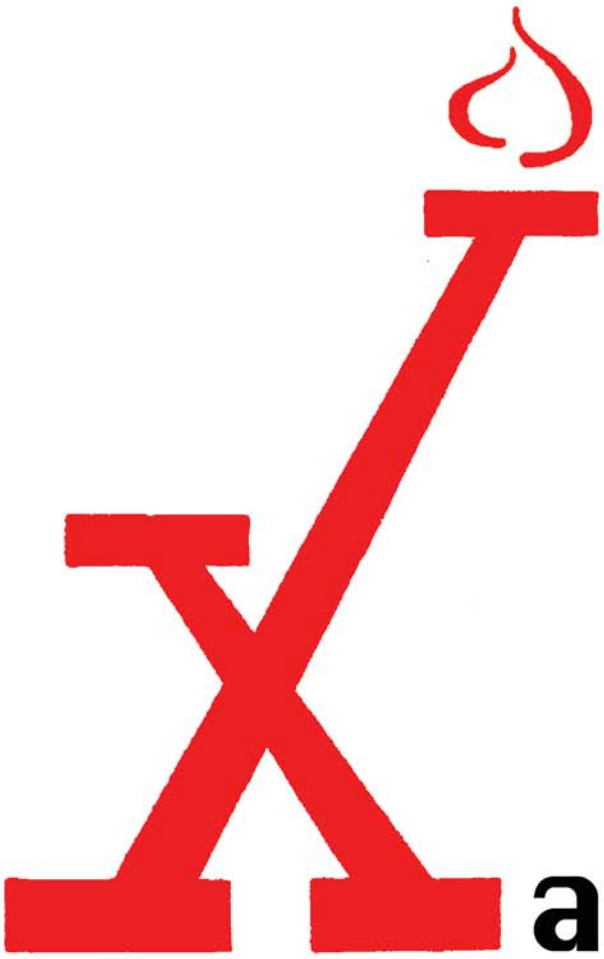

anadu

A proposed solution to the problem of information retrieval on the World Wide Web

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The *Eternal Flaming X* on the title page is reproduced with kind permission of Ted Nelson

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Abstract

Despite its popularity, the World Wide Web is notorious for its inability to facilitate accurate and relevant retrieval of information. Its one-way hierarchical links, deletion of documents, and disregard of issues relating to copyright represent a serious problem for the information professional. These issues are discussed in the dissertation, supported by evidence from various authors whose expertise lies in the field of information retrieval. In this dissertation I seek to highlight the difficulties associated with the Web and to investigate possible solutions that have been proposed. The main focus is Xanadu - a hypertext system created by Theodor Holm (Ted) Nelson in the late '60s.

The aim of the dissertation is to raise awareness of Nelson's system and to investigate how it could be used as a tool for information retrieval in conjunction with the World Wide Web.

The history of hypertext and its pioneers is examined; from Paul Otlet to Tim Berners-Lee and his vision of a Semantic Web. Also discussed is the way in which theories about hypertext have developed between the years 1934-2006. Several storage management systems have been built implementing the principles of Xanalogical structure and these have been appraised in this dissertation. It was discovered that, whilst incorporating many of the elements of Xanadu, the systems were far more shallow than the system Nelson had developed and therefore did not entirely solve the inherent problems of retrieval on the Web.

The dissertation concludes with the suggestion that if Xanadu is ultimately implemented and released globally running on a parallel with the World Wide Web, it could indeed become a useful tool for the information professional.

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1.0 Introduction and rationale for investigation

1.1 Description of the World Wide Web

As early as 1976 ideas about linking hypertext and computer networks began forming in the mind of Tim Berners-Lee. The concept of the World Wide Web is probably best explained by the inventor himself

> *"Suppose all the information stored on computers everywhere were linked. Suppose I could program my computer to create a space in which anything could be linked to anything. All the bits of information in every computer.... on the planet, would be available to me and to anyone else. There would be a single, global information space"* (Berners-Lee 1999:5)

The network protocol for the Web is *TCP/IP*. Berners-Lee decided to begin all programs incorporated in the system with the prefix 'HT' which was a shortened form of *hypertext*. From these beginnings he wrote the specifications for the language that computers would use for communicating across the network - Hyper Text Transfer Protocol (HTTP); the scheme for addressing documents - the Universal Resource Identifier (URI); and the Hyper Text Markup Language (HTML) which detailed how to format pages which contained hypertext links. Once these specifications were written, Berners-Lee continued to expound his ideas and in 1991 the international hypertext system that became known as the World Wide Web was finally made available via the Internet - a network of networks made up of computers and cables (Berners-Lee 1999).

1.1.1 Inherent problems associated with the Web

There are several concerns about the World Wide Web and its usefulness as a tool for information retrieval. The main issues are:-

- reliability of information on the Web
- structure and organisation of information on the Web
- copyright issues

The information that is found on the Web needs to be evaluated thoroughly by the searcher, since individuals can publish their work without having to go through a process of peer review. Articles on the Web are not filtered by an editor or publisher or by any kind of refereeing process and can therefore be biased or inaccurate. There is also no way of knowing whether any article is the original or if it has been quoted out of context, or simply plagiarised. Data can also be encrypted in such a way that it is impossible to identify the originator, which leads to further uncertainty over authority.

The timeliness of a document on the Web is also a consideration. With traditional publications, such as books, it is simple to tell how up to date the content is. On the Web this information is not easy to discern as a large number of web sites are not dated at all.

In 1999 Woodward stated that the Internet *"is currently in a state of near chaos in terms of access and organisation, and because searching is usually performed only with word-based search engines it is generally not adequate for the needs of most users"* (Woodward, in Chowdhury 1999: 215).

Seven years on, it is clear that there has been little improvement. The volume of information available on the Web is a problem - not for storage reasons, as advances in storage technology have increased capacity and greatly reduced unit cost - but because of the difficulty in identifying the relevant data out of the mass of disorganised data which is available. Furthermore, much of this digital information is dynamic, subject to modification if not deletion which introduces further uncertainty into the information retrieval process. Dawson (1995) says of the myriad of documents that are affected by this modification and deletion, that this problem occurs because linkages on the Web are uni-directional.

These days, almost all original works are subject to copyright the moment they are written, and require no notice of copyright (Langford 2000). On the Web the law is no different to that concerning paper-based works, but the global availability of the Web and its vast resources present a challenge to the legal rights of original authors who, understandably, want to collect royalties for their work. These problems are inherent to searching the Web.

1.2 Description of Xanadu

"Long before there was a World Wide Web, there was a project with greater intent. This was project Xanadu, a bunch of clever, cynical idealists who believed in a dream of world-wide hypertext - somewhat like the web, but deeper and more powerful and more integrated, rooted in literary ideas,

and mindful from the beginning of the copyright problems that would come"

(Nelson, lwn.net 2005)

Thirty years before the World Wide Web even existed, Ted Nelson had begun work on a similar project, albeit much more ambitious than our present day Web. The name of his hypertext project was *Xanadu* - inspired by Coleridge's poem, *Kubla Khan* - and was to be a complete hyperworld containing all of the world's literary documents (Nelson 1987). Nelson describes Xanadu as

"simply a storage manager. It will enable you to organize and reorganize what is already there without complication. The same materials may be organized in many different ways, and put to many different uses without significantly expanding the storage needed. It's all a unified structure, and no form of organization disturbs any previous one" (Nelson 1987:143)

This is a much simplified description of Xanadu, but describes perfectly the intended purpose of the hypertext system. Nelson believes that all information is parallel in nature and that hypertext should represent the way the human mind works. Human minds do not think sequentially. Therefore, information on screens should be displayed as parallel documents where similarities and differences between versions are highlighted. This is one of the faults of hypertext on the World Wide Web - it is not possible to see connections side by side. Xanadu would be collaborative and participatory; users would be able to annotate and provide their own links to any document in the system.

1.3 Aims and objectives

It is clear that information professionals need more coherence than the Web can currently offer. Therefore, Nelson's organised system of data management is a concept worth investigating as a solution to the retrieval problem. The aim of this report is to provide readers with an informed view of the purpose of Xanadu, and to show how this hypertext system would have worked had it been publicly deployed. It will also provide readers with an insight into projects implemented by other innovators who have used Xanalogical principles as the basis for their software designs.

