Structuring an Information Universe using a Fourth Spatial Dimension

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Abstract

The thesis discusses information handling issues associated with office environments, and the adoption of more innovative mechanisms designed to combat problems associated with screen clutter and information overload. It postulates that the concept of two-dimensional information workspaces, based solely upon physical world metaphors e.g. mimicking a wooden desk in the electronic world as a desktop, are arguably becoming outmoded as they experience identical fundamental problems with space organisation. The thesis postulates that an information-based workspace should therefore be modelled upon an entirely different metaphorical foundation; namely the physical laws of geometry associated with the physical universe.

The thesis focuses on modelling an extension to present day information-based software engineering architectures with a view to linking more directly the management presentation layer to that of the file system hierarchy. It views information as being part of the physical universe and proposes a different architectural approach that is based upon natural metaphors of this universe whilst employing an additional spatial dimension. Two models are derived, the first of which, the Generic Management Model, uses a nesting principle with data being accessed across the different layers of the nests. The second model, Information Universe Model, structures the information into an implementable model which uses metaphors from the natural physical world in its design.

This new approach extends information space from its traditional representation in 2D/3D through the use of an underlying fourth data dimension. This allows information to be effectively organised through the use of the Information Universe Model. This is used to provide a foundation which not only affords more room for storing or traversing data/tasks, but also allows a means for manipulating information in a more intuitive (combining the presentation and storage layers) and richer (deeper path analysis with metadata) manner than those that exist in present day computer information workspace structures. The fourth data dimension is mirrored in the implementation by using a 3D stereographic projection of a 4D spatial dimension.

Declaration

I certify that this thesis does not, to the best of my knowledge and belief:

(i) incorporate without acknowledgement any material previously submitted for a degree or diploma in any institution of higher education;

(ii) contain any material previously published or written by another person except where due reference is made in the text; or

(iii) contain any defamatory material.

Signed: …………………………….

Date: ……………………………..

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David Richardson, May 2009

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Chapter 1: The Information Environment

1.1 Introduction

Information management and retrieval are extremely complex issues with a variety of professional end-users, subsequently termed '*knowledge workers*' (Boardman *et al.*, 2003, Malhotra, 1998, Staniszkis and Nowicki, 2001), solutions ranging from two-dimensional menu-driven display system designs, like those found within computer-based office applications, to the utilisation of three-dimensional interactive menu objects, such as those found in computer-based desktop manager shell replacements, providing an illusion of immersive space. At present, in 2009, the majority of primary office or business related task presentation layer techniques (the layer with which the knowledge worker interacts) can always be found symbiotically entwined with the increasing problems associated with viewable screen space whether using computer monitors, flat panel display devices or handheld pocket mobiles as viewing mechanisms.

Techniques such as point-and-click or direct-manipulation provide the necessary interaction methods when working with task objects, whilst the perspective of the third-dimension ordinarily provides the illusion on the screen of moving into, or out of, the searched information extending the constrained viewing space. This therefore suggests that there are dimensions to spatial task data in the form of screen display (one task) and file storage (many stored task versions) which are represented through static, animated or interactive visual techniques. In all cases this illusionary world, currently based upon physical world metaphors, attempts to simulate and organise a vast number of tasks or product documents, to make it easier to retrieve, select or search information, which cannot normally be achieved effectively, or efficiently (Edmunds and Morris, 2000, Hwang and Lin, 1999, Hutchings and Stasko, 2003) due to the volume of information.

1.2 The information problem

As estimated in a University of California Berkeley study (Lyman and Varian, 2003), physical storage containers continue to double in capacity roughly every year (University_of_California, 2000), suggesting that mission-critical raw data volumes may also continue to double (Mehta, 2001). Wilcox (2001) reports that as much as 80% of this data may well be in unstructured forms due to the inefficiencies in the way it is tagged (made searchable) and formatted (collectively managed). Independently commissioned statistics from both IBM and Workshare (Vanson Bourne), seem to corroborate this view, although with an even larger percentage, suggsting that as much as 85% (B.B.C., 2004, Chase, 2002, Bourne, 2004, Mehta, 2001) of information currently flowing through organisations is unstructured, providing very limited characteristics that make it searchable. These vast repositories of data are becoming unmanageable (Bourne, 2004, B.B.C., 2004) as many organisations are still based around knowledge workers saving their active task-based data locally, even if some data, like Web page articles, were originally obtained remotely via an Internet connection or a report document synchronised to or from a shared networked repository, like a server-based content management database.

Wilcox (2001) suggests that companies are only just starting to introduce a preference towards improved software methods (searching) of structuring (managing) archived information stored deep within data repositories, either locally or remotely, for although the hardware is cheap, the workforce needed to maintain it is not. These inefficiencies are already visible in the traditional desktop file systems, server based relational databases, content management software, or extended remote storage array methods. In addition, historians and archivists are increasingly becoming concerned about the implications of electronically stored data (B.B.C., 2004), its future ease of access, or whether new technologies will be backwardly compatible, so enabling accessibility.

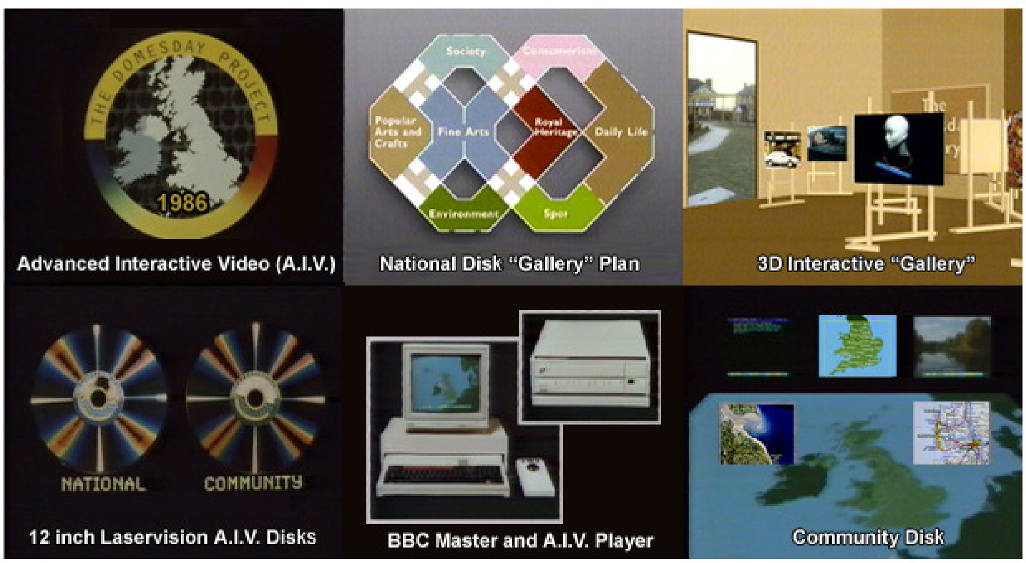


Figure 1. BBC 1986 Domesday Project, co-developed by the BBC, Acorn and Philips (Finney, 1996)

Indeed, this aspect can be highlighted by the 1986 Domesday Project (Figure 1), a pair of interactive video disks originally developed by the BBC to celebrate the 900th anniversary of the 1086 Domesday Book (Shneiderman, 1980, Finney, 1996). This modern day Domesday, could be considered the ancestor to today's multimedia authored encyclopaedia CD-ROMs such as Encarta 2008 (Microsoft, 2008a) or tools such as Google Earth/Maps/Street View

(Google, 2009a, 2009b, 2009c), as it contains 250,000 place names, 25,000 maps, 50,000 pictures, 3,000 datasets, 60 minutes of video, 20,000 newspaper/magazine articles and over 150,000 pages of text, including surveys/statistical trends. Collectively, this was stored on two specialised Advanced Interactive Video (AIV) 12-inch laservision disks, which were controlled using a computer programmed file structure that was specially written only for the BBC Master microcomputer.

However, as reported (Ananova, 2004, Guardian_Unlimited, 2004) these disks are now unreadable (searchable) using modern day (2007) conventional technologies, through the hardware becoming obsolete, software progressing down different avenues and operating systems becoming incompatible with the original programmed file system structures. Unlike the 1086 Domesday paper-based book, this means that in less than 21 years valuable information has now become lost, requiring innovative ways of rescuing it (University_of_Michigan, 2003). This same problem could be seen in 1995, when it was again reported (Guardian_Unlimited, 2004) that NASA had lost digital records sent back by its early space probes. Also, they allegedly (Imaginova, 2004) had lost the original blueprints for building the Saturn 5 rockets due to the obsolescence of its data retrieval technologies. In 2005, a recent Voyager 2 space probe to Titan (Rincon, 2005) has sent back once-in-a-lifetime photographic imagery and scientific statistical data about the planet's surface, an invaluable resource as it is considered unlikely that another mission would ever again be sent. So, what are the implications if data should also become lost (inaccessible) in a similar way due to rapid advances in technology?

The essence of the argument purported by Wilcox (2001) is that knowledge workers can often spend inordinate amounts of precious work time, accumulating to hours of lost time per year, hunting and pecking around, trying to locate their previous or most recent documents, due to a deluge (B.B.C., 2004) of other stored versions, folders, file names or document formats. To compound matters, constant changes to visual presentation interface objects or revisions of visual task-based methods found in areas like operating system environments or software applications, often lead to expensive re-education through training (Galli, 2006) as manufacturers alter their products for the sole purpose of extending sales within the product life cycle, normally marketed as usability enhancements, such as can be seen in promotional material associated with MacOS X, Windows XP or Vista. Therefore, current technology solutions are unlikely, on their own, to rectify this situation and, indeed, may only serve to compound these difficulties even further.

A solution needs to be sought that encapsulates how data is currently organised, linked, searched, presented and structured. This data-driven environment deemed an 'information universe' or workspace, would allow for a management system which would focus more directly upon the best use of virtual space. Thus, such a system would not solely rely upon measures for extending or integrating product life cycle gimmicks, known as mechanisms, as it would replace today's unnatural organisational techniques within the graphical presentation layer, in such areas as operating systems or application environments.

1.3 Fourth-dimensional solution

It is the emphasis of this thesis to analyse the metaphorical foundations of information-based environments with a view to examining how current systems visualise information back to knowledge workers, for the purpose of understanding their current requirements. In addition, it will highlight that scalability issues are now forcing current graphical interfaces to adopt innovative new mechanisms in order to combat the problems associated with scalability, screen clutter or information overload. It will postulate further that the concept of the two-dimensional information workspace, based solely upon physical world metaphors like that of mimicking a wooden desk in the electronic world as a desktop, has now outlived its usefulness. This metaphor now encompases the same fundamental problems of organising space for a multitude of task items, which can be attributed to the same issues faced with that of a cluttered wooden desk within the physical world. The argument focuses on the extent the same flawed task container designs are imported into an electronic world where these same management problems will eventually also occur and ultimately be exacerbated. In the past mimicking physical world metaphors was deemed an excellent way of making knowledge workers feel more comfortable in this new environment, as they simulated techniques with which they were familiar. However, with greater dependency being placed upon searching for information, it is the assertion of this thesis that these structuring containers should be replaced instead of remaining static and unchanging.

The thesis will postulate that an information-based workspace foundational structure should instead be optimised towards information management and modelled upon a different metaphorical foundation. It will suggest that the reasoning for this is that knowledge workers physically interact with three-dimensional physical world universe objects, which is natural, and of which they are a part. In essence, it will suggest a modelled searchable interface approach which adopts the very best information-based characteristics taken from current information-based interfaces and then use these as the initial starting point for constructing an information-based structured workspace modelled instead upon metaphors from the natural world which are supported with findings about the physical universe and its geometric laws.

Beyond this originality, the implementation design part of this thesis' original contribution to knowledge, as published (Richardson, 2004) in patent GB2414574 (Appendix 3), is based on a mathematically structured geometrical model, where aspects such as information extraction, search, storage and data mining are all combined directly within a single three-dimensional presentation layer (visualisation), known as 'Virtual Gatekeeper'. The theory being forwarded is that due to the enforcement of the underlying inductive geometrical structure and associated ontology, every data object that is stored automatically in this way can now touch each other, thereby capturing or discovering thought processes or link type patterns which were involved within their creation.

Thus, the thesis will propose a new formulated 'Generic Management Model' (GMM) which suggests a means for governing an Information Universe (Chapter 6) when specifically applied to an integrated desktop management file system. The argument will be that this foundational model with the linked geometric visualisation should be used as the approach for generating future information intensive environments, through enforcing structure onto abstract raw data. This approach to information storage and management provides better ways for manipulating data in a more intuitive and richer way than using existing computer-based information workspace structures.

To investigate this theoretical approach, a conceptual prototype tool, subsequently termed 'Virtual Gatekeeper', has been constructed (Chapter 7) from the ground up. The tool consists of a manager and a smart client component (Chapter 6), which monitors and extracts all actionable knowledge value, from cubed clusters of task-based documents via direct knowledge worker inputs.

The aim of this thesis will therefore be to:

- To explore the possibility of expanding information space dimensionality from traditional 2D/3D to 4D as a means of structuring/categorising meta tagged information with a view to assessing whether participants can successfully complete task activities through understanding these underlying concepts.

In order to examine and satisfy this aim the following research objectives will be satisfied:

- To examine in detail existing modelling of information space within a 2D/3D environment.
- To investigate possible extensions of present 2D/3D representations of information in order to facilitate information management.
- To develop a conceptual model of a possible extension from 2D/3D information space to a higher dimension.
- To test the developed conceptual model in terms of its ability to manage information.

1.4 Outline of chapters

Chapter 2 explores the problems surrounding information overload and briefly discusses the present solutions to this challenge. Mechanisms for information and knowledge usage are then discussed and the chapter suggests that there is a significant flaw in file hierarchical structures in the form of too much information compounded by unique cognitive patterns for knowledge worker profiles in organising these.

Chapter 3 focuses more directly upon the methods and techniques which are employed between the presentation and file system layers in order to combat deficiencies which ultimately occur. It concludes that two specific areas should now be considered as a priority, being cognitive issues relating to using the system in the physical sense and information management/structuring issues relating to the storage of information.

Chapter 4 examines the cognitive issues, by identifying more deeply, the presentation layer spatial techniques used when visualising information. Further, it investigates existing modelling of information space within the domain of 2D and 3D office-based environments. It concludes that in every case these techniques are not really solving the problem, but instead making more space, which therefore compounds it, even further.

Chapter 5 discusses the methods that are being employed or researched for optimising space through the perceived advantage of an added third-dimension. It therefore investigates possible extensions in the form of 3D representations of information in order to facilitate information management. It postulates that 3D in the right form could improve the management and access of large information spaces even though present research attempts at 3D alternatives, to the traditional desktop workspace or menu file system hierarchy, seem to suggest otherwise.

Chapter 6 advances a formulated ‘Generic Management Model’ as a means of governing an information universe (Information Universe Model) and overcoming five identified issues. It then specifically applies this solution to a single knowledge worker’s business desktop through a domain specific prototype implementation termed ‘Virtual Gatekeeper’. In order to conceptualise the underlying data structure and data linking, the chapter then shows that it is necessary to use techniques inspired from geometry as a method of mapping data dimensions in 4D onto 3D stereographic geometric object representations of 4D objects. It will then be shown that this enables facilitating interaction between the underlying data objects as mirrored back to the data dimensionality.

Chapter 7 discusses the research philosophy and methods that were employed in testing the physical implementation of the model in a highly structured way. Specifically, the chapter highlights an approach and a set of complimentary methods that governs and provides the necessary triangulation of results. It then introduces the key concepts that will be of specific focus within the prototyping phase trials.

Chapter 8 reports on the results obtained from the prototyping phase which mimicked as closely as possible the natural office environment. The chapter summarises various results, but specifically reports that a 3D graphical portrayal for projects, workspaces and segments was a good method for working with documents, although with the caveat to offset it against its present level of maturity. The chapter also suggests that tighter integration between applications, data generated and formats of documents stored and that this integration was entirely accessible from within a single interface, rather than from a myriad of differing tools interacting with the desired underlying operating system. Concluding, it finds that 90% of participants would continue to use the management model and even recommend it further to their own departments, should it become a robust/supported tool.

Chapter 9 discusses four umbrella concepts which pertain back to the issues as highlighted in Chapter 6. Specifically, it focuses upon the underlying management model approach and interactions when working with task activities. It then looks at how this now approach impacts upon the use of screen space by a knowledge worker. It finishes with a comparison of how this new approach compairs in relation to other computing environments.

Chapter 10 reports upon the final conclusion and limitations of the thesis. Specifically, it details how the thesis has shown that it is possible to extend information space from its traditional representation in 2D/3D through the use of a hidden fourth-dimension which allows information to be better organised (information management) through the use of structured categorisation ontology thereby potentially combating certain aspects as identified from the 5 issues (Chapter 6). It then examines the limitations of the research and possible future work. Finally, it concludes with a summary describing the whole thesis.

We now proceed to the focus of these chapters in depth.

Chapter 2: The Information Problem

2.1 Background

In the last 70 years, society has started producing information faster than it could be processed (Shenk, 2003). Technological advancements in the same period have continued to make information much more readily accessible and obtainable. These information technology advancements have continued to be updated, organically spreading in both a vertical and horizontal (Raitoharju, 2000) fashion across organisational structures, where it has resulted in a near virtual tsunami (Crosby-Muilenburg, 1999) of data being generated on a daily basis. This is not just particular to organisations, as inferred by Ho and Tang (2001), who cited evidence from a recent survey carried out by University of California, Berkeley which suggests that the overall amount of information that the world now produces is in the range of one to two exabytes (a billion gigabytes or 10^{18} bytes) per year. This accounts for about 250 megabytes for every man, woman and child on earth. Therefore, the resulting commercial or service sector workers within organisations are now being re-branded as knowledge workers (Farhoomand and Drury, 2002, Malhotra, 1998, Kidd, 1994), the term arising because information, and hence knowledge, is available to them at the touch of a button. Further, these knowledge workers are described throughout recent organisational literature in terms of '*an army of document creators*' or '*human processors*' (Bourne, 2004), who translate and record their experiences or knowledge within their roles, into electronically shared, or collaboratively created, information-based resources.

It seems that the vast body of literature pertaining to this topic often spans a variety of disciplines (Edmunds and Morris, 2000, Starr *et al.*, 1985) such as computer/information science, human factors engineering, management science, and the wider social sciences. Although most of these refer to an abundance, even an explosion, of information, they tend to cite only single examples of the Internet-turned-Information-Superhighway (Nelson, 1995). This literature (Edmunds and Morris, 2000, Mehta, 2001) lists the number of data objects available over the Internet from so-called typical periods such as two million snippets in 1995 (Edmunds and Morris, 2000) or seven million pages a day (Mehta, 2001). It is then claimed that the Internet is continuing to double in size every year (Nielsen, 1995) and so accordingly, further statistical figures seem to be extrapolated, using this 1995 total figure and others, claiming these are real figures. The most plausible reason for employing such a method is that it is the easiest way of estimating the Internet size. The huge numbers of pages which appear and disappear very quickly often mean that it is extremely hard to determine accurate figures at any one time. In fact only generalised approximate figures are available from year to year. This shows the limitations of the Internet as a viable resource for those organisations sourcing accurate information or data. Indeed, the quality of the pages and their finite natures, also mean that capturing accurate snapshots over a given period is hard work - needing robust scrutiny. Once one webpage publishes a single object of inaccurate data, this can spread exponentially around the world and will appear cited on websites of a similar nature within minutes as AOL has found (B.B.C., 2006). Thus, part of the knowledge workers' role must always be to use their expertise to sift this information for the required objects of data by recognising their validity. Inaccurate assimilation could ultimately pollute the knowledge pool of information being shared with other individuals in their respective organisations.

It is also important to recognise that the term information refers to any meaningful symbol or set of symbols, words, sentences, paragraphs, pictures or icons (Gonzales, 1994) which are often automatically combined as a larger grouped unit based upon their shared relationships. These components should be considered as data, until such time as they are aggregated, consolidated or ordered together through co-located accurate relationships (Gonzales, 1994). When further examining the term knowledge, it is crucial (Curtain, 1998) to understand that it additionally encompasses the social dimension (Figure 2) and not just that of the information or technology itself (Stenmark, 2002). Thus, it therefore refers to not only the transferral of data to information from books, or other electronic media, but overwhelmingly through tacit context-related awareness or understanding of the facts, as provided through additional human-to-human contact, experiences or other forms of learning (Howells, 1995a, 1995b, Colonia-Willner, 1999, Sternberg, 1999, Reber, 1993). This is an important distinction, discussed further in this chapter, as literary references tend to use these terms interchangeably.

Figure 2. Tacit knowledge can be articulated into information if made vocal
(Stenmark, 2002)

One of the most commonly cited historical examples referring to such tacit knowledge in action was that of Collins' (1972 cited in Busch *et al.*, 2001) work dealing with the building of lasers. The successful scientists had incorporated tacit knowledge into their explicit laser design methodologies (Collins 1972 in Henderson 1975 cited in Busch *et al.*, 2001; Collins 1974 cited in Meerabeau, 1992; Collins 1974 cited in Senker, 1995). It is argued (Busch *et al.*,

2001) within Information systems literature that all our knowledge resides at this underlying tacit level. Further, Saint-Onge (1996 cited in Busch *et al.*, 2001) defined this tacit knowledge level as being intuition, perspectives, beliefs and values that people form as a result of experiences of interacting with information. However, Nonaka *et al.* (1998) considered that the tacit knowledge process is more explicitly broken down into four distinct phases:

- socialisation (tacit to tacit)
- externalisation (tacit to explicit)
- internalisation (explicit to tacit)
- combination (explicit to explicit)

Thus, it is tacit knowledge which underpins knowledge workers' understanding of codified knowledge, where what first begins as a pool or data, is transformed through parts being articulated, other parts being categorised and then finally the relationships are encoded and codified based upon emergent principles as suggested by Busch and Dampney (2000) and Busch and Richards (2000a, 2000b). Alternatively, knowledge can be embedded (Loh *et al.*, 2003) into physical objects but not in an explicit way, that is, it requires other knowledge to be extracted first before the object is understood by the knowledge worker. Thus, the very action of organising data implicitly helps turn it into information. As an example the shape and characteristics of an unknown device could contain the key elements to understand how that device could function.

It is now evident that this battery of information (Nelson, 1995, Dalsgaard *et al.*, 2005) which according to Shenk, 2003) is increasing by as much as 100% each year, is now threatening to exceed the knowledge workers' cognitive abilities to find, review, understand, manage or structure it in any meaningful way so adding any value to their roles. The estimated (Nelson, 1995) cost to organisations for this lack of structure is that individuals who on a regular basis manually attempt to assimilate this information, require much more time, effort and resource, resulting in increased workloads or extended deadlines. This is further highlighted by Shenk (2003), as he suggested that the law of diminishing returns will take effect when the glut of information no longer adds to the quality of life, but instead induces stress, confusion and even ignorance so diminishing control over our lives. This is further substantiated in a Reuter's study (Reuters, 2000), which suggested that 49% of managers felt that they were quite often or very frequently unable to handle the volume of information that they regularly received. Kerr and Hiltz (1982) pointed out that '*the volume and pace of information can become over-whelming, especially since messages are not necessarily sequential and multiple topic threads are common, resulting in information overload'*. They went on to say that '*intensive interaction with a large number of communication partners results in the* *mushrooming of the absolute amount of information and the number of simultaneous discussions, conferences, and other activities, that go well beyond normal coping abilities'*. Thus the evidence from a wide variety of literature suggests that the crux of the issue is that in today's society, it is now being implicitly seen that the success or survival of many organisations or individuals, hinges solely upon their pressured ability to locate, analyse and use information skilfully and appropriately (Nelson, 1995), so gaining a competitive advantage over the competition.

