and (maybe also for that reason) that its place in hypertext theory was questioned from the very start: Tim Berners-Lee's paper was famously rejected at the Hypertext'91 conference at San Antonio but he still attended and gave a demonstration of the system, cf. [211, p. 5]. Had the application of Hypertext to the network structures of the Internet been developed according to the standard of knowledge in the late 1980s, the Web would certainly look different today. On the other hand, it probably would still be a rather unaccessible scientific toy without much social influence. It seems appropriate to draft the genesis of the WWW at this point as I am constantly referring to it in various sections of this dissertation.

In march of 1989, Tim Berners-Lee, a British physicist then at CERN (the European Particle Physics Laboratory), proposed a project that would lead to the convergence of the Internet and hypermedia. In that year, the Internet was 20 years old, twenty countries were connected to the NSFNET backbone, the central data stream, and it was still primarily a network dominated by students and scientists, cf. [460], [515]. Yet, all signs pointed to growth: "While an average of only one billion data packets rushed through the NSF Net backbone in mid-1989, just one year later, that data flow had tripled. Other developments as well signaled a breakthrough for the Internet. At the end of 1989, the first commercial Internet dial-up provider, The World, debuted, and in October of the following year, CiriNet offered the first commercial information resource on the Internet" [293]. At that time, the technology of the Internet was dominated by e-mail, protocols such as FTP and Telnet, and not yet services like Archie (released in 1990), Gopher and WAIS (both released in 1991), cf. [83], [292, p. 18-20, 429-434].

Tim Berners-Lee's *project*, as it was referred to, proposed to develop a distributed hypertext system to enable high energy physicists, both within CERN and around the world, to share information. In his proposal concerning "the management of general information about accelerators and experiments at CERN", Berners-Lee claimed that information was constantly being lost at CERN because of the high turnover of people (two years being a typical length of stay). However, he was aware of the globality of this issue:

> "The problems of information loss may be particularly acute at CERN, but in this case (as in certain others), CERN is a model in miniature of the rest of world in a few years time. CERN meets now some problems which the rest of the world will have to face soon" [51].

The proposal, which can be recognized as the birth certificate of the World Wide Web, derives a solution based on a distributed hypertext system, as shown in fig. 3.2. Note that many of the connections that Berners-Lee drafts are typed links. Arguably the main innovation was the Uniform Resource Locator (URL), which elegantly combined the various Internet protocols with machine names and the hierarchical Unix file system[14]: "By using URLs it became possible to uniquely identify anything accessible on the Internet. Another, not as innovative but still essential, part of the WWW was the Hyper Text Markup Language (HTML). HTML allowed users to markup their documents to some degree and to insert URL links into these HTML pages" [70, p. 35]. The HyperText Transfer Protocol

[14] Berners-Lee explains in the FAQ section of his Web page: "The relative URI syntax is just unix pathname syntax reused without apology. Anyone who had used unix would find it quite obvious. Then I needed an extension to add the service name (hostname). In fact this was similar to the problem Apollo domain system had had when they created a network file system. They had extended the filename syntax to allow //computername/file/path/as/usual. So I just copied Apollo. Apollo was a brand of unix workstation. [...] I have to say that now I regret that the syntax is so clumsy. I would like `http://www.example.com/foo/bar/baz` to be just written `http:com/example/foo/bar/baz...` " [52].

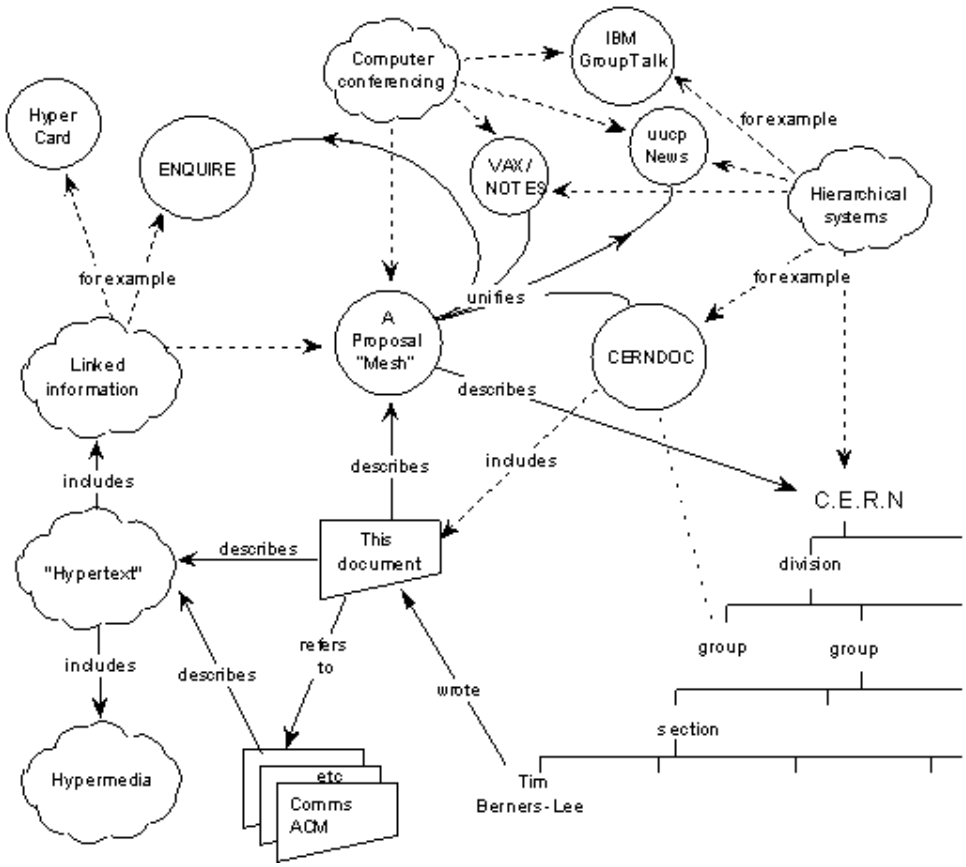


Figure 3.2: Berners-Lee's *Proposal*. Source: [51].

(HTTP), which at the time was a simple stateless file transfer protocol, was created in order to control many connections created and destroyed over ordinary browsing.

By November of 1990, the design document was completed and Tim Berners-Lee started his work on the prototype. The world-wide-web, as it was then called, went into use at CERN in May of 1991, and in August its existence was announced in several Internet newsgroups. From that point on the development became a communal affair with the standards being hammered out through heated debate in various newsgroups and mailing lists, cf. [52]. The Web was originally conceived as collaborative, and the first graphical Web browser (developed by Berners-Lee for the NeXT operating system) was a browser/editor, cf. [53]. This browser, however, never gained popularity. A key development was the July 1992 release of the WWW tool library. It was these tools that were used to develop the various Web browsers and servers that have made the WWW viable. One of these was Mosaic, the first cross-platform Web browser developed at the National Center for Supercomputing Applications (NCSA) at the University of Illinois in Urbana-Champaign. NCSA Mosaic was a read-only browser (which soon morphed into the Netscape Navigator, see section 4.7.6) and played a key role in triggering the explosive growth of the WWW. With the release of the Mac and Windows versions in the fall of 1993 (version 1.0 had been designed for X-Windows), it put a user-friendly browser in the hands of a broad public of Internet users. The result was a dynamic growth of Web traffic, servers, and documents.

Ingredients contributing to the Web's success were its simplicity, the freely available standards & software and its decentralized architecture. But also its scalability and the fact that every document/picture/file available via HTTP can also be saved locally on a hard disk

must be considered important factors for the WWW's success.

1995 was not only proclaimed by the Time magazine as the "Year of the Internet". It was also the year of the broad emergence of the platform independent programming language Java and its little brother, JavaScript, a scripting language based on Java and designed to be accessible to non-programmers. Besides other aspects, these tools have been developed (and are still widely used) to cover the Web's Achilles' heel in regards to usability.

3.1.18 Hyper-G and Hyperwave

Inspired by the early Web, the researchers at Graz University created the Hyper-G system, cf. [15]. Though very similar in some aspects (both used e.g. tagged ASCII almost compatible document formats), the Hyper-G system also provided some advanced functionality, including hierarchical navigational structures, and built-in multiple language support:

> "In many ways Hyper-G was technologically superior to the Web. [It] offered (automatically) indexed document collections, that could be shared and combined arbitrarily. The collections could be distributed and replicated automatically. Using the appropriate clients, users could create bidirectional point-to-point links, that were stored outside of the linked documents. Hyper-G was multi-protocol, as it could interface to Gopher and Web clients. And yet, it did not replace the Web" [70, p. 37].

The main problem with Hyper-G was the need for proprietary clients. While Hyper-G offered a Web interface, the full benefits of the system could only be harvested through the Hyper-G clients, such as *Amadeus*. Yet, "at the point of introduction (1995), the Netscape Navigator was the dominant browser with more (visual) bells and whistles than the Hyper-G clients" [70, p. 37]. Furthermore, authors and webmasters at that time did not recognize Hyper-G's potential to make Web sites easier to administer, as the system handles documents, updates links, etc. if documents are moved. Of course, the implementation of this valuable service only pays back as Web sites grow large, which was lesser the case in the early days of the WWW than today.

Thus, Hyper-G's main features have been integrated into a new product – commercialized as HyperWave – which was tailored for the Web, as well as Intranets and eLearning. Hyperwave, as a way to enhance the WWW's hypertext functionalities, will be dealt with in section 4.2.3.

3.1.19 The XML Family and the Semantic Web

XML emerged as a way to overcome the shortcomings of its two predecessors, SGML and HTML. SGML, the international standard for marking up data, has been used since the 1980s. It can be described as a powerful and extensible tool for semantic markup which is particularly useful for cataloging and indexing data but too complicated for the everyday uses of the Web. Furthermore, adding SGML capability to a word processor could double or triple its price and the commercial browsers made it clear that they did not intend to ever support SGML. So in 1996, discussions began which focused on how to define a markup language with the power and extensibility of SGML but with the simplicity of HTML. The World Wide Web Consortium (W3C) decided to sponsor a group of SGML gurus including Jon Bosak from Sun to develop XML. Like SGML, XML can be used to create an infinite number of markup languages. Whereas HTML is merely one SGML document type, XML is a simplified version of the parent language itself and yet it is free of cost.

The first phase of the XML activity culminated in the W3C *XML 1.0 Recommendation*, issued February 1998 (revised Oct 2000). In the second phase, work proceeded in a number of Working Groups to create XSL, the advanced language for expressing style sheets, *XLink*, which describes a standard way to add hyperlinks to an XML file, *XML Namespaces*, a specification that describes how to associate a URL with every single tag and attribute in an XML document and *XML Schemas*, which help to define particular XML-based formats. In September 1999, the W3C began the third phase, continuing the unfinished work from the second phase and introducing other working groups, e.g. to develop *XML Query*, a query language for XML.

As mentioned, *XLink* is a general XML format to describe navigational hypermedia, and to allow expressions of navigational hypermedia to be inserted into XML documents. While the main application of XLink is expected to be linking within XML documents, the standard itself is not limited to address solely XML locations. XLink can support the linking currently found on the Web (e.g. unidirectional unary untyped links, cf. 3.7), as well as bi-directional *n*-ary typed links. Links can be stored externally (out-of-line) of the documents they address, or they can be in-line (as with HTML documents). *XPointer* is used to identify regions of interest in XML documents. XPointer allows for selection based on IDs, hierarchical structure (from *XPath*), or an arbitrary user selection (e.g. selecting a string in the rendered XML document). This is a quite sophisticated addressing scheme that should cover most uses.

”To date, the Web has developed most rapidly as a medium of documents for people rather than for data and information that can be processed automatically. The Semantic Web aims to make up for this” [54]. At the time when XML will be widely used, the Web will become a place where data can be shared and processed by as well as by people. The Semantic Web takes this idea even further: Having information on the Web defined and linked in a way that it can be used by machines not just for display purposes, but for automation, integration and reuse of data across various applications: ”The Semantic Web is an extension of the current Web in which information is given well-defined meaning, better enabling computers and people to work in cooperation” [54]. Knowledge representation, the technology required for the Semantic Web to function, is ”currently in a state comparable to that of hypertext before the advent of the Web: it is clearly a good idea, and some very nice demonstrations exist, but it has not yet changed the world. It contains the seeds of important applications, but to realize its full potential it must be linked into a single global system” [54].

A probable intermediate step between HTML and XML is XHTML, due to the inertia of the existing approximately 1×10^{12} Web pages, many of which do not conform to HTML standards, cf. [70, p. 70]. But once the Web evolves into a space of XML documents, initiatives such as XLink will come into play. In the best-case scenario, where XLink has been adopted by the leading Web browsers, the Web would have evolved into a state-of-the-art hypermedia system, allowing arbitrary linking and annotations to take place. Furthermore, a XML future could also entail that other document types, such as word processing files or spreadsheets, would migrate to XML, and would then also be subject for easy linking, cf. [404].

As the recent history of the WWW is linked with a strong commercialization of the medium (described in section 4.7), the breakthrough of XML and the Semantic Web depends largely on the launching strategies of the big players in the Internet economy. Therefore, it remains ”a dangerous game to predict anything about the Web that’s more than two weeks away”.[15]

In 1990, Nielsen summed up his history of hypertext:

> ”In conclusion, we can say that hypertext was conceived in 1945, born in the 1960s, and slowly nurtured in the 1970s, and finally entered the real world in

[15] Derek Powazek, cited in [418].

> the 1980s with an especially rapid growth after 1985, culminating in a fully established field during 1989" [387, p. 41].

Today, we can extend the metaphor by adding that after the marriage with the network structure of the Internet, hypertext graduated from university, fanatically started up his own business in the early 1990s but had to face the rough winds of the real-life business world at the turn of the century.[16]

Hopefully, agents will soon take over some of the more tedious work, so that hypertext can concentrate on the key strengths: Connecting people, ideas and visions to support learning and understanding.

3.2 Hypertext Applications

Bieber et al. [60] describe an experiment at IBM where an expert system and a hypertext system were compared in their ability to support computer network maintenance. The results were that the two systems scored about the same in various measures of efficiency but the hypertext system won in the overall comparison because the operators could easily find out how to update the information it contained. In the expert system, the information was coded in a machine-readable knowledge base and required the assistance of special "knowledge engineers" for updates [387, p. 12].

The savings potential of hypertext in technical documentation was recognized early and has led to a shift from paper to hypertext in technical support (primarily for computer hardware) and help functions for software. The information (mostly in hypertext form, but also as linear texts) is commonly stored on local harddisks, CD-ROMs or Web servers. Hypertext strongly supports "just-in-time-learning", therefore compensating the deficits that stem from "Nielsen's first law of computer manuals", which states that "users do not read manuals, period" [387, p. 43].

Eleven years ago, Nielsen categorized hypertext applications in

computer applications (online documentation, user assistance, software engineering, operating systems),

business applications (repair and other manuals, dictionaries and reference books, auditing, trade shows, product catalogs and advertising),

intellectual applications (idea organization and brainstorm support, journalism, research),

educational applications (foreign languages, classics, museums), and finally,

entertainment and leisure applications (tourist guides, libraries, interactive fiction).

While this taxonomy does not appear to be very precise in the first place, the last decade has surely shifted the focus and broadened the spectrum of hypertext applications, especially in the commercial sector. This is also reflected in the evolution of Risak's taxonomy from [439] to [443]. Risak, like other authors, distinguishes between hypertext as a gathering device (personal and groupware), artistic production, learning tools and applications such as help systems, eCommerce, orientation systems, etc.

In order to specify useful applications of hypertext, Ben Shneiderman [488] has proposed what he calls the three golden rules of hypertext:

[16] I chose Hypertext to be male for this metaphor because text naturally is of that grammatical gender in Germanic and Romance languages. The (network) structure, in these languages is female and, fittingly, in Spanish the Internet is often called la *red* (the net).

- A large body of information is organized into numerous fragments,
- the fragments relate to each other,
- the user needs only a small fraction at any time.

Nielsen adds a fourth golden rule:

- Do *not* use hypertext if the application requires the user to be away from the computer [387, p. 43].[17]

As computer chips are getting integrated in household appliances, mobile phones, etc. and with the advent with more powerful PDAs using intelligent agents, the forth rule will loose importance in our society: If we like it or not, most of the people who read these lines, soon will never be ”away from the computer” again for long.

I do not want to contribute a great deal to a discussion of further hypertext applications. However, I will add a digression on two specific fields that hold great chances as well as challenges for the scholarly use of hypertext, eLearning and CSCW.

3.2.1 Hypertext and Learning

It is frequently suggested that hypermedia may have a significant effect on the learning process, but also that the ways how hypertext systems may be used to support human learning at different levels has to be fully understood before building effective systems, cf. [241], [285].

From its very beginning, hypertext has been involved in the storage of information and connecting it by ways of human learning.[18] Thus, Vannevar Bush proclaimed:

> ”The human mind [...] operates by association. With one item in its grasp, it snaps instantly to the next that is suggested by the association of thoughts, in accordance with some intricate web of trails carried by the cells of the brain. [...] Memory is transitory. [...] Man cannot hope fully to duplicate this mental process artificially, but he certainly ought to be able to learn from it. In minor ways he may even improve, for his records have relative permanency” [80].

According to Rumelhart and Norman, there are three modes of learning: accretion, tuning, and restructuring [457]: In accretion, learning takes place by means of accumulation of new information; in restructuring, learning occurs when existing memory structures (net work of schemata) are not adequate to account for new knowledge and new structures are created; In tuning, learning occurs when an existing schema is served as the base for the development of new ones by minor changes (fine tuning). It has been claimed that hypertext can support all three modes of learning processes because the node-link structure of hypertext is considered to be an analogy for the semantic networks that exist in human minds, cf. [550]:

[17] While he criticizes Shneiderman’s three rules, Kolb does not comment on Nielsen’s, cf. [283].

[18] Kolb’s ”paradigmatic scholar, the classicist studying Greek and Roman literature or history knew the books, could trace the references, make the connections.” Besides, ”memory was never all of scholarship,” [283, p. 30].

> ”A ’learner’ can manipulate a hypertext by means of changing the contents within nodes or changing the links that are connecting the nodes, such that the node-link structure of the hypertext becomes a model of the learner’s semantic network. This hypertext describes what the learner knows, which provides the foundations for learning new ideas, that is, expanding the learner’s semantic network. In this case, hypertext is considered to be the ultimate accretion medium, a knowledge base of interrelated ideas that can be readily accessed and assimilated. Restructuring is permitted by creating and reorganizing links in the system. Tuning is provided by changing the contents of the nodes in the hypertext” [550].

This idea of using hypertext to simulate the semantic networks of human thinking is being criticized as ”rather shaky” by Romiszowski [447] and ”the simple web structures of hypertext are not of the same order of complexity as human semantic knowledge structures” [542].

Most researchers, however, have concentrated on the navigational aspects of document-centered hypertexts (see section 3.4.3) and its impacts on learning. It has been claimed that simply letting learners wander freely within a complex, highly interwoven network of information nodes is less sufficient for learning than guiding them, giving prompts, clues and suggestions as to which parts of the information network are appropriate to their needs, cf. [286], [212, p. 111]. This claim seems to refer rather to abstract, reflective learning styles than to learners called ”concrete perceivers” and ”active processors” by Honey and Mumford [233]. Even enthusiastic advocates have to admit that hypertext ”may be less suited for the drill-and-practice type learning that is still necessary in some situations” [387, p. 65]. Yet, this learning method is mainly required for novices in the subject of study: According to Vygotsky [528,529], cognitive development results from a dialectical process whereby the learner learns through problem-solving experiences shared with someone else, usually a teacher but sometimes a peer. Initially, the teacher (or tutor) assumes most of the responsibility for guiding the problem solving, but gradually this responsibility transfers to the learner. This means that, once the basics of a new subject have been trained, the exploratory learner can branch out from these guidelines and to determine his or her own needs, cf. [387], [241]. In hypertext, this strategy can be realized by obliging the first time user to complete a guided tour before more links are made accessible.

Kolb’s four learning styles (converger, diverger, assimilator, accomodator) are based on Jean Piaget’s definition of intelligence and Guilfords’s structure-of-intellect model[19] , cf. [282]. Except for the assimilator (who would prefer guided learning), all learning styles described by Kolb seem to be suitable for learning in a hypertext environment: The learner can gradually extend his or her semantic net by acting as an author. Linking materials, building trails, adding annotations and gathering relevant material are typical actions of exploratory learning in hypertext. However, it seems that the required self-discipline and explorartory spirit are not self-evident to the common student. To avoid misunderstandings, the self dependent learning strategies in a hypertext environment have to be pointed out to them before-hand. Aiken [4] recommends student training and orientation to

- ”emphasize learning by doing – by providing opportunities to learn on and with IT,
- stress collaborative, project work that allows people to work together over time and space,
- and most importantly, *teach our students how to manage change*” [4, p. 12], his emphasis.

[19] See footnote 30 on page 86.

Hammond's "aim of didacticizing the, to him, obviously too liberal hypertext" has been strongly criticized by Schulmeister [476]. Laying great importance on controlling every move of the learner, Hammond argues that, if traditional learning methods get ported to hypertext systems for learning in an unreflected manner, the following problems can occur:

1. Users get lost because the knowledge base may be large and unfamiliar; the links provided will not be suitable for all individuals and for all tasks, and the user may be confused by the embarrassment of choice.
2. Users fail to gain an overview of the material and therefore miss large relevant sections of the material entirely.
3. Users have difficulty finding specific information because the knowledge base may not be structured in the way that they expect, or lack of knowledge might mislead them. A related problem is that of uncertain commitment, where the user is unsure where a link will lead or what type of information will be shown.
4. Users may "ramble through the knowledge base in an instructionally inefficient fashion, with choices motivated by moment-to-moment aspects of the display which attract attention" [212, p. 111].
5. Coming to grips with the interface for controlling the various facilities may interfere with the primary task of exploring and learning about the materials.

The first point made by Hammond has to do with cognitive path-dependency of human learning. Clark puts it this way: "Certain ideas can be understood only once others are in place [...] you can't get everywhere from anywhere; where you are now strongly constrains your future trajectory" [98, p. 171-72]. But "when confronting devices which exhibit some degree of path dependency, the mundane observation that *language allows ideas to be preserved and to migrate between individuals* takes on a new force. For we can now appreciate how such migrations may allow the communal construction of extremely delicate and difficult intellectual trajectories and progressions" [98, p. 172] (my emphasis). In other words, if we enrich the navigational model with a linguistic, or more generally speaking a semiotic level, we can perceive a "stunning matrix of possible inter-agent trajectories. The observation that public language allows human cognition to be collective [...] takes on new depth once we recognize the role of such collective endeavor in transcending the path-dependent nature of individual cognition" [98, p. 172]. The role of language and culture for what, and how to think, has been revealed in Vygotsky's social cognition learning model, cf. [528, 529].

Points 2 – 4 seem to be facets of Conklin's two major dangers of free-formed hypermedia access within an associative network, disorientation and cognitive overhead [108], and will be analyzed on a broader base in section 3.6. The fifth of the above problems is being studied in a joint project of the IBM T. J. Watson Research Center and The Museum of Modern Art, New York, cf. [478, 262]. The project explores learning by discovery and grows out of current research into "cognitive HCI". Cognitive HCI is "HCI which is both informed by our knowledge of cognitive processes as well as aimed at developing systems to support and enhance cognitive behavior" [262]. The aim of this project is to produce an interactive computer kiosk to present the museum's photography collection with an interface that can be thought of as being self-teaching, as explained by Lauretta Jones and Sharon Greene:

> "Throughout our work in designing self-teaching interfaces we observed that people do not have to be given directions to learn how to use a system. Most people learn quite readily by discovering what can be done and how to do it if the interface design supports such discovery. People also appear to

> enjoy the process of learning by discovery. One way of understanding what is meant by an *intuitive* interface is that it is really a *discoverable* interface. It has been observations such as these that have motivated us to invest in research in Cognitive HCI" [262].

In his keynote speech at the International Conference on Information and Communication Technologies for Education (EDICT) in Vienna, Hermann Maurer claims that knowledge is split into source knowledge and object knowledge and stored in different parts of the brain: "This is why we remember stories, not URLs!" [343].[20] This quote reminds me of Persson's narrative approach to hypertext navigation, described in section 3.7.8.

3.2.2 Groupware

Risak sees the roots of groupware in the scholars' commentaries and margin notes in manuscripts[21], as explained in section 3.1.1 on the prehistory of hypertext. Annotation functionality allows any user to add comments and additional links within applications, which can be private or shared among a work group. Hypertext structuring can help to organize discussions around any element of interest (e.g., using argumentation tools), cf. [108], [61, p. 3].

The argument that hypertext also can improve individual and organizational memory, cf. [108], is strongly supported by cognitive science, e.g. Tomasello et al. [519]: "Collaborative problem solving involves much more than the mere exchange of information and orchestration of activity. It involves actively prompting the other to work harder at certain aspects of a problem, and allowing the other to focus your own attention in places you might otherwise ignore. Here, then, the co-ordinative function of *linguistic exchange* phases into the further one of manipulating attention and controlling resource allocation" [98, p. 171] (my emphasis). Collaborative problem solving is the basis for the open source approach, a method and philosophy for software licensing and distribution designed to encourage use and improvement of software written by volunteers by ensuring that anyone can copy the source code and modify it freely. Raymonds's "Cathedral and the Bazaar" was a seminal paper describing the open source phenomenon, cf. [431].

Turoff's proposed that "groups must be able to impose a shared view and their own evolving collaborative indexing approaches on a collaborative hypertext system" [521]. Rao/Turoff [430] believe that their proposed taxonomy would also help in collaborative hypertext work because members of a group could contribute adequately and understand each other's judgements in carrying out the group objective.

Due to its pliable architecture, the Web forms the infrastructure for many kinds of applications, not least the support for collaboration. Collaboration on the Web takes many forms from classical CSCW applications such as Basic Support for Common Work (BSCW, cf. [16]) to link recommendation and discussion forums such as Slashdot, and the WebDAV standard (stands for Web Distributed Authoring and Versioning, cf. [544]). A noteworthy advance in easy-to-use pictorial communication on the WWW is Vectorama.org, a "multiuser playground" on which a maximum of ten users at the same time can design a picture together.

Geyer-Schulz et al. [190] present *Virtual Notes*, small yellow stickers which can be freely placed on instrumented HTML-pages using standard Internet technology. In a teaching

[20] Furthermore, he put strong emphasis on using network features (such as notification, version control, discussion boards, etc.) for eLearning and the active document concept (cf. [428], [516]).

[21] "Eine frühe Form der Zusammenarbeit von Leser/Autor ('groupware') bestand darin, daß Leser Randbemerkungen hinzufügten, die späteren Lesern verfügbar blieben. Auf diese Weise entstanden insbesondere im mosaischen Kulturkreis wesentliche Weisheitstexte, in denen die gesammelten Randbemerkungen der Rabbiner zusammengefaßt wurden" [439].

and research environment, this tool provides a user-friendly and flexible way of improving collaboration by annotations, feedback, post-its and blackboards (A tool of the same name, but for the Windows Desktop, is available as shareware from Mindmettle). Virtual Notes differ from the comments that are placed in the source code, for they can be included by everyone, whereas the source code of a typical Web document can only be edited by the author[22] of the node. The virtual note icon (or, Graphical Link Marker, see section 4.6) can be placed anywhere within the text or over an image.[23] Whenever the user pulls his mouse over the GLM, the note will pop up, showing last comments first. When clicking the GLM, the user can annotate to the note. The author of the HTML page is also the administrator of the notes placed on his pages. On the one hand, this puts authors in the position of having to review the notes for inappropriate or insulting annotations by anonymous users. On the other hand, this workload (which could be automated, cf. [190]) seems to be a fair price for the valuable annotations they can obtain from his readers.

3.3 Hypertext Paradigms

The term ”paradigm” gained prominence due to the enourmous repercussions of Kuhn’s work [294], and has since been applied in multiple contexts, scientific and otherwise, cf. [466, p. 122]. In the context of HCI, a paradigm can be described as the basic rule for a an interface metaphor.[24] In hypertext systems, there are three commonly used paradigms.

The card paradigm uses the index card as a model. Index cards are still widely used in organizations that house large material collections, such as libraries and museums. As each index card stands for an object, the manipulation and state of the collection can be represented by the spatial distribution and marking of the cards. This system was the most powerful way to maintain, document and search large holdings before the advent of computer systems. Therefore, electronic collection management systems (such as Gallery System’s The Museum System) usually employ this metaphor-set. HyperCard, the main example for a system using the card paradigm together with hypertext functionality, is shortly described in section 3.1.8. The essence of the card paradigm in hypertext systems is that a card cannot be bigger than the monitor screen, or in other words, scrolling is not necessary. The cards can be sorted in stacks and moved around the desktop. Furthermore, link destinations are always cards themselves, not destination anchors within the text. This means that a certain link will not point to some word on the same – or another – card, but to the upper left corner of another card, like the links departing from node A in figure 3.3. Note that the points where the links leave, or link anchors, are visualized by small boxes (the link markers). It goes without explaining that this paradigm is useful for short nodes only. It is a valuable way to help authors sort their ideas, short notes, pictures etc. before sitting down to write. It also seems to be the most promising paradigm in connection with spatial hypertext, see section 3.1.15.

The encyclopedia paradigm relates to collections of articles as standardized by the enlightment project of the *Encyclopédie ou Dictionnaire raisonné des sciences, des arts et des métiers* (see section 3.1.1). In the paper-form encyclopedia, the articles are sorted alphabetically and cannot be rearranged. Also, after having followed a chain of references, the

[22] Or, generally speaking, by anyone with writing access to the document. In HTML, comments and meta information can included in the source code with the <!-- --> tag. This information is invisible to the user unless he reviews the source code of the page. Veith Risak reminded me that other document formats (e.g. MS Winword, Star Office, etc.) allow annotation and changes to the document. The document owner can accept or reject these suggestions.

[23] In medieval manuscripts, comments and instructions were placed on the page margins. The yellow stickers that served as the source domain for the *Virtual Notes* have changed the way we annotate. They can be placed anywhere and later be removed without leaving a trace, cf. [7, p. 63].

[24] In section 3.6, I will pay special attention to the theoretical basis of the usability approach and its practical implications on HCI.

reader will experience difficulties in remembering what he was actually looking for. Numbered bookmarks can help to pull ”Ariadne’s thread” (see section 3.7.2 on bookmarks) to return to the point of departure in the book. Of course, electronic encyclopedias facilitate navigation with history functions, full searchability and editable bookmarks. This is generally true for every hypertext system using the encyclopedia paradigm, such as Hyperties (see section 3.1.9). References always point to the beginning of other articles (as in the card paradigm) which can lead to cognitive overhead if an article is several pages long. Thus, articles should treat with one subject only; otherwise the text paradigm seems more suitable.

The text paradigm relates to a writing support that has become rare in the western world: the scroll. Papyrus was the main writing material of the ancient world. Sheets were glued together and rolled up into scrolls of varying lengths which were written in short columns an read horizontally. It was flexible but it can never have provided a very stable surface for paint making it improper for large text illustrations. Weitzmann’s theory is that, though illustration of all kinds of texts was executed on papyrus in ancient Greece, and earlier still in Egypt, it was the changeover under the Roman Empire in the second to fourth centuries AD from roll to codex that left us with the book in today’s form.[25] The scroll differs fundamentally from the codex in the way it is handled (rolling vs. turning pages). Furthermore, the book page (especially if it is illuminated) invites comparison with a framed picture[26] whereas the scroll facilitates continuous reading. As each word can serve as a destination anchor for incoming links, this paradigm is highly suitable for associative linking within the text and for texts with commentaries. In figure 3.3, the destination anchors are represented by circles. A typical example for the text paradigm is the monolithic hypertext system Guide, described in section 3.1.10, and the WWW.

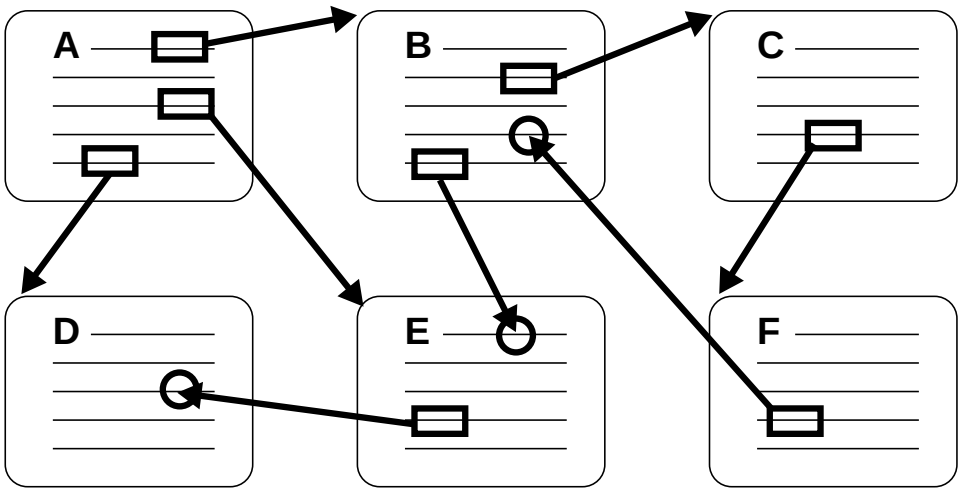


Figure 3.3: Hypertext structure with six nodes and eight links
(Source: [387, p. 1])

The desktop/window metaphor is underlying to most of systems that run on current GUIs (see section 3.6 on usability). Yet, not all hypertext systems employ multiple tiled windows within the application. Hypertext systems that provide readers with the ability to compare

[25] Cf. [537] and [7, p. 35, 151]. The wax tablets, however, were only used when writing materials were scarcer or more costly and lost importance at the end of the early Middle Ages. The stone tables, serving merely as a part of an architectural environment, were employed for representational inscriptions and mounted on monuments and houses; cf. [452, p. 176] and [42, p. 131-135].

[26] Cf. [7, p. 35]. See also [410, p. 19-21] for the design rules – *Gestaltungsprinzipien* – that such a picture plane requires.

two pages of text, write notes while viewing a second page, and so on, include gIBIS, Intermedia, Notecards, and Storyspace. On the Web, multiple windows are mostly used in connection with Java and JavaScript.

3.4 Hypertext Structure

In terms of the Dexter Reference Model, the storage layer models the basic node/link network structure that is the essence of hypertext and describes a ”database” that is composed of a hierarchy of data – containing ”components” interconnected by relational ”links”. cf. [209]. The other two layers in the Dexter model are the within-component layer and the run-time layer. The interface between the storage layer, in which the hypertext network is stored, and the within-component layer is called anchoring. It is a mechanism for addressing locations or items within the content of an individual component. Anchoring is a mechanism that provides this functionality while maintaining a separation between the storage and within-component layers. The within-component layer contains the (textual and graphical) content of the hypertext; the run-time layer of the model provides tools for the user to access, view, and manipulate the network structure.

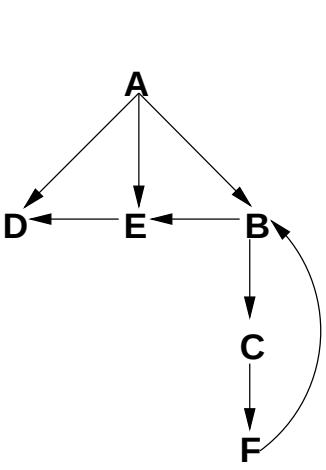
The hypertext authors and readers, however, perceive the hypertext structure as blocks of text and the electronic links that join them, cf. [129, p. 3], [37]. While the passage from one node to the other (or, navigation, see section 3.7) is based on the linear selection and combination of elements, hypertext structure itself is seen as modular non-sequential and variable. As the nodes need not have a fixed place in a spatial order to form this network of text (and other hypermedia), hypertext structure is commonly analyzed by means of graph theory.

3.4.1 Graph Theory

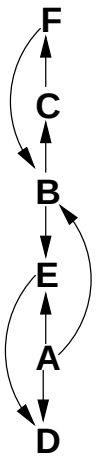
In information science, graph theory[27] is used, primarily, as a method of structuring and organizing data, cf. [256, p. 136-145]. But graphs are also a good way to analyze (and visualize) information structures, such as hypertexts. By means of graph theory, hypermedia structures, seen as aggregations of nodes (containers of information) and links (dynamic connectors) can be automatically visualized in overview diagrams (described as a navigation tool in section 3.7). The simple hypertext of figure 3.3, can be represented by a directed graph (fig. 3.4a).

In general, a graph is a pair of sets, V and E, where every element of E is a two-member set whose members are elements of V. A directed graph consists of a set of nodes, denoted V and a set of arcs, denoted E. Each arc is an ordered pair of nodes {u,v} representing a directed connection from u to v. The *out-degree* of a node u is the number of distinct arcs, $\{u,v_1\}...\{u,v_k\}$ (i.e., the number of links from u). The *in-degree* is the number of distinct arcs $\{v_1,u\}...\{v_k,u\}$ (i.e., the number of links to u); cf. [73]. For example, graph 3.4 can be formally described as: V = {A,B,C,D,E,F}, E = {{A,B}, {A,D}, {A,E}, {B,C}, {B,E}, {C,F}, {E,D}, {F,B}}. Thus, node A has an out-degree of 3 and an in-degree of 0 (making it a root node), node B has an out-degree of 2 and an in-degree of 2, and so on. The graph also has a cycle where B is the initial as well as the the terminal node. Note that the same graph could be visualized in a lot of different ways (e.g. 3.4b) to put the emphasis

[27] The earliest paper on graph theory was written by the Swiss-born mathematician Leonhard Euler, called *Solutio problematis ad geometriam situs pertinentis,* in the *Commetarii Academiae Scientiarum Imperialis Petropolitanae* (1736). Euler discusses whether or not it is possible to stroll around Königsberg (later called Kaliningrad) crossing each of its 7 bridges across the Pregel exactly once. Euler encoded the problem in a graph by representing the land areas as vertices and the bridges as edges and gave the conditions which are necessary to permit such a stroll; cf. [222].



(a) Directed graph



(b) Linear alignment of nodes

Figure 3.4: Two hypertext graphs base on fig. 3.3.

on certain topological details, while its formal description remains unchanged, as can be seen in the representation as a matrix or a table (see figure 3.5).

$$\{u,v\} = \begin{bmatrix} 0 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \end{bmatrix}$$

	A	*B*	*C*	*D*	*E*	*F*
A	0	1	0	1	1	0
B	0	0	1	0	1	0
C	0	0	0	0	0	1
D	0	0	0	0	0	0
E	0	0	0	1	0	0
F	0	1	0	0	0	0

Figure 3.5: Hypertext (fig. 3.3) as matrix and table.

Without going into detail, it can be shown that the matrix, when read from left to right, show link {A,B} as the second ”1” in the first row, etc.

Goodman underlines the digital character of graphs, by which he means that how a graph is visually represented is irrelevant compared to its formal correctness: Figure 3.6 shows different visual representations of the same graph.[28]

Figure 3.6: Three depictions of the same graph. Source: [222].

In a graph, the nodes and arcs act as characters in a notational language and its ”diagram” is purely digital. Goodman [194] uses the dichotomy digital/analog to illustrate the difference between diagrams, maps and models on the one hand and images, or pictorial

[28]Note that the first depiction implies a non-planar graph, that is, a graph that cannot be drawn in the plane without crossing edges. However, the other two depictions show that the graph is actually planar. This distinction becomes important for the visual representation of highly interconnected (or dense) graphs, cf. [99].

representations on the other: According to this distinction, a representation system is digital if it uses a discrete class of states of affairs to indicate a discrete class of states of affairs. A representation system is analog if it uses an infinite class of states of affairs to indicate an infinite class of information and each class is dense, namely, its members can be ordered in the way that between each pair of elements there is another element.

In his analysis of schemata as notations, Elkins concentrates on trees: For him the tree descends from deduction, and therefore it expresses both simultaneous relations (a taxonomy) and chained deductions (a genealogy): "In Ferdinand de Saussure's terms, genealogy is diachronic and taxonomy is synchronic. In genealogy, the smallest twigs are the newest, as in a real tree; in a taxonomy the distance between any two twigs matters more than their age" [160, p. 221].

Graph theory is an important method for building Web search engines (see section 3.7.9), such as Google, Altavista, Lycos, etc., for measuring and mapping the Web. The "Web graph" (containing several hundred million nodes, and a few billion arcs) is actually a directed multigraph (because two nodes can be connected by more than one link), but many analyses ignore these complications and treat the Web as if it were a simple, undirected graph; cf. [73], [222]. There is also terminological inconsistency and diverging results concerning the *diameter of the WWW*. While Barabási et al. [5] come up with a diameter of 19 (which means that if you select two Web pages at random, you will need 19 clicks, on average, to get from one node to the other), Broder et al. do not believe in this "small world phenomenon"[29]:

> "Our experimental evidence reveals a rather more detailed and subtle picture: most ordered pairs of pages cannot be bridged at all and there are significant numbers of pairs that can be bridged, but only using paths going through hundreds of intermediate pages. Thus, the Web is not the ball of highly-connected spaghetti we believed it to be; rather, the connectivity is strongly limited by a high-level global structure. [...] We show that the diameter of the central core (SCC) is at least 28, and that the diameter of the graph as a whole is over 500. [...] We show that for randomly chosen source and destination pages, the probability that any path exists from the source to the destination is only 24%" [73].

It is to be hoped that future research will shed some more light on these contradictory findings. Cunliffe notes that "different forms of dynamic, interactive 2-D and 3-D visualisations which support abstraction and clustering need to be investigated" [114, p. 41]: Theoretically, it is possible to use graph matching techniques to find isomorphisms and clusters. However, the matching of graphs is still an active research area and computational challenge. The two major problems, that of sheer size and that of arbitrary interconnection structure, remain a challenge, cf. [166].

In hypertext, nodes represent the documents or primary content containers, cf. [209]. Thus, it is the connection of nodes by means of hyperlinks, which makes graph theory applicable. At this point, it is important to distinguish the underlying link anchor from the manifested link marker displayed on the screen and the link destination. Link markers visibly indicate a link's presence. Link anchors contain parameters and other internal information, which users do not see. However, showing information on the link and its destination (e.g. in pop-up), could reduce the problem of uncertain commitment, e.g. the user is unsure where a link will lead or what type of information will be shown, cf. [212, p. 110]. Properly designed

[29] In the calculation of the Web diameter, it is important whether or not the indexing databases of the search engines are included. If they are, all those nodes saved in a Web crawl are connected at a maximum diameter of 2, as pointed out to me by Veith Risak. See section 3.7.9 for IR techniques and search engines.

hypertext systems contain a variety of link parameters, such as source/destination-points, type, condition, annotations, etc, which shall be described hereafter.

The possibility to categorize links, e.g. as ”definition links”, ”reference link”, or ”external” vs. ”internal links” promises to reduce cognitive overhead in hypertext navigation.

Rao and Turoff observe that ”hypertext should be treated as a general purpose tool with approaches to handling nodes, links, and retrieval, that fits within the context of any application and conveys common meanings to users. To accomplish this, we need a comprehensive framework for hypertext based on a cognitive model that allows for the representation of the complete range of human intellectual abilities” [430]. They propose such a framework based on Guilford's Structure of the Intellect Model[30], cf. [204]. Their framework classifies nodes into six different semantic types – detail, collection, proposition, summary, issue, and observation. Links can be categorized into two major types – convergent links and divergent links. Convergent links can be classified into specification, membership, association, path, alternative and inference links. These links help in focusing or narrowing the pattern of relationships between ideas. Divergent links are classified into elaboration, opposition, tentative, branch, lateral, and extrapolation links. These links expand or broaden relationships between ideas.

Arbitrary labeling gives authors more flexibility to express exact meaning, but carries the danger of inconsistent type names: When writing documents and setting hyperlinks, the users rarely bother to select link types or assigned link names other than the default ones. At least this is implied by a two-year field study with over 200 users of the MUCH hypertext system, cf. [533]: If a link type was chosen, the choice was often inconsistent with the way other authors would categorize the link. Thus, Wang and Rada suggest that system designers providing semantic typing should make them as easy to specify as possible. Thoth-II [104] is designed to contain all structural information in the links. It provides three types of links. *Value links* connect one node to another, *text links* link text to nodes and *lexical links* point from regions of text to nodes, cf. [104]. According to Parunak [413], there are at least three major types of links: association links, aggregation links and revision links, each of which can be further sub-divided. Risak distinguishes between the two categories associative links and structural links, cf. [439, keyword:Verweise]. In figure 3.3 on page 82, the node A seems to be the home page containing a table of contents with structural links to the main nodes of the hypertext. The link $F \rightarrow B$, however, seems to be an associative link.

Durand/DeRose [151] state that most of the proposed type-sets are ”grab bags” (a collection of inhomogeneous items), because they mix rhetorical, topological and syntactic types.

Typed links can be displayed at the user interface by changing the shape of the cursor, as Guide does, or by having a special link marker notation for various link types. This notation can include different colors, icons (like gIBIS) and line patterns (like NoteCards). It can also be expressed by showing the link type in another window, frame, pop-up menu (preview list), or in an overview diagram, cf. [536, 62, 388]. In fact, HTML 4.0 also supports link types and titles, but hardly any author uses them, probably because they are not supported by most popular Web browsers and editors.

Adrian Miles' hypertext on cinematic narration ”does what it describes: It contains a simple series of nodes that contain the major argument – this is its canonical text – and while it can be read serially, it is densely interlinked” [361]. In addition, he uses the CSS to color

[30] In Guilford's Structure of Intellect (SI) theory, intelligence is viewed as comprising operations, contents, and products. There are 5 kinds of operations (cognition, memory, divergent production, convergent production, evaluation), 6 kinds of products (units, classes, relations, systems, transformations, and implications), and 5 kinds of contents (visual, auditory, symbolic, semantic, behavioral). Since each of these dimensions is independent, there are theoretically 150 different components of intelligence. SI theory is intended to be a general theory of human intelligence. Its major application (besides educational research) has been in personnel selection and placement.

four other types of links: commentary, quotation, reference and external (see figure 3.7). Although this pseudo-typing only takes place on the presentation level (in the terminology

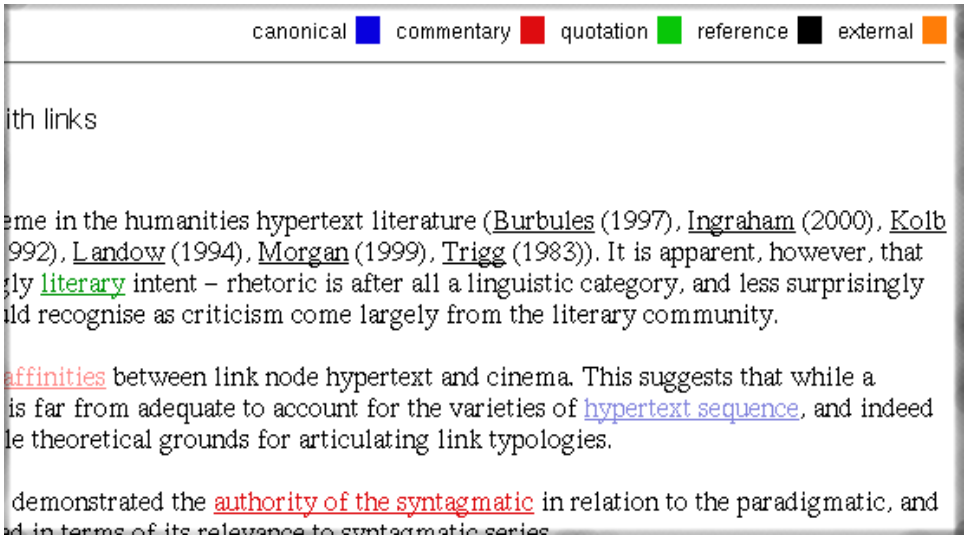


Figure 3.7: Detail of a screen-shot from [361].

of the Dexter Model, see section 3.4) , it works surprisingly well for the user.

Vitali et al. [527] propose a simple method called *displets* for HTML-authors to include pop-up boxes with link labels for typed links. Weinreich and Lamersdorf's *HyperScout*, a prototype implementation of their proposed concept to present several types of Web hyperlink information is a similar approach to show useful link information (see fig. 3.16 on page 123), cf. [536].

Thüring et al. [517] state that "providing semantic link labels" should be a leading principle of hypermedia design. In XML, other semantics – in addition to types – can be attached to links, such as labels, names, keywords or timestamps. A single link type defining a conceptual relationship between nodes can have multiple labels representing the type tailored for different contexts, cf. [430]. The keywords attached to a link – by authors and readers alike – can include its type and labels, cf. [151].

Except for Rao/Turoff's scheme [430], the concept of typed nodes has been treated with a little less consideration in hypertext literature.[31] After a long paragraph about typed links, Bieber et al. [62, p. 37] only add: "Similarly, node types categorize a node's contents." But sometimes, what is an argument for one issue, might be a counter-argument for another and self-defined types will produce an unlimited taxonomy. Yet, Wang and Rada's study [533] suggests that, if default types are given, the creativity of authors will stay on a low rate. Within homogenous user groups and/or fields of applications, enforced semantic node and link structures can help authors organize information more effectively and lend context for readers: In the gIBIS system, the hypertext model corresponds to the dialectic model of augmentation among the software developers (see section 3.1.12). According to the issue, that may have a position supported – or objected to – by arguments, the corresponding hypertext model consists of three node types: 'issue', 'positions' and 'arguments': gIBIS' eight link type represent the interrelations among the nodes, e.g. an argument supports an issue, or, objects to it; an issue generalizes/specializes/replaces/questions another issue, etc. Yet, "together the types create and maintain a semantics for the hypertext network

[31] Veith Risak reminded me that types for nodes are an important issue, as they can be used to indicate the credibility/authenticity of the node (draft, under review, final,...) and for versioning.

designed specifically to support its domain of argumentation dialogues" [62, p. 37]; cf. [109]. Nanard/Nanard [376] envision a type scheme for link anchors as well, but their concept moves quite beyond the graph model (see section 3.4.2).

Usability studies by Spool et al. [503] bore out that Web links are usually not sufficient for the user to predict the referenced document. Yet, surrounding information aside, the vast majority of Web authors rely on the link marker in its context or the destination address to convey the link's purpose and destination. Stayner/Procter's study [504] on how people make link selections confirmed that users are often forced to fall back on heuristics drawn from past experience and interpret the URL before selecting a link. The address was used to predict different aspects of the referenced object, like their contents, the expected download time, and the destination Web site. However, "the readability of URLs for humans is poor as they are primarily technical addresses. Particularly less experienced users are unable to understand URLs and do not know how to interpret the different parts," [536]. Consequently, several projects aim to make URLs avoidable, like RealNames, a service that maps key phrases to Web pages and passes them on to the browser.[32] Furthermore, it has become difficult to judge a node's content by its name and location, because aggressive commercial domain name policy, including Cybersquatting[33], have made URLs sometimes quite misleading (see section 4.7.3 for an account of information authenticity and copyright issues on the WWW).

Therefore, it seems hardly surprising that "we experience many Web users complaining that sometimes they do not really know where a link will take them. This adds to cognitive overhead for the reader. We view this, in part, as both a user-interface design question and a hypermedia design question" [62, p. 37]. Advanced Web authoring environments could take advantage of semantic types to declare templates. These templates could combine nodes and links that go together, like in the gIBIS system. If links have attributes by themselves, readers can inspect the dependencies between documents by running structure-based queries. Implementing structure-based query on the Web will be facilitated greatly by maintaining external link databases, as will be the case with XLink, cf. [133], [151].

Bi-directional links in hypertext, meaning that the system can display a list of incoming links. This functionality also depend on external link bases: "From a computer science perspective it would be almost a trivial task to implement such a feature, but almost none of the current hypertext systems do so. It would just involve updating two lists instead of one every time a new link was added" [387, p. 4]. The structure of today's WWW inhibits bi-directional link transversal (unless using the backtrack function). However, the HyperWave environment can show incoming links from the same domain, see section 4.2.3.

The notion of a diameter of the WWW was presented at the beginning of this section. Broder et al. [73] note that the possibility of transversing bi-directional links could enhance the navigatability of the Web: They show that, if a path directed between two randomly selected nodes exists, "its average length will be about 16. Likewise, if an undirected path exists (i.e., links can be followed forwards or backwards), its average length will be about 6" [73].

Some systems display labels to help the reader distinguish among multiple links from the same link anchor. This makes great sense in combination with typed links. That way, a single link marker can be the anchor for links to a definition, a citation, an annotation, a picture etc. The *displets* suggested by Vitali et al. [527] include pop-up boxes with link labels for multiple links, typed links, as well as many other features that could be specified

[32] On their Web site www.realnames.com, the company states that "Keywords CANNOT be resold [sic]. If registered Keywords fail to comply with the Keyword Selection Policy, they will be revoked and registration fees will not be refunded." The marketing of keywords will be treated in section 4.7.

[33] The famous legal case about the reverse process (the domain name etoy.com was taken *before* the company that later wanted the URL, eToys, was even founded) will be treated in section 4.7.7.

from within HTML and XML.[34] The problem with displets and other workarounds in Java, JavaScript, etc., is that they tend to multiply loading times. The Lotus Organizer uses multiple links with easy pop-up menus. Figure 3.8 shows the pop-up menu beside the

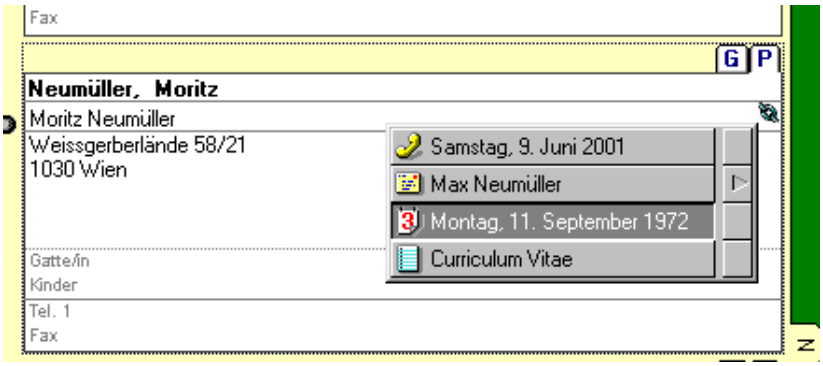


Figure 3.8: Multiple links in the Lotus Organizer 4.1.

GLM (in the form of a chain) in the address book. The links point to a phone call, another address, an anniversary, and a text file.

3.4.2 Beyond Graph Theory

In a classical node-link hypertext, a graph can be constructed on the set of nodes where each edge is identified with a link and structure discussions typically take place with respect to this graph. However, many other structure models have been proposed: Halasz [207] folds these primitives into node/link "composites." DeRose [134] distributes link functions over a taxonomy of "intensional" and "extensional" links. Parunak [413] replaces the concept of linked nodes with set-theoretic groupings, while Marshall et al. propose relations [334], and Stotts/Furutta [510] base their Trellis model on Petri nets. Thus, it seems adequate to follow Rosenberg in counting as hypertext "any kind of system in which text contains embedded interactive structure operations" [449].

Transclusions are examples of such interactive structure, however in a quite different sense. Bieber et al. point to this concept from the earliest days of hypertext that could vastly enhance the WWW's functionality (see section 4.2.3 on Web augmentation):

> "Transclusions (or inclusions) was one of the first hypermedia features to be proposed by hypertext visionaries, but thereafter ignored by hypermedia implementors. [...] Ted Nelson proposed transclusions as a mechanism for having the exact same object (document content) exist in multiple places. Whereas copying and pasting creates an identical copy, transclusions act similar to pointers that connect the original copy to all places that use it. Transcluded data is *alive*, still connected to the original and automatically updated. Through transclusion, readers always have access to the original and therefore to its original context (through a context link)" [62, p. 41-42].

Xanadu's virtual document structure (see section 3.1.3) is built around transclusions: each document is a list of pointers to pieces of data, which originate in that document or are included from others. A similar approach is called composites: Whereas transclusions refer to sub-parts of a node, composites intrinsically refer to whole nodes, [207]. Composites,

[34] The ongoing project is documented at www.cs.unibo.it/projects/displets/.

and even more, transclusions are hard to formalize in graph theory: are they nodes themselves? If they are, they would transform trees into directed graphs. I have included them in this section, as they seem to mark a breakpoint of graph theory.

The overall structure of a hypertext may not be apparent to the reader from the beginning.[35] Rather, readers discover structure through activities provided by the hypertext. Many of the hypertext models that diverge from graph theory concentrate on the structure of these activities, explicitly based on the reader's point of view. Rosenberg [449] presents a three-layer scheme for discussing hypertext activity:

- Session
- Episode
- Acteme

In Rosenberg's terminology [449], the *acteme* is an extremely low-level unit of activity, such as following a link. Multiple actemes are combined into an intermediate level unit, which he calls the *episode*, and at the high end he sees a unit called the *session*. He focuses his discussion on the episode, emergence of the episode from the acteme and the structure of multiple episodes:

> "An episode is simply whatever group of actemes cohere in the reader's mind as a tangible entity. In a node-link hypertext, the episode will probably consist of all or part of a trail or path. Whereas the acteme typically has an identity which is clear from the hypertext's user interface, the identity of the episode may not be so clear. The user may follow a chain of links as part of a process of exploration that may or may not prove fruitful. Simply following a chain of links does not necessarily make these visitations *cohere* into a tangible entity. The episode is not simply a unit of hypertext history – where any act is necessarily part of some episode; rather, the hypertext experience consists of executing multiple actemes, some collections of which will resolve into episodes, and some of which may not be part of any episode at all. Indeed, part of the hypertext experience may be described as *foraging for episodes"* [449].

Having shifted the focus from the structure of the hypertext to whatever the reader makes of it, Rosenberg illuminates classic hypertext problems, such as navigation (see section 3.7), including the "lost in (hyper)space" phenomenon, Bush's trails (section 3.1.2), backtracking (section 3.7.6) and history lists (section 3.7.7) from a new point of view. But most of all, [449] uses his toolkit on spatial hypertext.

3.4.3 Spatial Hypertext

Hypertext excels at representing "soft" data structures that do not fit well in databases, cf. [439, 438]. The associations that constitute the links between nodes are frequently on the intuitional or emotional side of our rationality scale: "This reminds me of…", or "This is somehow related to, or similar to…", cf. [439, Hypertext als Paradigmenwechsel der Textverarbeitung]. In contrast to narrative texts (novels, etc.) and hierarchical texts which structure and go into depth (e.g. dissertations divided into sections and subsections), hypertexts reach out laterally, they *connect* similar thoughts. In the context of psychology, the philosophy of symbolic forms (see section 2.2) is often counted to a large body of literature

[35] In fact, the overall structure of large hypertext spaces as the WWW is not easily measurable with our current technology, see sections 3.4.1 and 3.4.3.

that supports the value of ”systems thinking” or ”intuition”, a field shared with multiple intelligences [184], learning styles [282] (see section 3.2.1), split-brain research [187], holistic and Gestalt psychology [281, 269, 280], etc. Cassirer states that ”reason” is a very inadequate term with which to comprehend the forms of man’s cultural life in all their richness and variety, as ”all these forms are symbolic forms. Hence, instead of defining man as an animal rationale, we should define him as an animal symbolicum” [90, p. 26].

Susanne K. Langer has reformulated the extension of reason with feeling, cf. [112], or, the incorporation of what had been considered part of emotional life into the realm of reason, cf. [306, p. 95ff.]. Intuitions, emotions, and other formerly ”non-rational” ways of knowing can now be thought of as under the umbrella of reason. Intuitive, inherited, or inspired knowledge as non-rational sources of knowledge spoil the traditional concept of the mind as an organ of understanding as the process of symbolization is acknowledged to be the quintessential part of human understanding: ”Rationality is the essence of mind and symbolic transformation its elementary process” [306, p. 99], see section 2.2. Graph theory reaches a point of breakdown when links are conceptualized to interconnect links, an idea expressed by Kathryn Cramer and cited by Rosenberg: ”What if a menu of link names itself contains an anchor? What about links to links? Similar issues have been raised in the past concerning dematerialization of the lexia” [449], cf. [449]. In graph theory, a link to a link depends on the creation of another node at the intersection, unlike spoken language and associations (according to Bush, the source domain of the metaphor): An example from spoken language would be: ”This red wine tastes like strawberries, I mean it tastes like strawberries in the same way that a perfume smells like a rose on the skin of a woman.” The association ”tastes like” is associated to the association ”smells like”, or, in other words: two relations form a new relationship. A possible direction to represent this kind of ”structural” information is spatial hypertext (see sections 3.1.15 and 3.4.3).

From a cognitive perspective, space plays a fundamental role in human reasoning, thought, language, and action, cf. [306,316]. Our comprehension of abstract domains is often shaped through spatial metaphors, a property which can be and has been directly exploited for a wide variety of successful user interface designs. Space as we experience it daily, from our desktops through the rooms and buildings we live in, to the cities and landscapes of our environment, has essential properties required from source domains of general-purpose interface metaphors: living and acting in space is a common experience for all users; spatial structures (cities, landscapes) and artifacts (desks, buildings) offer familiar affordances and operations; human memory relies on spatial arrangements and layouts of items; human spatial experience is tightly linked to visual and auditory perception, the primary channels of human-computer interaction; spatial structures offer both simplicity at a single level of resolution and hierarchical refinement through operations like zoom and pan, go to, open, enter. Spatial structures convey a wide range of auxiliary information in subtle but intuitive ways, including wayfinding assistance (maps, directions), visualizing choices for actions, and tracing past operations, cf. [295].