The objectives are as follows:

- to raise awareness of Nelson's Xanadu and its usefulness as a tool for information retrieval
- to reach an informed view of whether the implementation of Xanadu could solve the inherent problems associated with information retrieval on the World Wide Web
- to discover whether the Web and Xanadu could co-exist to provide information retrieval researchers with one coherent tool

Due to the technical nature of this report, there are a number of words that may not be easily understood by the layman. These words are italicized and explanations of them appear in the glossary if not expounded upon in the body of the text. This is also true of Nelson's neologisms.

2.0 Literature review

2.1 The need for Xanadu

The increase in the amount of electronic information and the rapid emergence of the World Wide Web has subsequently led to greater interest in the retrieval of digital information and the resulting complications thereof. There have consequently been a significant number of books and journal articles written on the subject of electronic information retrieval, and the proposed solutions to its many difficulties, although to date, none have reached a consensus on the answer to the retrieval problem.

Traditional information retrieval struggles to cope with the complexities of the World Wide Web and the rapid changes which are inherent in this hypertext network. McGarry recognises this and states that

> *"So rapid are the developments in computer technology that any attempt at detailed description or evaluation is like trying to step twice into the same river - and a fast flowing one at that"* (McGarry 1993:90)

Chowdhury (1999) concurs, and perceives too that new issues are being raised relating to the storage and retrieval of information on the World Wide Web, and that information professionals are perforce being faced with new challenges. The difficulties are hardly ameliorated by the fact that the Web has provided a publishing arena to anybody who has Internet access, giving rise to a plethora of articles which have not been subject to a refereeing process. Chowdhury cites authors such as Maurice Line and David Ellis and notes the contribution

they have made towards advancing theories and solutions to the intrinsic problem of searching the World Wide Web and retrieving relevant information. Information professionals have, in the past, been accustomed to a print oriented environment, which Felker states

> *"has not adequately prepared us for the issues and challenges involved in writing and organizing information conceptually online. Many of us are carrying models of interaction from the print world and the traditional reference desk into the online medium, where they do not really work"* (Felker 2002:325).

The need for Xanadu arises because of several problems associated with the World Wide Web; most notably, issues concerning links that only go one way; are often broken and take the user nowhere; and the ongoing problem of copyright infringement on the Web.

One of the main thrusts of Nelson's work has been the need to provide bi-directional linkages to documents. Felker (2002) recognises as one of the limitations of the Web the fact that bi-directional links are not possible and that the user is forced to use the 'back' button to return to the original document. He states that because of this

> *"it is impossible to construct a dynamic map of a hypertext that might show all its links and lexias. Such a feature does appear in other kinds of hypertext, and would be a boon to lost travelers on the WWW"* (Felker 2002:331).

This is a limitation which is noted by many technical writers, including Adam Bosworth of Google, who says of hyperlinks, *"As long as there is a Back button,*

they work" (Bosworth 2005:28). The uni-directional links of the World Wide Web mean not only that this medium cannot provide information in context, but the links also create the problem of user disorientation - a fact noted by Ellis who states that

> *"Disorientation has been widely reported as a serious problem for users of hypertext databases; users find that they forget where they are, and how and why they got there."* (Ellis 1996:129)

Furthermore, there is the problem of deletion. A document may have been deleted by the author, or maybe only moved; either way, this results in links which take the user nowhere.

Nelson's system supports bi-directional sideways links to multiple versions of documents, rather than the one way hierarchical links of the Web, and allows for no deletion. In this way, the original document is always available and the links remain connected. Wolf states that

> *"Xanadu, if it existed, would be better than the World Wide Web. In Xanadu, you could link to any public document. Also, you could easily discover the origin of all the links into any document. For instance, you can start at a verse of the Bible and find all the other documents that had links to this verse. The ability to place links in any document and to follow links backward is known by the Xanadu programmers as 'extrinsic, bi-directional linking'"*.
>
> (Wolf 1995:152)

Wardrip-Fruin (1999) describes Nelson's paradigm as *"dynamism without loss"* and states that instead of the ultimate archive envisaged by Nelson, we have *"the Web, where 'Not Found' is a daily message"* (Wardrip-Fruin 1999: 353).

Another well recognised problem relating to information available on the World Wide Web is that of copyright (Abbott 1999; Berners-Lee 2000; Fisher & Tuck 1997). There is currently no successful way to avoid contraventions of copyright on the Web. Albeit unintentionally, Berners-Lee - in providing the technology - has made it far easier for people to infringe copyright, and most of these contraventions escape detection due to the vastness and unprecedented growth of the Web, which only serves to exacerbate the problem.

Seay notes this shortcoming of the Web and states that

> *"The lack of transclusions makes royalty payments and copyright protection very difficult, thus excluding tens of millions of valuable documents from being on the web, despite the web's enormous efficiencies of distribution"*
>
> (Seay. *Hyperworlds*. n.d)

Nelson foresaw the problems associated with copyright and made provision for this in his hypertext system. The solution, he believed, was transcopyright - his many to many publishing scheme with automatic royalty micropayments for owners of documents.

Nelson still maintains that this paradigm is the answer to copyright concerns, and states that

> *"Today's central controversy seems to be the question of how to manage copyright and royalty on the sale of digital content. The standard question has been 'How do we prevent infringement?' If we re-frame the question as 'How can we allow re-use?', the solution may be simpler and more powerful than anyone thinks, with benefits for everyone"* (Nelson, Transcopyright.1997)

Berners-Lee understood Nelson's need to provide a way for this re-use of information to be managed, and stated that

> *"Different people had tackled different aspects of the social implications of hypertext. For Ted [Nelson], hypertext was the opposite of copyright. The whole idea of Xanadu was driven by his feeling that anybody should be able to publish information, and if someone wanted to use that information, the creator ought to be automatically recompensed"* (Berners-Lee 2000:70)

Although the literature cited in this section has a tendency to be quite dated, it is useful in aiding understanding of Nelson's work and how he sought to provide answers for the problems mentioned by means of his system. It also provides a context and background for newer researchers in this area who seek to build on the theories already expressed.

2.2 Observations of the original hypertext system

Nelson's Xanadu originated in the late '60s before personal computers were everyday objects and well before the Internet existed. This fact is reflected in the opinions of authors writing at this time about Nelson's nascent hypertext system. Many authors writing in the seventies and early eighties saw Nelson as a visionary and revolutionary who changed our world (Levy 1984; Rheingold 1985). As Levy stated *"He [Nelson] had a self-diagnosed ailment of being years ahead of his time"* (Levy 1984:174).

It has to be recognised that at the time Nelson was talking about Xanadu most people did not understand it. Even today, a large majority of lay people have trouble understanding the whole concept of Xanadu (Wolf 1995). Nelson states that

> *"Many people know our goals and ideals, but only a few understand our real technical direction"* (Nelson 1987:142)

However, the feeling that Xanadu would probably never amount to anything, seems to be a theme that runs through the literature (Rheingold 1985; Abbott 1999). This feeling was almost certainly due to the fact that the technology needed to create such a system as Xanadu was just not available at the time, and could also be due to the formerly mentioned lack of comprehension.

Rheingold notes this, but states that

"The idea people in universities and corporate laboratories, the research and development pioneers who made the technology possible, were not the only contemporaries whom Nelson watched and applauded in the mid-1970s as they streaked past him on their way to somewhere"

(Rheingold 1985:297)

Rheingold does recognise however, that Nelson saw the potential of computers long before they became commonplace, and that he predicted accurately the explosion of personal computing even though computers were a mystery to most lay people at this time.

As long ago as 1974 for example, Nelson predicted that

"Everywhere, the computer screen will be mankind's new home. Where you now see transistor radios and portable tape players, you will soon see portable personal computers: in Third World village squares, at cafe tables.... There will be computer network hookups from phone system, cable and satellite in an ever-growing variety" (Nelson, Computopia now! 1974)

This prescience of Nelson's is a point on which all authors concur (Abbott 1999; Wolf 1995; Rheingold 1985). There is little doubt in the mind of authors that the visionary had startling insights into the then enigmatic world of computing, and that his theories about the electronic library (Xanadu) were extremely valid.