Unfortunately, there is also another by-product to sifting through the information for the accuracy of data objects, as knowledge workers often ingest information constantly to the point of '*choking on it*' (Winkle, 2004), not recognising when they have hit the optimum level as they implicitly believe they may have missed a valued fact which they have not yet found. The knowledge worker is intoxicated making these subjective judgements concerning the quality or relevance of each data object (Nielsen, 1995). Technological innovations far from bringing about the anticipated '*paperless office'* (Winkle, 2004) and reducing workloads, have instead increased both areas (Winkle, 2004). If an employee has to use e-mail to communicate with another colleague who is less than 20 feet away, sending an information document, data object or even a communication response in order to transform the tacit knowledge into explicit codified information, then there is a definite problem within the organisation in terms of communication and information processes. This can mount up to multiple e-mails per day of potentially useless junk (Starr *et al*., 1985) which knowledge workers feel duty bound to sift through, even respond to instead of undertaking their normal duties.

The combination of entrenched organisational processes/practices and society norms exacerbates the pressures knowledge workers' place on themselves to inhibit the personal flow of useless junk, without risking in their eyes, losing potentially useful information. Thus, this overload within the context of an organisation is essentially a behaviour phenomenon, where social norms and sanctions should be addressed alongside the underlying problems of the technology. Burdened by information overload, knowledge workers feel stress, strain, and anxiety, thus threatening organisation productivity and the adoption of any new technologies (Franklin, 1997). In a survey (Farhoomand and Drury, 2002) of 1300 managers in Hong Kong and Singapore, 25% of managers responded that they had suffered from ill health, ranging from headaches to depression, as a direct result of the enormous amounts of data which they had to constantly absorb.

Adhering and understanding the transformation processes (tacit to explicit), which data must go through in order to become more than the sum of its data parts i.e. information, might include solution techniques other than technology, such as training knowledge workers in best practices for transforming data in combination with new enhanced software technologies. This approach has already been applied according to Nielsen (1995), suggesting that human judgement, rather than just software alone is a more promising approach to reducing information overload in the long term. Indeed Nielsen (1995) also suggested that any new enhanced software must include sufficiently good artificial intelligence to augment traditional software so allowing the computer to further understand the content of data objects and thus automatically take the appropriate action to assist in the knowledge worker decision making process. However, due to the technological limitations of existing systems and a reluctance on the part of organisations to acknowledge the information overload problems that inherently exist in the 21st century organisation, 94% of managers according to LaPlante (1997), do not expect the situation to improve while 56% expect the future to be even more stressful.

2.2 The knowledge dilemma

Information Management as a term seems to have multiple meanings, contexts and scopes which emphasise a dependency on specific constituent components, as previously discussed in 2.1. The literature often uses this term to describe library or information-related studies in general terms (Martin, 1999), usually referring back to the more general information science field of Informatics which tries to be more encompassing by providing a framework (Macevieiute and Wilson, 2002) approach focusing on information-based topics, software engineering and computers. The difference between this and Knowledge Management seems to be extremely nebulous, and shrouded in confusion (Wilson, 2002). There is very little, and in some cases believed to be no, consensus (Bouthillier and Shearer, 2002) from the literature over the specific nature of the differences, with many who have tried to elucidate a consensus seemingly contradicting each other. It appears in many cases that Knowledge Management is given an interchangeable meaning to that of Information Management (Rowley, 1998). However recently in the literature the term '*knowledge worker*' (Farhoomand and Drury, 2002, Malhotra, 1998) seems to be gaining acceptance as a more generally accepted term for bypassing this confusion through describing an organisational employee in terms of a synergy between the person, information, technologies and cognitive or behavioural issues (Malhotra, 1998) related to raw data processing in the electronic workplace.

According to Edmunds and Morris (2000) and Gonzales (1994), any electronic data should always be identified as raw material until such time as it has been processed by a human mind into a form which makes sense of the data; thus they become information. It is suggested that at the point when a document is formed, it ceases to be just meaningless data and should now instead be termed 'information'. This distinction is very important as it denotes that a process change has occurred collecting together the data based upon co-located relationships into their own unique document repository. This is something that most of the literature tends to ignore, but rather interchangeably generalising information as data. So more accurately, information overload, as described in some cases, should instead be termed 'data overload' as it is a mass of data or facts which, prior to process formation, neglects having any appropriate description of the describing characteristics, relationships or meanings, placed upon it for co-locating it.

Recently, other authors such as Rowley (1998), Kirk (1999) and Davenport and Prusak (2000), have also tried to draw a distinction between knowledge and information in order to provide better clarity. As an example, in the business field literature, information is seen as a higher level management function (Macevieiute and Wilson, 2002), especially when it is labelled as Knowledge Management. Authors such as Mintzberg (1980) typify this apparent observation, by describing the information roles of managers and by viewing management as an information intensive job. Macevieiute and Wilson (2002) further observe that much of the researched literature tries to subsume Information Management under the umbrella term of Knowledge Management or vice versa.

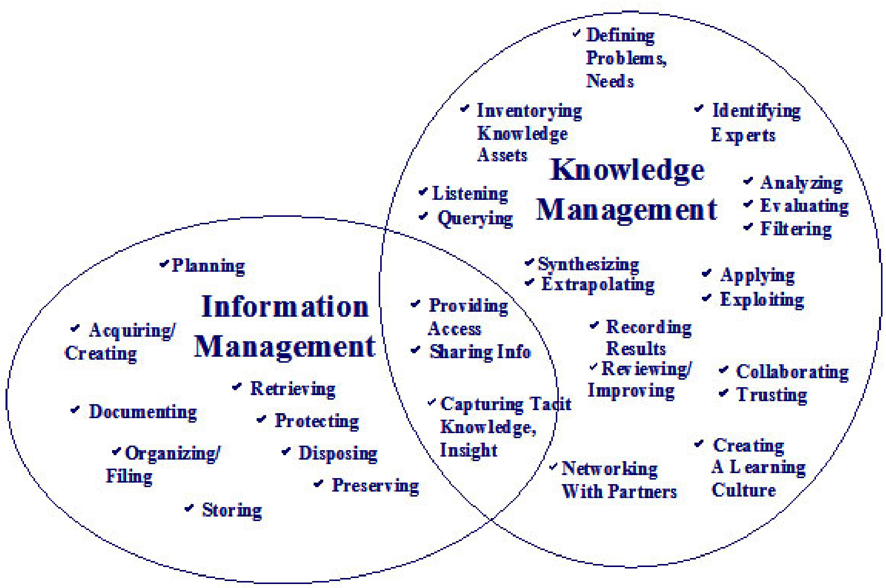


Figure 3. Knowledge management and information management crossover

(Lipchak, 2002)

However, Macevieiute and Wilson (2002) controversially concluded from observations that Information Management has a stronger theoretical base than that of Knowledge Management, a view which is also supported by Bouthillier and Shearer (2002). They suggested that the latter is simply only used as a presentational label to impress consumers of consultancy companies. However, recent work undertaken by Stenmark (2002) seems to provide a clearer distinction between these two areas and suggests that the conclusions of Macevieiute and Wilson (2002) are indeed wrong due to the fact that there seems to be clearly defined categories which very importantly do overlap (Figure 3).

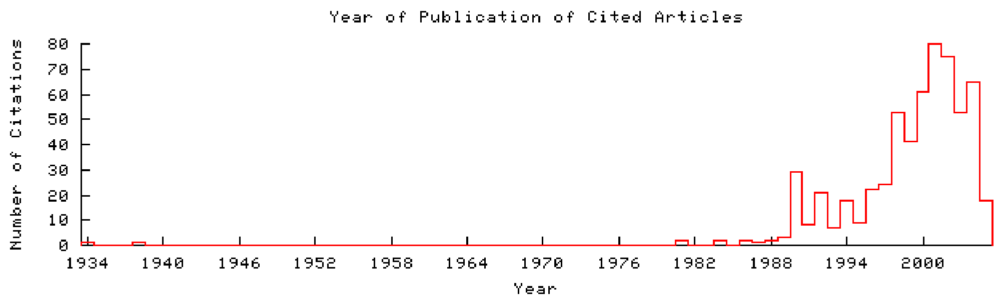


Figure 4. CiteSeer: Information management citation statistics
(Citeseer, 2006)

To test this observation, this author undertook a standard Boolean keyword literature search looking at computing citations, as similarly undertaken by Eppler and Mengis (2002) and subsequently republished in 2004 (Eppler and Mengis, 2004). What is interesting is the shape of the curves that result from related articles under the terms of Information Management (Figure 4) and Knowledge Management (Figure 5). Whilst the Information Management term citations date back to 1934, Knowledge Management in electronic online documents seems to be more recent, only dating back to circa 1988. This is crucial, as if this confusion, as proposed, does exist between the interchangeable use of these two terms, it suggests that publications may have been subjectively published under the wrong categories or keywords.

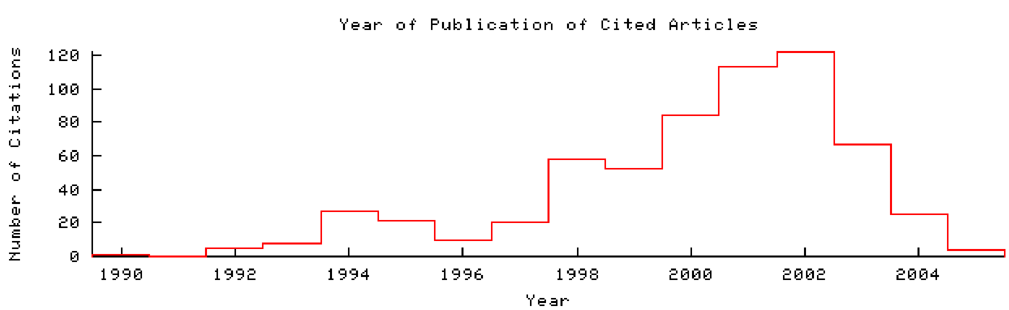


Figure 5. CiteSeer: Knowledge management citation statistics
(Citeseer, 2006)

This would result in important related conclusions getting lost amongst the mix of publications. As observed by Naisbitt (1982 cited in Nelson, 1995), '*it takes less time to do an experiment than to find out whether it has actually been done before'*, which seems very true based upon this suggested evidence. In support of the conclusion (Macevieiute and Wilson, 2002) that maybe Knowledge Management was only a label, the curves around 2002, seem to show that both terms have a similar pattern in that they both decrease, with Information Management marginally having more papers around 2004 than that of Knowledge Management. What is even more telling is if both these keywords are plotted against information overload (encompassing related terms as discussed later), there seems to be a very clear pattern (Figure 6) after 1997.

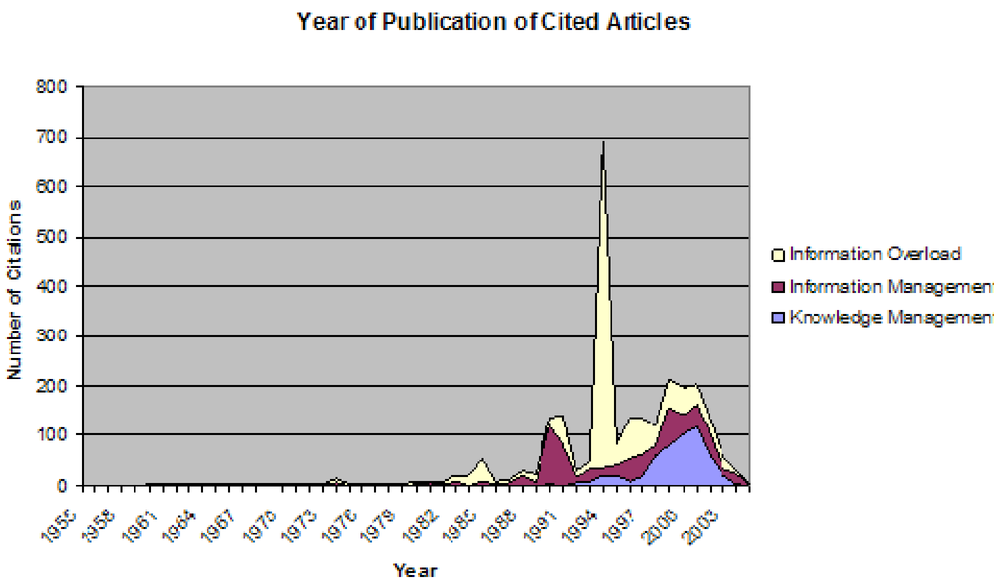


Figure 6. Published citations analysed by the author's use from CiteSeer

This is reflected in both Information Management and Knowledge Management, suggesting that all three areas are perhaps linked. It is therefore the view of this author that when taking a data transformation approach (Figure 7) to this subject, the distinction becomes very clear. If the Edmunds and Morris (2000) view is applied, where data only becomes information once collected together using co-located relationships (Stenmark, 2002, Edmunds and Morris, 2000, Gonzales, 1994), following these categories (Figure 3), then it will naturally follow an information field route. However, once subjective tacit decisions (Busch *et al.*, 2001), knowledge or thought processes are included or placed upon the data in order to transform it into information (tacit to explicit) by aggregating, consolidating or ordering it together (Gonzales, 1994) through co-located relationships based upon the knowledge workers' cognitive judgements, there is an overlap with that of Knowledge Management.

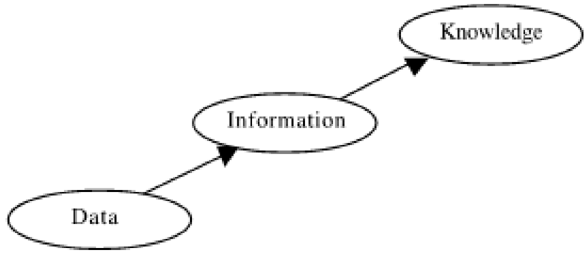


Figure 7. An oversimplified image of the relationship between data, information, and knowledge
(Stenmark, 2002)

It is therefore proposed that taking on board the more recently (2002) accepted term of the knowledge worker (Farhoomand and Drury, 2002, Malhotra, 1998) would happily encompass both these areas interchangeably. This would be a good starting point for combining both subject areas under a new umbrella with the re-branded term of perhaps 'Knowledge Fusion' or similar. It is proposed that this particular term potentially would fuse the two disciplines, as per the name implies, specifically focusing on data, information, knowledge and intelligence (Bouthillier and Shearer, 2002) and all related issues therein. This would provide greater transparency for classifying the literature and for organisations as a whole when describing knowledge workers in relation to workplace challenges like information overload.

2.3 The information overload challenge

The concept of information overload is not a new challenge, as it was originally experienced in the traditional paper-based office through storing or accessing documents. In recent years the pervasiveness of communication technologies, coupled with both the speed and increased flow (Raitoharju, 2000) by which information is delivered and the increasingly diverse electronic formats, have raised public awareness (Edmunds and Morris, 2000) to the point where it is now considered a genuine health or productivity concern by organisations. In a 1998 Reuter's report, described by Raitoharju (2000), information overload is seen as a problem by 42% of respondents. In the United Kingdom (UK) 47% stated (Raitoharju, 2000) that information overload damaged their relationships and 42% thought it reduced their job satisfaction. The principal reason is due to the amount of electronic information and the plethora of storage structures used in organising it.

According to Raitoharju (2000), there does not seem to be a universally agreed definition for information overload. However, Farhoomand and Drury (2002) found that two of the most common definitions were an excessive volume of information as reported by 79% of study respondents and difficult or impossibility of managing it, as reported by 62% of the respondents (Farhoomand and Drury, 2002). A limitation to exploring the evolution of these issues, as observed by Eppler and Mengis (2002), is that the literature uses different labels or keywords interchangeably in discussion. Terms highlighted by Eppler (1998) include data smog, information fatigue, overkill, overabundance, breakdown, explosion, deluge, flood, stress, plethora, document tsunami and sensory overload. However, in every case these labels are used to convey the simple notion of receiving too much information (Eppler and Mengis, 2002). This has led to various constructs or synonyms, and related terms such as Knowledge Overload (Hunt and Newman, 1997), Cognitive Overload (Vollmann, 1991), Information Fatigue syndrome (Wurman, 2001), Communications Overload (Meier, 1963) and Sensory Overload (Libowski, 1975). However Farhoomand and Drury (2002), from also looking at study respondents, succinctly summarises all these related areas together as specific components (Figure 8) from the most to the least problematic.

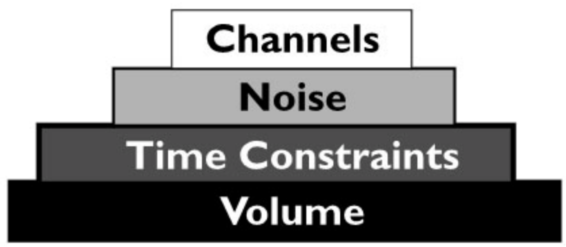


Figure 8. Components of information overload in ascending order from most to least problematic
(Farhoomand and Drury, 2002)

The volume of organisational data, according to Mehta (2001), doubles each year while the Internet grows by seven million pages a day. However, as sources (B.B.C., 2004, Mehta, 2001, Bourne, 2004, Chase, 2002) show, 85% of organisational information and an even higher percentage of Internet content is unstructured (little or no identifying characteristics), thus making it extremely difficult to organise through traditional manual classification methods. According to Wurman (2001), the greatest crisis that is currently facing modern civilizations is how to transform unstructured or islands of information into structured knowledge. The literature has termed these unstructured information resources as '*information landfills*' (Mehta, 2001) as it provides very limited properties, known as metadata, or embedded describing characteristics, which determine what the content is within any document. Thus, for organisations, there is a significant overhead of resource cost which is needed when mining or managing (Bourne, 2004) this information in a way that is meaningful to the knowledge worker.

Information overload impacts upon both the personal and organisational perspectives (Hagel and Singer, 1999, Oard, 1997) where any information that is provided beyond a certain point (Farhoomand and Drury, 2002) will no longer be integrated or absorbed into the decision making process. The big question is how this impacts upon decision accuracy, decision time and general performance (i.e. the quality of decisions or reasoning in general) (Eppler and Mengis, 2004). As illustrated (Figure 9) it was controversially discussed (McKinnon and Bruns, 1992, Malhotra, 1982, Russo, 1974), but later confirmed, as an accurate representation of information overload. However, there is a wide consensus (Eppler and Mengis, 2004) that heavy information load can affect the performance of an individual negatively, whether measured in terms of accuracy or speed.

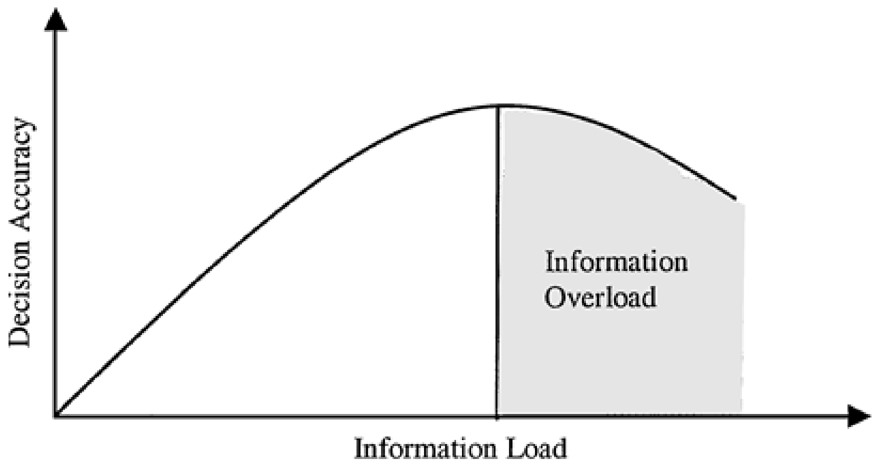


Figure 9. Information overload as inverted u-curve
(Eppler and Mengis, 2002)

Specifically, information processing demands on an individual's time for performing given interactions exceeds the supply or capacity of the time available for such processing (Farhoomand and Drury, 2002) and information overload will be the direct result (O'Reilly, 1980). Hawes (1994) perceived that it is a product of human behaviour since it relates directly to a human capacity for locating, storing and handling often small snippets (Nelson, 1995) of information. The quantity of information can exceed the mental processing abilities of an individual as, for example, when there are too many sources of information, or when information is incoherent or contradictory, or when new unfiltered raw material is constantly being added, or when low signal-to-noise rates obscure information (Dalsgaard *et al.*, 2005).

Ho and Tang, (2001), in addition to identifying the quantity of information, also more importantly suggest two other factors of information format and information quality as contributing factors towards information overload. If any of these factors (Wurman, 2001) are out of balance (Figure 10), then a person:

- does not understand available information
- feels overwhelmed by the amount of information to be understood
- does not know if certain information exists
- does not know where to find information
- knows where to find information but does not have the key to access it

With the development of the Internet, raw and unfiltered information is produced at speeds which exceed human cognitive capacity to process it. Since much of this information is never indexed by search engines due to a variety of factors, principally its finite nature, these repositories are therefore invisible from some Internet knowledge worker communities (Ho and Tang, 2001).

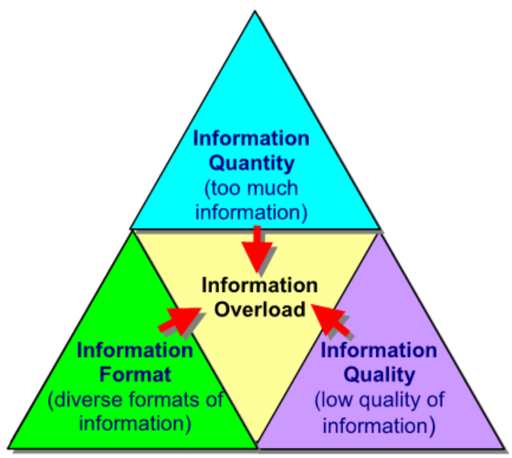


Figure 10. Dimensions of information overload
(Ho and Tang, 2001)

The quality of what is actually seen may well be a diluted '*data smog*' (Ho and Tang, 2001) or an overabundance of low quality information. The diverse nature of information formats may also tremendously hinder the effectiveness of information processing. This can cause information overload since these files have internal virtual file structures which are not immediately evident and the file name may bear no relation to the contents. Ho and Tang (2001) go on to say that the multiplicity in information formats, which include their structures, is perceived to be a major obstacle to resolving information overload.

Starr *et al.* (1985) suggested that novice knowledge workers will learn to cope with information overload after they gain a sufficient experience level. Intermediate knowledge workers seem to be the target audience who suffer the most in decisions-making situations as they feel compelled to observe all the communications they can access in order to maintain confidence that nothing relevant was overlooked. In the case of experienced knowledge workers, they will normally develop effective ways of coping. Starr *et al.* (1985) conclude that different individuals are overloaded at different levels as a function of how much information they can perceive and deal with cognitively. Dalsgaard *et al.* (2005) highlighted that the reasons for this are that consumers are continually bombarded both verbally and visually, with the maxim that if information is good, more information is always better, and that if they don't follow they will be left behind.