Space is a strong ordering and organizing principle and therefore is used by many people as a mnemonic system. This use was known already by the Greek as *mnemotechnics* or the Art of Memory, and used primarily to memorize long pieces of text. Speakers mentally created a house and walked though it. Putting various objects like pictures or statues at distinguished places in the house structured that space. At those objects pieces of text were mentally attached.[36]

The task of navigating an information space occurs over and over again in the computer domain, cf. [345], because ”all applications, be they calculating programs, word processors, or flight simulators, evince spatiality and dimensionality of various kinds and are therefore capable of generating virtual environments within the user’s mind. This corresponds to

[36] Prof. Purcell at the Vienna University of Economics and Business Administration has developed these approaches further. He proposes different methods to extend the human short-term and long-time memory.

spoken language, since behavior and movement in a time-space continuum, real or virtual, is oriented by spatial, personal and temporal deixis" [247, p. 559]. In the case of hypertext, navigation problems are inherently a problem of communicating the structure of the information space to the user, because hypertext structure is not based on Euclidian[37] space, but on graph theory metrics:

As shown in figure 3.9, the distance relations in graph theory differ from the Manhattan (or cab-driver) metric and, the metric of Euclidean space. There is only one shortest way from point A to point B in a two-dimensional Euclidian space (the dotted line). The Manhattan

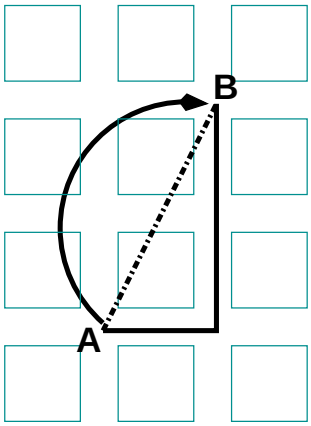


Figure 3.9: Manhattan metric, Euclidian&topological space. Source: based on [142].

metric is defined by a distance function that calculates the distance a cab driver has to drive to reach a certain point in a rectangular grid of houses. The way from A to B can be to go east and then north (as drafted in figure 3.9) or first north and then east. Ceteris paribus, the costs of transportation around the block are equal. Yet, the basic form of human movement is not riding a taxi, though, but walking. Walking involves a factual human *experience* on the way between two points on a map, it builds what Bollnow calls "hodological space", which is "absolutely different from the geometrical line uniting two points" [158, p. 8].[38] As users "remember stories, not URLs" [343], this distinction can help to understand user navigation.

Finally, the arrow in figure 3.9 represents any link from node A to node B in a graph model: The relation or distance function defined on this non-metric space is one of connectedness. A hypertext link connecting the nodes A and B does not have a length, because A and B do not have a fixed position. In a subway map, the distance, or, number of stops to pass from one point on the map to another point gives a rough indication on the time needed to travel. This distance assessment is subjective, based on real-world experience and possible changes according to the time of the day. It is not a metric distance function as one or more of the metric properties may not hold. In general, a topological space is one in which there is some arbitrariness in the positioning of locations (nodes) and arcs (links) and where the

[37] Euclid systematized and generalized the entire geometrical knowledge of antiquity in his "elements". Space that follows those basic geometric rules and man's everyday experiences is called Euclidean space. The Euclidean space concept is not consistent with contemporary knowledge from cosmology and physics: Einstein's general theory of relativity disproves the assumption of independence of space and time from matter. Space is not seen any more as a three-dimensional concept but instead as a four-dimensional space-time continuum. Even if the philosophical view of space in heavily influenced by physics, Euclidian space is still an adequate concept of space for most every-day phenomena, cf. [142, p. 15]; [496]; [49].

[38] "The term *hodological space* is derived from Greek *hodos*, path, way. In contrast to the mathematical concept of space as presented on maps, plans etc. hodological space is based on [...] physical, social and psychological conditions a person is faced with on the way from point A to point B whether in an open landscape or within urban or architectural conditions" [158, p. 2-3].

only relation that matters is contiguity, cf. [100, 222, 73]. It is important to note that, in graphs, it is possible to define distance functions by reachability or adjacency functions as well as by attaching distances to arcs. Yet, most hypertext systems (including the WWW) do not make use of the latter method.[39]

Another possibility to define distances is by calculating the similarity of the contents of nodes. This approach is common practice in open hypertext systems, cf. [319], [432]; see sections 3.1.16, and 3.4.1.

Dieberger underlines the fact that "spatialization with well-defined semantics can be much more than only an arrangement – it can express meaning and serve as a tool for thought and communication. Even machines sometimes can understand its meaning and support the user to make implicit structure explicit" [142, p. 62]. While Marshall/Shipman took up that point and built the simple but working systems described in section 3.1.15 and hereafter, Dieberger proposes the *Information City* as a user interface metaphor on the basis of Jay Bolter's two approaches to combine virtual environments and hypertext, "hypertextualizing the space" and "spatializing the (hyper)text". While the former can be realized by giving graphic elements in virtual space a symbolic significance, the latter advocates to make the space concept explicit and to use more spatial representations of hypertexts to make hyperspace a real "space" [142, p. 73f.].

"The Information City goes beyond the pure city metaphor because it provides users with magic features explicitly designed to support navigation. In a metaphor making use of a metaphor based on an Euclidean space concept, these features are necessary to provide for instance hypertext linking functionality" [142, p. 76]. For example, Dieberger uses the subway as a metaphor to explain why two hypertext nodes, which appear distant in an overview map, may be considered close at the same time when connected by a link: "When the overall structure of the hyperspace is such that closeness in the overview map expresses similarity of content, then such a link is perceived as a tunneling through space" [142, p. 74]. Freksa claims that "the special cognitive reality of space [...] makes the spatial domain particularly suitable as a medium for conveying knowledge, since its properties are universal to different cognitive systems" [179]. Semioticians, however, have pointed to the limitations of the Lynchian and cognitive perspective (see section 3.7).

Dieberger claims that the "strive for realism leads to a tendency to spatialize user interfaces – objects are not only more realistic but look like spatial objects and the overall environment gets a more spatial conception. [...] The spatial user interface is not any more a collection of abstract symbols on a screen but an environment usable to organize objects in space" [142, p. 8]. But spatialization does not necessarily mean 3-dimensional Euclidian space. The step from one dimensional movement on the input line to the 2-dimensionality on the surface of the visual desktop, or on the page of a book is another form of spatialization, cf. [247]

One reason for the trend towards spatialization into the third dimension, however, is the amount of information people have to keep organized in their computer systems – "a flat organizing scheme seems not to be sufficient and adequate for the great number of data objects users handle today. People are used to organize their lives spatially – be it at home or in the office place. The world we live in is a space. It therefore seems only logical that our computer systems are spaces the more they get realistic" [142, p. 8]. Even if 3-dimensional interfaces, such as the "cave"[40] are still not available to the average user today, spatialization has become an important issue in hypertext and navigation research: Navigating and viewing large information spaces, be they hierarchical (trees) or network structure

[39] "In the hypertext literature, the notion of 'hyperspace' is sometimes used for the topological space defined in a hypertext. However most systems do not make explicit use of the spatial properties of hypertexts" [142, p. 70].

[40] To my knowledge, the cave environment of the ars electronica center in Linz, Austria, is still the only one open to the general public.

(hypertext) suffer the problems of viewing a large space on a small screen. Distorted-view approaches, such as hyperbolic visualization, have great potential to reduce these problems by representing detail within its larger context but introduce new issues of focus, transition between views and user disorientation from excessive distortion. Fisheye view graphs show the center of interest in a large scale and with great detail, while areas further from the center are successively smaller and in less detail (see section 3.7). By using forshortening on the ”Perspective Wall”, a similar effect can be achieved, cf. [327]. Hyperbolic visualization is a technique falling under the fisheye paradigm, cf. [275]. The idea is to lay out the hierarchy in a uniform way on a hyperbolic plane and map this plane onto a circular display. A commonly used technique for 3D visualization of hierarchical graphs is to represent each level as a plane at different z-coordinates. This technique is also used

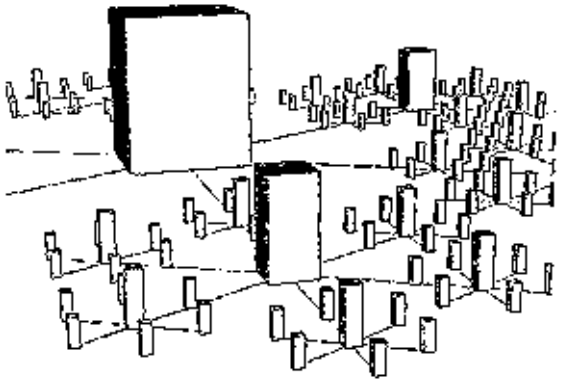


Figure 3.10: Viewing details in the cityscape-visualization of a tree. Source [275].

in the cone tree approach. In cone trees [445] each subtree is associated with a cone such that the vertex at the root of the subtree is placed at the apex of the cone and its children are circularly arranged around the base of the cone. Keskin/Vogelmann describe an implementation of the cityscape metaphor to visualize trees, cf. [275]. The cityscape metaphor is a generalization of barcharts in 3D that serves for better exploitation of human perception capabilities (see figure 3.10). They employ effective visual cues like node position and size, and determine node positions in terms of perceptual organization. In MapNet’s cityscape view, Web sites look more illusionistically like skyscrapers (see figure 3.15 on page 121).

While all these efforts fall under the term spatial hypertext in the broadest sense[41], spatial hypertext systems, as described in section 3.1.15, has been an important hypertext research topic since its inception with the first well-known spatial hypertext system, VIKI, which appeared in 1994. At the time of writing, Spatial Hypertext in this narrower sense is being institutionalized by the First Workshop on Spatial Hypertext at the Hypertext 2001, Århus, Denmark. This approach (also referred to as Information Analysis [324] or Information Triage [337]) has been proposed as an alternative to and an enhancement for ”document-centered hypertext”. By this term, Marshall and Shipman mean a ”model in which links are closely associated with navigation and mechanisms for traversal; they are a way to move from node to node, to keep readers focused on the current node or document, until they decide to move on to the next” [336, p. 88]. In spatial hypertext, on the other hand, it is possible to create and move nodes freely and to express relationships by spatial proximity and visual cues, such as color or shape: ”If we remove the explicit links from a browser, it can become a dynamic canvas for interaction” [336, p. 89]. This strategy leads to some interesting possibilities. If, for instance, a node is slightly misaligned with other nodes then this might express an uncertainty about whether this node is actually part of this relationship. In other words it expresses classification within relationships, where some nodes are

[41] As pointed out to me by Veith Risak.

more related than others. Nodes may appear in different contexts through multiple spatial references to the same underlying content, while authors may use ”any unit of text as a new element in an expanding vocabulary of signs” [68], cited in [336, p. 89]. Millard et al. summarize spatial hypertext in a conceptual model:

> ”Nodes can be aggregated (visually) thus building collections of related objects. Composites are the visual representations of these collections, they also have visual characteristics and therefore can also be aggregated into other composites, although this relationship may not be circular. These collections are typed, i.e. they may form lists, matrixes, sets, stacks etc. This effects their visual presentation but also acts as an organizational aid, adding both order and internal structure to the collections” [362, p. 95].

Spatial hypertext has arisen through experiences with applications that explore alternative structures for content and applications in which the domain structure is not well understood at the outset. In situations that promise changes during the course of a task[42] and the blurring of the roles of reader- and authorship, this approach is most valuable:

> ”Spatial hypertext is most appropriate when there is no distinction between readers and writers, and more prescriptive design methods might hamper exploratory structuring” [336, p. 89].

Many of these applications involve the collection, comprehension, and interpretation of diverse materials, often collaborative efforts, cf. [449]. Systems such as Aquanet, the Virtual Notebook System, NoteCards, VIKI and VKB allow structure to emerge very gradually, as people work with the visual characteristics and spatial positions of symbols: ”Spatial hypertext is thus inherently flexible, decidedly less formal than other models of hypertext, and readily supports volatility and change” [336, p. 91]. The flexibility results from the combination between a pictorial language, natural language (full-text) and the hypertext concept.

Aquanet uses relations rather than links: Links may be described as disjunctive substructuring, in contrast to relations which are conjunctive: whereas a user may typically choose any link out from a lexia, a relation exists among all of its slots: ”Disjunctive substructuring is ’or-based’ but conjunctive substructuring is ’and-based”’ [449]. Rosenberg himself proposes a concept called simultaneities, which have unnamed structurally equal slots [448]. In this system, the acteme consists of moving the mouse cursor among different no-click hot-spots, each of which opens a different slot, or moving the mouse cursor out of all of these hot-spots, which closes the simultaneity.

VIKI includes spatial aggregates (i.e. piles), cf. [336]. The acteme (still in Rosenberg’s terminology, see section 3.4.2) here is to click on a partially obscured element of a spatial aggregate, bringing it forward where the whole object is visible. Both spatial aggregates and simultaneities are conjunctive and non-directional.

Storyspace offers, in addition to conventional links, spatial placement of ”spaces” in a map view, cf. [265], when opening a space may reveal a lexia or a further map. Spaces used in this way resemble piles and ”the acteme is opening a space” [449].

Another form of spatial hypertext substructure is the set. HyperSet used an explicit formal set paradigm, and VIKI incorporates sets (called collections) as a substructuring method, cf. [413], [336]. For Rosenberg, ”set-based actemes include choosing a superset (possibly closing the current element) or opening one of the elements of a set. Sets offer a quite

[42] See section 3.1.15 on the genesis of the spatial hypertext approach and section 3.2.2 on groupware.

complicated picture. There is a clear notion of 'up' and 'down' (up to superset, down from set to element) making sets somewhat directional. Choosing a superset is arguably disjunctive; whether opening an element is conjunctive or disjunctive will depend on the specific hypertext" [449]. Any spatial system has to make all of these relationships explicit in the system so that queries can be made of the information and that visual information can be stored economically. To this end many systems use spatial parsers to convert the implicit spatial relationships into explicit associations within the system. It is this parser that recognizes the way in which nodes have been lain down and decides on an appropriate structure to store the information such as a list or a set, cf. [485], [363, p. 95]. Geometrically-based relationships arise from spatial configurations of nodes: "Nodes may be close to or on top of each other (be proximate); nodes may be under, over, to the left of, or to the right of one another (show deliberate alignment in either the x or y dimension); or nodes may be clustered or grouped (set apart from other elements of a space)" [336].

In document-centered hypertext, spatial relationships can be visualized by intensity of link colors: the color of the link marker fades in correlation with the spatial distance of the node. Yet, this scalable distance must not be confused with the levels in a hierarchical tree structure. It has also been proposed that distance in a hypertext is better conceptualized in terms of time to get to a destination node, measured by the number of clicks, or number of hierarchical levels that need to be traversed, cf. [490].

The omnipresent desktop metaphor in today's graphical user interfaces (GUIs) plays an ambiguous role in the further spatialization of hypertext. Thus, until the advent of feasible VR solutions, the spatial hypertext systems have to deal with the restrictions of the two-and-a-half-dimensionality of the GUI desktop: Windows can be raised, piles can be made, relief buttons can be pushed down, but the "computer screen, however, is a vertical plane. We can therefore not be deceived by expressions like 'at the bottom' or 'at the top'. These do not refer to depth below the surface, but to the lower and upper part of the screen [...] The origo of personal deixis, the 'here', is naturally situated by the window where the action takes place" [247, p. 566-67]. Using the desktop metaphor for vertical computer screens means turning tables. By force of gravity, objects can only sit on top of the table surface, arranged side by side in a certain order or in heaps and piles on top of one another, but they cannot float in space, cf. [18], [336]. As we will see, lifting the desktop in a fronto-parallel position also involves the need to organize its content in accordance to the viewer's upright body, cf. [384].

Furthermore, except for the "clean up my desktop" function that neatly arranges the desktop icons, the current operating systems do not take any account of *how* the GUI icons are arranged on the desktop or within the windows. Again, the virtual desktop does not display any distance in the third dimension, it is flat. According to the sticky-note metaphor, the objects on its surface are indefinitely thin, and the spatial distance between piled objects cannot be measured. The obvious conflict with the window-metaphor, which implies a depth of space, seems to have little influence on most GUI-based information systems. But in a system that builds upon the construction of information by creating flexible relationships and the "space" in which this action takes place, cf. [337], the multiple metaphor mismatches could be a threat. Having said that, one must admit that spatial hypertext systems do not require a rigid adherence to a strict two-dimensional topology. In this aspect, spatial hypertexts function like collages – an achievement of Synthetic Cubism – portraying space as a total object, cf. [455], [201, Collage]. While the invention of the collage may have reintegrated the image by drawing it out of fictive depth and flattening it against the surface as silhouettes, it did not solve the question of composition. Each projection of an image – flat as it may be – such as an object in a spatial hypertext system, a pasted imitation-woodgrain wallpaper on a drawing, or a woven flower on a medieval tapestry, is part of two different reference systems. Even in early medieval art, which seems to be based mainly on semantic principles (size corresponds to importance, grouping to relationships

etc.), the mechanic reproduction of spatial relationships was *always* linked to the arrangement of forms on the picture plane – in other words – the composition, cf. [410, 509]. In order make their pictures work, artists have been sacrificing spatial relations to the aesthetic norms of the medium for centuries.

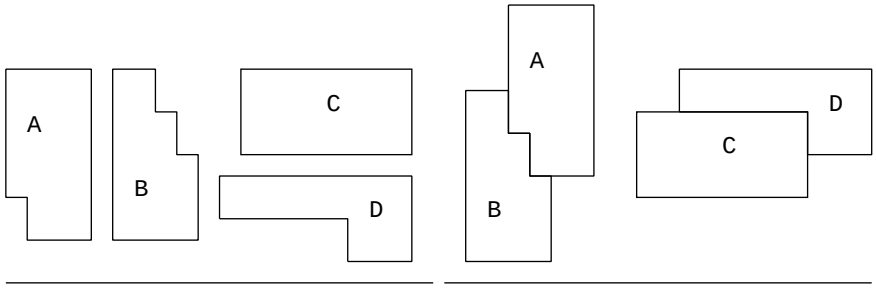
The reason for this semantic violation is embedded in the nature of the human eye, an interactive sensor that demands a certain organization of the pictorial field, a balanced composition. In a balanced composition all such factors as shape, weight, direction, and location are mutually determined by each other in such a way that no change seems possible, and the whole assumes the character of "necessity" of all parts, cf. [17]. This rule does not only apply to fine art, it has always shaped our daily lives but has only been canonized by graphic designers since the beginnings of modern advertisement in the twenties, cf. [359, 18].[43]

Pohl and Purgathofer have shown that people also try to organize information to make it look "right": In experiments concerning the authoring process of hypertext documents, their students have spent a significant amount of time to arranging nodes on an overview map, "an indication for the importance of the visualization of information in hypertext," [422]. The human need to compose objects on a surface is bound to interfere with hybrid activities like the collaborative construction of meaning (in which the space must be intelligible to a number of people). But where does this desire come from?

In his reflections on the innocent eye, Danto points out that some animals (such as doves) have pictorial competence (but that they can categorize only what they know), cf. [120, pp. 25-28]. Elkins claims that nonart or non-Western images tend to be just as "perceptual" as Western art, cf. [160]. Psychologists have shown that a dynamic center is invariably present in every visual field, but that human beings experience the world as being anisotropic, or non-symmetrical: "Unlike the space of the physicists, the phenomenologist's ether is heavier at the bottom than it is at the top, denser in the back of objects than it is in front of them, and different on the right side than on the left," [66, p. 89]. Arnheim proposed that the interaction of these two tendencies, which he calls centric and eccentric tendencies, represents a fundamental task of life and that in almost every practical case both systems are at work, cf. [18]. He claims that a frame determines its own content and establishes its own center simply through the dynamic interaction of the four sides – a center based on visual equilibrium and only roughly coinciding with the geometric center. In other words, rotating a spatial hypertext alters its meaning. Furthermore, certain shapes have certain functions in a composition: A round shape is so complete and stable in itself that it adapts itself badly to the context of a composition, an oval is prescribed by the demands of the setting it bedecks rather than those of the composition it encloses, a geometrically correct square looks too high. While the latter phenomenon is due to the anisotropy of space, which makes us overestimate distances in the vertical, other visual phenomena have to do with induced spatial relations of shapes, such as depth by color or depth by overlapping (figure 3.11): Four simple shapes A, B, C and D are arranged in two different ways, (a) and (b). While the shapes of (a) seem to be lying on the same picture plain, they suggest a spatial depth in (b). Note that the shapes A and C, whose lines continue straight at the point of confrontation, are placed in the foreground by our vision.

The semantic relations suggested by our "creative eye" may be unintended, or even nonexistent and our interpretation of visual information relies on assumptions we know to be false but cannot change: Whereas the explicit transitions from one locality to another are part of any hypertext, that does not mean that spatial hypertext is immune to the need for composition, for conventional spatial topologies may apply locally. Thus, even the "multiplanarity" of opening a collection (e.g. in VIKI) to fill the window does not inhibit the dependence of semantic relations on the composition.

[43] These principles, of course, have been ported to Web design, cf. [458].



(a) Shapes do not suggest overlapping. (b) Shapes suggest overlapping.

Figure 3.11: Depth by Overlapping. Source: [17, Fig. 186].

Keeping this in mind, let us go back to the artists' studios for a moment: By soaking their paint into the canvas, Barnett Newman and Mark Rothko avoided the connotations of a discrete layer of paint on top of the surface (future research could include a comparison of their soaked canvases with the transparent text fields of Visual Knowledge Builder). And with a new kind of flatness gained from a darkened, value-muffling color, the omission of the frame and their mere size, Newman's painting escaped the "object" associations that normally attach themselves to the easel picture. Newman's works have to be called, as art critic Greenberg pointed out, "fields", cf. [201, American Type Painting]. Jackson Pollock had painted his drippings horizontally on the floor but lifted them up to judge their visual qualities, cf. [454]. In some works of Mondrian, "neither the composition as a whole nor any of its parts is permitted to act as a center around which the neighboring shapes might organize hierarchically," [18].

But how can these findings be adopted to explain the tension between spatial hypermedia systems (the working interpretive structures) and the virtual desktop (the finished presentational structure)? If it is true that the frame establishes the picture and that an object is always compared to its surroundings, any effort to solve the conflict between the need of the "eye" for a compositional balance and the need of the "mind" for semantic relations has to focus on the involvement of the user with the system. Spatial orientation influences the way the object is perceived, cf. [18].

Spatial hypertext, before setting out for the stormy waters of the third dimension (which, again, has already been explored by installation artists in the last decades), will have to undergo a questioning processes: We will have to contemplate how to create "information fields", instead of framed picture planes (while VIKI's collections serve this purpose in a certain way, the window metaphor's frame always pulls back the view and therefore inhibits the necessary oceanic feeling that is needed to overcome the power of composition). In Arnheim's words, only the blue sky has no composition and no center, cf. [18]. For only if he is "in the picture" (Pollock), can the user of a spatial hypertext system suppress "the modest satisfaction experienced by a housemaid who arranges knickknacks on the mantelpiece in symmetrical order", [17].

Once the interface looses its object-like character, the desire to structure it by means of composition may become marginal. On a conceptional level, the multiple desktops used in the Linux Graphical User Interface might serve as a point of departure for this journey. Technical experiments might involve over-dimensional touch screens or other projection techniques. It seems promising to perform studies with horizontal monitors, reflecting Walter Benjamin's distinction between painting, the "longitudinal cut" of representation and drawing, the symbolic "transversal cut" that encloses signs, cf. [45]. The aim, however, is to enable the creation of meaning according to semantic – not aesthetic – principles.

Future inputs and developments will probably concentrate on the *Seven Directions for Spatial Hypertext Research* drafted out by Shipman [483] for the First Workshop on Spatial Hypertext.

In her position paper for this workshop, Mancini draws two parallels between spatial hypertext systems and cinematic language: between the visual shapes used in spatial hypertext systems and the iconic nature of the minimal units of a film, the shot; between the loose relationships of adjacent hypertext nodes and the transition between the cinematographic shots, cf. [330].

3.4.4 Time-based Hypermedia

Mark Bernstein [55] describes a series of structures that are derived from extant instances of hypertextual practice. These structures, each conceived of as the outcome of a series of nodal relations, bear a remarkable similarity to the patterns or rhythms adopted in cinematic narrative. However, the main difference between Mark Bernstein's *Patterns of Hypertext* and the patterns employed by cinema is that:

> "Films by their very nature are literal, temporally controlled linear sequences, unlike what is pragmatically understood to be hypertext where multilinearity retains an ideality actively sought by many. Hypertext, unlike traditional cinema, provides for nodes that can be reused, or reappear, in any particular pattern, and this practice of reuse or repetition is one of the principal methodologies employed in hypertext writing (and reading)" [361].

While an individual node shares similar qualities to the cinematic shot[44], "it is the development of syntagmatic series that concerns hypertext narration, whether fiction or nonfiction" [361]; cf. [329].

Time-based hypermedia has integrated hypertext functionality into film (or video) and music (or sound, in general): In respect of how to link *within*, *out of*, and *into* video files, the earliest approaches and experiences have been made with the InterVideo system, the work with the *Elastic Charles* project and *The Interactive Kon-Tiki Museum*; cf. [205], [74], [320]. Brøndmo and Davenport used Micons (moving icons that take the form of a short digital sample of the contents of the video they are used to represent) as link indicators *within* video sequences: "When linking from video to video, a Micon appears on the video screen as the link it represents becomes relevant and disappears once the link is no longer relevant" [74]. To develop a device pointing *out of* a video sequence by means of an ostensive reference, Liestøl borrowed a convention from the Apple Macintosh GUI: "When a document is opened or closed, the relationship or link between the document window and the icon representing it is visualized by a moving rectangle zooming in or out between the two positions. [The Interactive Kon-Tiki Museum] project adopted this convention to visualize the relationship between a part of a video sequence describing a specific topic and the button that links to further information about this topic," [320, p. 221]. The jump to specific points within a longer video sequence, or linking *into* video, is rather a technical questions than a problem of hypermedia rhetoric.

The most difficult implementation task for Liestøl, was the linking out of video into text: "This problem, which demanded an aesthetic or even rhetorical solution, was caused by

[44] "The minimal linguistic unit of natural language is the phoneme, a symbolic non signifying differential element, whose combination generates morphemes successively articulated to generate the enunciation. The cinematic minimal linguistic unit is the shot, an iconic and indexical semantically rich element, which, in semiotic terms, is the equivalent of a linguistic enunciation" [330]; cf. [355].

moving from a dynamic to a static mode, and the solution was to give the text node dynamic qualities" [320, p. 220].

Hardman et al. [216] modified the Dexter Model to adept it for dynamic temporal media such as video or audio recordings and add temporal constraints to its scope. The Amsterdam Hypertext Model (AHM) supports synchronization among components by synchronization arcs (figure 3.12).

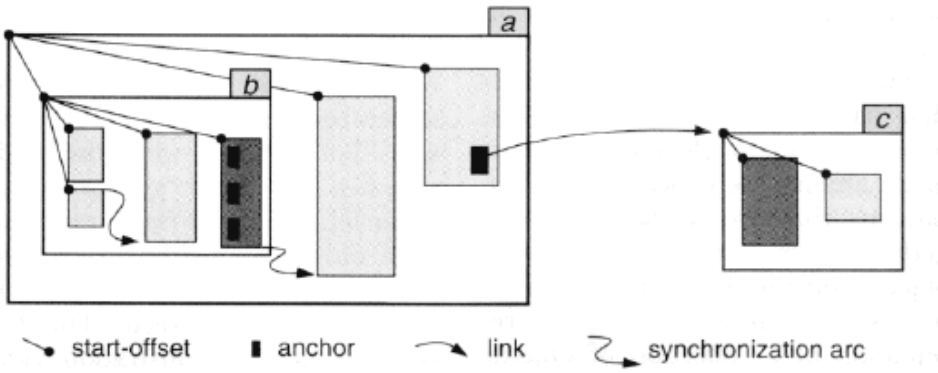


Figure 3.12: AHM components and timing relations. Source: [216, p. 58]

However, Auffret et al. [20] claim that, even customized, the traditional Dexter-like approach is still inadequate for hypermedia authoring systems. They propose a model that is based on the concept of structured documents (cf. [180]) where any source document available in the archives is referred to by using a *structured representation* of its content: "These representations can then be used as a basis for linking. [...] Once this interrelated network of structured documents is created, it can be browsed by users as a hypermedia application" [20, p. 172]. Similar approaches include (SMIL) and (HyTime).

The general problems of linking in hypermedia have been discussed by Landow [303] who establishes a rhetoric of arrival and departure. He stresses the importance of orientation and the need always to provide the user with appropriate contextual information when departing and arriving at nodes.

Some of the issues described above also apply to the field of auditory hypermedia. Obviously, the HCI to activate auditory links has to be different from Micons, because you cannot click easily on a sound. From a semiotic viewpoint, music is a pansemiotic system and its notation (or musical semiography) could serve for docking link anchors, cf. [57, 399, 194]. Blackburn/De Roure [26] concentrate on content based retrieval and navigation in music, but the question of the auditory link marker still seems to be an open field of research. However, there is a rich experience with this kind of systems from building non-visual hypermedia systems for blind users which can be applied, cf. [367], [255].

3.4.5 Personalizable Hypertext and Adaptive Systems

Although the memex was conceived a personal machine, the topic of personal hyperspaces has not been examined and developed as extensively as might be expected. According to Cunliffe [114, p. 30f.], a personalisable hypertext might include the ability of the user to add links, new link types and annotations to links, ranking, interface features and so on, allowing them to impose their own structures over the information space and create a hypertext based on personal associations:

> ”The users may be able to create and maintain and evolve their own structures within the context of the broader hypertext structure, perhaps naming and defining their own landmarks that have personal relevance. They may be able create their own tools for manipulating that space within a set of general tools provided to them, including autonomus or semiautonomus agent-based tools” [114, p. 30].

The resulting hypertext system, in terms of both its content and its functionality would be related more directly to the needs of users and their tasks. This type of system could finally lead to the blurring of traditional distinctions between readers and writers, cf. [31, 268, 304, 539]

The alternative to providing users with a truly personalisable hypertext is to provide an adaptive system, where the personalisation is system-controlled rather than user-controlled. An adaptive system may be an appropriate approach where the hyperspace is reasonably large and the intended users have different goals and knowledge. The WWW has been cited as a prime example, cf. [186, 114]. Adaptive systems have typically focused on the adaptive presentation of content and of links, or on adapting the user interface, for example in terms of the modality used, content organization, language style and linguistic choices[45]. Of course, conditional links and personalized systems have a great potential for hypertext and learning (see section 3.2.1) and eCommerce (section 4.7.1).

3.5 Hypertext Semiotics

Semiotics has been applied to the notion of the Internet as a global network, a phenomenon of wired life, and the unbounded, self-organizing, rhizomatic nature of cyberspace, cf. [524, 31, 33, 106, 150, 240]. This kind of semiotic research[46] will be treated in chapter 4, especially section 4.3. Semiotics has also entered the realms of Computer Science via Andersen’s Computer Semiotics [9] and other approaches, e.g. programming languages, Semiotic Engineering, Artificial Intelligence and Computational Semiotics, cf. [203, 501, 372, 373, 264, 127, 398, 426, 532, 555]. To broaden traditional views and to look in new directions for inspiration, guidance, and lessons is becoming more and more natural for those hypermedia, computer science and structural computing scientists, who want to position themselves ”and the larger community closer to the humanities than to engineering. One difficulty we as computer scientists face is that we have never been trained to reflect upon our own field or the methodologies we use”, [403, p. 183]; cf. [9, 404, 432]. This dissertation can be seen as part of this effort, although (or, rather: because) the author does not consider himself a computer scientist. My approach is trans- and multidisciplinary and includes economic, philosophical, and aesthetic viewpoints. Besides the presentation of concrete findings and their application on the phenomena of eCommerce, the intention of this work is to fertilize the field of Hypertext Semiotics for future research. A field which is still mined with terminology-mismatches, it has unknown border lines and is crowded with short-sighted gold-miners digging for quick results.

[45] In the Middle Ages, prayer books were personalized for their noble comissioners with their portraits, personalized calendars, etc. At the climax of this bibliographic boom, Pope Benedict XIII (1394-1423) comissioned the Avignon Pontifical with an ”adaptive user interface” for him: Each paragraph’s initial had an important function for the Pope in the matter of ceremonial procedure: “The manuscript gave him a text which told him what he must say for what purpose, that is blessing a stole or a nun or a bishop. But it did not tell him certain other things which he needed to know, such as whether to sit, or stand, or to wear his mitre. So the pictures were an essential part of the manuscript, and in this example the directions to the artists were, passed on by the artist via his image” [7, p. 71]. This manuscript is another example of the potential and flexibility derived from a combination of text and image, see section 40.

[46] This research has to be distinguished from what Søren Brier labelled as cybersemiotics: an approach to cognition, especially in ethology and biosemiotics, cf. [72, 271].

In the tradition of hypertext research in the early 1990s, several theoretical approaches have narrowed the gap between semiotics and hypertext theory. However, the rise of the WWW and a vast need for technical solutions might have inhibited the growth of a broader basis for Hypertext Semiotics. Despite valuable contributions (e.g. [399, 398, 434, 383, 332]) in the field, a lot of research has to be done to establish a firm fundament for this kind of analytic thinking. I hope that the present dissertation will be seen as an integral part of this general and multidisciplinary approach. While similar approaches (like Karin Wenz's work[47]) mostly remain in the theoretical realms of linguistics and critical theory, my findings (according to the requirements of a dissertation written at the

Vienna University of Economics and Business Administration, WU Wien) will be applied to the commercial sphere of hypertext, or, eCommerce, see section 4.7.

Semiotics has often been applied to computer science in the field of interface design, e.g. [14, 127, 426, 333]. As building ever faster, cheaper, smaller, more robust etc. machines and applications is an important branch of computer science, this development (and the growing accessibility of PCs) fosters the need to bring man and machine closer together. According to Keeler and Denning, the development of multimedia gives interface designers the ultimate challenge to develop interface technology that will simulate human-to-human communication. Referring to Peirce's semiotic concept, they try to answer the question whether human communication theory can treat the conceptual deficiencies of interface design philosophy, cf. [272]. Andersen, however, insists that, although there are some resemblances between the system concepts of Computer Science and Linguistics, "the concepts cannot be considered identical, and therefore computers cannot play the role of participant in a communicative process. Instead, they are assigned the role of a medium for communication between human users. A computer system is described as a calculus of empty expression units, some of which can be part of the sign system that emerges when the system is used and interpreted by humans" [9, p. 134]. This opinion is shared by others who have developed semiotic approaches that perceive the user's work at interface as a communication act between designers and users, using the computer as a medium, cf. [372, 127, 11, 128, 426]. In section 2.9, I have linked the psychoanalytic notion of the computer as a transitional subject and Bahr's view of machines as active counterparts that raise our receptive sensuality to superhuman levels. Analyzing hypertext as a sign system is not a mere extension of the semiotic project for the sake of completeness; rather, this approach promises insights that can help to make that medium a more useful, intuitive, rich and productive one:

> "As opposed to any form of sequential closed communications, hypermedia requires means for and ways of generating an infinity of meaningful interpretations. A non-linear structure is, after all, a graph constituted from nodes and links. The semiotic level of such nodes and links is quite abstract, but without a good understanding of these communicational entities, we will never exercise an efficient command of the process of generating the infinity of meaningful interpretations" [374].

It is commonly agreed upon that, as computers get more powerful, it is possible to invest more computer power to make the user interface more realistic. In this context, spatialization has become an important issue: "As mankind is a species used to live in a spatial environment it indeed makes sense to use a spatial concept for the overall user interface" [142, p. 61]. Enriching and spatializing a virtual world is possible in various ways,

[47] Wenz, like Landow and many other important figures in the HT research community, come from a literary studies background. The complimentary string of work is done by computer scientists, while other approaches include film and photo theory. The present dissertation is shaped by my own fields of research at the interface of art history, image theory, economics and information management.

e.g. the use of a virtual sun and virtual shadows to show the passing of time or using different sizes for information objects according to their size, cf. [505]. ”A spatialized virtual space allows moving objects closer of farther from the user. Objects that are important for the present work should be closer than others. This spatialization leads to the extension of the desktop space to room, house or city spaces” [142, p. 76]; see also section 3.4.3.

In fact, mankind shares this spatial orientation with other species, but is separated from them because it is a ”speaking-being” (l’être parlant, or parlêtre), cf. [300]. Ipsen claims that spatial deixis falls back on vocabulary describing laterality (left/right), verticality (above/below) and sagittality (front/back). The most important semantic axis, however, seems to be close/distant: Ethnologists have found that societies depend upon this dichotomy in the structuring of their mythology, villages, hunting techniques, seasonal migrations, marriage policies, etc. and Lévi-Strauss has elaborated his structural anthropology on the basis of the proximity axis, cf. [316]. The difference of close and distant, or self and other, is the first spatial/ semantic relation a child has to learn. In the early stage, transitional objects mediate between the self and the world, cf. [546]. The dialectical relation of the ”I” to the ”you” is developed only at a later stage.[48]

Some theorists assert that, unlike verbal language, the visual image is not suited to exposition (e.g. [416, 2.291]; [193, p. 138, 175]; [307, p. 88]). In that logocentric view, syntagms are defined purely as sequential or temporal ’chains’ (see figure 2.3 on page 27). Chandler argues that spatial relations are also syntagmatic:

> ”Whilst most obviously associated with art and photography, they are no less structurally important alongside temporal syntagms in media such as television, cinema and the World Wide Web. Unlike sequential syntagmatic relations, which are essentially about before and after, spatial syntagmatic relations include: above/below, in front/behind, close/distant, left/right (which can also have sequential significance), north/south/east/west, and inside/outside (or centre/periphery)” [95, Syntagmatic Analysis].

Such structural relationships are not semantically neutral. George Lakoff and Mark Johnson have shown how fundamental ”orientational metaphors” are routinely linked to key concepts in a culture, cf. [302].[49]

These aspects of dimensionality also refer to textual environments, where ”we find the semiotic paradox of the (linear) text as a three-dimensional space” [247, p, 560]. According to Wenz [538], Lotman’s thesis, which says that there are certain parallels between consciousness/text/culture points to the capacity of texts to represent our perception of space. Signs of space in texts are products of a complex process of linearization which have to transform three-dimensional space into linear and therefore one-dimensional language. The term *sign spaces* refers to the possibility of texts to create their own spaces in a metaphorical sense.

Spatial metaphors used in referring to the written text or to passages within the text create a textual space with places such as above, and below, center, and margin. These concepts

[48] Emile Benveniste argued that ”language is possible only because each speaker sets himself up as a subject by referring to himself as ’I’ in his discourse. Because of this, ’I’ posits another person, the one who, being as he is completely exterior to ’me’, becomes my echo to whom I say ’you’ and who says ’you’ to me”. For Benveniste, neither of these terms can be considered without the other: ”they are complementary [. . .] and at the same time they are reversible”, cf. [46, p. 225] and Rotman’s extension of this concept in [451, p. 30]. The connexion to the spatial dimension can be shown by the social phenomenon that the person who sits down *first* defines all other relations.

[49] The metaphor, in general, ”is pervasive in everyday life, not just in language, but in thought and action. Our ordinary conceptual system, in terms of which we both think and act, is fundamentally metaphorical in nature” [302, p. 3]. For Wenz, ”metaphor is not just a figure of speech and a linguistic phenomenon, but includes a cognitive dimension” [538, p. 576].

refer to the physical and logical form of the written text: the shape as it appears on the page and the textual structure itself, cf. [538, 247]: ”Writing is always spatial, and each technology in the history of writing (e.g. clay tablet, the papyrus roll, the codex, the printed book) has presented writers and readers with a different space to exploit” [68]. Readers form mental representations of a paper document’s structure in terms of spatial location and overall organization: Such representations or models are derived from years of exposure to the information type (e.g. academic journal articles) or can be formed in the case of spatial recall from a quick scan of the material: ”Such models are useful in terms of predicting where information will be found or even what type of information is available. Consideration of existing models is vital in the design of new versions so as to avoid designing against the intended users’ views of how the information should be organized” [144, p. 100].

On the one hand we have the two-dimensionality of the page or of the screen with its (visual) borders, on the other hand there is the one-dimensional linearity of speech and writing, as far as the result of the linearization process is concerned, and the one-dimensionality of reading in the sequence of time. At the intersection between space and time, we are confronted with ”the semiotic paradox of the spatial nature of the text” [400] which contrasts with the linearity of speech in its temporality. The metaphors of the written text with *loci* to which we can refer illustrate that the text is perceived as a static space. It has macro-textual structures, such as chapters, sections, headings, paragraphs, footnotes, etc. and is bounded by margins, a top, and a bottom to which the text makes reference, cf. [538, p. 579]. Such references construct connections between different passages in the text which are semantically connected but separated in the surface structure in the linearizing of complex ideas. Thus, the reading process follows the linear ordering from the beginning to the end and can be compared to a way from a starting point to a goal, cf. [538, p. 577].

Philosophers from Hobbes to Derrida have pointed out that there is no stopping the generation of meaning by contiguity, and spatial adjacency allows uncontrollable contiguities. While physical space allows for unintended adjacencies, in a standard node-and-link hypertext, nothing is officially next to anything else until a link is created, cf. [284] In such hypertexts, all connections are supposed to be intentional. There should be no unavoidable and uncontrollable adjacencies such as occur in physical space, e.g. if a barber shop happens to be located besides a café, the costumer can be served a coffee while waiting. Or, to cite Kolb’s example:

> ”In an office building the suite just next door may be ’miles away’ in terms of its function, so that trajectories of action that pass through my office never go through the one next door, yet because the two offices are physically adjacent, other kinds of interaction will develop. Even if the employees never eat lunch together, or never speak to one another, the contrast between the two offices will still function as an overtone of meaning on their official meanings” [284].

There may be adjacency effects also in hypertexts, due to window location and other accidents of implementation, as well as the unavoidable effects of linguistic echoes and associations. If the node-and-link hypertext includes an overview or map, then there may be additional modes of accidental adjacency within that presentation. Furthermore, textual linearity is more than mere sequence. It depends on devices which provide cohesion, such as deixis, anaphora or reader instructions of the type ”see above”. These cohesive devices construct larger syntactic entities which are hierarchically structured and in sum lead to macro-textual[50] structures, cf. [538, p. 579]. These structures can be compared

[50] Just as the reader of a linear document constructs a local and global mental representation of the document, the author of a linear document uses cues both at the local and at the global levels, ”dividing the document into chapters, sections, paragraphs, sentences, words etc. This facilitates comprehension and navigation” [518].

to landmarks (see section 3.7 on navigation) which provide the reader with information concerning his or her whereabouts. The text described in topological terms, consists of units and connections between them. Note the ethymological connection between topos – the place – and the topic, or subject, which indicates a strong spatio-semantic bond in our thinking: "With or without the computer, whenever we write, we write topically" [68]. Furthermore, typographical convention will help the reader to predict which object will follow next: a new section, paragraph, or a new sentence. Connection by reader instructions undermine partly the congruence and linearity of discourse, [538, p. 579].

Here, we think of Langer's distinction between discursive and presentational language:

> "The meanings given through language are successively understood, and gathered into a whole by the process called discourse..." [306, p. 89].

As pointed out in section 2.2, discursive in this context means sequential: Words cannot be piled one upon the other, neither can they be arranged arbitrarily in a sentence because they have to follow a pre-defined grammar. It takes time to form, listen to, or read each word of a sentence and only once you have perceived the last word of a sentence you know its meaning. Langer thought that, even if our ideas are nested (like clothes that are draped around a body), we have to string them in order to communicate them to others, like hanging them out to dry on a clothes-line: You place one piece of language at a time onto the straight line; at the end of the process the parts add up to a whole argument or proposition, cf. [307, p. 88]. The argument of hypertext is that ideas do not have to be arranged on a long clothes-line. In fact, hypertext represents a variable structure that permits an interlinked presentation of ideas.

Wenz, who is approaching hypermedia semiotics from a literary studies background, points out that spatial metaphors of textuality and hypertextuality produce a textual space which guides the reader's orientation in the process of reading. For her, metaphor is not just a figure of speech and a linguistic phenomenon, but includes a cognitive dimension, cf. [538, p. 576].

Writing and reading lead to awareness of linguistic structure and awareness of language structure, which is a product of writing, and not a precondition for its development. In the same sense, spatial configurations are not only a product, but the producers of a cognitive system, cf. [538, p. 575]. Derrida who positioned writing as being prior to speech defines writing not as the activity of writing, but as the movement of differentiation of sign systems (différance).[51] Language, like any other code, constitutes itself as a texture of differences:

> "Difference and opposition are the cognitive foundations of semiosis and therefore the precondition for every semiotic coding. This is a process which leads to an unbounded referring of signs. Writing in Derrida's sense creates networks by 'spacing of speech' and can be interpreted as a metaphor of the human mind" [538, p. 575], cf. [135]; see section 2.8.

Studies that formalize their view of the Web as a graph "ignore the text and other content in pages, focusing instead on the links between pages" [73]. Furthermore, formal graph theory sets all possible spatial representations of a graph as equal: As outlined in section 3.4.1 on graph theory, the three diagrams of figure 3.6 represent one and the same graph.

I follow those authors insisting that a theory of space is essential for any advance in hypermedia design, cf. [376, 268, 362, 449]. Spatialization plays an important role in the development of new hypertext models, such as FOHM (cf. [363, 362]) that concentrate on the nodes and links as part of a (visual and textual) sign system:

[51] Derrida sought to challenge the phonocentric privileging of speech over writing in Western culture and to demonstrate the instability of this opposition, cf. [135]. He also challenged the privileging of the signified over the signifier, seeing it as a perpetuation of the traditional opposition of matter and spirit or substance and thought.

> ”With a visual workspace, analysis proceeds by manipulating the visual representations of documents while constructing an interpretation of the task, domain, and source materials. [...] By enabling the flexible application of visual attributes, the workspace allows the codings to evolve with the users understanding of their task and domain. Over the course of an analysis, this often leads to the emergence of a visual language” [486].

The renaissance of the image (described in section 2.7) found its way into hypertext theory also via spatial hypertext: In their survey, [335] noticed that authors sometimes prefer to express relationships among nodes by using geometric cues like proximity and alignment, and visual cues like graphical similarity: ”These geometric and visual cues correspond to Bertin’s notion of planar and retinal variables. By combining geometric and visual cues, authors may build up surprisingly complex hypertext structures” [336]. The work they refer to is Bertin’s *Semiology of Graphics* [57]. According to Bertin, a network becomes a map, if the planar relationships between all parts of each component are represented by their location on the plane. Only if nodes have a ”geographic order”, we may visualize them in navigation maps, otherwise they stay topological constructs. This construction of meaning does not only correspond to our *natural* semiotic environment, but also to our cultural sign systems: It is important, if a text block in a book precedes or follows other lexia; they might be separated by other lexia, an empty page, or three more volumes. In the electronic text, we have lost the tactile connection with the medium, which used to indicate the difference between a paperback novel, a leaflet, or a book of three volumes, cf. [251,474]. Bolter [68] suggests that hypertext creates a new ”writing space”, a field whose boundaries can always be expanded by the introduction of new material.

The traces of texts and images make hypermedia an augmented reality, an enriched reality in contrast to virtual reality, the 3-dimensional, artificial reality. Schulmeister thinks that the multimedia space consists of a representation space, a symbol space, and an event space.

Wexelblat [540] invokes the term “semantic space”, an environment that is quite different from any physical or constructed/mapped space we know. The nature of this space resists easy definition as familiar metaphors from physics, architecture, and everyday experience have only limited value here ”since it is deeply connected to the production of meaning, interpretation, and other activities involving symbols” [268, p. 207]. It becomes obvious that this notion of a ”semantic space [...] involving symbols” is a proto-semiotic one: The term ”symbol” is used in its widest sense (cf. [401, p. 142]) and the ”semantic” value of the sign is seen as isolated from its semiotic context. It is not clear if the authors refer to semantics as the branch of Semiotics that is devoted to the study of the relationship between signs and their objects (to be exact: between the sign vehicles and their designata). It seems, rather, that they refer to ”semantic” as ”relating to meaning” in the most general sense. I could not agree more to the general conclusion that ”semantic and architectonic spaces cannot be perfectly reconciled [and that] we should aim for systems that harmonize the two as well as possible, but which acknowledge the contingent nature of any such harmony” [268, p. 215]. Yet, it seems important to place this conclusion in the semiotic context. In this discussion of the roots and aims of Hypertext Semiotics, I believe that changing ”symbol” to ”sign” and ”semantic” to ”semiotic” in Kaplan/Moulthrop’s definition is more than a mere terminology purism: Semiotics and that branch of linguistics known as semantics have a common concern with the meaning of signs, but John Sturrock argues that whereas semantics focuses on *what* words mean, semiotics is concerned with *how* signs mean, cf. [511, p. 22], [95, 154, 155]. With this in mind, let us go back a few lines in Kaplan/Moulthrop’s argumentation to show the impact of this maneuver.

They criticize Marshall and Shipman’s conception of Spatial Hypertext (see sections 3.1.15 and 3.4.3) as reflecting only one aspect of the complex phenomenology of virtual space:

Their general idea of space ”tends to collapse into the much narrower domain of *screen real estate*. The user’s manipulation of objects within a graphic representation implies some related transformation in a mental or linguistic space, but that space is accessible only through the representation. Space comes to be defined in terms of the active window on a display screen” [268, p. 207].

So, if Marshall/Shipman’s concept of spatial hypertext invoke architectonic space in the context of writing, ”semantic [read: semiotic, MN] space emerges more clearly in the act of reading or reception – though since hypertext tend to blur the roles of reader and writer, these distinctions cannot be absolute” [268, p. 207]. The semiotic space I impose on hypertext has more to do with Lotman’s ”semiosphere”, a pansemiotic space outside of which the existence of semiosis is impossible.[52]

The concept of space used in this account shares little of the clarity and unambiguousness of architectonic space. As McKnight et al. [348, 169-190] observe, the psycholinguistic or semantic space of a text (electronic or otherwise) can never be represented with perfect accuracy by any physical system: ”We cannot navigate semantic space, at least not the way we navigate physical environments, we can only navigate the physical instantiation that we develop of the semantic space” [348, 187]. Harpold, who applies a ”semiology [of] Lacanian flavor” discusses hypertextual linking as detour, not a definitive trajectory from departure point to arrival point, but an elliptical and fundamentally uncertain displacement. The hypertextual detour, he says, is ”a turn around a place you never get to, where something drops away between the multiple paths you might follow. The consequence of this falling away is that the fabric of a hypertext is riddled with holes” [217, p. 172f.].

As I have laid out in section 3.4.1, one of the most important axioms of graph theory, the main reason for its functionality in topological calculations is the Achilles’ heel of hypertext graphs: ”In graph theory all that matters is the pattern of connections: the topology, not the geometry” [222]. Accordingly, the three diagrams in figure 3.6 all depict the same graph. Furthermore, the directed graph does not show the ”holes in the fabric of hypertext” Harpold talks about. Besides the navigation of the physical links, the reader interprets the content of each node syntagmatically and builds his own paradigmatic associations (which he may, or may not make explicit by authoring annotations or links). The consideration of semiosis as a force that works both on the node and the link levels explains the similarities between hypertext, language and thought, cf. [25, p. 6-9], [62, 521, 517, 108]. Kaplan and Moulthrop continue:

> ”In the directed graph we can see clearly where we have come from and where we are going; but this is not the case in semantic space. For every point of actual arrival in a hypermedia text, there are an unspecified number of places we never get to, alternative destinations which the system has either disclosed to us, and which we have chosen not to visit, or which may be simply undeveloped or unexpressed in the current version of the text. Semantic spaces are n-dimensional, as McKnight et al. [348] point out, while architectonic spaces have at best three dimensions, and more usually two” [268, p. 208].

While architectonic space (including the liquidly architectonic space of the computer screen) is always either empty or filled, in semantic space, the default condition is not definitely

[52] Thinking in ’ecological’ terms (e.g. biospheres) about the interaction of different semiotic structures and languages led the Russian cultural semiotician Yuri Lotman to coin the term semiosphere to refer to ”the whole semiotic space of the culture in question” [323, p. 124-125]. Whilst Lotman referred to such semiospheres as governing the functioning of languages within cultures, John Hartley comments that there is more than one level at which one might identify a semiosphere – at the level of a single national or linguistic culture, for instance, or of a larger unity such as *the West*, right up to *the species*; we might similarly characterize the semiosphere of a particular historical period, cf. [219, p. 106], [95, 401]. This conception of a semiosphere ”may make semioticians seem territorially imperialistic to their critics, but it offers a more unified and dynamic vision of semiosis than the study of a specific medium as if each existed in a vacuum” [95, Introduction].

empty but rather indefinitely filled. A semantic space (as defined by them) is a domain of possible expression: ”It is semantic because it is the place where meanings or interpretations come into existence; and in hypertext [...] there is always a surplus of meaning” [268, p. 208]. By substituting, again, semantic by *semiotic* space, McKnight’s ”domain of possible expression” [349] can be firmly based on principles of unlimited semiosis (see section 2.5).

Kaplan/Moulthrop [268] offer two design exercises that underline their critical review of navigation and information mapping. Their approach to these issues is guided by Winograd and Flores’s notion of “ontological design”, a design philosophy based on the recurrent breakdown that addresses human-machine interactions in terms of complex environments instead of simple, end-directed functionality.

> ”In Winograd and Flores’s theory of design, this coupling of architectonic and semantic spaces manifests itself as breakdown, or the moment when the constraints of a particular formal system become apparent by juxtaposition with their alternatives. As a defining instance of breakdown, they cite ELIZA’s infamous response to an exasperated subject who announces, ’I am swallowing poison’. The program replies, ’How long have you been swallowing poison?’ [547, p. 121]. Assuming we are not dealing with a Hannibal Lector, we would not expect any human psychiatrist to give such a response. ELIZA’s imitation breaks down at this point because we are confronted with a case that falls outside its linguistic parameters. We have dropped out of architectonic space (the space of rule-bound knowledge representation) into the more chaotic space of language and cultural assumptions” [268, p. 208].

Given my re-definition of the semantic to a *semiotic* space, I strongly support their conclusion that any attempt to represent this juxtaposition in stable, objective terms must inevitably reach a breakdown situation. As semiotic space resists isomorphous[53] transformation to an architectonic space, all navigational tools based on a travel metaphor (see section 3.7 on navigational metaphors) can only succeed by actively using bricolage techniques. If system designs are to reflect an intelligent anticipation of such breakdowns, we must understand that any attempt to represent the two domains of virtual space, the architectonic space of mapping and the space of semiosis must inevitably reach a point of obvious constraint. In fact, bricolage is a magnificent technique to deal with breakdown situations and unbridgable, or unintelligible antagonisms.[54] Thus, research that is aiming at developing ”intuitive” interfaces should be disposed to adapt and extend structuralist methods: ”If it is true that the systems are the real things and humans only manifestations of them, then the most sensible way to build a computer system is to begin by constructing the system, without regard if to whether processes are performed by human or computer” [9, p. 135].

Spatial Hypertext developers have become aware of these issues and the breakdown situation and call the bug (”mismatch between architectonic and semantic spaces” [268, 348]) a feature (”ability to leave structure implicit and informal” [336, p. 90]). Marshall and Shipman claim that the characteristics of spatial hypertext include ”the separation of symbol and underlying content [and] the use of these visual symbols to create hypertextual meaning” [336, p. 90]. What they mean by ”the separation of symbol and underlying content”, is actually a development of a language that can draw on visual signs as well as on written signs.

In our normal lives, we use several sign systems at the same time to communicate with our environment.

[53] Langer uses the term analog, cf. [306].

[54] Lévi-Strauss coined the term bricolage as the process of creating something not as a matter of calculated choice and use of whatever materials are technically best-adapted to a clearly predetermined purpose, but rather in a ”dialogue with the materials and means of execution” [317, p. 29].

The semiotic systems we use include

perfumes to support or overrule our biosemiotic olfactory communication channels,

clothing to hide or underline significant parts of our body or to express meaning,

architecture to signify spiritual or profane importance of buildings,

our bodies to show sympathy, interest and enthusiasm (or the exact opposite).

We use these codes simultaneously and we use them in concerted action (cf. [401, 154, 155, 477] for an overview of the different sub-disciplines of semiotic research). For example, if we want to communicate to our business partners that we are interested in a long term relationship, we will not only tell them verbally, but use other codes as well, e.g. invite them to an exclusive restaurant, show them our premises, switch off our mobile phones while we are in a meeting with them, etc.

In computer interaction, however, we have to separate and omit most of these sign systems. On today's terminals, we can either write (command line interface) or point (GUIs), but we cannot fully reproduce the integrated, multi-channel communication of real-life actions, like negotiating. Following Schmauks's vision of deixis in HCI, Ipsen comes to a similar result: "Pointing actions consist of verbal and nonverbal components, resembling multimedia actions" [247, p, 560]. He takes the example of a customer asking the question "Is this computer IBM compatible?" accompanied by a pointing movement of our finger (☞) at the shelf: "Here, linguistic ('this computer') and gestural (pointing finger) means of communication are used. In computing [esp. in hypertext, MN], language is assisted by other pointing tools, such as the cursor moved by keyboard or mouse, a figure on the screen, or other graphical devices. In cyberspace, a representation of one's hand may appear" [247, p, 560].[55] Of course this shopping example has even more facets to it: The secondary function of the question might be more important than the primary function: Instead of the message "Tell me if this computer is IBM compatible", the sender might want to communicate "I know that this computer is not IBM compatible, and I want to lower the price"; cf. [155, 43ff.].

The mouse has followed the keyboard as the main input device in hypertext structures. To move within the WWW, we do not have to use complicated commands but simply mouse-click on a link marker to follow the link. Thus, we point on it, using the mouse as our prolongated index finger. This is also indicated by the way the cursor changes its appearance when dragged over a hyperlink. Most standard browsers show "a view from above" on a hand with a stretched-out index finger.[56] Interestingly enough, only the LINUX version of the Netscape Navigator still uses an index finger that indicates a pointing movement in a direction ("if you follow this link, it will lead you to…") rather than a tactile pressing on an object. The German word "peilen" (to take the bearings of, to get a fix on) shares its etymology with the "Pfeil" (arrow). An arrow – in hunting just as well as in taking the bearings of celestial bodies to calculate one's position – is used for long-distance aiming, just like the finger that points on an object that is out of reach.

The touching finger is a short-ranged device identify a near-by object, that can possibly be lifted, dragged and dropped again. Most standard browsers have followed Microsoft

[55] Many other authors use the term cyberspace interchangeably for VR, hyperspace, the Internet, etc. In regards to the spatial relativity of the Human-Computer Interfaces, Ipsen continues: "There is an interface device for the user to be connected with the machine or rather with the application. By means of this interface, the user's *origo* is set to the coordinates defined by the software, which is the most crucial point of the whole story. […] The user's point of view is shifted to some virtual place that is totally separated from the real environment" [247, p, 560].

[56] Naturally, this does not hold true for all text-based browsers, such as lynx. The Guide system had four different cursors, according to the link type, see section 3.1.10.

Internet Explorer's adaption to the desktop metaphor: The drag & drop metaphor highlights the implied tactile relationship between the user's hand and the objects on the GUI's virtual desktop, cf. [251, 474]. By showing the mouse pointer as an index finger that taps on the link markers, the spatial character of the hypertext docuverse was tied to the "small world" on the top of a virtual writing desk[57].

The pointing finger and the index are etymologically connected with *digitus index*, the Latin word for forefinger. In printing, index refers to an arrow-shaped character to call attention to a particular paragraph or section. In this function, the index is somehow related to the bookmark, as it marks (indicates) a point to start reading. The pictorial connection of the index finger (☞), the pointing act and the concept of leaving a mark became very strong in book illustration: In a certain medieval illuminated manuscript, the script/illustrator Isodorus shows himself writing the inscription in which he says he executed the picture in his Gospels: "His pen is once again on the letter 'x' of 'finxit', in a clever conceit which draws attention both to his making of the manuscript ('finxit – he made it) and shows him as if in the process of actually writing it" [6, p. 18]. In Latin codices of the *corpus iuris civilis*, we find little drawings of hands and index fingers that mark certain passages. In a fresco cycle in the Palazzo Pubblico of Siena, we see a little boy that can be interpreted as a "personification of the index finger" that we usually find in the codices, cf. [213, p. 140]. The notion of leaving a mark is, of course, also connected with the finger print, a unique sign of individuality and an indexical sinsign in Peircean terminology, like the hand signature, or the electronic password, cf. [375]; see section 2.4 on sign classifications.