Bolter, writing in 1991, stated that

"The image of the electronic library as a community of writers in instant and effortless communication - this image will persist, and it will define the next age of writing" (Bolter 1991:103)

Freiberger & Swaine too, recognise Nelson's ability to predict the future of computing. They call Nelson the *'Thomas Paine of the personal computer revolution'* (Freiberger & Swaine 2000: 441) and note many of Nelson's former predictions that had become a reality.

"In 1974, before the Altair was announced, before there was anything that could be accurately called a personal computer, he [Nelson] self-published Computer Lib, in which he explained computers to the lay reader in clear and witty prose and laid out the political agenda for the personal computer revolution"

(Freiberger & Swaine 2000:442)

On the topic of copyright however, not all authors are in agreement that Nelson's ideas for Xanadu are the solution to the problem. Fisher and Tuck (1997), when discussing proposed systems to address the issues of copyright in a digital environment, state that

"One clear requirement at this stage is a map of the territory to find out what the options are, what models have been proposed, what technologies might contribute and then to do an appraisal (including a "reality check" - there can be a strong element of fantasy in some of the proposals, such as Ted Nelson's Xanadu)" (Fisher & Tuck 1997:20)

Although Fisher & Tuck seek to address such issues as copyright and legality in their paper, they do little to suggest a solution to the problem of copyright infringement. Indeed, their conclusion is that the enigma of copyright is one which will probably never be solved.

> *"The problem with copyright is that whenever one tries to sort out the issues it turns into a can of worms"* (Fisher & Tuck 1997:20).

The evidence these authors provide concerning Nelson's work is largely inconclusive since they have all evaluated Nelson's original system, but remain seemingly unaware of his continuing work on Xanadu. They fail to mention the successes that Nelson has already had, such as Udanax Green (originally named Xu88.1) which is a working version of Xanadu, and only concentrate on his failures. Views about Nelson's subsequent works therefore need to be developed and further tested before authors can reach any ultimate conclusions about Xanadu. An important purpose of writing this report is to further explore Nelson's system to show that the views of these authors need to be re-evaluated in the light of Nelson's successes.

2.3 Progression of thought concerning Xanadu

With the introduction of hypertext and its common usage by the late '80s, Nelson's ideas suddenly did not seem so futuristic and unachievable as they had in the '70s.

Nelson himself says that

"In 1986, due to the sudden ascendance of hypertext, I found myself abruptly promoted from Lunatic to Visionary, with new interest in my work"

(Nelson 1987:16)

People started to see Xanadu as something that could be achieved, rather than the irrational dream of a *'discombobulated genius'* (Naughton 2003:220). Freiberger & Swaine are two writers who recognised the importance of Nelson's system as a means of organising thoughts electronically. They write that

"Xanadu would be a world of interconnected text, graphics, sound and video, like the World Wide Web, but unlike the Web it would provide version management, links that worked both ways and didn't break, transparent compensation for authors, and support for expression that recognized the nonlinearity of thought. In short, the World Wide Web done right (and conceived long before)" (Freiberger & Swaine 2000: 445)

However, as time went on and Xanadu showed no signs of ever reaching completion, attitudes changed and authors began to write disparagingly about Nelson's system. A much cited author, Gary Wolf, wrote an infamous article for Wired, entitled *'The curse of Xanadu'* in which he described Nelson's system as *'the longest-running vaporware project in the history of computing'* (Wolf, in Wired 1995:137). Wolf examines the entire history of Xanadu from its nascency to the stage it had reached at the time he was writing in 1995, and concludes that *"In the end, Xanadu was like a defeated rebel whose corpse is destroyed in*

secret so as not to become a shrine" (Wolf, in Wired 1995:199).

Although *Wired* is not an academic publication - or indeed a specialised one - Wolf's article is possibly the most cited work concerning Nelson and the history of his hypertext system. This source is drawn on particularly by many publishers on the Web who write about Xanadu. Wolf's article also provides a useful starting point for further research.

Naughton, writing eight years later, is in agreement with Wolf and states that

> *"In the circumstances the surprising thing about Xanadu is not that it is so far behind schedule but that it is still going at all"* (Naughton 2003:223)

Now we have reached the twenty-first century, authors writing about the future of Xanadu have mixed feelings about the system. It is clear to most (Wardrip-Fruin 2004; Naughton 2003; Yee 2002) that Xanadu, in its original form, will never be realised. However, the principles of Xanalogical structure remain valid and have been implemented by many programmers seeking to solve the same problems Nelson attempted to find a solution for back in the late '60s.

The author who writes most positively about the future of Xanadu is, of course, Nelson himself who still maintains that Xanadu can and will be finished, and is currently working on a project which will eventually be ported to the Web. Nelson explains his project as follows:-

> *"The Transquoter allows you to create a document which quotes dynamically*

from all over the net (text files and web pages) and keeps each quoted portion connected to the original context" (Nelson. lwn.net. 2005)

This, of course, goes back to Nelson's original idea of transclusion, but Nelson believes that it will be much more workable than the original Xanadu system that it was based on. The programming for this new implementation of Xanadu is being done by Andrew Pam from Xanadu Australia, and a working demonstration of Transquoter can be seen at xanadu.com.au (*"The Little Transquoter"*). Transquoter has now been implemented and released as open source software. If this program is developed further, then the vision of Xanadu will finally be realised.

Already, this system is leading the way for a much more ambitious system envisioned by Nelson, called *Transliterature*, which he is currently working on at the Oxford Internet Institute where he is now based. Nelson states that

"This may not be finished in my lifetime. But the important thing is to start"

(Nelson. n.d. xanadu.com.au)

Nelson's own publications - both printed and electronic - are perhaps the most useful sources there are since he is one of the few people who understands exactly what he hopes to achieve with Xanadu. Other authors offer speculation and admit only a vague comprehension of Xanadu, but do not fully understand the depth of the intended system. They are therefore quick to criticise and to conjecture that the system will never be publicly deployed, but they lack the technical knowledge to explain why they hold this opinion.

3.0 Methodology

There were several ways in which the usefulness of Xanadu could have been explored in this project, but for various reasons these were considered briefly, then abandoned. It may have been possible, for example, to do a comparative study of Xanadu and the World Wide Web, evaluating the usefulness of them both. However, Nelson would say that Xanadu was not meant to be anything like the Web and that comparing the two would be like saying *"How is a kitten different from an octopus?"* (Nelson n.d.). A comparative study would have required a great deal of experimentation and evaluation in order to gain any empirical evidence. The subsequent quantitative data analysis would have been far too intense and time consuming and therefore unmanageable in the time scale allowed for this project. For these reasons, this method was ruled out.

An interview with Nelson may also have been a possibility, but a search of the World Wide Web showed that there are already several existing up-to-date interviews, so this method would not have produced anything new or worthwhile. The practicality of this would have been another obstacle - Nelson works late into the night and therefore sleeps in the daytime. Since he is based in Oxford, a meeting would have been extremely difficult to organise, especially taking into consideration the time constraints. However, *"as Alasuutari argues, false leads and dead-ends are just as worth reporting as the method eventually chosen*" (Silverman, 2000:236).

The central method of research chosen for use in this project is desk research, focusing specifically on the work Nelson has done - and is currently doing - on Xanadu, and looking into other innovators' implementations using principles of Xanalogical structure. This is described by Duffy (1999) as the *'problem-oriented approach'* which he says *"involves formulating questions by reading secondary sources, reading what has already been discovered about the subject and establishing the focus of the study before going to the relevant primary sources"* (Duffy, in Bell 1999:107). The cardinal aim of this report is to raise awareness of Project Xanadu and to investigate its usefulness to the information professional; this could only be achieved by thoroughly researching and evaluating existing literature - both primary and secondary sources.

A significant amount of the information evaluated was literature originating from the time Nelson began working on his hypertext system, and is perforce, quite dated. However, there are also some reasonably more up-to-date journal and Web articles which have been written about Nelson's work and the work of others implementing the core features of Xanadu. These articles have also been read and appraised. A substantial amount of the literature is written by Nelson himself, and from this source it can be seen how Nelson's thinking about Xanadu has changed, especially since the advent of the World Wide Web in 1991.