The knowledge workers' symptoms which are experienced due to these issues are cognitive stress (Figure 11) and strain (Raitoharju, 2000), a general lack of perspective (Schick *et al.*, 1990), a greater tolerance of errors (Sparrow, 1999), lower job satisfaction (Jacoby, 1984) and the inability to use information to make decisions (Wilson, 1995, Bawden, 2001). Indeed, according to Eppler and Mengis (2002), heavy information load will utterly confuse an individual, affecting their ability to set priorities, or by making prior information harder to recall (Schick *et al.*, 1990) with the net affect of an inability to extract meaning from a wide accumulation of data sources (Nelson, 1995).

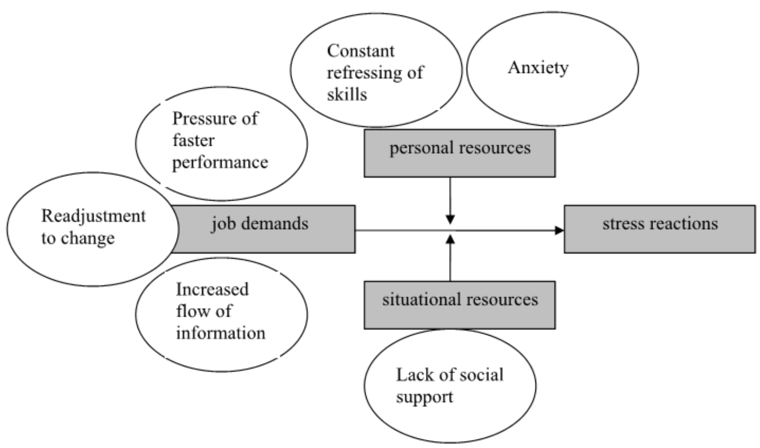


Figure 11. Possible influence of IT in relation to job stress

(Raitoharju, 2000)

Jacoby (1977) suggests that a person who has difficulties identifying relevant information may become highly selective (diminished decision making) and will then ignore large amounts of information (Bawden, 2001, Herbig and Kramer, 1994). David Lewis of the International

Stress Management Association coined the phrase Information Fatigue syndrome as a condition for best describing these physical and mental costs (Winkle, 2004). Although other literature, such as Arnetz and Wiholm (1992), suggests a different phrase of Technostress to describe this state of mental and physiological arousal. David Shenk as described by Winkle (2004), cites psychological studies spanning over thirty years and lists six key symptoms accompanying information overload:

- increased cardiovascular stress, due to a rise in blood pressure
- weakened vision, citing a Japanese study which predicts a nearly universal near-sightedness in the close future
- confusion and frustration
- impaired judgement based upon over-confidence
- decreased benevolence to others due to an environmental input glut (which may very well account for part of the brusqueness which is commonly attributed to big-city dwellers)
- engendered feelings of helplessness, confusion, and anger which erode work efficiency

Whatever the name or slight differences in nuances, in general the literature at present (2006) seems to agree that it will increase in the future due to the rapid changes transcending working life. For the knowledge worker the ability to adapt to this new style of working will be determined by personal characteristics such as stress tolerance and by the environment such as the availability of social support (Le Blanc *et al.*, 2000). There are three psychological examples as described by Shenk (2003) which show how these symptoms could be manifested based upon job personality types. For instance accountants, who store forms on a computer without any difficulty, could become frozen with indecision when confronted with the open-ended world of the Internet. In the case of lawyers their progressive introduction to computers could culminate in terrifying nightmares about being trapped in an endless library. Finally, in the case of librarians who have been professionally trained to grapple with quantities of information, it is suggested that they could easily succumb to feelings that the information supply is getting out of control.

Shenk (2003) claims that symptoms are directly linked to information quality and accuracy (Nelson, 1995) as the knowledge worker is unable to process or cognitively interpret the data any longer, even though it may be clearly displayed to them on the computer screen. A good example could be financial investors (Ho and Tang, 2001) who deal in stocks, commodities, futures or shares, as their screens are constantly being updated and they must respond very rapidly to the changing market conditions by quickly assimilating this new information. Too many changing variables can lead to instant confusion and frustration. In essence, the knowledge worker's brain shuts down to the point where it can no longer respond to any new input stimuli and in extreme cases can lead to eventual physical break down. This is captured very well by Wurman (2001) who writes that '*information anxiety is produced by the ever-widening gap between what we understand and what we think we should understand. It is the black hole between data and knowledge and it happens when information does not tell us what we want or need to know'*. Other aspects that lead to this condition are frequent interruptions of concentration through tools such as the telephone, instant messaging or colleagues interrupting a train of thought through brief conversations. Recent studies (Bawden, 2001, Wilson, 1996) are even now focusing on collaborative and interdisciplinary work as root causes rather than as countermeasures to information overload.

Information overload is therefore the relationship (Figure 12) which has been tested through numerous studies (Hwang and Lin, 1999), between information load, information processing and decisions quality. Thus, to knowledge workers it occurs when they fail to attend to pre-offered information or they assimilate it incorrectly. As an example, this could be in the form of a constant stream of e-mails flooding into a worker's inbox, where they do not have enough time to make sense of the true meaning behind some of the content data, due to the sheer volume or load, resulting in a response or action decision which could be fundamentally better should either of these variables decrease.

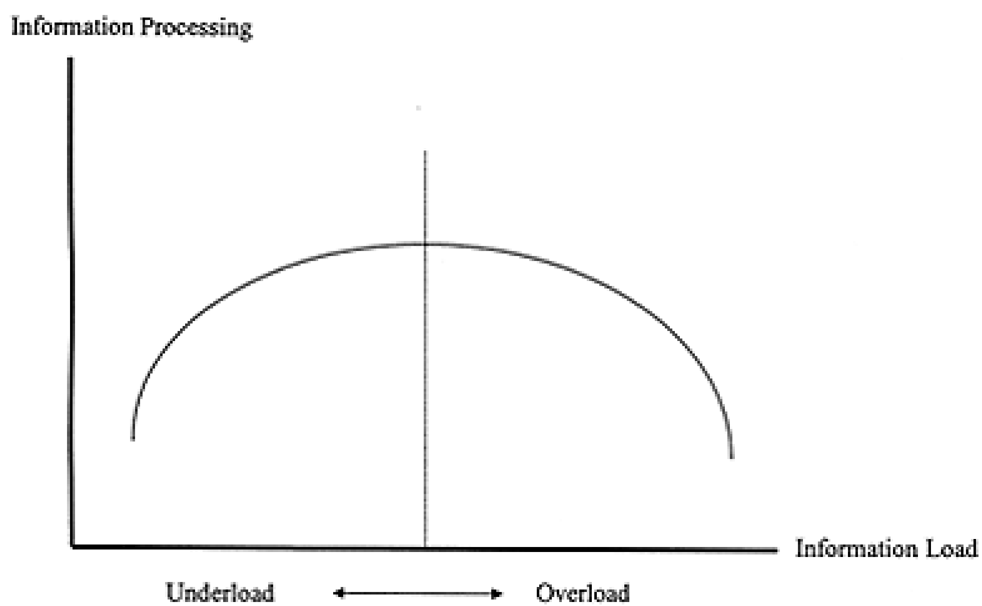


Figure 12. Information processing against information load relationship
(Hwang and Lin, 1999)

In today's information-based economy it is estimated that 10% to 14% (Bourne, 2004) of a knowledge worker's time is spent in the creation of information documents or collections of data which equates to half a day in organisational resource terms per week. Bourne (2004) suggests that 200 million people use Microsoft Office around the world, with approximately 40 million being described as heavy document knowledge workers. If this were then equated into the documents produced, it is estimated that tens of millions of documents are produced every month. Technology has empowered knowledge workers by giving them machines with the capacity to generate and transmit information (Farhoomand and Drury, 2002) to a wide range of recipients, but this power has come at a price. Information technology and its use or misuse, is a major reason why information overload has become a high priority challenge in many organisations from the 1980s to the present day. Bawden (2001) points out that Internet, Intranets, Extranets and especially e-mail are universally seen as the major causes of information overload.

2.4 Solutions to information overload

The consequences of information overload for the knowledge worker are stark, as they are required to deal with constant streams of information or data as part of their everyday job tasks. Indeed, Lewis (1996) points out that professional and personal survival in our modern society clearly depends on knowledge workers' ability to digest rapidly vast amounts of new information. So how does this affect the knowledge worker if they are manually forced to absorb such unwieldy quantities of information? Klapp (1986) provides an answer for this question as he states that large amounts and high rates of information act like noise when knowledge workers reach overload point, a rate too high for the receiver to process efficiently leading to distraction, stress, and increased errors. Thus, as Feather (1998) asserts, there is so much data available that it is no longer possible to process it effectively through simple cognitive functions alone. The Utopian belief in organisation that all these difficulties could be implicitly solved by throwing yet more technology at the problem is unrealistic. Lack of specific recognition of what is really involved has potentially ranked the problem as low as fifth place (Figure 13) in 14% of literature studies.

Category	Solutions	Number	Percentage
P1	Filter the information	59	47%
P2	Eliminate the source	30	24%
P3	Delegate work	30	24%
P4	Prioritize	22	18%
T1	Utilize technology	17	14%
O1	Organize work	14	11%
O2	Enhance communication	10	8%
O3	Other	10	8%
O4	Consult top management	9	7%
O5	Help from IS/IT department	8	6%
I1	Ignore information	5	4%

Key: P = personal T = technological O = organizational I = ignore

Figure 13. Solutions to information overload

(Farhoomand and Drury, 2002)

Such technologies include intelligent agents (Berghel, 1997, Kuhlthau, 1996) which act as '*mediators*' (Ho and Tang, 2001) for sifting huge amounts of information to satisfy knowledge workers' needs. Portals (Ho and Tang, 2001) are websites which provide a broad range of services including searching, yellow pages or links and Syndicators (Ho and Tang, 2001) which sift various types of sources and aggregate them into a single package based upon knowledge workers' pre-selected requirements. Indeed it is believed that these new technologies will automatically transform or filter unprocessed information into the useful suggested technologies already under development which are trying to satisfy this vision of the future are identified as Personal Knowledge Management systems. These systems include such functionality as content aggregators and news feed readers (Lerner, 2004). The term personal is added to the name as a way of suggesting (Henderson, 2004) that the documents contained therein are owned by specific knowledge workers and are directly under their control, where they acquire, store, manage and retrieve these digital documents. However, it was pointed out by Dalsgaard *et al.* (2005) that these systems only respond to the symptoms of the problems of information overload, rather than address the root causes. Starr *et al.* (1985) pointed out that unless computer-mediated communication systems are structured, knowledge workers will always be overloaded with information, regardless of any technology advancements which organisations put in place to improve things. Specific structuring of this information should be imposed by individuals rather than the systems (Starr *et al.*, 1985) as any process which limits overload by changing individual structuring abilities will ultimately destroy potential benefits like establishing mental mind maps of where documents are stored in a hierarchy. However, this is a debateable argument (Nielsen, 1996) as some suggest that basic file-system models are inadequate to fully satisfy the needs of knowledge workers, despite the flexibility of the underlying code and data structures. The argument, as forwarded by Nielsen (1996), suggests there is no need for knowledge workers to know how their information is stored since a document is normally stored on a hard disk in chunks as non-contiguous sectors. It is only when it is retrieved that it is truly reconstructed as a document. The same argument was reinforced later by Nielsen (1996) when he also suggested that current file systems are based on three assumptions:

- information is partitioned into coherent and distinct units, each of which are treated as a separate object (file)
- knowledge workers typically manipulate information using a file and are restricted to be in one file at a time
- information objects are classified according to a single hierarchy: the subdirectory structure

A document (file) in itself can be described as a collection of data that as a whole is termed 'information'. Typically, at any one time, knowledge workers manage and maintain a diverse collection range of digital information (Boardman *et al.*, 2003), storing these according to the knowledge worker's own unique cognitive filing system, made up of folders based on thought patterns or processes. File systems are thus commonly structured as strict hierarchies of directories and subdirectories. These information documents can also be sub-divided (Boardman *et al.*, 2003) between those stored within an application filing system and that of the hard disk filing system repository. These structures are also useful for compacting, condensing, and organising information (Starr *et al.*, 1985). According to Shenk (2003), memory in a knowledge worker's brain is structured according to specific cues or contexts within which the information is experienced. Hence, these structured repositories reflect the unique mental cues of specific individuals and means that no filing structure is ever the same if it is manually created. For knowledge workers, however, the same information units may often have multiple classifications, where the graphical systems represent the files in the knowledge worker's interface by their names (Figure 14) with a few additional attributes (mainly data types illustrated by icons). As an example, Microsoft Outlook stores its entire virtual filing system of folders, documents and corresponding attachments as a single super compressed file (Personal Store or PST) which is only readable through the hosted application. This everyday process of working with information documents, where an individual gathers, handles and organises these documents into their separate file systems (Figure 15) is the meaning behind the term personal information management (Lansdale, 1988).

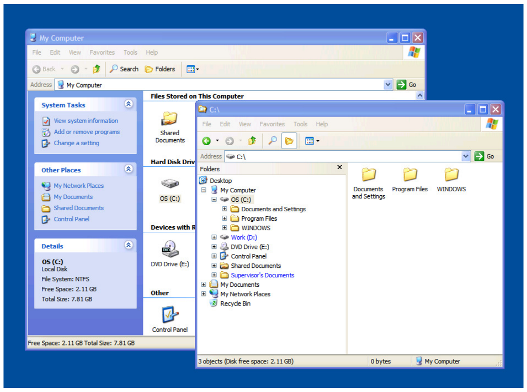


Figure 14. Windows XP desktop file system windows

(Microsoft, 2002a)

Figure 15. MacOS X Panther desktop file system windows

(Apple, 2004)

It is precisely this which knowledge workers struggle to manage as files accumulate over time (Boardman *et al.*, 2003). It was observed by Henderson (2004) that although hierarchies are a very powerful and a natural way of organising files, there is no clear reason why these systems must always use hierarchical structures. Indeed, Henderson continued by suggesting that there is no clear evidence that these systems are necessarily the best option for document management citing previous studies of how people manage and use paper documents (Malone, 1983, Whittaker and Hirschberg, 2001), e-mail (Ducheneaut and Bellotti, 2001, Mackay, 1988, Whittaker and Sidner, 1996) and files (Barreau and Nardi, 1995) as supporting evidence. Indeed there is an argument by (Edmunds and Morris, 2000) about the stress advantages in using asynchronous communication methods with their own self contained hierarchies. E-mail provides this type of asynchronous communication method, as knowledge workers are less likely to be interrupted in normal task workflows (Eppler and Mengis, 2004) or for these files to get lost. These systems are preferable to methods like instant messaging that subsume the received files among existing folders on the hard disk. In terms of pushing selected pieces of information to specific groups of knowledge workers, it might initially reduce their information retrieval times, but conversely would increase the amount of potentially useless information with which each a person has to then deal (Edmunds and Morris, 2000).

There seems to be two main types of physical world structuring approaches known as '*neat and messy*' (Mackay, 1988, Malone, 1983) for organising desks. In both cases, these environments are increasingly prone to spotty memories, or '*cue overload*' (Shenk, 2003) where the information is not organised or where there are too many records to go through. In two studies reported by (Henderson, 2004) comparing this to electronic documents, it was revealed that many respondents did not create any kind of digital organisational structure at all (Barreau and Nardi, 1995), and that respondents used location knowledge of files to retrieve them in preference to searching for a file using a technological solution. Indeed, it seems that the research literature according to Henderson (2004) works under the assumption that hierarchical systems are inadequate for a document and often propose radically different organisational schemas, such as 3D (Chapter 3 and 4), as a way of solving the information overload problem. However, as this chapter asserts, it is not necessarily just a single component dimension that needs to be replaced and even this replacement may well be judgmental, being based on outdated research conclusions.

In modern knowledge worker interfaces, information objects often have multiple presentations and units when combined in multiple ways for different knowledge workers and tasks (Nielsen, 1996). As an example a typical Web page document consists of a text file and one or more image files that exist in *n*-dimensional hyperspace (Nielsen, 1996) which are not necessarily combined together until the page is displayed by the browser. The web page contents, like the images, may well be shared over multiple pages at the same time for different reasons. Indeed, modern database generated website GIF or JPEG image files may not even exist in the filing system, but be auto generated on demand from an underlying image representation known as a Binary Large Object or BLOB with parameters such as compression or colour-map depth determined dynamically by either bandwidth or other considerations (Nielsen, 1996). Therefore, whilst the information document has relevance to the knowledge worker, the constituent data parts in their virtual or obscure directory structures have little or no relevance information (Ho and Tang, 2001) without the need for a human-in-the-loop operator. The ultimate vision has therefore been that this technology would unify all data sources (Ho and Tang, 2001) wherever they are located, or in whatever forms the file structures are consolidated, for the average knowledge worker wanting to undertake a given task. In the case of an e-mail inbox, for example, these components should definitely be treated as a multiplicity of message-virtual-objects, where on the hard disk these components may be compressed and stored as a single stored unintelligibly named file (PST archive).

In relation to other document files in the hard drive hierarchy, knowledge workers rarely generate good file naming conventions. Nielsen (1996) suggests they may prefer not to type, or have limited creativity of thinking, or are hit by the premature classification problem (Nielsen, 1996). The named object is generated long before the contents are created and so knowledge workers often do not understand what they are about to name. When searching for a specific information document, the knowledge worker may not recognise the abstract name or see it amongst numerous other abstract names. Thus named information documents are fundamentally unsuitable for hierarchical systems which are supposedly designed for speed as there are limited ways (2007) of reading inside an information document archive without first opening it up with the referenced application, leading to penalties on both screen space and performance. This means that a hard disk filing system is laced with these islands of information, each holding virtual filing structures of data.

It is therefore suggested that the low level restructuring of information should facilitate the ability to filter and search out information or communications automatically (Denning, 1982) for these are not just bolted on technologies to help the knowledge worker but a rethinking of the entire organisational structuring hierarchy, including organisational processes. This is summarised extremely well in Figure 16 and Figure 17, where countermeasures may include the incorporation of knowledge worker roles or multiple sub identities which could correspond to specific organisational functions. The concept of using roles as a category for indexing is actually a psychologically appropriate approach (Starr *et al.*, 1985) in that it is easier for knowledge workers to adapt to this than to alternative standard database approaches which may require unique numbered identifiers. Strategies which allow knowledge workers to structure information or communications are intrinsically better suited for alleviating electronic information overload. At its simplest it may involve a mandatory project task title linked with the person's role on the project for describing the document or communication.

This full unification of the activity space as seen to a limited extent in systems such as Lifestreams (Fertig *et al.*, 1996, Freeman, 1997, Freeman and Gelernter, 1996) would ultimately unite information management and information retrieval (Boardman *et al.*, 2003) where filing, organising, sharing and searching become very simple tasks. Whether visual (Hwang and Lin, 1999), spatial (Edmunds and Morris, 2000) or programmatic mechanisms are used in the structuring of this repository, it has obvious, far reaching, implications upon software design and function. No longer would a document be an island or a unique cluster of data, but it would instead be a window onto the underlying information-based universe that serves a specialised function towards a common goal.

The potential freedom from information overload will come at a price since knowledge workers will need to learn perhaps more complex management systems or features. These would go beyond simply sending and receiving operations (Starr *et al.*, 1985) and alter the established cognitive working patterns or mental pathways with which they have grown accustomed. Indeed, as Starr *et al.* (1985) observed, people are not easily sold on anything which promises radical change to cognitive processes or well organised social structures.

	Countermeasures	References
Personal factors	• Improve personal time management skills and techniques	Bawden, 2001
	• Training programs to augment information literacy: information-processing skills such as file handling, using e-mail, classification of documents, etc.	Bawden, 2001; Jones, 1997; Schick et al., 1990; Koniger and Janowitz, 1995
	• Improve personal information management	Edmunds and Morris, 2000
	• Systematic priority setting	Schick et al., 1990
	• Improve the screening skills for information	Van Zandt, 2001
Information characteristics	• Raise general quality of information (i.e., its usefulness, conciseness) by defining quality standards	Allert, 2001; Keller and Staelin, 1987; Meglio and Kleiner, 1990; Simpson and Prusak, 1995
	• Focus on creating value-added information	Simpson and Prusak, 1995
	• Promulgation of rules for information and communication design (e.g., e-mail etiquette)	Bawden, 2001
	• Compress, aggregate, categorize, and structure information	Ackoff, 1967; Grise and Gallupe, 1999/2000; Hiltz and Turoff, 1985; Iselin, 1988; Koniger and Janowitz, 1995; Scammon, 1977
	• Visualization, the use of graphs	Chan, 2001; Meyer, 1998
	• Formalization of language	Galbraith, 1974
	• Brand names for information	Berghel, 1997
	• Form must follow function must follow usability	Herbig and Kramer, 1994
	• Simplify functionalities and design of products	Herbig and Kramer, 1994
	• Customization of information	Ansari and Mela, 2003; Berghel, 1997; Meglio and Kleiner, 1990
	• Intelligent interfaces	Bawden, 2001
	• Determine various versions of an information with various levels of detail and elaborate additional information that serves as summaries	Denning, 1982
	• Organize text with hypertext structures or gophers	Nelson, 2001
	• Interlink various information types (as internal with external information)	Denton, 2001; Meglio and Kleiner, 1990
Task and process parameters	• Standardize operating procedures	Bawden, 2001; Schneider, 1987; Schick et al., 1990
	• Define decision models developed for specific decision processes (e.g., decision rules)	Ackoff, 1967; Chewning and Harrell, 1990
	• Install an exception-reporting system	Ackoff, 1967
	• Allow more time for task performance	Schick et al., 1990
	• Schedule uninterrupted blocks of time for completing critical work	Sorohan, 1994
	• Adequate selection of media for the task	Schick et al., 1990
	• Handle incoming information at once	Sorohan, 1994
	• Collaboration with information specialists within the teams	Edmunds and Morris, 2000
	• Bring decisions to where information exists when this information is qualitative and ambiguous	Galbraith, 1974
	• Install process enablers for cognitive support	Grise and Gallupe, 1999/2000
	• Use simpler information-processing strategies	Schick et al., 1990

(Continued on next page)

Figure 16. Countermeasures to information overload - Part 1

(Eppler and Mengis, 2004)

	Countermeasures	Reference
	• Regulate the rate of information flow	Grise and Gallupe, 1999, 2000
	• Search procedures and strategy	Ackoff, 1967; Bawden, 2001; Meyer, 1998; Olsen et al., 1998; Revsine, 1970
	• Define specific, clear goals for the information in order to contextualize it and turn it meaningful	Baldacchino et al., 2002; Denton, 2001; Meglio and Kleiner 1990
	• Communicate information needs to providers	Meglio and Kleiner, 1990
	• Provide incentives that are directly related with decisions in order to make decision relevant information be processed more effectively	Tuttle and Burton, 1999
	• Install a measurement system for information quality	Denton, 2001
Organizational design	• Coordination through interlinked units	Tushman and Nadler, 1978
	• Augment info processing capacity through chances in org. design	Galbraith, 1974; Schick et al., 1990; Tushman and Nadler, 1978
	• Creation of lateral relationships (integrate roles, create liaisons between roles, teamwork etc.)	Galbraith, 1974
	• Coordination by goal setting, hierarchy, and rules depending on frequency of exceptions (uncertainty)	Galbraith, 1974
	• Creation of self-contained tasks (reduced division of labor, authority structures based on output categories) → autonomous groups	Galbraith, 1974
	• Reduce divergence among people (e.g., with regard to expectations) trough socialization (e.g., frequent face-to-face interactions)	Schneider, 1987
	• Install appropriate measures of performance	Ackoff, 1967
	• Hire additional employees	Schick et al., 1990
	• Create slack resources	Galbraith, 1974
Information technology application	• Intelligent information management (prioritization)	Bawden, 2001; Meyer, 1998; Schick et al., 1990
	• Install voting structures to make users evaluate the information	Denning, 1982; Hiltz and Turoff, 1985
	• Prefer push to pull technologies	Edmunds and Morris, 2000; Denning, 1982; Friedmann, 1977; Herbig and Kramer, 1994
	• Facilitator support through (e-)tools	Grise and Gallupe, 1999, 2000
	• Decision support systems should reduce a large set of alternatives to a manageable size	Cook, 1993
	• Use natural language processing systems (search with artificial intelligence)	Nelson, 2001
	• Information quality filters	Ackoff, 1967; Bawden, 2001; Denning, 1982; Edmunds and Morris, 2000; Grise and Gallupe, 1999, 2000; Hiltz and Turoff, 1985; Jones, 1997
	• Intelligent data selectors (intelligent agents)	Berghel, 1997; Edmunds and Morris, 2000; Maes, 1994
	• Use systems that offer various information organization options (e.g. filing systems)	Hiltz and Turoff, 1985; Sorohan, 1994

Figure 17. Countermeasures to information overload - Part 2

(Eppler and Mengis, 2004)

2.5 Summary remarks

This chapter introduces the foundations of information-based environments, whereby information is described by organisations as a commodity of grouped data objects. Further, it suggests that once information is transformed through information workers' tacit knowledge becoming explicit, it then becomes more than just a collection of data objects, but is a knowledge document in itself. Highlighted are the problems and issues surrounding the literature which focuses on either information or knowledge management, for it is proposed that an entirely new title should replace and encompass both domains since there seems to be so much ambiguity in the literature over the term's use. It suggests the major issue affecting organisations is the topic of information overload. It further points out, that this is a real problem for knowledge workers, as it is physical in nature being attributed to symptoms, culminating from stress, frustration and a feeling of helplessness due to deficiencies in the electronic workspace. Specifically, the chapter highlights the significant flaw in file hierarchical structures of too much information compounded by unique cognitive patterns for knowledge worker profiles in organising these. The key finding of the chapter is the need for full unification of the activity space by it providing closer integration between tools that are used in the generation of information and those which are used in the management of information documents.