Ipsen's example shows that combining communication channels (e.g. linguistic and gestural) produce meaning economically: Being precise in just one of the channels affords much more time and cognitive effort: "Is the forth computer from the left on the second lowest shelf on the right hand side of your showroom IBM compatible?" or asking the question in a charade-like manner. In both cases, the coding in a single channel complicates the communication significantly in comparison to the multi-channel variant, cf. [247, 98, 88].

Let us stay with the notion of language (esp. its discursive qualities, cf. [306]) and Harpold's hypertextual detours, cf. [217, p. 172f.]. Reading nodes means putting them in a syntagmatic sequence, distinguishing between a main string of rhetoric (connection) and possible detours (associations).

Benjamin Whorf introduced the concept of the *connection* of ideas as "quite another thing" from the *association* of ideas. While the former corresponds to a controlled association, the latter has "an accidental character" as the subject "jumps at the first idea that comes to [his] mind. [...] One of the necessary criteria of a connection is that it be intelligible to others, and therefore the individuality of the subject cannot enter to the extent that it does in free association, while a correspondingly greater part is played by the stock of conceptions common to people" (Letter to Horace B. English, first published in [545, p. 37]).

In the context of hypertext, one might argue that the chain of nodes that the author/reader links or follows, form a sentence-like structure based on connection. The path that the user *did* follow assigns to those links which were *not* followed the status of assotiations, reminding us of Saussure's syntagmatic chain as opposed to the associative, or paradigmatic, axis described in section 2.2). Hypertext contains disjunctive substructuring, or, links, as well as relations, which are conjunctive. This passage from Dick's Valis ties most of these issues to the semiotic and cognitive research presented earlier:

> "Journal entry 37. Thoughts of the Brain are experienced by us as arrangements and rearrangements – change – in a physical universe; but in fact it is really information and information processing that we substantialize. We do

[57] Consequently, the Opera browser allows to drag links out of the browser window. On dropping the link, the users get asked whether they want to copy the *node*, or the *link* itself to the new location.

> not merely see its thoughts as objects, but rather as movement, or, more precisely, the placement of objects: how they become linked to one another. But we cannot read the patterns of arrangement; we cannot extract the information in it – i.e. it as information, which is what it is. The linking and relinking of objects by the Brain is actually a language, but not a language like ours (since it is addressing itself and not someone or something outside itself)" [139], as cited in [28].

Of course, this description of an uncontrollable process in the brain reminds us of what is probably the most over-quoted Lacanian phrase: "The unconscious is structured like a language."[58] Lacan stresses the importance of his choice of situating this *comme* (like) in-between language and the unconscious. He explicitly contrasts comme with *par* (by); the unconscious is structured *like* a language, but not *by* a language: "You see that by still preserving this 'like' (comme), I am staying within the bounds of what I put forward when I say that the unconscious is structured like a language. I say *like* so as not to say – and I come back to this all the time – that the unconscious is structured *by* a language" [301, p. 48] (my emphasis).

Generally, hypertext is defined as the use of the computer to transcend linear, bounded and fixed qualities of the traditional written text, as it is composed, and read, non-sequentially: "It is a variable structure, composed of blocks of text (or what Roland Barthes terms lexia) and the electronic links that join them," [129, p. 3], cf. [37]. The passage from one node to the other (or, navigation, see section 3.7) is based on the selection and combination of elements. As stated in section 2.2, the act of navigation means a linearization of those nodes that the hypertext user chooses to read along a personal thread that is laid upon the network. According to Wenz [538, p. 581], such linearization can be compared to linearization processes which underlie the transfer of complex and simultaneous nonverbal perceptions into language, as different possibilities of selection in different situations create a multiplicity of linear discourses. It is important to remember that already Langer has described the discursive process (see section 2.2) as making the meanings given through language successively understood, cf. [306, p. 89]. The virtual multiplicity of linearities depend on different reader perspectives and contexts which can be chosen.

Following Liestol [321], Genette's discourse–story dichotomy has to be extended with hypertexts to cover the discoursed text, or, as he calls it, "discourse-as-discoursed" [321, p. 96]. For him, "non linear is an empty term in the discourse on hypermedia that only shows how preoccupied writers on the subject have been with defining hypermedia in opposition to traditional media" [321, p. 110]. Wenz concludes:

> "Therefore, multiplicity of linearity instead of non-linearity should be the key word in discussing the reading process in hypermedia" [538, p. 581].

Of course, the critical reader is reminded of Kristeva's concept of intertextuality which divides the text into two axes: a horizontal axis, which is the linear connection between author and reader through the text, and a vertical axis, which connects the text to other texts "of the anterior literary corpus and the text as an absorption of a reply to another text" [291, p. 69]. These two axes create a two-dimensional space. There is no fixed position in the connection between these four elements. There is only movement between author, reader, text, and intertext, cf. [434]. This movement is the movement of différance, only available as a trace which can be elucidated in interpretation. The virtual presence of many voices is interwoven in these intertextual relations. As Barthes puts it, "the text is not

[58] Adrian Johnston argues that – like both the Queen and the Minister in Poe's *The Purloined Letter* – Lacan too is made to "silently witness the removal of a letter of his by a certain translation and ensuing set of interpretations" [260]. This particular letter is – for Johnston – the famous quote.

a line of words but a multidimensional space in which a variety of writings, none of them original, blend and clash" [38, p. 146].

In conclusion of this section, which forms the core of my prolegomena of a theory of hypertext semiotics, I do not think to have produced a new "hypertext model". Yet, I was able to interlace the existing models with the findings of semiotic research, on all levels of the textual, aural, visual, tactile and olfactory channels.[59] While this connection between hypermedia and the field of media semiotics is clearly visible in Nöth's *Semiotics of the Media* [399], computers play no role whatsoever in Bignell's *Media Semiotics* [63] published the same year! The long-term goal of Hypertext Semiotics (as I see it) is to enhance hypermedia as a multi-level semiotic system that incorporates spatio-temporal aspects, the power of the image and "language as the ultimate upgrade" [98, p. 182].

3.6 The Usability Approach to Hypertext

As indicated in the paragraph about the Dexter Reference Model at the beginning of section 3.4, "hypertext is fundamentally different from traditional databases from a user perspective" [387, p. 8], cf. [439, 438]. The propinquity of this approach to semiotics becomes apparent by the role that sign systems play in the construction of reality: "Although things may exist independently of signs we know them only through the mediation of signs. We see only what our sign systems allow us to see" [95, Strenghts].

Nielsen defines usability within the scope of system acceptability: Given that a system is socially acceptable, we can further analyze its practical acceptability within various categories, including cost, support, reliability, compatibility and usefulness. Usefulness is the issue of whether the system can be used to achieve some desired goal. Following figure 3.13, it can again be broken down into the two categories utility and usability, where utility is the question of whether the functionality of the system in principle can do what is needed and usability is the question of how well users can use that functionality, cf. [387, p. 144]. The usability of a hypertext system is determined by a combination of the usability of the

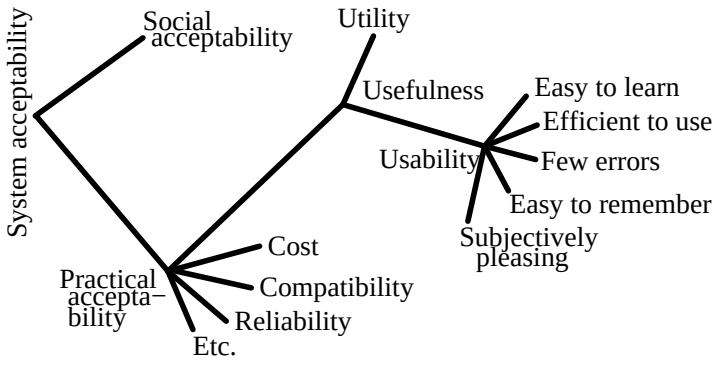


Figure 3.13: Parameters associated with system acceptability. Source: [387, p. 145].

underlying hypertext system engine and the usability of the contents and structure of the hypertext information base, and by how well these two elements fit together. From the user's perspective, all of these elements are of course seen as a single interface, and the user will not care whose "fault" it is if something is not usable. From an analytical perspective, of course, the distinction between the underlying system and the information base is an advantage, cf. [387, p. 145].

[59] Gunther Kress and Theo van Leeuwen underline the need to recognize that these "different semiotic modes [...] have their potentialities, and their limitations" [290, p. 31], cf. [251, 474].

Numerous studies have showed that users find the current hardware support for hypertext systems less convenient than paper and that their reading speed and accuracy drop by ca. 30% when reading from displays, cf. [552], [392], [199]. Anti-aliasing (a computer graphics technique for fonts using gray-scales instead of black-and-white only pixels), sensible color coding and larger displays can smoothen the difference, but never close the gap.

The field of action where man meets machine (a transitional subject, as shown in section 2.9) is the user interface: "The human-computer interface (or user interface) is the connection between a user and an object to be used by this user. This object may be as simple as a light-switch" [142, p. 54]. Risak [439, 438, 443] underlines that Human-computer interaction (HCI) is a triangular relationship between the user, the computer and the task. For Dillon,

> "Human-computer interaction can be conceptualized as a communicative dialogue whose purpose is to complete a task. The interface is therefore the communication channel afforded by the computer, allowing transfer of modality independent information between machine and user. As a communication channel the interface is both physical (keyboard, mouse, display) and representational (iconic, metaphoric) i.e., it offers the means of control as well as providing a model of its operations. . . " [144, p. 93].

De Souza et al. single out semiotics as a promising new player on the stage where cognitive and social theories contribute to provide insights about HCI. They encourage scientists and technologists to devise methods and tools to help designers achieve better quality in software design, cf. [128, 426, 127]. Under the name "Semiotic Engineering", they accumulate semiotic theories that can help HCI designers increase their power to perceive, reason and communicate.

For Engelbart, the sensorimotor system ("the body") is at the interface between the "mental part" of the human being and the "outside world", cf. [162]. The deliberate decision to "begin with the basics" of HCI for hypertext led Engelbart and his group to develop a series of artifacts that mirrors the importance of the body on the computer side of the interface. Among the various devices developed by Engelbart and his group at SRI, the most famous is the mouse (see section 3.1.4 on NLS and Engelbart's work at SRI). Bardini [28] points out that the invention of the mouse was inspired by the planimeter which had been re-invented by Vannevar Bush in 1913 as his Master's thesis project at Tufts College. Bush called the device that he invented (by using the principle of the planimeter) a Profile Tracer, "an arrangement of gears, shafts, and servo-driven pens which translated mechanical motion into graphical mathematics" [409, p. 29]. As the conceptual grandchild of the planimeter, the mouse also translates motion (the arm of the holder) into graphical mathematics:

> "It therefore not only allows the user to point at any object on the screen, but also introduces a direct connection between the topographical space of the interface and the human gesture of the user. By extension, the invention of the mouse opens space for any translation of human motion into the electronic space of the computer interface. This point is fundamental in that it allows us to evacuate definitively the notion of cognition as purely intellectual representation, to introduce instead the 'embodied action' in the computer space" [28].

The introduction of space into hypertext and the mouse as a prolonged index finger have been treated in sections 3.4.3 and 3.5. According to the shift from keyboard to mouse to VR, Brown [77] sees an evolutionary development from symbolic to iconic and finally indexical interfaces:

> ”The first generation interfaces that used keyboards and command/control languages were concerned with Symbolic (linguistic, alphanumeric) communications. [...] The second generation (Menu-based, WIMP) interfaces involve Iconic communications. [...] Iconic interfaces allow gestalt methods of recognition and simple *point ‘n pick* input. The iconic bonding to the reference ’reality’ is intuitive (at least within cultural groups that share similar conditioning). [...] The newer interfaces involve [...] multi-sensory and ’immersion’ technologies. These include the areas variously described as hypermedia, multimedia, virtual reality, telepresence, Cyberspace and artificial reality. They can include sophisticated methods for recognition of human behaviours (handwriting, speech, gesture, expression, etc...) [...] and binaural and spatial sound and voice synthesis and both force and tactile feedback. These interfaces can be described using Peirce’s Indexical classification. This is a rich experiential and existential set that has a close bonding with the underlying ’reality’ to which it refers [...] a ’natural’ relationship” [77].

Nadin tries to shift the interest of semiotic HCI from the ”popularized 3 forms of representation iconic, indexical, symbolic” to Peirce’s other classifications (see section 2.4 on sign classification), e.g. the types of signs. He describes passwords as sinsigns (see section 3.5), smileys as qualisigns (see section 4.5) and virtual buttons as legisigns. These semio-virtual ”light switches” [142] are omnipresent in GUIs and hypermedia and, obviously, have a strong indexical relation to the referent:

> ”If you triggered a shutdown procedure (on a PC, on a UNIX machine, or on a Macintosh), the semiotics of the process has to be simple and direct: No more and no less heavy than the semiotics of a switch (ON/OFF).[60] Still today, this almost trivial operation is only rarely supported by an interface that is both precise and expressive” [375].

As a legisign, the shutdown button must force a procedure to take place. In hypermedia, the activation of a button or link marker has to ignite a link following process. Broken links on the WWW question the status of the legisign, thus being a major semiotic and usability problem that leaves the user with distrust and frustration about the medium. It is interesting to compare linkrot to missing reference objects in the triadic Peircean scheme (see section 2.1): As pointed out by mediaevalist and semiotician Umberto Eco, the sign ”unicorn” makes sense, even if there is no reference object that it points to: We all have a concept of that fabulous being, although the animal does not exist. The same is true for a dead hyperlink that still makes sense in the syntagmatic chain of the text it is embedded in. Therefore, it is important to avoid link markers that do not lie on the syntagmatic axis of the text, such as the infamous link marker ”click here”. The equivalent to the link marker ”click here” that leads to an ”Error 404”, would be a golden plaque that says ”unicorn” on an empty cage for someone who believes in unicorns (as did the medieval man). A link marker that makes sense in its textual environment but still does not lead anywhere, in this metaphor, could equal a tapestry that shows the hunting of a unicorn, like the famous piece on the Cloisters of the Metropolitan Museum of Art in New York. It embeds the concept into a narrative structure that makes sense as long as you do not ask ”Has anybody ever seen such an animal?”. Section 4.2.3 will present methods to avoid ”dead links”.

hypermedia has become omnipresent in the everyday use of computers: The seamless integration of hypertext has widely shaped the current generation of operating systems, GUIs, applications and, naturally, Internet applications. The fact that many users do not take notice of this development underlines the ”ancient” HCI wisdom that the best interface is the

[60] Semiotically, the on/off switch is also an example of a digital sign. From a usability point of view, the decision between analog and digital displays and switches is not a trivial one (as pointed out to me by Veith Risak).

one that you do not notice. Semiotics has long been considered an adequate way to look at HCI as methods and terminology are naturally shared, e.g. [9, 372, 373, 426, 127]. Indeed, Nadin claims that "if there is a science of interface (computing interface or any other kind), then this science is semiotics" [372]. After the seminal CHI'2000 workshop, it seems that Semiotics has finally entered HCI on a broad basis. One outcome of this workshop is the Website *Semiotics for the HCI Community* [375] where Nadin defines HCI as a result of a semiotic process:

> In human-computer interaction, we can consider the computer as the object (what is represented); the operating system as the representamen (the desktop metaphor is an example of a representamen), and a specific use as one possible interpretation. Word processing is such an interpretation. Obviously, in such an interpretation (one application from many), a lot is left out. But after all, for a typist, the computer is a not the computer with its many functions and components, but a typewriter with more possibilities" [375].

Bardini has proposed to link Nelson's "virtuality"[61] metaphor with hypertext in a "historical analysis of the development of the technology, going from the seminal work of Douglas Engelbart and Ted Nelson to the current issues in the field" [28]. It is important to note the relevance of the two particular visions of the earliest hypertext implementations, Ted Nelson's Xanadu (see section 3.1.3) and Douglas Engelbart's NLS (see section 3.1.4): "For Nelson, hypertext is a fundamental tool for individual creativity, and for Engelbart, hypertext is a necessary capability of a system designed to improve communication. These two alternatives parallel two different conceptions of the user, seen either as a creative individual or as a member of a community in a human organization" [28]. Bardini considers "association" and "connection" as the two opposite poles of a continuum describing hypertext systems. On the axis between the two poles, he sees Nelson's location nearer to *association*, while Engelbart's position is closer to the *connection* pole.

HCI experts do not get tired of pointing out that the seamless integration of hardware, HCI, (hyper-)textual structures and the system design determines the acceptance of a system:

> "Wenn es in einem Hypertextsystem gelingt, die gewohnte Vorstellung von den Arbeitsmitteln nachzubilden, oder den Lesegewohnheiten entgegenzukommen, dann fördert das die Akzeptanz. Diese Anpassung wird u.a. durch die Hardware, die Mensch-Maschine-Schnittstelle, die Textstruktur und das Layout beeinflußt" [439].

While the menus and toolbars of current standard browsers obviously try to support first-personness[62], certain toolbar and menu functions break with the travel metaphor (esp. the "history" tool, as pointed out in section 3.7.7) and thus inhibit the user to be fully immersed in the hypertext navigation.

Andersen emphasizes two aspects that are "normally neglected by HCI textbooks but are predicted to be important by semiotics: (1) Humans are compulsive interpreters and (2)

[61] "I believe that movies and computer screen are both best understood in still larger terms. It is for this I propose the term virtuality. The virtuality of a thing is what it seems to be, rather than its reality, the technical or physical underpinning on which it rests. Virtuality has two aspects: conceptual structure – the ideas of the thing – and feel – its qualitative and sensory particular" Ted Nelson, cited in [28]. Nelson's virtuality seems to be closely related to Brown's indexical interface type, cf. [77].

[62] First-personness is the ideal situation in the relationship between user and computer where the users consider themselves to behave in a way as if they continuously say: "I am going to…" or "I can make…". In comparison with first-personness, second-personness expresses itself in statements like "You have to…" or "You should…", whereas examples of third-personness are "She did so and so" or "The system decided…". First-personness means that a user is immersed in a world, that he or she is *in* it, cf. [308].

Humans are compulsive talkers!" [11] These aspects are touched also in section 3.5 on hypertext semiotics, and section 3.7.8 on social navigation of this dissertation. As pointed out by Carroll et al., interface metaphors seek to increase the initial familiarity of actions, procedures and concepts that are already known instead of reducing the absolute complexity of an interface, cf. [258, 67]. Metaphors should be exhaustive and appropriate to enhance the user's understanding. For example, Dieberger uses the subway as a metaphor to explain why two hypertext nodes, which appear distant in an overview map, may be considered close at the same time when connected by a link: "When the overall structure of the hyperspace is such that closeness in the overview map expresses similarity of content, then such a link is perceived as a tunneling through space" [142, p. 74] (see section 3.7). Yet, metaphors, by definition, must provide imperfect mappings to their target domains: "If a text-editor truly appeared and functioned as a typewriter in every detail, it would be a typewriter.[63] The inevitable mismatches of the metaphor and its target are a source of new complexities for users" [258, 69]. On the other hand, these mismatches of metaphors often are important factors of the force of the metaphor. Mismatches in the metaphor can help considerably making a system useful if the mismatches are designed well: "The user interface principle of forgiveness is particularly important in metaphor mismatches – it allows the user to explore those unfamiliar features of the system and by exploring them she easily learns to use them for her own benefit" [142, p. 57]. The Aspen Movie Map's season knob is an interesting example from an early hypermedia system, described in section 3.1.13. Metaphors, in a psychoanalytic view, are *Verdichtungen*, condensations that shape our view of the world and the posibilities for setting actions. Even if useful magic features are generally well accepted, orgies of false signifiers [507] endanger the usability of the interface.

Dieberger emphasizes the importance of spatial metaphors defining them as "user interface metaphors which make their space concept explicit and where the spatial relation that is expressed in this space has or can have a defined meaning". He regrets that there are many user interface metaphors that do not fulfill this definition fully, allowing users to rearrange objects – yet this rearranging has no meaning ("an object A is in no way different if it positioned left, right or below an object B", [142, p. 61]). He points out that, in a true spatial metaphor, the spatial position of an object and the arrangement of several objects has a certain meaning and that this meaning can be predefined, or it can evolve from working with the system. If the spatial conception is consistent throughout the system, it can serve as a mnemonic system and as a means of communication. This gap has been filled by spatial hypertext; see section 3.4.3.

Several approaches to formalizing the user interface metaphor have been described in literature (for instance based on algebraic specifications, cf. [245, 244, 295]). The mapped elements of the metaphor are called objects and operations; the kinds of structures that are preserved during this metaphorical mapping are called image-schemata. In teaching the metaphor to users those image-schemas must be made explicit and deviations from the working of the metaphorical objects must be pointed out. Features not found in the source domain but in the target domain of a metaphor are called *magic features*, i.e. it is possible to search documents in a GUI folder without opening it: "The working of the magic feature in the user interface has to be supported by a fitting *enactment* which makes it easy for the user to cope with the additional functionality", cf. [142, p. 60]; [310, 309].

Brown notes that Alan Kay, when developing Smalltalk (the prototype of today's GUI) used

[63] Another example for richness issues in metaphors with cost relevance is described by Johnson: "Would it be appropriate for users to have to affix electronic stamps, obtained from an electronic 'post office', to a document before sending it on its electronic way? That depends upon how conscious one wanted users to be of the cost of mailing an object. If, as in most electronic mail systems, users are not charged on a per-mailing basis or not at all, then adding such detail seems silly. On the other hand, if users are for some reason charged on a per-mailing basis, perhaps even depending upon the size of the mailed object, such a design might well be superior to the one used in most commercial time-sharing systems, in which the dollar balance in user's accounts decreases invisibly, requiring users to ask the system repeatedly for the amount remaining" [259].

the categories *enactive*, iconic and symbolic borrowed from children's learning abilities studies, cf. [77, 310]. Brown, who sees a number of problems arise from "the obsession with verisimilitude" and "the super-realism of much modern computer graphics imaging" concludes:

> "Perhaps because he [Alan Kay, MN] was unaware of the semiological analysis he seems unable, or unwilling, to acknowledge the inherent limitation of iconic communication: icons allow intuitive comprehension but their gross simplification and tight bonding with the signified object prevents then from offering the power of a more complex and flexible, symbolic language" [77].

The limitations of the two-dimensional desktop metaphor for real engagement of the user and first-personness were soon realized by its creators at Xerox PARC. Yet the success of the metaphor[64] as well as technical restrictions make it hard to implement "hypermedia interfaces in virtual space-like designs [which allow] a real connection of users and designers". For Bardini, this would be the ultimate meaning of interactivity [28].

Nadin sees semiotic adequacy as a key factor for interface design. As opposed to the reactive model of measuring user performance, semiotic adequacy is a method of fine tuning the semiotic elements involved in HCI, cf. [375].

3.7 Navigation in Hypertext Systems

In vivid conversations with others – and silent conversations with ourselves – we often stop and and ask "How did we ever get to this subject?" Accordingly, for somebody who takes the minutes at a business meeting, it is important to know which subjects have been touched and which connections and associations have been made. That way, side issues can be identified, postponed and revisited later, without loosing the overview of the main subject. Navigational tools in hypertext have the same function and follow a similar logic. However, due to the spatial implications of the "navigation" metaphor, they often relate to a movement in a physical space, or rather, the movement of the environment around the user:

> "Computers today are used mainly for organizing large amounts of data. Data that is organized in such a way that it is accessible when needed, can be seen as more than data – as information. The task of navigation in computer systems is similar to the way finding tasks in cities. Here the goal of the user is to 'get to some information'. In computer systems [of today, MN] navigation does not involve physical movement of the user – instead information or the representation of an environment is moved in front of the users eyes on a screen. The navigation task in computer environments therefore concerns moving the environment around the user" [142, p. 54].

Navigation through hypertext is the most commonly cited difficulty with the new medium and the suitability of the navigation facilities varies with the task and information space, again highlighting the relevant attributes of users, tasks and information in designing usable hypermedia interfaces, cf. [144]; see usability section 3.6. For Dieberger, computer systems can be seen as environments and navigation therefore is essentially "an activity in space.

[64] In GUIs, such as Xerox, Apple, MS Windows, X-Windows, Comfodesk, KDE, GNOME, etc., text models are represented by books, notepads, catalogs, binders and scrolls. As described in section 3.3, some of these models are also commonly used as paradigms for the HCI of hypertext systems.

In most cases the spatial concept of a computer system is fundamentally different from real life space, however" [142, p. 54]. Dahlbäck, Höök, and Sjölinder's study [234] suggests researchers to distinguish the spatial ability for problem–solving in the physical world and the spatial ability for problem solving in abstract information spaces. Chen/Rada [96] synthesized findings in experimental studies concerning individual differences in terms of cognitive styles, learning styles, and spatial ability in using hypertext systems. Their meta-analysis supported the hypothesis that users with better spatial ability will be able to use hypertext more efficiently and found that graphical maps reduced the differences in dependent measures. I conclude that the first problem in hypertext navigation results from the mismatch of spatial metaphors which has been in depth in the sections 3.4.3 and 3.5.

It is questionable if navigation in computer systems which makes use of the same navigational strategies as navigation in real world environments, such as the Identifier Strategy, the Path Strategy, the Direction Strategy, the Distance Strategy, and the Address Strategy, plays any important role in hypertext navigation, cf. [142, p. 54-55]. In fact, it has been questioned if the navigation metaphor is adequate for interaction at the hypertext interface at all, cf. [48].

The lexicon definition of navigation relates to the theory and practice of navigating, or the charting of a course for a ship or aircraft and travel or traffic by vessels, especially commercial shipping. Metaphorically, navigation is extended to navigation on land and in space and more generally to be the activity of finding one's way throughout an environment. In architecture, the term *wayfinding* is preferred (and used synonymously with the term navigation). Passini [414] defines wayfinding as, a person's ability, both cognitive and behavioral, to reach spatial destinations. He bases his conception on Downs/Stea [148] who see wayfinding as composed of four steps: orienting oneself in the environment, choosing the correct route, monitoring this route, and recognizing that the destination has been reached (or approached). Summing up, outside computer science, the navigational task mainly is a *planning* task. In the computing domain, it is common to use the term also for a less systematic and more or less tentative exploring and browsing, cf. [142, 48, 421]. Dahlback concludes:

> "When the destination is not known beforehand, the user is exploring the space. In that case, the destination in the definition of Downs and Stea above can be thought of as an overall goal to explore the space. The user can undertake this exploration with a more or less definite goal in their minds, be it just for the pleasure of wandering in the space. In those cases, orientation will still be a relevant activity, as will monitoring the path traveled. In these cases there will not be a correct route. Recognizing that the destination has been reached will in an exploration task more be a matter of feeling that one has had enough. Sometimes exploration will turn into wayfinding, and vice versa" [116, p. 8].

Recognizing that one has not reached the destination, or even that on is unable to define the next destination and its relatedness to the current location nhas become known as the "lost in hyperspace"-problem. In his seminal hypertext survey [108], Conklin identifies two major dangers of free-formed hypermedia access within an associative network, disorientation and cognitive overhead. Conklin defines disorientation as "the tendency to lose one's sense of location and direction in a nonlinear document," using the expression "lost in space" to describe it. He defines cognitive overhead as the "additional effort and concentration necessary to maintain several tasks or trails at one time" [108].[65] Cognitive overhead refers to the reader's ability to follow links related indirectly to the current reading task, either on a purposeful tangent or detour, or by accident, cf. [62]. It is also the need to follow several interconnected paths to visit as much of the associative network as necessary, and to choose

[65] Think of a conductor who simultaneously reads the musical notation for the whole orchestra.

among multiple links (especially for novice not familiar enough with the domain it is hard to decide among them), cf. [553].

Researchers in the field have different opinions about the potential of practical implementations to solve the limitations of the current hypertext model:

> ”While many hypermedia researchers believe that disorientation and cognitive overhead are problems inherent in hypermedia, proper implementation of advanced hypermedia features will alleviate these problems as well as provide readers with a richer information environment” [62, p. 32].

It has often been pointed out that the fields of city-planning, hypertext and virtual environments use a set of similar or even identical notions which are used with slightly different meanings, e.g. [142, p. 11]. In Kevin Lynch’s ontology of environmental terms for city planning, the mental representation of an environment is called the *environmental image* and consists of five elements: node, path, edge, district and landmark, cf. [326]. These elements are the constituents of the ”image of the city”.

Although hypertext makes partial use of the same terminology, it does not apply the terms node, path and landmark in a spatial sense: Lynch describes a node as a distinct location in the environment, e.g. a place, a piece of a forest path, a room or whatever – it is a strategic spot in an environment the user can enter.[66] Hypertext nodes, on the other hand, cannot be entered in the spatial sense. Another element of the environmental image is the path. It is a channel along which the observer moves: ”For many people paths are the dominant environmental elements as people often remember spatial concepts in terms of paths. Paths connect nodes or lead to nodes” [142, p. 11-12]. The last of Lynch’s five elements is the landmark. Landmarks are strong points of reference often to be seen from far off. Paths and landmarks are the most important elements for orientation and navigation (to find and re-find one’s way) in the city environment.[67]

Dieberger claims that many navigational tools (as described hereafter) ”are useful mainly for avoiding disorientation – they do not really help to find information” [142, p. 73]. Therefore, he proposes a spatial user interface based on a *Information City Metaphor* (see section 3.4.3), with the aim of supporting navigation in large hypertexts:

> ”The city metaphor was chosen as a basis because people seldom get really lost in a real city even when they are in this city for the first time. Cities provide people with lots of informational and navigational infrastructure. Besides in all cities there are always other people around to help in navigation[68]” [142, p. 76].

The idea of ”asking the other people around for help” has led to a valuable approach known as social navigation, cf. [143, 116, 174, 512], which will be described in section 3.7.8. In Dieberger’s *Information City*, users can read maps and signs, and easily understand the structure of a city. And with the help of its inhabitants who are always willing to be engaged in an unconstrained chat, navigating the virtual metropolis should not be any trouble. Or so it might seem.

[66] The building metaphor was used for the Book House project [417]. It is also being used for a 3D spatial hypermedia simulation of a library at Virginia Tech University [121].

[67] As described in section 3.1.2, Bush envisioned that ways through material collections would be recorded and exchanged (also commercially) in the form of ”trails”. He did not use a navigation metaphor, though, but referred to associative trails of the human mind, cf. [80]. It is worth repeating that graph theory’s first application was a navigation task in the city of Königsberg (see section 3.4.1) and that Lynch’s book appeared at the beginning of the decade in which NLS and Xanadu were born (see sections 3.1.4, 3.1.3).

[68] This approach has been furnished with that author’s more recent research in the field of social navigation, e.g. [143].

Yahoo!3D was an experimental three dimension cyber-map of part of Yahoo's hierarchical Web directory (figure 3.14) which is no longer available. A series of 3D VRML worlds

Figure 3.14: Yahoo!3D map. Source: [145]

representing parts of the Yahoo directory had been created, which the user could walk or fly through to access relevant Web sites. Another example for a 3D cityscape view of the Web was generated by Map.Net. The user flies through the world, with individual Web sites represented by different buildings. Based on visualization techniques presented in section 3.4.3, the large skyscrapers show the most popular sites on the Web (figure 3.15).

The idea of a crystal clear structure of a city created on the drawing table reaches from Vitruvio's plans for an ideal city to Alberti's Sforzinda, or from the chequerboard patterns of the Roman provincial towns to the typical American metropolis[69]. Yahoo!3D (figure 3.14) still seems to be planted on the basis of Vitruvio's *firmitas* (solidity), *utilitas* (functionality) and *venustas* (beauty).

Navigation, seen as the individualistic, objectivist and cognitive task to explore such a city can draw on a large body of work on how people develop cognitive maps of their environment which enables them to find their way to a specific location.

Traditional solutions suggested to reduce cognitive overhead including tools to allow an overview over the hyperspace, the enhancement of link capabilities, the demonstration of past activity (where do I come from?) and potential future steps (Where can I go from here?).

[69]The Roman towns were always structured by the major streets, a north-south cardo and east-west decumanus, which met in the center of the rectangular walled town.

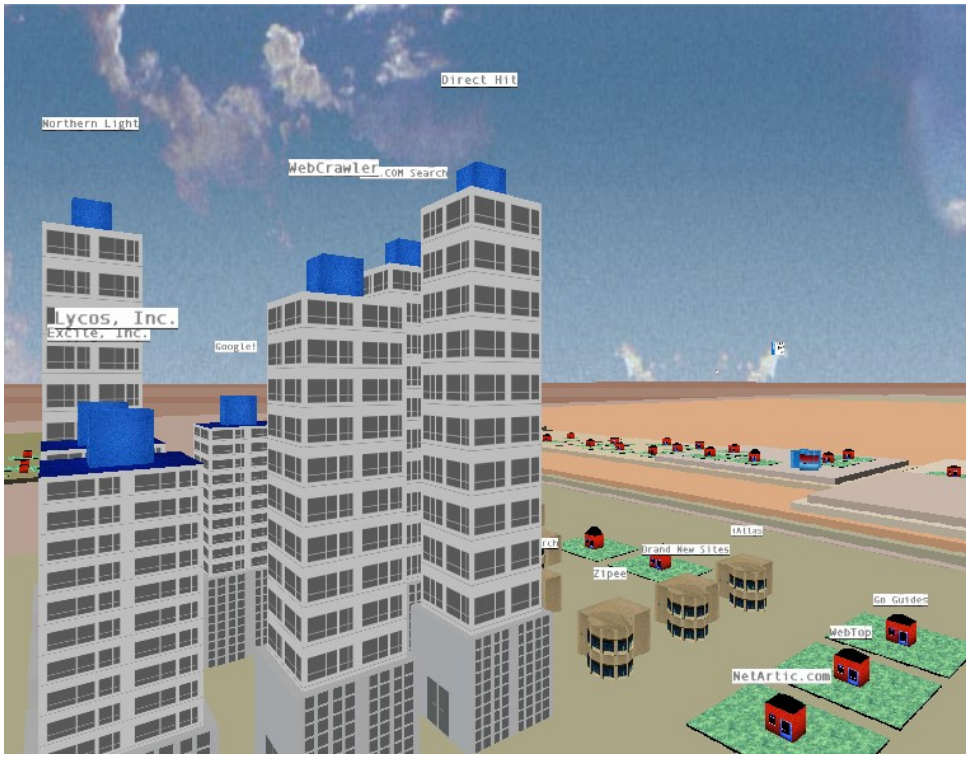


Figure 3.15: 3D cityscape view of the Web generated by Map.Net. Source: [145]

3.7.1 The Hypertext Session

Let us start defining the *end*, before returning to the *starting point* of a hypertext session: "There is a clear break in hypertext activity when the user quits" [449]. Douglas has also dedicated a large part of his excellent discussion of issues pertaining to the hypertext session on the issue of closure, or, in other words, how the reading of a hypertext "comes to an end", cf. [147].[70]

One of the most problematic reasons for the end of a hypertext session include accidents or external circumstances (the phone rings, or the power fails, or the computer crashes). While it is tempting to simply dismiss this as a not very interesting null case, it is precisely by measuring the sense of loss at an artificial termination that we may properly assess what needs to be *saved* from a hypertext session. In Rosenberg's words: "How does the reader recover not only the lexia but the episode as well? Can the episode be recovered? If the reader is associating multiple episodes, can that be recovered? Should it be recovered?" [449].[71]

Another case may be that the reader gives up after a fruitless search for episode. Similarly the reader may suffer sheer episode fatigue: episodes are at hand, but they seem too similar to episodes already undertaken.

By contrast, the reader may have achieved a complete sense of episode satiation. For Rosenberg, this is not necessarily the same concept as closure, as discussed by Douglas

[70] Veith Risak reminds me that there is a related phenomenon when the authoring of a hypertext "comes to an end"; this authoring closure is shown by a saturation of articles (nodes) on one subject, cf. [443].

[71] In the case of mainstream commercial Web browsers, only the Opera browser has a proper functionality for accidental termination: At the next startup, the user gets asked if he wants to "continue where the interruption occurred, start with saved windows [or] start with no windows". If the first case is chosen, each episode (or "window history" gets recovered).

[147]: ”Particularly in a large poetic work, the reader may have no sense of completion in a logical or narrative sense, but may be satiated in a purely imagistic way that makes it seem fruitful to put the work aside for a time” [449].

The forth case is that the reader has reached a tangible ”success point” in gathering information, cf. [147]. Rosenberg borrows Michael Joyce’s topographical bent:

> ”The reader may quit because of a feeling of having reached a point on the landscape from which the vista seems complete. Or as Douglas puts it, the reader is satisfied that enough logical questions are answered that there is no need to continue. With the luxury of a formal gathering interface, the reader may obtain a sense of completion about the gatherings; i.e. the reader’s sense of completion is exactly a writer’s sense of completion: the gathered result ’works’ artistically as-is, now is a good time to stop” [449].[72]

Similarly, there are several other ways to begin a hypertext session. In the WWW, one can start a session from a predefined home page, by typing an URL directly into the browser or by following the results provided by a search engine (see section 3.7.9). More complex, and highly useful, tools are bookmarks, history lists, guided tours and maps. They can serve both as an entry point to a hypertext, or as navigation tools in the course of a session.

3.7.2 Bookmarks

The bookmark breaks with the navigation metaphor of moving in a physical space (like a tourist, or flâneur walking in the city) even more explicitely than the other common names for the same function, i.e. favorites or hotlist. Rather, they all relate to the metaphor of navigating a text space, as described in section 3.5 on hypertext semiotics. The bookmark is a magic feature in the navigation metaphor[73], as there is no way to mark a place in real spaces the way a bookmark does in a book: A bookmark indicates a personal interest of a reader in a certain topic, but if it is taken out of the book (e.g. if the book is returned to the library) the bookmark leaves no traces (as opposed to a graffiti, footprints, etc.; cf. [116, 143, 540]). It is also more explicit that similar marking techniques, such as ear marking. Often against the advice of librarians who fear for the books, many people use sticky noted to mark pages or paragraphs. When the user defines a bookmark, the system may put the node’s name[74] on the bookmark list, or it may prompt the user for a small text to remember the node by. Bookmarks are especially useful in electronic texts because it is possible to use more of them than it would be practical in physical books, cf. [387, p. 130].

Bookmarks are most important for the revisit of Web pages, as bookmarks obviously are kept by a user mainly for this purpose (other reasons might include trading or publishing them in some form). Tauscher and Greenberg found that about 60% of all pages an individual visits are pages he has visited before[75] [514].

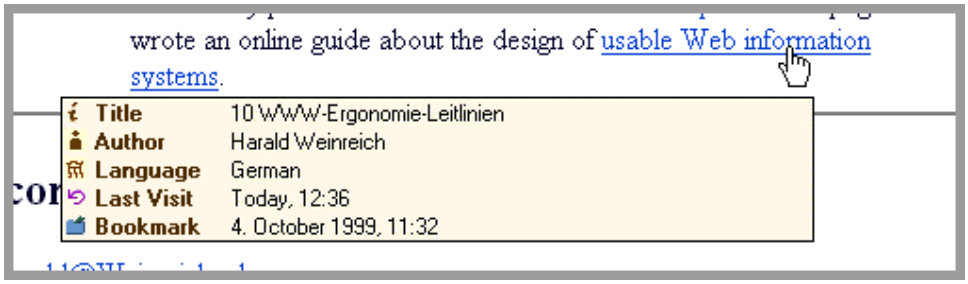
Bookmarks are a further aspect of backward navigation that have been considered by Weinreich/Lamersdorf [536] for their *HyperScout* project. In the WWW, users cannot determine easily, if they have already bookmarked a particular node. Weinreich/Lamersdorf suggest showing this (and other data) in pop-ups next to links (see figure 3.16a).

[72] The formal gathering interface Rosenberg envisions is a spatial hypertext system (see sections 3.1.15 and 3.4.2), such as Aquanet [334], VIKI [336], or its successor VKB [485].

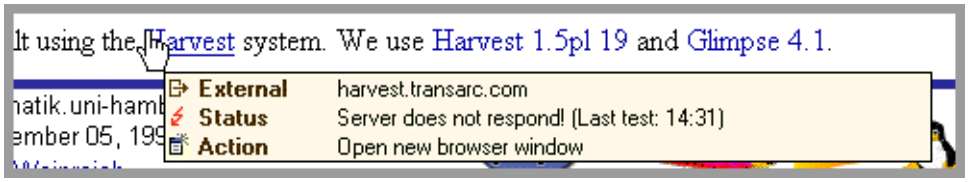
[73] Extensions of metaphors, magic features and metaphor mismatches commonly meet the users acceptance if they are well designed and easy to learn, thus increasing usability (see section 3.6).

[74] In hypertext, marks can be left on nodes and on links. However, standard Web browsers concentrate on bookmarking nodes without the information how the page was reached.

[75] To be more precise, they found an overall recurrence rate of $R = 58\%$ ($\sigma = 9\%$) for their 23 subjects, and $R = 61\%$ ($\sigma = 9\%$) for 55 subjects from another study, [91] ($R = \frac{total\ URLs\ visited - different\ URLs\ visited}{total\ URLs\ visited} \times 100$) [514, p. 112].



(a) Link to a node that has been visited before. The user has also bookmarked that link.



(b) An external link that opens a new window. The server is down.

Figure 3.16: Web link attributes in the HyperScout prototype, Source: [536].

As a sign, the bookmark can be said to have an indexical relation (apart from the text-passage it points to), to the reader who has placed the mark.[76] Reading marks in the form of pointing fingers have already been found in ancient law books (see section 3.5). The magic feature that makes bookmarks so useful in hypertexts is that they can be kept separately from the texts, sorted, interchanged and annotated (a rudimentary substitute for the missing annotation facility in the WWW).

A useful extension of the bookmark tool could be borrowed from the world of computer games, where it is possible to save the current level, including all items, maps etc. the player has gathered so far. This magic feature would create bookmarks with a memory, or, in hypertext terminology, with a history (see section 3.7.7) of how the site was found. This magic feature, supported by a fitting enactment which makes it easy for the user to cope with the additional functionality (cf. [142, p. 60]; [310, 309]; see section 3.6) could enrich bookmark lists by the principles of causality and consecutiveness: ”Why did I bookmark this site?” as a means of ”How did I get there?”. In a personal e-mail on July 24, 2001, Brian Proffitt at BrowserWatch tells me that to his my knowledge, no current browser ”keeps a complete history trace such as you describe”. He thinks to recall ”one of the early browsers doing something like this, but it was quickly phased out. I want to say is was NCSA Mosaic, but I could be way off here”. Problems of this feature would include the question how many sites are kept in the history of the bookmark; the increased size of the bookmark file; and, if the bookmark history should be imported into the global history, once the bookmark gets opened.

[76]”Leaving marks is also a common strategy in physical places: ”The graffitist leaves a mark. [...] With the graffito, the expressive mark has a substance made up of the physical residue left ba the markers incursion [...]. But the form of the mark — at this level of ’expression’ — is itself peculiar; for it inhabits the realm of the clue, the trace, the index” [288, p.259].

3.7.3 Guided Tours

The guided tour functionality inscribes itself emphatically into the travel metaphor. This linear path through the densely interwoven information net serves as a hands-on introduction to the new environment. The advantage of hypertext guided tours compared to tourist guided tours is "that the hypertext reader can leave the guided tour at any spot and continue browsing along any other links that seem interesting. When the reader wants to get back on the tour, it suffices to issue a single command to be taken to the point where the tour was suspended. The 'guide' will be waiting as long as it takes" [387, p. 128]. Risak calls this a "soft guided tour" whereas the "hard guided tour" cannot be left, as links have been disabled, cf. [439, Entwurf von Guided Tours].

Nielsen calls guided tours the most simple solution to the navigation problem from the user's perspective, cf. [387, 388, 520]. To remove the requirement for navigation by providing guided tours through the hypertext is "somewhat like the original 'trails' suggested by Vannevar Bush in 1945. A guided tour may be thought of as a 'superlink' that connects a string of nodes instead of just two nodes. As long as users stay on the guided tour, they can just issue a 'next node' command to see more relevant information" [387, p. 127/8]. Bush's original passage goes:

> "When the user is building a trail, he names it, inserts the name in his code book, and taps it out on his keyboard. [...] Thereafter, at any time, when one of these items is in view, the other can be instantly recalled merely by tapping a button below the corresponding code space. Moreover, when numerous items have been thus joined together to form a trail, they can be reviewed in turn, rapidly or slowly, by deflecting a lever like that used for turning the pages of a book. It is exactly as though the physical items had been gathered together from widely separated sources and bound together to form a new book. It is more than this, for any item can be joined into numerous trails" [80].[77]

Bieber et al. distinguish between trails and guided tours, where trails can record a path of information that the reader may wish to remember and share with others, cf. [62]: "Continuity and guidance distinguish trails from random links in documents. The trail should be clearly marked, so users will know which links keep to the trail and which constitute detours from from the trail". Guided tours, in their view, are "hard guided tours" [443], as they "restrict users to the trail, prohibiting detours. Nodes viewed during the [guided] tour will have other links dimmed or hidden" [62, p. 8]. The logical conclusion from this distinction is that "trails lower cognitive overhead by recommending the next logical link to take," while guided tours "reduce overhead further by removing all other choices" [62, p. 8]. They agree with other authors that overview maps can do a great deal to maintain the orientation along the trail or tour, cf. [185, 518].

On the Web, its impossible to dim or hide other authors' links as HTML has no tags for "superlinks". Even if an author creates a guided tour through a site by adding forward/back buttons to certain selected nodes, the user cannot jump back on the "tour bus" with one mouse-click once he has left it. However, he can backtrack until he gets to the point where he has left the tour. Metaphors can loose their importance (and validity) if they cannot be implemented or remain unused in a certain system. Although the "previews" and "free tours" are often available at pay-sites (especially with pornographic content), the guided tour in its original sense is hardly used in the WWW. So infrequently, it seems, that it was reinterpreted in the Web site of a major Austrian bank, called Bank Austria. Instead of a guided tour, the link in the background window of figure 3.17 activates a new window containing a help function, with definitions etc.

[77] It is important to distinguish who defines the guided tour. If it is the user, then the relation to Bush's trails is even closer.

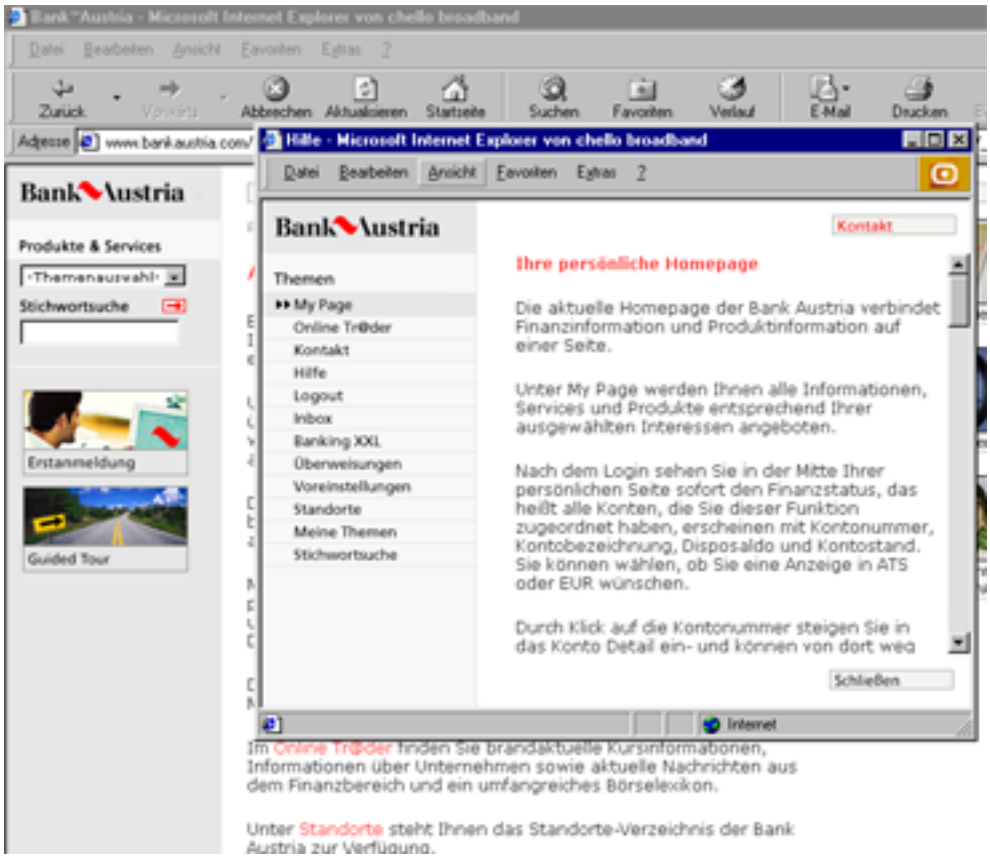


Figure 3.17: Metaphor misuse: The help function of www.bankaustria.com.

A soft guided tour on the Web, also called trail, can only be composed using ”frame-sets”. An example of a guided tour through this author’s Web site can be found under www.unet.univie.ac.at/∼a9108095/new/tour.html.

The source code for `trail2.html`, the second page on this guided tour is:

```
<HTML>
<FRAMESET rows="*, 60" BORDER=0 FRAMEBORDER=0 FRAMESPACING=0>
<FRAME src="MenuPapers.html" name="" noresize frameborder=0
border=0>
<FRAME src="trail_nav2.html" name="" noresize frameborder=0 border=0
scrolling="no">
</FRAMESET>
</HTML>
```

It loads the page `MenuPapers.html` and the navigation frame at the bottom of the screen called `trail_nav2.html`. Thus, if the user follows a link on the main page, the navigation frame will still be there to return to the tour (”this stop”), go to the ”next stop” of the tour, or to return to a ”previous stop”, resp. start again from the beginning of the tour. Another possibility would be to write a JavaScript that controls backtracking to the guided tour.

Besides usability issues of framesets, there are copyright and illegal content responsibility questions involved in such a soft guided tour on the Web: From a legal standpoint, it seems that the farther the user walks away from the virtual tour bus, the more problematic it gets for the tour guide (see section 4.7.3 on copyright, authenticity and availability of information on the WWW).

3.7.4 Maps

Maps are closely connected to the navigation metaphor also, as ”despite diversity of physical expression all maps are basically representations of a set of spatial and temporal relationships” [498].[78] In the context of interest, there are two basic types of maps. One of them illustrates how to reach a single location. This map is a route description, a visualization of a guided tour, or a trail. Route description maps are strongly influenced by the mental image of the person drawing the map, as this person tries to transfer route knowledge from her mental representation of the area to paper, cf. [142, p. 30]. The other type of map describes a whole area (overview map) or larger parts of it (regional or local map). In any case, ”success in using a map, then, is in a large measure determined by the congruence of the map with the [user’s concept of the space, MN]” [498].

Most hypermedia systems that provide semantic types display the types as labels within an overview diagram. Link labels appear *next to*, or *on* the arrows that represent links, while node labels may appear either as the text of the node or next to the node, cf. [517, 108, 62]. While some hypertext systems provide additional overview maps, or extra hierarchy viewers for structural navigation[79], Web clients do neither of the above:

> ”In fact the present concept of the Web does not inherently provide any kind of structural information (except of the file-system folder structure represented in the URL)” [536].

Links are embedded in the HTML documents and have to be extracted first to create overview maps. While local overviews are still possible and several tools are available, comparable global navigation tools are not supported.

A fisheye view shows great detail for those parts that are close to the user’s current location of interest and gradually diminishing amounts of detail for those parts that are progressively farther away. An algorithm creates a view that is similar to looking at a scene with a wide angle lens. This algorithm generates an image of the neighborhood by computing a relationship between *a priori* importance of a node and the distance between that node and the current position in the hypertext network, cf. [86]. Fisheye views represent schemes for mapping both the global architecture of the hyper-document and one or more regions, cf. [394, 439, 441].[80] The goal of Noik’s fisheye representation is to distort the visual elements of the global map so as to foreground or enlarge the target regions, the areas of interest the reader has identified. In developing this scheme, Noik identifies two important anchors: a current position or focal point (IT) and a desire or query intended to explore possible “next” locations. Possible “next” regions can have variable Degrees of Interest (DOI) which influence the size of their graphic representation. This scheme recognizes that “nextness” or semantic relatedness need not be confined either to geometrically proximate spaces or to those explicitly linked: the relations can be expressed as collocations or gatherings of nodes according to some other user-defined property, cf. [394, 268]. This concept seems related to Bollnow’s space of action, which he distinguishes and describes as an extension of the hodological concept, see footnote 38 on page 92. Space of action and the scheme of nextness are three-dimensional ergological structures. They are organized according to any type of human work (stockroom, warehouse, library, etc.) and connected to Heidegger’s notion of ”Zuhandenheit”, cf. [158, p. 13].

[78] Southworth and southworth further comment that ”almost without exception maps communicate information about locations and connections. Locations and their connections have attributes that may be the quantity or quality of certain variables, or their change over time. These variables may be objective or measurable, [or] subjective, such as personal interpretations of scenic appeal” [498].

[79] The hypertext System Thoth-II has a directed graph browser (called *Spiders*) where a global map is created dynamically as a user browses through linked nodes, cf. [25].

[80] Fisheye views are especially useful in hierarchical hypertexts without crossing links.

Topic maps are another concept of growing importance: Topics are nodes and their type may be symbolized by different colors, shapes and textures. However, the number of different shapes, colors and icons is limited. Class hierarchies can be used to reduce topic types to a small number of "super-types" (cf. [419]), thus reducing the need to one specific shape and/or color for each super-type. Topic maps may contain millions of topics and associations. Therefore it is essential to select relevant information as it is impossible to display the whole data efficiently. Filtering techniques are needed in order to select and display only relevant information. Le Grand and Soto [311] have developed a tool that enables users to filter topics and associations according to their name and/or type, provided that name and type are implemented as XML attributes, cf. [137]. They plan to enhance their tool so that it can handle scope:

> "Users will specify which themes they are interested in and the tool will filter names, associations, etc. on that basis. [...] Let us compare topic maps with geographical maps. You will never find a map of a country with the whole information about the country on it. There will be a topographical map, a political map, an economic map, etc. In the same way, topics and associations can be classified into different ontologies and different topic maps will be provided to the user according to his interest" [137].

Another example of structured hypertext mechanisms is the use of link inheritance to allow simplified views of an information space without having to show all the links. Link inheritance replaces the individual links between nodes in an overview diagram with lines connecting clusters of nodes, thus simplifying the diagram considerably, cf. [166]. Bertin has elaborated a semiotic theory of maps that should be considered in graphical representations of information spaces, cf. [57].

3.7.5 Landmarks

Those hypertext nodes that the user knows very well and which are recognized easily are called *landmarks*. Landmarks are "usually defined by the author of a hypertext system as part of the process of providing a usable structure for the readers" [387, p. 132]. Examples are nodes containing initial screens of a system or tables of contents, or "home pages" as they are called on the WWW. When encountering landmarks the users know where they are, because landmarks always help in orientation. Hypertext landmarks often contain helpful information or links to helpful information, cf. [443, 442]. As they are defined as entry points to "city districts" (clusters), they are typed nodes (see section 3.4). Landmarks are of special importance when giving directions to other people since they are so easily recognizable. In route descriptions it is very common to describe a series of landmarks. Encountering one of them triggers attention for the next in the series. This sequence gives the traveler a feeling of progress and allows to estimate distances in the description. Landmarks often occur as starting or ending points of major paths or in the center of districts, cf. [142, p. 38]. The same, of course, can be said about chapters, sections, indices, glossaries and tables of contents in a book. Thus, calling these important hypertext nodes "landmarks" and the initial screen "home", is a emphatic affirmation of the spatial navigation, or travel metaphor.

Landmarks play a decisive role in Persson's narrativization approach. In Rosenberg's three-layer scheme (introduced in section 3.4.2) for discussing hypertext activity – a term that includes, if it is not synonymous to navigation – link-following is the most familiar form of acteme[81]. In accordance to Rosenberg's compound layers, episode and session, and

[81] And it is clearly a *directional* form of acteme: "A link may be followed by (1) clicking on an anchor either

mnemotechnic principles[82], Persson has developed a narrative approach to hypertext navigation, cf. [421]. Persson asks himself how system developers can trigger users to make narrative connections between information units (i.e. hypertext nodes) and claims: "Making connections between landmarks will produce a richer mental representation of the environment and thus enhance memory (which will enhance navigation). This mental network will be a powerful mental tool in upcoming navigating situations" [421, p. 192].

3.7.6 Backtrack Function

Direction is an essential aspect of hypertext navigation. From the user's view, direction can point forward, or backward from the current node.[83] Forward navigation occurs if a user is looking for new information, whereas backward navigation occurs when he tries to regain information obtained before, cf. [517]. The most important tool for backward navigation on the Web is the back button, followed by the Bookmarks and the History function, cf. [514].

Nielsen [387] explains the backtrack facility and its dependency on the user's movement and the order in which the nodes were visited: "Assume that we are currently located in node D in [figure 3.3]. If we had arrived at this node via the path $A \rightarrow B \rightarrow E \rightarrow D$, then the backtrack command would take us to node E the first time it was issued. A second backtrack would then take us further back along our path to node B. If, on the other hand, we had jumped directly from node A to node D, then issuing the backtrack command at node D would take us to node A since that would then be where we came from" [387, p. 2-3].

But he does not mention another problem about the backtrack function that I consider important in the context of navigation: Most standard Web browsers do not give the users the option whether to use the backtrack function according to the metaphor of Adriadne's thread.[84]

Let us illustrate the problem by drafting a navigation in a small hypertext (figure 3.18) that differs from figure 3.3 only in one detail: the link from node F to node B is missing[85]. As indicated by the dotted line (Adriadne's thread), we take the path $A \rightarrow B \rightarrow C \rightarrow F$, then backtrack $F \rightarrow C \rightarrow B$ and proceed $B \rightarrow E \rightarrow D$. If we execute the backtrack command now, it will take us to the starting point A on the shortest way[86] ($D \rightarrow E \rightarrow B \rightarrow A$) and not on the actual hodological path $D \rightarrow E \rightarrow B \rightarrow C \rightarrow F \rightarrow C \rightarrow B \rightarrow A$. In other words, we "loose the memory" of ever having been at point F because Adriadne's thread has been *pulled tight* by the system. This method of saving the shortest way from the starting point of the navigation to the current location is sometimes called stack, and implicitly used by all standard WWW browsers, cf. [443]. In the graph, this amnesia is visualized by fading arrowheads on some of the dotted lines.

graphically visible or inferred by the reader; (2) operating an intermediate interactive device showing all possible links, such as a menu of link names; (3) clicking on an overview map (this is really a special case of (1)) and perhaps others" [449].

[82] Prof. Purcell at the Vienna University of Economics and Business Administration has developed several advanced mnemotechnic approaches. He proposes different methods to extend the human short-term and long-time memory.

[83] Bollnow describes the "dynamics of back and forth" as the "basic double movement of departing and returning which articulates human space". This leads him on to the description of all kinds of paths, streets and ways and how space is perceived during movement along them, cf. [158, p. 7]. See footnote 38 on page 92 on hodological space.

[84] In Greek Mythology, Adriadne knew the secret to the maze built by her father Minos and inhabited by the Minotaur, a bloodthirsty creature half beast and half man. She told her lover, a hero named Theseus, who entered the maze (using a spool of golden thread to find his way back out) and clubbed the Minotaur to its death.

[85] In the terminology of graph theory, the graph has lost its cycle.

[86] To be exact: on the shortest way that can be built using already transversed links. As the link $A \rightarrow D$ had not been crossed, this absolutely shortest connection is not considered by the backtracking mechnanism.

In the case of Theseus, who is longing for the encounter with his beloved Ariadne, the fastest way out of the maze is the primary goal. But imagine he realizes that he has lost his amulet on the way: Having pulled his string back from the detour, he might never find it again! The analogous effect will happen to a user who has visited nodes in a browsing session but cannot backtrack to them.[87]

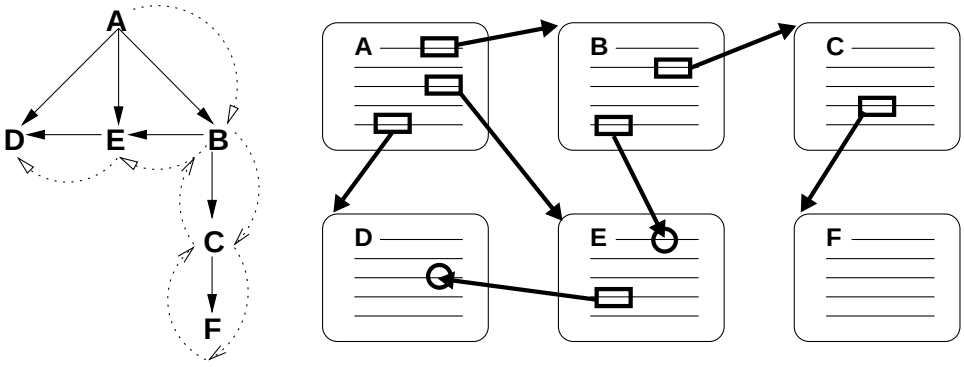


Figure 3.18: Loosing track with the backtracking command.