The advantages of using desk research are self-evident: there is no quantitative data to analyse, correlate and report on, therefore it is less time consuming and

more cost efficient; collecting secondary data is far more straightforward and the information is already available for processing; desk research can be done either in the library or at a computer terminal. There are clear disadvantages also, in that the information gathered may not be up to date or accurate - especially concerning the accuracy and authority of Web-based material; it can also be difficult to find, given the vast amount of electronic information that is out there. These problems are the same issues that Xanadu seeks to solve, and are, of course, part of the reason that this investigation was carried out.

4.0 Origins of Xanadu

In 1960 Nelson went to graduate school at Harvard where he took a course in computing. On this course he attempted a term project creating something similar to a word processor, which would allow different documents and versions to be linked together non-sequentially. This was an attempt to keep track of the notes he had made for his own use. In 1965 Nelson presented a paper at the ACM (Association for Computing Machinery) in which he first coined the term *hypertext* (Nelson 1965).

Nelson continued to work on his system after leaving Harvard, and in 1967 named the system Xanadu. Nelson's system was to be a global network which would allow information to be stored as connected literature which would always remain accessible. Virtual copies could be made of documents and the owners

of these documents would automatically receive micropayments of royalties. As Abbott states, this would be *"a welcome advance on today's unwieldy copyright legislation"* (Abbott 1999:122).

4.1 Paul Otlet

The history of hypertext can be traced as far back as 1934, to a Belgian internationalist named Paul Otlet - one of the creators of the Universal Decimal Classification system. Rayward states that Otlet *"anticipated many of the features of Bush's memex, Nelson's Xanadu, and hypertext"* (Rayward 1994: 235). In his book, the *Traité de documentation* (1934), Otlet describes his ideas about how the world's information should be organised, incorporating notions of hyperlinks and search engines. He called the system that he envisaged, an *International network for universal documentation*, and this has been the main focus for historians of hypertext (Rayward: Visions of Xanadu.1994).

4.2 Vannevar Bush

Nelson was inspired by visionaries such as Vannevar Bush and Doug Engelbart. In fact, in his book *Literary machines*, Nelson devotes a whole chapter to Bush, reprinting his article *'As we may think'*. In this article Bush talks about a hypothetical system of storage and retrieval of information which would provide links between any two items. Bush's article originally appeared in the July 1945 issue of *The Atlantic Monthly* and his system, *Memex*, was to be a

solution to the rapid growth of information (Nelson 1987:1/39). Bush felt that this rate of growth was making it difficult for specialists to follow their subject and in his article stated that

"There is a growing mountain of research. But there is increased evidence that we are being bogged down today as specialization extends. The investigator is staggered by the findings and conclusions of thousands of other workers - conclusions which he cannot find time to grasp, much less to remember, as they appear". (Bush 1945:101)

The Memex desk would have a set of translucent screens, a keyboard, buttons and levers, and would serve as a large storage device. Bush introduced the idea of links and trails as he described his concept of textuality. Abbott states that

"Most importantly the structure of the Memex was associative according to the way we think, thus providing the title to Bush's article" (Abbott 1999:120)

Bush's vision incorporated the principles of hypertext fifty years before the advent of the World Wide Web and thirty years before the invention of the personal computer. (Abbott 1999; Nelson 1987)

4.3 Doug Engelbart

Engelbart shared Bush's vision and five years after reading about Memex started developing his own ideas about how to use technology to aid mind expansion. In the late '60s Engelbart developed a hypermedia which he

named *NLS*. Using hypertext, this system aided the introduction of electronic libraries, and the dissemination of digital documents. Computer interaction was facilitated by the mouse - another of Engelbart's inventions. NLS offered the user a variety of word processing options and on-screen video teleconferencing, which demonstrated ground-breaking technology at this time. The first public presentation of NLS was at the Joint Computer Conference in San Francisco in 1968, which was attended by over one thousand computer professionals. This demonstration was carried out by two people at separate sites who communicated with each other over a network using audio and video interfaces. This was the first recorded demonstration of the now ubiquitous linking technology that is hypertext. NLS was the first operational hypertext system and was the second computer node connected to the *ARPANET* which later evolved into the Internet of today (Rheingold 1985).

4.4 Nelson's Vision

Nelson's project Xanadu began in 1960 and was an attempt to create an organised system of data management, and an electronic literary system for use globally. Nelson refers to Xanadu as *"a magic place of literary memory"* (Nelson 1987:1/30) and stresses that it was not an attempt to create the World Wide Web. Indeed, in hindsight, he goes so far as to say that Xanadu was an attempt to prevent the World Wide Web which has

"displaced our principled model with something far more raw, chaotic and short sighted. Its one way breaking links glorified and fetishized as 'websites' those very hierarchical directories from which we sought to free users, and discarded the ideas of stable publishing, annotation, two-way connection and trackable change" (Nelson 1999)

This system incorporated Nelson's concepts of *transcopyright; transpointing windows; and transclusion*. As bandwidth increases, it becomes easier for people to steal and swap files. Nelson's solution to this is *transcopyright* - an element of *Xanalogical structure* which allows unlimited use of contents on the Web and is compatible with existing law and ownership. It makes possible virtual republications of excerpts from the contents of participating rights holders. Nelson calls this *transpublishing.* The owner of the original document, whether author or publisher, would receive micro payments of royalties. This does not apply solely to text, but to streaming video, high resolution movies and other such media.

The concept of *transpointing windows,* Nelson explains as editing that shows the origin of the document. The windows show a side by side connected comparison of parallel documents, the connections of which always remain connected to the contents in each window no matter how the windows scroll or move around. The windows would show both links and/or shared content between two or more documents.

At the present time of writing, there is no other software which provides this facility to connect screens by visible lines which point from part of a text in one window to corresponding parts of that text in another window (Nelson 1987).

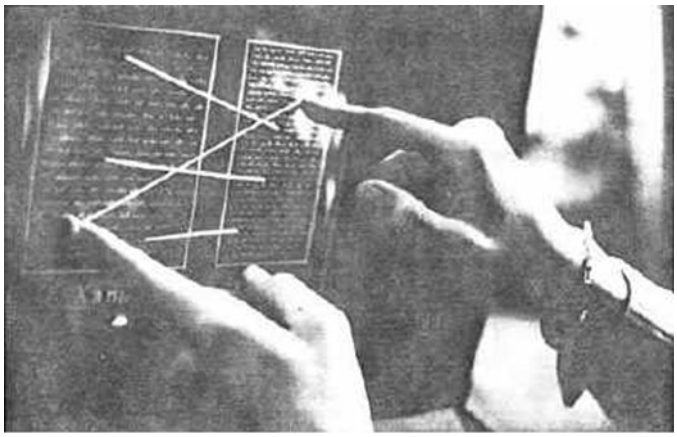

fig.1 Mock-up of transpointing windows
source: ACM 1972

Nelson is highly critical of the 'cut and paste' function in computing and says that we try to mimic paper on screens instead of digitally representing the literary forms of connection. He uses *Adobe Acrobat* as an example of this, and states that the Web is bound by old paper-based ideas (Nelson 1999). A functioning demonstration of transpointing windows is downloadable on Nelson's web site, Xanadu.com/cosmicbook.

The adjacent versions of documents in the windows are called *transclusions.* Nelson describes transclusions as *"the same thing, knowably and visibly in more than one place"*, and states that Vannevar Bush's trails were transclusions and not links (Nelson 1999). Within Nelson's hypertext system, as soon as one document is updated, the new version automatically appears on all the other documents.

In 1986, an article in the *Economist* stated that

"Mr Nelson looks forward to the day when anybody can create what he or she wants..... and put it into Xanadu's database and quote or cite anybody else. Royalties and subroyalties, monitored automatically by the host computer, would be paid according to the amount of time a user was on-line and reading a specific document. It sounds pretty wild at the moment, but hypertext could be commonplace before the century is out" (*Economist*: 23 Aug 1986)

Although Nelson's vision was perfectly sound in itself, he lacked the technical knowledge to implement Xanadu and as a consequence never got the backing that the project deserved. Now, of course, we have the World Wide Web - a much shallower version of what Nelson was proposing, but nevertheless, a successful hypertext system which is being used globally and has seemingly diminished the need for Xanadu.

Nelson writes

"We bring banners. We have held to ideals created long ago, in different times and places, the very best ideals we could find. We have carried these banners unstained to this new place, we now plant them and hope to see them floating in the wind. But it is dark and quiet and lonely here, and not yet dawn"

(Nelson 1987:6/6).