Chapter 3: Finding Information and Knowledge

3.1 Approaches to finding information

It is now believed (Bourne, 2004) that organisations are in document chaos, where knowledge workers labour on duplicate information documents or folder structures and constantly reproduce similar data sources through the failings of current technologies to make better sense of this information or to provide it in timely formats that are useful (Edmunds and Morris, 2000). As an example, over 81% of knowledge workers keep a copy (Bourne, 2004) of every iteration of a document and 63% of documents are created from previous (Bourne, 2004) version templates. Indeed, even though all these failings exist, managers still believe (Edmunds and Morris, 2000) that they are not getting all the required information they need to do their jobs. Therefore as Teitelbaum-Kronish (1985) suggest, by enhancing the usability of current system features to supplant or augment the knowledge worker's own cognitive process, this would greatly improve upon the current searching situation (Allen, 1992).

3.2 Multi-repository desktop information search

The concept of searching document objects based on their metadata tags is not limited to that of Internet-based search engines, as recently the same technologies are being applied to computer-based operating system desktops (Figure 18) for the local file system hierarchy of data.

Figure 18. Mac OS X 10.4 Tiger showing the Spotlight feature initiated from the desktop (Apple, 2006)

Indeed, as seen later, some hybrid search tools (Eppler, 2000) like Groxis Grokker (Figure 30) even incorporate these local file system results into their single search window as another repository, rather than separating them out as seen with similar Google or Microsoft technologies, thereby adding value. In April 2005 Apple released a new desktop technology with their Mac OS X 10.4 Tiger (Apple, 2006) operating system with a feature directly integrated into it called Spotlight (Figure 19) with the aim of making searching much easier for the knowledge worker. It was the first time that search had been seen as being a key pillar of any operating system, as until this point technologies were based around metadata tagging, or so called desktop search tools. These needed to be installed as third party additions to the operating system, and are notably seen with rival Microsoft and Google technologies. What was novel about Spotlight was it was the first fully integrated, fast, and efficient search tool, based on Internet search keyword context technology, to be included across all files within an operating system. The architectural model (Figure 20) placed the Spotlight search pillar as being between that of the applications and the underlying file system and in doing so, ensured that every file was always properly indexed, catalogued, and readily accessible, in the background, for whenever the search query might be issued. This meant there was very little delay or performance loss, either from a search initiated from inside an application or from the operating system (Figure 19) presentation layer (desktop). According to Apple (2006) the layers illustrated in Figure 20 are:

- a database consisting of a high-performance metadata store and content index that is fully integrated into the file system
- Application Programmable Interfaces (API) that are part of the standard frameworks enable querying of the metadata store and content index
- a set of importer plug-ins that are used to populate the metadata store and content index with information about the files on the file system
- a plug-in API allowing metadata and content to be indexed for third party application-based custom file formats

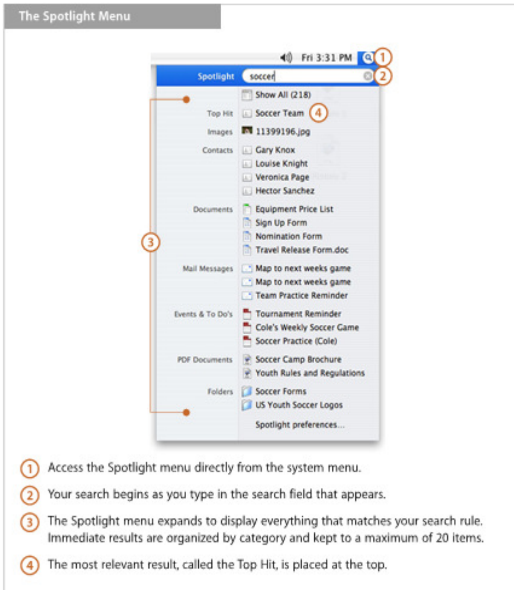


Figure 19. Mac OS X 10.4 Tiger showing the Spotlight feature options menu (Apple, 2006)

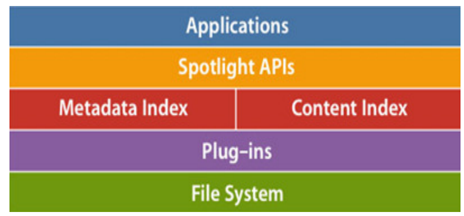


Figure 20. Mac OS X 10.4 Tiger showing the Spotlight Architecture (Apple, 2006)

Spotlight, although stated as being revolutionary (Apple, 2006), is inheritably just another response in making sense of the vast array of files/folder repositories which exist within the file system hierarchy. It bypasses the structure originally put in place by the knowledge worker for remembering certain document locations. It is still, therefore, only a keyword driven system that must always be initiated by the knowledge worker. This architecture (Figure 20) clearly shows that at the present time organisations are only focusing on a layer for bypassing the file system, instead of concentrating on the file hierarchy itself and redesigning or linking this in a better way to the presentation layer.

Presently, knowledge workers in addition to searching, will also '*manually tag*' (Mehta, 2001) documents, a term also used for marking information in some way for processing at a later date. This method for finding data can be seen if a knowledge worker copies a set of documents into a named folder within a hierarchy for the purpose of creating a new single document from it, or alternatively through grouped bookmarked pages from the Internet.

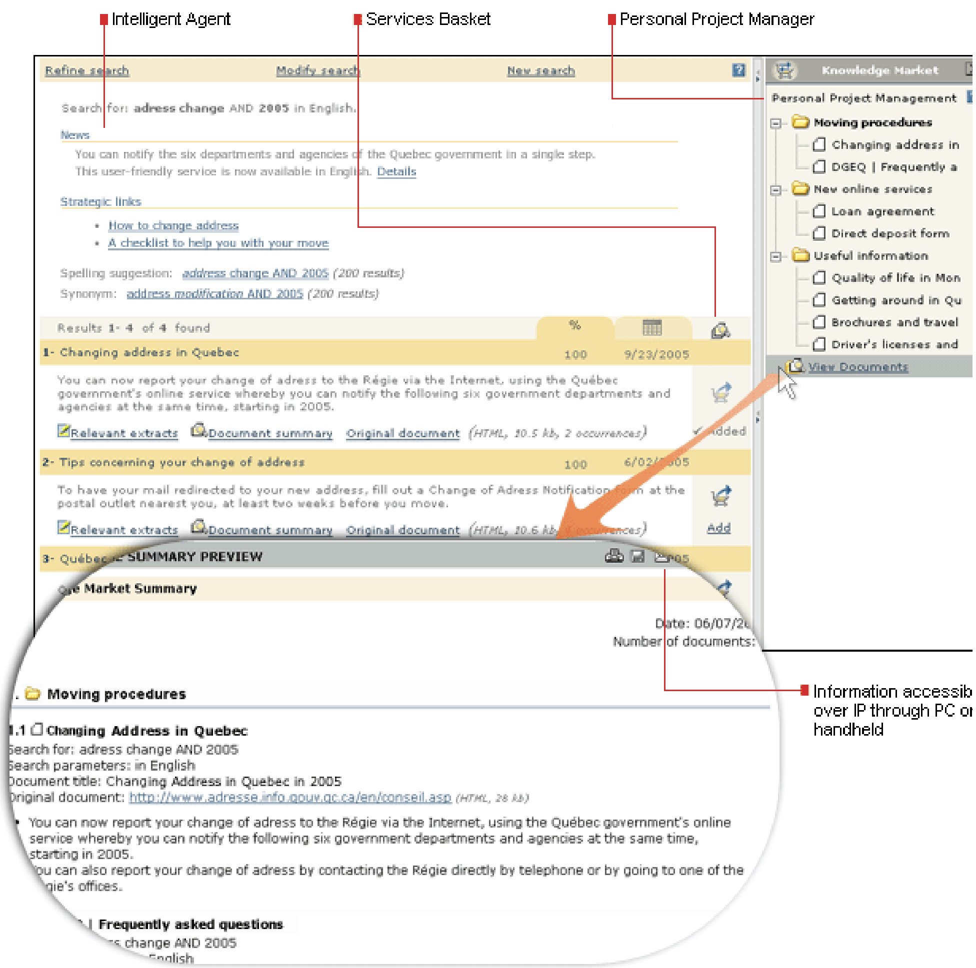


Figure 21. Delphes Portal for organising corporate knowledge using intelligent agents (Delphes, 2006)

However, this approach quickly breaks down due to the expense of time in being methodical. Inconsistencies and variable quality of the data are obtained, and are included in their common created document. In addition, it is very labour intensive to selectively find the right level of consistent information from each individual data source, for this process in itself adds yet again to the information overload problem.

3.3 Value-added information search

Thus, technologies are needed that would facilitate tools to provide value-added information (Edmunds and Morris, 2000). In other words, tools which judge and filter (Badenock *et al.*, 1994) the quality of the information automatically and push it to the knowledge worker. These tools, known as '*intelligent agents*' (Edmunds and Morris, 2000) (Figure 21) and Rich Site

Summary (RSS) XML syndication aggregators (Figure 22 and Figure 23) would automatically process and organise corporate information (Mehta, 2001) by allowing knowledge workers to find what they need in a single activity space location (Figure 22 and Figure 23). According to Eppler (2000), this reduces the complexity of the viewed results by organising them through categorisation techniques that make options for action systematically visible. This would remove the need to store these documents and to toggle or to multitask between different documents. Intelligent agents, according to Edmunds and Morris (2000), scan and comprehend text by classifying and summarising automatically before routing it back to the appropriate knowledge worker's activity space.

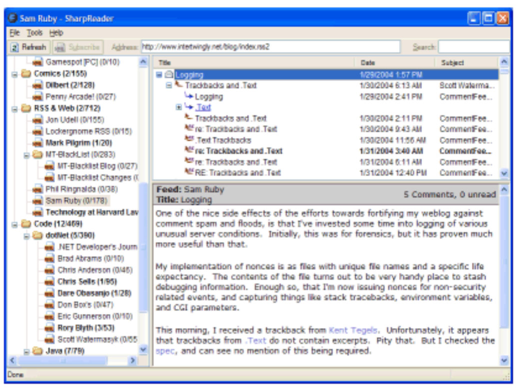


Figure 22. Rich Site Summary (RSS) reader (Hutteman, 2006)

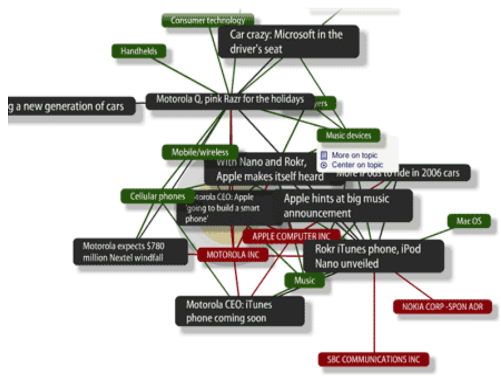


Figure 23. LivePicture Discovery Engine showing associated topics (CNET, 2006)

Natural language processing systems, according to Nelson (1995), use artificial intelligence algorithmic methodologies to search for relevant information. These systems generally find information based on the relationship between the content of the available data and the knowledge worker's query interest. According to Nelson (1995), such systems use sophisticated techniques to search and prune the information datasets and return filtered, highly relevant information, back to the knowledge worker. It is suggested by Pereira and Costa (2000) that these multi-agent adaptive systems are a better alternative to standard search engines as online agents do not suffer from any scalability problems since they search the current environment and dynamically adapt to changes both in the information resources and the interests of the knowledge worker.

An Intelligent Agent can be configured for an Internet Portal (Figure 21) using one or more pre-selected documents containing promotional or other targeted information. Whenever a query relates to a concept matching any information contained within the pre-selected document, those alongside or other related document links will be automatically presented

(Figure 21) and summarised back to the knowledge worker in a specific fully customisable section. According to Mehta (2001), automated classification involves three specific tasks:

- building a customised hierarchy for information
- classifying documents quickly and accurately into this information hierarchy
- presenting documents based on these classifications as knowledge workers need them

Intelligent agents act with full autonomy by making decisions on the basis of data they acquire about their environment, rather than as a direct result of knowledge worker instruction. According to Belfourd and Furner (1997), the facility to learn about individual personal information preferences gradually enables these tools to pre-predict the likelihood of certain data items being required and so reduces the time needed by suggesting these to the knowledge worker. However, these systems are not infallible, for they may assume incorrect meanings behind a search word or phrase, with multiple meanings being interpreted wrongly according to the first occurrence. Nevertheless, as Edmunds and Morris (2000) further assert, the benefits of saving time outweighs any lack of control and unreliability in using intelligent search agents. An ideal approach (Mehta, 2001) would be to automate all three tasks while allowing knowledge worker judgement to guide the process where appropriate. However, according to Pereira and Costa (2000, the disadvantage of this approach is that the knowledge worker will have to wait longer before relevant information can be retrieved. However, Curtis & Rosenberg (cited in Nelson, 1995) point out that an individual must be willing to sacrifice time (instantaneous response) in order to allow the possibility of greater accuracy of retrieval.

3.4 Visual information search

Analysing a document like a web page to find patterns and structures within it is just one approach to establishing the context and use of a document (Chalmers *et al*., 1998). Another potentially viable approach is for objects other than text (like video or images) to have pattern recognition applied to them (Figure 24), unlike similar image search engine options which exist, such as that of Google Image Search (Google, 2006), which employs a search on the image name, file size or type. This actually analyses the image pixels intelligently for subtle differences. Although some literature dismisses this technology as it exists at present (Nielsen, 1995), in recent years image recognition has been used for analysing the texture within images for detecting the presence of three-dimensional human bodies in such areas as swimming pools through systems such as Poseidon (Vision_IQ, 2006). Recently this has even saved the life of a child in a swimming pool in the UK (B.B.C., 2005) by raising an alert to the lifeguards. Indeed, recent promising work (SearchTools_Consulting, 2003, Funkhouser *et al.*, 2003) is investigating the use of pattern recognition techniques for search engines by performing a query (Figure 25) where knowledge workers choose either a 2D/3D image or draw an outline which is similar to that of the desired image. Then the engine does a pattern recognition search using global/local comparisons of colour, shape or texture. Although this is still experimental, companies such as Google have implied that they are working at this as a possible replacement or supplement for their online Image Search sections at a later date.

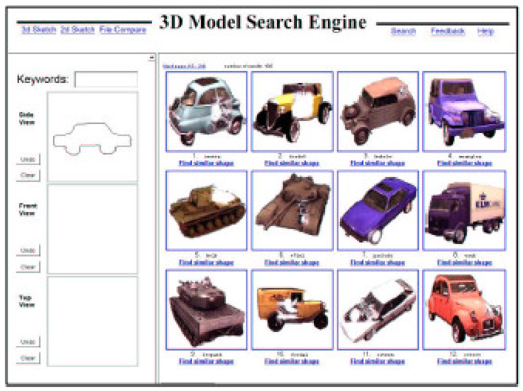


Figure 24. Search engine for 3D models
(Funkhouser *et al.*, 2003)

The benefit according to Nielsen (1995) is that since humans are very visually orientated, they often rely on images to remember things, and image-based searches might well be a very useful supplement to text and attribute-based search engines. However, until these technologies, specifically the algorithms, are developed beyond just research builds/projects and incorporated directly into text search engines, simple ways need to be used for categorising or mining documents to understand their usefulness.

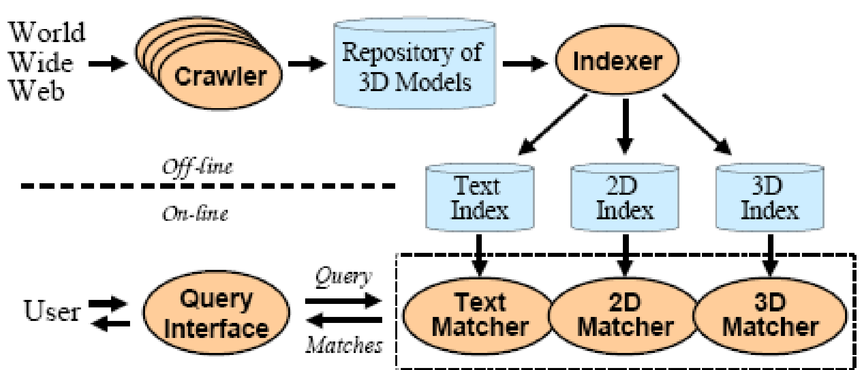


Figure 25. Knowledge worker image search engine query approach
(Funkhouser *et al.*, 2003)

3.5 Clustering and categorising information

In order to cluster information in a meaningful way, it must be monitored or tracked so as to understand what knowledge workers do from one query to the next, but this can lead to issues over excessive invasions of privacy (B.B.C., 2006, Chalmers *et al.*, 1998). Technologies such as customised Internet browsers, toolbars, cookies and/or spyware, will do this tracking automatically for they will monitor the web activity of knowledge workers, classify web pages according to their subject, search the web for additional pages related to subjects the knowledge worker has browsed, and add links to subsequently accessed pages that suggest additional pages of interest (Barrett *et al.*, 1997, Lieberman, 1997), is a similar system that records the URLs chosen by knowledge workers and adaptively maintains a knowledge worker's profile based on word frequencies in accessed pages. Each time a knowledge worker moves to a new page, this system (Lieberman, 1997) searches outward from the page's contained links and looks for nearby pages that match the knowledge worker profile. However, these systems, according to Chalmers *et al.* (1998), are constrained by the difficulties of clustering and categorisation, and are limited only to textual data.

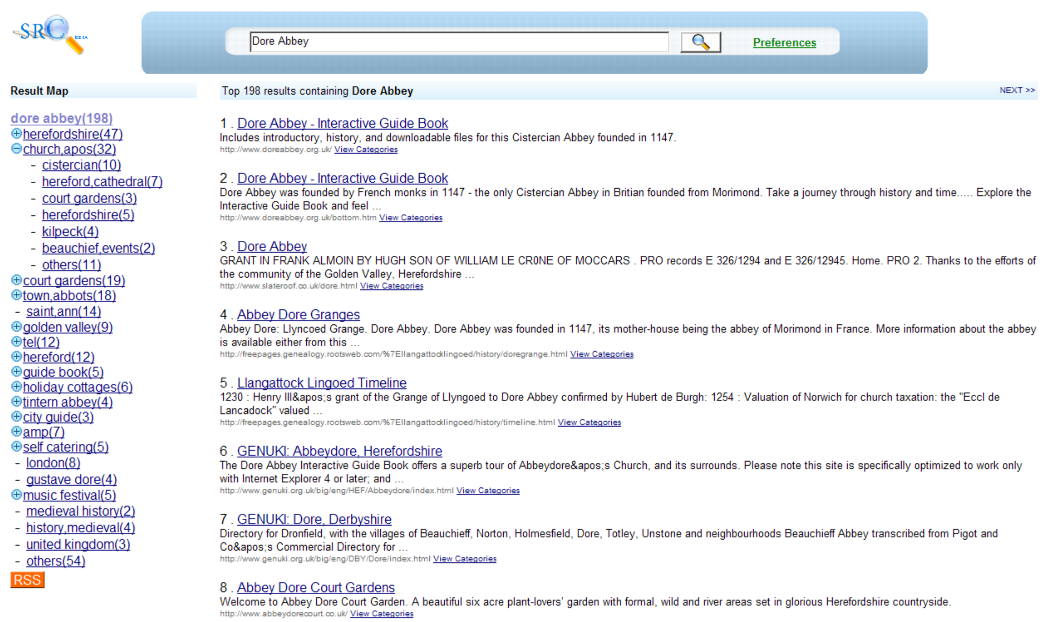


Figure 26. Search Result Clustering (SRC) searches the Internet using a clustering technique (Microsoft, 2006a)

Microsoft has developed an experimental tool (Zeng *et al.*, 2004) for searching the Internet which looks at the very issue of clustering search results. The difference between this and something like Google is that it provides on-the-fly clustered search results as different groups and provides meaningful names for these items. It then represents these pages, as in Figure

26, in a non-linear way, where a uniquely tailored hierarchy of clustered category pages is created on the left. The novelty of the algorithm technology behind this is that it tries to first identify salient topics by identifying distinct and independent keywords, and then classifies these search results into the given topics.

According to Norman (1991) a visual hierarchy with clustered or chunked groupings facilitates better visual navigation. He further suggests that the content and structure of these grouping could be made even clearer with no more than seven blocks of information paragraphs per page and the use of customisable labels on groups of related items, such as headings, which concisely characterise the relevance of the group based on the knowledge workers' task query.