Hyperties3 is one of the few hypertext systems that uses Ariadne's thread. The hodological path of the user, which can be retrieved from log files is an important tool for usability analyses of hypertexts (e.g. Web sites). It shows where the users ran in circles, which landmarks were frequently revisited for re-orientation, etc. In those cases, the stack solution can be very helpful to show the shortest way back, cf. [443]. There is no optimal solution, but the usability standpoint would call for an implementation that makes the function explicit to the user, or an easy way to opt for either stack or thread.

Hypertext backtracking has been discussed in detail by Bieber et al. [62], with a focus on multiple-window environments. Bieber asks: "Should backtracking trigger an 'undo' operation or simply reflect the current state of the departure nodes?" This is an important question, with serious implications for hypertext rhetoric and functionality. A good example for the problems that occur in multiple-window environments is the Web-interface of the Austrian universities' library system before its update in August 2001. After searching on "hypertext", I browsed through the first few result pages and found a book on hypertext navigation in the library of the Vienna University (The first book on the list in figure 3.19). A click reveals details about the book (see the window marked as ① in figure 3.20) and a further click on "Bestand" – holdings – opens a new window (window ② in the same figure) with information on how to order this book. Before ordering the book from the library, the user has to enter his or her login in another window (window ③). After having ordered the book, windows ② and ③ are closed automatically and only ①, the main window remains. So far, so good. But imagine that the user now wants to look at other books that resulted from the search. As the search had brought up over 100 results, clicking back/forth book by book is not an option. So the user might want to go to the next result page (which would look somehow similar to figure 3.19). Now, using the backtrack function of the browser (the system works only with Internet Explorer and Netscape Navigator) revives the two "order this book" and the "login" windows. The first-time user might assume that the ordering process is just being undone, or that it has to be repeated. The limitations of the browser for this kind of ordering process becomes obvious, cf. [393]. This issue, of course, plays an important role in my reflections on eCommerce in section 4.7.

[87] It can be argued that the user gets this information from the history function. Yet, for usability reasons, unnecessary switching between various navigation tools is not preferable. Furthermore, the history function, as will be showed in section 3.7.7, has usability problems itself and is used far less than the backtracking function, cf. [514].

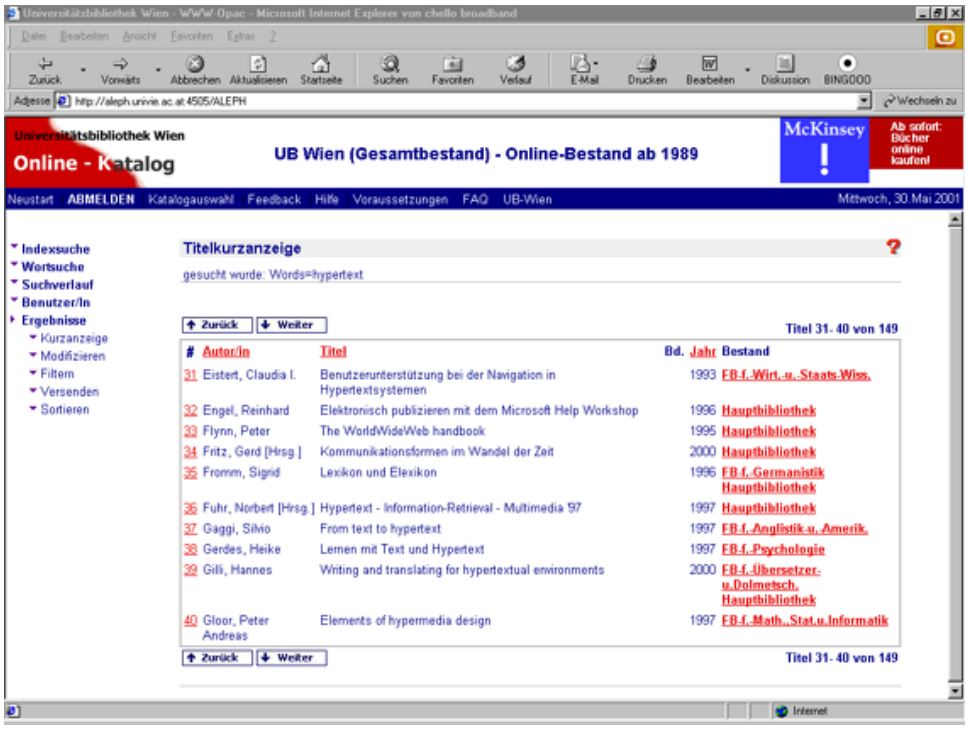


Figure 3.19: Online Catalogue of the Vienna University: Book list.

According to Jim Rosenberg, the backtracking command should allow for qualification: ”Whether backtracking is an ’undo’ or not must be answered by the user! Likewise, the user must determine whether backtracking should or shouldn’t be recorded in the trace of the episode” [449]. He arrives at this conclusion by rephrasing backtracking in the context of his three-layer scheme for discussing hypertext activity described in section 3.4.2. Therefore, the question for him really is if backtracking revokes membership of actemes in an episode or not and the answer is that this depends on the circumstances, both of the hypertext and the reader’s frame of mind:

> ”The reader might revisit a previous lexia to read it again – perhaps for a sheerly ’musical’ repetition, or to reread a prior lexia based on some resonance or reference in the present lexia. Here one might argue that all of the backtracking history is part of the episode. Or, the reader may be backtracking to undo having arrived at the current lexia by mistake – backtracking to remove from the episode the acteme that caused arrival at the current lexia. The episode is thus a combination of history through the hypertext, the reader’s intention, and the reader’s impression of what ’hangs together’. Of course the reader may arrive at a previously read lexia via a different pathway than simple backtracking; in this case most likely arrival at this lexia should be part of the episode” [449].

In conjunction with hypertext systems for learning, Hammond [212, p. 110] points out that the backtrack facility does not necessarily contribute to facilitate navigation: ”Once in an unknown or unexpected part of the knowledge base, the user may have difficulty in reaching familiar territory; like a stranger in a foreign city without a map, he may miss the correct turning. Providing a backtrack facility is unlikely to solve the problem.” The same holds true for the history tool, which also concentrates on past navigation without showing all related (future) navigation possibilities.

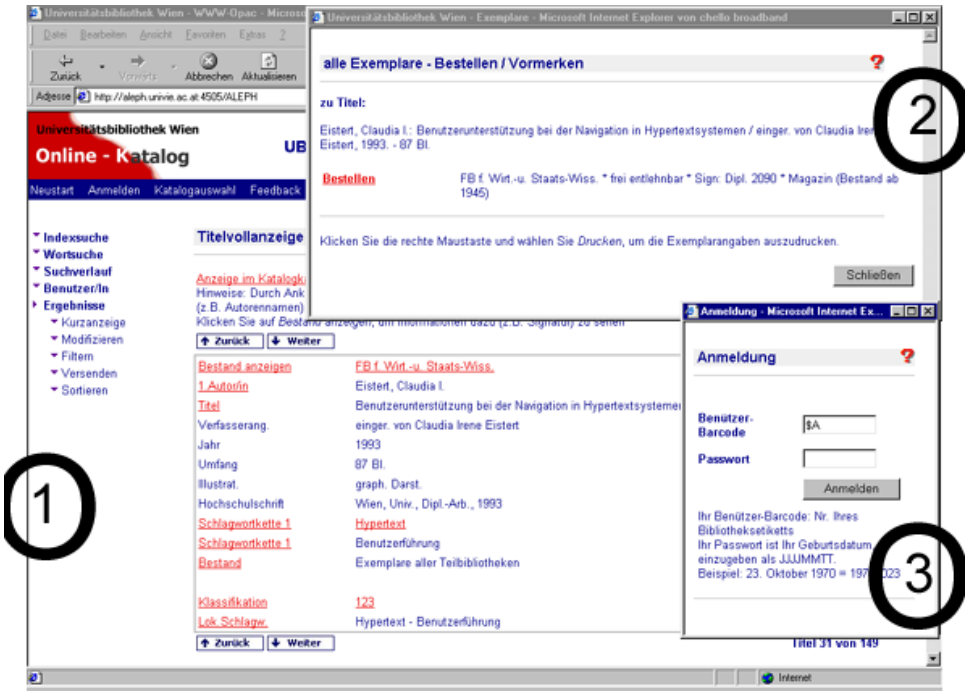


Figure 3.20: Vienna University: Multiple-windows book-ordering.

3.7.7 History lists

In its most elementary form, the history list consists of the names of visited nodes but its usability for navigation purposes depends on the amount of meta-information about the nodes themselves and attributes of the visit. This meta-information should be available in different views, searchable and sortable, cf. [64]. Bilinski and Bumann have developed a "HistoryTool" to compensate the weaknesses of standard Web browsers in this concern.

The name of this function, from a semiotic viewpoint is a false signifier, because it does not correspond to the requirements of the basic travel metaphor: "History" carries a strong connotation of universality that counteracts the notion of a *personal* navigation history.[88] The toolbars of hypertext engines and Web browsers (see section 4.6) emphasize this breach with the consistency of the travel/navigation metaphor, by representing the history function with icons such as pyramids (Hyperties) and sundials (Microsoft Internet Explorer).[89] While the pyramids of Egypt and Mexico could still be defended as popular travel destinations, the sundial shows quite clearly the semiotic inadequacy, an unnecessary metaphor mismatch: The /sundial/ refers to another semantic marker of history than the travel metaphor. In other words, the icon designers of Hyperties and the MS Internet Explorer obviously thought of "history" as the science of past cultures, and tried to represent this concept with pyramids and sundials. An often cited and comparable case of semiotic inadequacy is the eject function on the desktop of the Apple/Macintosh, where "one can take the icon of a floppy disk and place it in the garbage can! The result is the Eject function, semiotically inadequate, but which, through use, became part of the Macintosh *language*" [375], see section 3.6 on the semiotic approach to usability.

In a media semiotic approach, the history tool can be compared to external memory systems, such as diaries. Diaries differ from history books in their quality of externalizing

[88] This reminds me of the postmodern argument that the nineteenth-century obsession with history did not die in the *fin de siècle* so that "an essentially historical epistemology" continues to shape our thoughts, cf. [176, 497].

[89] Netscape Navigator does not even feature this navigation tool on its toolbar.

inner dialogues and reflecting past communicative action in a personal way. They are written in a private ideolect and can involve visual signs like drawings, etc. While the reader of a history book learns about previously *unknown* facts, the owner of a diary can use it to remind herself of situations she has personally lived through. Kierkegaard knew that the ability to remember memorable things, but to forget unimportant (or even unpleasant) ones is an important human demand: ”Hat man dergestalt in der Kunst zu vergessen und in der Kunst, sich zu erinnern geübt, sich vervollkommnet, so ist man imstande, Fangball zu spielen mit dem ganzen Dasein” [277].

To avoid semiotic disasters, the conceptual elements of interface metaphors have to be carefully selected in order to make the respective functions attractive for the user. In the navigation paradigm, of course, ”logbook” would have been a better terminology choice than history,

1. because it accords with the navigational metaphor in its most literal sense,
2. because it delivers a feeling of first-personness, an enactment with the user's own actions rather than a passive role in the passage of time (see sections 3.6 and 4.6).

Applications/interfaces that do not draw on a travel paradigm could make use of the term ”diary”.

From a usability perspective, one might argue that, as the term *history list* is already widely established (”it has entered the browser language”), any attempt to rename it would be confusing. However, research has shown that the history function accounts for only half a percent of all navigation actions.[90] This under-representation may be owed to the fact that users have an unclear concept of the function, as well as the fact that commercial browsers have paid too little attention to usability issues of this functionality.

Even if the developers of the Web browsers decide to stick with the term *history* (e.g. because they are convinced that users have learned the awkward convention and in order to keep the default shortcut ”Ctrl+H”), choosing a book icon for the visualization would probably help: A book (as a history book, a logbook, a travel diary) seems suitable to signify both the established and the intuitive notion for this navigation tool, thus supporting the semiotic process.

Given the high recurrence rate on the Web (60% of all pages an individual visits are pages that have been visited before, cf. [514]; see section 3.7.2), the history (or logbook) function should be taken more seriously as a navigational tool. In the three most common Web browsers (Netscape Navigator, MS Internet Explorer, Opera Browser), it has been integrated (or hybridized) with the ”Back” button and a drop-down list under the URL field. However, the logbook/history should be easily accessible and contain all important information about visited pages, such as title, URL, date and time of last visit, number of revisits and duration. Chiou/Donath [183] suggest ”perceptual thumbnails” while Ayers/Stasko [21] discuss graphical history functions in MosaicG, WebMap and The Navigational View Builder.

Web browsers also consider past visits by changing the color of the link markers (this functionality is called bread crumbs). Weinreich/Lamersdorf suggest a method showing the last time a certain node was visited in a pop-up at the link marker (figure 3.16): ”By displaying the information gathered from the users history, we want to seamlessly integrate the users navigation direction into active Web operation” [536].

[90] ”The Open URL category makes up 50% of all navigation actions. However, the Open URL category is itself comprised of individual events” [514]. One of these events is the history function, which ”was used rarely to select a URL (1% of all Open URL actions)”.

It seems noteworthy that Web browsers cannot save, edit and reload history files in order to produce a ”trail” in the sense used by Vannevar Bush (see section 3.1.2). In an e-mail on May 8, 2001, Brian Proffitt from BrowserWatch confirms that ”To my knowledge, no browser makes use of trails”. He thinks that the reason for this is that ”more people were interested in the vision of Ted Nelson, who promoted a less-rigid notion of information”. Bush’s sequential trails, Nelson maintained, were not needed in the computer medium because memory storage precluded a need to keep data sequential–which had to be done in Bush’s memex. Proffitt also points out that ”there are, I think, two descendants of the trail notion that still exist: the history function of browsers and the saved search capacity found in some browser-based tools like Copernic and Bingooo”. Yet, a saved search is not the same as a string of actually visited nodes, a hodological trail.

Meyrowitz makes the same point, although he speaks of paths, rather than trails: ”Paths are essentially histories that have been captured, edited, shortened, and made into concrete desktop objects that can be played back again... We’d like users not to have to program these paths but to be able to create them by actually doing the traversals and editing out events that they don’t necessarily want to keep” [405, p. 304]. As this passage suggests, Meyrowitz here combines his earlier emphasis on Nelsonian form of hypertextuality with after-the-fact trails.

Shipman/Hsieh have integrated a navigable history function into their spatial hypertext system VKB, [484]. It follows the logic of the ”undo” command in text and graphic editors. A less complete solution are snapshots of the browser window, e.g. in Vectorama.org’s ”multiuser playground”: A maximum of ten users at the same time can design a picture together, and the system saves the state of the playground every 5 minutes (if changes have been made).[91]

3.7.8 Agents, Narrative, Personal and Social Navigation

Based on Brenda Laurel’s two qualities to perform action, responsiveness and capacity, which in fact ”comprise the metaphor of agency” [309], Bardini argues that the resulting ”invisibility” of the computer must be the result of a negotiation between user and designer on the competence of the interface agents:

> ”The efficacy of the computer interface as actant depends on developing convincing ’characters’ in the ’narrative’ of the user-interface. If their negotiation is successful, user and designer reach a consensus on the competence of the agent to perform a task (an action), and the medium (the computer) disappears in the process: User and designer agree on the ’truth’ of the representation embodied in the agent, and, in consequence, his/hers/its action appears as ’real.’ The object of the negotiation is the plot (or the narrative) itself, and in the present case, the alternative representations of the user and the designer of the task to be performed” [28].

This argument calls on the basic rule of HCI, that the best interface is the one you do not notice, cf. [443]. One is also reminded of Persson’s narrative approach, [421]: Besides using stories as landmarks (see section 3.7.5), Persson proposes interactive storytellers comparable to the wizards in the Microsoft Office package for unexperienced users.

Being the result of a consensus between designer and user, Bardini’s interface agent combines the two orthogonal dimensions of a representation (delegation and inscription): ”Delegation is the process by which the agent is granted the right to represent action in the interface, and inscription is the process that enables the agent to perform this action. These

[91] This is, of course, a compromise between history functionality and storage costs, as thousands of users have been using the playground since Vectorama.org was launched in the middle of September 2000.

two processes conjointly define the competence of the agent as the embodiment of the consensus reached by users and designers". This possibility to shape the environment and to produce a subjectively defined space through activities and practice is, of course, related to Benyon's ideas: "There is a context to space which needs to be communicated, negotiated and understood between people. More than just space, there is the idea of place" [48] (see pages 142ff. in section 3.5 on the conceived space and postmodern geography). With the advent of the Semantic Web, intelligent agents will take over a lot of activities which are today still defined as navigation, or Information Retrieval, cf. [54] (see section 3.7.9).

Another strategy that "offers an alternative to the prevailing methods for navigating metaphors" [174] is called personal, or social navigation: "Social navigation relies on interactions with other people" [116, p. 10]. Social navigation can mean interacting with other users (*direct*), or studying what a group of users does (*indirect*). Furthermore, social navigation may be *intended* or *unintended* by the advice-giver. An example of direct intended social navigation is an email recommending a Web site, cf. [174]. An example of an indirect unintended navigation is the Footprint system by Alan Wexelblat [541]. This (prototype) system provides a way to take advantage of Web site usage information from log files generated by the Web-server. Users browsing a site can see the most common path taken from the current page being viewed, resembling the way paths in the grass show if many people frequently use them. In terms of semiotic HCI, this system falls under Brown's category of indexical interfaces, cf. [77]; see section 3.6 for this usability approach to hypertext.

The inspiration for the Social Navigation approach comes from the fact "that most information navigation in the real world is performed through talking to other people. When we need to find information about an illness, we talk to our relatives, friends and medical doctors, when we are lost in a city, we approach people walking by, etc." [174]. Social navigation and CSCW share a lot of properties and problems, but a main difference is the question of anonymity (which is usually not given in CSCW). According to Svensson, a related difference is that "in systems that implement indirect social navigation, it is not the case that users collaborate to solve a task, at least not consciously. That is, the advice provider does not have to know that her actions will have a future influence on someone else's navigation" [512, p. 25]. For groupware and CSCW in a hypertext environment, see section 3.2.2.

3.7.9 Navigating by Query

Svensson also discusses the difference between (social) navigation and Information Retrieval (IR):

> "The fact that navigation can take place in non-Euclidean spaces such as the Web, makes it sometimes hard to see the difference between navigation and IR. Is a person navigating or searching for information when she types a question into a search engine?" [512, p. 25].

Information Retrieval on the Web has become an important research issue as about 85% of the Internet users claim to be using search engines and search services to find specific information of interest. The same surveys show, however, that "users are not satisfied with the performance of the current generation of search engines; the slow speed of retrieval, communication delays, and poor quality of retrieved results (e.g., noise and broken links) are commonly cited problems" [279]. On the other hand, hypertext experts see the difficulties of finding information on the WWW as a result of the poor interconnectedness of the Web, which has also been revealed the latest results concerning the *diameter of the WWW*, cf. [73, 222], and [5] (see section 3.4.1 for the underlying model of the Web graph). Wendy Hall has identified a major reason for the users' reliance on the search engines:

> ”The lack of associative linking means that users need other mechanisms for finding related information in the Web. This vacuum has of course been filled by the search engines [...] As Halasz commented in 1991, navigation by query is a true alternative to navigation by link following, and in the Web has become the main form of navigation in part because there are few links for users to follow” [211, p. 10].

Approaches to end both the ”tyranny of the link” and the oligarchy of the search engines also come from OHS researchers who sought to integrate these ”two worlds”: ”The world of hypermedia and the world of search engines, are still separate both in terms of technology and the way users perceive them” [211, p. 10]. Bernard Bekavac describes this as the difference between *browsing* and *matching*, cf. [41].

> ”Support for browsing has often been identified as a defining characteristic of hypertext systems that distinguish them from database systems. This exploratory, discovery-based, serendipitous form of search, typified by poorly defined goals – ’I’ll know it when I see it’ – has typically been contrasted with traditional goal oriented search as addressed by Information Retrieval (IR)” [114, p. 26].

To emphasize the difference between finding by navigating versus finding by searching, let me introduce the following metaphor: An eye-witness of a crime wants to help the police in finding the criminal. Searching with a search engine is like identifying a delinquent from behind a glass wall: A variety of suspects that somehow could have committed the crime get pre-chosen by the police. Only if the thug is among them he can be recognized: ”That’s him!”, or, ”No, he is not among these guys!”. On the other hand, finding by associative linking is like describing the delinquent in order to produce an identikit picture: ”He looked a bit more like a movie star... yes, but his nose was somehow more onion-shaped... yes, that’s him!”[92] Finding information and acquiring knowledge in hypertext is based on fuzzy information and the interaction with other authors/readers, by means of the traces (nodes/annotations/links) they have left. Speaking metaphorically, one can say that the users can get ”near” to a certain information by encircling it in a hypertext environment, while in IR they have to know concrete terms to look for.

The need of the browsing functionality to be augmented with search facilities, particularly in large-scale systems has not only been emphasized by research, but also by the cited numbers of users who use the search engines on the Web, cf. [114, p. 26]. In his discussion of the classic contributions to IR, Panny [411] emphasizes the distinction between Information (or Document) Retrieval and Reference Retrieval, cf. [412]. He also points to the vagueness of the term ”information”, which has already been noted by van Rijsbergen [525]. This struggle for a good definition is shared by media theory and semiotics. Beynon-Davies [59] defines the terms data, knowledge and information as follows:

- Data is facts. A datum, a unit of data, is one or more symbols that are used to represent something.
- Information is interpreted data. Information is data placed within a meaningful context. [...] Information is necessarily subjective. Information must always be set in the context of its recipient. The same data may be interpreted differently by different people depending on their existing knowledge.
- Knowledge is derived from information by integrating information with existing knowledge.

[92] In fact, computerized systems nowadays combine the photofitting approach with genetic algorithms.

In contemporary semiotic terminology (after Nöth [401]), this definition could be shortened down to: In a process of semiosis, a *datum* is the sign vehicle for the reference object *fact* making sense as *information*. In the next level of semiosis, *information* becomes *knowledge*.

Important attributes of information are accessibility, completeness, accuracy, timing, relevance and presentation. Moreover, high quality information must be complete, to the extent required by the task, and be accessible to the user. Timing is often crucial to the usefulness of information, which must be relevant to the audience, or individual for which it is intended and accurate enough to service particular tasks. Finally, how information is presented is also important for users, it must be unambiguous and precise, and in a form that helps understanding and interpretation, cf. [516, p. 5-19] and [411]. The argument of the usability approach (see section 3.6) that the same data sets may be interpreted differently by various people depending on the current task, their existing knowledge, and on their attitudes and beliefs, coincides with semiotic theory.

Panny sees classification and indexing as the main methods of classic IR, while the center of gravity (especially on the Web) has strongly shifted towards indexing techniques, cf. [411, IR2-17ff.].

As opposed to the semiotic and conventional definitions for index, in IR, index(ing) has a specific meaning. In Baeza-Yates/Ribeiro-Neto's words, "an index term is a (document) word whose semantics helps in remembering the document's main themes [whereas] indexing is building a data structure that will allow quick searching of the text" [23]. According to Mei Kobayashi and Koichi Takeda, the four approaches to indexing documents on the Web are:

1. human or manual indexing,
2. automatic indexing,
3. intelligent or agent- based indexing, and
4. meta-data, RDF and annotation-based indexing.

While the first two appear in many classical IR texts (e.g. [459]), the latter two are relatively new and promising areas of study. Kobayashi/Takeda claim that "indexing Web pages to facilitate retrieval is a much more complex and challenging problem than the corresponding one associated with classical databases" [279].

These developments have led to "a rich cross-fertilisation of research between hypertext and IR" [114, p. 26] and the "unusually attractive interfaces" of the search engines [279]. The advent of the Semantic Web [54], might be the *summum bonum* of the convergence of IR and browsing.

Svensson concludes that, if a user has a well-defined information need, s/he retrieves the information that matches the need, while in navigation the need (or destination) may not be clear to users:

> "Whether or not a search in a search engine is navigation or not, depends on a user's intentions. If she knows exactly what she wants and she uses the engine to retrieve that information, we would classify it as information retrieval. Conversely, a user that uses a search engine in order to clarify her goal, or get a better understanding of some subject, is navigating. In general, we argue that navigation always has an element of information retrieval to it. In navigation the navigator continuously has to retrieve information that tells her where she is, where to turn, when the goal has been reached, and so on" [512, p. 25].

Augmenting the Web will have to involve a great effort to encourage linkage. In today's WWW, many efforts have been made to increase the capabilities of search engines, and there is hardly any valid word that does not bring up a number of hits, or, to stick with our police metaphor, "suspects". Search engines present their results as dynamic HTML pages, sometimes including machine generated links to search similar documents, to directories or to translations of the found documents. This is a revolutionary increase of functionality especially at the beginning of a hypertext session. Yet, it cannot substitute user-defined links between nodes. Furthermore, the number of retrieved references is often just too great to be feasible for review: Who has the time and concentration to look at thousands of suspects from behind the glass wall? The identikit picture metaphor, of course, leads to the question of non-text navigation.

3.7.10 Navigation in non-text hypermedia

"Because I seek an image, not a book" says Ille in W.B. Yeats' poem Ego Dominus Tuus to Hic. And this is exactly what many users are doing in hypermedia. At the time of writing this dissertation, the search engine Google implemented a beta version of an image searching tool on the WWW. A search for the word "eagle" in early August 2001 brought up 845 image files, of which the first and the last are shown in figure 3.21.

(a) First match: Bald Eagle.jpg

(b) Last match: Jim & Robin of Eagle SongFlutes

Figure 3.21: Search request for "eagle" on Google Image Search.

As can be easily determined from this result, the search mechanism looks for the requested term in the file name as well as in the context of the image on the Web page. Accordingly, the grade of usefulness of the retrieved images varies a lot, and the browsing of the 43 result pages can be quite tiresome.

This result corresponds with the findings of Smolinar et al. [494] who have used Semiotics to formulate an authoring perspective to multimedia search. They point to the research of Gerald Edelman, who has been investigating "the construction of automata that not only are capable of general visual perception but also have designs that reflect our knowledge of the neural architectures that support biological perception. [...] However, while the technology for representing an object's shape is promising, the segmentation technology that identifies an object in the first place is far weaker". They conclude that we have to accept that searching on such a query can only be viable if it yields a set of candidates, "some (if not many) of which may have nothing to do with the content we had in mind and many of which may only be valuable to the extent that they can help us formulate a more accurate query" [494, p. 5-6].

Half a decade later we have a number of promising approaches using Content Based Retrieval (CBR) and Content Based Navigation (CBN) together with the Open Hypermedia paradigm, such as Miyabi, ARTISTE and MAVIS [226, 340, 319]. The ARTISTE system includes algorithms for color, textile/fabric and shape matching for parts of, or entire images. ARTISTE will integrate art collections while allowing the owners of each collection to maintain ownership and control of their data by using the concept of distributed linking: "The distributed linking will add links to content (both text and images) at presentation time. This will enable a user to add links to content that they do not own or have write access to" [340].

MAVIS (the Multimedia Architecture for Video, Image and Sound) brings together techniques for CBR/CBN in different types of media, into a single hypermedia system, allowing cross-media navigation, concept navigation and retrieval via a multimedia thesaurus [513]. To overcome the inadequacies of the low level feature matching of images, Tansley et al. propose a mid-level extraction method for images based upon scale space matching and graph matching to achieve topological matching of images and object retrieval. Yet, in spite of significant progress in content based retrieval, it is clear that "to achieve truly robust and versatile retrieval of images based on content will require a general solution to the recognition problem in image analysis and this is far from being achieved" [318]. Furthermore, it seems that in comparison with textual linking and the latest research on time-based hypermedia, navigation in images-spaces have been theorized and formalized to a lesser extent.

In the process of building MAVIS2, Joyce et al. investigated the applicability of semiotic concepts and intelligent agents for integrating and navigating through multimedia representations of concepts [264]. First, they follow Smolinar et al. [494] in considering the Saussurian notion of signifier and signified as the focal concepts in multimedia data. But then they reject it because they "note that the 'user' is abstracted out of the Saussurian model" [264, p. 133]. They turn to Ogden/Richards' interpretation of Peirce's system as a semiotic triangle and Peirce's second trichotomy iconic/indexical/symbolic [406, 416].

Of course, this leads into the direction of Computational Semiotics, a field of research which applies and implements semiotic principles into Artificial Intelligence systems. As any thorough approach to these issues would by far go beyond the scope of this dissertation, I want to limit my commentaries on the following points of departure, which may serve as a basis for further work:

- The simplified model of a semiotic triangle promoted by Morris [368] and Ogden/Richards [406] has been criticized by many semioticians, e.g. Umberto Eco, Renzo Raggiunti and Mihai Nadin [154, 155, 429, 375]. In his pansemiotic view, Peirce sees the whole world as a semiotic system, cf. [264], [401, p. 59ff.] which works by means of semiosis (see section 2.5). This means that the user never gets to (i.e. never uses, never means) the "real object" but he decodifies the sign as far as he needs it for the communication act.

- This unlimited semiotic chain is also inherent in the Saussurian syntagmatic and paradigmatic axes (despite Derrida's critique, it can thus be described as multi-dimensional, cf. [534]). In my point of view, it is simplistic to say that Saussure's model "abstracts out" the user while Peirce's "includes" him/her. Especially extensions of the Signifier/Signified model (from Lacan and Jakobson to Kristeva) make it obvious that the user is not a closed entity that stands either inside or outside.

- In Peirce's own words, the sign is "something which stands to somebody for something in some respect or capacity" [416, vol. 2, p. 228]. Thus, the "meaning" of a sign depends on the context. In connection with CBR, Santini/Jain have tried to

close the semantic gap by considering these different ”meanings”: ”Context is essential for the determination of the meaning of an image and for the judgment of image similarity” [467]. They use an interaction model that seems very similar to the spatial hypermedia approach – although they do not explicitely refer to this approach, cf. [335, 336, 337, 486, 485].

- Peirce’s other two trichotomies are often neglected, because they are a bit harder to grasp than the taxonomy iconic/indexical/symbolic. Yet, they can be just as vital to close the semantic gap. The important question if the depiction of a car means a certain cat or any cat (the class) is an example for the decision between rhema and dicent. Nöth [397] claims that this distinction is logocentric because ”a particular photograph of a cat on a mat, being an indexical sign, is certainly in the first place about an individual cat and not about a member of a class. [...] The individuality of the cat and the mat an be easily identified in many details” [397, p. 141]. Elkins’ image theory, which relates Wittgenstein’s early philosophy and Goodman’s notation systems contains some interesting considerations in this context (see section 2.7).
- Accordingly, Wexelblat’s Footprint system [541] (see section 3.7.8 on social navigation) can be interpreted as a system of indexical qualisigns. Social navigation could play a major role in this kind of IR and navigation in non-text hypermedia.
- A common base of psycho-visual particularities that delimit the human eye against artificial image recognition, e.g. seeing in *gestalts* (cf. [281, 280, 269]), has to be defined for this kind of research.

3.7.11 Semiotic Aspects of Hypertext Navigation

As we have seen in section 3.7, Lynch’s *The Image of the City*, serves as the model for wayfinding in hypertext using traditional geography, spatiality and virtual reality, like Dieberger’s *Information City*, cf. [142]. On the other hand we have the connection to textual and semiotic models (described in section 3.5 on hypertext semiotics), that concentrate on the sequential selection of textual nodes by following links. The latter concept of hypertext navigation resembles the discursive use of language, or parole. One is also reminded of the dichotomy of structural vs. associative links underlined by Risak, cf. [439]. In the middle, we find Wittgenstein’s metaphor of the language as a city:

> ”Unsere Sprache kann man ansehen als eine alte Stadt, ein Gewinkel von Gäßchen und Plätzen, alten und neuen Häusern, und Häusern mit Zubauten aus verschiedenen Zeiten; und dies umgeben von einer Menge neuer Vororte mit geraden und regelmäßigen Straßen und mit einförmigen Häusern” [549, 18].

Smuda [495] has analyzed the metropolis as text and Wenz [538] takes on his account of the coherence between perception and narrativity in Futurism, the artistic school at the beginning of the 20^{th} century that captured speed as a spatio-temporal movement on canvas and paper. Speed has changed our perception just like our way of living, as recorded by Walter Benjamin, cf. [44], and Laszlo Moholy-Nagy:

> ”The motor car driver or airplane pilot can bring distant and unrelated landmarks into spatial relationships unknown to the pedestrian. The difference is produced by the changed perception caused by the various speeds, vision in motion” [366, p. 245].

Wenz concludes that ”the same increase of velocity and stimulus satiation is achieved in the medium of hypertext, which leads to the difficulty that we deal with a space which stretches our capacity of imagination. Therefore, the hypertextual data space is virtually constructed as a landscape by metaphors of space which we also use in other fields of experience in order to make us acquainted with the new medium” [538, p. 582]. So, is the queasy feeling of being lost in hyperspace merely a motion sickness of unexperienced cybernauts? Or rather, is that feeling of nausea a variation of the so-called Stendhal Syndrome, the intense psychical disturbances that foreign tourists experience when they visit for the first time the grand architectural beauties of Florence and Rome, cf. [322]?

What these sicknesses have in common is a feeling of inability to take control, be it as a passive traveler in a machine that transports the body at speeds far beyond its natural abilities, or be it as a spectator who is overwhelmed by the inconceivability of the sublime beauties. Conditional links and personalized systems (see section 3.4.5) may help the users to introduce themselves to the new environment. Paradoxically, these systems create a feeling of secureness and control by taking control out of the users' hands. These reflections insinuate that the problem has a lot more facets than Cunliffe's concept of user control: ”Guided tours provide perhaps the least amount of control for the user, and direct access and, to a lesser extent, searching provide perhaps the most control” [114, p. 28]. Yet, as explained in section 3.7.3, there are ”hard” and ”soft” versions of guided tours.

Bahr explains that machines raise our receptive sensuality to superhuman levels[93], (e.g. they enable us to explore the surface of the Mars without even having to be there) while, at the same time, they keep sensuousness away from our bodies:

> ”So heben uns die Maschinen von unserer leiblichen Struktur ab und übersetzen sie in eine 'kontemplative' Struktur. Man spricht angesichts der Erscheinungen immer weniger von Er-fahrungen, immer mehr von 'Daten', weil sie uns weniger in Bewegung bringen als vielmehr über Bewegung informieren. [...] So steigern die Maschinen die Sinnlichkeit, die sie uns zugleich vom Leibe [halten]” [24, p. 28].

But if we ”are” at, or *in* a place, we want to be there with all our senses: ”The body image schemas described by Lakoff and Johnson, among others, are fundamental to thought, and to think that we can divorce 'information' from emotion (cf. [117]) and bodily experience leads us down a slippery cognitive slope” [524], cf. [302].[94] Wenz criticizes hypertext implementations that place the reader outside of the text. The information ”which a hypertext opens when the user is clicking an icon and opens a new window characterizes the reader as appositioned outside, as an observer who has to open the windows of a complex building with rooms with different spatial arrangements and borderlines. Where is the reader's position in hypertext? Is it merely outside? This seems to be a strange metaphor which compares the reader to a voyeur” [538, p. 578].[95] To be lost in hyperspace does not only mean that we do not know where we are in the sense that we are peeking into the wrong window, or that we have taken the wrong exit on the information highway. To be lost in hyperspace means to find oneself buried under an avalanche of information and having to find out which direction is up and which down, how to get out, and how one ever got there. Hypertext is a constructed, not a transformed (virtual) space. This lack of isometry with the Euclidean space[96] we believe to live in is one reason for our navigational difficulties in a

[93] The idea of the artificial magnifying and reducing our senses has also been described by Umberto Eco [156] as ”effects of prostheses”: Any device that replaces parts of our body or extends the range of action of some part of our body can be regarded as a prosthesis which is more specialized than the original function, e.g. a telescope increases the depth of vision at the cost of breadth of vision. See sections 2.9 and 4.4.

[94] Compare this with Rotman's reiterated concern with reinstating the body in mathematics, cf. [451].

[95] Veith Risak reminded me that the blurring of the author/reader roles is an important factor for a reader to be ”inside” a hypertext.

[96] See section 3.4.3, especially figure 3.9 and footnote 37 on Euclidean space.

hypertext-as-space metaphor. And accepting this breakdown and actively confronting it on the conceptual and the interface design level seems a more fruitful strategy than denying it. Lost in hyperspace is neither a pseudo-biblical quotation nor a ”pedagogical myth” that has grown for its own sake, cf. [476]. In the most basic form, it is a concentration weakness, an incidence of ”loosing the thread”, be it in a lecture, reading a book, driving through a city, following a discussion, or: navigating a hypertext. Of course, ”poorly designed”, ”boring”, or ”confusing” hypertexts run a greater risk of disorienting the reader, cf. [518].

If Schulmeister insists that ”a disorientation through faults in the navigation is more similar to confusion than to losing one’s bearings” his intention might be to promote hypertext as an adequate tool for learning, defending it against Hammond, ”who has filled quite a lot of articles with his idea of a didacticizing of navigation” [476, Components of Navigation]. And the current development of decreasing linkage in the Web seems to underline the necessity to relieve the link from the spell of tyranny, cf. [207, 208]. As pointed out in sections 4.2.3 and 3.7.9, abundant linking is a way of *increasing* the usability of hypertext, as search engines are a useful enrichment, but not a substitute for navigation by browsing. Section 3.7.9 on Information Retrieval (IR) will reveal that a thousand search results by no means give more control over an information space than a reasonable number of handcrafted links. Thus, the serendipity effect is not an ”alternative hypothesis to the concept of lost in hyperspace” but, rather, the other side of the same coin. Some authors even see the serendipity effect as explorative learning, cf. [476, Components of Navigation]. In summary, the ”lost in hyperspace” phenomenon should not be denied. Rather, it should be faced by developing new hypertext models and by increasing linkage in connection with powerful navigation tools, as further developed in section 4.2.3 and 3.7.9.

The absence of the time axis is a direct result of the absence of distance, or, as Ipsen puts it, hypertext is a peculiar example for time dislocation:

> ”In analogy with the steering of ships, where the everchanging sky and celestial bodies are essential for navigation, which means time is essential, hypertext, which lacks stability by its nature, can only be navigated by detailed knowledge of positions of chunks, nodes, and links, otherwise the user gets lost, like a ship bereft of nautical instruments or maps. What makes navigation even harder is the lack of diachrony. Due to the possibility of adding chunks to the hypertext without leaving a trace[97] of the former state of the document, hypertext evinces a present state at all times. [...] In an ideal case, [...] documents from all over the world are accessible in one single moment, reducing distances to naught. [...] The user in the hypertextual network is omnipresent. Regular time and space are neutralized” [247, p. 570-71].

Accordingly, Wenz argues that streams of users are not only part of hypertextual structure, but constitute its basic feature as dynamics and change within a stable network: ”Hyperspace cannot be merely unstable”. For her, there must be some mechanism which creates significant structures and reduces complexity in favor of the development of symbolic systems: ”The question should not be in how far hyperspace excels three-dimensional ’real’ space, but in how far the limits of space will return to hyperspace through its users” [538, p. 578].

In *Sémiologie et urbanisme* [36] Barthes indicated how in his theory of the language of dreams, Freud had emptied the metaphor of language of its metaphorical content: ”Barthes considered his study as that of an amateur, and he began his exposé with a quotation from Victor Hugo to demonstrate that someone had already intuited that the city was a kind of writing” [339, p. 63f.]. Tschumi defended the analogy between Freud’s dreams – fragments

[97] Nielsen recommends to keep a version history of each node. See also section 3.1.3 on Xanadu’s versioning concept.

of the unconscious – and architecture as a way to explain how architecture, too, is an assemblage of real and virtual fragments, cf. [339, 103].

In direct opposition to 'The Image of the City' and the view of navigation which is essentially individualistic, objectivist and cognitive, 'The City and the Sign' [198] presents a number of views from urban semioticians that highlight the limitations of the Lynchian and cognitive perspective. They share the view that the crucial thing missing form the traditional geographies is the failure to appreciate how environments are *conceived* by people as opposed to simply *perceived* by people, cf. [48].

In their postmodern geography, the environment is not simply some physical structure to which humans must adapt. When animals move through a maze, they use landmarks, districts and even signs (e.g. urine marks that indicate an indexical relation to the territory of another animal) to orient themselves in the space they are confronted with. People, however, play a role in *producing* the space, through their activities and practice, an argument put forth by Lefebvre in his 'The Production of Space' [313]. Soja argues that academic study has, in the modern era, privileged time over space and geography[98]. Foucault focused our attention on another spatiality of social life, an "external space", the actually lived and socially produced space of sites and the relations between them, cf. [176]. The heterogenous spaces and relations – Foucault's heterotopias – are constituted in every society. They are what Lefebvre would describe as *l'espace vécu*, actually and socially created spatiality, cf. [496, 497, 313]. Soja has employed his insights in an analysis of the relation of the hypertext navigator and the flâneur of Certeau's "Walk in the city": The hypertext readers become virtual *Wandersmänner*, cf. [125]. They produce a hodological space[99], a type of space which is based on "physical, social and psychological conditions a person is faced with on the way from point A to point B whether in an open landscape or within urban or architectural conditions" [158, p. 2-3].

The spatial relations of memory maps should be seen from this hodological perspective, like the medieval mappae mundi[100] which were often drawn from verbal accounts of travelers and children's mappae mundi which are suggestive of uncanny dreamscapes and drawn in circular form of varying sizes depending on the amount of information a child is able to recall (see also section 3.7.4). The cognitive approach to geography leaves the use that people make of their environment out of the analysis. For hypertext navigation, "this is not to say that all studies of cognitive mapping and all the analysis provided by cognitive geographies needs to be thrown away. Only that the social construction and the ideological impact of space needs to be considered also" [48, p. 706].

Gottdiener comments that "in the case of [shopping] malls [...] on the one hand the mall is the materialization of the retailers intention to sell consumer goods [...] on the other hand, the mall is the physical space within which individuals come to a participate in a certain type of urban ambiance" [197]. In the context of the commercialization of the Internet, such accounts should be taken very seriously when building eCommerce portals (see section 4.7). Barthes' notion that two neighborhoods are adjoining, if we rely on the map but radically separated in the image of the city from the moment when they receive two different significations could be compared to conflicts about similar sounding domain names in cyberspace (see section 4.7.7). These differences are ignored by the objectivist tradition of the analysis of space. The semiotic analysis of space recognizes that there are many different views of space and that space is a subjectively defined concept:

"We recognize that we as people negotiate a shared understanding of space.

[98] In hyperspace, it seems, the "prioritization of time over space" [497, p. 114] has subconsciously pervaded the navigational metaphor, as shown in section 3.7.7 on the "history" function.

[99] The term *hodological* space is derived from Greek *hodos*, path, way. See footnote 38 on page 92.

[100] "The Latin word mappa originally meant signal cloth, napkin, or towel probably because early portable maps were drawn on cloth and used as signals or guides for armies moving across unknown terrain. In medieval times, the word mundi, world, was added to form mappa mundi" [498]. See section 3.7.4 on maps.

> There is a context to space which needs to be communicated, negotiated and understood between people. More than just space, there is the idea of place. People produce or construct their places at different times and there is a knock on effect from one place to another. [...] The city centre retains it's physical structure but changes from a shopping place during the day to a place where gangs hang out at night. The gangs have notions of 'their' space which would not be recognised by the shoppers. With these ideas, navigation (as opposed to wayfinding) includes a number of activities which occur in space and which people are willing to agree are sorts of navigation" [48].

Analyzing space this way leads us to think that virtual spaces, or information spaces, may be like physical ones or they may not be. We can distinguish navigation from wayfinding. Navigation can also lead away from the geographical space and towards a social space – i.e. a space for safety, or a heteropia: a church, a brothel, a museum, a fairground, etc., cf. [176].

These reflections have driven quite far away from the initial, and rather unawakened notion of navigation: "*Navigation of Information Space* is not (just) a metaphor, it is a paradigm shift. [...] Shifting the paradigm changes the way you think about things" [48]. Benyon explains his semiotic paradigm of *Navigation of Information Space* by comparing it to our physical space, which he calls activity space:

> "The information system (or information space) is a system which has a similar structure to the activity system. The important difference is that it uses information artefacts to represent relevant features of the activity system. [...] The information space uses signs, structured into information artefacts to represent (certain aspects) of the activity space [...] An information artefact consists of two levels of description; a conceptual level provides some abstraction of the experienced world and a perceptual level provides a view, or viewport onto that structure. [...] All information artefacts employ various symbols, structured in some fashion, and provide functions to manipulate the symbols (whether conceptually or physically)" [48].

The cascade of multiple levels of information artefacts, each built upon the others reminds us of the principle of unlimited semiosis (see section 2.5).

Yet, hypertextual navigation is more than just recognizing symbols and icons, pressing buttons and following links. Accordingly, I cannot agree to Dieberger's view which (despite his spatial approach) still clutches on the graph model:

> "The main difference between file systems for computers and hypertextual information is that file systems are hierarchical constructs whereas hypertexts are networks and therefore mostly non-hierarchical. That means that there often are several paths to a certain node. Except for that the navigational task is similar" [142, p. 71].

This simplified view ignores the particularties of text and interpretation. I do not support the opinion that finding a file in a hierarchical file system (i.e. clicking through folders until the file is spotted) is similar to active hypertext reading. Dieberger's view limits hypertext navigation to some kind of *information zapping*, or database search. Yet, reading hypertext is not merely clicking crosswise on the paradigmatic axis. It also means working on the syntagmatic axis, reading in full-text the words that surround the link markers. Finally, it is constructing a meaning of the text, creating *coherence*:

> ”In hypertext, coherence has to be created by the user in the act of reading, and therefore it is not totally different from traditional forms of reading. The reading paths of the user are linear and they are constructed in the process of reading. The connection between the different entities or chunks is associative and guided by the reader’s interests. The chunks of a hypertext themselves are passages of traditional texts. The difference to traditional texts lies in the fact that cohesion between different nodes is avoided because the user has the possibility to come to one node through different paths” [538, p. 580].

On the basis of these reflections and the results of Benyon’s analysis, let us reconsider the very first metaphor of hypertext navigation: ”With one item in its grasp, [the mind] snaps instantly to the next that is suggested by the association of thoughts, in accordance with some intricate web of trails carried by the cells of the brain” [80]. Bush’s conviction that man ought to be able to learn from the brain trails as a basic function of the human mind holds the promise that hypertext, as a memory extender (see section 3.1.2 on the memex) allows our thoughts to wander freely, without the worldly conventions of space. As ”the linking and relinking of objects by the Brain is actually a language, but not a language like ours”[101] can we hope to learn that language and use it for navigation, now that we have systems that can ”duplicate this mental process artificially” [80] ?

McKnight, Dillon and Richardson’s definition of ”semantic navigation” points toward the interpretation of the meanings contained in the application: ”In other words, to what extent does a user or reader need to find his way about the argument that an author creates as opposed to, or distinct from, navigating through the structure of the information?” [348, p. 85]. It does not seem surprising that we feel at home only in the hypertexts we have written ourselves, because our memory can only be extended with thoughts we have already had. New ideas have to be created or re-created from texts or conversations. Thus, the third reason for our navigational difficulties in hypertext is that, most of the times, we have to follow other people’s thought trails until they are our own. In other words, we pretend to speak a language we do not know (like the Pope when he gives the Urbi et Orbi blessing, and Easter greetings to the world, in more than 60 different languages). From the pedagogical perspective this can be re-formulated as: ”The learner can only overcome discrepancies in actively coming to terms with the material”. So, how can we familiarize with that *terra incognita*?

Connecting Wenz’s notion of *coherence* with the postmodern concept of *produced space*, one could say that only link navigation (the order and direction in which links were chosen) produces a hypertext: ”A node is something through which other things pass, and which is created by their passage” [492, p. 126]. Wenz concludes that, ”coherence in hypertext is nothing else than the reader’s performance of constructing a connection which is governed by metatextual instructions so that the reader is able to perceive the pattern that connects” [538, p. 580], which is a slightly more complicated way to say the same thing. Thus, the traditional reader/author model begins to shake and it breaks down if annotations and linking are permitted. In personalisable hypertext (see section 3.4.5), the isolated roles that come with first ”authoring” and only thereafter ”reading”, or ”navigating” blur which has been seen by many as an important potential of hypertext systems[102]:

> ”The processes of reading and writing are also inseparably linked. [. . .] What we read not only enriches our ability to communicate; reading is but a part of

[101] Dick [139], as cited in [28]. This assumption is, of course based on Lacan, see section 3.5 on Hypertext Semiotics.

[102] It appears that Davis Marshall deliberately misunderstands Landow/Delany’s sentence ”Hypertext systems permit the individual reader to choose his or her own centre of investigation and experience” [129, p. 19], as he says: ”By definition, then, a hypermedia system is fun for the reader, not the writer. In the case of the Internet [sic] there is, emphatically, no author. But does perhaps the structuring of the links, rather than what is linked, provide a role for the author?” [338].

> a greater communication process. This should be a basic assumption in the design of Hypertext [...] Efforts to treat these two areas as different problems are not consistent with designing systems for humans" [521].

In hypertexts that allow the user to add nodes, links, new link types and annotations to links, ranking, interface features and so on, the roles of the reader and the author oscillate, just like the roles of the speaker and the listener in a conversation. In the WWW of today, the lack of democratic structures and multi-vocality is not only a technical issue (see section 3.1.17). The arrival of (fast) money, (copyright) law and (Foucaultian) order to the Internet makes it seem questionable if the necessary features will ever be installed; see section 4.2.

Thus, the *Semiotic Aspects of Web Navigation*, although an important viewpoint, should be viewed critically, as "unlimited semiosis" in a pure sense is very limited in the current form of the WWW. Thus, McGuire's conclusion seems rather naive in this account:

> "The act of 'surfing' the Internet, following links can be compared to Pierce's [sic!] concept of 'unlimited semiosis'. Indeed, Hypertext appears to fulfill the demands of many Post-Structuralist theorists. Barthes's criteria for 'writerly' texts necessitating activity and creativity on the part of the reader are met in Hypertext, while Derridean concepts of Intertextuality, Multivocality, and De-centering are made extremely explicit. This convergence cannot be seen as accidental, as undoubtedly theoretical concerns have influenced the development of hypertextual systems, which in turn have inspired and been discussed by semioticians" [346].

In fact, these promises (one could also cite Foucault's questioning of the author role [175]) cannot be kept due to the very limited hypertext functionalities of the WWW (see section 4.2.3). To support Web development in this direction, a firm basis of semiotic research can play a crucial role. Thus, it is also important to keep a certain seriousness in an applied semiotic analysis and avoid pseudo-semiotic terminology such that of Balasubram, who claims that "the theory of semiotics or the study of symbols shows that the understanding of knowledge takes place at four levels: lexical, syntactic, semantic and pragmatic..." [25, Ch.1, p. 7].

Chapter 4

Reading the Signs of the World Wide Web

Literary scholars insist that we have to give up models which try to describe the text as one world in favor of an open multifaceted view of (inter-)textuality. They claim that hypertext can be described as the number of its possible links and that it communicates by branching out. On the other hand, analyses have shown that the WWW is less interconnected than suggested by literary and hypertext theory, cf. [5, 73, 222]; see section 3.4.1. Furthermore, the WWW is far more than a text medium: Post-photography and Web design have shaped the look of the WWW and require an image theory in the hypertextual context. Further integration of time-based hypermedia (film/video, music/sound) and other media (olfactory, haptic and gustatory inputs) will call for theoretical approaches that include and go beyond usability studies:

> ”With the advent of networking, and especially under the influence of the semiosis of hypermedia, Web publishing made it all the more critical to understand the semiosis of multimedia. Here again, what defines the approach is the pragmatics of distributed tasking and cooperative conjuring of meaning” [374].

On the other hand, the Web is no more a backyard of academic Acadia. As if following an predefined order, sex, money and power have migrated onto the electronic medium.[1] This chapter tries to apply the findings of Semiotics and Hypertext Theory to the reality of today’s WWW, especially the growing visualization and commercialization of the medium.

4.1 The WWW metaphor

The name World Wide Web was coined by Berners-Lee as early as 1990 during a conference in the CERN cafeteria, cf. [293].

[1] A two-year study by Alexa Research has revealed, that that the most popular term people search for online is ”sex”, cf. [115]. The commercialization of the Internet in the mid-90s is now followed by a wave of governmental efforts to control the medium, e.g. by installing filters or controlling access, cf. [433]. The Institute of Socio-Semiotic Studies (ISSS) in Vienna has started a seminar series with the first session on ”Sex and the Meaning of Life” in 1998, to be followed by ”Money, Meaning and Mind” in October of 2001. According to co-organizer Jeff Bernard, the series is dedicated to the most important sign systems (personal interview). As the insignia of power seem to be as old as mankind itself, this might be the next topic on the organizer’s list.

> ”Looking for a name for a global hypertext system, an essential element I wanted to stress was its decentralized form allowing anything to link to anything. This form is mathematically a graph, or web. It was designed to be global of course. (I had noticed that projects find it useful to have a signature letter, as the Zebra project at CERN which started all its variables with ’Z’. In fact by the time I had decided on WWW, I had written enough code using global variables starting with ’HT’ for hypertext that W wasn’t used for that.). Alternatives I considered were ’Mine of information’ (’Moi’, c’est un peu egoiste) and ’The Information Mine (’Tim’, even more egocentric!), and ’Information Mesh’ (too like ’Mess’ though its ability to describe a mess was a requirement!),” [52].

Even though Berners-Lee claims that he derived the term World Wide Web from graph theory, it has been widely understood as a metaphor based on textile weaving[2] or the spider’s cob*web*[3]. Schneider/Berz have shown that the weaving metaphor breaks down when taken literally.[4] For Harpold, ”metaphors of linking suggest an intersection of two or more threads at a common point, metaphors of knots suggest a more dynamic interlacing of the threads, each looping around the other at a central point of detour” [217, p. 177].[5]

The World Wide Web is often used synonymously with the Internet and some authors have contributed to this misunderstanding: ”The ultimate hypertext, or rather hypermedia, system is, of course, the Internet” [338]. Another metaphorical term closely connected with the development of computer networks and the WWW is Cyberspace (see section 4.4).

4.2 Hypertext functionalities of the WWW

While most of the CERN requirements listed in Berner-Lee’s proposal found their way into the WWW, some did not make it into HTML, e.g. annotations (”One must be able to add one’s own private links to and from public information. One must also be able to annotate links, as well as nodes, privately”); typed links (”An intriguing possibility, given a large hypertext database with typed links, is that it allows some degree of automatic analysis”); and live links (”In many cases at CERN information about the state of systems is changing all the time. Hypertext allows documents to be linked into ’live’ data so that every time the link is followed, the information is retrieved”); cf. [51].

The fact that the WWW does not make use of many elaborate hypertext functions described in sections 3.1.17, 3.4, and 3.7 has mainly practical reasons: ”Tim Berners-Lee was not a hypertext theorist, but rather, a utilitarian who applied hypertext as a minor, isolated feature, but a profoundly convenient one, to the existing model of source documents: that is, to the word-processor file model” [229]. Furthermore, the success of the read-only Mosaic browser gave the WWW a momentum into a direction that lead away from multi-vocality, intertextuality and democratization and towards the broadcasting model of the mass-media.

[2] Cf. [475]. Hypertext had evoked textile metaphors already before the advent of the WWW: ”Writing and reading the threads, moving along the weave of the hypertextual fabric, subjects the writer and the reader to the individual and cumulative effects of the dislocations at each detour in the tapestry” [217].

[3] Programs which collect information from WWW sites are called *Web Spiders*.

[4] ”Das frei in alle Richtungen knüpfende Prinzip der Netztechnik ist der strengen Logik der Webtechnik entgegengesetzt und hat nichts mit Rhizomen oder der Verbindung von Orten und Datenpoolen im World Wide Web zu tun. Als Metapher für den Computer ist Weben eher mit Programmen und dem sturen Abarbeiten von Daten vergleichbar. Der zeilenweise Webvorgang steht in enger Verwandtschaft zu linearen Texttechniken und ist das Gegenteil einer assozitiv springenden (Denk-) Struktur, die sich an jedem Ort für eine neue Richtung entscheiden kann” [475].

[5] While I consider these reflections highly interesting, I doubt the general applicability of the Lacanean knotting metaphors for the WWW not only because of their complexity. Among psychoanalytic scholars, there is a rumor that the late Lacan did not even himself fully grasp the applicability of topology on his third register, the Real.

Today, it seems that the WWW is ”trapped by the success” of the browser, just as much as HCI by the success of the desktop metaphor, cf. [28]; see section 4.7.6, a digression on the Browser War. According to usability experts Nielsen and Tognazzini, browsers even fail to support the actual task of browsing the Web:

> ”Netscape Navigator does not have many navigation features, and Internet Explorer does not help users explore new information spaces. Page viewing is truly all they excel at. Movement between pages and the ability to understand where you have been and where you can go? Forget about it” [393].

Browsers merely succeed in the presentation of hypertext, that is, on the ”run-time layer” of the Dexter Model. In this context, it is important to note that hypertext systems can also be built *specifically* to display a single document and therefore provide an especially rich interaction in respect to the content of that particular document. Yet, most known hypertext systems, including Web browsers, are really ”hypertext engines”:

> ”Besides the obvious advantage of not having to program a new application, the use of hypertext engines also has the advantage that they provide a user interface common to many documents. [...] The author just pours text into them and they take care of everything else. [...] Considering that most people are poor interface designers, this may well be an advantage.” [387, p. 111].

While some hypertext systems like Guide and Hyperties are truly *plain* engines, other hypertext engines, e.g. HyperCard, allow the hypertext designer to customize the user interface within a certain framework. The programming facilities of Java and JavaScript allow authors to elaborate the browsers’ facilities and enrich the presentation features, interactivity and navigation tools to a growing extent. Using the right tools to make a site interesting and aesthetically pleasing for the user while keeping it functional and fast has become the main focus of Web design.

4.2.1 Web Design

In early hypertext systems, the main distinction concerning nodes was ”between frame-based systems and window-based systems”. This distinction, as pointed out by Nielsen [387, p. 105], basically refers to the card paradigm vs. text paradigm. HTML browsers switch between the paradigms according to the quantity of information per page: If the information does not fit anymore, a scrolling bar gets displayed. Since HTML 4 has re-coded the term *frameset* to ”a window within a window”, the distinction has to be reformulated to ”non-scrollable” vs. ”scrollable windows”. Whereas the HTML anchor tag <a name> supports the text paradigm, many Web designers try to avoid scrollable windows.

Siegel/Dray [491] have analyzed the different approaches of Marketing Research and User-centered design. From a usability point of view, Web design minimizes what Nielsen calls the homogeneity problem, cf. [387, p. 133]. A successful (re-)design of a Web site depends on many factors, as can be perceived from the experiences at the Vienna University of Economics and Business Administration (WU Wien), cf. [206] and its Virtual University, cf. [188, 189].

Saddler [458] proposes conversations, proposals, spaces & clusters, sketches, symbolic & schematic illustrations, scenarios & storyboards, and prototypes as categories of representational form for design, especially Web design. Making ideas and intentions tangible and manipulable, and involving multiple semiotic channels, for him, are important

factors in representations. In hypermedia, this means a seamless integration of graphical contents[6], complemented by more elaborate sound design, video editing, olfactory, ergonomic/haptic and gustatory/culinary design.[7] A lot of (semiotic) research seems necessary as "the rhetoric of non-linear text is not fully understood and the creation of the underlying hypertext structure is as important as the design of the interface" [114, p. 35]. Saddler asks the question "What is the relationship between a representation and the thing it describes?". This question "has real consequences for information design, in that the things we design and our descriptions of them are often executed in the same media: graphics and interactive software" [458, p. 23]. To solve this "semiotic puzzle", he recurs (as many others in his field, see section 3.6) on the Peirceian types of relationship: symbolic, iconic and indexical. In fact, "hypertext designers also need to address the issue of effective media combination and the matching of media to information. Ways of integrating different media effectively are not fully understood" [114, p. 35].

In the context of the commercialized Internet, Web design nowadays is heavily connected with advertisements issues, as in the case of banners (see section 4.7.4).

4.2.2 WWW or What's Wrong with the Web?

I have borrowed this humorous section title from Bouvin [70, p. 39], who states that, on the one hand "the Web is hugely successful and must clearly be doing something right", but on the other it "could be more than it has become". In the hypertext research community, it is widely agreed upon that the main shortcoming of the WWW's linking model is that links are inlined in HTML documents, and that this is the cause of most of the other problems: "The Web link is in essence little more than a goto or a jump instruction to the Web browser to retrieve and display a new document (and in this sense quite similar to KMS)" [70, p. 40].

Annotation tools are missing just as much as flexible and personalized linking on the Web. As links are unidirectional, this lack of a rhetoric of arrival inhibits knowing whether there are links pointing to a given node or resource[8]. Furthermore, it is not possible to have bidirectional, typed or multiple links, versioning and transclusions, etc. described in section 3.4. Bouvin concludes:

> "Some of these points are minor, but the perhaps most serious consequence of the inline linking model is that there can be only one set of links per document. This is a drawback as it limits the possible uses of a Web page. If it was possible to have multiple sets of links to a given page, this page could be reused in other contexts without any modifications to the page" [70, p. 40].