4.5 Principles of Xanalogical structure

In his book, *Literary machines*, Nelson describes his proposed system - Xanadu - as one that could not possibly work if it were linear, and one which would

have to cope with the increase in information without slowing down drastically or deteriorating in performance in any other way. A document in the Xanadu database could be in any form, including:-

- text (linear or hypertext)
- graphics (including 3D)
- *CAD/CAM* data
- movies
- symphonic scores
- seismographic data numbers (Nelson 1987)

The specificity of the list above is deliberate, although the list is incomplete and would incorporate documents in many more forms. Nelson's system would unify and organise all types of documents and hypermedia and would *"bring literature, science, art and civilization to new heights of understanding, through hypertext"* (Nelson 1987:0/4).

The Xanadu *docuverse* consists of a server; user; document; and bytes and links. It is built up of original (native) bytes and also bytes which are inclusions from other documents in which they are themselves native. The docuverse is indexed by *tumbler addressing* which is a storage management system created by Mark Miller of *XOC* in 1980. Miller devised this system as a way to cope with the anticipated growth of the network. This hierarchical addressing scheme was partly inspired by the Dewey Decimal System and would allow the network to remain organised as it grew. New documents could be added to the tumbler

space and would be given their own tumbler address which would become a permanent address for those documents. Nelson says of tumbler addressing that

> *"this is a curious, bizarre, powerful, consistent, non-obvious and hard to visualize system"* (Nelson 1987:4/40).

For this reason, and to aid visualisation of this concept, the following diagrams are included which should give a basic understanding of the way tumbler addressing would work.

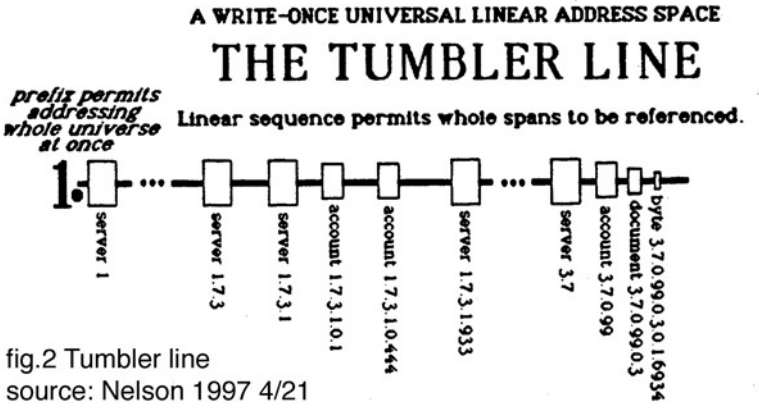

fig.2 Tumbler line
source: Nelson 1997 4/21

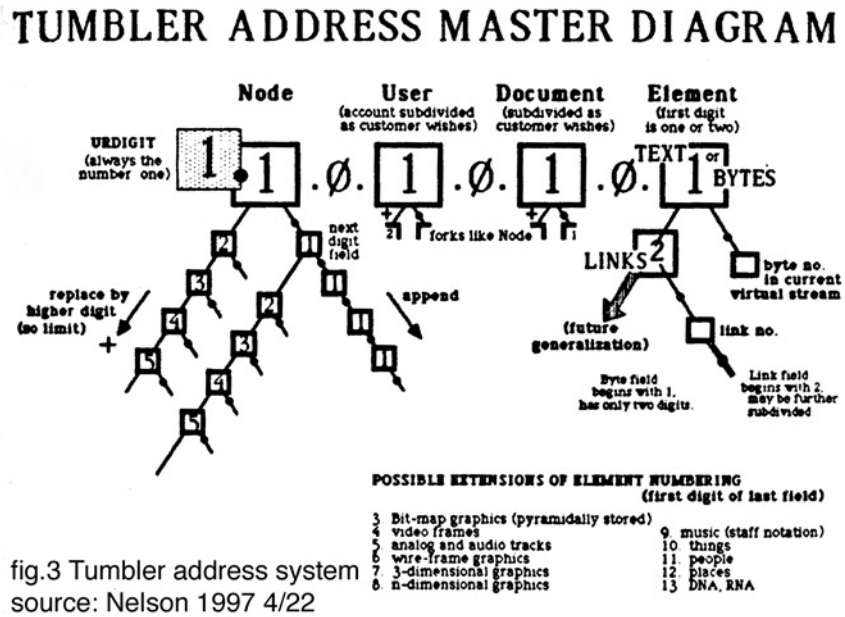

fig.3 Tumbler address system
source: Nelson 1997 4/22

A core concept of the addressing system is that of *humbers* which were created to allow an infinite number of IDs to be generated for labelling stored texts.
A complex numbering scheme such as this was used because all the bytes and links in the database needed a large quantity of numbers to address them all and to facilitate the reality of an ever expanding address space. Humbers are composite numbers which are 1-127 bytes long. A further purpose of these humbers was to aid the management of deep versioning in the Xanadu docuverse (Nelson 1987).

Wolf explains that

> *"With tumblers, Miller and Gregory could give a similar address to every document and fragment of a document in Xanadu's sprawling domain of words, pictures, movies, and sounds. The address would not only point the reader to the correct machine, it would also indicate the author of the document, the version of the document, the correct span of bytes, and the links associated with these bytes".* (Wolf 1995: 147)

This addressing scheme is much like the Uniform Resource Locators of the World Wide Web, but is a much more effective idea since it makes it possible to address any substring of any document from any other document.
A single search of any account (see fig.2) would find any of the documents associated with that account and the author of each document in the system would receive royalties every time his article is accessed. These royalties would

be fixed per byte (Nelson 1987).

Xanadu protocols are called *FEBE* and *BEBE*. The FEBE protocol is mostly concerned with retrieving documents using the tumbler addresses. Commands of the protocol are written in *ASCII*, and one of these commands (Retrievev) is concerned with the dissemination of the documents that have been retrieved. Connection from the Xanadu server to the user would be via the telephone line, *LAN* or any other channel convenient to the user, communicating via FEBE.

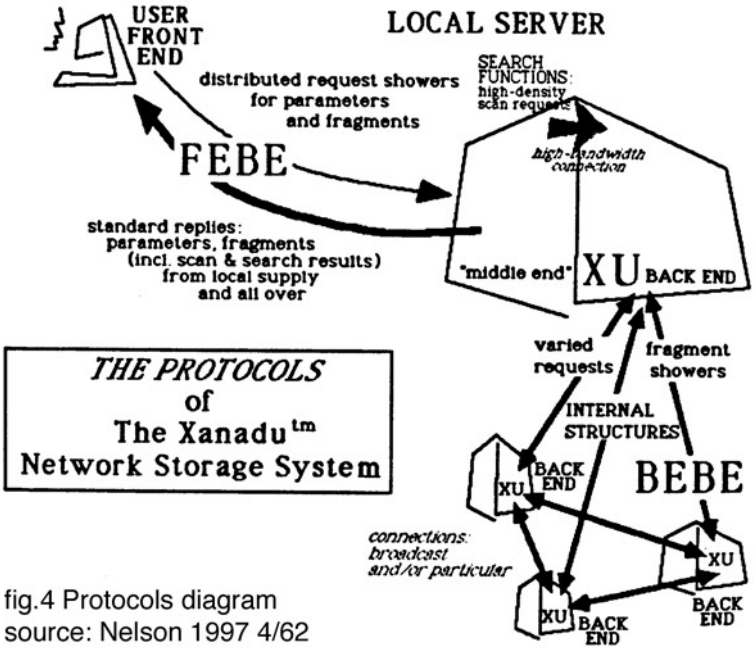

fig.4 Protocols diagram
source: Nelson 1997 4/62

The BEBE protocol connects nodes of the Xanadu network, and its function is to combine the contents of separate Xanadu servers into a single unified space. By means of this protocol, user requests and replies are forwarded between servers.