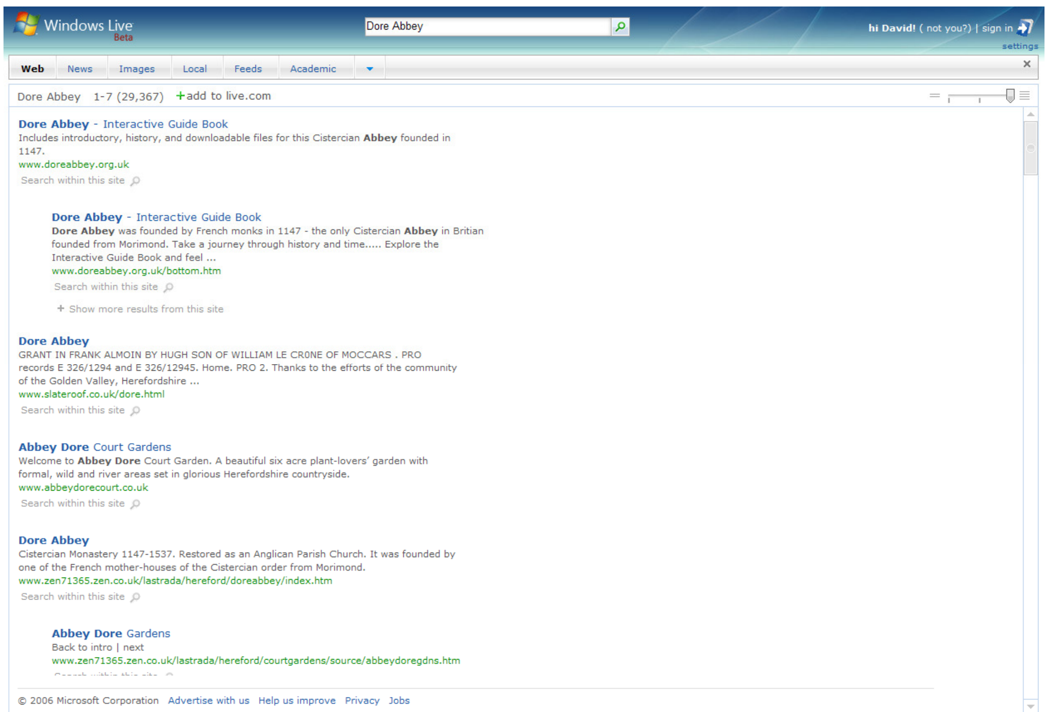


Figure 27. Live Search showing a standard results query page (Microsoft, 2006b)

As a standalone technology for searching text only, and in direct comparison to Google, it does mean that the knowledge worker can quickly cross-reference and drill down to the specific document enabling them to compare a large set of information simultaneously (Eppler, 2000) by using a combination of both the category hierarchy tree and the page listings. However, other technologies, such as Microsoft Live Search (Figure 27), which manipulates in real-time desired search values or the level detail of search results, seem to be more useful from a usability viewpoint. It is suggested that perhaps by combining these two technologies they would together provide a better results engine, especially since in Figure 27 there is vast amount of wasted space on the right (although it is a beta tool and subsequent versions might use this space for advertising), which in desktop search mode is used for previewing documents as in Figure 28. A combination of both the preview feature in Figure 28 for documents and the clustering hierarchy technique in Figure 26, coupled with further real-time options would greatly enhance a single metadata hybrid tool to augment today's search engines.

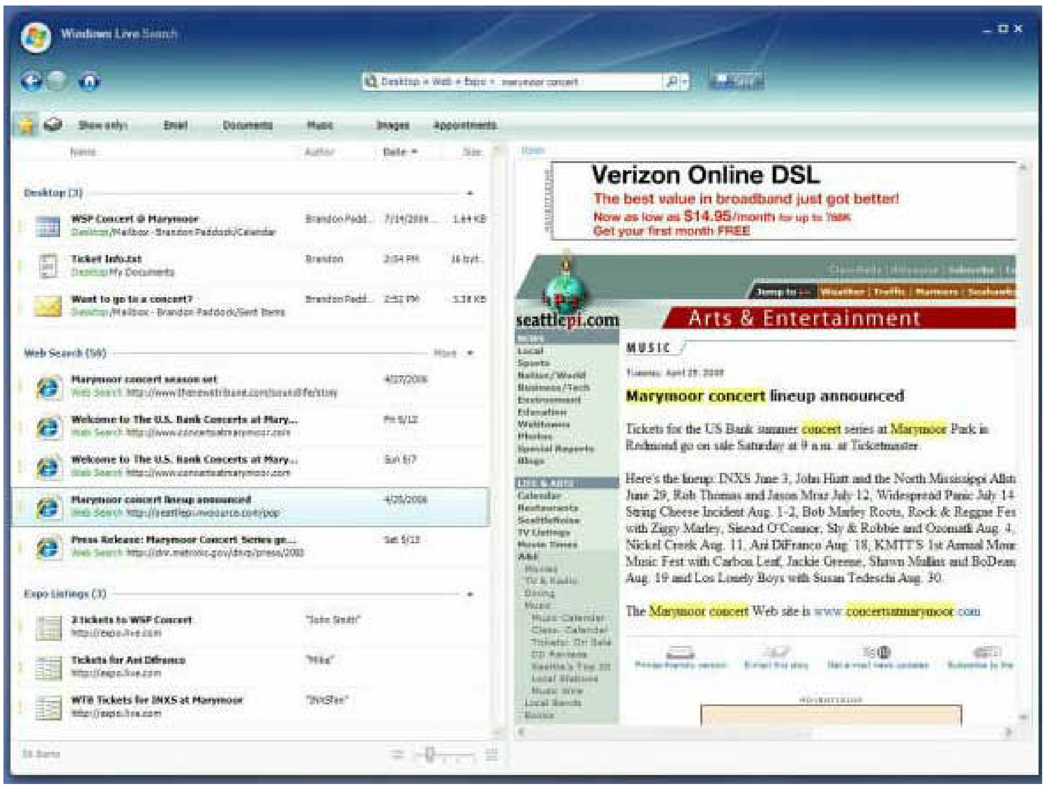


Figure 28. Microsoft Live Search showing a standard results query page (Microsoft, 2006b)

Grokker (Groxis, 2005) is an early example of a such a hybrid metadata search tool as it integrates data mining capabilities to establish links between data sources through clustering results by source or by the data itself. It is very similar to that of the Microsoft Research Search Result Clustering tool (Zeng *et al.*, 2004, Microsoft, 2006a) although it can also pool together a wider set of data simultaneously from both external information sources such as local or disparate file systems. In addition, it can access several Internet search engines at once, presenting these results back as a single page using both a visual map (Figure 30) and traditional text-based format (Figure 29) for formatting them. It can even integrate directly with the Google Search Appliances (Figure 19) as an embedded tool for organisations wanting to mine this data more visually, but securely, only within the corporate network. The advantages of tools such as this is the tabbed approach and the single screen with aggregated data based upon the subject categories or sources and the visual approach to mining the related data areas (Figure 32) as it provides a better means of showing patterns between data.

There is ongoing research attempting to build a perfect search, where the ideal is that it returns the exact information which is sought given a fully specified information requirement (Teevan *et al*., 2004). These attempts have sought to improve the keyword search by permitting knowledge workers to specify their requirement through metadata (Yee *et al.*, 2003), natural language (Lin *et al*., 2003), and even context (Lawrence and Giles, 2000), although this perfect search has still yet to be realised.

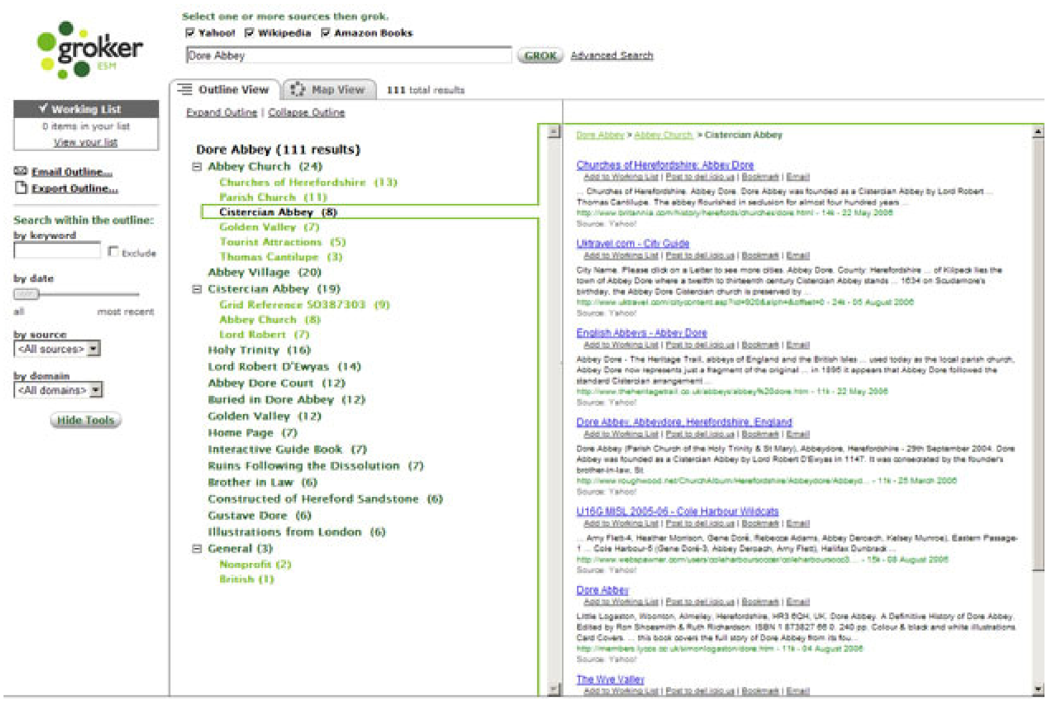


Figure 29. Grokker showing the outline view of categories and query results (Groxis, 2005)

In a recent announcement (Lombardi, 2006) it seems that further hybrid tools based on these, coupled with analysing search relevance, could well be on the horizon, where these would focus on the ways knowledge workers browse through specific content in order to improve the algorithms used to rank results. The key to this technology is that the results are tailored to an individual knowledge worker's profile. Bates (1989) and Belkin (1993) envisioned the idea where a search interface would allow knowledge workers to modify and refine their queries as their information needs evolved over time, thus modelling a search profile based on the knowledge worker's activities rather than any single, static disposable search. A positive viewpoint for such tracking-based systems, as opposed to the querying-based alternatives, is that these are passive in operation, so they avoid using querying languages to function and naturally become more precise over time.

The problem with search engines in general, such as in Figure 27, is that they are unnatural ways of interacting with the world. In everyday life, according to Chalmers *et al.* (1998), knowledge workers are able to move through information, to understand what they hear and see, and to speak and act in the world, without requiring formal plans or descriptions of their behaviour (Nardi, 1996, Suchman, 1987). Nardi, 1996, Suchman, 1987) go on to say that knowledge workers '*do not, and generally can not, describe their work in coefficients and classifications valid for all situations at all times'*. A good analogy (Open_University, 1996) is the number of times in real life that knowledge workers have to return to the basement of a hotel in order to go to another adjacent room. In other words, it is saying that the basement is the operation to get to the place and the hotel room is the presentation world or desktop. Knowledge workers want to go from room to room freely, without having to search using the basement function each time in order to find the path to do this.

Personal profiles of interest, based on a given subject matter, can be tracked through personalised recommendations (Chalmers *et al.*, 1998) such as subject objects or links. It is an iterative process of being presented with objects and a rating given at the same time to the knowledge worker based on the related frequency of the content with which they are presented. Over time the accuracy of the system increases, as it starts to anticipate more and more the correct results, based on the knowledge worker's behavioural profile. This is the basis of a more collaborative type of social filtering, known as communities of practice, as suggested by Goldberg *et al.* (1992). In these interlinked and shared tracking systems, the relevance of information is defined from the point of view of a particular set of individuals. The results of a single person's categorisation is then shared by all, but not tailored specifically to any particular person or situation (Chalmers *et al.*, 1998). This according to Chalmers *et al.* (1998), allows complex, heterogeneous data to be handled because it does not have to measure similarity based on profiles with the content or objects, but provides a simple rating system based on only the information provided. It is pointed out (Chalmers *et al.*, 1998) that the use of such systems is extremely subjective as amalgamated profiles of manually selected individual objects, provide little to no associations either temporal or otherwise, between the individuals' different ratings. Consequently there is no context in which to tailor recommendations to a particular knowledge worker's current activities. Thus path modelling needs to be used in order to try and readdress this imbalance.

According to Chalmers *et al.* (1998), early work on path modelling arose out of making layouts or maps of complex information (Chalmers, 1996), where they were presented with direct interaction in both a 3D map (Chalmers *et al.*, 1996) and a 2D map (Brodbeck *et al.*, 1997) format. The results of this work suggest that useful patterns are often found in information sets when they are viewed using these specific abstraction methods, since they provide a view which is more fluid and visual than that of the rigid formal classification hierarchical methods underlying similarity metrics. As a result they are more difficult to understand.

Figure 30. Grokker showing the map view of categories and query results (Groxis, 2005)

One such tool that employs this path modelling to visualise data is Groxis Grokker (Groxis, 2005), as discussed earlier. It has (Figure 30) squares which represent single files, and circle colours representing the age of the data, with blue representing old cold data and red showing newer hot data. Further information is shown if the cursor hovers inside these circles, such as the item count, the size of the largest item and the latest modification date. File systems can be accessed in search or browse modes, with browse mode giving a total file system view, while search mode can be used to find specific files.

3.6 Path modelling theory

Hillier (1996) identifies a path modelling theory resonant with '*As We May Think*' (Bush, 1996). This led to Bush writing of human 'trail blazers' constructing paths through bodies of information, thus representing similarities or associations, which he calls '*space syntax*' as applied to architectural and urban forms. This new theory addresses the concept of putting movement and visibility at the centre of structural development for cities, where it emphasises the importance of considering the extended paths that people take, rather than the short steps between city elements. It uses people's paths through a city as a basis for their expressions, activities, interests, and associations, where Hillier deliberately avoids any prior categorisation of structures but instead relies on building up statistical trends of movement and activity. The paths people made were not just pair wise links, but could span any number of objects, which reinforces the view that paths are objects of utility and have value unto themselves (Chalmers *et al.*, 1998). Hiller however ignores the value of paths as compound objects. Instead he focuses on the pair wise links and the great number of possible connections which could be made from any given point. Thereby, he established that the significance of the entire path is about anticipating and constructing the particular sequence of links or path required from any given point.

This theory reflects well with what is required for profiling search engines which use a passive tracking based capability. Indeed Chalmers *et al.* (1998), suggest that if information objects are treated like Hillier's urban spaces, where if the names or identifiers of the information objects are moved through, they are continually logged which builds up a path representing past activity. Therefore Chalmers *et al.* (1998) conclude that '*if one contributes to a configuration of paths, shared by a community, then one helps to build up a continually evolving set of paths and, consequently, their relative similarities'*. Chalmers *et al.* (1998) again continue that this could therefore be a contiguous substring or segment at the end of the full path and thus it is possible to find similar segments earlier in that path or in the paths of others. Thus, what both Chalmers *et al.* (1998) and Hillier (1996) are eluding to is that objects that consistently arise within those segments but have not recently been visited, can be presented as recommendations. The greater the community which shares these profiles of tracked paths the more efficient the technology will become at predicting more accurate recommendations for people's paths. It is suggested that this, in conjunction with a combination of the other search technologies as discussed, would provide a more intuitive layer for managing knowledge workers' information if the entire file system hierarchy was in some way to adapt accordingly to the trends or patterns of the knowledge workers moving through the information.

3.7 Improving the effectiveness of information retrieval

It is apparent that there are several layers to the information overload problem when related to finding information, which go well beyond the underlying technologies. According to Nielsen (1995), it is necessary for a good knowledge worker to have good editorial preparation skills for handling data, resulting in the ability to rapidly skim or find the information sources and to pick out or recall the exact pieces of interest. This conclusion comes out of popular model studies by Gonzales (1994) and Belkin and Croft (1992a, 1992b) used for measuring the effectiveness of information retrieval by recalling with recognition and with recall with precision:

- humans have a working memory limited to five to seven chunks of information
- humans must have their attention refreshed frequently
- recalling information requires more cognitive effort than recognising information

Belkin and Croft (1992a, 1992b) further extrapolates this, by suggesting that '*recall is the proportion of all relevant documents that are actually retrieved, whilst precision is the proportion of a retrieved set of documents that are actually relevant'*.

The first model according to Nelson (1995), suggests that systems should accommodate human limitation, by maximising the need to recognise useful information as opposed to recalling it. This would therefore indicate that systems which use menus are more effective and knowledge worker-friendly that those which require knowledge of particular commands (Large, 1984). The second model according to Nelson (1995) considers how accurate a system is at retrieving relevant documents. It suggests that a system is not very usable if a person must exert significant effort in order to retrieve relevant documents or discard irrelevant ones. Accurate document selection is thus an important factor in determining the usability of an entire system as a whole for finding relevant information (Belkin and Croft, 1992a, 1992b).

Information retrieval is normally undertaken by knowledge workers, when they are looking for a certain piece of data that goes towards a larger document, whereas filtering is done as a continuous activity, with knowledge workers being kept informed about certain events or snippets of information (Belkin and Croft, 1992b, 1992ab). In this situation, very clear intuitive navigation mechanisms are fundamental elements of a usable information space. This space should be small enough to be covered exhaustively but familiar enough for the knowledge worker to find his/her way around (Nielsen, 1995) without any confusion. Miller (1962) found that individuals tended to focus on filtering or omitting (ignoring) information and suggests that this was a primary coping mechanism for high rates of information overload wherever the spaces were too large or had ineffective navigation. Therefore as Reffell and Waterson (2001) point out, it is the quality and appropriateness of received information that are crucial to these spaces, rather than the quantity. Thus, in this case the navigation mechanisms, which are used first to filter and then enable traversing of this information, are highly significant factors to determine if knowledge workers become overloaded or not. A possible suggestion is that these interfaces should present grouped or chunked snippets of information, rather than just a long list which make the knowledge worker apprehensive or even stressed.

According to the literature (Lang, 1996, Crosby-Muilenburg, 1999, Bawden, 2001, Meyer, 1998, Schick *et al.*, 1990, Ackoff, 1967, Edmunds and Morris, 2000, Grise and Gallupe, 1999/2000, Cook, 1993) knowledge workers should consider incorporating the following technology related points:

- plan for the long and short range projects
- prioritise tasks and communication
- group similar tasks and perform them in blocks
- use intelligent agent filters for email (knowledge worker-defined)
- use intelligent agents for searching the web and set up profiles with services
- learn what to look for and know when enough is enough
- consolidate sources into mediums that are compatible with many different tools
- filter and categorise messages or information already seen
- have unlimited storage so would not have to delete
- flag alerts for messages that need immediate attention
- sort the information, nice to know, need to know and need to do
- incorporate decision support systems which reduce a large set of options

Indeed, the literature goes on to say that the following physical workspace counter measures should also be incorporated for combating information overload symptoms:

- eliminate clutter
- reduce noise
- reduce interruptions
- surround yourself with colours and images
- discard paper with established retention schedule for documents
- use memory aids
- skim materials
- do one task at a time
- set up a universal in basket/mailbox that routes all deliveries

- multidimensional index and file using keywords, subjects, or concepts
- read and summarise information
- categorise items by action needed and add notes

3.8 Summary remarks

This chapter points out that a layer in the form of search technologies is often used between the presentation and file hierarchy layers in order to try and overcome deficiencies that occur in both of these areas. Alternatively, it suggests that 3D radical solutions are now being proposed, where little thought is considered towards the usefulness of these approaches. It suggests that aspects from present and future search engine technologies, such as intelligent agents, path modelling and content aggregators might all be possible ways of redefining the way that present day file systems are defined. In conclusion, it suggests that two aspects need to be considered for a future approach to combating information overload. These are first the cognitive issues relating to using the system in a physical sense - providing added knowledge value, and secondly, the information-based structuring/management issues in relation to holding this data.

Chapter 4: Information Workspace Visualisation

4.1 Traditional office information spaces

Prior to the information technology revolution (Palfreman and Swade, 1991) many traditional offices workspaces included specific features which can now be attributed as the metaphorical foundations of present-day computer information desktop interfaces. Metaphors are described by Baecker *et al.* (1995) as a means of comprehending a new target domain in terms of the source domain which a knowledge worker understands. This traditional office metaphor provides a useful basis for these desktop information interfaces due to the affordance of realising and organising tasks.

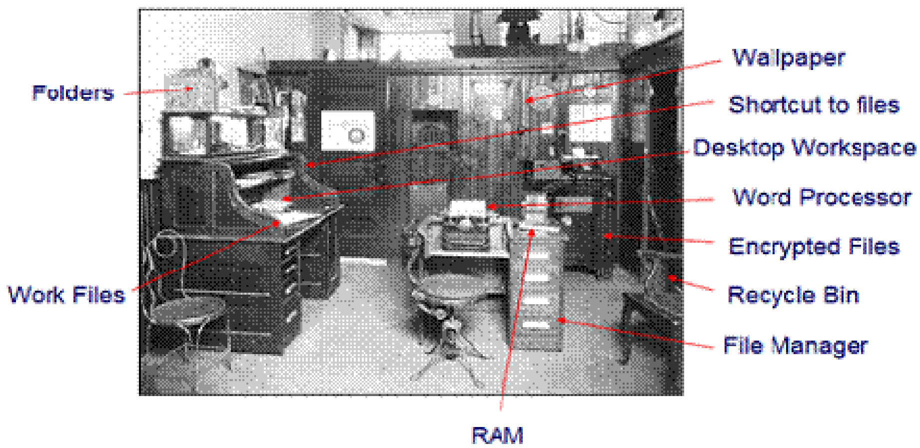


Figure 31. Computer attributes of a traditional office
(Utah_State_University, 2003)

As an example, a traditional office desk (Figure 31) can be described as a static piece of furniture intended to be used for organising documents as it cannot be a direct container for holding the written words on paper. Alternatively, paper is portable, can be cut, copied, stored, bound, filed or destroyed, thus providing an appropriate metaphor when applying it as a container for information. As illustrated in Figure 31, another computer-based metaphor could be RAM (Random Access Memory) which is illustrated in the physical world as sticky notes which serve as temporary containers for important mission critical information until such time as it can be transferred to a more permanent location. These examples are but a few instances of real world metaphors which have now been directly transcribed onto the computer desktop information workspace as mechanisms for interacting with data.

However, an argument could be postulated as to whether an information workspace that exists inside a computer-based interface in 2007, and utilises these metaphors, really does improve task efficiency over the traditional physical working environment. Certainly, it makes the office more compact and portable, akin to filing cabinets holding files, but does it really only serve as a new means of giving knowledge workers increased effort when organising their files? Reflecting on this question, as an example, a University library requires a careful index or catalogue to find a relevant book, but if these books are filed out of order on the shelf then the indexing structure will fail to achieve its intended goal as no one will find the book. Many other Information spaces in real life mirror this problem as they can be unfortunately large and unfamiliar and so require the use of queries to find information (Nielsen, 1995). This is mimicked in the electronic world through folders or notes being misplaced across the file system in either obscure or cognitively unidentifiable hierarchies.

Although storage issues have been rectified by computers in a traditional office through the use of hard disks or removable storage technologies, aspects such as index search tools for finding these documents are increasingly being relied upon (Chapter 3). Also, it could be argued that with limited space in a traditional office and also within early computer hard disk storage devices, it originally forced knowledge workers to be more organised or structured in their approach to filing regularly used documents. Erroneous data in both the traditional and computer-based office environment would therefore be kept to a minimum due to a premium on physical space. So, it is believed by this author, that there is an argument that physical world issues could also become the metaphors or indications of where desktop environments, which mimic these traditional environments, could go wrong in the future, thus becoming unintuitive. It is precisely these failings which are now becoming apparent and are now the subject of concern by organisations (Chase, 2002, Mehta, 2001, Bourne, 2004, B.B.C., 2004). Thus, an argument could be posed that a desktop information workspace, as it is designed in 2007, should reflect a radically new innovative approach, rather than relying solely upon the now rapidly aging office-desktop based metaphor.