Maurer/Scherbakov put their fingers on the same points: "Hypermedia systems based solely on the Node-Link model suffer from a number of shortcomings. They include: a) Maintaining link associations is tedious b) Links, by virtue of being physically embedded, break the integrity of document contents c) Links are not context-dependent, leading to i) user disorientation ('lost in hyperspace' syndrome) ii) limited, often unsatisfactory, re-use of hypermedia resources" [344].

[6] Such as photos, diagrams and icons (which I call Graphical Link Markers, see section 3.4.2).

[7] In his talk at the Ars Electronica festival on Sept. 4th 2001, Hiroshi Ishii, the director of the Tangible Media Group at MIT emphasized the same point, cf. [251].

[8] Some search engines offer work-arounds for this problem: In such as Google's "Page-Specific Search" one can enter a URL to "find pages that link to the page". Of course, only for those resources that were collected at the last Web crawl (the process of building a database of Web pages).

4.2.3 Web Augmentation

The Web and its users could benefit greatly from more complex hypertext features, as described in sections 3.4 and 3.7. Indeed, Bieber et al. [61] point out that even users of non-Web applications could benefit from the hypertext approach and that the myriad of today's personal, scientific and business applications, which were not designed specifically as hypermedia-oriented and do not appear on the Web, should be augmented with hypertext features. Their *Hypertext Functionality* approach focuses on incorporating hypertext features into software systems so as to provide their users with an associative way of accessing, analyzing and organizing information. This is somehow similar to the OHS approach (described in section 3.1.16), which has been proposed for Web augmentation, cf. [70]. Web augmentation allows users to create and use external hypermedia structures imposed on Web pages (i.e. not previously present on the pages), that they themselves not necessarily have write-access to. This would empower users as they would be able to use the Web in a more flexible way. Given Web augmentation tools, it becomes possible to annotate, link, and otherwise structure all Web pages. OHS functionalities would also allow Web users to share their links with others, or professionals to publish their work to their colleagues, clients, or readers.

OHS is one promising way of adding hypertext functionality to the Web. Another is Hyperwave, which (as mentioned in section 3.1.18) evolved from the Hyper-G server software. This data model extends the node-link model with an information structuring facility orthogonal to hyperlinking as it introduces the notion of a collection of objects: A Hyperwave collection is a composite object, comprising documents and/or other collections. It is analogous to folders or directories in a hierarchical file system. The Hyperwave collection therefore describes a hierarchy of collections, cf. [344]. Technically, the Hyperwave collection hierarchy is a directed acyclic graph (see section 3.4.1) where each document or collection must have at least one parent (except for the root collection of each server). While a document or collection can be a member of more than one collection, the collection hierarchy must be cycle-free. These rules form the basis for what Maurer/Scherbakov [344] call second generation hypermedia: As links are stored separately from the nodes, *isolated nodes* can be avoided because the added node is accessible through collection hierarchy navigation. Accordingly, *dead links* (also called broken links, Error 404[9] or linkrot) are avoided as the deletion of a node results in the automatic removal of all its related links. By creating "virtual links", a sequence of nodes can be stored somehow similar to Bush's concept of trails (see section 3.1.2 and [80]). Links may be assigned keywords, they may be typed, private, and searchable. Finally, the Hyperwave server software can create overview maps, multiclusters and alternative clusters (or, conditional links).

Using both transclusions and composites could reduce or eliminate redundant storage and greatly simplify the update process of Web pages, see section 3.4.2. Other authors recommend *warm* and *hot links*, which is a similar concept, cf. [132], [489]. These concepts have already proved their practicability in operating systems and commercial applications: Composites parallel to UNIX *symbolic links*, MacOS *aliases* and MS Windows'95 *short cuts*. Just like composites, symbolic links allow containers (i.e. directories) to share the same components without duplication and just like composites, only whole files can be shared among containers. Publish/subscribe in the Macintosh operating system and dynamic data exchange (DDE) in Microsoft Windows allow applications to create live channels for displaying portions of data from one application to another, in other words, transclusions (or warm/hot links), cf. [62, p. 43].

Transclusions are perfectly suited for systems such as Xanadu which do not allow deletion and un-monitored modification of documents (As mentioned in section 3.1.3, Xanadu is

[9] Even if Sterling D. Allan claims that Error 404 was foretold in the Bible, broken links have become the hypostasis of (partly avoidable) usability problems in the WWW.

read-only). Otherwise, the problem with transclusions (and links in general) is that information update can desynchronize the link's reference in a link-base and its new location in the document. Before using it, one needs to check link validity, i.e., whether the nodes still exist, whether they are still reachable, and whether the stored references still point to the exact location within the nodes. It also means checking link relevance, i.e., whether the link still has a reason to exist, or, more exactly, whether the changes in the documents have made the link useless, inappropriate or wrong. These problems arise when there is loose control between the link and the connected nodes, i.e., when a change in one of them does not necessarily imply a modification in the others. cf. [62]. As small content changes in Web documents can be very hard to detect for the human eye, it would seem crucial to manually administrate the update history and keep older versions of modified documents[10] until these functionalities will be implemented on the WWW, cf. [388, 62].

XML and the Semantic Web can be seen as part of what James Mohler describes as a "Web convergence [that] is beginning to dawn upon the horizon of the new millennium. It is a shift from the 'immediacy reaction' that spawned the millions of pages in the later half of the 90's to 'intelligent proaction' where information, communication and applications are singular and are guided by a process-based backbone" [365, p. 17].

By calling themselves second, third or forth generation hypermedia[11], the above described approaches and systems claim to be phylogenically superior to the WWW. In fact, they represent the evolution and current state of the art of hypermedia approaches outside the WWW, as described in section 3.1. Yet, it cannot be underlined often enough that, on the publicly acknowledged tenth anniversary of the World Wide Web, the shift from quantity to quality is finally becoming tangible: With the advent of the Semantic Web, OHS's embellished Web-integration and commercially available server tools that work around the limitations of HTML, such as Hyperwave, the WWW has the potential to use a lot more of the immanent hypertextual advantages and to "assist the evolution of human knowledge as a whole" [54]. And that way, the task of reducing cholesterol (as jokingly promised by Meyrowitz, [357]) can be left to the "Web-enabled microwave oven consulting the frozen-food manufacturer's Web site for optimal cooking parameters" [54].

4.3 The Internet as a Global Agora

In ancient Athens, the agora, or marketplace, was the major focus of everyday affairs in the city and was particularly spacious – about 100 meters by 200 meters: "Trade of all kinds took place here, including not just 'ordinary' goods, but barbershops, bathhouses, perfume vendors, drinking establishments and brothels, [2].[12]

The "Global Agora" is a metaphor for the semiotic projection of real-life interaction and communication on the Internet, cf. [440], [221, p. 30ff.], [71, p. 40ff.]. Thus argues

[10] As Veith Risak has reminded me, the "redundant storage argument" has lost its relevance with the prices decreases for storage units.

[11] For Maurer/Scherbakov [344], the HTML-based WWW is first generation hypermedia and the enhancement through the Hyperwave server software epitomizes the next evolutional step. Note that for Bieber et al., the WWW is a hypermedia environment analogous to second-generation computing languages, and following this analogy, they call for "third- and fourth- generation hypermedia features", such as "typed nodes and links, link attributes, structure-based query, transclusions, warm and hot links, private and public links, hypermedia access permissions, computed personalized links, external link databases, link update mechanisms, overviews, trails, guided tours, backtracking and history-based navigation" [62, p. 31].

[12] Custom dictated that respectable women and young men should be absent from the agora until after midday, though in fact lower class women would often be present from the early morning, selling such things as food and bread. Bread-sellers were notoriously loud-mouthed and vulgar, cf. [2]. Today, virtual bread-sellers make use of intrusive marketing techniques on the Internet, such as spamming and user tracking. These and other iMarketing techniques will be highlighted in sections 4.7.4 and 4.7.5.

Carlos Colón in his *Semiotics in Cyberspace*, using the following statement from Elmer-DeWitt's article *Welcome to Cyberspace*: "Stripped of the external trappings of wealth, power, beauty and social status, people tend to be judged in the Cyberspace of the Internet only by their ideas and their ability to get them across in terse, vigorous prose" [161], cf. [106]. In current systems, this multitude of social codes that determine a person is reduced down to the simple rules of netiquette (Etiquette on the Internet). Mark Poster points out that traditionally, a person's identity is defined by contact:

> "Identity is rooted in the physical body. This stability forces individuals to be accountable for their positions and allows trust to be built up between people. The Internet, however, allows individuals to define their own identities and change them at will" [423].

Even if the changing of identities is also a common strategy in the physical world (indeed, it seems to be a deeply rooted human desire), a person's changed identity can still be perceived and interpreted in its whole physical presence. A counter-model to the global agora was coined as the global swarm by Jean Umiker-Sebeok [524].

4.3.1 The Global Swarm

Taking Peircean semiotics, augmented by Foucault's notion of discourse as power, as her theoretical starting point, Umiker-Sebeok examines some of the ways in which the Internet serves as a site of disciplining rituals and at the same time undermines the institutions which seek to use those rituals to exercise control. Her study is meant "as a contribution to our understanding of how experiences with Internet technology affect people". Yet, it limits its focus to "how people talk about these effects, primarily on the Internet, rather than on how this talk or the behavior purports to describe actually impacts the speakers' lives" [524].

Peirce argued that we come to know the world and ourselves only through a dialogue with members of a community of knowers:

> "What anything really is, is what it may finally come to be known to be in the ideal state of complete information, so that reality depends on the ultimate decision of the community; so thought is what it is, only by virtue of its addressing a future thought [...] In this way, the existence of thought now depends on what is to be hereafter; so that it has only a potential existence, dependent on the future thought of the community [...] The individual man, since his separate existence is manifested only by ignorance and error, so far as he is anything apart from his fellows, and from what he and they are to be, is only a negation" [416, 5.317].

Merrell notes that this hypothetical *state of complete information*[13] – "where absolute difference meets absolute sameness" – would be an asemiotic one, [352, p. 128ff.]. According to Merrell, we can only indicate what some experience of our world is *like* (through iconocity and the category of firstness), *what it is not* (through indexicality and the category of secondness), and what it *would be like* under some set of conditions (through symbolicity or thirdness), cf. [352, 524]. Because symbols always rest upon a base of iconocity and indexicality, we usually rely upon all three of these modes of semiosis, see section 2.5. Given that iconocity is inherently fuzzy and symbolicity incomplete, "our only hope for

[13] This *state of complete information*, is somewhat related to the trait of *perfect information* in the model of the *homo economicus*. This hypothetical creature is a greatly simplified model of man used in the economic models of the Classical school of economics, cf. [464, p. 5ff.].

emerging enlightenment is through the collaborative interpretive work of dialogue, where our interpretations acquire meaning in contrast with those of our interlocutors" [524]. From the interpreter's point of view, these three paths of Peirce's categories serve to reinforce the view "that signs, and especially symbols, do not 'represent,' 'refer to,' 'stand for,' or 'describe' the furniture of our world. At the very most they provide a guide, a call to action, a set of instructions, by means of which we can more or less experience (relate to) what the symbol emissor once experienced" [352, p. 123].

Umiker-Sebeok bridges this principle of dialogue with Hoffmeyer's parallel production of meaning and knowledge on a macroscopic level, or, the *swarm intelligence* of the body:

> "The brain is [...] immersed in the immune system's floating morass of physicality and the cognitive scientists' search for the brain's supreme center – or 'central processor' has proved futile. There do not appear to be any such centers or processors. Rather than the brain being pre-programmed to produce intelligence, intelligence seems to swarm out of it" [230, p. 113-114].

By replacing "community" with "swarm" in order to highlight the process of interpretive structuration over causative structure, Umiker-Sebeok gets: "Reality depends on the ultimate decision of the swarm" [524]. Her semiotic swarm of cyberspace, or *global swarm* is a metaphor she prefers for modern, "wired" life, over terms such as "global village" or "global network", because "ironically, the individual inhabitants of the 'global village' seem to be in a position only to think and act locally, rather than globally, and putting their faith in the hope that their individual blind wanderings will nevertheless, through communion with others, lead to knowledge on the level of the swarm" [524]. Thus, Umiker-Sebeok's global swarm

> "captures the unbounded, self-organizing, rhizomatic nature of cyberspace, where every interpretive point can and must be connected with every other point, where millions of semiotic trails or traces can be erased, reversed, and continually modified, and where there is no inside or outside and hence no possibility of a global description 'from the outside' but only a kind of 'blind groping' following some 'myopic algorithm' made possible through countless dialogic encounters" [524], cf. [130, 157].

4.3.2 Information Gluttony

From that starting point, Umiker-Sebeok explores the Internet as a disciplining technology in the Foucaultian sense – or rather, "as the medium for a range of human discourses which can be seen as disciplining – by examining recent threads of discourse about excessive use of the Internet, or what is usually called 'Internet Addiction' (IA)" [524]. As traditional disciplining techniques (such as family, peer group pressure, manners, etc.) are gradually being replaced by "technical methods" for controlling information flow such as bureaucracies and their experts (cf. [424, 43, 524]), uncontrolled "information overflow" breaks down on the individual user. Comparing information consumption with dispatching food and slamming down drinks, Umiker-Sebeok coins the term "information gluttony" which, in her view, stems from abandonment of traditional disciplining processes. This abandonment has severed the "tie between information and human purpose [so that we have] information without meaning, information without control mechanisms" [424, p. 70].

Another hint that surfing, chatting and e-mailing can be seen as an online "groaning table of shared understanding" [252], rather than social interaction on the global agora comes from Jacobson, who proposes replacing the "marketplace of ideas" metaphor with that

of ”the groaning table, the medieval feast, where one stuffs oneself with every morsel of information and swills a heady brew of knowledge” [252, p. 330].

Hartmann expresses similar thoughts: ”Information ist etwas, zu dessen Essenz ein zuviel ebenso gehört wie ein Zuwenig. Sie verbindet in einer Art kultischem Glauben die Realität mit unserer Meinung davon, womit der Begriff gar eine metaphysische Dimension berührt” [221, p. 41]. Accordingly, he speaks of information as a fetish, a self-made god of those who have access to it, the virtual class. Information overflow, for Hartmann, is a lack of knowledge context.[14]

4.4 Cyberspace

Peter Marx remarks that in ”so-called cyberspace” one finds ”several concepts of space (being attached to different symbolic forms) used. On the one hand, there is the concept of geometric space, but there are also elements of the concept of space according to the symbolic form of [...] myth/religion” [342, p. 347]. Departing from Cassirer’s Philosophy of Symbolic Forms (see section 2.2), Marx takes architectural CAD reconstructions as examples of isomorphous transformation from one space to another:

> ”By superseding any indexical or referential relations to reality, the new image space assumes increasing autonomy. What we perceive as a photographic duplication exists in fact as a mathematical algorithm simulation or modeling the geometrical form of the image it generates. This dislocation of image and referent reinforces its perception as an object in its own right [...] In the factitious space of the computer memory it becomes possible to simulate surrogate reality, a synthetic hyperreality that is difficult to differentiate from our conventional reality, and that, indeed, now threatens to eclipse it” [446, p. 156-57].

Of course, the mere movement in a (virtual) space is not yet hypermedia, or to cite Nielsen, ”the fact that a system is multimedia-based does not make it hypertext [because] only when users interactively take control of a set of dynamic links among units of information does a system get to be hypertext,” [387, p. 10]. Furthermore, the interaction with the system must have a rhetoric in order to be intellectible and bring benefits to the user, as ”linking by itself is not enough” [303, p. 81].

The word *cyberspace*, based on Norbert Wiener’s cybernetics[15], was coined by science fiction writer William Gibson. He used it for the first time in his story ”Burning Chrome” in 1982 and thereafter extensively in his book Neuromancer (1984). But ”by 1989 it had been borrowed by the online community to describe not some science-fiction fantasy but today’s increasingly interconnected computer systems – especially the millions of computers jacked into the Internet” [161]. Accordingly, for Colón, ”the WWW, however, is just one of the activities that are going on in Cyberspace”. While he gives a rather vague prediction of a potential ”Semiotics in Cyberspace”, I have tried to elaborate a more concrete

[14] ”Im ähnlichen Sinn wie ein Zeichen durch seine Zugehörigkeit zu einem Code bedeutsam wird, werden Informationen erst dann sinnvoll, wenn sie in einen Orientierungsrahmen, in einen Wissenskontext passen. Ohne diesen Kontext ist die Information leer, sinnlos, redundant. Von einer Informationsflut klagen wir nur deshalb, weil uns ein bestimmter Kontext verlorengegangen ist” [221, p. 47].

[15] Norbert Wiener defined cybernetics as the science of transmitting messages between man and machine, or from machine to machine. The term cybernetics has its roots in the Greek word for ”steersman” or ”governor,” and Wiener’s use of it suggests how people interact with machines through a controlling device, such as a steering mechanism. Wiener’s remarkable insight, which is the premise behind all human-computer interactivity and interface design, is that human communication should be a model for human-machine and machine-to-machine interactions, cf. [221, p. 56ff.] .

set of semiotic principles and techniques that can be applied to hypertexts, and especially to the WWW:

> "Cyberspace is a universe of opportunities for semiosis to occur. Notice that we are no longer speaking about a specific medium like radio, television, news prints or telephone. Cyberspace is more like an environment or a complex system engineered for the act of signification to take place. It is not the real universe, it is a virtual universe made out of signs. It is a semioticians [sic] heaven" [106].

Other authors, too, keep using "virtual reality" and "cyberspace" interchangeably to refer to all kinds of activities in electronic media[16]:

> "*Cyberspace*, in the sense of 'being in the same room', is an experience, not a wiring system. It is about people using the new technology to do what they are genetically programmed to do: communicate with one another. It can be found in electronic mail exchanged by lovers who have never met. It emerges from the endless debates on mailing lists and message boards. It's that bond that knits together regulars in electronic chat rooms and newsgroups. It is, like Plato's planed of ideal forms, a metaphorical space, a *virtual reality*" [161], my emphasis.

This new ambiguity towards space and reality corresponds with Jameson's debates on space and spatial theory [255] which proved to be some of the most persuasive elements of his postmodern theory: "The deeper logic of postmodernism is that whilst everything is submitted to the change of fashion, the image and the media, nothing fundamentally can change any longer. As Foucault once put it in The Order of Things, we are faced with the monotony of absolute dispersion and absolute difference" [231]; cf. [232, 177]; see section 3.7.11 on postmodern geography's concept of conceived vs. perceived space.

4.5 Cybersigns

As shown in section 4.4, today's general use of the prefix *cyber-* generally relates it interchangably to computers, networks, interfaces, virtual reality and the Internet. In a semiotic analogy to cyberspace, one could speak of cybersigns.[17]

According to The Free Online Dictionary of Computing (FOLDOC), a computer is "a machine that can be programmed to manipulate symbols..." This view, naturally, is shared by Computer Semioticians: Mihai Nadin claims that the computer is a semiotic machine (cf. [375]): "Semioticians without knowing it, Norbert Wiener, Herbert Simon, Vannevar Bush, and Marvin Minsky gave computers an underlying semiotic structure. Bush, for instance, made us aware of the semiotic associative path of non-linear structures" [375].

Whilst Saussurean semioticians have sometimes been criticized for seeking to impose verbal language as a model on media which are non-verbal or not primarily verbal, the virtue of adopting a linguistic model lies in treating all signs as being to some extent arbitrary and conventional – thus fostering an awareness of the ideological forces that seek to naturalize signs, cf. [113, p. 92], [95, Strenghts]. Semioticians argue that signifiers are related to

[16] Virtual Reality (VR) in the technical sense refers to a simulated 3-dimensional environment.

[17] It has to be noted, though, that the term cybersemiotics should be avoided in this general context, as it is used by Søren Brier and others to describe an approach to cognition in the sphere of living systems (ethology and biosemiotics), cf. [72, 271].

their signifieds by social conventions which we learn. In our daily use of various media they become so ”natural” that it can be difficult for us to realize the conventional nature of such relationships. When we take these relationships for granted we treat the signified as unmediated or ”transparent”, as when we interpret television or photography as ”a window on the world”, cf. [95, Strenghts]. Semiotics demonstrates that the ”transparency” of the medium is illusory, [170, 466, 399, 19, 63]. Andersen touches the conventional nature of the signifier-signified relationship in his *Computer Semiotics* [9]. I believe that a similar point can be made by analyzing a remarkable cybersign: the ”@”.

This siglum has become omnipresent on the WWW. Of course, it mainly figures in mailto-links, separating the user’s name from the domain name in e-mail addresses. The user@host convention in e-mail address lines was developed by Ray Tomlinson who wrote a program to enable electronic mail to be sent over the ARPANET in 1972[18]. Other networks chose other conventions, inaugurating a long period known as the e-mail ”header wars” (a predecessor of the Browser War in the 1990s, as described in section 4.7.6). It was not until the late 1980s that the ”@” finally became a worldwide standard. It has been claimed that ”Tomlinson [chose] the @ sign arbitrarily from the non-alphabetic symbols on the keyboard” [515]. This unmotivated choice, of course, has to be rejected as legendary, because the human mind cannot choose a character at random. Psychoanalysis has shown that every human decision is predetermined by the unconscious, or, to use Lacan’s most fitting metaphor that ”a letter always arrives at its destination”, cf. [260, 300].

> ”The ’@’ symbol was used by grocers and accountants throughout the English-speaking world to indicate a rate, or cost per unit, as in ’10 gal @ $3.95/gal’ (ten gallons at three dollars and ninety-five cents per gallon)” [224].

Indeed, the symbol might be much older and stem from the Latin word for at, ”ad”, cf. [381]. Thus, the change from /at/ meaning *for a given amount per* to /at/ meaning *in a specified (electronic) location* ”comes fairly naturally to English speakers” [224]. Thus, besides this technical function in the user@host convention, and its original use as a commercial symbol for cost per unit, the ”@” has entered relations of significance and connotation in many languages.

As the sign was new for native speakers of other languages[19] than English, for whom neither ”at” nor ”@” meant anything until e-mail came around, it had to be given a name. In semiotic terms, one could argue that the signifier /@/ became a signified of its many names in different languages. On could also say that, by the new denomination, the @ sign gets taken to a higher level from which the process of semiosis is ignited. Most of these names are based on the shape of the character, others are more abstract. Some are original and unique, others are derived from other languages. Some have ancient antecedents, others are still ”works in progress.” (According to Herron [224], Internet users in Sri Lanka decided on the siglum’s name only last year). In some countries, a variety of idiosyncratic names have appeared simultaneously, while in others, government bureaucracies are charged with selecting an ”official” term. Metaphors range from animals (snail, worm, little dog, horse) to animals’ body parts (elephant’s trunk, monkey’s tail, cat’s foot, pig’s ear) to food (rollmops herring, strudel, cinnamon roll, pretzel). Herron [224] and Neubauer [381] present a sampling of the many names of @ that are in use around the world.

In linguistic terminology, the @ sign is often called a logogram, a character in writing which represents a word as a whole, cf. [58].[20] Other examples of logograms include the punctuation signs, numbers and the symbols #, &, %, ©. These signs denote no

[18] Cf. [224], while Neubauer claims that the @ celebrated its 20th birthday this year, cf. [381].

[19] Even more for Internet users who live in countries that don’t use the Latin alphabet, and where the keyboards did not conveniently include the @ character until after its widespread use on the Internet made it a necessity.

[20] There seems to be an overlap in the distinction between logograms and *ideograms*, that is: characters in writ-

phonemes, yet they determine meaning defining sentences as questions, exclamations, etc. As a sign vehicle, the @ has entered a myriad of new semiotic relations, e.g. as a way of avoiding gender-specific pronouns in Spanish: ”hola amig@s” means ”hola amigas y amigos”. Richard Janney sees the @ sign as one of the precursors for Vilém Flusser’s digital writing, simplifications or ”transcodings” in our electronic communication that make it easier to digitize information and faster to process it, cf. [257, p. 519-20]. The other transcodings are acronyms, such as FYI (For Your Information), smileys and emoticons and the restrictions of pure ASCII code itself.[21]

Business or product names have integrated the @ into their names in order to connotate electronic communication and ”up-to-dateness”, e.g. @Home[22], ZDNet’s Sm@rt Partner magazine, and many more. Other logograms have entered similar transcoded relations, e.g. the number two in b2b, the eCommerce term for wholesale (”business-to-business”).

As language is discursive by its nature (see section 2.2), its connotations are general. Langer calls language ”a poor medium for expressing our emotional nature”. It cannot really articulate ”the ambivalences and intricacies of inner experience” [306, p. 100]. Thus, non-verbal acts, such as pointing, exchanging looks, and change of voice are necessary to attach specific connotations to its expressions (see section 3.5 and cf. [247]). On the Internet, smileys and emoticons imitate those non-verbal acts; from the basic smiley :-) which is used to inflect a sarcastic or joking statement[23] to ”widely used smileys [sic]”, including

@:-) ”user wears a turban”,

:-@ ”user is screaming”, but also

%*@:-(”hungover with headache” etc., and even more scurrile characters; cf. [380].

Following Nadin [375], the smiley is an example of a qualisign, as a certain quality (friendliness) of an object or an action stand for the entire object:

ing seen as representing an idea in abstraction from words. For Elkins, the @ would probably be a ”typographical morpheme” that fits in the category ”semasiographs”, as do mathematical symbols: ”In mathematics, a number of symbols and symbol configurations have the feeling of pictures without either being pictures of anything or conforming to schematic or graphic rules. Mathematics is replete with typographical morphemes that have the feeling if pictures, such as $\prod, \phi, \pm, \div, \geq, \leq, \neq, \int, \partial, \sum,$ *and* ∞”. In his account of ∞, the infinite, Rotman uses the @ to express the Subject’s ”cognitive fade-out into unintelligibility” [451, p. 109].

[21] Janney calls the computer ”a sort of third partner between ourselves and our [e-mail] addressees” and describes three stages in that triangular relationship on our way toward developing our ”cybernetic ego”, cf. [257, p. 529-33]. The important parallel of the computer monitor to Lacan’s registers, of course, not new in post-modern media theory, cf. [171, 300, 299, 530, 33, 239]. Another interesting relationship that is even more important for the relationship of the hypertext author to the reader and the medium are Janney’s three basic alignments to the network: ”We can see ourselves as participants in it, or as parts, nodes terminals, or extensions of it. Or we can regard the network as a sort of prosthetic extension of ourselves and our interests. [In] the third type of alignment [. . .], the user simply does not know where he or she stands in relation to the computer network, and moreover, does not care” [257, p. 528-29]. The idea of the magnifying and reducing effects of prostheses come from Umberto Eco [156]: Any device that replaces parts of our body or extends the range of action of some part of our body can be regarded as a prosthesis. But prostheses are more specialized, e.g. a telescope increases the depth of vision at the cost of breadth of vision. It is sometimes claimed that the WWW is a global memory and that ”hypertext networks are in many ways highly similar to human long term memory, structurally as well functionally. Both hypertext networks and human long term memory store information by coding its meaning in a distributed network of relations between semantic sub-components” [67].

[22] Pronounced ”at home”: The corporation states on their Web site www.home.com that ”@Home, Excite@Home, @Work, [. . .] and the @Home logo are service marks or registered service marks of At Home Corporation in the United States and other countries”. See section 4.7.2 for copyright issues.

[23] ”A smiley is a sequence of characters on your computer keyboard. If you don’t see it, try tilting your head to the left – the colon represents the eyes, the dash represents the nose and the right parenthesis represents the mouth. Smileys usually follow after the punctuation (or in place of the punctuation) at the end of a sentence. A smiley tells someone what you really mean when you make an offhand remark. They are also called emoticons because they intend to convey emotion!”, [380].

> ”The smiley [...] suggests that the object or action semiotically identified through this quality support an interaction that is friendly. The design of such an element involves understanding how from many characteristics of a sign one can be selected to stand for the entire object or action it represents” [375].

With the smiley, a prehistoric circle seems to close, as the scribbled face – two dots and two scratches – seems to be a predecessor of written signs as much as a mimetic depiction, cf. [522, p. 108]. Following Elkins, that dichotomy never really existed, as ”the analytic distinction between pictographic and ideographic is insupportable [and] there might be no such thing as a pure alphabet, and therefore no such thing as pure writing” [160, p. 128].

4.6 Iconicity of Graphic Link Markers

In the WWW, small graphic files that remind us of the ”GUI icons” described in section 3.6 have become what Otto Neurath [385, p. 359] called a ”helping language”, used instead of or along with words to form link markers. In his article of April 1995, Carlos Colón claims, “The WWW works best in [sic!] a computer running a graphical user interface like Macintoshes, Windows based systems and X-Windows. In such environments, all you have to do to activate a hyperlink is to ’click on it” [106]. Only one month earlier he had concentrated on the *Signification of Icons in a Computer GUI* [107]. It can be assumed by his rather unexperienced use of computer terminology that the author does not approach the issue from the technological point of view, but rather from the user side. Accordingly, Colón’s three analyses of spring 1995 reflect the freshness of his understanding of computers as well as his interest for Sebeok’s interpretation of the semiotic tradition of Peirce.[24] In the paper on *Semiotics in Cyberspace*, however, he wants to reflect only on one of the three kinds of signs in Peirce triad:

> “The GUI is the computer industry’s attempt to make personal computing a reality for every one. This virtual environment provides pictures that are suppose [sic] to be familiar and allows users to interact directly with them by virtue of a kinesthetic action like the movement of a mouse. This has proven to be a lot more appealing for a great amount of people as oppose [sic] to having to memorize and type verbal (symbolic) computer commands” [106].

Key words and sentences that provide instructions or alert the user of the status of the system, for him, are symbols: ”A user is considered computer literate when he or she can understand those symbols” [107]. Another way in which a computer system communicates with a user is by means of indices, e.g. lights and sounds that indicate that a disk drive is reading or writing and a bar of variable length that displays a proportion of the time needed to complete an operation, see section 3.6.

Colón shows that ”computer icons” relate to a certain accuracy of the representation and, of course, the user’s ability to recognize the relationship. Furthermore, he makes it clear that today’s ”computer icons” are hardly ever iconic in the Perceian sense:

[24] “In 1867 in his paper ’On a New List of Categories’, Charles Peirce said that there were three kinds of signs: icons, indices, and symbols. According to Thomas Sebeok ’a sign is said to be iconic when there is a topological similarity between a signifier and its denotata’. Icons are then something that resembles the object that they represent. That similarity between icon and object is fundamentally what sets icons apart from the other two kinds of signs. Indices do not have any similarity with their significants, but have a cause and effect relationship. Symbols do not have any direct relationship with an object other than the meaning that imposed or collectively agreed upon a group of humans,” [106].

> ”The name icon has been adopted as a generic term used for all the pictures that sit on a GUI desktop. However, not all of those pictures are actually icons. In fact, many of them are not easily recognizable or in some cases are simply commercial logos. [...] Icons and other kinds of signs may transform into a different kind at different moments in time. Computer icons are a good example of this. Some icons like folders and mailboxes can be become indices when they serve the function of alerting the user that a folder have [sic] been opened or that new mail has arrived. The pictures are still icons in the sense that they still have a similarity with the real object. They become a new kind of sign (index) because of their communicative action. In fact, some computers use sounds of animals or musical instruments that are considered icons. However, the specific purpose of alerting the user of a specific system's status classifies those sounds, no matter what they sound like, as indices. [...] Also, it is important to note that when pictures are not a good representation of a real object they will only become a symbol that represents a specific function of the computer. There is the chance that in such an instance, other more conventional methods of representation like simple words might be better suited for the task than an unrecognized picture” [106].

Elkins recognizes the parallels between GUI icons and heraldry. For him, ”the most striking similarity between computer screens and heraldic fantasies is the presence of emblems, because 'icons' on computer screens are nothing other than little pictures with attached explanatory text” [160, p. 210].[25]

As GUI ”icons” are not iconic but emblematic and symbolic, and in order to avoid confusion with the semiotic terminology, I will invent a new name for ”icons” in hypertext: When an ”icon”, ”bullet”, ”animated GIF”[26], ”clipart image”, ”thumbnail” or other small picture is used in a hypertext as a link marker, I will call it Graphical Link Marker (GLM)[27]. Accordingly, one could speak of Textual Link Markers (TLMs) in order to underline that the link marker is not a graphical element, such as GLMs, the submit button of a form, or a pull-down menu. This way I hope to avoid the tangling terminology – as buttons, icons, links and anchors are often used interchangeably, or in a confusing manner; e.g.: ”If the intended meaning of a button is expressed graphically, we speak of an icon” [248, p. 264]. In fact, the iconocity of a GLM (in relation to its symbolic character and its indexicality) is an interesting question.

Laurel does not speak of iconocity but of mimesis[28]: ”It is a certain kind of representation. It is a made thing, not an accidental, or arbitrary one: using a pebble to represent a person is not mimetic, using a doll is” [308, p. 70].

Current GUIs use mimesis on a general basis, e.g. to show that the wastebasket contains files, it is shown as full of paper. Jorna and van Wezel state that, ”from a semiotic point of view, at least in the Peircean sense, this implies that, for example, icons approach the

[25] In Goodman's terms, the desktop is a mixed metaphor, combining various routes of reference into a single, almagated image, cf. [195, p. 55-70]. For Elkins, desktops are even notations in the strict sense, ”as they restrict the user to certain sequences of operations — closing and opening, clicking, moving duplicating and deleting — that cross the surface of the screen in a manner utterly unlike writing” [160, p. 211]. Yet Heraldry cannot not be spoken or written without using a natural language, and, even if the specific symbols can have rich connotations, it can only signify emblematically, not narratively: ”L'emblème est un signifiant qui a pour signifié un individu ou un groupe d'individus; le symbole es un signifiant qui a pour signifié un concept, une notion, une idée” [415, p. 36]. The growing iconocity of the GUI icons (see figures 4.2, 4.3) is a further argument against Elkin's comparison with heraldry.

[26] Animated GIFs – small clips of moving images – are more related to ”Vexierbilder” or Puzzle Pictures than to film or video. Therefore, I see them as GLMs rather than as time-based hypermedia.

[27] If the text size is set to ca. 12 points, the height of GLMs in relation to text size hardly ever exceeds 10:1. Bigger pictures are seldomly used as link markers. This ratio coincides with heraldry and GUI icons alike.

[28] In Greek, *mimêsis* means imitation and is related to *mimos*, the mime.

ideal of mimesis more than symbols. Apple and the Microsoft Corporation intuitively followed this road in developing the windows and icon environment on PC's"[29] [263, p. 494]. However, there is still potential to elaborate mimesis in the desktop metaphor: A consequential use of the mimesis principle, to stick with our example, would be to indicate the user by the size or shape of his wastebasket *how* full it really is.[30]

However, Nadin claims that there is an optimum in the transition from pictographic/concrete to abstract, as shown in figure 4.1.

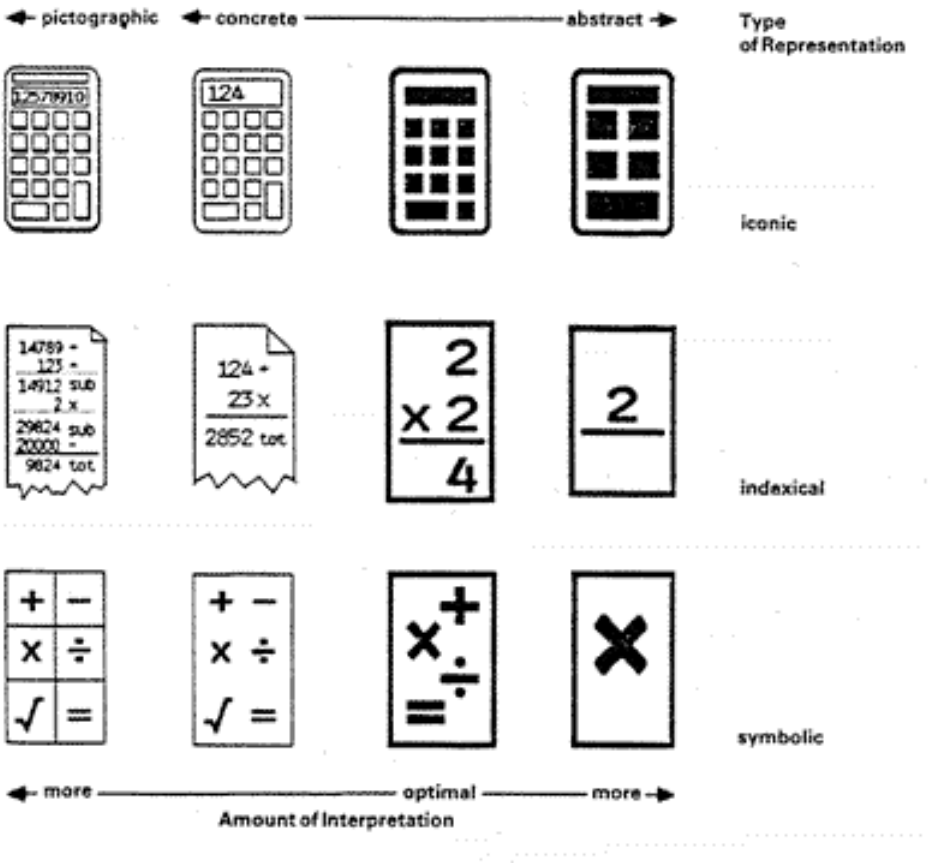


Figure 4.1: Transition from pictographic to abstract representation types. Source: [375].

An interesting standardization effort for GLMs combined with a workaround of typed links is QBullets.

These are freely available (partly animated) GIFs that can be placed directly after a TLM. In the case of the above link (accessible from the electronic versions of this dissertation) to the QBullets Webpage, I have placed the bullet "OutLink" after the link marker, in order to indicate an external link. The full list of bullets include navigational, multimedia, content, and net service issues. These categories are not very consistent and the only semantical link types are "definition" and "info" (see section 3.5). However, some of the more useful are the bullets for links that open a new window, a form, a download process, a mailto, etc.

[29] Note how difficult it is to follow the distinction between semiotic and GUI icons in this quote.

[30] In relation to the wastebasket, the process of discarding documents can also be presented symbolically, in an action called erase/discard, cf. [375]. The virtual wastebasket was implemented in GUIs to support the human need to dispose of objects without immediately removing them beyond recovery. Another safety-net in computing that which is not based on real-world experience is the *undo* command. It is a magic feature, see section 3.6.

A technically more elaborated implementation based on the same idea is the *HyperScout* project [536] (see figure 3.16).

The integration of hypertext navigation tools into the latest generation of file managers (e.g., MS Windows Explorer; KDE Konqueror; Finder in Mac OS X) indicates that the OS developers have a strong interest in the convergence of Web browsers and file managers. It seems that the notion that "every information seeking task in a computer system is a navigational process" [142, p. 8], and the integration of the Hypertext Functionality approach have been widely accepted. Thus, any research regarding navigation in non-text hypermedia should draw upon the findings concerning file representation and navigation in GUIs, cf. [14, 235, 345] and the semiotic approach, cf. [9, 373, 11, 128, 502].

Dieberger describes the development of file representations from the file-name over the *generic file icon* to *typed icons* and further to *document proxies* (see figure 4.2): "Such proxies are often easier to identify on the screen than icons with names. [...] The challenge is to enrich user interfaces without overloading them with so much information that they get unusable because of 'information clutter"' [142, p. 61-62].

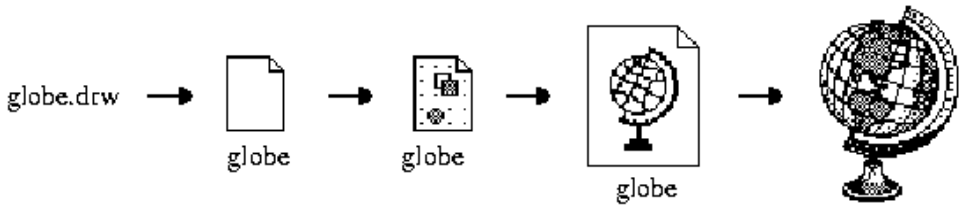


Figure 4.2: Development of object representations according to Dieberger [142, p. 61].

Under Linux, KDE's Konqueror creates and displays proxies of common image formats for local files automatically. As downloading times on the Internet get more reasonable, this thumbnail feature can be expected to become very useful for the WWW, be it in a visual history list or for GLMs. Houde and Salomon suggest a new generation of rich and flexible file interpretations, based on meaningful containers, scale representation and selective emphasis (figure 4.3).

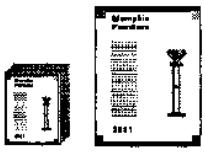
This development is exactly what Brown described as the transition from symbolic to iconic interfaces, cf. [77]. Thus, "icons" are finally becoming iconic, after all. Houde/Salomon extend the scheme by adding a symbolic component: A frame for a bitmap image, a TV-screen-layout for a video clip and a cube for a 3-D animation. The results are compound signs in Neurath's sense: TV-screen-layout plus teacup makes video clip that starts with a shot of a tea cup. Yet, their GLMs do not show a third category of crucial attributes, that is image size, clip duration, number of page, resolution, etc., all of them related to file sizes. In Brown's terminology, these should probably be called indexical, or natural qualities. Houde/Salomon [235] propose scale to indicate file properties, but two major reasons speak against this: First, the dependency on the user's monitor resolution and second, Neurath's iteration rule for showing quantitative data: This rule says that to represent a relation of 1:4, the same symbol should be shown four times in a row rather than a symbol that is 4 times as big, cf. [385, 50].

In the system that I envision, the GLM of a film clip could show its first shot[31] on the first, or iconic level, combined with a symbol for the file type film clip (e.g. a film strip) on the second layer. Accordingly, a PDF file would show its first page with a dog-ear, indicating that it is an electronic paper. The components that influence the downloading or consuming of the medium, e.g. file size, length of sound-clips and film clips, image resolution, numbers

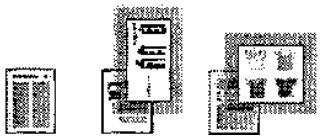
[31] "The cinematic minimal linguistic unit is the shot, an iconic and indexical semantically rich element, which, in semiotic terms, is the equivalent of a linguistic enunciation" [330].

(a) Generic file icons, application icon, document proxy

(b) Meaningful Containers: 3D-model, video frame, bitmap image



(c) Preserving scale: book, poster



(d) Flexible views, e.g. bitmap emphasis

Figure 4.3: Development of object representations. Source: [235].

of pages in PDF-files, etc, should be shown on the third level of the Graphical Link Marker. Following Neurath [385], I think that the quantitative data on the third level of the GLM should not be represented by the size of the GLM, but by the quantity of integrated symbols. The symbol for 100 kilobyte, for example, could be a square ■ borrowed from the GUI downloading bars: For film clips, an inverted square stands for every minute of duration, as in the GLM of figure 4.4a. A photo is held by an increasing number of sticky tapes, according to its size (4.4c), a text document by a number of stacked paper sheets, etc. The metric must be chosen in a way that only in rare cases the maximum of these quantitative exceeds seven pieces (the limit of items that can be grasped at a glance, cf. [144]).

For Houde/Salomon's example of book vs. poster (fig. 4.3c), I propose to replace scale by quantitative symbols for pages, resp. for resolution. Another important issue in the design of GLMs is the representation of other the link attributes, such as type, multiple destinations, last visit etc. Drawing from the insights gathered in the sections on semiotics and hypertext theory, I propose that GLMs should be able to show these attributes either graphically in a pop-up (see figure 3.16 for such an implementation). Yet, the GLM can only display three attributes at a time, following the basic concept of Neurath's International Picture Language, or "Wiener Methode" that informational pictures should not contain more than three levels of signification:

> "Ein Bild, das die Regeln des Systems gut anwendet, gibt bei der bildlichen Darstellung einer Aussage alle wichtigen Tatsachen wieder. Auf den ersten Blick sieht man das Wichtigste, auf den zweiten das weniger Wichtige, auf

(a) GLM for Film Clip

(b) Original image, Copyright by http://www.parkviewmc.com/

(c) GLM for Image File

Figure 4.4: Graphic Link Markers. Source: based on [235] and [385].

> den dritten Einzelheiten, auf den vierten nichts mehr – wenn man dann noch etwas sieht, ist das Lehrbild schlecht" [50, p. 20].

Thus, the user must be able to decide at any time to change to the view he prefers, showing the attributes type (e.g. in a color/symbol code), quantity of links from one link anchor (e.g. by quantity of arrow symbols), last visit (brightness, hue, etc.) on the third layer.

4.7 The Commercialization of the Internet

It is commonly agreed upon that eCommerce, the expansion of the Information Technology branch (sometimes called *Wintelism*, [69]) and the increasing capital market orientation on *New Markets* have changed our economy, cf. [111], [437], [331]. The *New Economy* phenomenon, if understood on a macroeconomic level, has promised higher non-inflationary economic growth due to increases in productivity caused by the digital revolution. Evidence put forward by mainstream protagonists of the New Economy suggests the end of the economic cycle and permanent stability of a finance-led regime of accumulation on the basis of the digital production paradigm. However, Scherrer [470] reasons that some basic causal relationships of such a regime, especially the connections between investment and profits; profits and wealth; and wealth and consumption seem too fragile for suggesting that a stable new regime of accumulation has emerged. For him, the New Economy thesis suffers from serious problems in measuring productivity in the service industries and seems to be based on massive borrowing by both companies and households, whose debts now stand at a record high, cf. [165]. Before the terror acts of September 11^{th}, and the yet unpredictable effects on the world economy, it seemed that the expansion of the late 1990s came to an end, and the crisis of the New Markets seemed the major threat for the world economy.

The WWW has seen a vast commercialization since the mid-90s of the last century. It has become a trading platform for many goods and services. While the retail sector consists mainly of books, CDs, and electronic devices, the business-to-business sector (b2b) is estimated to grow on a much larger scale.

But the New Economy in the strict sense of the word is based on the commercialization of intangible goods, broadly labled as information goods, cf. [481, p. 3]. These goods are produced with high fixed costs but negigible marginal costs, which has important implications on product-pricing and intellectual property protection. Information is furthermore an "experience good" [481, p. 5] as consumers must experience it to value it. This experience

is based on access, not on property ownership. This shift from ownership of assets to the payment for the right to access the assets of others is the principle of what Jeremy Rifkin calls the ”Hypercapitalistic Economy” [437]. Ownership, says Rifkin, is seen today as a limit to an individual’s and society’s ability to adapt to change, rather than an competitive asset.

As the consumer does not know whether a purchased information is really worth its price in advance, branding has become one of the key factors in the ”Economy of Attention”: ”Image is everything in the information biz, because it’s the image that carries the brand name and the reputation” [481, p. 6]. For Naomi Klein [278], the brand is the core meaning of the modern corporation, whereas the advertisement is only one vehicle used to convey that meaning to the world. What made early branding efforts in the last third of the 19th century different from more straightforward salesmanship was that the market was now being flooded with uniform mass-produced products that were virtually indistinguishable from one another. Competitive branding became a necessity of the machine age – within a context of manufactured sameness, image-based difference had to be manufactured along with the product. So the role of advertising changed from delivering product news bulletins to building an image around a particular brand-name version of a product. The first task of branding was to bestow proper names on generic goods such as sugar, flour, soap and cereal, which had previously been scooped out of barrels by local shopkeepers. In the 1880s, corporate logos were introduced to mass-produced products like Campbell’s Soup, H.J. Heinz pickles and Quaker Oats cereal, cf. [278]. A similar strategy has been applied a hundred years later on electronic links and digitalized information. Thus, it seems that the creative potential of the Economy of Ideas is still captivated by intellectual property laws based on the assumption that – for information[32] too – value is based on scarcity, as will be shown in section 4.7.2. Sections 4.7.4 and 4.7.5 will show that – beyond the invisible editing[33] techniques of Web sites, such as internal link structures – a myriad of disturbing techniques is being developed to manipulate the hypertext user.

4.7.1 eCommerce

Shortly after its conception (see section 3.1.17), the Web has been discovered as a global market place of unpreceded growth. The consequent commercialization of the Internet has led to a great range of changes and developments, such as massive increases of advertising, iMarketing (including keyword selling and user tracking), copyright and other legal issues, spam mailings etc. In this section, I want to concentrate on the implications, challenges and dangers of eCommerce for the World Wide Web. As shown exhaustively in sections 3.1.17 and 4.2.3, the Web is a rather simple, but incredibly huge hypertext system that is navigated but millions of people using one of the standard browsers.

Thus, I think that the main challenges for eCommerce from the viewpoint of Hypertext Semiotics are: Firstly, it has to adept to the strengths and weaknesses of hypertext in general, just because the WWW *is* a hypertext environment. Secondly, it has to cope with the problems that come from the technical shortcomings of HTML. Thirdly, even after the advent of XML, eCommerce will still be confronted with a dynamic, unmonitored and decentralized information space.

As outlined in section 3.7, hypertext navigation can never be studied in isolation, because there is no clear-cut line between pure information navigation, decision-making, object-identification and exploration, cf. [174, 512].

[32] The common difficulties in defining the concept of ”information” have been described in section 3.7.9. Hartmann partly adopted Barlow’s trichotomic definition of information as an activity, a life form, and a relationship, cf. [29, 30]. He links the idea of information as a relationship with the ”Gegenüberstellung von Arbeit und Interaktion, über die Jürgen Habermas seine Theorie des kommunikativen Handelns entwickelt hat” [221, p. 50].

[33] Invisible editing is a term borrowed from Cinematography, cf. [360, 93, 63].

As shown by many usability studies and even more DotCom failures, adapting hypertext for eCommerce is far from a trivial task: ”Space is the opportunity; place is the understood reality” [218]. Hypertexts have been conceptualized as information spaces, not market places. The Social Navigation approach has taken these facts in account (see section 3.7.8).

After half a decade of eCommerce, it seem that the *direct* commercial potential of hypertexts such as the WWW have been overestimated: An explorative navigation may well find its adequate (and rewarding) end in the feeling that ”I have seen enough!”. Even though no concrete transaction has been made, the acquired knowledge may well lead to a future buying decision (be it online or off-line). The successful wayfinding navigation leads to a destination (”Here it is!”). The end point of a navigation, e.g. certain product, can be pre-defined or emerge in the course of navigating/exploring. When the user has reached this tangible ”success point” in gathering information (cf. [147, 449, 448]), there is a vast change of rhetoric that seemingly has not been mastered by current Web Design techniques, cf. [391].

This change of rhetoric takes place at the very point of the buying decision. While the finding of a product (in the supermarket as well as in an online store) is an act of navigation, the purchase of the product is a dialectical process of negotiation that leads to a contract. This distinction is, of course, related to Norman’s dichotomy of world metaphor vs. conversation metaphor[34], cf. [395]: ”Stated in semiotic terms one can say that in these situations the structure and sign in the design of the interface hamper adequate semiosis (understanding)” [263, p. 488].

In the context of home page design, applying the rules of an appropriate code which is familiar to the interpreter is the key to success. This is a process which Peirce referred to as abduction (a form of inference along with deduction and induction). As Mick notes, abduction is particularly powerful if the inference is made about someone or something about whom or which little more is known, cf. [358, p. 199], [442].

From the viewpoint of hypertext semiotics in a commercialized Internet, the (commercialized) distribution process of digital texts and mp3-files is not a great deal more interesting than the computer-supported retail of tangible books and CDs. The more elaborated the electronic goods and services get, the more need for this kind of research will arise. With the evolution of the WWW and eCommerce, the focus will shift from ”how to deactivate the back-button in order to inhibit the users to leave our corporate Web site?” to ”how can we make more useful tools using hypertext functionality?” At the moment, disputed copyright issues and intellectual property claims are great obstacles in the full evolvement of a new economy.

4.7.2 Intellectual Property and Copyright

Copyright issues on the Internet have become something like a science of its own right. While in the early days of the Internet, everything was allowed in the virtual space, law and order (and those who believe to represent it) have entered the arena, cf. [292, 266]. Hypertext authors and other producers of ”soft property” are aware of the difficulties to market their work and seem to be more interested in the availability than the protection of the material. But ”unfortunately, neither the companies they work for nor the lawyers these companies hire have enough direct experience with non-material goods to understand why

[34]”Characteristics of the world metaphor are that it consists of objects, that manipulation of objects is possible, that one can act as if one were in the world and that one experiences a feeling of direct engagement. Its most emphatic aspect is its directness. [. . .] Properties of the conversation metaphor are that it is indirect, that is to say a user has to make a mental model for communication, that it requires (complicated) expressions to make things clear and that it normally demands a rigid syntax. In the conversation metaphor one also may distinguish several layers of granularity, that may be called low and high level languages” [263, p. 487].

they are so problematic. They are proceeding as though the old laws can somehow be made to work, either by grotesque expansion or by force. They are wrong" [29].

Barlow draws a short history of economic development from the darker parts of human history, when the possession and distribution of property was a largely military matter and "property was the divine right of thugs" to the "dawning of the Industrial Revolution, when humanity began to focus as much on means as ends". It was then that tools acquired a new social value and "to encourage their invention, copyright and patent law were developed in most Western countries" [29][35]. At the beginning of the 21st century, it is possible to create useful tools that never take physical form. So people have started patenting "abstractions, sequences of virtual events, and mathematical formulae – the most unreal estate imaginable". Barlow concludes his synopsis of economic history:

> "In certain areas, this leaves rights of ownership in such an ambiguous condition that property again adheres to those who can muster the largest armies. The only difference is that this time the armies consist of lawyers. Threatening their opponents with the endless purgatory of litigation. [...] They assert claim to any thought which might have entered another cranium within the collective body of the corporations they serve. They act as though these ideas appeared in splendid detachment from all previous human thought. And they pretend that thinking about a product is somehow as good as manufacturing, distributing, and selling it. [...] Humans have not inhabited cyberspace long enough or in sufficient diversity to have developed a Social Contract which conforms to the strange new conditions of that world. Laws developed prior to consensus usually favor the already established few who can get them passed and not society as a whole" [29].

For Barlow, the widespread disregard for commercial software copyrights (who can can honestly claim to have no unauthorized software on her/his hard disk?) is the prototype example for such a profound divergence between law and social practice which "stems from a legislative failure to understand the conditions into which it was inserted" [29]. And as unbounded intellectual property is very different from physical property, it can no longer be protected as though these differences did not exist:

> "The central economic distinction between information and physical property is that information can be transferred without leaving the possession of the original owner. If I sell you my horse, I can't ride him after that. If I sell you what I know, we both know it" [29].

Barlow contributes to defining information by calling it an activity (information is a verb, not a noun), a life form (information wants to be free and to change) and as a relationship. The relationship of the sender and the receiver makes data information, as it is found meaningful within a mental context. While exclusivity of information has a value (e.g. insider knowledge on the stock exchange), "most soft goods increase in value as they become more common. Familiarity is an important asset in the world of information. It may often be true that the best way to raise demand for your product is to give it away" [29]. Thus, for Barlow, "the best way to protect intellectual property is to act on it. It's not enough to invent and patent; one has to innovate as well. Someone claims to have patented the microprocessor before Intel. Maybe so. If he'd actually started shipping microprocessors before Intel, his claim would seem far less spurious" [29]. Six years after his seminal article [29], Barlow revisits his Economy of Ideas and repeats that "noncommercial distribution of information *in*creases the sale of commercial information. Abundance breeds

[35] In 1710, the Statute of Anne, the world's first modern copyright law, passed the British parliament, cf. [30].

abundance" [30]. Accordingly, he predicts that "there will be no property in cyberspace", but only after the unwanted war against those who try to protect it by anachronistic means has been won.[36]

Pamela Samuelson takes a similar point of view, claiming that the robustness and efficiency of the Internet as a communications medium is a product of its present end-to-end, open, nondiscriminatory architecture, cf. [461, 462].

> "Computers are not only more valuable to people because they can so quickly and easily copy information from disk to disk, but the ease of copying enables many beneficial new uses of information that copyright owners neither need to nor ought to be able to control [...] The agenda of a new politics of intellectual property obviously needs to be about more than just opposing the high protectionist initiatives of copyright industry groups. It needs to have a set of affirmative policy objectives of its own. Articulating a positive case for an open information environment is probably the single most important thing the new politics of intellectual property might do" [463].

For her, innovation and competition would be stifled if mandated trusted systems became the law. Moreover, the market for digital information products would be vastly smaller if every piece of information must be tightly locked up at all times.

The real change from the "old" to the "new" economy can only take place, once exclusive property for ideas is given up in favor of an active relationship of those who share the ideas:

> "Relationship, along with service, is at the heart of what supports all sorts of other modern, though more anonymous, 'knowledge workers.' Doctors are economically protected by a relationship with their patients, architects with their clients, executives with their stockholders. In general, if you substitute 'relationship' for 'property,' you begin to understand why a digitized information economy can work fine in the absence of enforceable property law. Cyberspace is *un*real estate. Relationships are its geology" [30].

The analogon to Napster.com (or what it originally represented) in the text world are platforms such as textz.com who consider themselves the "&" in "copy & paste" and are not interested in "constituting a canonical body of historical texts by authors so classical that they've all been watching the grass from below for almost a century of posthumous copyright [nor in] htmlifying freely available books into unreadable sub-chapterized hyperchunks"[37]. Yet, one thing is to make ASCII texts available for download and another is linking to nodes that may change its contents without prior notification. Non-hypertext that is published on the Web shares only part of the difficulties that is connected with linking. Is the owner of a link responsible for the content of the link target? Copyright and responsibility issues for hyperlinks are beginning to fill the order books of law firms, because the jurisdiction varies between countries and guidelines are rare[38].

[36] "It's a pity that entertainment moguls are too wedged in to the past to recognize this, because now they are requiring us to fight a war anyway. So we'll fatten lawyers with a fortune that could be spent fostering and distributing creativity" [30].

[37] Cited from textz.com's mission statement. The well known Project Gutenberg makes only texts available are that were taken from books published generally pre-1923 to avoid copyright problems.

[38] In the USA, the Motion Picture Association of America has prevailed in its lawsuit aimed at stopping Web sites from posting – or even *linking* to – the disc-cracking code DeCSS, cf. [30]. Cf. [146] for the situation in Germany.

4.7.3 Authenticity of Information

A related issue is that of authenticity of information. The loss of authenticity in electronic media is complemented with a new feeling of information availability (see section 2.7). Having visual and textual information at our fingertips, the ability to copy, paste, edit and reuse it at our will has changed our relationship to authenticity (Greek: authenteô – to have full power or authority over something). On the Web, information has a lesser "authenticity rate" for other reasons, too: Cybersquatting, the speculative purchase and sale of potentially valuable domain names, can take the form of buying domain names very similar to those of large companies, copying the original design and filling them with indecent or misleading material until companies redeem the name. An even more intrusive method is, of course, hacking the original site and filling it with new contents. Until the owner of the site finds out, many users may be mislead and (potential) customers may be lost that way.

The case where the accused "cybersquatters" had registered the domain name "etoy.com" and run it as an artist space before the "victim", eToys, Inc. was even founded will be described in section 4.7.7, a digression on the Toywar.

As described in section 2.7, the status of the photographic document as evidence has been called into doubt with the arrival of "postphotography". Yet, the manual falsification of photography is nearly as old as the medium itself and the same holds true for the relationship between scripture and falsification of written documents, which was highly common in the Middle Ages.[39] To the same degree that the wax impression of a signet ring (an indexical link to its owner) could verify and seal a document in those times, passwords and biometrics now protect our electronic files, see sections 3.5 and 3.6. Encryption and decryption of data is a kind of coding (see section 2.6) that is as probably just as old as communication itself, see footnote 46 on page 38. On the WWW, SSL and S-HTTP are two (complementary rather than competing) technologies to ensure the authenticity of information: The Secure Sockets Layer (SSL) is a protocol for transmitting private documents via the Internet and works by using a public key to encrypt data that's transferred over the SSL connection. The other protocol for transmitting data securely over the World Wide Web is Secure HTTP (S-HTTP). Whereas SSL creates a secure connection between a client and a server, over which any amount of data can be sent securely, S-HTTP is designed to transmit individual messages securely.

4.7.4 Banners

According to the first HTML Style Guides, banners were to be used to give the WWW site a concise appearance and to provide the user an easy way to return to the main page ("internal banners"). At some point, however, banners were discovered as a marketing tool that contain clickable advertisements for other Websites ("external banners"). This means that the maintainer of a frequented site ("the seller") can put one or many banners on his pages and charge the advertising company ("the buyer") for this marketing tool. In fact, this tool serves 3 different goals:

1. As a visual advertisement for the buyer,
2. As a direct link to the buyer's Web site,
3. As a source of income for the seller.

[39] The German system analyst and "private scholar" Heribert Illig even claims that about three hundred years of our medieval history only exist on paper, cf. [243]. A major conspiration of this kind, if it ever happened, would have worked only by the falsification of *all* written accounts at a certain point of time, a huge "find & replace" command applied to all documents.

The price of the service is calculated according to the number of impressions and clicks, cf. [328, p. 1, 22]. It has become a common practice to include a third party to audit the counting of these variables in order to avoid "noncompliance, misstatement and manipulation", because "using the same organization to perform the counting and the auditing is a clear conflict of interest" [223, p. 19].

For the users, banners imply:

1. Additional information they never requested,
2. Longer loading times and the burden of related costs,
3. Aesthetic effects: Possible entertainment as well as annoyance, especially due to animations.