Between the years 1971-2 Nelson created algorithms called *enfilade files* which aided the management of interconnection and formed the basis of all of Nelson's later works. He was assisted by Jonathan V E Ridgway and the late Cal Daniels. An enfilade file resembled a tree structure and it allowed fast editing of text - insertion; deletion; re-arrangement - which was also storage efficient. (Nelson. *Xanadu technologies* 1999)

The way it would work

The back end protocol for Xanadu would be sold to businesses and research institutions. The source code for the front end protocol would be sold to individual enterprises for a 'negotiable figure' (Nelson 1987), and would then be maintained by these enterprises. Nelson saw the back end protocol as the most important aspect of the Xanadu system, and the work of his programmers reflected this and was concentrated mainly on perfecting this protocol. The front end (user interface) protocol was therefore neglected - a fact which worried some of the programmers who had begun to use the Internet and realised how important the *GUI* was to users. Jellinghaus - one of the programmers who worked for Nelson in the late '80s - said that

> *"The front end is the most important thing. If you don't have a good front end, it doesn't matter how good the back end is. Moreover, if you do have a good front end, it doesn't matter how bad the back end is"*
>
> (Jellinghaus, in Wolf 1995:198)

The Xanadu network would incorporate *Silver Stands* where the user would learn how to use Xanadu and would be able to open accounts and process publications.

Nelson states that, at your local Xanadu station

> *"a cheery young person in futuristic garb will sit you down at a screen, and show you through an area of material of interest to **you**--text and/or pictures. Then, at the moment of Xanadu Shock, when you **get it**, when you cry "Holy ----!" the kid grasps your forearm and says, "Mr. Jones, Welcome to Xanadu!""* (Nelson 1987: 5/6)

An extravagant image maybe, but in essence the rôle of the *'cheery young person'* (*ibid*) is much like that of the reference librarian; a public relations representative directing users to various areas of the Xanadu library; and aiding the user with on-line searching.

The Xanadu stands would be accessed by dial up from the user's home computer, and would be depots for storage and dissemination of information. The stands would be franchised out as the network grew. Nelson likens this paradigm to that of McDonald hamburger restaurants and further states that

> *"The license will be offered on a basis quite like McDonald's: the licensee must be an individual of suitable character, knowledge and attitude, who presents a certain amount of capital. The licensee will be trained at Xanadu Central, and must personally work in the Xanadu station."* (Nelson 1987: 5/9)

Wolf adds that

"The Xanadu franchises ..... contained a solution to a genuinely difficult problem. If there was to be a universal library of electronic documents, who would pay for it? Nelson's answer was to imagine a corporate information entity that resembled McDonald's, a chain of franchises whose operating costs were paid by their individual owners out of revenue from the information-starved masses" (Wolf 1995:144)

Nelson describes a scenario where a person will be driving along the road with the family when they suddenly notice the tall illuminated Xs which are an indication that they are approaching one of the Xanadu stations. Once there, the family would be able to dial up and access any of the world's information (Nelson 1987). This paradigm bears a close resemblance to the Internet cafés which are commonplace around the world today.

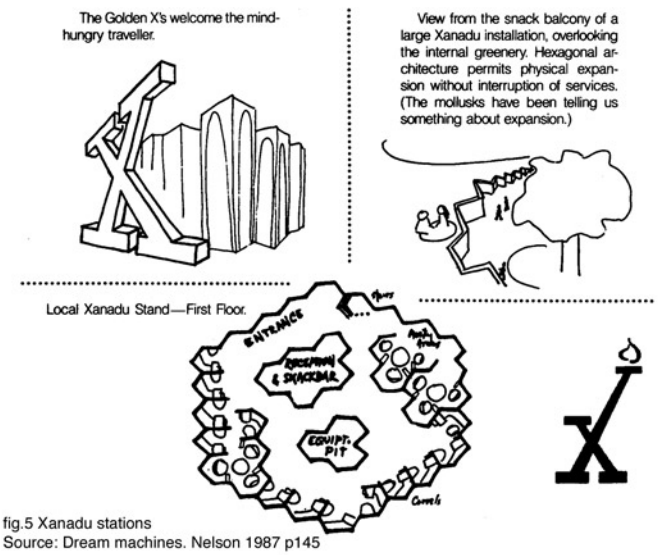

fig.5 Xanadu stations
Source: Dream machines. Nelson 1987 p145

The Xanadu hypertext system would consist of documents that were editable by anybody and could be freely linked to and from any other document in the Xanadu library. These documents could be quoted in other documents without actually copying the text (transclusion) so that every item in the Xanadu library

would have a single unique identity irrespective of the number of copies. The transclusion is a virtual copy (or pointer), which when clicked upon, brings up the original file or document. In the Xanadu system, literal copying of a document is only permitted under the provision that its associated identity is preserved, thus ensuring that the original author of a document always gets the recognition for his work and would be paid a small royalty for that piece of work every time it was accessed. This would be achieved by means of the back end software, which would bill users every time they accessed a document, or part of a document, and by a user interface which is able to automatically edit documents which have been retrieved from several different sources. Nelson calls this republication scheme *transcopyright* and suggests that it would be a solution to today's copyright problems (Nelson 1987; Moore 2002; Wolf 1995). In an e-mail dated 23 April 2006, Pam stated that *"the intention is to provide a mechanism to permit authors who choose not to publish their works for free on existing networks such as the web to offer works for a fee that would otherwise not be offered online at all"*.

Moore explains that

> *"In his [Nelson's] concept of a Xanaolgical [sic] structure for a Docuverse, the world would contain one huge, interconnected electronic library, where both authors and readers could create links between documents, make changes, and add comments. His vision stretched to the idea that people would want to work on parallel documents, side by side on a screen".* (Moore 2002:118)

Individuals wanting to use the system would dial their nearest Xanadu stand and would then be connected with the whole of the Xanadu network, where they would be able to read or write documents, send messages, or play computer games. Nelson envisaged his network system as having at least a hundred million simultaneous users by the year 2020. This, he stated punningly, was his 2020 vision (Nelson 1987; Wolf 1995).

5.0 Implementations of Xanadu

5.1 Project Xanadu

Project Xanadu was the original implementation of Nelson's hypertext system. Nelson published his ideas about Project Xanadu in his books, *Computer lib/Dream machines*, *Literary machines,* and *The future of information.* The layout of Computer lib/Dream machines was designed to resemble that of Stewart Brand's *Whole Earth Review* and was written entirely in hypertext (non-sequentially). The first demonstration version of Project Xanadu was shown in 1972 by Cal Daniels on a computer which Nelson had rented specifically for the purpose. This version was, however, never released. For the next two years, Nelson continued working on the Xanadu system, and in 1983 received financial backing from Autodesk which allowed him to continue his work on the project. Whilst at Autodesk, Mark Miller became chief designer of the Xanadu operating system. A demonstration of the resulting system was given at the Hackers Conference in October 1987 (Wolf 1995; Rheingold 1985).

A year later, John Walker - computer programmer and founder of Autodesk - stated that

> *"In 1964, Xanadu was a dream in a single mind. In 1980, it was the shared goal of a small group of brilliant technologists. By 1989, it will be a product. And by 1995 it will begin to change the world".*
>
> (Walker 1988)

Unfortunately for Nelson, Autodesk dropped their support of Xanadu in 1992 before Walker's prediction could become reality, when the company was taken over by new management. Rights were then licensed to Memex, Inc of Palo Alto, who, for a time, continued development of the Xanadu server until they ran into financial difficulties and had to relinquish their rights to the technology. Nelson relocated to Japan in 1994 where his work was continued and where he founded the Sapporo Hyperlab. From there he moved on to Keio University where he inspired students to get involved in the continuing programming of the Xanadu system. In 1998 the Xanadu Operating Company (XOC) released Xanadu's source code as Project Udanax; later to become Udanax Green and Udanax Gold (Wolf 1995; Nelson 1998).

Since that time Nelson has further expounded upon his ideas and has released working versions of several implementations of Xanadu. Nelson's system has had a major impact on the evolution of network based information management systems - most notably, the World Wide Web. His ideas and many of the

elements of Xanalogical structure have been of interest to others who have subsequently designed and implemented systems containing many of the original features of Xanadu.

5.2 ZigZag

A further implementation of Nelson's Xanadu is ZigZag, which Nelson states, is

> *"very hard to explain, especially since it resembles nothing else in the computer field that we know of, except perhaps a spreadsheet cut into strips and glued into loops"* (Nelson 2000).