4.2 Screen clutter and workspace management

The main cause for multitasking between tools (Figure 32), differing devices or screen notes and thus the root cause for screen clutter, according to Boardman *et al.* (2003), is the fact that knowledge worker production activities are distributed across a wide range of data sources which are used to accomplish a project. The lack of integration between devices and tools provides the side effect of multiple windows open (Figure 33) at the same time promoting screen clutter. To compound this, a majority of knowledge workers surveyed (Boardman *et al.*, 2003), described themselves as globally messy, suggesting that there is little organisation behind their strategy of opened tasks on screen, or generally because they do not wish to undertake the mundane task of managing these more productively.

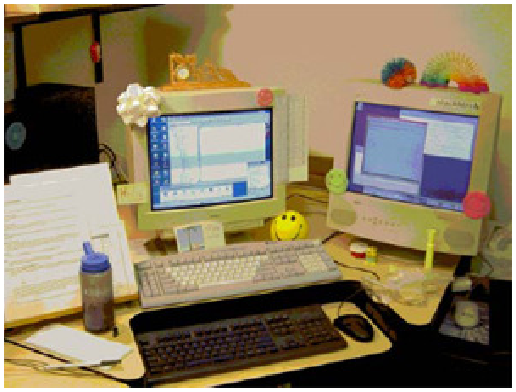


Figure 32. Physical office desk task-based clutter
(Hutchings and Stasko, 2003)

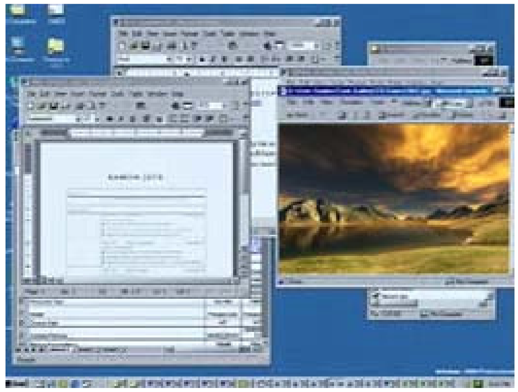


Figure 33. Windows 2000 desktop task-based clutter
(Microsoft, 2004a)

Gauging the effectiveness of how a knowledge worker undertakes their job under these circumstances, is therefore very hard for organisations, as according to Hutchings and Stasko (2003), it requires measuring how well the knowledge worker switches between tasks using the toolbar or Alt-tabs (Figure 43) whilst undertaking single or multiple activities. Thus, the how well is a significant challenge to quantify, as it is based on time to complete the task, the tidiness of the desktop and the speed at which the knowledge worker switches between multiple tasks at the same time as completing the selected benchmark task.

Also, it should be noted whether the results provided from Hutchings' study (Hutchings and Stasko, 2003) are truly representative of knowledge workers who use multiple large screen desktops concurrently, if they use only small screen devices, or if a combination of large/small screen devices is used to complete a single task. Additionally, it is pointed out (Hutchings and Stasko, 2003) that drawing parallels with the management of space in the real world may be unnecessary or even inefficient, as interacting with windows is now an event in itself.

What has dominated HCI over the last 25 years (Hutchings and Stasko, 2003) is that screen clutter may exist on one system, whilst it may be negligible on others. Thus, it is worth pointing out that the inherent problem is space management of these systems and the significant lack of mechanisms, such as a taskbar, employed in the efficient management of this space, empowering the knowledge worker. If a knowledge worker is left to their own devices, then they are apt to fill this space completely with task windows or switch between windows to get information from one window to interact with another. To combat this, knowledge workers tend to make use of prioritised quick launch icons (Hutchings and Stasko, 2003) which reside on the desktop or the taskbar, where knowledge workers select these to open related groups of documents, watch the status of aspects like print jobs, or open commonly used applications. However, often screen task windows cover these icons so that the task windows must be minimised before the knowledge worker can view the desktop. In which case, some knowledge workers tend to close or move windows around accordingly (Hutchings and Stasko, 2003), for no other reason than to reveal hidden screen icons or window tasks that have become unreadable. Thus, there should be safety/screen task mechanisms built into these interfaces, which automatically activate when task windows get above a certain number, or means employed which force the knowledge worker/window tasks to work with these workspaces uniformly and more productively, without detracting the knowledge worker from their task.

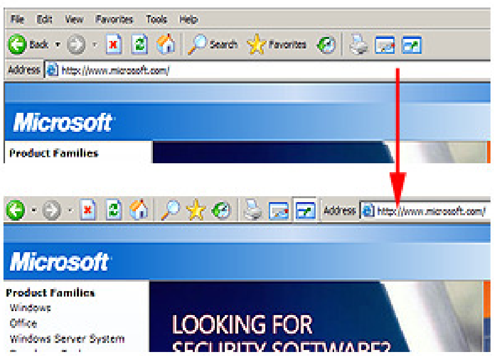


Figure 34. Internet Explorer 6.0 showing a Web page with the fullscreen option (Microsoft, 2002b)

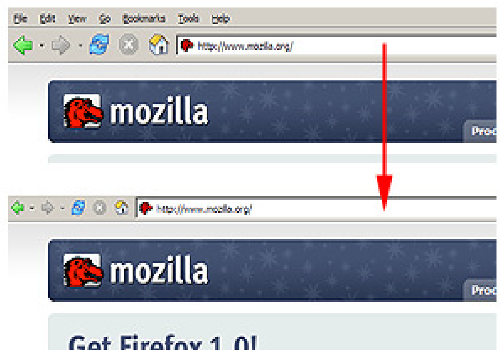


Figure 35. Mozilla Firefox 1.2 showing a Web page with the fullscreen option (Mozilla_Organization, 2004)

The restrictions of 14-24 inch desktops or palm style devices, mean that space is always at a premium. Thus over the years developers have devised innovative manually initiated screen mechanisms for utilising more space in the two-dimensional plane. Figure 34 and Figure 35 illustrate one such mechanism through the inclusion of a fullscreen feature that enables a knowledge worker to remove, or make smaller, unwanted menus or screen controls. Recent developments within tools such as Lotus Notes (Figure 36) and Firefox (Figure 37), have attempted to address the screen clutter problem associated with switching (Card and Henderson, 1987a, Hutchings and Stasko, 2003) tasks, by hosting all individual window tasks associated with an application inside a single taskbar button. This second screen mechanism enables separate windows which each contain many individual task windows or sessions. Indeed, they provide the ability to save entire, named, session tab groups, each containing individual session pages. However, once individual session tabs, or task windows, increase above a certain number, a knowledge worker has to again switch through these cluttered workspaces. Therefore, whilst there is an initial productivity gain at the start, this technology soon realises the same problems, as displayed in Figure 38.

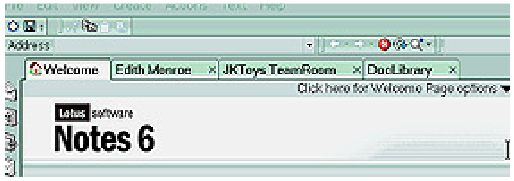


Figure 36. Lotus Notes 6 showing four multipage session tabs with one tab selected (IBM, 2005)

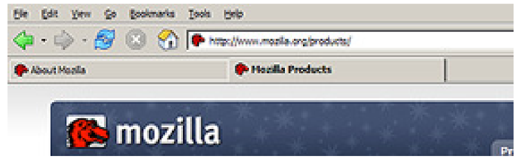


Figure 37. Mozilla Firefox 1.0 showing two multiple Web page session tabs with one tab selected (Mozilla_Organization, 2004)

Where modern operating systems now often fall down is in their scalability factor, that being the total volume of active application-based tasks increasing to a level where the GUI can no longer comfortably handle them. As an example, out of a project called GroupBar (Smith *et al.*, 2003), under Windows XP (Figure 38) an automatic solution has been to group eight or more similar tasks under their corresponding application task button or alternatively under Windows Vista where they are stacked as preview thumbnails (Figure 39), similar to the recent browser mechanism solution (Figure 36 and Figure 37).

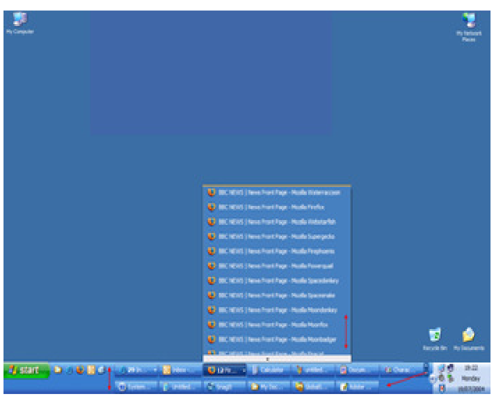


Figure 38. Windows XP desktop with taskbar list of active windows (Microsoft, 2002a)

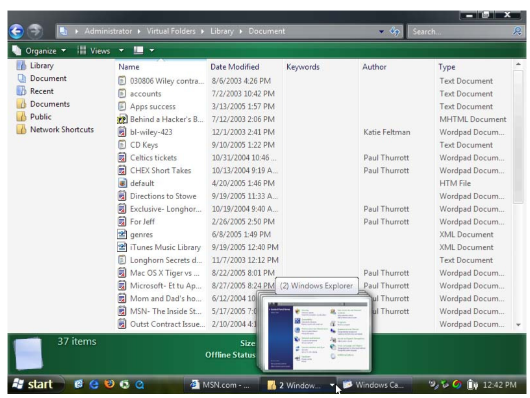


Figure 39. Windows Vista showing a stacked taskbar preview window pop-ups (Microsoft, 2005b)

Thus, when a knowledge worker wishes to select one item, he/she simply selects that button, resulting in a vertical list being displayed. However, even this has screen display issues when there are over twenty five or more, open application documents, especially if there are more than eight different applications open at once. Aspects such as scrolling through several separate taskbars of applications are then introduced, all of which make it increasingly harder for a knowledge worker to find the item they were working on, or the corresponding document(s) that are associated with it. MacOS X (Figure 40) suffers the same issues, as unlike Windows XP, it does not group tasks under their corresponding photographic icon. Instead it places a cluttered mixed set of tasks, varying upon when they were opened, along the task dock (Figure 41) at the bottom of the screen. The original application icons are then shunted to the left when a new task is introduced on the right hand side. This solution works well until, like Windows XP, there is an increase in the number of documents open at once.

Figure 40. MacOS X Panther desktop showing
the dock and application task icons
(Apple, 2004)

In this case, the solution mechanism provided in MacOS X is to reduce the scale of the icons and dock so that scrolling does not take place (Figure 41). However, if fifty or more tasks are open at once, this dock gets so small, that distinguishing the difference between icons at a glance is impossible; thus one solution that MacOS X endeavoured to incorporate to resolve this issue was that, when hovering over a task icon (Figure 42), an animated miniature preview is sized to something that is marginally readable.

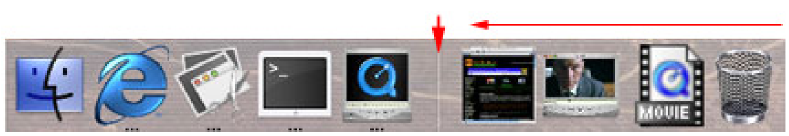


Figure 41. MacOS X showing the divided dock with applications (left)
and window tasks (right)
(Apple, 2004)

If again the number of open tasks increases above a certain number, this animated solution of finding tasks could easily become irritating and confusing, especially if a knowledge worker wants to find a specific task very fast. There is a final screen mechanism which therefore exists in both Windows XP and MacOS X which is provided as a shortcut in order to get to the desktop or a selected task window within one selection, without using the dock or taskbar. As seen in Figure 43, Windows XP has a pop-up window that sits above all other screen tasks, or alternatively a 3D stack is animated in Windows Vista (Figure 44) and enables a knowledge worker to Alt and tab using the keyboard, between task windows illustrated as icons.

Figure 42. MacOS X Panther showing the dock magnified as a cursor moves over an icon (Apple, 2004)

This technique also provides visual feedback in the form of a single screenshot of a selected icon window, where if it is the desired window, a simple release of the keyboard would then switch to it. Alternatively, visible on the taskbar (Figure 45) is a Show Desktop icon, which when selected by a mouse pointer, will then minimise or shrink from view, all windows tasks to their corresponding icon button on the taskbar.

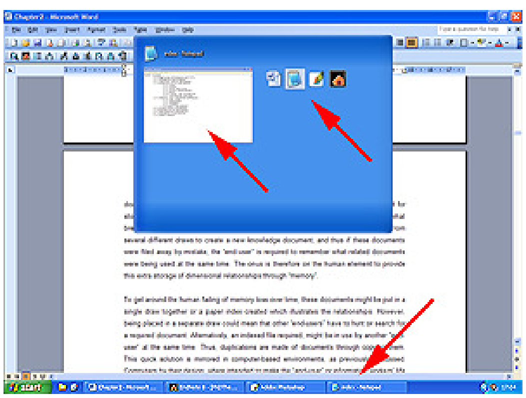


Figure 43. Windows XP 2D alt-tab for switching between open windows (Microsoft, 2002a)

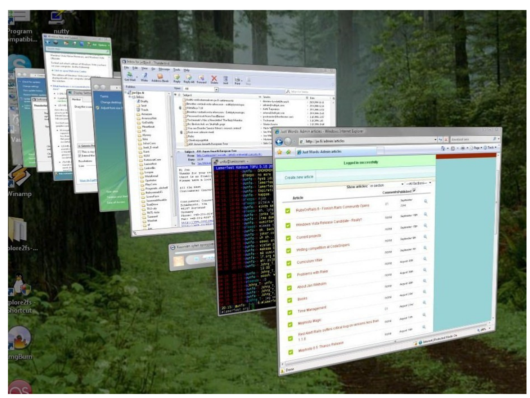


Figure 44. Windows Vista 3D alt-tab for switching between open windows (Thurrott, 2005)

Both these operations will speed up the time taken to get to the desktop or a selected task preview, but they still do not solve the issue of cluttered taskbars or desktops with numerous icons or shortcuts, as they simply provide an alternative selection method in a slightly modified form.

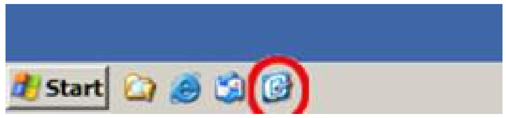


Figure 45. Windows XP illustrating the show desktop icon for minimising all open windows (Microsoft, 2002a)

MacOS X, on the other hand, provides a similar technique named Exposé (Figure 46, Figure 47 and Figure 48) for switching between task windows. However, this equivalent is significantly more advanced than Windows XP and at the same time uses a default means of interaction initiation through the keyboard. Although, it must be noted that the corners of the screen can be customised to start these functions as well, if required. Three keyboard function operations are intuitively available to a knowledge worker, that being the ability to view all open tasks as small sized windows (function key F9), the ability to tab between windows associated within a single application (function key F10) and lastly to minimise everything so the desktop is visible (function key F11). The Exposé feature is very similar to the technique described by Hutchings and Stasko (2002a) where the windows are arranged on various levels on the z axis so that they do not overlap and consume space of the desktop yielding space-filling tiles (Hutchings and Stasko, 2002a).

Figure 46. MacOS X Exposé - view open windows and change the front window using the F9 key (Apple, 2005b)

Figure 47. MacOS X Exposé - view open windows and tab between them using the F10 key (Apple, 2005b)

Figure 48. MacOS X Exposé - view desktop objects and drag files to an active application using the F11 key (Apple, 2005b)

However, these techniques on both systems, whilst comparatively similar, would not be needed if there was a more efficient way of handling screen tasks. What modern operating system desktops demonstrate clearly is that they are not scalable, when faced with coping (Warren, 2003) with vast numbers of open documents-based tasks. In addition, these information workspaces provide limited functionality for recording relationships when associating open documents or in conjunction with the stored files on the hard disk. In essence there are two separate, cognitively different, ways of viewing and managing documents. When looking at a physical world metaphor, it is like having a filing cabinet for storing files and a separate desk as the only means for viewing these. However, what breaks down in this instant is that a given task might use several stored documents from several different drawers to create a new information document, and thus if these documents were filed away by mistake, the knowledge worker is required to remember what related documents were being used at the same time. The onus is therefore on the human element to provide this extra storage of dimensional relationships through memory. It seems apparent that the failings of the current interfaces in their scalability factor are only now being addressed through limited extra mechanisms, which seem to be temporary measures in order to paper over the growing problem, instead of entirely rethinking and redesigning the multitasking concept.

4.3 Extending information spaces

Menus are ubiquitous and can also be considered synonymous with that of modem information workspaces such as operating systems or applications. The scope of the term menu, therefore, covers much more than simply a list of words or phrases (Lee and Raymond, 1993) as it covers anything which displays knowledge worker-selectable data. According to Lee and Raymond (1993) menu-driven systems share the following fundamental characteristics:

- they exploit recognition rather than recall through reducing memory load, promoting exploration and avoiding certain syntax errors
- they decouple the functions of input and display by presenting screens without a corresponding increase in input
- they are also concise if the terms are understood

Lee and Raymond (1993) further describe these systems as providing high information bandwidth for human perceptual systems whilst making maximum use of the low bandwidth for human motor systems. Thus, the evolution of present menu-based systems often arises out of the aspirations of designers wanting to make more usable interfaces within modern information workspaces.

There are numerous variations of menus, but at their simplest they provide a short vertical list of words or phrases either as a hierarchy or as a linear list. If the menu then takes up the entire display, it is normally termed '*a frame*' (Lee and Raymond, 1993). Menus can be static, dynamic or a combination of both, through application menu bars with pull down options which are dependent upon an intended purpose. According to Lee and Raymond (1993), a static menu occupies a fixed position and area of a screen for the duration of some activity, whilst a dynamic menu is often invisible, except when a selection is required. Modern operating systems or application-based workspaces often utilise these as a combination, as highlighted by personalised menus, a type of slip off (Lee and Raymond, 1993) menu, found within the start menu/panel of Windows XP systems. As a rule, menu bars and pull-down menus are best suited for single task environments, whilst multitasking environments often adopt the use of derivations of pop-up menus, where the menu appears at the current location of the cursor in response to an input action like a mouse or key button click where they could be further pinned, held down or torn-off (Macleod and Tillson, 1990).

The internal structure of modern menu-based information workspaces can be extremely complex, often with options being organised according to frequency, their alphabetical, numeric or functionality, in which case, grouping occurs through the use of white space or the use of lines when organising these methodically into associated common functional groups. As indicated in Windows XP start menu, frequency (Fisher *et al.*, 1985) can also determine where and when specific menu options appear. These options may be removed completely, hidden temporarily or dimmed, to show that they are no longer selectable. However, there is a case (Francik and Kane, 1987) against leaving dimmed options visible on screen as it was suggested that deleting will reduce the size of the menu and lead to better performance. Indeed, the limits to the number of menu options or levels required to initiate a task was first postulated by Norman, 1983) when he pointing out, that knowledge workers best remember items in groups of seven. More recently, Shneiderman (1980) pointed out yet again, a maximum breadth of seven options per menu, perhaps referring back to Miller's earlier work. Similarly, Shneiderman (1980) also suggested a principle of frame simplicity emphasizing no more than six options per menu. However, it seems that these principles were only based upon theoretical observation, until Norman (1983) gave an empirical analysis based on knowledge worker satisfaction studies, suggesting that maximum breadth was better for novices and minimal breadth was better for experts (Lee and Raymond, 1993). As an example of how these usability studies have benefited the development of more usable interfaces, the dock feature under MacOS X (Figure 50), presents currently active tasks as shortcut icons or as minimised real-time application feedback previews, which fill up the bar at the bottom of the screen. In the case of Windows XP (Figure 49) this concept is based upon static, clearly named, shortcut style buttons that are laid out or grouped along a taskbar strip. Both these mechanisms allow a shortcut to applications within one to three selections, quick access to active tasks, and can be moved around the screen to a position at which a knowledge worker feels comfortable.

Historically, the first phase (1st generation) of designing menu-based information systems was for novice knowledge workers, as experts would prefer command-line equivalent option interfaces, such as UNIX or DOS, over graphical-based alternatives (Lee and Raymond, 1993). These menus were often characterised as being slow, often utilising fixed dialogues and very primitive interface hardware. The second phase (2nd generation) of menu-based systems was to construct menus that were valuable and effective (Lee and Raymond, 1993) for most knowledge workers, be they expert or novice and was concerned with complex information management. This phase was characterised by a wide variety of menu styles or types, which focused on rapid, flexible, menu interfaces that were supported by powerful interface hardware. The third phase (3rd generation) focused upon active or dynamically generated menus, with knowledge workers' migration away from traditional paper-based alternatives to solely electronic-based environments. It was typically characterised by options being placed directly within documents, such as the use of buttons, smart tags or hyperlinks, providing means for navigating via a mouse input device, in a non-linear fashion, to other related online content (Lee and Raymond, 1993). Finally, extending upon this earlier work, the fourth phase (4th generation), still in its infancy, focuses directly upon knowledge worker tasks, rather than on the specific hosting menu options, thereby distinguishing between interface, application and data by adapting to the task options that a knowledge worker selects. This phase is characterised by the best use of screen space in accordance with providing only the options or screens needed at any particular time. In essence, it is concerned with intelligently adapting the interface through information or menu options that are associated with a specific task being performed and hiding those items which are not required.

Menu-driven information systems, again according to Lee and Raymond (1993), grew out of the desire for simple, easily learnable, software. This ease of learning is characterised through competency, focussing on the types of tasks being performed in relation to the basic minimum level of training needed. Also they are judged on their effectiveness, focussing on the efficiency with which tasks were performed by the knowledge worker who has reached a level of competence through practice. However, whilst this has been the benchmark for constructing 3rd generation menu-based information systems, it is clear according to Raymond, 1984), that menus now lack usefulness for all queries when concerned with finding multiple sources of related information that could be widely scattered throughout entire file systems or disparate database structures. Thus, menu-driven systems must also consider innovative new intelligent approaches in solving this problem, where the designer thinks out-of-the-box in providing a solution, not being content in reusing existing approaches. As seen later in this chapter from present research, this task is a challenging one as most studies (Lee and Raymond, 1993) continually suffer from poor cognitive models of typical use cases, individual knowledge workers varying too much over time or the task requirements scope being too large/overly complex. Thus, future menu design research modelling focussing on 4th generation menus should be carefully targeted, both upon selecting the appropriate knowledge worker group and specifically on defining clearly manageable tasks to perform, otherwise the intention of the interfaces' purpose will either be missed, considered irrelevant for the intended task, or even worse annoy through being overly simplistic.

Since 1973, after researchers at the Xerox Corporation were missioned with the task to create architecture for information, culminating in the announcement of the Alto computer running Smalltalk at PARC (Graphical_User_Interface, 2000, Nielsen, 1999, Schaller, 1997, Lee and Raymond, 1993), the Graphical User Interface (GUI) has readily become the standard means of interaction with computer systems worldwide. At its simplest, the GUI provides a graphical tool for accessing, or drilling-down-to, information that is typically stored within a file system/database repository, such as a computer hard disk. Therefore, it could be deemed as an elaborate menu-driven system (Shneiderman, 1980, Goodwin, 1983) for organising knowledge, where knowledge workers can accomplish tasks (Mullet, 1995). However, whilst the aesthetics of the interface appearance have changed over the years, making it increasingly photorealistic and more like physical world objects, each interface shares core two-dimensional Human Computer Interaction (HCI) metaphors and characteristics which translate into very similar systems across different hardware/software platforms.