Today, there is a whole myriad of variations of the banner, including Flash Banners, Pop-Ups, Interstitials, Superstitials, Sticky Ads and Nanosites employed in Web design.

4.7.5 Keywords

Banner ad keying – a controversial practice that accounts for about a quarter of the search engines' ad revenue – has become a major issue since numerous companies have filed lawsuits against Excite Inc., cf. [274, p. 4]. When a Web user searches for a specific keyword, the rights to that word often have been sold to a specific advertiser whose banner will appear on the search results page. For the uninformed user who thinks that the search engine brings up advertisement banners that are "related" to the requested search terms, this function might seem handy and random at first sight. However, Excite, a unit of Excite@Home, has at least twice been accused of selling company names – in the form of search keywords – to those companies' business rivals. Other search engines have been sitting back and let Excite test that new legal ground alone: "Yahoo! Inc., operator of the Net's leading search site, said it 'does not knowingly sell company or brand names to a company's competitors.' A spokeswoman at Infoseek, the search service behind Walt Disney's Co.'s Go Network, said the firm does not sell company names as search keywords that prompt competitors' banner ads. Lycos Inc. gives firms first rights to buy their trademarked names, and will hand over a name to the trademark owner even if another company has already bought it," [274, p. 4]. RealNames, a service that maps key phrases to Web pages and passes them on to the browser states that "Keywords CANNOT be resold [sic]. If registered Keywords fail to comply with the Keyword Selection Policy, they will be revoked and registration fees will not be refunded" (RealNames Web site, www.realnames.com, as of June 15th, 2001).

Ending what is arguably the last bastion of advertising-free content online, RemarQ Communities Inc. began selling keywords in its discussion groups in 1999. The provider of Internet discussion services to more than 1,000 ISPs and Web sites launched *Midstream Marketing* in late August of that year: "The program lets advertisers buy keywords within any combination of of RemarQ's 30,000 discussion groups. Under the plan, a keyword bought by an advertiser will be highlighted in blue if mentioned in a message posted on a discussion. A click-through leads to the advertiser's Web site" [276, p. 3]. According to the senior analyst of new media at Forrester Research, Cambridge, MA, "Community traffic has been both attractive and problematic" for advertising, "attractive in that you get enthusiasts in niche areas"[40], but problematic because of its lack of control: "For example, advertisers' keywords could show up in a debate of which they want no part." A simple example for such an instance could be: An advertiser (A) has bought the word "experience"

[40] Lisa Allen, cited in [276, p. 3].

to link a Web site promoting his plumber services (He thinks that the plumbing experience of three generations is his company's mayor asset). In a posting to an Asian food discussion group, a user (B) writes about his visit to a Sushi Restaurant and concludes with the sentence "This was the worst experience of my life". After the message has been transmitted to the server, it is manipulated by a routine that makes the word "experience" the node for a hyperlink to A's Web site.[41] For the readers of this discussion group (N), it must now seem that B had created the link.[42]

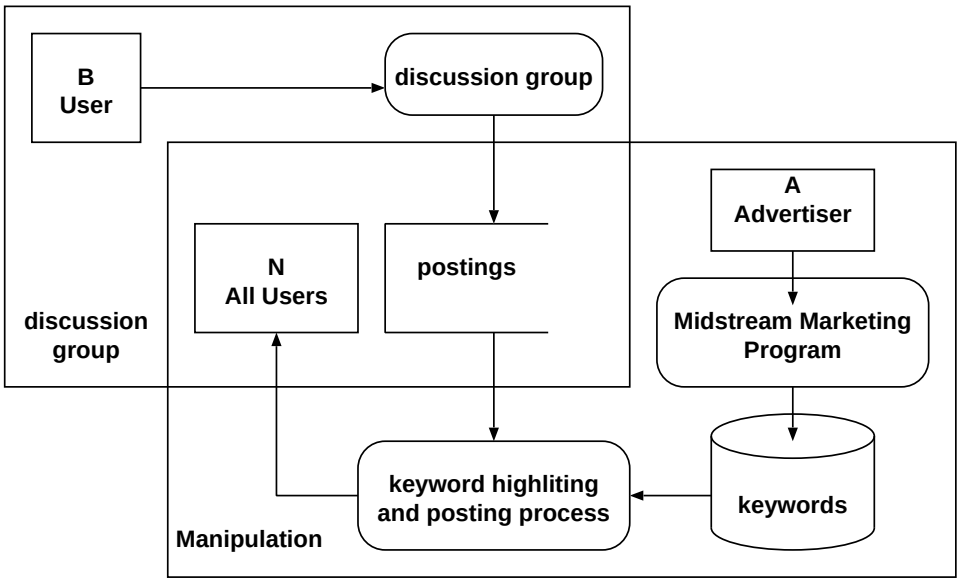


Figure 4.5: Midstream Marketing Program. Source: based on [276].

In [382], I have presented a semiotic analysis of a link injection to a posting that contained the keyword visa.[43] I showed that, in the genealogy of Katz and Fodor [270], one semantic marker has been exchanged for another (as demonstrated in fig. 4.6). Thus all implied semantic markers on the path to the relative selection ω1 become false connotations.

The manipulation process shown in figure 4.5 has the following consequences:

1. The inappropriate link alters the meaning and the authenticity of the original phrase.
2. On the syntagmatic axis, the word "experience" is part of the syntagmatic chain "worst experience". Thus, a relationship between the syntagm and the intended signified of /experience/ is produced.[44]
3. When finding out about the unintended link, B will be (at best) surprised about the outcome of his posting.

[41] "These messages are not posted in real time, in contrast to chats that take place in an immediate or live environment" [276, p. 3].

[42] As "there is no ad next to the word or obtrusive commercial message" [276, p. 3].

[43] "In a posting to RemarQ's discussion group *Home > Regional > Americas > Latin America > Latin America – Travel*, a user writes the following text: 'My fiance, who is a citizen of Kyrgyzstan, and I would like to go to Venezuela in January. We will have about two weeks in the US before our departure. She will need to get a *visa*, and we would appreciate hearing others' experiences in getting visas from their embassy in the US.' Stunningly, the word *visa*, which has obviously been sold to the credit card company, leads to http://www.visa.com/ ! As no other information is given [276], it must seem to users who are not aware of this 'program' that the author of the posting has created the link himself" [382, p. 238f.].

[44] The use of "false signifiers" has been exemplified in Stastny's Analysis of Kubrick's film "Eyes Wide Shut", cf. [507].

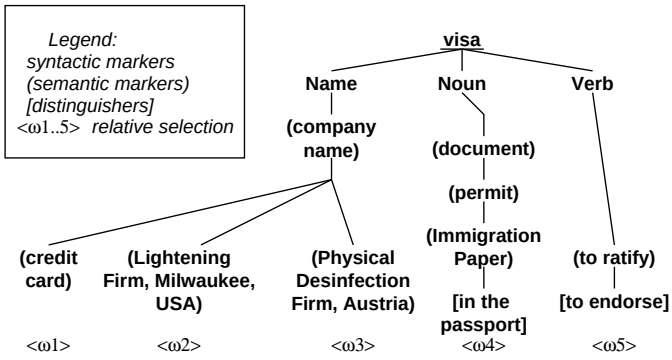


Figure 4.6: Katz Fodor Tree for /visa/. Source: [382, p. 239]

4. The insertion of links might antagonize N (including B) who fear the invasion of privacy or unwanted commercial intrusion.

While the first two impacts affect the meaning of the text, all others have direct results outside the semiotic world. Semiotics is interested in the sign as a social force. According to Eco, the logical problem of lie or wrongness is a pre-, or post-semiotic one, cf. [153, p. 73]. For Nöth, however, the question whether signs can lie is an important semiotic issue, cf. [397].

Interestingly, the unwanted effect for A only takes place in case that the keyword is used in a negative (or inappropriate) context, whereas the unwanted effects for B and N always take place. The only case that the text *can* keep its original meaning is, when the keyword is a unique name. One might think that, if the Internet bookstore Amazon.com Inc. buys the keyword "Amazon", the hyperlink must always lead to the right place, because a name serves as a "label". On the other hand, Eco [155] has shown that names in general are exceptionally homonymous and can only work in a predefined context, a *system of semantic entities* which must correspond to a *system of cultural entities*, cf. [155, p. 176ff.]. Even if /Amazon/ is meant to signify a company name (not the mythological figure nor the South-American river), it might well be that B writes about a coffee shop in New York or a traveling agency in Brazil.

Yet, the idea of generating profits from link injection still seems to be on the agenda of iMarketers: According to BrowserWatch News, Microsoft Corp. backed away from plans to include the "Smart Tags feature" in Windows XP's Internet Explorer 6 in June 2001 only after weeks of outraged criticism.[45] The Smart Tags feature would allow the browser to turn any word on a Web site into a link at Microsoft's discretion. That link, without the Web site author's knowledge or consent, could lead to a Microsoft site or, conceivably, the site of a Microsoft partner or even an advertiser.

These examples show a (partly unnoticed) replacement of information by commercial content in the WWW. In the last sections, I present two bellicose digressions on this subject, one about the Browser War, a dispute which has been going on for years now, and the other one on an electronic *Blitzkrieg* that is known to Internet historians as the Toywar.

[45] Microsoft spokesman Jim Cullinan is reported to have told Reuters: "We have gotten feedback in the beta process and there are some legitimate concerns that we need to address before this technology is ready to deliver on our vision of the Web for consumers" [78].

4.7.6 Digression I: The Browser War

As discussed in section 4.5, Ray Tomlinson developed the user@host convention in 1972. Subsequently, other networks chose other conventions, ”inaugurating a long period known as the e-mail ’header wars.’ Not until the late 1980s will ’@’ finally become a worldwide standard” [515]. Today, the @ sign may be called the Internet’s most famous logogram; in fact, it has become a quasi-synonym for electronic communication. Tomlinson’s convention, from a historical perspective, seems to have won the e-mail header war for two important reasons: First, the @ sign was, of course, *not arbitrarily* chosen from the non-alphabetic symbols on the keyboard (see section 4.5), and second, ARPANET soon became the most important of the networks.

Accompanied by far more sophisticated battle mechanisms and vastly heavier armory, a comparable conflict situation lead to the Browser War (see figure 4.7) of the 1990s: ”The first networks that were the foundation of the Internet went online in the late 1960s. For the next 25 years, the Internet remained the exclusive province of technocrats. The browser changed all that, giving real people unprecedented access to information” [393]. As described in section 3.1.17, ”the boom in interest in the Web closely followed the development of Mosaic, the first graphical Web browser” [346]. NCSA Mosaic had been written by Marc Andreessen for X-Windows and was released for the Mac and Windows in the fall of 1993. In mid-1994, Andreessen co-founded Mosaic Communications Corp. but had to change the company’s name soon after to Netscape Communications Corp., as the University of Illinois claimed that he had stolen Mosaic from them and demanded a name change or else he would have to quit distributing their product. By 1996, 75% of Web users employed the Netscape Navigator. At that time, Microsoft decided to enter the Internet browser market, and developed the rival product – Internet Explorer. Microsoft started to include the Internet Explorer as an embedded part of their market leading operating system – MS Windows. This maneuver (which became a key element of the US Government’s antitrust case against the software giant) showed to be effective, and soon Netscape’s browser market share came down plummeting .

Figure 4.7: Browser War. Source: [425].

By 1999, Netscape was battle-weary and America Online bought it for $10 billion in stock, with only a third of consumers still using its Communicator package. Jennifer Powell analyzes how ”a company that once defined the word Internet [could] fall so completely out of the race”: Besides Microsoft’s hardball marketing she believes that some of Netscape’s management and company strategies also contributed to its fall, cf. [425].

It is often said that the Browser War has negative influences on Web design, as pages that look good on Netscape do not look so good on Explorer, and vice versa. While these two browsers still dominate the market, the Opera browser is gaining terrain due to its impressive usability and speed. Furthermore, BrowserWatch lists dozens of other available browsers from ”Act 10” to ”YooZee”.

For Powell, the lesson from the Browser War is that ”Netscape’s ’superiority’ simply wasn’t enough to ensure success as the Internet market changed and grew” [425]. For Griffin, ”the new marketplace of the World Wide Web is a very volatile and dynamic one. Getting to the top is difficult, but staying there is even harder. In an environment that changes so rapidly it would seem that competitors too would have to be willing and able to change continuously” [202, Chapter on Marc Andreesen]. Nielsen and Tognazzini’s conclusions go further: For these usability experts, the Web browser has only one big advantage, anyway:

> ”The basic functionality needed to read an article is fairly easy to use, and even novice users can view content from across the world in a reasonably nice layout. That’s it for the benefits. Browsers fail to support the actual task of browsing the Web. [...] Within months, the browser was running out of steam, and programmers struggled to get beyond the confines of HTML, designed purely to display fixed text and graphics pages. The answer was JavaScript, a huge kludge that accelerated the move to two-way communication within Web pages” [393]; see section 4.2.

Nielsen and Tognazzini blame Microsoft’s integration practice and Netscape’s development strategy in the Browser War for the fact that the browser’s capabilities were frozen four years ago and that the commercial browsers have failed utterly in their attempts to keep up with the increasing demands of Web users:

> ”What went wrong? Microsoft. By forcing Netscape Communications and Sun Microsystems out of the market, it eliminated the competition. As a result, all competitive pressure to fix the problem has been eliminated. [...] Maybe it would have lost in any case, but several releases of the Netscape browser seemed to have no goal except increasing the bug count, allowing for more fancy page viewing and adding features that did not facilitate Web browsing. Robust code quality and features to support users’ goals took the backseat, thus making it unreasonably easy for Microsoft to win” [393].

Web browsers have grown into huge software packages with thousands of available plug-ins and add-ons in order to supply application functionality without the need for users to install further software on their computers. On the other hand, ”billions of dollars are wasted every year in lost productivity as people wait for Web pages to perform duties that could have been handled better by a 1984 Macintosh-style graphical user interface application” [393]. Nielsen and Tognazzini conclude that ”Web pages are not even a good metaphor for accessing information [as] several other forms of information access are needed for the Internet to reach its potential. We also need better ways of visualizing the information space so that users don’t get lost so easily. [...] Enough. Browsers kicked off the Web revolution, but it’s time to retire them to their rightful place in the Computer Museum and get more powerful tools to support the hours of work and play we are all going to spend on the Internet every day in the future” [393].

Yet, most of the future tools that Nielsen and Tognazzini describe are neither new nor inspiring: ”Instead of a browser window, you’ll have windows onto continuously changing data streams [...] that won’t bring down the Internet because everyone will tap into the same stream. Broadcasting will become a major player on the Web”; ”Internet ’radio sets’ that pick up commercial-laden Internet ’broadcasts”’; ”audio-visual receivers with music-on-demand capabilities”; ”movies-on-demand, the great promise of a decade ago, will finally be a reality, as long as greed doesn’t get in the way”; ”videophones will first be embraced by the sex industry, but it will quickly spread”; ”chat rooms where people type at each other will be replaced by face-to-face meetings”.

Nielsen and Tognazzi argue that new technologies are needed to *get the best of both worlds:* ”Network computing frees the user from having to act as system administrator, and personal computing dedicates a powerful system to being immediately responsive to the user’s smallest whim. Why not cache application functionality on the user’s local hard disk and download upgrades transparently as they are needed?” [393]. Indepently of the concern that any corporation given these rights will use this ”transparency”[46] for its own use, I want to pose a counterquestion: ”How are we going to find, navigate and select all this new information, be it movies/programs we want to watch, songs we would like to listen to, products we want to buy, or, names of people we want to meet online ?”

From the outcomes of this thesis, Web augmentation in the field of hypertext functionalities is the only way to cope with the new flood of information that will come in via the new channels (see section 4.2.3). Not only Web browsers in today’s form, but the simplified hypertext approach that has enabled the unpreceeded growth of the WWW should find a place of honour in the Computer Museum and leave the field for fourth-generation hypermedia [62], Open Hypermedia Systems [432], intelligent agents and the Semantic Web [54].

4.7.7 Digression II: The Toywar

In Kahin/Keller’s collection of articles on the coordination of the Internet, a whole chapter is dedicated to ”domain-ia”, the dispute over Trademarks and domain names, cf. [266]. At first sight, the Toyway may seem like just another cybersquatting case over an ”s” in a domain name. But a closer look reveals the bizarre details of this peace of Internet history.

The corporation-mocking Internet artists behind Swiss-based etoy ”incorporated” their ”business” in 1994 and won the Golden Nica at the Ars Electronica Festival – the Academy Awards of the Internet arts – in 1996. In 1999, they were offered $516,000 for their domain name and trademark by eToys Inc., an American online toy retailer founded two years later than etoy. Speculating on a higher bid, the artists rejected the offer of the DotCom which had a market capitalization of more than 8 billion dollars at this time. Consequently, eToys Inc. filed a lawsuit accusing etoy of unfair competition, trademark delusion, security fraud, illegal stock market operation, pornographic content, offensive behaviour and terrorist activity, cf. [164].

Etoy saw the artistic and political potential of this media war and played along: ”1798 activists, artists, lawyers, celebrities and journalists were selected and recruited between november 1999 and february 2000 to join the playful TOY.army” [164]; see figure 4.8.

The Toywar broke out and worked on the base of ”self organized, multi-level intelligence”. It was a virtual war in the sense of an isomorphous transformation of the real-world actions onto a battlefield on the Toywar Web site:

> ”Like a swarm of bees, hundreds of well-informed people, industry insiders, kids and legal experts contested the aggressor on every level (filing counter court cases, infiltrating customer service, pr departments, the press, investor news groups and also on the level of federal trade commission etc.). more than 300 articles (New York Times, Wall Street Journal, Le Monde, CNN) reported the story and 250 resistance sites and net-shelters were established.[47]

The outcome of this battle was viewed as a victory of David against Goliath and celebrated with artistic propaganda worthy of a virtual war over plastic toys. For etoy, ”TOYWAR was

[46] Veith Risak has emphatically underlined this security issue in our discussion of this section.

[47] The Google Web directory has collected much of the material under the category ”Society > Activism > Media > Culture Jamming > etoy”.

Figure 4.8: etoy soldier and bomber. Source: www.toywar.com.

the most expensive performance in art history: $4.5 billion dollars" [164]. The bill was paid by the investors: "Within 2 months the eToys Inc. stock (NASDAQ: ETYS) dropped from $67 (the day the battle started) to $15 (the day eToys Inc. finally dropped the case)" [164]. After eToys' bankruptcy in march 2001, KB Toys Inc. purchased most of eToys inventory, its name and trademarks and its Web site address.[48]

[48] In their FAQ section, the KBKids.com Web Site euphemistically states that "after some financial difficulties, eToys declared bankruptcy on March 7, 2001 and shut down its online store the following day. We at KBkids.com look forward to providing you the great toys and services you came to expect from eToys".

Chapter 5

Summary

Many people will not even be aware of the fact that there is a difference between the signifier /dog/ and its signified, our concept of the dog. Ferdinand de Saussure sees the sign as their interactive totality. From the experience that a child will automatically say "dog" whenever it sees a drawing of one, we can see that the process works in both directions. In the semiotic terminology, a sign is to be distinguished from what we often call a "sign" in colloquial language. Thus, hypertext theorists who ignore the key results of decades of semiotic investigations (whilst using the terms sign, text, communication, code, metaphors, etc.) risk failing to produce state of the art user-centered research. Saussure had stressed that the signifier and the signified were as inseparable as the two sides of a piece of paper, they were intimately linked in the mind by an associative link, and wholly interdependent, neither pre-existing the other.

Jacques Lacan was one of the main engineers in the conversion of the Saussurean sign model, appropriating Saussure through Roaman Jakobson to Sigmund Freud: He related metaphor to *Verdichtung* (condensation) and metonymy to *Verschiebung* (displacement).

Charles Sanders Peirce offered a triadic relation between the representamen, the interpretant and the object. Accordingly, signs might be considered in themselves, or in relationship to their object, or finally in relationship to their interpretants. These three considerations yield three trichotomies: a sign considered in itself might be a quality and thus a qualisign, an individual thing or event, thus a sinsign, or a law, hence a legisign; the relation of a sign to its object can be an iconic or indexical or symbolical; the relation of the sign to its interpretant is a rheme or dicent or argument.

Wilfried Nöth has substituted the terms representamen, interpretant and object for more intuitive terminology: the sign vehicle, the sense and the reference object. This concept, of course, can be seen as going beyond Saussure's emphasis on the paradigmatic and syntagmatic value of a sign in its relation to other signs. Peirce's second trichotomy has been cited more than once in isolation from the two other trichotomies for approaches to computer science and hypertext theory. An iconic relation is a mode in which the sign vehicle physically or perceptually resembles the reference object (e.g. a portrait, a scale-model, the sound of a gun in a computer game). A sign function in which a sign vehicle represents its object by virtue of a causal or physical connection is called indexical. This linkage can be observed or inferred (e.g. fingerprints in biometrics, medical symptoms for certain illnesses, etc.). In a symbolic relation, the sign vehicle does not resemble the reference object but is arbitrary or purely conventional, like most words of our natural languages, road signs, an arrow on a Web page or the browser tool bar that points to the left for "back", etc. Naturally, different cultures show very different conventions, e.g. the arrow to the left in Arabic or Hebrew means "forward". Semiosis, a term borrowed from Peirce, is expanded by Umberto Eco to "unlimited semiosis" to refer to the way in which a series of

successive Peircean interpretants lead to a (potentially) *ad infinitum* process, as any initial interpretation can be re-interpreted.

In information theory and computer science, codes play a major role in programming, data transmission, cryptography, etc. In semiotic literature, two meanings of code are encountered most frequently: In one sense, code means a set of rules prescribing how to act or how to do, and in another, a key (or set of instructions) for translating a message.

Semiotics has changed over time, since semioticians have sought to remedy weaknesses in early semiotic approaches: Yet, it is only fair to note that much of the criticism of semiotics has taken the form of self-criticism by those within the field. Against the critique of Charles W. Morris and Julia Kristeva, Wilfried Nöth argues that (under certain preconditions) the consequent semiotic self-reflection actually does establish semiotics as a scientific activity.

There is also a consistent line of thought from Ernst Cassirer to Susanne K. Langer and Claude Lévi-Strauss that intersects with the classic semiotic path at several points. Cassirer's definition of man as an *animal symbolicum* that lives in a *symbolic universe* is inherent in any discussion about human thinking, understanding, culture, and communication, including telecommunication and hypertext. In the age of computer interfaces, tele-working and global hypertexts, man truly lives no longer in a merely physical universe, but in a symbolic universe. Cassirer's philosophy of symbolic forms is concerned with the questions of knowledge, as he tried to develop a new science of culture closely connected to the project of European structuralism.

Langer remarks that, in modern science, the object of study has been displaced by measuring and control technology, by displays and visual representation material: Indices have taken the place of the cause, and observation has become almost entirely indirect. In accordance to Alfred North Whitehead's dichotomy, Langer distinguishes between *rational discursive language* and *presentational language*. In the context of hypertext theory, discursiveness is similar to sequentiality: Words cannot be piled one upon the other, neither can they be arranged arbitrarily into a sentence (they have to follow a pre-defined grammar); it takes time to form (and listen to) each word of a sentence and only once you have heard the last word of a sentence you can be sure of its meaning. Langer thought that, even if they are nested, we have to string our ideas in order to communicate them to others in a language; like clothes that are draped around a body, but hanging out to dry on a clothes-line. You place one piece of language at a time into a straight line; at the end of the process the parts add up to a whole argument or proposition. The argument of hypertext is that ideas do not have to be arranged on an infinitely long clothes-line. In fact, hypertext represents variable structure that permits an interlinked presentation of ideas and navigation means a linearization of those nodes that the hypertext user chooses to read. Thus, the chain of nodes that the author/reader links or follows, form a sentence-like structure based on connection. The path that the user *did* follow assigns to those links which were *not* followed the status of associations, reminding us of Saussure's syntagmatic chain as opposed to the associative, or paradigmatic, axis. The passage from one node to another, or navigation, is a syntagmatic linearization of those nodes that the hypertext user chooses to read along a personal thread that is laid upon the network. Such linearization can be compared to linearization processes which underlie the transfer of complex and simultaneous nonverbal perceptions into language, as different possibilities of selection in different situations create a multiplicity of linear discourses. The virtual multiplicity of linearities depend on different reader perspectives and contexts which can be chosen. Reading hypertext is not merely clicking crosswise on the paradigmatic axis. It also means working on the syntagmatic axis, reading in full-text the words that surround the link markers. Finally, it is constructing a meaning of the text, and creating coherence.

In our daily lives, we are used to employing several sign systems (pointing and speaking, accompanied by clothing, perfumes, etc.) simultaneously. Human experience is inherently

multisensory, yet every representation of experience is subject to the constraints and affordances of the medium involved. Peirce's consideration of the medium instead of signs has often been revisited, reminding us that the study of the sign just like the study of the media is the study of the process of mediation between ourselves and the world outside. While aural and visual signs seem to be privileged in current hypermedia systems, other channels are also helpful for the reception of expressive signs. The visualization of the WWW is echoed by the evolution of interfaces from symbolic to iconic. Furthermore, language faces severe limitations in articulating the ambivalences and intricacies of our inner experience. Thus, non-verbal acts, such as pointing, exchanging looks, and change of voice are necessary to attach specific connotations to its expressions. On the Internet, smileys and emoticons imitate those non-verbal acts.

As pointed out by Risak, optical presentation of home pages can communicate a lot of messages to the user. Screen designs that resemble glossy magazines and brochures rely of the eye-catching quality of the image, and also on an immediate (and easy) understanding of its meaning. In other words, that what Langer calls presentational immediacy. While some ask if the intrusion of the image catapults us back into an age when most people were educated by narration and murals on church or cave walls, others face this development by tearing down the wavering distinctions between ”art” and ”nonart,” ”expressive” and ”inexpressive” that have been obstructing the way to a wider panorama on visual codes. In a short disquisition on the state of art in image theory, I tried to clarify the potential of (photo-)graphics in hypermedia.

Searching and navigating in hypermedia is a special case of the exploratory, discovery-based, serendipitous form of search, typified by poorly defined goals which has typically been contrasted with traditional goal oriented search as addressed by Information Retrieval and queries in a database. In today's WWW, many efforts have been made to raise the capabilities and usability of search engines. This is a revolutionary increase of functionality especially at the beginning of a hypertext session. Yet, the results are often frustrating or just too numerous to be feasible for review. I propose semiotic methodology for those theoretical issues that have to be taken into account – besides technological considerations – in Content Based Navigation and Content Based Retrieval.

Whilst Roland Barthes sought to revalorize the role of the signifier in the act of writing, Derrida's grammatology was designated to challenge the phonocentric bias of semiotic investigation. Derrida uses the Greek word gramma to break with the view that our (Latin) alphabet can describe every meaningful linguistic unit (morpheme) by means of a sound (phoneme) — arguing that différance, but also hyphens, commas, periods, quotes etc. prove the prevalence of writing over spoken language. An interesting example in the Internet age is the metaphoric description of the @ sign in many languages, ranging from animals (snail, worm, little dog, horse) to body parts (elephant's trunk, monkey's tail, cat's foot, pig's ear) to food (rollmops herring, strudel, cinnamon roll, pretzel).

The tendency of euphorically celebrating the liberating qualities of hypertext, its positive social and democratic impacts, its immense educational potential, the end of all linear reading, the death of the printed book, etc., has given way to reflections that comprise the economic factor. A short history of hypertext, from its prehistory to today's state of the art and the current developments in the commercialized WWW creates the context for my theory of hypertext semiotics. Based on Peter Bøgh's seminal work on computer semiotics, which adapts and extends the structuralist methods, I intend to prove the semiotic approach's applicability on hypertext and hypermedia. Hypermedia (the multimedia content of a hypertext system) combines different semiotic channels with an interactivity and the construction of meaning by concrete linkage. Thus, hypertext semiotics should be seen as a fortification of the connection between the media semiotic approach and computer semiotics. Computer semioticians, such as Mihai Nadin, claim that the computer is a semiotic machine. Accordingly, the importance of semiotics for the construction of the next

hypertext generation, the Semiotic Web, has been pointed out by John F. Sowa.

The field of action where man meets machine is the user interface. As a side-product of my investigation on the computer as a transitional subject, I propose the substitution of the German term *Schnittstelle* by the more adequate term *Verbindungsstelle*. Risak underlines that Human-computer interaction (HCI) is a triangular relationship between the user, the computer and the task. For Andrew Dillon, HCI can be conceptualized as a communicative dialogue whose purpose is to complete a task. Semiotic interface engineers view semiotic adequacy as a key factor for interface design. As opposed to the reactive model of measuring user performance (epitomized by Jakob Nielsen's studies), semiotic adequacy is a method of fine tuning the semiotic elements involved in HCI. In hypermedia, the activation of a link marker has to ignite a link following process. Broken links on the WWW question the status of the legisign, thus being a major semiotic and usability problem that leaves the user with distrust and frustration about the medium. This was demonstrated in a comparison of linkrot and missing reference objects in the Peircean scheme.

In hypertext models, topological space of graph theory is contrasted with our everyday notion of Euclidean space, the cab driver metric and hodological space. Graph theory is an important hypertext model and the underlying method for building Web search engines. In a classical node-link hypertext, a graph can be constructed on the set of nodes where each edge is identified with a link and structure discussions typically take place with respect to this graph. However, many other structure models have been proposed. Besides node/link composites, "intensional" vs. "extensional" links, set-theoretic groupings, Petri nets, transclusions, and Rosenberg's three-layer scheme for discussing hypertext activity, spatial approaches have gained great importance. The difference of close and distant, or self and other, is the first spatial/ semantic relation a child has to learn. In the early stage, transitional objects mediate between the self and the world. The dialectical relation of the "I" to the "you" is developed only at a later stage. Therefore, I follow those authors insisting that a theory of space is essential for any advance in hypermedia design as spatialization plays an important role in the development of new hypertext models that concentrate on the nodes and links as part of a (visual and textual) sign system. Spatial Hypertext builds on the notion that hypertext authors sometimes prefer to express relationships among nodes by using geometric cues like proximity and alignment, and visual cues like graphical similarity. Spatial hypertext has arisen through experiences with applications that explore alternative structures for content and applications in which the domain structure is not well understood at the outset. In situations that promise changes during the course of a task and the blurring of the roles of reader- and authorship, this approach is most valuable. Using transdisciplinary research methodology, I have pointed to the potential limitations of visual expression and the need for studies of the impact of spatial and representations on authoring. The need for a "balanced composition", an organization of a pictorial field that is pleasing to the eye has been identified as interfering with the effectiveness of expression in a spatial hypertext environment. Especially in comparison with the variable structures of a hypertext model based on graph theory, the notion that rotating a spatial hypertext changes its meaning is striking.

I have identified many reasons for navigational difficulties in hypermedia. One of them is the unreflected metaphor mismatch between Euclidean and hypertextual space. With the exception of bookmarks, all standard navigation tools refer to wayfinding in a physical space, such as maps, landmarks, home, and guided tours. Metaphors, in a psychoanalytic view, are *Verdichtungen*, condensations that shape our view of the world and the possibilities for setting actions. Magic features are generally well accepted – if they are useful extensions to the metaphor. Yet, orgies of false signifiers endanger the usability of the interface.

Semiotics will have to play a major role in the successful introduction of gustatory, olfactory and tactile data into hypermedia and the construction of indexical interfaces, as

these sensual inputs are extremely interesting for the human understanding, learning and interpreting of data: For example, odors, and even tastes are stored mostly in the long-term memory. Olfactory and gustatory sign vehicles have a strong indexical relation to the referent, which will influence future use in hypermedia environments: We can identify certain odors, even if their source has long left the place. These media will strongly enhance our comprehension, as we understand through our bodies. The detachment of the bodily senses is equally disturbing as the lack of integration into hypertext of those social habits that produce a space. Following postmodern and semiotic critique on traditional geography, I call for a view on hypertext that differs from mere information zapping.

By comparison with other disturbances, the ”lost in hyperspace effect” was identified as a feeling of inability to regain orientation and control. The ”serendipity effect” of making accidental discoveries is therefore not an alternative hypothesis but, rather, the other side of the same coin. Instead of denying the ”lost in hyperspace” problem, I propose facing this breakdown as a special challenge to hypertext theory, which should be approached by developing new hypertext models and by increasing linkage in connection with powerful navigation tools.

In a multi-dimensional analysis of hypertext navigation, I focused on the metaphorical roots of navigation tools, as well as their usefulness and potential. Proposed extensions include bookmarks with a memory and a more flexible backtracking function. Those navigation strategies based on environmental terms for city planning were contrasted with the respective semiotic critique and other approaches, including Social Navigation, Content Based Navigation, navigation by query (Information Retrieval, Content Based Retrieval) and Rosenberg’s compound layers.

The inability to actively come to terms with the material in today’s state of the WWW is a main reason for navigation difficulties in this medium. As the historical reasons for the lack of many important hypertext functionalities have long been identified, ”Web augmentation” is under way. By calling themselves second, third or forth generation hypermedia, valuable approaches and systems claim to be phylogenically superior to the WWW. In fact, they represent the evolution and current state of the art of hypermedia approaches outside the WWW. Yet, it cannot be underlined often enough that, on the publicly acknowledged tenth anniversary of the World Wide Web, the shift from quantity to quality is finally becoming tangible: With the advent of the Semantic Web, OHS’s embellished Web-integration and commercially available server tools that work around the limitations of HTML, such as Hyperwave, the WWW has the potential to use a lot more of the immanent hypertextual advantages (such as the blurring of the reader/author roles) and to assist the evolution of human knowledge as a whole.

The interdisciplinary spectrum of methodology enabled detailed analyses, e.g. of the browser’s pointing device. In most standard implementations, this cursor mimics a human forefinger seen from above, revealing a strong tactile incorporation of the hypertext link markers into the GUI desktop. Interestingly enough, only the LINUX version of the Netscape Navigator still uses an index finger that indicates a pointing movement in a direction rather than a tactile pressing on an object. These details gain importance in the light of a Browser War that has become part of the Internet’s economic history.

It is commonly agreed upon that eCommerce, the expansion of the Information Technology branch and the increasing capital market orientation on *New Markets* have changed our economy. The WWW has seen a vast commercialization since the mid-90s of the last century. It has become a trading platform for many goods and services. While the retail sector consists mainly of books, CDs, and electronic devices, the business-to-business sector (b2b) is estimated to grow on a much larger scale. I think that the main challenges for eCommerce from the viewpoint of hypertext semiotics are: Firstly, it has to adept to the strengths and weaknesses of hypertext in general, just because the WWW *is* a hypertext environment. Secondly, it has to cope with the problems that come from the technical

shortcomings of HTML. Thirdly, even after the advent of XML, eCommerce will still be confronted with a dynamic, unmonitored and decentralized information space.

From the viewpoint of hypertext semiotics, the (commercialized) distribution process of digital texts and mp3-files is not a great deal more interesting than the computer-supported retail of tangible books and CDs. Yet, the more elaborated the electronic goods and services get, the more need for this kind of research will arise. Web design that incorporates this approach will soon shift its focus from questions such as ”How can we deactivate the back-button in order to inhibit the users to leave our corporate Web site?” to ”How can we tailor advanced tools using hypertext functionalities?” At the moment, disputed copyright issues and intellectual property claims are great obstacles in the full evolvement of a new economy which is based on the commercialization of intangible goods, broadly labeled as *information goods*. These goods are produced with high fixed costs but negligible marginal costs, which has important implications on product-pricing and intellectual property protection. Information is furthermore an ”experience good” as consumers must experience it to value it. This experience is based on the payment for the right to access the assets of others, not on property ownership. As the consumer does not know whether a purchased information is really worth its price in advance, branding has become one of the key factors in the ”Economy of Attention”. While competitive branding became a necessity of the machine age in order to bestow proper names on generic goods such as sugar, flour, soap and cereal, which had previously been scooped out of barrels by local shopkeepers, a similar strategy has been applied a hundred years later on electronic links and digitalized information. Thus, it seems that the creative potential of the Economy of Ideas is still captivated by intellectual property laws based on the assumption that – for information too – value is based on scarcity.

Having visual and textual information at our fingertips, the ability to copy, paste, edit and reuse it at our will has changed our relationship to authenticity. Postphotography and the creation of ”synthetic” or ”infographic images” have greatly increased the deceptive potential of the visual medium. On the Web, information has a lesser ”authenticity rate” due to Cybersquatting and hacking. As shown in a digression on the Toywar, it is sometimes hard to define who is the aggressor, and who the victim. Intrusive marketing techniques on the Internet, such as spamming and user tracking have become typical for virtual bread-sellers on a Global Agora, as demonstrated by a semiotic analysis of link injection, banner ads, keywords and other iMarketing tools.

In conclusion, I do not think to have produced a new ”hypertext model”. Rather, the outcomes of this approach should be seen as prolegomena of a theory of hypertext semiotics, as I was able to interlace the existing models with the findings of semiotic research, on all levels of the textual, aural, visual, tactile and olfactory channels. The long-term goal of hypertext semiotics in a commercial context – as I see it – is to enhance hypermedia as a multi-level semiotic system that incorporates spatio-temporal aspects, the power of the image and language as the ultimate upgrade.

Appendix A

Glossary

The glossary is especially useful in the electronic versions of this document, as the individual entries are targets of hyperlinks throughout the text. Due to the multidisciplinary character of this paper, the glossary spans over many fields of research.

Acteme In Rosenberg's terminology ([448], [449]), acteme is a low-level unit of hypertext activity such as link-following.

Aesthetics Aesthetics is the branch of philosophy that aims to establish the general principles of art and beauty. It can be divided into the philosophy of art and the philosophy of beauty.

Agent A piece of software that runs without direct human control or constant supervision to accomplish goals provided by a user. Agents typically collect, filter and process information found on the Web, sometimes with the help of other agents.

Anchor See link anchor.

Arbitrariness In semiotics, arbitrariness is the absence of any degree of necessity between the signified and signifier of a sign. For example, there is no intrinsic connection between the signifier D-O-G and the four-legged, furry animal signified by these letters. Antonym: motivation.

ARPA The Advanced Research Projects Agency (ARPA), founded in 1957 by President Eisenhower and controlled by the U.S. Department of Defense, was part of the U.S. reaction to the Soviet Union's launch of Sputnik.

ARPANET A physical network constructed in 1969, linking four Universities in the western USA and wired together via 50 Kbps circuits. ARPA's Program Plan for the ARPANET was titled "Resource Sharing Computer Networks" and submitted June 3, 1968. In 1990, the Department of Defense disbanded the ARPANET and it was replaced by the NSFNET backbone. The original 50Kbs lines of ARPANET were taken out of service. Having used the TCP/IP since 1983, ARPANET can be seen as the ancestor of the Internet.

ASCII The American Standard Code for Information Interchange (ASCII) is the most common format for text files in computers and on the Internet. In an ASCII file, each alphabetic, numeric, or special character is represented with a 7-bit binary number (a string of seven 0s or 1s). 128 possible characters are defined.

Bricolage A term introduced by Lévi-Strauss [315,317] to designate a manner of construction that relies on improvisional (or *ad hoc*) and makeshift responses and far-flung analogies for problem-solving and to explain the world. In a general sense, bricolage is the process of creating something not as a matter of calculated choice and use of whatever materials are technically best-adapted to a clearly predetermined purpose, but rather in a dialogue with the materials and means of execution. In such a dialogue, the materials which are ready-to-hand may suggest adaptive courses of action, and the initial aim may be modified.

Browse In hypertext theory (and practice), browsing is often used as a synonym for navigation. In a narrower sense, browsing means an intuitive and exploratory way to encounter information in a hypertext, analogous to leafing through books or strolling through a city.

Browser Generally speaking, a browser is a hypertext engine that gives access to a hypertext. While the first WWW browser (called WorldWideWeb by its inventor Tim Berners-Lee) was a browser/editor, today's browsers give read-only access to documents on the WWW. NCSA Mosaic was the first Web browser of this kind. Standard browsers today include Netscape Navigator, Microsoft Internet Explorer, Opera and the text-only browser lynx.

Button While some authors generally use the term to signify any link marker, a button in the context of this dissertation denotates an active element in hypertext documents that looks and behaves like a real-world pushbutton. In other words, a button pretends tactile responsiveness and it can be activated by pressing it down.

CAD Computer-Aided Design (CAD) or computer-aided design and drafting (CADD) is the production of drawings, specifications, and other design-related elements using special graphics- and calculations-intensive computer programs. Used in such fields as architecture, electronics, and aerospace, naval, and automotive engineering, CAD systems originally merely automated drafting but now often include three-dimensional modeling in a VR environment.

Code The establishment of a conventional rule-following relation in a symbol, represented as a deterministic, functional relation between two sets of entities.

Communication The process of transmitting and receiving messages. According to Roman Jakobson and others, an analysis of this process yields six factors: addresser, addressee, contact (or channel), context, code, and the message itself. Corresponding to these factors are six functions: emotive, conative, phatic, reference, metalinguistic (or metacommunicative), and aesthetic or poetic. This process has been taken as the focal object of semiotics.

CSCW Computer-Supported Cooperative Work is a generic term which combines the understanding of the way people work in groups with the enabling technologies of computer networking, and associated hardware, software, services and techniques. While groupware is often used as referring to real computer-based systems, CSCW means the study of tools and techniques of groupware as well as their psychological, social and organizational effects. Key issues of CSCW are group awareness, multi-user interfaces, concurrency control, communication and coordination within the group, shared information space and the support of a heterogenous, open environment which integrates existing single-user applications. CSCW systems are often categorized according to the time/location matrix using the distinction between same time (synchronous) and different times (asynchronous), and between same place (face-to-face) and different places (distributed).

CSS Cascading Style Sheets (CSS) are an extension to HTML to allow styles, e.g. colour, font, size to be specified for certain elements of a hypertext document.

Cybernetics The theoretical study of communication and control processes in biological, mechanical, and electronic systems, especially the comparison of these processes in biological and artificial systems. From Greek kubernêtês, governor and kubernan, to govern.

Cybersquatting The speculative purchase and sale of potentially valuable domain names. Also called ”domaingrabbing”.

DBMS A DataBase Management System (DBMS) is a software application which allows the storage, retrieval, and manipulation of information in a prescribed format. One common form of organization is the table, which is formatted by row (record) and column (field). In its purest form, a DBMS does not allow for unformatted data. This restriction allows quick indexing, sorting, and other data processing. Contrast this with full-text.

Destination anchor A location or string within a node that is the target of a hyperlink.

Diachronic From the Greek, *dia-*, through, across, and *chronos*, time. Diachronic analysis focuses on change over time, dealing with phenomena (for example, the spelling of words or the rules of grammar) as these change over a period of time; roughly equivalent to historical or temporal.

Dicent A term introduced by Charles S. Peirce to designate a specific type of sign or sign function; namely, one corresponding roughly to a statement. The other parts of this third Peircean triad or trichotomy are rheme, and argument (see section 2.4).

Dichotomy A twofold division or distinction, especially one between mutually exclusive things. While a trichotomy cuts things in threes, a dichotomy cuts them in two.

Dicisign A term used by Charles S. Peirce as a synonym for dicent, a sign roughly corresponding to a statement in the context of its utterance.

Différance A word coined by Jacques Derrida as part of his critique of phonocentrism and of the metaphysics of presence. It involves a pun, for he is playing on two senses of *differ*: to differ and to defer (postpone or put off). In addition, this word itself is supposed to show the dependence on speech upon writing, for the difference to a French speaker between *difference* and *differance* is no difference at all. That is, the difference is discernible to the eye but not to the ear.

Discourse A term sometimes used to translate parole (more usually rendered "speech"). Ferdinand de Saussure separated language (langue), conceived as a self-contained system of formal differences, from speech (parole), the actual utterance of individual speakers. He did so for the purpose of making language for the formal object of linguistic and he thought that the study of language should focus on language, not speech or discourse.

DNS The Domain Name System (DNS) is an Internet service that translates Internet domain names (such as wu-wien.ac.at) to their corresponding IP addresses (in this case 137.208.7.48) and routes the connection to the appropriate system.

Episode In Rosenberg's terminology [449], the acteme is an extremely low-level unit of activity, such as following a link. Multiple actemes are combined into an intermediate level unit, which he calls the *episode*, and at the high end he sees a unit called the *session*.

External link In this paper, external link means a link that points to another site in the WWW. In other words, the two nodes connected by the link reside on two different servers.

FAQ Frequently Asked Questions (FAQ) sections explain common problems of the average user in a dialectic form.

FTP The File Transfer Protocol (FTP) is a set of commands for transferring files on the Internet. Technically speaking, it is an application protocol that uses the Internet's TCP/IP suite of protocols.

Full-text Full-text refers to unstructured, free, natural language text. This term is usually used in contrast to fixed-structure, record-oriented, or otherwise restricted text, such as that found in a DBMS. Indexing and other common database techniques are complicated in full-text, since every word is, by default, equal in importance to every other. The structure of the data cannot be as easily used to optimize indexing.

Geisteswissenschaften A German word designating the human sciences as distinct from *Naturwissenschaften* (the natural sciences). It has been and, to a large extent, still is customary to distinguish the human sciences as studies aiming at understanding (*Verstehen*) and the natural sciences as investigations aiming at explanation (*Erklärung*). The human science (*Geisteswissenschaften*) roughly correspond to what, in Anglo-American discourse, are called the social sciences. But since the context in which the human sciences have been pursued has been in some respects significantly different from that in Continental Europe the human science have not been modeled on the natural sciences, whereas in Great Britain and to an even greater extent in the United States they have.

GIF The Graphics Interchange Format (GIF) is one of the two most common file formats for graphic images on the World Wide Web. The other is the JPEG. An animated GIF is a file in the Graphics Interchange Format that contains within the single file a set of images that are presented in a specified order, i.e. a small clip of moving images. An animated GIF can loop endlessly or it can present one or a few sequences and then stop the animation. Animated GIFs are frequently used in Web ad banners.

Gramma Greek word meaning that which is drawn, picture, written letter, and piece of writing. Together, gramma and graphein, preserve a memory of a time when the division between writing and picturing were less rigid, as both are kinds of scratching, or inscribing.

Grammar Set of rules governing the formation and combination of the basic units in a semiotic system.

Graph Informally, a graph is a finite set of dots called vertices (or nodes) connected by links called edges (or arcs).

Grapheme A letter of an alphabet, or all of the letters and letter combinations that represent a phoneme, such as *f*, *ph*, and *gh* for the phoneme [f] sound. As they are graphic representations of phonetic units, graphemes can also be called phonograms.

Graphein Greek word that means to write, draw and scratch. See gramma.

Graphic According to the American Heritage Dictionary of the English Language, the adjective *graphic* means ① Of or relating to written representation; ② Of or relating to pictorial representation. What seems to be a discrepancy at first sight, is explained by the ethymological root of graphic, the greek word graphein. The noun *graphic* is mainly used to signify a pictorial device used for illustration, or a graphic display generated by a computer or an imaging device (see graphics).

Graphical Link Marker In this dissertation, I suggest the term Graphical Link Marker (GLM) for a graphical element in a hypertext node that serves as a link marker. Accordingly, to emphasize that the link marker consists of one or more words, I use the term Textual Link Marker.

Graphical User Interface A GUI is a graphical (rather than purely textual) user interface to a computer. Web browsers typically use the elements of the GUI that come with the operating system and add their own graphical user interface elements. GUIs mostly use one or more metaphors, such as the desktop, the view through a window, or the physical layout in a building. Elements of a GUI include windows, pull-down menus, buttons, scroll bars, latexhtmliconsA, etc.

Graphics In technical sciences, the plural form of the noun graphic means ① the making of drawings in accordance with the rules of mathematics, as in engineering or architecture; ② the pictorial representation and manipulation of data, as used in computer-aided design, in typesetting and the graphic arts, ③ the process by which a computer displays data pictorially.

Groupware are computer-based systems that support groups of people engaged in a common task (or goal) and that provide an interface to a shared environment. See CSCW.

HCI Human-computer interaction (HCI) is the sum of methods and afforts to optimize the relationship between the user and the computer in order to fulfill a task.

Hodological space Path-space or hodological space corresponds to the factual human experience during movement between two different points on a map. It is absolutely different from the geometrical line which connects two points.

Hyperlink In a hypertext, hyperlinks (or simply links) are connectors between nodes.

HTML HyperText Markup Language (HTML) is a simple programming language used to format documents for display on the World Wide Web. When displayed using a World Wide Web browser, documents prepared in HTML include formatting, graphics, and hypertext links to other documents or multimedia. HTML is a subset of the Standard Generalized Markup Language (SGML).

HTTP The Hypertext Transfer Protocol (HTTP) is the set of rules for exchanging files (text, graphic images, sound, video, and other multimedia files) on the World Wide Web. Relative to the TCP/IP suite of protocols (which are the basis for information exchange on the Internet), HTTP (just like FTP) is an application protocol.

Hypermedia Most hypertext researchers view the terms hypertext and hypermedia as synonymous and use them interchangeably, with a preference to sticking to hypertext "since there does not seem to be any reason to reserve a special term for text-only systems" [387, p. 5]. This is also true for the context of this dissertation, where I will make use of the term hypermedia mostly in names (such as "Open Hypermedia System") or to put special emphasis on multimedia content of a hypertext system.

Hypertext A body of electronic text that can be authored, and read, non-sequentially. In classic hypertext theory, blocks of text (lexia or nodes) are joined by electronic hyperlinks. In this dissertation, hypertext also includes linked multimedia material (hypermedia) and alternative hypertext approaches, such as time-based hypermedia and spatial hypertext.

Icon Ultimately from Greek eikon (likeness, image, portrait), an icon (or ikon) is an image, a representation, a simile. Accordingly, ① iconicity in a semiotic sense refers to signs where the motivation is due to some kind of physical resemblance or similarity between the signified and signifier (see section 2.4); ② a Christian icon is a picture of a sacred or sanctified personage, traditional to the Eastern Church, which can be seen as hand-made (painted) or non-manmade (archeiropoietos). ③ Semiotically incorrect, but nevertheless widely used, is the denomination of the symbols on the GUI desktop and in WWW documents as "icons". In this paper, I call the graphic representations of hyperlinks Graphical Link Markers (GLMs).

Image Stemming from Latin imago (imitation, copy, likeness, bust), the image is generally a representation, or double of something. The emphasis of this term does not lie on a graphic quality, but on the likeness (a difference that can be compared to index vs. icon). Thus, the image is ① a (mental) picture of something not real or present; ② a figure of speech, especially a metaphor; ③ concrete representation, as in art, literature, or music; ④ in mathematics, the image is a set of values of a function corresponding to a particular subset of a domain; ⑤ in computer science it is an exact copy of data in a file transferred to another medium; ⑥ in the context of media theory and semiotics, the image of a person or an institution is the public opinion of that person or institution, especially as interpreted by the mass media.

Index ① In the general context of science, an index is mostly understood as an alphabetized list of names, places, and subjects treated in a printed work, giving the page or pages on which each item is mentioned. Accordingly, indexing has become an important method to store and retrieve information in computer science. Indexicality, in its semiotic sense, however, is a quite different concept: ② In Semiotics (and in this dissertation), the index is a proper sign where the motivation is due to some kind of physical connection or causal relation between the sign vehicle and reference object. For example, smoke is an indexical sign of fire (see section 2.4). These and other definitions of the index (e.g., ③ the character "→" used in printing to call attention to a particular paragraph or section; ④ an indicator or a pointer, as on a scientific instrument; ⑤ a number or symbol, often written as a subscript to a mathematical expression; ⑥ a number derived from a formula, used to characterize a set of data; ⑦ a list formerly published by Catholic Church authorities, restricting or forbidding the reading of certain books) are ethymologically connected with *digitus index*, the Latin word for forefinger.

Indexing Indexing, in Information Retrieval, is a method for building a data structure that will allow quick seaching of the text.

Information Retrieval Information Retrieval (IR), or document retrieval is the systematic manipulation of textual information so that it can be easily be found again (retrieved). On the WWW, the most important method of IR is the indexing of free-form text. IR exhibits similarities to (but is not the same as) other areas of information processing, such as expert systems and data base management systems (DMBS).

Internal link In this paper, internal link means a link that points to a document on the same WWW server. A link to an anchor in the same document is by definition an internal link.

Interpret To take something for something else in virtue of a coding.

Interpretant One of the three essential parts of a sign or of a process of semiosis. The interpretant is e.g. what you – the interpreter – think of when you read the letters D-O-G. This concept, idea, or sense of the sign, should not be confused with the interpreter himself.

Interpreter That entity, typically a human subject (or a computer agent), which interprets the sign, or more precisely, the sign vehicle. I have made special notice of those cases where I refer to the technical meaning of that term as defined in computer science.

Intertextuality A term introduced by Julia Kristeva and widely adopted by literary theorists to designate the complex ways in which a given text is related to other texts. As every text is constructed as a mosaic of other texts, every text is an absorption and transformation of other texts. According to Kristeva, the notion of intertextuality comes to replace that of intersubjectivity.

JPEG A JPEG is a graphic image created by choosing from a suite of compression algorithms. JPEG is the acronym for Joint Photographic Experts Group, the committee that established the baseline algorithms. Together with GIF, the JPEG is one of the image file formats supported on the World Wide Web, usually with the file suffix of ".jpg", or ".jpeg"

Langage In French, the English term "language" can be rendered in two ways: langue and langage. Put simply, langage is the human ability to build a structured communication system, grammar, and style that governs the formation of statements.

Language The term often used by semioticians and others in a very general sense to mean any system of signs. It is also frequently used in a narrower sense to designate a system of verbal signs, talking *verbal* here to include both spoken (or auditory) and written signs. Language is the most common English translation for langue, although some authors propose "tongue" to be the better choice. In this paper, I will use language in a more general sense and langue as defined by Saussure.

Langue Langue designates an actual, specific language system: English, French, German. It's approximately equivalent to the English "tongue," and emphasizes the everyday employment of language. The act of *using* a langue, e.g. by saying the sentence "English is my mother tongue," is called parole.

Legisign A term coined by Charles S. Pierce to designate a specific type of sign or sign function, specifically one in which a category, law or regularity serves as a sign vehicle. A word is an example of a legisign. See qualisign, sinsign.

Lexeme The fundamental unit of the lexicon of a language. Lexemes are complimented by morphemes. For example, the lexeme *do* changes its meaning if combined with the morphemes *-es*, *-ing*, *-ne*. Yet, in the word *construction*, the *con-* and *-ion* are morphemes, while the lexeme *-struct-* has become meaningless in contemporary English.

Lexia In the sense of Roland Barthes' S/Z [37], lexia are units of textual meaning that can be analyzed according to their codes of signification. In hypertext theory, lexia are unordered blocks of texts connected by links. Lexia are also referred to as nodes.

Link In a hypertext, (hyper-)links are connectors between nodes.

Link anchor For some authors, links lead from one link anchor to another. In HTML, an anchor is the destination of a link within a document, e.g. `index.html#anchor`. In the terminology of this paper, a link leads from the link anchor, which is represented by a link marker, to a link destination.

Link destination, or link target A node, or a part of a node, that is the end point of a link. To emphasize that the link destination is a certain point within a node, e.g. a word, this point of arrival is called destination anchor.

Link marker The link marker is the visual representation of the link anchor, or, point of departure of a link. Some authors use the term "button" for the link marker. The link marker can be a word (a Textual Link Marker), or a Graphical Link Marker.

Logo In popular usage any image (map, picture, text, monogram, emblem, acronym, siglum) used as a sign for a company, brand, and so forth. Logos are often descended from heraldry.

Meaning it is often helpful to distinguish the *Sinn* (or meaning) of a word or expression from its *Bedeutung* (or reference). The two expressions "Morning Star" and "Evening Star" mean something quite different (as different as day and night or, at least, dawn and dusk); they, however, refer to the same planet: Venus.

Mailto A mailto is similar to a hyperlink, only instead of retrieving a node, it opens up the default e-mail program and a new message already addressed.

Message Whatever is conveyed or transmitted in a communicational exchange. The message is one of the six dimensions or components of communication. In any act of communication, an addresser conveys a message to an addressee. In order for a message to be conveyed, there must be both a code and a channel (or contact). All messages occur in a context. When a communicational exchange is directed toward the message itself, that exchange serves a poetic or aesthetic function.

Metaphor ① A figure of speech in which a word or phrase that ordinarily designates one thing is used to designate another, thus making an implicit comparison, as in *head of household*, or, *a sea of troubles*. ② One thing conceived as representing another, such as calling the Internet a *global agora.*

Metonymy A figure of speech in which one word or phrase is substituted for another with which it is closely associated, as in the use of *Washington* for the United States government or of *the sword* for military power.

Morpheme A meaningful linguistic unit consisting of a word, such as *man*, or a word element, such as *-ed* in walked, that cannot be divided into smaller meaningful parts

Motivation In semiotic terminology, motivation is used to designate that the link between signifier and signified is in some respects not completely arbitrary – that there is a motive, necessity, or ”reason” for connecting a particular signifier with a particular signified.

Multiple link A link that has more than one link destinations.

NSFNET The National Science Foundation Network (NSFNET) was built in 1984 using T1 lines, which were twenty-five times faster than the old ARPANET lines.

Node In graph theory, a node (or vertex) is a dot in a graph. In hypertext theory, it is one of many blocks of text connected by links and to be read in an unsequential order.

notation ① as used here, an image employing organizational principles other than the formats associated with pictures or writing systems, especially reference lines and other geometric configurations. Examples of notations are heraldry, graphs, charts and other maps, tables, and mathematical notations. ② In Nelson Goodman’s sense, a system of characters that fulfills five criteria: syntactic disjunction, syntactic finite differentiation, semantic unambiguousness, disjoint compliance classes, and semantic finite differentiation.

Object That which stands over against something else; that which confronts one as other. In contrast to Saussure’s self-contained dyad signifier/signified, Charles Sanders Peirce offered the triad representamen/interpretant/object, where object is that to which the sign refers.

OHS An Open Hypermedia System (OHS) is typically a middleware component which provides hypertext functionality to all applications on the users’ desktop. Hence, existing tools and applications can be hypermedia enabled using the functionality provided by OHSs.

Operating System An operating system (sometimes abbreviated as OS) is the program that, after being initially loaded into the computer, manages all the other programs in a computer. The other programs are called applications or application programs. Today, most users interact with the operating system through a graphical user interface (GUI).

Pansemiotic, pansemiotism The view that everything is, in some manner and measure, a sign.

Paradigm In general, pattern, exemplar, or example (especially an outstanding or unproblematic example); more technically, a theoretical, methodological, or heuristic framework. Originally meaning the exemplification of the rule, the term paradigm has become the rule that governs the example. In modern structural linguistics, particularly with Roman Jakobson [253], the paradigm is defined by complementary opposition to the syntagm, the paradigmatic axis being the system of associations from which the constitutive elements of the discursive chain, or syntagm, are selected.

Parole Parole is the *act* of speaking. In referring to the concrete and individual *usage* of a known set of rules (grammar, syntax, social connotations of words, etc.), it differs from langue and langage.

Path In graph theory, a path is a sequence of consecutive edges (links) in a graph and the length of the path is the number of edges traversed (in figure 3.18, the navigation from A to F has path lenght of 3).

Phoneme The smallest phonetic unit in a language that is capable of conveying a distinction in meaning, as the sound *m* in the English word mat and the *b* of bat. Accordingly, *mat* and *bat* are two different morphemes.

Polysemy Having many or at least several meanings.

Pragmatism A philosophical doctrine formulated and defended by Charles S. Peirce, William James, John Dewey, George Herbert Mead, and C. I. Lewis. It was originally formulated by Peirce as a maxim for how to make our ideas clear. Having evolved into the theory of meaning, pragmatism insists upon the necessity of interpreting our utterances in terms of their conceivable bearing upon our conduct. As a theory of truth, it proposes that we conceive truth in terms of such notions as what facilitates our commerce with experience.

Protocol An agreed-upon format for transmitting data between two devices. On the Internet, TCP/IP, FTP and HTTP are the most important standard protocols.

Qualisign A type of sign or sign function in which a quality serves as a sign vehicle. According to Charles S. Peirce, a sign may be considered ① in reference to its representamen, ② in reference to its object, and ③ in reference to its interpretant. By considering signs in reference to its representamen, Peirce derived the trichotomy of qualisign, sinsign, and legisign. (By considering them in reference to their objects, he derived to trichotomy of icon, index, and symbol. finally, by examining them in relation to their interpretants, he established the classification of rheme, dicent, and argument.) A sign vehicle might be a quality, in which case it is a qualisign; or it might be an individual object or event, in which case it is sinsign; or, finally, it might be a law, regularity, habit, or general, in which case it is a legisign.

RDF Resource Description Framework (RDF) is a scheme for defining information on the Web. RDF provides the technology for expressing the meaning of terms and concepts in a form that computers can readily process. RDF can use XML for its syntax and URIs to specify entities, concepts, properties and relations.

Reader The decoder or interpreter of text, verbal or otherwise. In some important currents of contemporary literary criticism and theory, attention has shifted from both texts and authors to readers. As part of his shift, the image of readers as consumers of fixed meanings is replaced by the view of them as producers of open-ended texts and, of course, hypermedia.