The ZigZag *(ZZ)* structure is a multidimensional system of interconnection; it is the ideal editing system because it has the same data in a multitude of different places - not copies, but transclusions. The ZigZag program has two windows; an action window and a data window. These windows allow the user

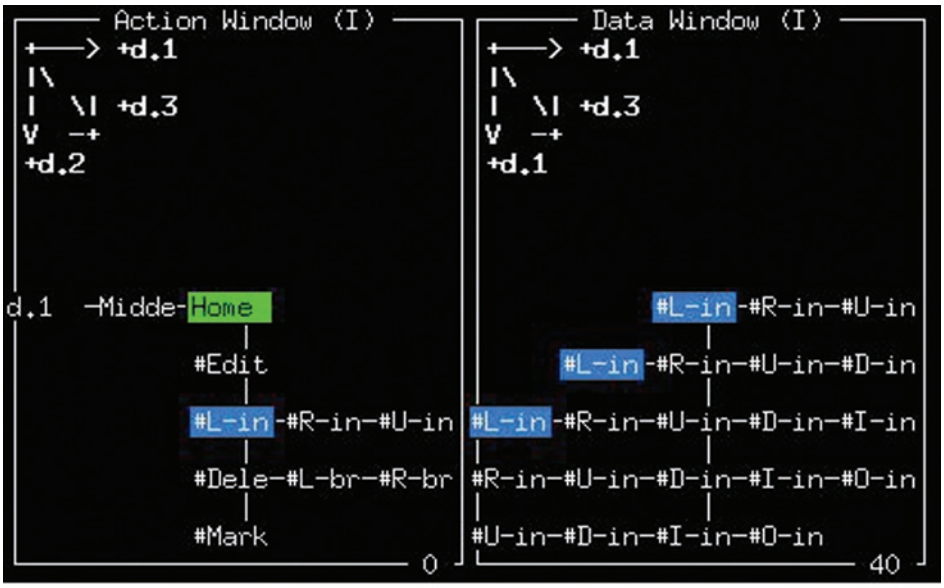

fig. 6 ZigZag source: Nelson 1998

two different views of the same set of data, and each window can show two dimensions at a time. There is also a third dimension which the user has access to; indeed, the user can access as many (hidden) dimensions as he/she wants, simply by putting its name into the dimension list as a new cell.

A working demonstration of ZigZag was seen at the Portland Digital Libraries Conference in July 2002 (Carroll 2002). The demonstration showed how data can by added to the ZigZag system; how new dimensions can be created; and the ability of the system to rotate views through different dimensions. A version of ZigZag can be downloaded from Nelson's web site, but this version is still in the early stages of development and is, as such, very difficult to understand and to use successfully.

Carroll (2002) explains the ZZ data structure as follows:

"Using ZigZag, the challenge of representing multiple dimensions on a 2D monitor remains - but the data is actually being called from an addressable multi dimensional structure. When multiple dimensions can freely cross in the same code space, the need for separate tables disappears, as well as the need for workarounds such as star schemas. 'Joins' loses its meaning, because ZigZag users can design the dimensions to intersect wherever they choose"

(Carroll 2002)

A subsequent Java version of ZigZag is Gzz, which is a free software implementation of ZZ structure architecture. Other implementations of ZigZag include one that is currently under active development using *OpenGL*

to provide 3D visualisations (Pam 2006).

5.3 PermaPub & PermaStore

To publish anything on the World Wide Web, it is usually necessary for the user to set up a domain, with a domain name; acquire an Internet Service Provider (ISP); and create a directory - all of which costs money. Nelson states that this can all be a problem, particularly if a payment is missed and the domain goes down. His solution to this is PermaPub - the user can publish his document (for a fee) on the Xanadu web site, or any other participating ISP, and that document will be available globally for the next five years.

A similar idea is PermaStore which is best explained by Nelson himself:

"The same service can of course also be provided privately, without publication. This will guarantee availability of corporate documents and records without having to keep track of them at company facilities. In the case of private personal content, it will mean guaranteed availability of letters, poems and photographs to one's children and grandchildren - guaranteed not to get lost when a household is moved"

(Nelson 2002 XU protocol specs.)

Again, as with PermaPub, the user's files will be available for a minimum of five years, although in an e-mail dated 23 April 2006, Andrew Pam pointed out that *"five years is just one offering; the idea is to offer a mechanism where funds can be set aside to guarantee the continued availability of works for any desired length of time"*.

5.4 Abora

Abora is a project which was set up to implement a hypertext system based on Xanalogical structure. Work on the project was inspired by Nelson's Xanadu; particularly the design of XOC's Udanax Gold. Some of the core features of the Abora hypermedia project are:-

- transclusions - Nelson's idea of virtual copies where the quote is always connected to the original text
- two way links which are stored separate from the content giving scope for annotation of documents by the user
- sensors that can detect when new instances occur, such as a new edition of a document added to the system, or a new link specified

The system is designed not solely for text, but for images, sound, movies or indeed, any other media, which of course is what Nelson originally envisaged for Xanadu. A working implementation of this system is the Abora Dolphin Demo (2002) which is written in Dolphin Smalltalk as an executable Windows file, and combines the above features of Xanalogical structure. This project is very much a prototype and as such is still subject to many of the same constraints that Nelson encountered with Xanadu (Jones 2003). Implementation of the Abora system would be extremely complex and time consuming and would require many skilled programmers; storage and dissemination of documents in the Abora system would be very costly due to the sophistication of the linking and

versioning software; and there would be far too much cognitive load on the user, which would hardly be an improvement on the World Wide Web.

5.5 token_word

This implementation is an experimental on-line literature system, featuring many of the attributes of Xanadu. It is the first fully realised implementation of Xanalogical structure, combining Nelson's ideas of micropayments and transclusion. However, this system was designed and built in ten days by one programmer! Rohrer - creator of token_word - states that the technology of Nelson's day was simply not ready for Xanadu, and that token_word is only possible now because of technologies such as the Web; *CGI*; *Perl*; and *PayPal*. Token_word is open source and is available for users to experiment with at *http://hypertext.sf.net/token_word*. When a document in token_word quotes another document, the quote is saved as a *deep reference*.

This means that the text is not simply copied into the quoting document - this is Nelson's idea of transclusion. Each character in the document is worth one token and readers are only required to pay once (via tokens) for the article they require. If another article contains quotations from the document that the reader already owns, those words are free, although the reader still needs to use his tokens for the remaining words that he does not own. Token_word differentiates between *chunk files* which are blocks of contiguous text, and *document files* which contain lists of references to text chunks.

Micropayments are automatic in token_word and are facilitated by PayPal. This could present a problem to the new user who has no tokens since the main page of the implementation is a *first-class token-word document*, which is a description of token_word, accessible only by depositing real-world currency

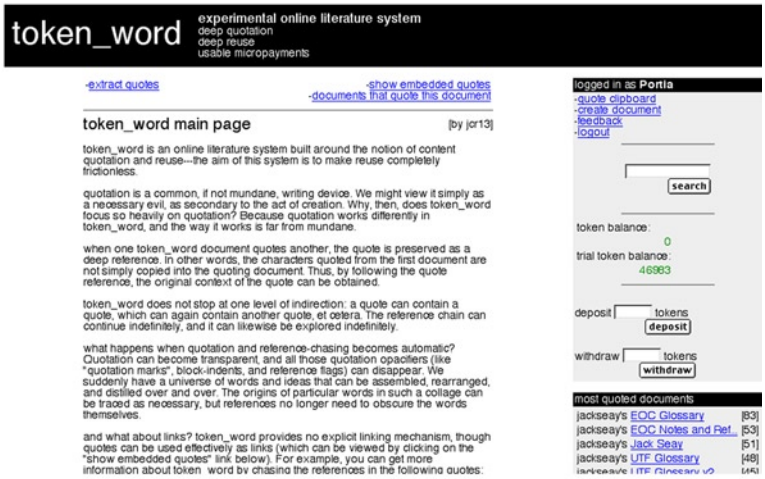

fig.7 token_word
source: http://hypertext.sf.net/token_word

into PayPal. This potential problem has been resolved by the introduction of *trial tokens* which can be used in token_word, but have no real-world value. Once signed up to token_word, anybody can write their own article, make it available for anybody else to read, and access articles already in the system. (Rohrer: token_word. n.d).