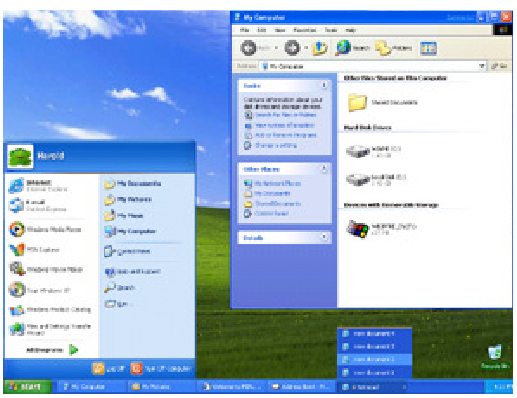


Figure 49. Windows XP desktop showing the start panel, taskbar and blue theme skin (Microsoft, 2002a)

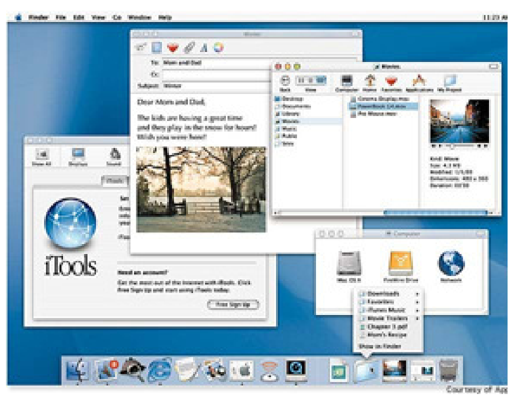


Figure 50. MacOS X Panther desktop showing the task dock at the bottom (Apple, 2004)

When looking at modern versions of Operating System GUI's, it is clear that aspects are either derived from previous versions, or features which have been closely mimicked or cloned (P.B.S., 1998) from competing technologies to aid usability, although this would never openly be admitted by manufacturers due to the fear of legal proceedings (Samuelson, 1990). As seen in Figure 49 and Figure 50, both systems use a desktop metaphor (Smilowitz, 1996) where knowledge workers are presented with a selection of menu options and both use a variety of pop-up window boxes to present more options than a knowledge worker could normally see at a cursory glance. In addition, the numbers of option levels are normally up to a maximum limit of seven menu levels (Norman, 1983), normally enabling a knowledge worker to get to an item within three click selections. The desktop tries to map upon the knowledge workers' physical world experience by exploiting metaphors which are common to the characteristics of the domain environment that the knowledge worker is used to seeing, such as familiar objects or activities (Smilowitz, 1996). However, as Smilowitz (1996) asserts, there is very little research which supports the popular belief that metaphors to indeed facilitate a performance increase when using the interface.

The concept of direct manipulation was coined in 1983 (Williamson and Shneiderman, 1992, Heeter, 1991) to refer to interfaces which continuously update visible screen areas or objects of interest, where actions with buttons, sliders or other screen widgets, result in providing immediate feedback or changes to the knowledge worker. The interface is portrayed as an extension of the real world by providing intuitive means for interacting with dataset or object information, which could include directly drawing on the screen using a stylus (Figure 52), a computer mouse (pointing device) or increasingly for areas such as the animation (Molet *et al.*, 1997, Kurlander and Ling, 1995) industry, the use of hand gestures (Figure 53) coupled with intelligent cameras that calculate and interpret movement. In all cases, a knowledge worker has direct control over the amount of information or objects which are being displayed, through the ability of the interface to modify instantly in familiar or natural ways. Direct manipulation systems eliminate the use of complex syntax methods for querying large datasets of information as they provide screen controls and other widgets which make it easier to query the information needed (providing graphical visualisation rather than command line statistics) without taking the knowledge worker away from the task that is being performed (P.B.S., 1998). According to Rutkowski (1982) Direct manipulation systems provide transparency, where one's intellect is applied to the task and not the tool. Thus, the concept of directly manipulating objects means that the normally constrained viewing spaces on a computer screen can display much larger amounts of information than that of physical-world alternatives, such as pieces of paper on a traditional desk. Indeed, by providing direct physical control over these interfaces, a knowledge worker can quickly visualise information patterns, trends or other aspects, without the need for complex calculations.

The Homefinder examples (Figure 51), published in a paper by Williamson and Shneiderman (1992), show data points or houses that are queried from a database and make up a real estate map of the Washington D.C. area in the USA. The attributes of each house were then described in square feet, giving the number of rooms, whether they were terraced, had a garden, the price or the location in kilometres. Prior to 1983, the usual way to interrogate a database of information and still used predominately today, was to create a query such as '*SELECT house FROM real_estate_db WHERE price <= 250000 AND rooms = 3*'. However, it meant that a knowledge worker using the visualisation system had constantly to work out each query before they are able to obtain the respective response from the statistical database.

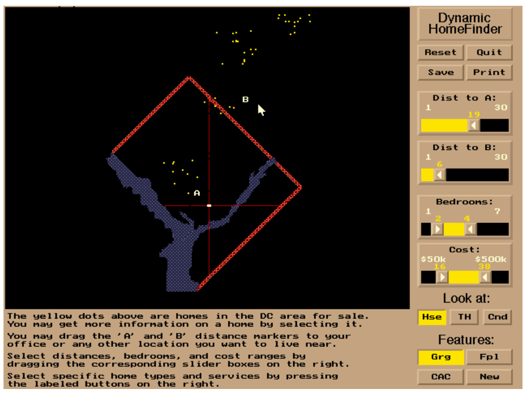


Figure 51. Homefinder formulates queries by adjusting graphical widgets, such as sliders (Williamson and Shneiderman, 1992)

Figure 52. Tablet PC provides drag and drop screen objects using a stylus (Microsoft, 2004c)

In the Homefinder interface and seen in similar systems such a Filmfinder (Shneiderman and Plaisant, 1998), it uses real time sliders to formulate/process the queries dynamically in the background and then to update the display as appropriate, thereby eliminate the need for the knowledge worker to be a skilled computer professional in order to find the desired information.

In today's information workspaces, this concept of direct manipulation of objects has started to be realised further, with the use of portable desktops (Figure 52) or Pocket PC (Microsoft, 2005a) style devices, where a knowledge worker can now draw directly on the screen, which either alters menus on a wirelessly connected desktop, or it moves the objects around under the stylus, as with physical world objects. This concept is not a new one, as Sun Microsystems first previewed this idea in a conceptual look at future computing in a project called Starfire (MacIntyre and Feiner, 1996, Open_University, 1996, Tognazzini, 1994). Starfire (Figure 53) envisioned a paperless office, where every aspect, such as video communication feeds, documents, audio, as well as other objects, could be directly manipulated on a flat desk screen/adjoining wall. The idea was to look at person-to-person communication and the subsequent effects on interaction with objects in this style of environment, at a futuristic point when computers were no longer limited by processing power.

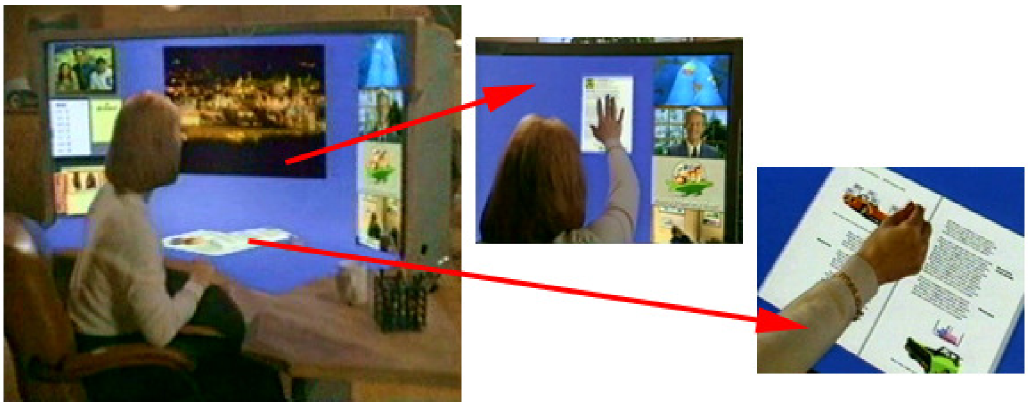


Figure 53. Starfire concept provides drag and drop screen document objects (Open_University, 1996)

Another look at an alternative future and maybe an extension to the Starfire project, can be seen in Mohageg *et al.* (1996), where a 3D museum is envisaged in which a knowledge worker could virtually walk through rooms of the museum and view art exhibits. This concept has already been made a reality in such systems such as Domesday (Figure 1) where the knowledge worker can select a piece of art and either hear further information about the selection or indeed step through into the artwork and experience what was in the artwork. This depth capturing of a knowledge worker's attention provides a sense of immersion where the viewpoints are updated either by the mouse position or passively through tracking head motions and other body movements made in the real work. This type of interaction is typically seen in Head Mounted Displays (Figure 57) and Cave Automatic Virtual Environments (Cruz-Neira *et al.*, 1993). What is typical in these type of environments according to Robertson *et al.* (1997), is that they always provide 3D cues and interactive animation as the means for aiding in the realism of immersion. This can be seen more recently in a scene from the movie 'Disclosure' (Figure 54), where the character interacts with a virtual reality workspace that resides on top of a content management database. This scene purports to extend direct manipulation into a whole new level of immersive, via a headset, virtual reality (Robertson *et al.*, 1997) as it suggests a simulated photorealistic three-dimensional environment where objects can be interacted with in a similar manner as those in the Starfire project. In the scene the knowledge worker wears special virtual reality goggles with a data glove and walks on a treadmill. It appears to the knowledge worker as though they are really inside the virtual environment; being able to touch filing cabinets or to rifle through stored files within the virtual environment.

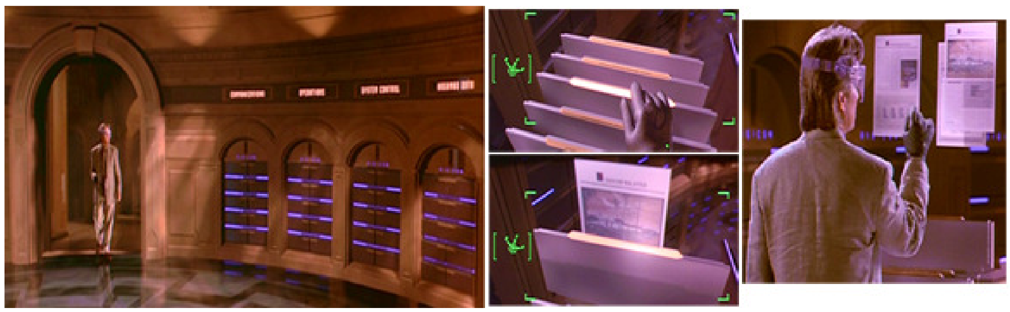


Figure 54. The Corridor - immersive virtual reality workspace as seen in the film Disclosure
(Levinson, 1995)

This environment tries to encapsulate the metaphor of the physical world more directly with an improved computer generated one, blurring the lines between that of reality and that which is simulated. However, in order to use this environment the knowledge worker must walk around in ‘The Corridor’ or select the correct room of files, a device which hardly improves on existing systems, if the knowledge worker is physically tired after wearing and using this technology. According to MacIntyre and Feiner (1996), what supports this is direct manipulation which is regularly touted as being a key feature of 3D immersive environments through the perceived notion of its naturalness and ease of learning due to reaching out or interacting with objects that appear to replicate those of the real world. However, MacIntyre and Feiner (1996) also indicate that this may well be far less convenient than that of 2D techniques, since a 3D object requires the knowledge worker to hold his/her hands up without any physical support for their arms (Figure 55) or clasping virtual objects (Figure 54) for extended periods of time. Also, according to MacIntyre and Feiner (1996), for many applications, this complete immersion is either unnecessary or inappropriate for the given tasks. However, the merits of the system are that it does allow the knowledge worker to open draws of files and then to place them inside according to their relationship or even in the air above the folder as a reminder, thereby improving marginally on the physical world by allowing the freedom for different interaction metaphors (Boyd, 1995). What is interesting during the film’s scene which demonstrates the system, another knowledge worker is also using a 2D command-line alternative computer interface to access the same database and in comparison, the command-line interface is able to access/delete files much faster than the other knowledge worker can locate and view within the 3D environment (Fellmann and Kavakli, 2007, Computer_Hope, 2007). Thus, it is interesting to note what the improvement gains are for this futuristic interface over the 2D alternative, as it seems that in reality there is very little productivity gain, apart from providing the aesthetically pleasing look for the knowledge worker.

Figure 55. Drag and drop interactive wall surface as seen in the film Minority Report (Spielberg, 2002)

A more realistic alternative to the Starfire concept can be seen in a film called ‘Minority Report’ (Figure 55) which envisions a wall-mounted light enabled interactive surface (Figure 60) which utilises hand gestures as a way of controlling object screen elements such as video feeds, photos or electronic documents. This style of interface tracks the movement or gestures (Buchmann *et al.*, 2004) of a hand glove with light sensors and then updates the display in real time so the appropriate objects are signalled actions. As an example Figure 55 shows the gesture of moving the characters’ arms apart in order to zoom in for more detail. For this type of interface to be successful and convincing, according to MacIntyre and Feiner (1996), it should respond immediately to the changes in tracked objects.

What this is alluding to is the use of Augmented Reality (Webster *et al.*, 1996), referring to displays that add overlay information graphics to a knowledge worker’s real world sensory perceptions (MacIntyre and Feiner, 1996). Augmented Reality (Figure 56) in comparison with immersive reality systems (Figure 54) does not aim to replace the real world with a simulated copy, but instead aims to augment reality by instead supplementing it (Feiner, 2004). As seen in Figure 56, Augmented Reality research focuses on see-through devices such as those worn on the head (Feiner, 2004) or screen displays which either supplement or overlay virtually created objects or landscapes onto physical world graphical, textural or location coordinate points/objects.

Figure 56. Augmented Reality File System - recall files of data depending upon real world relationships
(Feiner, 2004)

Figure 57. Nomad Augmented Reality provides the ability to recall map data over real world landmarks
(Microvision, 2005)

These types of technologies track via the Global Positioning System (GPS), position and orientation, normally through headset or laser target sightings (Milbert_Engineering, 2005), thereby providing enhanced virtually generated information. As seen in Figure 56 a knowledge worker could store/access files based on the relationships with real world objects. Indeed this type of visualisation imagery is being heavily explored by the military (Livingston *et al.*, 2002, Thomas *et al.*, 2002) in projects such as FIST (SPG_Media, 2005) in the United Kingdom, or LandWarrior (Garamone, 2003, Federation_of_American_Scientists, 1999) in the United States, for the purpose of enhancing situational awareness of the battlefield landscape or alternatively by providing realistic training scenarios for urban environments.

Figure 58. Augmented Reality - ability to recall information based on their real world locations
(Hutton, 2005)

Indeed, at a recent conference, British Telecommunications (BT) illustrated (Hutton, 2005) one such example of this mixed reality information fusion through visuals of a dismounted soldier in an urban environment (Figure 57).

The sample imagery illustrated (Figure 57) can be accessed through the soldier moving either his/her head or laser gun sight, whilst viewing real world objects. This type of menu system automatically pre-selects items, based on what is being viewed, and then enhances the perceptual view of these items by including additional situational information about hazard areas or other such navigational aids. The soldier typically would then see outline labels, lines text and/or coloured blocks as seen in Figure 58.

4.4 Summary remarks

This chapter demonstrates that, prior to the information technology revolution, many traditional office workspaces included specific features which can now be seen as the metaphorical foundations of present-day computer information desktop interfaces. It postulates the argument that an information workspace which exists inside a computer-based interface in 2009 and utilises metaphors, does improve task efficiency over the traditional physical working environments. It notes that the main cause for multitasking between tools, differing devices or screen notes, and thus the root cause for screen clutter, is that knowledge worker production activities are distributed across a wide range of data sources for completing a project, highlighting that the lack of integration between devices and tools provides the side effect of multiple windows open at the same time so promoting the screen clutter. This brings in the concept of space, whereby the restrictions of 14 to 24 inch desktops or palm style devices, mean that space is always at a premium and promotes switching or multitasking. Further, it highlights various operating system examples of techniques which are devised to overcome these restrictions and the associated problem of scalability. It then introduces the techniques used presently for extending space through techniques like direct manipulation, increasing the physical display screen size, utilising immersive 3D space, providing novel interaction methods such as drag-and-drop wall surface, or indeed using augmented reality techniques. However, in every case, these techniques are still not really solving the problem, but just making more space, which compounds the scalability issue.

Chapter 5: Organising Information Workspaces

5.1 Optimising information space

The previous chapter introduced a vision, through films such as Minority Report (Figure 55) and 'Disclosure' (Figure 54), of the ways knowledge workers might interact with their information workspaces in the future. The literature as surveyed was originally intended to provide a glimpse of potential information workspaces. However, with rapid advancements in technology it has meant that many of these conceptual techniques are now being fully realised and exploited with newly available commercial technologies, an example of which could be the British Telecommunications (BT) developed (Personal_Computer_World, 2004) light device (Figure 59) and the Microsoft developed (Microsoft, 2007) touch screen Surface (Figure 60).

Figure 59. Minority Report style light enabled interface (Personal_Computer_World, 2004)

Figure 60. Surface touch sensitive screen that can recognise objects placed on it (Microsoft, 2007)

The BT device uses a Minority Report style interaction, where it will notify knowledge workers of personalized news and information using ambient light sequences or sound alerts. To access information, according to BT, a knowledge worker simply waves a hand across the device, thus prompting a response to read out relevant details. As an alternative to this, the Microsoft Surface provides a table with a 30-inch touch sensitive screen that can recognize objects placed on it. It is envisaged that it will be used to allow knowledge workers to sit down in a restaurant, hotel, or airline lounge and use the interactive table surface to get work done using their hand or fingers. Indeed, the use of input devices other than the traditional keyboard and mouse (Wakefield, 2007) are increasingly being used for many devices or indeed by various industry sectors, such as the animation and engineering industry, through gesturing techniques (Molet *et al.*, 1997, Kurlander and Ling, 1995) in order to naturally animate computer generated models (Figure 61) within a workspace without the need for unintuitive input devices in order to annotate them.

Figure 61. CyberGlove positioning and movement using finger or wrist actions (Mindflux, 2004)

Figure 62. Supervolcano electronic 3D holographic bird table (Riley *et al.*, 2005)

However, what is very evident is that research at the present time seems to provide very little consensus concerning which of these directions, if any, future information workspaces will eventually take. Indeed, other recently available films, based on real world commercial technologies, illustrate ways to extend the use of light enabled devices even further by combining them with 3D interactive simulations, as displayed on a secondary holographic style bird table (Figure 62) thus providing a 360 degree interactive view of an otherwise 2D computer screen display.

Figure 63. Physical office workspace
(Web_4_Marketing, 2007)

It is suggested that these recent developments are starting to part-way realise the 1965 vision of Ivan Sutherland when he presented at the IFIP conference (MacIntyre and Feiner, 1996) the notion of the ultimate display where knowledge worker workspaces would get to the stage where they could be a single room which contains synthesised objects that are convincing to all our senses and interpreted as real objects. What is apparent though is that the vast majority of knowledge worker workspaces, at the present time, has still remained statically unchanged (Hutchings and Stasko, 2003), using primarily a single screen electronic monitor as the means of displaying a physical desktop workspace (Figure 63). Thus, it is believed, it would be more appropriate to find better ways of optimising or replacing existing workspaces through methods such as enhanced window system techniques.

According to Hutchings and Stasko (2003) it is very difficult to determine what aspect of a window system to fully evaluate because defining the task of window management is extremely complex due to multiple paths or ways that knowledge workers might undertake a task. Indeed, few if any, organise their windows or folders in exactly the same way. As displays and screen resolutions continue to become larger for information workspaces, so knowledge workers are now apt to leave more tasks open for easy multitasking; this has the side effect that large numbers of task windows will increase the time spent on arranging or switching between tasks (Robertson *et al.*, 2004a). Arising out of this, is now a desire to support complex information management tasks, resulting in menu driven systems for sophisticated knowledge workers, a contribution according to Lee and Raymond (1993) that is now deemed the '*philosophy of augmenting the knowledge worker'* (Engelbart and English, 1968, Engelbart *et al.*, 1973). According to Kirsh (2000), this workspace is also now described as an activity space, where it is populated by tools and resources that facilitate knowledge worker actions and where it is controlled by a component called a '*window manager*' that governs or controls display and input device resources (Foley *et al.*, 1996). A window manager, (Foley *et al.*, 1996) goes on to say, allows the knowledge worker to bring up windows, menus and dialogue boxes associated with running applications, where they can then manipulate the windows or minimize them. This window manager is also the component that determines the ultimate look and feel of the interface.

As identified in earlier chapters, the current desktop metaphor ultimately suffers from two main problems, task management and the comparison of multiple open windows. As already seen in previous chapters, these workspaces then exhibit symptoms of getting crowded or cluttered as knowledge workers work on large numbers of very different tasks simultaneously, yielding a desktop that has a large number of windows or views at any one time (Hutchings and Stasko, 2002a). According to Hutchings and Stasko (2004), 78.1% of the time, knowledge workers have eight or more windows open, so they may often experience screen clutter problems whilst using the taskbar. Among single monitor knowledge workers, there is often no empty screen real estate for almost 48% of the time and for 89% of the time, less than one-fifth of the desktop is visible. This is also concurred by Henderson and Card (1986) where they suggest knowledge workers tend to interact repeatedly with small clusters of information, through tasking through them, behaviour they term '*locality of reference*' or alternatively by Card *et al.* (1991) '*reference clustering'*. Further, it is also suggested by Card *et al.* (1996) that this behaviour of switching and moving objects around is exhibited so as to tune the environment to the costs of the information, thereby making them more efficient in the eyes of the knowledge worker.

Indeed, according to Hutchings and Stasko (2004), this display space management can be split into two sub issues - across-task management, in which interfaces focus on helping knowledge workers switch (Robertson *et al*., 2004a) among different tasks, and within-task management in which the interface focuses on the display of one or more windows that constitute a task.

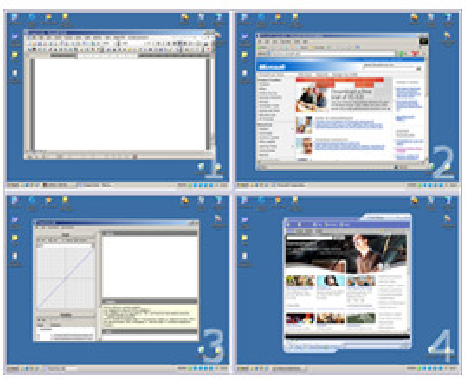


Figure 64. Virtual Desktop manager showing multiple virtual desktops on the same workstation (Microsoft, 2004d)

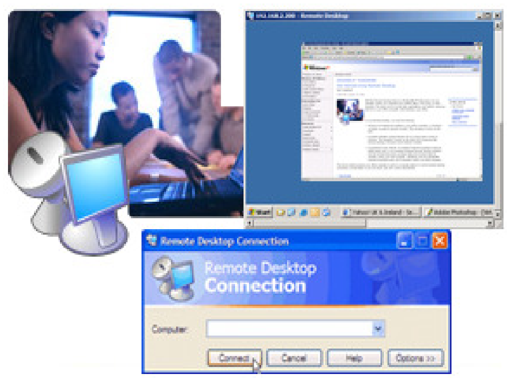


Figure 65. Remote desktop connection showing a virtual desktop from a remotely connected workstation (Microsoft, 2004e)

Virtual Desktops (Figure 64 and Figure 65) occupy defined portions of a screen, and sets of virtual desktops are often arranged according to a matrix or grid pattern (Figure 64). These virtual desktops compartmentalise different tasks to different windows and thus help with locality of reference by physically segregating tasks into their own desktop. Thus, a knowledge worker may undertake one task set of applications/windows in one virtual desktop and an entirely different set of task applications/windows in another. In this way it cognitively breaks up the tasks from an unmanageable clutter into clearly identifiable groups. The distinction here from prior chapters is that virtual desktops do not replace the existing desktop workspace metaphor, but rather augment or extend the physical space through linking with other desktops. In an office environment a knowledge worker must fulfil several different daily roles (Hutchings and Stasko, 2003) within their job so a virtual desktop manager could allow a knowledge worker to complete one task through the aid of several windows and then enable them to switch to or monitor a set of different tasks.