Readerly The word ordinarily used to translate *lisible*, the French term used by Roland Barthes to identify a certain kind of text, one in which the reader is called upon to do nothing more than consume a pregiven meaning. Antonym: writerly.

Reference The range of (real) objects to which a sign refers or points, in contrast to the conceptual and individualized sense, or meaning of a sign.

Referent See reference.

Relatum (plural relata). Latin word for anything insofar as it is related to something else; the term of, or item in, a relationship.

Representamen A term proposed by Charles S. Peirce to designate sign in the broadest possible sense. In contemporary a terminology that is shared by this dissertation, the representamen is called sign vehicle

Representation The process by which one thing stands for another or by which it is presented, depicted, or portrayed in some fashion; the result of such process.

Resource Web jargon for any entity. Includes Web pages, parts of a Web page, devices, people and more.

Rhematic sign, rheme A term derived from Greek ῥῆμα and introduced by Charles S. Peirce to designate a specific kind of sign, namely, one which has qualitative possibility for its interpretant: a possible, not a concrete object; every sign which is neither false nor true, such as nearly any word except ”yes” or ”no”. Peirce derived the trichotomy of rheme, dicent, and argument by considering a sign in reference to the nature of its interpretant. This threefold classification at least roughly corresponds to the more traditional logic trichotomy of concept, statement, an argument.

Rhetoric A term used to designate, in ancient times, the literary art of persuasion and, in contemporary semiotics, persuasion by any and all semiotic means.

Script ① The sum of characters used to write, independent of allographic variations; ② A particular system of writing, e.g. cuneiform script; ③ in computer programming, a script is a program or sequence of instructions that is interpreted or carried out by another program rather than by the computer processor, e.g. JavaScript code can be imbedded in HTML pages and interpreted by the Web browser (or client).

Secondness One of Charles S. Peirce's three universal categories. By means of secondness, Peirce is calling attention to opposition of reaction, to the brute fact of one thing standing *over against* another. See firstness, thirdness.

Semantic General, relating to meaning or signification. In Semiotics, *semantic* means more narrowly, concerned with the relationship between the signs and the objects.

Semantic marker Any semantic feature seen as systematic in a given language: e.g. in words like man vs. boy, woman vs. girl, horse vs. foal, a marker 'Adult' (or [+ Adult]) is systematically opposed to 'Non-adult' (or [- Adult]). In an account by J. J. Katz and J. A. Fodor [270], features which were not seen as systematic were 'distinguishers'.

Semantic Web In today's WWW, information is mainly presented for human users. The Semantic Web, as envisioned by Berners-Lee and others [54], promises to make the hypertextual information presented to the human users available as computable data by making explicit the underlying structure.

Semantics the study of meaning. As used by Charles Morris, that branch of semiotics devoted to studying the relationship between signs and their objects.

Semeiotic The way Charles S. Peirce often spelled the word designating the general theory of signs; thus, a synonym for what is more commonly called Semiotics. Sometimes *semeiotic* is used today to differentiate the Peircean approach to the study of signs (the "American" tradition) from other approaches (especially the Saussurean, or "European" orientation of semiology).

Seme, sememe A unit of meaning; more narrowly, the smallest unit of meaning. In structural linguistics, sememes are explained in terms of an analogy with phonemes. That is, they are units defined in terms of a system of relationships, in particular, oppositions. This view of meaning is holistic; it locates meaning, first and foremost, in language as a system of oppositions rather than in the individual units themselves. The sememe "bat" contributes to the working of language not because of its intrinsic qualities but because of its discernible difference from "cat", "mat", "hat", etc. As constituent of language, a phoneme attains its identity through its differences with other phonemes. Analogously, so do sememes.

Semeion (plural Semeia). Greek for sign. From very early (beginning with Hippocrates and Parmenides in the fifth century B.C.), *semeion* was used as a synonym for *tekmerion* (evidence, proof, or symptom).

Semiology A name for the general theory of signs; It is also used as a translation of *semiologie* – Ferdinand de Saussure's science of signs – which is sometimes referred to as the European tradition of Semiotics.

Semiosis A term originally used by Charles S. Peirce to designate any sign action or sign process; in general, the activity of a sign. It is commonly supposed that signs are instruments used by humans and also other animals: In themselves, they are thought to be inert and thus ineffectual. *Semiosis* is often used in such a way as to challenge this perspective, for it signifies an inherently dynamic process over which human sign-users exert no or at most limited control. In other words, signs are not mere instruments: They exert any agency of their own. For Charles S. Peirce, semiosis is an irreducible triadic process in which an object generates a sign of itself and, in turn, the sign generates an interpretant of itself. This interpretant in its turn generates a further interpretant, ad infinitum. Thus, semiosis is a process in which a potentially endless series of interpretants is generated.

Semiotic triangle According to Peirce, a sign is irreducibly triadic, its components being the sign (or representamen) itself, the object, and the interpretant. In order to avoid Peirce's unfamiliar terminology and a confusion of the interpretant with the interpreter of a sign, Nöth [396] has changed the terminology of the Peircean semiotic trias: The sign vehicle (Peirce's *representamen*) is the form of the sign; Peirce's interpretant is now called the sense of the sign; the referent (or reference) is what the sign refers to (the Peircean object). A simplified version of this concept has become known as the semiotic triangle.

Semiotics The study of doctrine of signs, sometimes supposed to be a science of signs; the systematic investigation of the nature, properties, and kinds of sign, especially when undertaken in a self-conscious way. While semiology is sometimes used to refer to the Saussurean tradition, and semiotics sometimes refers to the Peircean tradition, nowadays the term semiotics is more likely to be used as an umbrella term to embrace the whole field.

Sender One who sends or conveys a message, thus a synonym for addresser.

Sense In the Peircean sign model, as reformulated by Nöth [396,401], sense, or *Bedeutung*, has taken the place of the interpretant. The sense made of the sign stands in a triadic relation to the referent and the sign vehicle. Their relation (and not the sign vehicle) is called the sign.

Serendipity "The gift of making delightful discoveries by pure accident". In hypertext navigation, the original goal sometimes becomes irrelevant or is forgotten over the current dominance of a new piece of information encountered in the browsing process. This is called the serendipity effect.

SGML The Standard Generalized Markup Language (SGML) is a standard for how to specify a document markup language or tag set. Such a specification is itself a document type definition (DTD). SGML is not in itself a document language, but a description of how to specify one. HTML and XML are SGML-based languages.

siglum, sigla ① An acronym in the form of a single symbol – for example a monogram. ② Loosely, an invented sign that contrasts with the normative allography of a script – for example, ¶.

Sign A term defined traditionally as ***aliquid stat pro aliquo*** (something that stands for something else). In the semiotic view, however, the sign is not a tangible object, like a road sign, but the relation of the sign vehicle, the referent and the sense (or between the signified and the signifier). Today, the term sign itself, apart from the specific meaning of these relations, is usually used by semioticians as an all-encompassing or all-inclusive term. In other words, sign is used as an umbrella term-a term under which a host of subtypes huddle.

Sign vehicle That component of a sign by which the sign function is fulfilled or at least taken up. Since a sign is ordinarily thought to convey a message, that component of it which is most directly responsible for this conveyance is appropriately called a vehicle (a term meaning, after all, a means of transport or conveyance). For example, a hand gesture is not really a sign, but a sign vehicle.

Signal A specific type of sign usually characterized as calling for an immediate response. In this sense, the stop sign at the end of an exit off the highway might more properly be called a stop signal (we do in fact speak of traffic signals). Its function is to call for an immediate response-here and now (that is, at the moment one reaches it). Failure to do so can result in another sort of signal – the siren of a police car.

Signified One of the essential correlates of the sign as defined by Ferdinand de Saussure. For him, a sign is an arbitrary correlation between a signifier and a signified. The signifier calls attention to something other than itself; the signified is the recipient of that attention.

Signifier That part of a sign which stands for the signified.

Sinsign A term used by Charles S. Peirce to designate a specific type of sign, one in which an *individual* event or object (not a category) serves as the sign vehicle. See qualisign, legisign.

Speech The term most often used to translate parole in contrast to langue**.** Language is the system making communication possible, whereas speech (or discourse) is the actual use of this system in some concrete circumstance.

Symbol A term frequently used to designate a conventional sign (for instance, a sign based on convention or established usage). But this term refers to various other types of signs as well. For Ferdinand de Saussure, a symbol is a sign in which the correlation between signifier and signified is, in some measure, motivated (that is, nonarbitrary). In Charles S. Peirce's elaborate classification of signs, a symbol is almost the opposite of this. Peirce defines symbol as part of a trichotomy: icon, index, symbol. This trichotomy is based on the relationship between the sign vehicle and its (reference) object. If a sign vehicle is related to its object by virtue of a resemblance to that object (for instance, a map to its territory), it is an icon. If it is related to its object by virtue of an actual or physical connection (for example, the direction of the weather vane to the direction of the wind being indicated by the vane), it is an index. If it is related to its object by virtue of a habit or convention (for instance a single red rose as the symbol of affection-or more), it is a symbol.

Synchronic Pertaining to what which is co-present or simultaneous or that for which the passage of time is considered irrelevant. Synchronic analysis studies a phenomenon as if it were frozen at one moment in time; Antonym: diachronic, pertaining to what changes over time.

Syntagm An orderly combination of interacting signifiers which forms a meaningful whole (sometimes called a *chain*). Such combinations are made within a framework of syntactic rules and conventions (both explicit and inexplicit). In language, a sentence, for instance, is a syntagm of words.

Syntax In writing or notation, the way characters and words are ordered, and specifically the orderings that affect meaning. In pictures, the impression that visual signs or marks are ordered as they would be in writing.

Taxonomy A classification; the study of the principles of classification.

TCP/IP The Transmission Control Protocol/Internet Protocol (TCP/IP) is the basic standard communication language or protocol of the Internet. TCP/IP is a two-layer program. The higher layer, Transmission Control Protocol, manages the assembling of a message or file into smaller packets that are transmitted over the Internet and received by a TCP layer that reassembles the packets into the original message. The lower layer, Internet Protocol, handles the address part of each packet so that it gets to the right destination.

Text A term used today in a very broad sense to cover not only verbal but also other forms of communication. The term text usually refers to a message which has been recorded in some way (e.g. writing, audio- and video-recording) so that it is physically independent of its sender or receiver. A text is an assemblage of signs (such as words, images, sounds and/or gestures) constructed (and interpreted) with reference to the conventions associated with a genre and in a particular medium of communication.

Textual Link Marker See Graphical Link Marker.

Thirdness One of Charles S. Peirce's three universal categories. Formally and abstractly defined, it is betweenness or mediation. See firstness, secondness.

Thought The process or act of thinking; the product or result of this process or act. In semiotics, thought is conceived as a sign process.

Token An individual replication or instance of a sign or, more exactly, of a legisign. There can be numerous tokens of a single type.

Topography ① Detailed, precise description of a place or region; ② Graphic representation of the surface features of a place or region on a map, indicating their relative positions and elevations.

Topology ① The topographic study of a given place, especially the history of a region as indicated by its topography; ② Topology is also a branch of pure mathematics dealing with the fundamental properties of abstract spaces. In this sense, it is the study of the properties of geometric figures that are not normally affected by changes in size or shape.

Transclusion The inclusion of the same material in two different documents.

Trace Trace or inspiration has the place in Derrida's grammatology that sign has in Ferdinand de Saussure's semiology and in Charles S. Peirce's semiotic. If a thing never left a *trace* of itself it could never be known, nor could it serve as a sign of anything else. Thus, without visible or tangible or, in some other way, perceptible marks or traces, semiosis (or sign action) would be impossible.

Triadic Three-termed; having three parts, aspects or levels. Charles S. Peirce's definition of sign as a correlation of sign vehicle, object, interpretant is described as triadic, whereas Ferdinand de Saussure's definition of sign as a correlation between signifier and signified is characterized as dyadic (two-termed).

Trichotomy While a dichotomy is the process of dividing something into two, or the result of this process, a trichotomy is the process of dividing something into three, or the result of this process (a threefold division or classification).

Type In semiotics, a sign considered as an indefinitely replicable entity or function, while token is an individual replication or instance of a sign or, more exactly, of a legisign. The type is itself the legisign, a form indefinitely replicable. There can be numerous tokens of a single type.

Typed link Besides holding its primary elements, the link anchor and the link destination, a link can be classified, thus holding a type, such as definition, update, citation, etc.

Unmotivated Synonym for arbitrary; lacking an intrinsic connection or natural basis.

URI Uniform Resource Identifier is the generic term for all types of names and addresses that refer to objects on the World Wide Web. A URL is one kind of URI.

URL The Uniform Resource Locator is the address of a WWW document, consisting of the Internet domain name (such as `http://www.wu-wien.ac.at/`) and the relative path to the document (e.g. `/infocenter/vvz/local.html`) that are used in hyperlinks.

XML The Extensible Markup Language (XML) is a flexible way to create common information formats and share both the format and the data on the World Wide Web. XML is ”extensible” because the markup symbols are unlimited and self-defining. XML, like HTML, is a simpler and easier-to-use subset of SGML.

XSL The Extensible Stylesheet Language (XSL) is a language for creating a style sheet that describes how data sent over the Web using the Extensible Markup Language (XML) is to be presented to the user. XSL is based on and extends the Document Style Semantics and Specification Language (DSSSL) and the Cascading Style Sheet, (CSS) standards.

Virtual Existing outside of physical sapce, e.g. as a product of the human imagination or as a model in the realms of a computer.

Virtual Reality A computer simulation of a real or imaginary system that enables a user to perform operations on the simulated system and shows the effects in real time.

Writable, or writerly text Two ways of translating Roland Barthes's term *scriptible*, a term used to distinguish a distinctive type of literary text. In contrast to readerly (*lisible*) texts, writerly texts are ones in which the reader is invited to engage self-consciously in the construction or fabrication of the text's meaning. Such texts are characteristically challenging: They try in various ways to jar their readers by exposing, rather than hiding, the devices and codes by which narratives are constructed.

Writing The process of inscribing signs in a more or less durable medium and the result of this process – in a word, inscription. Traditionally, it has been supposed that writing is a secondary system of signs, written words being themselves signs of spoken signs. If seen through Jacques Derrida's deconstructionist theory, writing (often called arche-writing) becomes nothing less than an equivalent of semiosis, or sign action.

WWW The World Wide Web (WWW) is an Internet-based hypermedium that consists of text, graphics, audio, animation, and video.

aesthetics

Appendix B

Bibliography

As this dissertation is available on paper and hypertextually, special attention has been given to the navigatability of the (electronic) document. If an Internet connection and a Web browser are available, all URLs are directly accessible from within the document by clicking on them.

Please note that in the PDF version and the paper version derived from it, the bibliography entries contain ”backlinks”. These numbers which follow each entry, indicate the pages on which that reference was cited. This way, the reader can judge the importance of each source for my work, as many citations of a single work indicate more influence.

References

[1] OhneWörterBuch. 500 Zeigebilder für Weltenbummler. Langenscheidt, Berlin & München, 1999. 12, 50, 51, 231

[2] The Greeks - Crucible of Civilisation. TV documentary and website: http://www.pbs.org/empires/thegreeks/htmlver/index.html, 1999. 151

[3] Europas Chancen bei Neuen Medien. Interview with Helmut F. Meier. *Der Standard*, page A2, February 8 2001. Feb. 8. 17

[4] Robert M. Aiken. Education and the Net: Hope or Hype? In *Proceedings of the EDICT 2000 Conference*, pages 11–15, Vienna, Austria, 12 2000. OCG. 78

[5] Reka Albert, Albert-Laszlo Barabási, and Hawoong Jeong. Diameter of the World Wide Web. *Nature*, 401(6749), September 1999. 85, 134, 146

[6] Jonathan J. G. Alexander. Scribes as artists: The arabesque initial in twelfth-century english manuscripts. In *Medieval Scribes, Manusripts and Libraries. Essays Presented to N.R. Ker*. Watson, London, 1978. 110

[7] Jonathan J. G. Alexander. *Medieval Illuminators and their Methods of Work*. Yale University Press, New Haven and London, 1992. 35, 49, 53, 54, 63, 81, 82, 101

[8] Peter Bøgh Andersen. Towards an Aesthetics of Hypertext Systems. A Semiotic Approach. In *Proceedings of the ECHT'90 European Conference on Hypertext*, Designing and Reading Hyperdocuments, pages 224–237, 1990. 15, 54

[9] Peter Bøgh Andersen. *A Theory of Computer Semiotics*. Cambridge Series on Human-Computer Interaction. Cambridge University Press, Cambridge, UK, [1990] 1997. 15, 22, 54, 55, 56, 58, 101, 102, 108, 115, 156, 161

[10] Peter Bøgh Andersen. Vector Spaces as the Basic Component of Interactive Systems: Towards a Computer Semiotics. *Hypermedia*, 4(1):53–76, 1992. 15, 54

[11] Peter Bøgh Andersen. What Semiotics Can and Cannot Do for HCI. Position paper for the CHI'2000 Workshop on Semiotic Approaches to User Interface Design. http://peirce.inf.puc-rio.br/chi2000ws6/ppapers/andersen.htm, April 2000. Last visited: Jul. 30, 2001. 19, 54, 55, 102, 116, 161

[12] Peter Bøgh Andersen. Semiotics and Informatics: A Bibliography. http://www.cs.auc.dk/~pba/Bib.html, apr 2001. Last visited: Aug. 30, 2001. 55

[13] Peter Bøgh Andersen, Berit Holmquist, and Jens F. Jensen, editors. *The Computer as Medium*. Learning in doing: Social, cognitive, and computational perspectives. Cambridge University Press, Cambridge, 1993. 15, 55

[14] Vladimir Andreev and Gennady Uzilevsky. Iconic signs and languages in user interface design. In *East-West International Conference on Human-Computer Interaction: Proceedings of the EWHCI'93*, volume 1 of *Foundations of HCI*, pages 180–190, 1993. 102, 161

[15] Keith Andrews, Frank Kappe, and Hermann A. Maurer. The Hyper-G network information system. *The Journal of Universal Computer Science*, 1(4):206–220, April 1995. 74

[16] W. Appelt. What Groupware Functionality Do Users Really Use? Analysis of the Usage of the BSCW System. In Bob Werner, editor, *Proceedings of the Ninth Euromicro Workshop on Parallel and Distributed Processing*, pages 337–344, Los Alamitos, California, February 7–9 2001. IEEE Computer Society. 80

[17] Rudolf Arnheim. *Art and Visual Perception. A Psychology of the Creative Eye*. University of California Press, Berkeley and Los Angeles, 4 edition, 1969. 13, 97, 98

[18] Rudolf Arnheim. *The Power of the Center: A Study of Composition in the Visual Arts. The New Version.* University of California Press, Berkeley, 1988. 39, 52, 96, 97, 98

[19] Roy Ascott. Photography at the Interface. In Druckerey [150], pages 167–71. 48, 156

[20] G. Auffret, J. Carrive, O. Chevet, Th. Dechilly, R. Ronfard, and B. Bachimont. Audiovisual-based Hypermedia Authoring: Using Structured Representations for Efficient Access to AV Documents. In Klaus Tochtermann, Jörg Westbomke, Uffe K. Wiil, and John J. Leggett, editors, *Proceedings of the Conference on Returning to Our Diverse Roots (Hypertext-99)*, pages 169–178, New York, N.Y., February 21–25 1999. ACM Press. 15, 100

[21] E. Z. Ayers and J. T. Stasko. Using Graphic History in Browsing the World Wide Web. In O'Reilly and Associates and Web Consortium (W3C), editors, *World Wide Web Journal: The Fourth International WWW Conference Proceedings*, pages 451–460. O'Reilly & Associates, Inc., 1995. 132

[22] Friedrich Teja Bach. *Struktur und Erscheinung*. Mann Verlag, Berlin, 1996. 49

[23] Ricardo Baeza-Yates and Berthier Ribeiro-Neto. *Modern Information Retrieval*. Addison Wesley, Reading, US, 1999. 136

[24] Hans-Dieter Bahr. *Über den Umgang mit Maschinen*. Kunkursbuchverlag, Tübingen, 1983. 57, 58, 140

[25] V. Balasubramanian. State of the Art Review on Hypermedia Issues And Applications. Technical report, Graduate School of Management, Rutgers University, Newark, New Jersey, March 1994. Available at `http://www.isg.sfu.ca/~duchier/misc/hypertext_review/index.html`. Last visited: June 08, 2001. 59, 62, 64, 67, 68, 69, 107, 126, 145

[26] Steven Balckburn and David De Roure. Musical Part Classification in Content Based Systems. In *OHS-6/SC-2*, volume 1903 of *Lecture Notes in Computer Science*, pages 66–76. Springer, 2000. 100

[27] Kurt Baldinger. Semasiology and Onomasiology. In Roland Posner, Klaus Robering, and Thomas A Sebeok, editors, *Semiotics. A Handbook on the Sign-Theoretic Foundations of Nature and Culture*, volume 2, pages 2118–2145. Mouton de Gruyter, New York, 1998. 50

[28] Thierry Bardini. Bridging the Gulfs: From Hypertext to Cyberspace. *JCMC*, 3(2), sep 1997. Available at http://jcmc.huji.ac.il/vol3/issue2/bardini.html. Last visited: May 16, 2001. 65, 66, 111, 113, 115, 117, 133, 144, 148

[29] John Perry Barlow. The Economy of Ideas. *Wired*, 2.03, mar 1994. http://www.wired.com/wired/archive/2.03/economy.ideas.html. Last visited: Aug. 19, 2001. 16, 164, 166

[30] John Perry Barlow. The Next Economy of Ideas. *Wired*, 8.10, oct 2000. http://www.wired.com/wired/archive/8.10/download.html. Last visited: Aug. 19, 2001. 16, 164, 166, 167

[31] Edward Barrett, editor. *The Society of Text - Hypertext, Hypermedia and the Social Construction of Information*. MIT, 1989. 101, 208, 224, 232

[32] Edward Barrett, editor. *Sociomedia. Multimedia, Hypermedia, and the Social Construction of Knowledge*. MIT Press, Cambridge, Mass., 1992. 16

[33] Edward Barrett and Marie Redmond, editors. *Contextual Media. Multimedia and Interpretation*. MIT Press, Cambridge, Mass., 1995. 55, 101, 157, 230

[34] Ann Marie Seward Barry. *Visual Intelligence: Perception, Image and Manipulation in Visual Communication*. State University of New York Press, New York, 1997. 31

[35] Roland Barthes. *Elements of Semiology*. Jonathan Cape, London, [1964] 1967. Trans. Annette Lavers & Colin Smith. 27, 28

[36] Roland Barthes. Sémiologie et urbanisme. *L'Architecture d'aujourd'hui*, (53):11–13, dec 1970. 141

[37] Roland Barthes. *S/Z*. Cape, London, [1970] 1974. trans. R. Miller. 53, 60, 83, 111, 190

[38] Roland Barthes. *Image – Music – Text*. Hill and Wang, New York, 1977. 112

[39] Roland Barthes. *Camera Lucida*. Noonday Press, New York, [1980] 1981. Trans. by Richard Howard. 47, 48

[40] Jean Baudrillard. *Selected Writings*. Polity Press, Cambridge, 1988. 33

[41] Bernard Bekavac. Methoden und Verfahren von Suchdiensten im WWW/Internet. http://www.inf-wiss.uni-konstanz.de/suche/, May 2001. Last visited: Aug. 03, 2001. 135

[42] Hans Belting. *Bild und Kult. Eine Geschichte des Bildes vor dem Zeitalter der Kunst*. Verlag C.H.Beck, München, 2. edition, 1993. 82

[43] James R. Beniger. *The Control Revolution*. Harvard University Press, Cambridge, MA, 1986. 153

[44] Walter Benjamin. Das Kunstwerk im Zeitalter seiner technischen Reproduzierbarkeit. *Zeischrift für Sozialforschung*, (5), 1936. 37, 46, 139

[45] Walter Benjamin. Peinture et graphisme. *La Part de l'oeil*, (6), 1990. 98

[46] Emile Benveniste. *Problems in General Linguistics*. University of Miami Press, Coral Gables, 1971. Trans. by Mary E. Meek. 103

[47] Emile Benveniste. The Semiology of Language. In Innis [246], pages 228–246. Trans. by Mary E. Meek. 41

[48] D. Benyon. Beyond navigation as metaphor. *Lecture Notes in Computer Science*, 1513:705–715, 1998. 118, 134, 142, 143

[49] Jacques Berleur, Andrew Clement, Richard Sizer, and Diane Whitehouse, editors. *The Information Society: Evolving Landscapes*. Springer Verlag, Captus University Publications, New York, 1990. 92

[50] Jeff Bernard and Gloria Withalm, editors. *Neurath. Zeichen*. S-Labor. ÖGS-ISSS, 1996. 45, 161, 163, 212

[51] Tim Berners-Lee. Information Management: A Proposal. `http://www.w3.org/History/1989/proposal.html`, mar 1989. 12, 72, 73, 147

[52] Tim Berners-Lee. Press FAQ. `http://www.w3.org/People/Berners-Lee/FAQ.html`, 2000. Last visited: 27. Apr. 2001. 72, 73, 147

[53] Tim Berners-Lee and M. Fischetti. *Weaving the Web: The Original Design and Ultimate Destiny of the World Wide Web by its Inventor*. Harper, San Francisco, 1999. 73

[54] Tim Berners-Lee, James Hendler, and Ora Lassila. The semantic Web. *Scientific American*, 284(5):34–43, May 2001. `http://www.sciam.com/2001/0501issue/0501berners-lee.html`. Last visited: May 21, 2001. 75, 134, 136, 151, 174, 195

[55] Mark Bernstein. Patterns of hypertext. In Kaj Grønbæk, Elli Mylonas, and III Frank M. Shipman, editors, *Proceedings of the 9th ACM Conference on Hypertext and Hypermedia (HYPER-98)*, pages 21–29, New York, June 20–24 1998. ACM Press. 99

[56] Mark Bernstein. Structural patterns and hypertext rhetoric. *ACM Computing Surveys*, 31(4es), December 1999. 17

[57] Jacques Bertin. *Sémiologie graphique*. Editions Gauthier-Villars, Paris, 1967. 39, 45, 100, 106, 127

[58] Steve Bett. Pictograms and Logograms. `http://victorian.fortunecity.com/vangogh/555/Spell/pic-logo.htm`, aug 2000. Last visited: Aug. 04, 2001. 156

[59] Paul Beynon-Davies. *Information Systems Development: An Introduction to Information Systems Engineering*. Macmillan Computer Science Series. Macmillan Press, Basingstoke and London, 1993. 135

[60] M. Bieber, S. Feiner, M. Frisse, P. Hayes, G. Peper, and W. Scacchi. Expert systems and hypertext. In *ACM Hypertext'89 Proceedings*, Panels, page 391. ACM Press, 1989. 76

[61] Michael Bieber, Harri Oinas-Kukkonen, and V. Balasubramanian. Hypertext functionality. *ACM Computing Surveys*, 31(4es), December 1999. 80, 150

[62] Michael Bieber, Fabio Vitali, Helen Ashman, V. Balasubramanian, and Harri Oinas-Kukkonen. Fourth Generation Hypermedia: Some Missing Links for the World Wide Web. *International Journal of Human-Computer Studies*, 47(1):31–65, 1997. 14, 59, 61, 69, 86, 87, 88, 89, 107, 118, 119, 124, 126, 129, 150, 151, 174

[63] Jonathan Bignell, editor. *Media Semiotics. An Introduction*. Manchester University Press, Manchester, 1997. 42, 55, 112, 156, 164

[64] Sandi Bilinski and Sigrid Bumann. Lost in History - Entwicklung von Strategien zur Minimierung der Orientierungs- und Navigationsschwierigkeiten in besuchten WWW-Seiten. Master's thesis, Fachbereich Informatik der Universität Hamburg, 1998. 131

[65] Christine Boese. Making a successful case for a hypertextual doctoral dissertation. In *Proceedings of the 11th ACM Conference on Hypertext and Hypermedia (HYPERTEXT-00)*, pages 232–233, N.Y., May 30–June 4 2000. ACM Press. 7

[66] Yves-Alain Bois and Rosalind E. Krauss. *Formless. A User's Guide*. Zone Books, New York, 1997. 15, 97

[67] Johan Bollen. Efficiency analyses of hypertext networks: Cognitive Complexity vs. Connectivity: efficiency analyses of hypertext networks. http://pespmc1.vub.ac.be/papers/bollen/Bolleneinmag.html, 1999. Last visitetd: Jul. 24, 2001. 157

[68] Jay David Bolter. *Writing Space; The Computer, Hypertext and the History of Writing*. Lawrence Erlbaum, Hillsdale, NJ, 1991. 38, 41, 54, 95, 104, 105, 106

[69] Robert Borrus and John Zysman. The Rise of wintelism as the Future of Industrial Competition. Working paper 96b, BRIE, University of California, Berkeley, feb 1997. 16, 163

[70] Niels Olof Bouvin. *Augmenting the Web through Open Hypermedia*. PhD thesis, University of Aarhus, nov 2000. 71, 72, 74, 75, 149, 150

[71] Horst Bredekamp. Politische Theorien des Cyberspace. Schriftenreihe der Staatlichen Hochschule für Gestaltung, Karlsruhe, pages 31–50. Cantz Verlag, 1996. 151

[72] Søren Brier. Cyber-semiotics: On autopoiesis, code-duality and sign games in biosemiotics. *Cybernetics and Human Knowing*, 3(1):3–14, 1995. 101, 155

[73] Andrei Broder, Ravi Kumar, Farzin Maghoul, Prabhakar Raghavan, Sridhar Rajagopalan, Raymie Stata, Andrew Tomkins, and Janet Wiener. Graph structure in the Web. *Computer Networks (Amsterdam, Netherlands: 1999)*, 33(1–6):309–320, June 2000. http://www9.org/w9cdrom/160/160.html. 83, 85, 88, 93, 105, 134, 146

[74] Hans Peter Brøndmo and Glorianna Davenport. Creating and Viewing the Elastic Charles – Hypermedia Journal. In *HYPERTEXT: State of the Art*, Navigation and Browsing, chapter 5, pages 43–51. Intellect, 1989. Revised from document published in the HT'89 Proceedings, York, England, July, 1989. 99

[75] Heather Brown, editor. *Hypermedia/Hypertext and Object-oriented Databases*. UNICOM Applied Information Technology. Chapman & Hall, 1991. 211, 215

[76] Peter Brown. Turning ideas into products: The guide system. In *ACM Hypertext'87 Proc.*, Sys. I, page 33. ACM Press, 1987. 69

[77] Peter Brown. The Ethics and Aesthetics of the Image Interface. Position paper for the CHI'2000 Workshop on Semiotic Approaches to User Interface Design. http://peirce.inf.puc-rio.br/chi2000ws6/ppapers/brown.htm, apr 2000. Last visited: Jul. 30, 2001. 42, 113, 114, 115, 117, 134, 161

[78] Browser News. Microsoft scraps smart tags in windows xp. http://browserwatch.internet.com/news/stories2001/news-20010628-1.html. Last visited: Aug. 18, 2001, 2001. 171

[79] Victor Burgin, editor. *Thinking Photography*. Macmillan, London, 1982. 39

[80] Vannevar Bush. As we may think. *The Atlantic Monthly*, 176(1):101–108, jul 1945. http://www.theatlantic.com/unbound/flashbks/computer/bushf.htm Last visited: May 07, 2001. 14, 64, 65, 77, 119, 124, 144, 150

[81] Vannevar Bush. Memex revisited. In Vannevar Bush, editor, *Science Is Not Enough*, pages 75–101. William Morrow, 1967. 65

[82] Eric Buyssens. *Les langages et le discours*. Office de la Publicité, Bruxelles, 1943. 34, 40

[83] by Scott Ruthfield. The Internet's History and Development. ACM Crossroads Student Magazine, http://www.acm.org/crossroads/xrds2-1/inet-history.html. Last visited: May 13, 2001, 1995. 72

[84] Deborah Cameron. *Feminism and Linguistic Theory*. Macmillan, London, 1992. 28

[85] Luca Caneparo and Gian Paolo Caprettini. On the Semiotics of the Image and the Computer Image. In Nöth [399], pages 147–158. 48, 51, 52

[86] Patricia Ann Carlson. *Hypertext and Intelligent Interfaces for Text Retrieval*. In Barrett [31], 1989. 126

[87] James Carney. Wittgenstein's Theory of Picture Representation. *Journal of Aesthetics*, 60:179–185, 1981. 44

[88] Peter Carruthers and Jill Boucher, editors. *Language and thought. Inderdisciplinary themes*. Cambridge University Press, 1998. 45, 110, 209

[89] Ernst Cassirer. *The Philosophy of Symbolic Forms*, volume 1–3. Yale University Press, New Haven, 1955. (These works were first published in German in 1923–29.). 24

[90] Ernst Cassirer. *An Essay on Man. An Introduction to a Philosophy of Human Culture*. Yale University Press, New Haven, 1992. First published in 1944. 24, 91

[91] Lara D. Catledge and James E. Pitkow. Characterizing Browsing Strategies In the World Wide Web. *Computer Networks and ISDN Systems*, 27(6):1065–1073, April 1995. 122

[92] Juan de Celaya. *Expositio magistri Joannis de Celaya, Valentini, in primum tractatum Summularum magistri Petri Hispani*. Paris, 1525. 63

[93] Daniel Glen Joel Chandler. The 'Grammar' of Television and Film, 1994. http://www.aber.ac.uk/media/Documents/short/gramtv.html. Last visited: Aug. 18, 2001. 164

[94] Daniel Glen Joel Chandler. *The Act of Writing: A Media Theory Approach*. The Registry, Aberystwyth, Wales, 1995. 28, 40, 49, 53, 54

[95] Daniel Glen Joel Chandler. *Semiotics: The Basics*. Routhledge, London, 2001. Citations taken from WWW version, *Semiotics for Beginners*, http://www.aber.ac.uk/media/Documents/S4B/semiotic.html. Last visited: Jul. 18, 2001. 17, 20, 21, 23, 24, 26, 27, 28, 29, 30, 36, 37, 38, 39, 40, 41, 45, 48, 52, 53, 54, 55, 103, 106, 107, 112, 155, 156

[96] Chaomei Chen and Roy Rada. Interacting with hypertext: A meta-analysis of experimental studies. *Human-Computer Interaction*, 11(2):125–156, 1996. 118

[97] Noam Chomsky. Human language and other semiotic systems. *Semiotica*, 25(31-44), 1979. 20

[98] Andy Clark. Magic words: how language augments human computation. In Carruthers and Boucher [88]. 79, 80, 110, 112

[99] David D. Clark. A Model for Cost Allocation and Pricing in the Internet. In McKnight L.W. and Bailey J.P., editors, *Internet Economics*. MIT Press, 1997. 84

[100] John O. Clark and Derek A. Holton. *A First Look at Graph Theory*. World Scientific Publishing Company, 1991. 93

[101] Alain Cochet. Lacan and science. http://www.chez.com/alcochet/, mar 2000. Last visited: Aug. 10, 2001. 12, 44

[102] Vincent M. Colapietro. *Glossary of Semiotics*. Paragon House Glossaries for Research, Reading, and Writing. Paragon House, New York, 1993. 20, 21, 22, 23, 26, 29, 31, 32, 38, 39, 41, 53, 54

[103] Alex Coles and Alexia Defert, editors. *The Anxiety of Interdisciplinarity*, volume 2 of *de-, dis, ex-*. BACKles Books, London, 1998. 142, 223

[104] George H. Collier. Thoth-II: Hypertext with explicit semantics. In *ACM Hypertext'87 Proceedings*, Systems II, pages 269–289, 1987. 86

[105] Carlos Colón. Communication Science vs. Semiotics. http://php.indiana.edu/~ccolon/Semiotics/ccolon1.html, Feb. 1995. Last visited: Jun 13, 1999. 29

[106] Carlos Colón. Semiotics in Cyberspace. http://php.indiana.edu/~ccolon/Semiotics/ccolon3.html, Apr. 1995. Last visited: Jun 13, 1999. 15, 101, 152, 155, 158, 159

[107] Carlos Colón. Significations of Icons in a Computer GUI. http://php.indiana.edu/~ccolon/Semiotics/ccolon2.html, Mar. 1995. Last visited: Jun 13, 1999. 15, 158

[108] Jeffrey Conklin. A survey of hypertext. Technical report, MCC, Software Technology Program, 1987. 69, 79, 80, 107, 118, 126

[109] Jeffrey Conklin and M. Begeman. gIBIS: A tool for all reasons. *Information Society for Information Science*, 40(3):200–213, 1989. 69, 88

[110] Guy Cook. *The Discourse of Advertising*. Routledge, London, 1992. 30, 35, 36

[111] Diana Coyle. *The Weightless World. Strategies for Managing the Digital Economy*. Capstone, Oxford, 1997. 16, 163

[112] J. E. Creighton. Reason and Feeling. *Philosophical Review*, 30(5), 1921. 91

[113] Jonathan Culler. *Saussure*. Fontana, London, 1985. 28, 155

[114] Daniel Cunliffe. Trailblazing: trends in hypermedia. *The New Review of Hypermedia and Multimedia*, 6:19–46, 2000. 17, 85, 100, 101, 135, 136, 140, 149

[115] Cyberatlas. Search Engines, Browsers Still Confusing Many Web Users. http://cyberatlas.internet.com/big_picture/traffic_patterns/article/0,,5931_588851,00.html, feb 2001. Last visited: Jul 23, 2001. 146

[116] Nils Dahlback, editor. *Towards a Framework for Design and Evaluation of Navigation in Electronic Spaces*, Stockholm, Sweden, 1998. Swedish Institute of Computer Science. 118, 119, 122, 134, 223

[117] Antonio R. Damasio. *Descartes' Error: Emotion, Reason, and the Human Brain*. G.P. Putnam's Sons, New York, 1994. 57, 140

[118] Marcel Danesi. *Messages and Meanings: An Introduction to Semiotics*. Canadian Scholars' Press, Toronto, 1994. 29, 33

[119] Marcel Danesi. *Encyclopedic Dictionary of Semiotics, Media, and Communication*. Toronto Studies in Semiotics. University of Toronto Press, Toronto, 2000. 29

[120] Arthur C. Danto. *Beyond the Brillo Box. The Visual Arts in Post-Historical Perspective*. Farrar, Staus and Giroux, New York, 1992. 97

[121] Fernando A. Das Neves and Edward A. Fox. A Study of User Behavior in an Immersive Virtual Environment for Digital Libraries. In *Proceedings of the Fifth ACM Conference on Digital Libraries*, pages 103–111, New York, 2000. ACM, ACM. 119

[122] H. C. Davis, D. E. Millard, S. Reich, N. O. Bouvin, K. Grønbæk, P. J. Nürnberg, L. Sloth, U. K. Wiil, and K. M. Anderson. Interoperability between hypermedia systems: The standardisation work of the OHSWG. In Klaus Tochtermann, Jörg Westbomke, Uffe K. Wiil, and John J. Leggett, editors, *Proceedings of the Conference on Returning to Our Diverse Roots (Hypertext-99)*, pages 201–202, New York, N.Y., February 21–25 1999. ACM Press. 71

[123] Howard and Paul Walton Davis, editor. *Language, Image, Media*. Basil Blackwell, Oxford, 1983. 30

[124] Hugh C. Davis, David E. Millard, and Siegfried Reich. OHP – Communicating between Hypermedia Aware Applications. In *Towards a New Generation of HTTP. A workshop on global hypermedia infrastructure held in conjunction with the Seventh International World Wide Web Conference (WWW7), 14 - 18 April 1998, Brisbane, Australia.*, 1998. 71

[125] Michel De Certeau. *The Practice of Everyday Life*, chapter Walking in the City. University of California Press, Berkeley, 1974. Translated by Steven Rendall. Originally published as L'invention du quotidien. Vol. 1, Arts de faire (1974). 142

[126] Teresa de Lauretis. *Alice Doesn't: Feminism, Semiotics, Cinema*. Macmillan, London, 1984. 28, 38

[127] Clarisse Sieckenius de Souza. The Semiotic Engineering of User Interface Languages. *International Journal of Man-Machine Studies*, 39(5):753–773, 1993. 55, 101, 102, 113, 115

[128] Clarisse Sieckenius de Souza, Raquel Oliveira Prates, and Simone Diniz Junqueira Barbosa. Report on CHI'2000 Workshop on Semiotic Approaches to User Interface Design. `http://www.acm.org/sigchi/bulletin/2000.5/semiotics.html`, apr 2000. Last visited: Jul 30, 2001. 15, 55, 102, 113, 161

[129] Paul Delany and George P. Landow, editors. *Hypermedia and Literary Studies*. MIT Press, Cambridge, Massachusetts, 4. edition, 1991. 60, 63, 83, 111, 144, 215, 221

[130] G. Deleuze and F. Guattari. *A Thousand Plateaus*. University of Minnesota Press, Minneapolis, 1987. 153

[131] Gilles Deleuze. *Woran erkennt man den Strukturalismus?* Merve, Berlin, [1969] 1992. 26

[132] Serge Demeyer. Virtual hypertext based on paths and warm links. Technical report, vub, June 1994. 150

[133] DeRose. XML linking. *CSURVES: Computing Surveys Electronic Section*, 31, 1999. 88

[134] Steven J. DeRose. Expanding the Notion of Links. In *ACM Hypertext'89 Proceedings*, Usability, Links, and Fiction, pages 249–257, Baltimore, 1989. ACM Press. 89

[135] Jacques Derrida. La structure, le signe et le jeu dans le discurs des sciences humaines. In *Conférende au Colloque International de l'Un*, Baltimore, 10 1966. John Hopkins University. 63, 105

[136] Jacques Derrida. *Grammatology*. Johns Hopkins University Press, Baltimore, [1967] 1976. 53

[137] Bénédicte Desclefs and Michel Soto. XML and Information Visualization - Application to Network Management. In *Markup Technologies 99, Philadelphia, USA*, dec 1999. 127

[138] Anne d'Harnoncourt and Kynaston McShine, editors. *Marcel Duchamp*. The Museum of Modern Art, New York, Prestel, 1989. 59, 63

[139] Philip K. Dick. *Valis*. Vintage Books, 1981. 111, 144

[140] Georges Didi-Huberman. *Ähnlichkeit und Berührung. Archäologie, Anachronismus und Modernität des Abdrucks*. DuMont, Köln, [1997] 1999. 46

[141] Georges Didi-Huberman. *Was wir sehen, blickt uns an. Zur Metapsychologie des Bildes*. Fink, München, 1999. frz. Original: Ce que nous voyons, ce qui nous regarde, 1992. 15

[142] Andreas Dieberger. *Navigation in Textual Virtual Environments Using a City Metaphor*. PhD thesis, Vienna University of Technology, 1994. Quoted according to online version available at: http://juggle5.50megs.com/other/PhDThesis.html. Last checked: Jul. 10, 2001. 13, 30, 92, 93, 102, 103, 113, 114, 116, 117, 118, 119, 123, 126, 127, 139, 143, 161

[143] Andreas Dieberger. Supporting Social Navigation on the World Wide Web. *International Journal of Human-Computer Studies*, 46(6):805–825, 1997. 119, 122

[144] Andrew Dillon. *Human Factors Issues in the Design of Hypermedia Interfaces*, pages 93–106. In Brown [75], 1991. 45, 104, 113, 117, 162

[145] Martin Dodge. An Atlas of Cyberspace. http://www.geog.ucl.ac.uk/casa/martin/atlas/info_landscapes.html, 2001. Last visited: Jul 31, 2001. 13, 120, 121

[146] Stefan Dokters. Haftung für Hyperlinks. http://www.web-kanzlei.de/texte/haftung.html, 2001. Last visited: Aug. 03, 2001. 167

[147] J. Yellowlees Douglas. Hyper/Text/Theory. In Landow [304], chapter 'How Do I Stop This Thing?': Closure and Indeterminacy in Interactive Narratives. 121, 122, 165

[148] M. Downs, Roger and David Stea, editors. *Image and Environment*. Aldine, Chicago, 1973. 118

[149] Timothy Druckerey. L'amour faux. *Perspektief*, 37, 1989-1990. 48

[150] Timothy Druckerey, editor. *Electronic Culture. Technology and Visual Represetation*. Aperture, New York, 1996. 48, 101, 204, 229

[151] David Durand and Steven J. DeRose. XML Linking. Unpublished script for a tutorial held at the HT'00 Conference in San Antonio, TX, jun 2000. 86, 87, 88

[152] Simon During, editor. *Cultural Studies Reader*. Routledge, London, 2. edition, 1999. 17, 232

[153] Umberto Eco. *Einführung in die Semiotik*. Fink, München, 1972. 12, 28, 38, 41, 171

[154] Umberto Eco. *A Theory of Semiotics*. Macmillan, London, 1976. 12, 20, 28, 30, 33, 36, 37, 41, 46, 106, 109, 138

[155] Umberto Eco. *Zeichen. Einführung in einen Begriff und seine Geschichte*. Suhrkamp, Frankfurt am Main, 1977. 12, 20, 21, 22, 33, 34, 35, 106, 109, 138, 171

[156] Umberto Eco. *Semiotics and the Philosophy of Language*. Macmillan, London, 1984. 140, 157

[157] Umberto Eco. *Die Suche nach der vollkommenen Sprache*. dtv, München, 1997. 153

[158] Nold Egenter. 0. E. Bollnow and the Ontology of Home and Movement Outside. Paper prepared for the Symposium on The Ancient Home and the Modern Internationalized Home Dwelling in Scandinavia, University of Trondheim, Norway, Aug. 1992. http://home.worldcom.ch/~negenter/015AcrobatArchives/IndiaManualQuest/24_Manual_D.pdf. Last visited: Aug. 03, 2001. 92, 126, 128, 142

[159] Mircea Eliade. *Images and Symbols: Studies in Religious Symbolism*. Harvil Press, London, 1961. trans. P. Mairet. 42, 46

[160] James Elkins. *The Domain of Images*. Cornell University Press, Ithaca/London, 1999. 12, 15, 35, 37, 43, 44, 46, 85, 97, 158, 159

[161] Philip Elmer-DeWitt. Welcome to cyberspace: What is it? where is it? and how to get there? *Times Magazine*, Spring 1995. http://www.webcom.com/~alauck/isd/times-1.html. Last visited: Jul 20, 2001. 152, 154, 155

[162] Douglas C. Engelbart and William K. English. A research center for augmenting human intellect. In *Proceedings of the Fall Joint Computing Conference*, volume 33, pages 395–410, Montvale, NY, 1968. AFIPS Press. 14, 66, 113

[163] Achim Eschbach. Bildsprache. ISOTYPE und die Grenzen. In Bernard and Withalm [50], pages 15–48. 15, 45, 46, 50

[164] Etoy. The Toywar Story. http://www.toywar.com, mar 2001. Last visited: Aug. 20, 2001. 174, 175

[165] Trevor Evans. Die Rolle finanzieller Faktoren im US-amerikanischen Wirtschaftsboom der 90er Jahre. *PROKLA 122 – Zeitschrift für kritische Sozialwissenschaft*, 21(1), mar 2001. 16, 163

[166] Steven Feiner. Seeing the forest for the trees: Hierarchical display of hypertext structure. In *Proceedings of the Conference on Office Automation Systems*, Hypertext and Information Retrieval, pages 205–212, 1988. 85, 127

[167] Udo L. Figge. Computersemiotik. *Zeitschrift für Semiotik*, 13(3/4):321–330, 1991. 55

[168] John Fiske. *Introduction to Communication Studies*. Routledge, London, 1982. 35

[169] John Fiske. Codes. In *International Encyclopedia of Communications*, pages 312–316. Oxford University Press, New York, 1989. 36

[170] John Fiske and John Hartley. *Reading Television*. Methuen, London, 1978. 28, 156

[171] Jerry Aline Flieger. The Listening Eye: Postmodernism, Paranoia, and the Hypervisible. *Diacritics*, 26(1):90–107, 1996. 157

[172] Jean-Marie Floch. *Visual Identities*. Continuum, London, 2000. 27

[173] Jerry A. Fodor. Imagistic representation. pages 63–86. MIT Press, Cambridge, MA, 1981. 46, 49

[174] Mattias Forsberg, Kristina Höök, and Martin Svensson. Design Principles for Social Navigation Tools. In *Proceedings of the Workshop on Personal and Social Navigation in Information Space*. SICS, Stockholm, Sweden, 1998. http://www.sics.se/humle/projects/persona/web/. 119, 134, 164

[175] Michel Foucault. Was ist ein Autor? In *Schriften zur Literatur*, pages 7–31. Ullstein Materialien, Frankfurt/Berlin/Wien, 1969. 145

[176] Michel Foucault. Of Other Spaces. *Diacritics*, (19), 1986. 131, 142, 143

[177] Michel Foucault. *Die Ordnung der Dinge*. Suhrkamp, Frankfurt am Main, 14 edition, 1997. 155

[178] Gottlob Frege. Über Sinn und Bedeutung. *Zeitschrift für Philosophie und philosophische Kritik*, 100:25–50, 1892. 44

[179] Christian Freksa. Qualitative spatial reasoning. NATO Advanced Studies Institute, pages 361–372. Kluwer, Dordrecht, 1991. 93

[180] R. Furuta, V. Quint, and J. Andre. Interactively editing structured documents. *Electronic Publishing—Origination, Dissemination, and Design*, 1(1):19–44, April 1989. 100

[181] Peter Galassi. *Walker Evans & COMPANY*. The Museum of Modern Art, New York, 2000. 46

[182] Klaus Gallert. *Markenzeichen aus semiotischer Sicht*. PhD thesis, Universität Wuppertal, 1998. 30

[183] Ta gang Chiou and Judith Donath. Perceptual thumbnail. http://www.media.mit.edu/~dc/research/thumbnail/chi98.html, 1998. Last visited: Jul. 22, 2001. 132

[184] Howard E. Gardner. *Multiple Intelligences: The Theory in practice*. Basic Books, New York, 1993. 91

[185] Franca Garzotto, Luca Mainetti, and Paolo Paolini. Hypermedia Design, Analysis, and Evaluation Issues. *Communications of the ACM*, 38(8):74–86, August 1995. 124

[186] K. F. Gates, P. B. Lawhead, and D. E. Wilkins. Towards an adaptive WWW: A case study in customised hypermedia. *The New Review of Hypermedia and Multimedia*, 6:89–113, 1998. 101

[187] Michael S. Gazzaniga. *The Mind's Past*. University of California Press, 1998. 91

[188] Andreas Geyer-Schulz and Michael Hahsler. Recommendations for Virtual Universities from Observed User Behavior. In Wolfgang Gaul, editor, *Tagungsband der 24. Jahrestagung der GfKl*, Karlsruhe, Germany, 2001. to appear. 148

[189] Andreas Geyer-Schulz, Michael Hahsler, and Maximillian Jahn. myVU: A Next Generation Recommender System Based on Observed Consumer Behavior and Interactive Evolutionary Algorithms. In Wolfgang Gaul, Otto Opitz, and Martin Schader, editors, *Data Analysis: Scientific Modeling and Practical Applications*, Studies in Classification, Data Analysis, and Knowledge Organization, pages 447–457. Springer Verlag, Heidelberg, Germany, 2000. 148

[190] Andreas Geyer-Schulz, Stefan Koch, and Georg Schneider. Virtual Notes: Annotations on the WWW for learning environments. In *Proceedings of the Fifth Americas Conference on Information Systems (AMCIS 1999)*, pages 136–138, Milwaukee, WI, 1999. http://citeseer.nj.nec.com/263780.html. 80, 81

[191] Peter Gloor. *Elements of Hypermedia Design. Techniques for Navigation and Visualization in Cyberspace*. Coopers & Lybrand, 1997. 67

[192] Ernst Gombrich. *Art and Illusion*. Phaidon, London, 1960. 49

[193] Ernst Gombrich. *The Image and the Eye: Further Studies in the Psychology of Pictorial Representation*. Phaidon, London, 1982. 39, 103

[194] Nelson Goodman. *Languages of Art: an approach to a theory of symbols*. Oxford University Press, London, 1968. 36, 43, 84, 100

[195] Nelson Goodman. *Of Mind and Other Matters*. Harvard University Press, Cambridge, MA, 1984. 43, 159

[196] Michael Goosens and Sebastian Rahtz. *Mit LaTeX ins Web. Elektronisches Publizieren mit TeX, HTML und XML*. Addison-Wesley, 2000. 7

[197] Mark Gottdiener. Recapturing the center: A semiotic analysis of shopping malls. In Gottdiener and Lagopoulos [198]. 142

[198] Mark Gottdiener and Alexandros Lagopoulos, editors. *The City and the Sign*. Columbia University Press,, New York, 1986. 41, 142, 214

[199] John D. Gould, Lizette Alfaro, Rich Finn, Brian Haupt, Angela Minuto, and Josiane Salaun. Why reading was slower from CRT displays than from paper. In *Proceedings of ACM CHI+GI'87 Conference on Human Factors in Computing Systems and Graphics Interface*, Displays and Output, pages 7–11, 1987. 113

[200] Dieter Graf. *point it. Traveller's language kit. Picture dictionary*. Dieter Graf Verlag, München, 3. edition, [1992] 1999. 50

[201] Clement Greenberg. *Art and Culture. Critical Essays*. Beacon Press, Boston, 1965. 96, 98

[202] Scott Griffin. Internet pioneers. http://www.ibiblio.org/pioneers/index.html, may 2000. Last visited: Aug. 15, 2001. 173

[203] R.R. Gudwin and F.A.C. Gomide. Computational Semiotics : An Approach for the Study of Intelligent Systems - Part I : Foundations. Technical report, RT-DCA09 - DCA-FEEC-UNICAMP, 1997. 101

[204] J.P. Guilford. *The Nature of Human Intelligence*. McGraw-Hill, New York, 1967. 86

[205] Bernard J. Haan, Paul Kahn, Victor A. Riley, James H. Coombs, and Norman K. Meyrowitz. IRIS hypermedia services. *Communications of the ACM*, 35(1):36–51, January 1992. 99

[206] Michael Hahsler and Bernd Simon. User-centered Navigation Re-Design for Web-based Information Systems. In *Proceedings of the Sixth Americas Conference on Information Systems*, pages 192–198. AMCIS 2000, Long Beach, CA, 2000. 148

[207] Frank Halasz. Reflections on NoteCards: Seven Issues for the Next Generation of Hypermedia Systems. *Communications of the ACM, ; ACM CR 8908-0577*, 31(7), July 1988. 68, 89, 141

[208] Frank Halasz. "Seven issues": Revisited, December 15 - 18 1991. Final keynote talk at the 3rd ACM Conference on Hypertext, San Antonio, Texas. 141

[209] Frank Halasz and Mayer Schwarz. The Dexter Hypertext Model. In *Proceedings of the Hypertext Workshop*, pages 95–133. National Institute of Standards and Technology, Gaithersburg, Md., NIST Special Publication 500-178, 3 1990. 83, 85

[210] Stuart Hall. Encoding/decoding. In *Culture, Media, Language: Working Papers in Cultural Studies*, pages 128–38, London, [1973] 1980. Centre for Contemporary Cultural Studies, Hutchinson. 28, 39

[211] Wendy Hall. The Button Strikes Back. *The New Review of Hypermedia and Multimedia*, 6:5–17, 2000. 71, 72, 135

[212] Nicholas Hammond. *Teaching with Hypermedia: Problems and Prospects*, pages 93–106. In Brown [75], 1991. 78, 79, 85, 130

[213] Dorothee Hansen. Antike Helden als 'causae'. Ein gemaltes Programm im Palazzo Pubblico von Siena. pages 133–148. Beck, München, 1989. 110

[214] Linda M. Harasim, editor. *Global Networks. Computers and International Communication*. MIT, Cambridge, Mass, 1993. 16, 218

[215] Linda Hardman, J. van Ossenbruggen, K. S. Mullender, L. Rutledge, and D. C. A. Bulterman. Do You Have the Time? Composition and Linking in Time-based Hypermedia. In Klaus Tochtermann, Jörg Westbomke, Uffe K. Wiil, and John J. Leggett, editors, *Proceedings of the Conference on Returning to Our Diverse Roots (Hypertext-99)*, pages 189–196, New York, N.Y., February 21–25 1999. ACM Press. 15

[216] Lynda Hardman, Dick C. A. Bulterman, and Guido van Rossum. The Amsterdam hypermedia model: adding time and context to the Dexter model. *Communications of the ACM*, 37(2):50–62, February 1994. 12, 13, 60, 100

[217] Terence Harpold. Threnodity: Psychoanalytic Disgressions on the Subject of Hypertexts. In Delany and Landow [129], pages 171–181. 54, 107, 110, 147

[218] Steve Harrison and Paul Dourish. Re-Place-ing Space: The Roles of Place and Space in Collaborative Systems. In *Proceedings of ACM CSCW'96 Conference on Computer-Supported Cooperative Work*, Learning from Space and Place, pages 67–76, 1996. 165

[219] John Hartley. *Popular Reality: Journalism, Modernity, Popular Culture*. Arnold, London, 1982. 107

[220] John Hartley. *Understanding News*. Methuen, London, 1982. 35

[221] Frank Hartmann. *Cyber.Philosophy: Medientheoretische Auslotungen*. Passagen, Wien, 1996. 54, 151, 154, 164

[222] Brian T. Hayes. Graph Theory in Practice: Part I. *American Scientist*, 88(1), Jan - Feb 2000. Available at: http://www.sigmaxi.org/amsci/issues/comsci00/compsci2000-01.html. Last visited: May 27, 2001. 12, 83, 84, 85, 93, 107, 134, 146

[223] Evelyn Hepner. Are Your Online Ads Hitting Their Targets. *iMarketing News*, 1(6), 1999. 169

[224] Scott Herron . A Natural History of the @ Sign. http://www.herodios.com/herron_tc/atsign.html, 2000. Last visited: Jul. 13, 2001. 53, 156

[225] Bernd Herzogenrath. On the Lost Highway: Lynch and Lacan, Cinema and Cultural Pathology. *Other Voices*, 1(3), jan 1999. http://share.geocities.com/Hollywood/2093/papers/herzogenrath.html. Last visited: Jun 1, 2001. 31, 42

[226] Kyoji Hirata, Hajime Takano, and Yoshinori Hara. Miyabi: A hypermedia database with media-based navigation. In *Proceedings of the 5th Conference on Hypertext*, pages 233–234, New York, NY, USA, November 1993. ACM Press. 138

[227] Robert Hodge and Gunther Kress. *Social Semiotics*. Polity Press, Cambridge, 1988. 28

[228] Robert Hodge and David Tripp. *Children and Television: A Semiotic Approach*. Polity Press, Cambridge, 1986. 41

[229] Michael Hoffman. Long pages and gentler separation of adjacent nodes. http://www.hypertextnavigation.com/contiguous.htm, dec 2000. Last visited: 26. Apr. 2001. 147

[230] Jesper Hoffmeyer. *Signs of Meaning in the Universe*. Indiana University Press, Bloomington, IN, 1996. 153

[231] Sean Homer. Fredric Jameson and the Limits of Postmodern Theory. http://www.shef.ac.uk/uni/academic/N-Q/psysc/staff/sihomer/limits.html. Last visited: Aug. 03, 2001. 155

[232] Sean Homer. *Fredric Jameson: Marxism, Hermeneutics, Postmodernism*. Key Contemporary Thinkers Series. Polity Press, Cambridge, 1997. Last visited: Aug. 03, 2001. 155

[233] Peter Honey and Alan Mumford. *The Manual of Learning Styles*. Peter Honey Pub., Maidenhead, Berkshire, 1992. 78

[234] Kristina Höök, Marie Sjölinder, and Nils Dahlbäck. Individual Differences and Navigation in Hypermedia. Technical Report R1996-01, Swedish Institute of Computer Science, March19, 1996.
ftp://ftp.sics.se/pub/SICS-reports/Reports/SICS-R--96-01--SE.ps.Z. 118

[235] Stephanie Houde and Gitta Salomon. Working towards rich & flexible file representations. In *Proceedings of ACM INTERCHI'93 Conference on Human Factors in Computing Systems – Adjunct Proceedings*, Short Papers (Talks): Visual Languages and Virtual Reality, pages 9–10, 1993. 13, 161, 162, 163

[236] Herbert Hrachovec. *Vorbei. Heidegger, Frege, Wittgenstein. Vier Versuche*. Stroemfeld, Roter Stern, Basel, Frankfurt am Main, 1981. 44

[237] Herbert Hrachovec. Reflexionen zur maschinellen Erzeugung von Denken. In P. Weingartner and G. Schurz, editors, *Berichte des 11. Internationalen Wittgensteinsymposiums*, pages 311–314, Wien, 1987. 48, 57

[238] Herbert Hrachovec. Photo-Semantics. In *Symposium: The End of Reality?*, pages 95–104, Bratislava, 1994. 48

[239] Herbert Hrachovec. Das Spiegelstudium. Schlüssel zum Cyberspace. In W. Müller-Funk and H. U. Reck, editors, *Inszenierte Imagination. Beitrge zu einer historischen Anthropologie der Medien*, pages 213–223. Wien, 1996. 31, 157