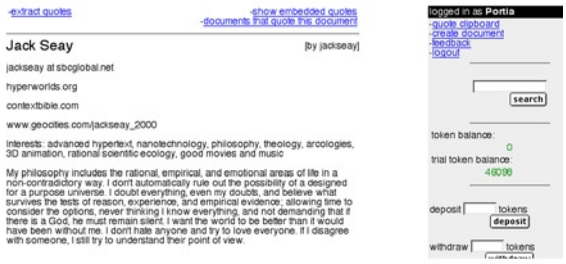

fig.8 an article in token_word
source: http://hypertext.sf.net/token_word

5.6 World Wide Web

Perhaps the system that most closely resembles Nelson's vision of a hypertext network is the World Wide Web, created by Tim Berners-Lee and fully implemented in 1991. Berners-Lee originally started out by developing a hypertext system he called *Enquire*, which had both internal and external links. The internal links were bi-directional - as were the links of Nelson's Xanadu - the external links, however, went in one direction only. This system was never released but laid the foundations for his much more ambitious project, the World Wide Web, which was built on top of the Internet (Berners-Lee 2000). The World Wide Web is a global hypertext network system which places little cognitive load on the user.

However, despite its popularity, Wolf (1995) states that

> *"The Web still lacks nearly every one of the advanced features he [Miller] and his colleagues were trying to realize. There is no transclusion. There is no way to create links inside other writers' documents. There is no way to follow all the references to a specific document. Most importantly, the World Wide Web is no friend to logic. Rather, it permits infinite redundancy and encourages maximum confusion. With Xanadu - that is, with transclusion and freedom to link - users would have had a consistent, easily navigable forum for universal debate".* (Wolf 1995:200)

Given Wolf's *schadenfreude* attitude to Nelson, this quote does seem to show that Xanadu is a project that is worthy of further investigation if the difficulties of retrieval on the Web are to be solved. The complexities of Xanadu and its incompletion meant that Nelson was never credited with the same acclaim that other life-changing inventors, such as Berners-Lee have received. The World Wide Web, although lacking any provision for version management or for rights management (intellectual property), and falling far short of Nelson's vision, is here and now, whilst Xanadu remains unfinished.

5.7 Semantic Web

A core concept of the Semantic Web is the need to give information a better defined meaning which can be understood, both by human intellect and by computers. Sure & Studer (2005) note that whilst HTML has its place in retrieving and disseminating digital information, it can only be used to express hypertext documents, and lacks the ability to provide machine-processability. This means that *"to interpret the information given in documents the human has always to be in the loop"* (Sure & Studer 2005:191).

As Berners-Lee notes

> *"Very little information on the Web is in a form that a machine can understand"*
>
> (Berners-Lee 2000:193)

To overcome this problem, Sure & Studer suggest that machine-readable ontologies are introduced into the system to aid the representation of

knowledge. They believe that if this machine-readable universal language is established as a Web technology, a new and more intelligent Web will exist. The World Wide Web Consortium (W3C) is currently developing such a language which will allow computers to represent and share data; and which can be embedded in HTML web pages. This mark-up language is called the Resource Description Framework (RDF) and will provide a way forward for the Web to become the *"Web of meaning"* that Berners-Lee envisioned (Berners-Lee 2000; Battelle 2005).

At the present time this is still only a vision which belongs to Tim Berners-Lee and his protagonists, but as Karen Spärck Jones optimistically states, if the vision becomes a reality,

> *"it will be possible to throw a large semantic net over the Web, that does far more to catch the information fish than purely syntactic hooks and with much less effort for the human fisherman"* (Spärck Jones 2004:18)

6.0 Conclusions

Although token_word, Abora, and other projects including the World Wide Web, do implement the core features of Xanalogical structure, they do not even come close to the ideal that Nelson envisaged for his hypertext system more than forty years ago. Xanadu still remains unfinished, but Nelson's utopian vision of 1967 was, and always has been, a 2020 vision.

"In the year 2020, we imagine a network with at least a hundred million simultaneous users, adding a hundred million documents an hour to the system" (Nelson 1987:144)

The year now is 2006 - fourteen years away from Nelson's dream - so it is still possible that Xanadu could become a reality.

Abbott states that

"As regards knowledge synthesis, at present there is nothing else remotely as ambitious as Xanadu in sight. So when T.S.Eliot asks 'Where is the knowledge we have lost in information?' the answer might well be 'Xanadu'."

(Abbott 1999:124)

Regardless of whether Xanadu becomes the answer that information professionals have been searching for or not, it can be seen from the literature that Nelson was always on the right track with his thinking and that, if Xanadu had received the financial backing and the programming expertise that it so badly needed, it would have evolved to become a life-changing paradigm.

The first objective of this study was to provide readers with an informed view of Xanadu and to highlight its potential usefulness as a tool for information retrieval. This objective has been met purely by the information presented in this report; explanations of what Xanadu is, and its intended use are provided for the reader and are supported by diagrams which seek to promote understanding of the more complex concepts of Nelson's hypertext system.

The second objective, which was to discover whether Xanadu could solve the problems relating to information retrieval on the Web, has also been met. It can be seen from Nelson's work and the subsequent work of others, that the principles of Xanalogical structure are very sound, and if implemented, could solve a lot of the problems of the Web that have been noted in this paper. The third objective is perhaps a little more ambiguous and it remains unclear as to whether this can be achieved or not. In theory, if Nelson's 'transliterature' is ever fully implemented, then Xanadu and the World Wide Web would co-exist and together, would provide a more structured and coherent approach to information retrieval. At the moment this is merely conjecture, but if Nelson's dream is realised, Xanadu will rise like a phoenix from the ashes, untrammelled by linear thinking, to become the answer that researchers of the Web have been waiting for.

Glossary

ACM	- Association for Computing Machinery
Adobe Acrobat	- Program which creates PDF files that can be viewed on any computer system
ARPANET	- Advanced Research Projects Agency Network. This later evolved into the Internet
ASCII	- American Standard Code for Information Interchange
BEBE	- Back End-Back End
CAD/CAM	- Computer Aided Design & Manufacture
CGI	- Common Gateway Interface. A means for allowing programs to add functionality to the WWW. e.g. search engine
Dialog	- Dialog provides access to the full content of over 600 databases through a Web browser
Docuverse	- Universe of documents
FEBE	- Front End-Back End
GUI	- Graphical User Interface
Humbers	- HUMungous numBERS
Hypermedia	- An extension to hypertext that supports linking graphics, sound, and video elements in addition to text elements
Hypertext	- Text that branches and allows choices to the reader

Internet	- A global network connecting millions of computers
Kubla Khan	- Unfinished poem by Samuel Coleridge, written in 1797 Coleridge wakes from a dream of a poem, forgets it and is left with only a fragment of the dreamed version
LAN	- Local Area Network
Lexias	- A term created by Barthes to describe elements that can take on various meanings for various readers
Memex	- A theoretical analog computer described by Vannevar Bush in his article “As We May Think.” The word was a contraction of ‘Memory extender’
Micropayments	- Technology which allows a person to pay for Web site access in very small amounts as they browse a document
NLS	- oN-Line System - computer system invented by Engelbart
PayPal	- Web based application for the secure transfer of funds via credit card between anybody with an e-mail account
PDF	- Portable Document Folder
Perl	- Practical Extraction & Report Language - a scripting language
Schadenfreude	- delight in another’s misfortune
Semantic Web	- A web of data that can be processed directly or indirectly by machines (Berners-Lee 2000:191)

TCP/IP	- Transmission Control Protocol/Internet Protocol. TCP ensures the correct delivery of data. IP is the technology that allows that data to cross networks
Transclusion	- Part of a document may be in several places without actually being copied there
Transcopyright	- Pre-permission for virtual republishing (Nelson:1998)
Transpublishing	- Transpublishing is an alternative approach to copyright which has some remarkable properties: especially, allowing copyrighted contents to be included in new on-line documents, by someone else, without negotiation. It keeps connections to the original, and has other benefits (Nelson:1999)
World Wide Web	- A hypermedia-based system for browsing Internet sites
Xanadu	- “A magic place of literary memory” (Nelson:1987)
Xanalogical structure	- Logical structure of Xanadu
XOC	- Xanadu Operating Company
ZZ	- ZigZag

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