[240] Herbert Hrachovec. Netz-Werke. In W. Loth, editor, *Wissenschaftszentrum Nordrhein-Westfalen. Kulturwissenschaftliches Institut: Jahrbuch 1995*, pages 201–207. Essen, 1996. 101

[241] G. A. Hutchings, W. Hall, and C. J. Colbourn. A model of learning with hypermedia systems. In *Proceedings of the Fifth International Conference on Human-Computer Interaction*, volume 2 of *III. Media*, pages 494–499, 1993. 77, 78

[242] A. Huxley. *Ends and Means: An Enquiry into the Nature of Ideals and into the Methods employed for their Realization*. Chatto & Windus, London, 1941. 16

[243] Heribert Illig. *Das erfundene Mittelalter. Die größte Geschichtsfälschung der Geschichte*. ECON Verlag, Düsseldorf, 1996. 168

[244] B. Indurkhya. An algebraic approach to modeling creativity of metaphor. *Lecture Notes in Computer Science*, 1562:292–306, 1999. 116

[245] Bipin Indurkhya. *Metaphor and Cognition: an Interactionist Approach*. Kluwer Academic Publishers, Dordrecht, The Netherlands, 1992. 116

[246] Robert E. Innis, editor. *Semiotics: An Introductory Reader*. Hutchinson, London, 1986. 20, 205

[247] Guido Ipsen. Linguistic Orientation in Computational Space. In Nöth [399], pages 547–558. 17, 92, 93, 96, 103, 104, 109, 110, 141, 157

[248] W. J. Irler and G. Barbieri. Non-Intrusive Hypertext Anchors and Individual Colour Markings. In *Proceedings of the ECHT'90 European Conference on Hypertext*, Navigation and Browsing, pages 261–273, 1990. 159

[249] Hide Ishiguro. Use and Reference of Names. pages 20–50. Routledge & Kegan Paul, London, 1969. 25

[250] Hide Ishiguro. Representation: An Investigation Based on a Passage in the Tractatus. pages 189–202. North-Holland Pub. Co., Amsterdam, 1975. 44

[251] Hiroshi Ishii. Tangible bits: Designing the boundary between people, bits, and atoms. In *Proceedings of the Graphics Interface 2000*, pages 1–2, Toronto, Ontario, May 15–17 2000. Canadian Information Processing Society. 60, 106, 110, 112, 149

[252] Robert Jacobson. *Sailing through cyberspace: Counting the stars in passing*, pages 327–341. In Harasim [214], 1993. 153, 154

[253] Roman Jakobson. *Selected Writings*. Mouton, The Hague, 1971. 39, 193

[254] Roman Jakobson. *Verbal Art, Verbal Sign, Verbal Time*. Minneapolis, University of Minnesota Press, 1985. 39

[255] Frankie James. *Representing Structured Information in Audio Interfaces: A Framework for Selecting Audio Marking Techniques to Represent Document Structures*. PhD thesis, Stanford University, 1998. 15, 100, 155

[256] Wolfgang Janko. *Informationswirtschaft 1. Grundlagen der Informatik für die Informationswirtschaft*. Springer, Berlin/Heidelberg, 1993. 40, 53, 83

[257] Richard W. Janney. The cold warmth of communication in computer networks. In Nöth [399], pages 519–534. 157

[258] Carroll J.M., Mack R.L., and Kellogg W.A. *Interface Metaphors and User Interface Design*, pages 67–85. Elsevier, 1988. 116

[259] Jeff Johnson. How faithfully should the electronic office simulate the real one? *ACM SIGCHI Bulletin*, 19(2):21–25, 1987. 116

[260] Adrian Johnston. Lacan's Purloined Linguistics. `http://www.lacan.com/lacinkXIV5.htm`, feb 2001. Last visited: May 16, 2001. 111, 156

[261] David H. Jonassen and H. Mandl, editors. *Designing Hypermedia for Learning*. Springer, New York, 1990. 229, 235

[262] Lauretta Jones and Sharon L. Greene. MoMA and the Three-Legged Stool: Fostering Creative Insight in Interactive System Design. In *Proceedings of ACM DIS'00*, pages 39–47. ACM, 8 2000. 79, 80

[263] René J. Jorna and Wout van Wezel. Objects and the world metaphor: A semiotic engineering approach. In Nöth [399], pages 481–496. 160, 165

[264] Dan W. Joyce, Paul H. Lewis, Robert H. Tansley, Mark. R. Dobie, and Wendy Hall. Semiotics and Agents for Integrating and Navigating through Multimedia Representations of Concepts. In *Proceedings of SPIE Vol. 3972, Storage and Retrieval for Media Databases 2000*, pages 132–143, 2000. 101, 138

[265] Michael Joyce. Storyspace as a hypertext system for writers and readers of varying ability. In *Proceedings of ACM Hypertext'91*, Technical Briefings, pages 381–387, 1991. 17, 70, 95

[266] Brian Kahin and James H. Keller, editors. *Coordinating the Internet*. The MIT Press, Cambridge (MA), London, 1997. 14, 165, 174

[267] Immanuel Kant. *Kritik der reinen Vernunft*. Felix Meiner, Hamburg, [1781] 1976. 24

[268] Nancy Kaplan and Stuart Moulthrop. Where No Mind Has Gone Before: Ontological Design for Virtual Spaces. In *ECHT '94 Proceedings*, pages 206–216. ACM, 1994. 44, 101, 105, 106, 107, 108, 126

[269] D. Katz. *Gestalt Psychology: Its Nature and Significance*. Ronald Press, New York, 1950. 91, 139

[270] J. J. Katz and J. A. Fodor. The structure of a semantic theory. *Language*, 39:170–210, 1963. 170, 195

[271] Louis H. Kauffman and Søren Brier. Peirce and Spencer-Brown: History and Synergies in Cybersemiotics. *Cybernetics and Human Knowing*, 8(1-2), 2001. 101, 155

[272] Mary A. Keeler and Susan M. Denning. The Challenge of Interface Design for Communication Theory: From Interaction Metaphor to Contexts of Discovery. *Interacting with Computers*, 3(3):283–301, 1991. 102

[273] Christopher Keep, Tim McLaughlin, and Robin Parmar. The Electronic Labyrinth. http://www.iath.virginia.edu/elab/elab.html, 2001. Last visited: Aug. 03, 2001. 70

[274] Ted Kemp. Playboy: Excite Fight Not Over. *iMarketing News*, 1(6):4, 8/20 1999. 169

[275] Can Keskin and Volker Vogelmann. Effective Visualization of Hierarchical Graphs with the Cityscape Metaphor. In *Proceedings of the Workshop on New Paradigms in Information Visualization and Manipulation*, pages 52 – 57, 1998. 13, 94

[276] Mickey Alam Khan. No Discussion: RemarQ to Sell Keywords. *iMarketing News*, 1(6):3, 8/20 1999. 13, 169, 170

[277] Søren Kierkegaard. *Entweder/Oder*, volume I. Gütersloh, 1979. 132

[278] Naomi Klein. *No Logo*. HarperCollins, 2000. 164

[279] Mei Kobayashi and Koichi Takeda. Information Retrieval on the Web. *ACM Computing Surveys*, 32(2):144–173, 2000. http://www.acm.org/pubs/citations/journals/surveys/2000-32-2/p144-kobayashi/. 134, 136

[280] K. Koffka. *Principles of Gestalt Psychology*. Harcourt Brace, New York, 1935. 39, 91, 139

[281] W. Köhler. *Gestalt Psychology*. Liveright, New York, 1929. 39, 91, 139

[282] David Kolb. *Experiential Learning: Experience as the Source of Learning and Development*. Prentice Hall, 1984. 78, 91

[283] David Kolb. Scholarly hypertext: Self-represented complexity. In *Proceedings of the Eighth ACM Conference on Hypertext*, Hypertext Rhetorics, pages 29–37, 1997. 65, 77

[284] David Kolb. Places and Spaces: Adjacency Effects. Position Paper for the First Workshop on Spatial Hypertext. http://www.well.com/user/jer/SH1/kolb.pdf, 2001. Last visited: Jul. 27, 2001. 104

[285] Piet A. M. Kommers, R. Scott Grabinger, and Joanna C. Dunlap. *Hypermedia Learning Environments. Instructional Design and Integration*. Lawrence Erlbaum Associates, 1996. 77

[286] Paula Kotzé. Why the Hypermedia Model is Inadequate for Computer-Based Instruction. *SIGCSEB: SIGCSE Bulletin (ACM Special Interest Group on Computer Science Education)*, 30, 1998. 78

[287] Audrie Krause. Selling Cyberspace: The Commercialization of the Internet. http://www.corpwatch.org/trac/feature/feature1/krause.html, 2001. Last visited Apr. 21, 2001. 14

[288] Rosalind E. Krauss. *The Optical Unconscious*. MIT Press, Cambridge, MA, 1993. 123

[289] Rosalind E. Krauss. *The Originality of the Avant-Garde and Other Modernist Myths*. MIT Press, Cambridge, MA, 11 edition, 1997. 26

[290] Theo van Kress, Gunther and Leeuwen. *Reading Images: The Grammar of Visual Design*. Routledge, London, 1996. 112

[291] Julia Kristeva. *Desire in Language: A Semiotic Approach to Literature and Art*. Columbia University Press, New York, 1980. 39, 54, 63, 111

[292] Ed Krol. *The Whole Internet*. O'Reilly and Associates, Inc., 2. edition, 1994. 72, 165

[293] Torsten Kroop et al. The Years on the Net. http://www.w3history.org/. Last visited: May 13, 2001. 72, 146

[294] Thomas S. Kuhn. *The Structure of Scientific Revolutions*. The University of Chicago Press, Chicago, 2 edition, 1970. 81

[295] Werner Kuhn and Andrew U. Frank. Spatial metaphors for user interfaces. In *Proceedings of ACM INTERCHI'93 Conference on Human Factors in Computing Systems – Adjunct Proceedings*, Workshops, page 220, 1993. 91, 116

[296] Raymond Kurzweil. *The Age of Intelligent Machines*. MIT Press, Cambridge, Massachusetts, 1990. 56

[297] Raymond Kurzweil. *The Age of Spiritual Machines: When Computers Exceed Human Intelligence*. Viking Press, New York, 1999. 56

[298] Raymond Kurzweil. The Singularity is Near. A Book Précis. http://www.kurzweilai.net/meme/frame.html?main=/articles/art0134.html, 2001. Last visited: June 02, 2001. 56

[299] Jacques Lacan. Das Spiegelstadium als Bildner der Ichfunktion wie sie uns in der psychoanalytischen Erfahrung erscheint. In *Bericht für den Internationalen Kongreß für die Psychoanalyse in Zürich am 17. Juli 1949*, 1949. 157

[300] Jacques Lacan. *Écrits*. Éditions du Seuil, Paris, 1966. 12, 26, 31, 103, 156, 157

[301] Jacques Lacan. *On Feminine Sexuality the Limits of Love and Knowledge: The Seminar of Jacques Lacan, Book XX Encore 1972-1973*. Norton, New York, 1998. 111

[302] G. Lakoff and M. Johnson. *Metaphors We Live By*. University of Chicago Press, Chicago, 1980. 46, 57, 103, 140

[303] George P. Landow. The Rhetoric of Hypermedia: Some Rules for Authors. In Delany and Landow [129], pages 81–103. 49, 59, 60, 100, 154

[304] George P. Landow, editor. *Hyper/Text/Theory*. Johns Hopkins University Press, Baltimore, 1994. 17, 54, 101, 211, 222

[305] Sasanne K. Langer. Feeling and Form. New York, 1953. 24

[306] Suzanne K. Langer. *Philosophy in a New Key*. Harvard University Press, Cambridge, MA, 1942. 24, 25, 26, 42, 45, 46, 91, 105, 108, 110, 111, 157

[307] Suzanne K. Langer. *Philosophie auf neuem Wege*. Fischer Verlag, Berlin, 1965. German translation of Philosophy in a New Key by Ada Löwith. 25, 26, 50, 103, 105

[308] Brenda Laurel. Interface as Mimesis. In Donald A. Norman and Stephen W. Draper, editors, *User Centred System Design: New Perspectives on Human-Computer Interaction*, chapter 4, pages 67–85. Lawrence Erlbaum Associates, Hillsdale, New Jersey, 1986. 115, 159

[309] Brenda Laurel. Interface Agents: Metaphors with Character. In Brenda Laurel, editor, *The Art of Human Computer Interface Design*, pages 355–365. Addison-Wesley, 1990. 116, 123, 133

[310] Brenda Laurel and S. Joy Mountford. *The Art of human-computer interface design*. Addison-Wesley, Reading, MA, USA, 1990. 116, 117, 123

[311] Benedicte Le Grand and Michel Soto. Information Management – Topic Maps Visualization. In *XML Europe 2000, 12-16 June 2000, Palais Des Congrès De Paris, France*. GCA, 2000. http://www.gca.org/papers/xmleurope2000/pdf/s29-03.pdf. 127

[312] P.D. Leedy. *Practical research: planning and design*. Macmillan, New York, 1980. 17

[313] Henri Lefebvre. *The Production of Space*. Blackwell, Oxford, 1991. 142

[314] Kurt Legat. Semiotik und Marketing. Master's thesis, Wirtschaftsuniversität Wien, 1993. 30

[315] Claude Lévi-Strauss. The Structural Study of Myth. *Journal of American Folklore*, 67:428–444, 1955. 24, 183

[316] Claude Lévi-Strauss. *Anthropologie structurale*. Plon, Paris, 1958. 24, 91, 103

[317] Claude Lévi-Strauss. *The Savage Mind*. Weidenfeld & Nicolson, London, [1962] 1974. 26, 108, 183

[318] Paul Lewis. Trends in Information Technology: Notes Usenet, WWW and Hypermedia Systems. http://www.ecs.soton.ac.uk/~phl/ctit/hyp98/hyp98.html, Mar 1998. Last visited: Jun. 23, 2001. 138

[319] Paul H. Lewis, Hugh C. Davis, Steve R. Griffiths, Wendy Hall, and Rob J. Wilkins. Media-based navigation with generic links. In *Proceedings of the Seventh ACM Conference on Hypertext*, Systems and Infrastructure, pages 215–223. ACM Press, 1996. 93, 138

[320] Gunnar Liestol. Aesthetic and Rhetorical Aspects of Linking Video in Hypermedia. In *Proceedings of the ECHT'94 European Conference on Hypermedia Technologies*, Papers, pages 217–223, 1994. 15, 99, 100

[321] Gunnar Liestol. Wittgenstein, Genette, and the Reader's Narrative in Hypertext. In Landow [304], pages 87–120. 111

[322] Amanda Lloret. Sobre el Síndrome de Stendhal. In *Arte y Locura*, pages 95–99. Buenos Aires, 1996. 140

[323] Jurij Lotman. *The Universe of Mind: A Semiotic Theory of Culture*. Indiana University Press, Bloomington, 1990. 107

[324] D. Lowe and W. Hall. *Hypermedia and the Web: An Engineering Approach*. Wiley, 1999. 94

[325] Peter Lunefeld. *Snap to Grid. A User's Guide to Digital Arts, Media, and Cultures*. MIT Press, Cambridge/London, 2000. 30, 46, 48

[326] Kevin Lynch. *The Image of the City*. MIT Press, 1960. 119

[327] Jock D. Mackinlay, George G. Robertson, and Stuart K. Card. The perspective wall: Detail and context smoothly integrated. In *Proceedings of ACM CHI'91 Conference on Human Factors in Computing Systems*, Information Visualization, pages 173–179, 1991. 94

[328] Ken Magill. Webshot Gets Traffic for Pennies. *iMarketing News*, 1(6):1, 22, 1999. 169

[329] Clara Mancini. From Cinematographic to Hypertext Narrative. In Shipman III et al. [487], pages 236–237. 99

[330] Clara Mancini. Building Visual Knowledge in a Cinematic Hypertext authoring environment. Position Paper for the First Workshop on Spatial Hypertext. `http://www.well.com/user/jer/SH1/mancini.pdf`, 2001. Last visited: Jul. 27, 2001. 99, 161

[331] N. Gregory Mankiew. *Makroökonomik*. Schaeffer-Poeschel Verlag, Stuttgart, 4 edition, 2000. 16, 163

[332] Aaron Marcus. Metaphor Design in Hypertext Systems: Managing Expectations and Surprise. In *Proceedings of ACM Hypertext'93 – Unpublished Program*, Courses, 1993. 102

[333] Aaron Marcus. Metaphor Design in User Interfaces: How to Effectively Manage Expectation, Surprise, Comprehension, and Delight. In *Proceedings of ACM CHI'95 Conference on Human Factors in Computing Systems*, volume 2 of *Tutorials*, pages 373–374, 1995. 102

[334] Catherine C. Marshall, Frank G. Halasz, Russell A. Rogers, and William C. Janssen, Jr. Aquanet: A Hypertext Tool to Hold Your Knowledge in Place. In *Proceedings of ACM Hypertext'91*, Discovering Structure II, pages 261–275, 1991. 89, 122

[335] Catherine C. Marshall and Frank M. Shipman, III. Searching for the Missing Link: Discovering Implicit Structure in Spatial Hypertext. In *Proceedings of ACM Hypertext'93*, Papers, pages 217–230, 1993. 70, 106, 139

[336] Catherine C. Marshall and Frank M. Shipman III. Spatial Hypertext: Designing for Change. *Communications of the ACM*, (38):88–97, 8 1995. 39, 70, 94, 95, 96, 106, 108, 122, 139

[337] Catherine C. Marshall and Frank M. Shipman III. Spatial Hypertext and the Practice of Information. In *Proceedings of the 1997 Conference on Hypertext*, pages 124–133. ACM, 1997. 70, 94, 96, 139

[338] David R Marshall. Art History & Multimedia: an ArteFactual Approach. In *Proceedings of the ASCILATE Conference 1995*, Melbourne, 1995. Australian Society for Computers in Learning In Tertiary Education. http://www.ascilite.org.au/conferences/melbourne95/smtu/papers/marshall.pdf. Last visited: May 05, 2001. 63, 144, 147

[339] Louis Martin. Interdisciplinary Transpositions: Bernard Tschumi's Architectural Theory. In Coles and Defert [103], pages 60–88. 141, 142

[340] Kirk Martinez. Outline of the ARTISTE Proposal. http://www.ecs.soton.ac.uk/~km/projs/artiste/proposal.html, 2000. Last visited: Jun. 22, 2001. 138

[341] Claude Marty and Robert Marty. *99 réponses sur la sémiotique*. Montpellier, CRDP, 1992. 22

[342] Peter W. Marx. The Paradise of Immediacy is closed. Some Remarks Concerning a Semiotics of Culture Rooting in Cassirerean Philosophy and Greimassian Semiotics. *S. European Journal for Semiotic Studies*, 11(1-3):327–352, 1999. 23, 24, 154

[343] Hermann Maurer. eLearning Has to Be Seen as Part of Knowledge. Keynote Speach at the EDICT Conference in Vienna, Austria, 2000. Dec. 8, 2000. 80, 92

[344] Hermann Maurer and Nick Scherbakov. Introduction to Hypermedia. Chapter 6: Second Generation Hypermedia. http://coronet.iicm.edu/Dbase1/courses/hyper/nur_html/hyphtm6.htm, 2001. Last visited: May 17, 2001. 149, 150, 151

[345] Rod McCall. Navigation In Graphical User Interfaces. In Dahlback [116]. 91, 161

[346] A. T. Y. McGuire. Some Semiotic Aspects of Web Navigation. http://www.comfortableplace.demon.co.uk/semiotic1.html, jun 1999. Last visited: 28. Apr. 2001. 14, 15, 38, 52, 54, 145, 172

[347] Alec McHoul and Phil Roe. Hypertext and reading cognition. http://wwwmcc.murdoch.edu.au/ReadingRoom/VID/cognition.html, may 1996. Last visited: May 04, 2001. 59, 61

[348] Cliff McKnight, Andrew Dillon, and John Richardson, editors. *Hypertext: A Psychological Perspective*. Ellis Horwood, 1991. 107, 108, 144

[349] Cliff McKnight, Andrew Dillon, and John Richardson. *Hypertext in Context*. The Cambridge Series on Electronic Publishing. Cambridge University Press, Cambridge, 1991. 108

[350] Marshall McLuhan and Eric McLuhan. *Laws of Media. The New Science*. University of Toronto, Toronto, Buffalo, London, 1988. 41

[351] Marshall McLuhan and Bruce R. Powers. *The Global Village. Transformations in World Life and Media in the 21st Century*. Oxford University Press, New York and Oxford, 1989. 41

[352] Floyd Merrell. *Peirce's Semiotics Now*. Semaphores and Signs. Canadian Scholars Press, Toronto, 1995. 152, 153

[353] Floyd Merrell. *Sensing Semiosis. Toward the Possibility of Complementary Cultural "Logics"*. Semaphores and Signs. St. Martin's Press, New York, 1998. 12, 22, 23, 33, 37, 42, 46

[354] Paul Messaris. *Visual 'Literacy': Image, Mind and Reality*. Westview Press, Boulder, CO, 1994. 52

[355] Christian Metz. *The Imaginary Signifier. Psychoanalysis and the Cinema*. Bloomington, 1982. Trans. C. Britton, A. Williams, B. Brewster and A Guzzetti. 42, 99

[356] Norman Meyrowitz. *The Missing Link: Why We're All Doing Hypertext Wrong*, pages 107–114. In Barrett [31], 1989. 71

[357] Norman Meyrowitz. Hypertext – Does It Reduce Cholesterol, Too? In Nyce and Kahn [405], page 361. 151

[358] David Glen Mick. Consumer Research and Semiotics: Exploring the Morphology of Signs, Symbols and Significance. *Journal of Consumer Research*, 13(2):196–213, 1986. 165

[359] Paul Mijksenaar and Piet Westendorp. *Open Here. The Art of Instructional Design*. Joost Elffers Books, New York, 1999. 45, 97

[360] Adrian Miles. Cinematic Hypermedia: Dissertation to be published at Monash University. Revised proposal available at: http://bowerbird.rmit.edu.au/adrian/phd.html. Last visited: Aug. 24, 2001. 164

[361] Adrian Miles. Hypertext Syntagmas: Cinematic Narration with Links. *Journal of Digital information*, 1(7), Dec. 2000. Available at: http://jodi.ecs.soton.ac.uk/Articles/v01/i07/Miles/. Last visited: Jul. 24, 2001. 12, 86, 87, 99

[362] David E. Millard, Luc Moreau, Hugh C. Davis, and Siegfried Reich. FOHM: A Fundamental Open Hypertext Model for Investigating Interoperability between Hypertext Domains. In *UK Conference on Hypertext*, pages 93–102, 2000. 95, 105

[363] David E. Millard, Luc Moreau, Hugh C. Davis, and Siegfried Reich. FOHM: A Fundamental Open Hypertext Model for Investigating Interoperability between Hypertext Domains. In *Proceedings of the '00 ACM Conference on Hypertext, May 30 - June 3, San Antonio, TX*, 2000. 96, 105

[364] Melanie Mitterbacher. Semiotik und Werbung dargestellt am praktischen Beispiel einer strukturanalytisch-semiotischen Analyse der klax.max. – Einführungskampagne. Master's thesis, Universität Wien, 2000. 30

[365] James L. Mohler. Rethinking the Immediacy of Web Development. In *Proceedings of the EDICT 2000 Conference*, pages 17–25, Vienna. Austria, 12 2000. OCG. 151

[366] Laszlo Moholy-Nagy. *Vision in motion*. Theobald, Chicago, 1947. 139

[367] Sarah Morley, Helen Petrie, Anne-Marie O'Neill, and Peter McNally. Auditory navigation in hyperspace: Design and evaluation of a non-visual hypermedia system for blind users. In *Third Annual ACM Conference on Assistive Technologies*, pages 100–107, 1998. 15, 100

[368] Charles W. Morris. *Foundations of the Theory of Signs*. Chicago University Press, Chicago, 1938. 22, 28, 46, 138

[369] Stuart Moulthrop. Traveling in the Breakdown Lane. A Principle of Resistance for Hypertext. *Mosaic*, 28(4), 1998. http://raven.ubalt.edu/staff/moulthrop/essays/breakdown.html. Last visited: Jul 20, 2001. 17

[370] Manfred Muckenhaupt. *Text und Bild*. Narr, Thübingen, 1986. 49

[371] C. Murray. Expression and Language. http://www.solucian.com/artheory/atlang.htm, Dec. 1997. Last visited: Jul. 17, 2001. 26, 46

[372] Mihai Nadin. The Semiotics of Man-Machine Communication. pages 463–470. University Press of America, Lanham, 1985. 55, 101, 102, 115

[373] Mihai Nadin. Interface Design. *Semiotica*, 69(3/4):269–302, 1988. 101, 115, 161

[374] Mihai Nadin. *Signs and Systems. A Semiotic Introduction to Systems Design*, chapter Visible Signs – The Language of Multimedia. University Press, Cambridge, 1997. http://www.code.uni-wuppertal.de/uk/all_pdf_files/sign+sys.pdf. Last visited Jul. 30, 2001. 55, 102, 146

[375] Mihai Nadin. Semiotics for the HCI Community, 2001. http://www.code.uni-wuppertal.de/uk/hci/. Last visited Jul. 30, 2001. 12, 13, 15, 22, 32, 38, 58, 110, 114, 115, 117, 131, 138, 155, 157, 158, 160

[376] Jocelyne Nanard and Marc Nanard. Should Anchors be Typed Too? An Experiment with MacWeb. In *Proceedings of ACM Hypertext'93*, Papers, pages 51–62, 1993. 88, 105

[377] Francis M. Naumann. *The Art of Making Art in the Age of Mechanical Reproduction*. Abrahams, New York, 1999. 59, 63

[378] Ted Nelson. Literary Machines. Unpublished manuscript. Available at http://www.sfc.keio.ac.jp/~ted/TN/PUBS/LM/LMpage.html. Last visited: May 07, 2001, 1987. 66

[379] Theodor H. Nelson. The Hypertext. In *Proceedings International Documentation Federation Annual Conference*, 1965. 14, 65

[380] Netlingo Online Dictionary. Smileys and Emoticons. http://www.netlingo.com/smiley.cfm, 2001. Last visited: Jul 20, 2001. 157

[381] Rita Neubauer. Der Klammeraffe feiert Geburtstag. *Der Standard*, June 21 2001. 156

[382] Moritz Neumüller. A Semiotic Analysis of iMarketing Tools. In *HT'00. Proceedings of the Eleventh ACM Conference on Hypertext and Hypermedia*, pages 238–239, May 30-June 4, San Antonio, TX 2000. 13, 15, 170, 171

[383] Moritz Neumüller. Applying Computer Semiotics to Hypertext Theory and the World Wide Web. In *OHS-6/SC-2*, volume 1903 of *Lecture Notes in Computer Science*. Springer, 2000. 15, 102

[384] Moritz Neumüller. Mind the Eye! On the Relevance of Composition in Spatial Organization. *The New Review of Hypermedia and Multimedia*, pages 197–202, 12 2000. 15, 39, 96

[385] Otto Neurath. *Gesammelte bildpädagogische Schriften*. Verlag Hölder-Pichler-Tempsky, Wien, 1991. 13, 45, 158, 161, 162, 163

[386] Bill Nichols. *Ideology and the Image: Social Representation in the Cinema and Other Media*. University of Chicago Press, Chicago, 1981. 39, 52

[387] Jakob Nielsen. *Hypertext and Hypermedia*. Academic Press, San Diego, 1990. 7, 12, 13, 14, 15, 60, 61, 68, 69, 70, 76, 77, 78, 82, 88, 112, 122, 124, 127, 128, 148, 154, 188

[388] Jakob Nielsen. *Multimedia and Hypertext: The Internet and Beyond*. Professional. Academic Press, 1995. 42, 66, 67, 68, 69, 86, 124, 151

[389] Jakob Nielsen. Alertbox: Changes in Web Usability Since 1994. http://www.useit.com/alertbox/9712a.html, dec 1997. Last visited: Aug. 03, 2001. 61

[390] Jakob Nielsen. Alertbox: Nielsen's Law of Internet Bandwidth. http://www.useit.com/alertbox/980405.html, apr 5 1998. Last visited: Aug. 20, 2001. 16

[391] Jakob Nielsen. Alertbox: Did Poor Usability Kill E-Commerce? http://www.useit.com/alertbox/20010819.html, aug 19 2001. Last visited: Aug. 20, 2000. 165

[392] Jakob Nielsen and Uffe Lyngbæk. Two Field Studies of Hypermedia Usability. In *Proceedings of the Hypertext 2 Conference (York, UK)*, June 1989. 69, 113

[393] Jakob Nielsen and Bruce "Tog" Tognazzini. Beyond the browser. *Interactive Week*, mar 2001. http://www.zdnet.com/intweek/stories/news/0,4164,2701166,00.html. Last visited: Jul. 15, 2001. 42, 129, 148, 172, 173, 174

[394] Emanuel G. Noik. Exploring Large Hyperdocuments: Fisheye Views of Nested Networks. In *Proceedings of ACM Hypertext'93*, Papers, pages 192–205, 1993. 126

[395] Donald A. Norman. Cognitive engineering. In Donald A. Norman and Stephen W. Draper, editors, *User Centred System Design: New Perspectives on Human-Computer Interaction*, chapter 3, pages 31–65. Lawrence Erlbaum Associates, Hillsdale, New Jersey, 1986. 165

[396] Wilfried Nöth. *Handbook of Semiotics*. Indiana University Press, Bloomington, 1990. 21, 22, 29, 30, 37, 196

[397] Wilfried Nöth. Can pictures lie? [399], pages 133–146. 46, 47, 48, 49, 50, 139, 171

[398] Wilfried Nöth. Representation in Semiotics and in Computer Science. *Semiotica*, 115:203–213, 1997. 101, 102

[399] Wilfried Nöth, editor. *Semiotics of the Media: State of the Art, Projects and Perspectives*. Mouton de Gruyter, Berlin, 1997. 40, 41, 42, 55, 100, 102, 112, 156, 208, 217, 218, 226, 231, 235

[400] Wilfried Nöth. The (meta-)textual space. In René Dirven and Martin Pütz, editors, *The Construal of Space in Language and Thought*, pages 599–612. Mouton de Gruyter, Berlin, 1997. 104

[401] Wilfried Nöth. *Handbuch der Semiotik*. Metzler, Stuttgart/Weimar, 2 edition, 2000. 21, 22, 23, 30, 33, 35, 36, 40, 106, 107, 109, 136, 138, 196

[402] Wilfried Nöth and Karin Wenz, editors. *Medientheorie und digitale Medien*. University Press, Kassel, 1998. 55

[403] P. J. Nürnberg. Repositioning structural computing. In Reich and Anderson [432], pages 179–183. 101

[404] P. J. Nürnberg and H. Ashman. What Was the Question? Reconciling Open Hypermedia and World Wide Web Research. In Klaus Tochtermann, Jörg Westbomke, Uffe K. Wiil, and John J. Leggett, editors, *Proceedings of the Conference on Returning to Our Diverse Roots (Hypertext-99)*, pages 83–90, New York, N.Y., February 21–25 1999. ACM Press. 75, 101

[405] James M. Nyce and Paul Kahn, editors. *From Memex to Hypertext: Vannevar Bush and the Mind's Machine*. Panels. Academic Press, Boston, 1992. 62, 64, 65, 133, 224, 227

[406] C. K. Ogden and L. A. Richards. *The Meaning of Meaning*. Routledge, London, 2. edition, 1949. 22, 138

[407] Ryan M. Olshavsky. Quotes. `http://design1st.org/ryan/quotes.html`, may 2001. Last visited: Sep. 08, 2001. 30

[408] Tim O'Sullivan et al. *Key Concepts in Communication and Cultural Studies*. Routledge, London, 1994. 28, 41

[409] L. Owens. Vannevar Bush and the Differential Analyzer: The Text and Context of an Early Computer. In Nyce and Kahn [405], pages 3–38. 113

[410] Otto Pächt. *Methodisches zur Kunsthistorischen Praxis*. Prestel, München, 1986. 82, 97

[411] Wolfgang Panny. Information Retrieval. Unpublished lecture materials available at `http://lux5.wu-wien.ac.at/~wyk/ir-vo/Skriptum_Kapitel_1.pdf`. Last visited: Jul. 19, 2001, apr 2001. 135, 136

[412] Jiri Panyr. Objektzentrierte Wissensrepräsentation und Information Retrieval-Methoden. In Angela Zimmermann, Harald H., Luckhardt, Heinz-Dirk, Schulz, editor, *Mensch und Maschine - Informationelle Schnittstellen der Kommunikation : Proceedings des 3. Internationalen Symposiums für Informationswissenschaft*, pages 166–178, Konstanz, FRG, November 1992. Universitätsverlag Konstanz. 135

[413] H. Van Dyke Parunak. Don't Link Me In: Set Based Hypermedia for Taxonomic Reasoning. In *Proceedings of ACM Hypertext'91*, Discovering Structure II, pages 233–242, 1991. 86, 89, 95

[414] Romedi Passini. *Wayfinding in Architecture*. Van Nostrand Reinhold, New York, 1984. 118

[415] Michel Pastoureau. *Les sceaux des rois et de régence*, volume 2 of *Corpus des sceaux français du Moyen Age*, chapter Le roi des lis. Embleèmes dynastiques et symboles royaux, pages 35–48. Archives Nationales, Paris, 1991. 159

[416] Charles Sanders Peirce. *Collected Papers 1931-35*. Harvard University Press, Cambridge, 1935. 21, 29, 31, 33, 37, 46, 47, 103, 138, 152

[417] A. M. Pejtersen. A Library System for Information Retrieval Based on a Cognitive Task Analysis and Supported by an Icon-Based Interface. In C. J. Belkin, N.J.; van Rijsbergen, editor, *Proceedings of the 12th Annual International ACM/SIGIR Conference on Research and Development in Information Retrieval*, pages 40–47, Cambridge, MA, USA, June 1989. ACM Press. 119

[418] Rosemary Pepper and Molly Wright Steenson. Net Luminaries Foretell the Future. Open Studio Interviews. http://home.netscape.com/computing/webbuilding/studio/feature19981217-2.html, 1999. Last vistited Oct. 10, 1999. 75

[419] Steven Pepper and H. Rath. Topic Maps: Introduction and Allegro. In *Markup Technologies 99, Philadelphia, USA*, dec 1999. 127

[420] Richard Persché. Immediate Feedback During Online Lectures. Master's thesis, Technical University of Graz, Austria, aug 1997. 67, 68

[421] Per Persson. Supporting Navigation in Digital Environments: A Narrative Approach. In *Proceedings of the Workshop Towards a Framework for Design and Evaluation of Navigation in Electronic Spaces*. SICS, Stockholm, Sweden, 1998. http://www.sics.se/humle/projects/persona/web/littsurvey/ch12.pdf. 118, 128, 133

[422] Margit Pohl and Peter Purgathofer. Analysis of the Authoring Process of Hypertext Documents. In Shipman III et al. [487], pages 240–241. 97

[423] Mark Poster. The Net as a Public Sphere? *Wired*, nov 1995. http://www.wired.com/wired/archive/3.11/poster.if_pr.html. Last visited: Aug. 05, 2001. 152

[424] Neil Postman. *Technopoly. The Surrender of Culture to Technology*. Vintage Books, New York, 1993. 153

[425] Jennifer Powell. Lessons from the Browser War (1995-2000). *PC Computing*, 64, mar 2000. 13, 172, 173

[426] Raquel Oliveira Prates, Clarisse Sieckenius de Souza, and Ana Cristina Bicharra Garcia. A Semiotic Framework for Multi-User Interfaces. *ACM SIGCHI Bulletin*, 29(2):28–39, 1997. 101, 102, 113, 115

[427] Publications of the Department of Information Business at the Vienna University of Economics and Business Administration. http://wwwai.wu-wien.ac.at/Publikationen.html, 2001. Last visited: Apr. 28, 2001. 17

[428] Vincent Quint and Irène Vatton. Making Structured Documents Active. *Electronic Publishing–Origination, Dissemination, and Design*, 7(2):55–74, June 1994. 80

[429] Renzo Raggiunti. *Philosophische Probleme in der Sprachtheorie Ferdinand de Saussures*. Alno, Aachen, 1990. 138

[430] Usha Rao and Murray Turoff. Hypertext Functionality: A Theoretical Framework. *International Journal of Human-Computer Interaction*, 2(4):338–358, 1990. 80, 86, 87

[431] Eric Steven Raymond. The Cathedral and the Bazaar. http://www.tuxedo.org/~esr/writings/cathedral-bazaar/cathedral-bazaar/, aug 2000. Last visited: Aug. 13, 2001. 80

[432] Siegfried Reich and Kenneth M. Anderson, editors. *Open Hypertext Systems and Structural Computing, 6th International Workshop, OHS-6, 2nd International Workshop, Sc-2, San Antonio, Texas, USA, May 30-June 3, 2000, Proceedings*, volume 1903 of *Lecture Notes in Computer Science*. Springer, 2000. 71, 93, 101, 174, 227

[433] Reporters without Borders. The Enemies of the Internet. Technical report, Transfert.net, feb 2001. 146

[434] Gabriele Resl. Hypertext und Intertextualität. Master's thesis, Universität Wien, 1999. 102, 111

[435] Burghard B. Rieger. Dynamic Word Meaning Representations and the Notion of Granularity. Text Understanding as Meaning Constitution by SCIPS. In A. M. Meystel, editor, *Proceedings of the 1997 International Conference on Intelligent Systems and Semiotics: A Learning Perspective. ISAS '97 (NIST-SP 918)*, pages 331–2. NIST, Gaithersburg, MD, USA, 1997. 55

[436] Burghard B. Rieger. Computing Granular Word Meanings. A fuzzy linguistic approach in Computational Semiotics. In Wang [532], pages 147–208. 55

[437] Jeremy Rifkin. *The Age of Access. The new Culture of Hypercapitalism, Where All of Life Is a Paid-for Experience*. Tarcher/Putnam, New York, 2000. 16, 163, 164

[438] Veith Risak. *Mensch-Maschine Schnittstelle in Echtzeitsystemen*. Springer-Verlag, Wien, 1986. 90, 112, 113

[439] Veith Risak. Mensch-Maschine-Schnittstelle Hypertext. Created on Hyperties version 3.05 (available from the author), mar 1995. 59, 61, 68, 76, 80, 86, 90, 112, 113, 115, 124, 126, 139

[440] Veith Risak. Das Internet eine globale Agora. Vortrag an der Universität Innsbruck, 21.1.98, 19h, 1 1998. 151

[441] Veith Risak. Langfristige Wissensspeicherung gestern und heute. *Computer Kommunikativ*, 5:19–24, dec 2000. 64, 126

[442] Veith Risak. Die Homepage als Zeichen. Lecture given at the "Semiotik-Seminar der Universität Wien", March 30 2001. 41, 42, 50, 127, 165

[443] Veith Risak. Lecture Notes for 'Mensch-Maschine-Schnittstelle mit Schwerpunkt Hypertext'. `http://www.cosy.sbg.ac.at/~risak/dat_prog/doku/wu.html`, 2001. Last visited: Aug. 1, 2001. 42, 76, 113, 121, 124, 127, 128, 129, 133

[444] A. D. Ritchie. *The Natural History of the Mind*. London, 1936. 26

[445] George G. Robertson, Jock D. Mackinlay, and Stuart K. Card. Cone Trees: Animated 3 Visualizations of Hierarchical Information. In *Proceedings of ACM CHI'91 Conference on Human Factors in Computing Systems*, Information Visualization, pages 189–194, 1991. 94

[446] Kevin Robins. The Virtual Unconscious in Postphotography. In Druckerey [150], pages 154–65. 48, 154

[447] A. J. Romiszowski. The Hypertext/Hypermedia Solution – But What Exactly is the Problem? In Jonassen and Mandl [261], pages 321–354. 78

[448] Jim Rosenberg. Navigating Nowhere / Hypertext Infrawhere. *SIGLINK Newsletter*, 3(3), dec 1994. `http://www.well.com/user/jer/NNHI.html`. Last visited: June 03, 200. 17, 95, 165, 182

[449] Jim Rosenberg. The Structure of Hypertext Activity. In *Proceedings of the Seventh ACM Conference on Hypertext*, Spatial Hypertexts, pages 22–30, 1996. http://www.cs.unc.edu/~barman/HT96/P17/SHA_out.html. Last visited: June 03, 2001. 61, 89, 90, 91, 95, 96, 105, 121, 122, 128, 130, 165, 182, 185

[450] Serge Rosmorduc. A Short Introduction to Hieroglyphs. http://webperso.iut.univ-paris8.fr/~rosmord/Intro/Intro.html, feb 1998. Last visited: Sept. 19, 2001. 38

[451] Brian Rotman. *Ad Infinitum: The Ghost in Turing's Machine (Taking God out of Mathematics and Putting the Body Back in: An Essay in Corporeal Semiotics)*. Stanford University Press, Stanford, 1993. 103, 140, 157

[452] R. H. Rouse and M. A. Rouse. Wax tablets. *Language and Communication*, pages 175–91, 9 1989. 82

[453] Michael Roy. How to Do Things without Words. The Multicultural Promise of Multimedia. In Barrett and Redmond [33], pages 53–62. 45

[454] William Rubin. Jackson Pollock and the Modern Tradition. *Art Forum*, 1:14–21, 2 1967. 98

[455] William Rubin. *Picasso and Braque. Pioneering Cubism*. The Museum of Modern Art, New York, 1989. 96

[456] August Ruhs. Appareillages sosies. *Cahiers pour la Recherche Freudienne*, (3):17–25, 1988. 56, 57

[457] D. E. Rumelhart and D. A. Norman. Accretion, Tuning, and Restructuring: Three Modes of Learning. pages 37–53. Lawrence Erlbaum Associates, New Jersey, 1978. 77

[458] Harry J. Saddler. Design: Understanding design representations. *ACM Interactions*, 8(4):17 – 24, jul 2001. 39, 97, 148, 149

[459] G. Salton and M. J. McGill. *Introduction to Modern Information Retrieval*. McGraw-Hill, New York, 1983. 136

[460] Peter Henry Salus. *Casting the Net: From Arpanet to Internet and Beyond*. UNIX and open systems series. Addison-Wesley, Reading, MA, USA, 1995. 72

[461] Pamela Samuelson. Is Copyright Law Steering the Right Course? *IEEE Software*, 5(5):78–86, September 1988. 167

[462] Pamela Samuelson. Legally Speaking: Is Information Property? *Communications of the ACM*, 34(3):15–18, March 1991. http://www.acm.org/pubs/toc/Abstracts/0001-0782/102875.html. Last visited: Jul. 19, 2001. 167

[463] Pamela Samuelson. Toward a New Politics of Intellectual Property. *Communications of the ACM*, 44(3):98–99, March 2001. http://www.acm.org/pubs/citations/journals/cacm/2001-44-3/p98-samuelson/. 167

[464] Paul A. Samuelson and W. Nordhaus. *Economics*. Singapur, 14 edition, 1992. 152

[465] Mike Sandbothe. DIGITAL ENTANGLEMENTS. A Media-Philosophical Analysis of Images, Language, and Writing in the Internet. http://www.uni-jena.de/ms/digi/digi.html, 1997. Last visited: Sept. 01, 2001. 42

[466] Lucia Santaella. The prephotographic, the photographic and the postphotographic image. In Nöth [399], pages 121–132. 46, 48, 81, 156

[467] Santini and Jain. Similarity Measures. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 21, 1999. 139

[468] Ferdinand de Saussure. *Course de linguistique générale*. Payot, Paris, 1916. 19, 20, 29

[469] Ferdinand de Saussure. *Grundfragen der allgemeinen Sprachwissenschaft*. Walter de Gruyter & Co., Berlin, [1916] 1967. 12, 20, 21, 27, 29, 31, 35, 53, 54

[470] Christoph Scherrer. New Economy: Wachstumsschub durch Produktivitätsrevolution? *PROKLA 122 – Zeitschrift für kritische Sozialwissenschaft*, 21(1), mar 2001. 16, 163

[471] Dagmar Schmauks. Wittgenstein kauft Gavagai: vom Nutzen sprachfreier Bildwörterbücher. *Semiotische Berichte*, 21:367–384, 1997. 15, 50

[472] Dagmar Schmauks. Die Rolle von Bildern in der internationalen Kommunikation. In Klaus Rehkämper and Klaus Sachs-Hombach, editors, *Bild - Bildwahrnehmung - Bildverarbeitung. Interdisziplinäre Beiträge zur Bildwissenschaft*, volume 21, pages 81–88. Deutscher Universitäts-Verlag, Wiesbaden, 1998. 50

[473] Dagmar Schmauks. Book review of [1]. *Kodikas/Code*, 23:155–157, 2000. 15, 41, 50

[474] Dagmar Schmauks. Tactile Perception as a Means of Object Recognition: Its Contribution in Everyday Life. In Walter Schmitz, editor, *Proceedings of the 7th International IASS-Congress (Dresden 1999)*, volume 21, 2001. 106, 110, 112

[475] Birgit Schneider and Peter Berz. Bildtexturen: Punkte, Zeilen, Spalten. In *Symposion "Mimesis. Zur Krise des Bildbegriffs", 5./6. Feb. 1999, Kassel, Universitätsgelände, Senatssal*, 1999. http://waste.informatik.hu-berlin.de/mtg/mtg4/Schneider_Berz/textil.html. 54, 147

[476] Rolf Schulmeister. Hypermedia Learning Systems. http://www.izhd.uni-hamburg.de/Book/Frames/start_frame.html, 1997. Last visited: Aug. 02, 2001. 14, 79, 141

[477] Thomas A. Sebeok, editor. *Encyclopedic Dictionary of Semiotics*. Mouton de Gruyter, Berlin/New York/Amsterdam, 1986. 29, 30, 109

[478] Linda Serenson Colet and Moritz Neumüller. Educational Hypermedia in a Museum Environment. In *Proceedings of the EDICT 2000 Conference*, pages 323–329, Vienna, Austria, 12 2000. OCG. 15, 79

[479] Helen Sewell. Tiny disk to record posterity. *BBC News*, jul 6 2000. http://news.bbc.co.uk/hi/english/sci/tech/newsid_815000/815681.stm. Last visited: May 07, 2001. 64

[480] Claude E. Shannon and Warren Weaver. *A Mathematical Model of Communication*. University of Illinois Press, Urbana, IL, 1949. 41

[481] Carl Shapiro and Hal R. Varian. *Information Rules: A Strategic Guide to the Network Economy*. Harvard Business School Press, Boston, MA, USA, 1999. 16, 163, 164

[482] Atsushi Shimojima. *On the Efficacy of Representation*. PhD thesis, Indiana University, 1996. 36

[483] Frank M. Shipman III. Seven Directions for Spatial Hypertext Research. http://www.well.com/user/jer/SH1/shipman.pdf, 2001. Last visited: Jul. 27, 2001. 99

[484] Frank M. Shipman III and Haowei Hsieh. Navigable history: a reader's view of a writer's time. *The New Review of Hypermedia and Multimedia*, 6:147–168, 2000. 133

[485] Frank M. Shipman III, Haowei Hsieh, and Robert Airhart. Analytic Workspaces: Supporting the Emergence of Interpretation in the Visual Knowledge Builder. Technical report, Department of Computer Science and Center for the Study of Digital Libraries, Texas A&M University, 2000. http://www.csdl.tamu.edu/~shipman/vkb/vkb.html. Last visited: May 31, 2001. 96, 122, 139

[486] Frank M. Shipman III and Catherine C. Marshall. Spatial hypertext: an alternative to navigational and semantic links. *ACM Computing Surveys*, 31(4es), December 1999. 70, 106, 139

[487] Frank M. Shipman III, Peter Nürnberg, David Hicks, and Kenneth Anderson, editors. *HT'00. Proceedings of the Eleventh ACM Conference on Hypertext and Hypermedia*, May 30-June 4, San Antonio, TX 2000. 222, 228

[488] Ben Shneiderman. Reflections of Authoring, Editing and Managing Hypertext. In Barrett [31]. 68, 76

[489] Ben Shneiderman. Codex, memex, genex: The pursuit of transformational technologies. In *Proceedings of ACM CHI 98 Conference on Human Factors in Computing Systems (Summary)*, volume 2 of *Plenary Session: Opening*, pages 98–99, 1998. 150

[490] Simon Shum. Real and virtual spaces: Mapping from spatial cognition to hypertext. *Hypermedia*, 2(2):133–158, 1990. 96

[491] David Siegel and Susan Dray. Business: New kid on the block: marketing organizations and interaction design. *interactions*, 8(2):19 – 23, mar 2001. 148

[492] John M. Slatin. Hypertext and the Teaching of Writing. In Edward Barrett, editor, *Text, ConText, and HyperText: Writing with and for the Computer*, chapter 7, pages 111–129. MIT Press, 1988. 144

[493] David Sless. *In Search of Semiotics*. Croom Helm, London, 1986. 28, 38

[494] Stephen W. Smoliar, James D. Baker, Takehiro Nakayama, and Lynn Wilcox. Multimedia search: An authoring perspective. In *Proceedings of the ISIS First International Workshop on Image Databases and Multimedia Search, Amsterdam, Netherlands*, 1996. 137, 138

[495] Manfred Smuda, editor. *Die Großstadt als Text*. Fink, München, 1992. 139

[496] Edward Soja. *Postmodern Geographies. The Reassertion of Space in Critical Social Theory*. Verso, London, New York, 1989. 92, 142

[497] Edward Soja. History: Geography: Modernity. In During [152], pages 113–125. First published 1989. 131, 142

[498] Michael Southworth and Susan Southworth. *Maps*. LittleBrown and company, Boston, 1982. 126, 142

[499] John F. Sowa. Syntax, Semantics, and Pragmatics of Contexts. In Gerard Ellis, Robert Levinson, William Rich, and John Sowa, editors, *LNAI 954, Conceptual Structures: Applications, Implementation and Theory*, pages 1–15. Springer-Verlag, Berlin, 14–18August 1995. Proceedings of the 3rd Int. Conf. on Conceptual Structures, (ICCS'95), Santa Cruz, CA, USA. 55

[500] John F. Sowa. A Peircean Foundation for the Theory of Context. In Dickson Lukose, Harry Delugach, Mary Keeler, Leroy Searle, and John Sowa, editors, *Proceedings of the 5th International Conference on Conceptual Structures*, volume 1257 of *LNAI*, pages 41–64, Berlin, August 3–8 1997. Springer. 55

[501] John F. Sowa. *Knowledge Representation: Logical, Philosophical, and Computational Foundations*. Thomson Learning, Stamford, Connecticut, 1999. 55, 101

[502] John F. Sowa. Signs and Processes - Foundations for Ontology. http://nm.wu-wien.ac.at/lectureseries/, 2001. Lecture held at the Vienna University of Economics and Business Administration on June 18th, 2001. 55, 161

[503] Jared M. Spool, Tara Scanlon, Will Schroeder, Carolyn Snyder, and Terri DeAngelo. *Web Site Usability: A Designer's Guide*. Morgan Kaufmann Publishers, 1998. 88

[504] Dominic Stanyer and Rob Procter. Improving Web Usability with the Link Lens. In *Proceedings of the Eighth International World-Wide Web Conference*, 1999. 88

[505] Loretta Staples. Representation in Virtual Space: Visual Convention in the Graphical User Interface. In *Proceedings of ACM INTERCHI'93 Conference on Human Factors in Computing Systems*, Perspectives and Illusions, pages 348–354, 1993. 103

[506] Andrew Starling. Who Controls the Internet? http://www.webdevelopersjournal.com/columns/ajs_who_controls_internet.html, jul 2000. Last visited Apr. 20, 2001. 14

[507] Peter Stastny. Eyes Wide Shut – Eine Orgie falscher Signifikanten. *Riss – Zeitschrift für Psychoanalyse*, 15(48):141–148, 2000. Trans. Hans Dieter Gondek. 116, 170

[508] Martin Stegu. *Texte, Bilder, Bildtexte. Möglichkeiten postmoderner Semiotik und Linguistik*. Habilitationsschriften. Wirtschaftsuniversität Wien, 1993. 30

[509] Leo Steinberg. *Other Criteria. Confrontations with Twentieth-Century Art*. Oxford University Press, London, 1972. 97

[510] P. David Stotts and Richard Furuta. Petri-net-based hypertext: Document structure with browsing semantics. *ACM Transactions on Information Systems*, 7(1):3–29, 1989. 89

[511] John Sturrock. *Structuralism*. Paladin, London, 1986. 106

[512] Martin Svensson. Defining and designing social navigation. Licentiate of philosophy thesis, Stockholm University, Dept. of Computer and Systems Sciences, 2000. http://www.sics.se/~martins/publications/thesis.pdf. Last visited: June 09, 2001. 119, 134, 136, 164

[513] Robert Tansley, Colin Bird, Wendy Hall, Paul Lewis, and Mark Weal. Automating the Linking of Content and Concept. In *Proceedings of Multimedia-00*, pages 442–444, N.Y., October 30 –November 04 2000. ACM Press. 138

[514] Linda Tauscher and Saul Greenberg. How people revisit web pages: Empirical findings and implications for the design of history systems. *International Journal of Human-Computer Studies*, 47(1):97–137, 1997. 122, 128, 129, 132

[515] The Computer Museum History Center. Internet History 1962-1992. http://www.computerhistory.org/exhibits/internet_history/index.page. Last visited: May 13, 2001. 72, 156, 172

[516] Julian Paul Thomas. *Active Documents as Interfaces to Information Systems*. PhD thesis, Computer Based Learning Unit, University of Leeds, 1999. 80, 136

[517] Manfred Thüring, Anja Haake, and Jörg Haake. Designing for Comprehension. A Cognitive Approach to Hypermedia Development. *Communications of the ACM*, 38(8):57–66, 1995. 87, 107, 126, 128

[518] Manfred Thüring, Jörg M. Haake, and Jörg Hannemann. What's Eliza Doing in the Chinese Room? Incoherent Hyperdocuments – and How to Avoid Them. In *Proceedings of ACM Hypertext'91*, Construction and Authoring, pages 161–177, 1991. 104, 124, 141

[519] M. Tomasello, A. C. Kruger, and H. H. Ratner. Cultural learning. *Behavioural and Brain Sciences*, 16:495–552, 1993. 80

[520] Randall H. Trigg. Guided Tours and Tabletops: Tools for Communicating in a Hypertext Environment. *ACM Transactions on Office Information Systems*, 6(4):398–414, October 1988. Selected Papers from the Conference on Computer-Supported Cooperative Work (CSCW '88). 124

[521] Murray Turoff, Starr Roxanne Hiltz, and Vijay Balasubramanian. The Human Element in Collaborative Hypertext/Hypermedia. http://eies.njit.edu/~turoff/Papers/cscwhy.htm, 1994. Short Workshop paper presented at the workshop on Collaborative Hypertext held at the CSCW 1994. 80, 107, 145

[522] Anna Katharina Ulrich. Zwei Schwestern. Zum Verhältnis zwischen Bild und Sprache. *Riss – Zeitschrift für Psychoanalyse*, 15(48):99–120, 2000. 45, 51, 52, 158

[523] Jean Umiker-Sebeok, editor. *Marketing and semiotics*. Mouton de Gruyter, Berlin, 1987. 30

[524] Jean Umiker-Sebeok. The Semiotic Swarm of Cyberspace: Cybergluttony and Internet Addiction in the Global Village. http://www.slis.indiana.edu/umikerse/papers/cgsec1.html. Last visited: Jul. 12, 2001, 1998. 57, 101, 140, 152, 153

[525] C. J. van Rijsbergen. *Information Retrieval*. Butterworths, London, 1979. 2nd edn available on the WWW at http://www.dcs.gla.ac.uk/Keith/Preface.html. 135

[526] G. J. Verdam. *Grundsätze der angewandten Werkzeugwissenschaft und Mechanik*, volume 2. Weimar, 1835. 57

[527] F. Vitali, C. Chiu, and M. Bieber. Extending HTML in a principled way with displets. *Computer Networks and ISDN Systems*, 29(8-13):1115–1128, 1997. 87, 88

[528] Lev Semenovich Vygotsky. *Thought and language*. MIT Press, Cambridge, 1962. 78, 79

[529] Lev Semenovich Vygotsky. *Mind and society: The development of higher psychological processes*. Harvard University Press, Cambridge, 1978. 78, 79

[530] Slavoj Žižek. *Looking Awry. An Introduction to Jacques Lacan through Popular Culture*. October Books. MIT Press, Cambridge, MA, 8 edition, 1998. 157

[531] Josef Wallmannsberger. *Kritische Apparate. Semiotik und Ökologie elektronischer Textualität*. Habil.-Schriften. Universität Innsbruck, Innsbruck, 1996. 55

[532] Paul Wang, editor. *Computing with Words*. John Wiley & Sons, New York, 2001. 101, 229

[533] W. Wang and R. Rada. Experiences with Semantic Net Based Hypermedia. *International Journal of Human-Computer Studies*, 43(3):419–439, 1995. 86, 87

[534] Eva Waniek. *Bedeutung? Beiträge zu einer transdisziplinären Semiotik*. Turia & Kant, Wien, 2000. 53, 138

[535] Peter Weibel. La Era de la Ausencia. In Claudia Giannetti, editor, *arte en la era electronica*. ACC L'Angelot, Barcelona, 1997. 15

[536] Harald Weinreich and Winfried Lamersdorf. Concepts for Improved Visualization of Web Link Attributes. In *Computer Networks, Selected Papers from the WWW9 Conference*, 2000. http://www9.org/w9cdrom/319/319.html. Last visited: 28. Apr. 2001. 13, 86, 87, 88, 122, 123, 126, 132, 161

[537] K. Weitzmann. *Illustrations in Roll and Codex. A Study of the Origin and Method of Text Illustration*. Princeton, revised 2nd edition, 1970. 82

[538] Karin Wenz. Principles of Spatialization in Text and Hypertext. In Nöth [399], pages 575–586. 54, 103, 104, 105, 111, 139, 140, 141, 144

[539] Karin Wenz. Cybertextspace. http://www.uni-kassel.de/fb8/privat/wenz/space/intro.html, Aug. 2000. Last visited: Jul 25, 2001. 17, 101

[540] Alan Wexelblat. Giving Meaning to Place: Semantic Space. In M. Benedikt, editor, *Cyberspace: First Steps*, pages 255–272. MIT Press, Cambridge (Mass.), London, 1991. 106, 122

[541] Alan Wexelblat and Pattie Maes. Footprints: Visualizing Histories for Web Browsing. http://wex.www.media.mit.edu/people/wex/Footprints/footprints1.html, 1997. Last visited: Aug. 01, 2001. 134, 139

[542] P. Whalley. Models of Hypertext Structure and Learning. In Jonassen and Mandl [261], pages 61–67. 78

[543] Alfred North Whitehead. *Process and Reality*. The Free Press, New York, corrected edition edition, 1978. 24

[544] E. James Whitehead, Jr. and Yaron Y. Goland. WebDAV: A Network Protocol for Remote Collaborative Authoring on the Web. In Susanne Bødker, Morten Kyng, and Kjield Schmidt, editors, *Proceedings of the Sixth European Conference on Computer Support Cooperative Work (ECSCW-99)*, pages 291–310, Dordrecht, NL, September 12–16 1999. Kluwer Academic Publishers. 80

[545] Benjamin Whorf. *Language, Thought, and Reality*. MIT Press, Cambridge, Massachusetts, 1956. 21, 110

[546] D. W. Winnicott. Transitional Objects and Transitional Phenomena, a Study of the First Not-Me Possession. *International Journal of Psycho-Analysis*, 34:89–97, 1953. 56, 103

[547] Terry Winograd and Fernando Flores. *Understanding Computers and Cognition: A New Foundation for Design*. Addison-Wesley Publishing, reissue edition, 1995. 108

[548] Ludwig Wittgenstein. *Tractatus Logico-Philosophicus*. Routledge & Kegan Paul, London, corrected, bilingual edition, 1933. Translated from the German by C.K. Ogden. With an Introduction by Bertrand Russell. 25, 33, 45, 46

[549] Ludwig Wittgenstein. *Philosophische Untersuchungen*. Suhrkamp Verlag, Frankfurt/Main, 1967. 33, 44, 45, 139

[550] William Woo. Hypertext for learning, 1995. `http://mansci2.uwaterloo.ca/~msci604/summaries/ht_lrn.html`. Last visited: Jul. 21, 2001. 77, 78

[551] Justin Wren-Lewis. The Encoding/Decoding Model: Criticisms and Redevelopments for Research on Decoding. *Media Culture & Society*, 2:179–190, 5 1983. 41

[552] P. Wright and A. Lickorish. Proof-reading texts on screen and paper. *Behaviour and Information Technology*, 2(3):227–235, 1983. 113

[553] Richard Saul Wurman. *Information Anxiety*. Doubleday, New York, 1989. 119

[554] G. Pascal Zachary. *Vannevar Bush: Engineer of the American Century*. Free Press, New York, 1997. 64

[555] H. Zemanek. Semiotics and programming languages. *Communications of the ACM*, 9(3):139–143, March 1966. Originally presented at the Proceedings of the ACM Programming Language and Pragmatics Conference, August 8–12, 1965. 55, 101