The earliest design of a potential virtual desktop manager could, according to Goldberg (1984), be seen in Smalltalk through the windows named Project Views which formed a tree of workspaces (Card and Henderson, 1987a). Later, perhaps the concept was taken further with work into Rooms (Henderson *et al.*, 1991, Card and Henderson, 1987b, Henderson and Card, 1986) the most well known of these type of systems, purported as a comprehensive virtual desktop. Rooms has a placement mechanism which allows a window to appear in multiple Virtual Desktop instances, but which requires forethought for setting up (Robertson *et al.*, 2004b) and thus is time intensive. Recently, a more comprehensive study was made of several Virtual Desktops (XDesk_Software, 2003) with recent academic work (Hutchings and Stasko, 2004) referring back to Bly and Rosenberg (1986) and Kandogan and Shneiderman (1997) as key papers for demonstrating situations in which advanced tiling with window managers outperform overlapping task windows, inferring that virtual desktops provide less screen clutter due to the increased virtual space. The support for task-based visualisation and switching between tasks is thus in a similar vein to other work carried out by Robertson *et al.* (2000), Kaptelinin (2002) and MacIntyre *et al.* (2001). Indeed, what all this earlier work alludes to is that knowledge workers are more efficient in their work, when memory recognition of whole images is used, in this case task windows (Czerwinski *et al.*, 1999a). Thus, as Hutchings and Stasko (2004) assert, visibility is a powerful tool in measuring the importance of a window; just because a window has become inactive, it does not diminish its importance and should always be given equal weighting or screen space allocation. Therefore, the significance of tiling versus switching is shown to be of paramount importance when referring back to the best use of space, especially in the way virtual desktops operate.

According to Grudin (2002), knowledge workers do not treat additional monitors as additional space but rather tend to manage windows within monitors and rarely place windows across physical monitor boundaries. Virtual Desktop knowledge workers, Hutchings and Stasko (2004) point out, prefer to have peripheral windows for tasks associated with applications such as email, rather than separate desktops, so that they do not distract from their primary tasks. The result of using a virtual desktop manager is that each of the virtual desktops will appear to be better organized and more productive than a cluttered single desktop workspace or an extended desktop. In actuality, the knowledge worker is given more natural space to work within applications as they would do naturally with familiar single desktop workspace. Arguably, this provides yet another mechanism which attempts to fix the failures associated with modern operating systems when faced with scalability task issues. Also, it must be noted that these separate virtual desktops are often, in addition, named or colour coded so that a knowledge worker can find them easily.

Figure 66. Remote desktop 2 allows connections to multiple workstations (Apple, 2005a)

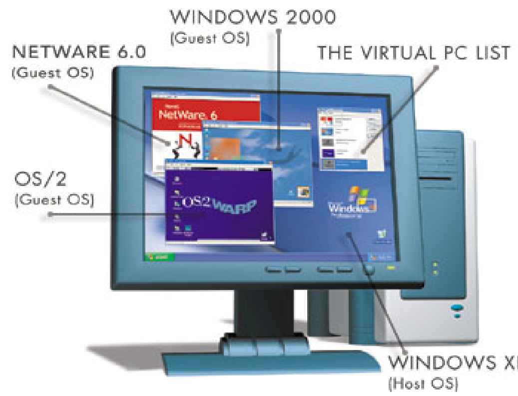


Figure 67. Virtual PC runs multiple operating systems simultaneously on one workstation (Microsoft, 2004b)

Unlike similar multi-monitor systems, where the desktop workspace is extended over two screens, virtual desktop systems through their ability, on some occasions to be self contained (Figure 66 and Figure 67), can give productivity gains, especially if the virtual desktop is on a separate computer system to that of the hosting manager (Figure 66 and Figure 67),. Therefore, the knowledge worker can make use of an entirely independent computer processor/memory, in order to run perhaps a significant memory intensive application, but which does not impact upon the performance of the hosting desktop workspace. The pervasiveness of this technology is in its ability to let support administrators make software additions or enable maintenance (Figure 66), without the need to be physically at the location of the knowledge worker's workstation. Indeed recently, some Virtual Desktop managers (Figure 67) have been developed to visualise multiple computer-based operating systems simultaneously on the same workstation, allowing for applications to be tested in safe/secure independent environments, or giving access to legacy applications which are not compatible with modern operating systems, often previously resulting in reconfiguration of several options and/or switching between differing computer operating systems.

According to Hutchings and Stasko (2002b) viable alternative advantages over current window and space management techniques exist through incorporating the following:

Universality: whether a desktop system knowledge worker uses an overlapping or a tiling strategy

Simplicity: the knowledge worker makes exactly one selection in order to perform an operation that affects the entire desktop - some window managers have the capability but require the knowledge worker to define a large number of constraints each time the operation is requested

Information Preservation: the sections of windows that were visible before an operation is still visible after that operation

A Virtual Desktop manager purports to have these advantages as it arises from the fact that it can mean that multiple screens are aggregated into a single place, allowing the knowledge worker to concentrate on the tasks and not search for windows or wait upon the applications to be run. Such benefits can be seen in presentations, when a development platform is demonstrated alongside a presentation, as often the development platform might need vast amounts of configuration time. Instead, the presenter can simply switch over to a Virtual Desktop window at the click of a mouse or keyboard function and immediately be ready to demonstrate. Indeed, the state of the demonstration can be saved in the precise place and can be returned back to the next day for another training session. According to Hutchings and Stasko (2003), drawing parallels to the management of space with virtual managers and the real world may be unnecessary or even inefficient as they suggest that interacting or switching with window mangers and virtual managers is now an event in itself which cannot be easily replicated.

5.2 Adding a third-dimension

Information workspaces are becoming more complicated (Sebrechts *et al.*, 1999). Ever-increasing pressures within product life-cycles (Lines *et al.*, 1996) are forcing companies to be innovative in their designs of new products or services to aid with this problem. Thus changes to the information workspace (P.B.S., 1998) provide a unique competitive edge over competing technologies. Interestingly, the catalysts fuelling this are a combination of increased use of photorealistic graphical content (Boyd and Darken, 1996), improved computational speeds (Mullet and Sano, 1995, Poupyrev, 1995), enhanced animation techniques (Robertson *et al.*, 1993) and the close integration with Internet technologies. Therefore, extensive research and development is being focused towards utilising the inclusion of an added dimension (3D) with the belief that it will facilitate new ways of increasing information workspace efficiency through providing better ways of displaying information, as well as fuelling a continuation of existing product life cycles.

The research seems to point to an added third-dimension as being the natural successor to that of 2D by increasing the utilisation of human spatial memory (Supersites, 2001) over 2D for managing tasks, where items in the real world would normally be organised by a knowledge worker based at their location. Indeed, Supersites (2001) considers that when a knowledge worker is not in charge or placing items in the space, they are forced to explore to find what they are looking for and additional signs or named directories are required to assist in this exploration. Indeed this requires time and commitment on the part of the knowledge worker in order to find the item, especially as spatial memory relies on repeated use. Therefore, would an added dimension really enhance the knowledge worker's experience or cause further frustrations due to the added time and complexity? There have been a few studies that have tried to address this issue, notably the hyperbolic browser (Lamping *et al.*, 1995) simulated changes in appearance of documents spread over a 3D spherical surface (Sebrechts *et al.*, 1999), using a focus context fisheye approach to manipulate large hierarchies. The experiments did a direct comparison of this against a conventional 2D scrolling browser with a horizontal tree layout. The results indicate that the knowledge workers preferred the hyperbolic visualisation and that there was no overall performance advantage over the 2D alternative (Sebrechts *et al.*, 1999).

Indeed, in a similar more recent study by Swan and Allan, 1998) they performed a controlled study comparing a 2D graphical based text system and a 3D based system, concluding that there was no evidence to substantiate an overall effectiveness increase in the use of 3D over 2D as it depended upon the tasks that the knowledge workers were undertaking. However, in both cases they concluded that more work was needed to address definitively both these issues. Indeed, a large body of literature has grown exploring both spatial cognition (Robertson *et al.*, 1993, Curiel and Radvansky, 1998) and wayfinding (Darken and Sibert, 1993, 1996, Tauscher and Greenberg, 1997) in order to address the concerns over knowledge workers getting lost in systems where an added dimension is present and they are required to navigate it. According to Wiss and Carr (1998), 2D information visualisation makes use of colour, size, position and semantic symbols to represent data, elements or properties. Alternatively, 3D according to Robertson *et al.* (1998), incorporates other aspects without incurring additional cognitive load, by the use of size that indicates a spatial relationship through exploiting the use of distance.

To date, there has been much academic and commercial research (Feijs and Jong, 1998, Hemmje, 1995, Finney, 1996) examining the subject of 3D workspace design. The most commonly explored approach includes the use of elaborate 3D style file hierarchies that are included in examples like Cone Trees (Robertson *et al.*, 1991), which visualises data as complex file structures (Figure 68), 3D File System Navigator (Silicon_Graphics, 1992) that visualises data as linked blocks on a virtual plane (Figure 69) and Data Mountain (Robertson *et al.*, 1998) that visualises data pages on an inclined plane in order of priority (Figure 73). An alternative approach to the file hierarchies uses 3D style rooms which include examples like TaskGallery (Robertson *et al.*, 2000), which visualises tasks/windows on the walls of a zoomable room (Figure 74), Domesday Project (Finney, 1996), which visualises available tasks as paintings on walls (Figure 1) and Win3D (Clockwise_Technologies, 1999), which visualises tasks within specialised activity buildings (Figure 77). However, both these approaches incorporate very different visual elements and/or techniques from each other and arrive at differing outcomes when exploring their effectiveness compared to their 2D alternative.

ConeTrees (Figure 68) are cited in the academic literature as the classical way of approaching hierarchical structures as applied to 3D workspaces. They are normally laid out uniformly in 3D (Robertson *et al.*, 1991) and through the use of interactive animation, ConeTrees provide, according to Robertson *et al.* (1991) and Cockburn and McKenzie (2001), a better sense of structure for an information workspace. Further, they go on to say that this interactive animation reduces cognitive load by exploiting the human perceptual system through the cues. Interactive animation within the structure allows a knowledge worker to be drawn into the environment through the nature of the human perceptual system to track the rotations of the cones with document labelled nodes.

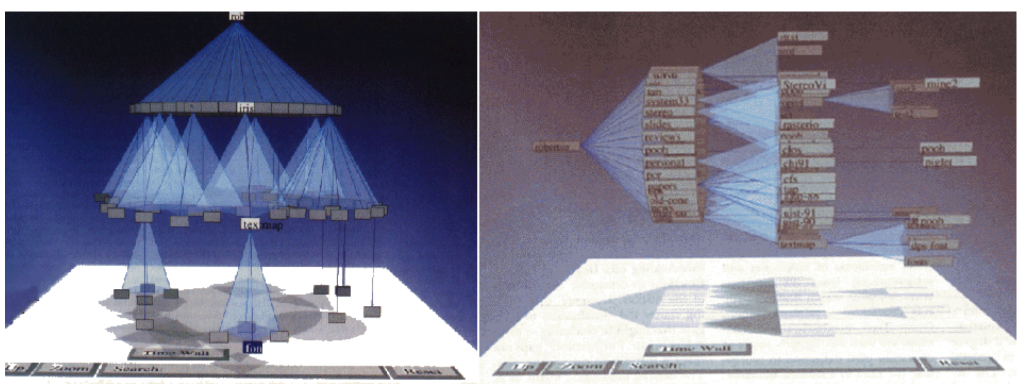


Figure 68. ConeTrees 3D file management concept

(Robertson *et al.*, 1991)

The animated rotations allow the knowledge worker to visually track sub structural relationship links between items without requiring them to additionally think about doing this task. Unlike a traditional 2D hierarchical system, ConeTrees maximise screen space by visualizing the whole structure from a single static viewpoint. Upon selecting items ConeTrees customise their 3D workspace structures so that all related documents are displayed directly to the knowledge worker along with all their link relationships (Munzner and Burchard, 1995) spidering out from a central node. However, the fundamental problem with ConeTrees according to Munzner and Burchard (1995) is that they become easily cluttered, similar to their 2D workspace counterparts, with no perceivable way of exponentially growing a tree that allows for simultaneous viewing of the entire structure, as well as, a close up of the particular region of interest. Indeed, it is hard to even see the benefit of this structure over its 2D counterparts, except for the fact that the entire workspace is now a 3D hierarchical structure, where as the traditional 2D alternative, is a different level within the presentation layer - normally accessed through a separate screen menu shortcut.

An alternative approach to ConeTrees is the 3D File System Navigator or FSN (pronounced fusion) (Figure 69) as instead of hanging a 3D file structure in the air, the hierarchy is laid out on a flat 2D surface and then interrogated through flying over the structure at an angle of 45 degrees. The directories of the hierarchy are then represented as pedestals, with the height of each pedestal directly proportionate to that of the size of the files within the directory. The pedestals are interlinked and so it is possible to travel along the interconnected links to an adjoining directory node. According to Silicon_Graphics (1992), FSN is neither a fully featured, nor a replacement to a traditional 2D workspace file manager, but simply serves as a concept demonstrator.

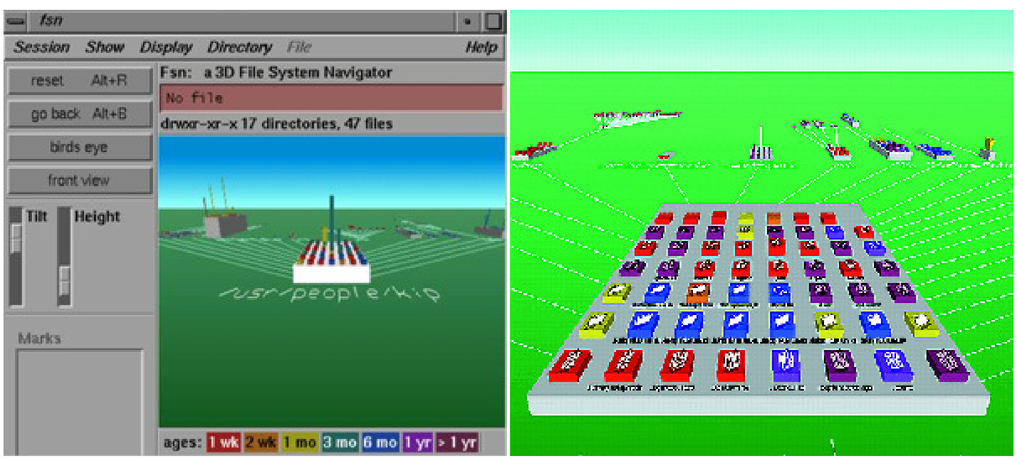


Figure 69. 3D File System Navigator as seen in the film Jurassic Park (Silicon_Graphics, 1992)

FSN was first highly publicised in the film 'Jurassic Park' in a memorable sequence of product placement where a child sees a workstation and happily declares '*this is UNIX, I can use that!*' The goal of FSN is therefore not to control a dinosaur park as depicted in the movie, but to illustrate an example of how potentially 3D could be used for managing quite large file systems (Silicon_Graphics, 1992). This approach has been mimicked recently by many systems, and adopted aspects can be seen to a certain degree in both 3D File System

Browser (Figure 70) and 3D-Space VFS (Figure 71) where a knowledge worker must navigate over suspended platters or a 2D surface and select files or icons to open. In both examples navigation employs both zooming and flying over a document hierarchy.

An alternative hybrid approach to that of ConeTrees or FSN is a technology called SpaceBrowser (Figure 72) which takes the concept of viewing all items simultaneously in 3D one step further. Instead of flipping between a stack of 2D page items, SpaceBrowser displays mini previews of all the documents from multiple sources at once in 3D, so knowledge workers can then tab between them. SpaceBrowser is similar to Exposé (Figure 46, Figure 47 and Figure 48) as it creates a mosaic of open items at a single push of a button so that a knowledge worker can visually see the item they require from the preview. In essence, SpaceBrowser tries to visualise documents and especially web pages as a fly-through within three space.

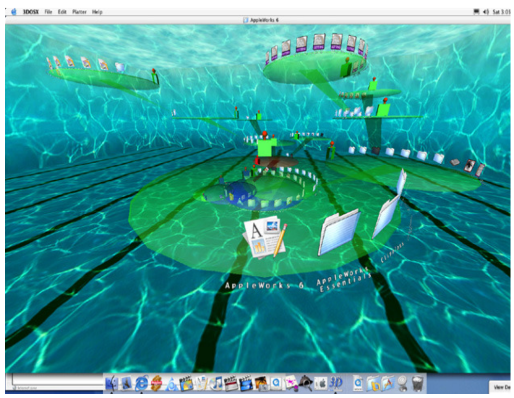


Figure 70. 3D File System Browser showing folders and files
(Chin, 2002)

Figure 71. 3D-Space VFS showing 3D drawers for point-and-click access to files and applications
(Moini, 2007)

The SpaceBrowser approach, echoed in other literature studies (Cockburn and McKenzie, 2002), seems to support the conclusions drawn from prior experiments, which purport that spatial organisation of information enables knowledge workers to access items more quickly and therefore leads to improved memory of where frequently used information is stored. However, Cockburn and McKenzie (2002) go on to suggest that the ability to locate information deteriorates as the freedom to use 3D is increased and further suggest that the SpaceBrowser's approach may well suffer from this, becoming less efficient through more screen clutter. It is hard to therefore see what benefit this approach has over the existing 2D workspace if it simply imports or compounds the already existing space management problems.

Figure 72. SpaceBrowser views web pages in a 3D spatial environmental layout
(Smith, 2005)

Microsoft Research has developed a concept prototype known as Data Mountain (Figure 73) as a way of analysing further the notion of spatial memory in conjunction with its usefulness in 3D. The Data Mountain approach employs similar techniques to those first seen in FSN, where thumbnail images of documents (such as that of web pages) are displayed in on a inclined fixed plane 3D view with the aim of exploiting humans' natural capacity for spatial memory and cognition (Cockburn and McKenzie, 2001, 2002). It is so designed through the mimicking of the real world, where spatial memory according to Robertson *et al.* (1998) often aids in finding items and so, according to Cockburn and McKenzie (2002), provides a valuable tool in supporting efficient information organisation.

Figure 73. Data Mountain file management concept
(Cockburn and McKenzie, 2001, 2002)

Figure 74. TaskGallery room concept
(Robertson *et al.*, 2000)

Thus, Data Mountain is deemed a document management system, as it employs layering controls within the 3D interface that act as natural governing metaphors for centralising the layering of thumbnails either by placing them nearer or instead occlude further away (Cockburn and McKenzie, 2001), an example being tree rings which are narrower, occupying less space, on the tree side facing away from the prevailing sun. Data Mountain experiments (Czerwinski *et al.*, 1999b, Robertson *et al.*, 1993) have reinforced the belief that placing documents in three space does indeed help knowledge workers find where documents are during task retrieval. Further, others go on to conclude (Patten, 1990) that mental cues are made available to the knowledge worker in the form of the visual thumbnail images and this, above all else, enhances memorability of items.

Media Browser (Figure 75) is a unified system for browsing, filtering and tagging personal image files. The browser seems to be a more recent research iteration of the Data Mountain approach, which unlike the prior work, augments a 2D grid layout of file image icons alongside a thumbnail toggle view in 3D. Each of the icon previews are then enlarged by hovering over them, when they are displayed with tagged information, such as their title or subject (Cockburn and McKenzie, 2001). The 3D approach, like that of Data Mountain and more recently Windows 7 (Microsoft, 2008b), represents perceptively a large number of thumbnails with minimal cognitive loading on the part of the knowledge worker (Robertson *et al.*, 1998). Elaborating on this, it is the ability to recognise spatial relationships based on the items' 3D depth cues (using up less screen space), thereby understanding their spatial relationships more intuitively.

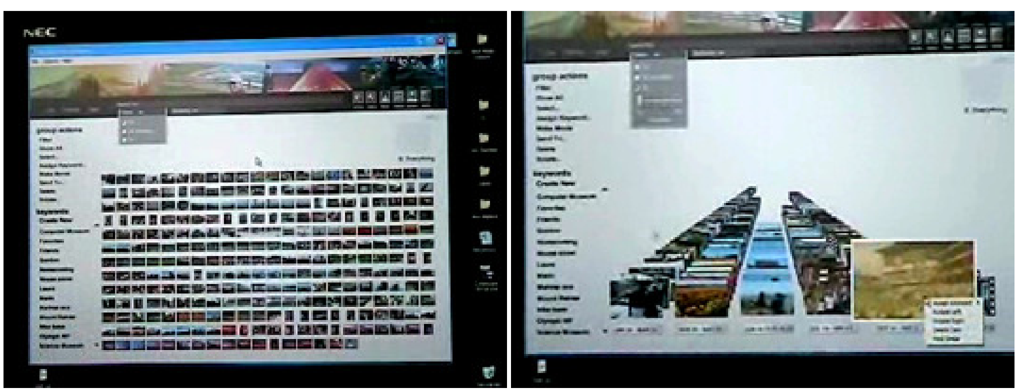


Figure 75. Media Browser arranges media files in 2D and 3D
(Schofield, 2004, Steven *et al.*, 2004)

The Media Browser's (Steven *et al.*, 2004) fixed plane 3D space view can be manipulated by the knowledge worker to display icon previews according to their tagged attributes and then to group these 3D thumbnail columns according to standard file system filtering attributes such as date/time. This approach provides very fast visual access to the images that are of most relevance to the knowledge workers' search criteria, but at the same time gives the option to always toggle back to a traditional 2D grid or hierarchical layout for speed of access or familiarity. This work seems to support the observations made by Cockburn and McKenzie (2002) that there is beginning to be a commercial shift towards systems which support a 3D interface for accessing standard file and document management tasks as a more rapid/accurate means of retrieval of documents. Indeed, further evidence arising out of this research can now be seen in the recent inclusion of grouped tasks and a 3D switching feature directly incorporated into Vista (Figure 39, Figure 44). In a follow-up study to Data Mountain, as described by Czerwinski *et al.* (1999b), it showed that subjects were able to rapidly retrieve web page thumbnails up to 6 months after their creation, due to their spatial organisational relationships.

The alternative to that of the hierarchical approach is to use either single or multiple rooms, where the walls, floors and ceiling are all possible activity spaces for laying out tasks or document objects. The classical example, as cited in the academic literature, is a research system known as TaskGallery (Figure 74). TaskGallery is a window manager that uses 3D to provide added support for task management and document comparison. Tasks are represented as artworks that are hung on the walls of a virtual gallery with the selected task available directly on the stage (Robertson *et al.*, 2000). Multiple documents can be displayed side-by-side each other using the extra three space. What is unique about TaskGallery is that

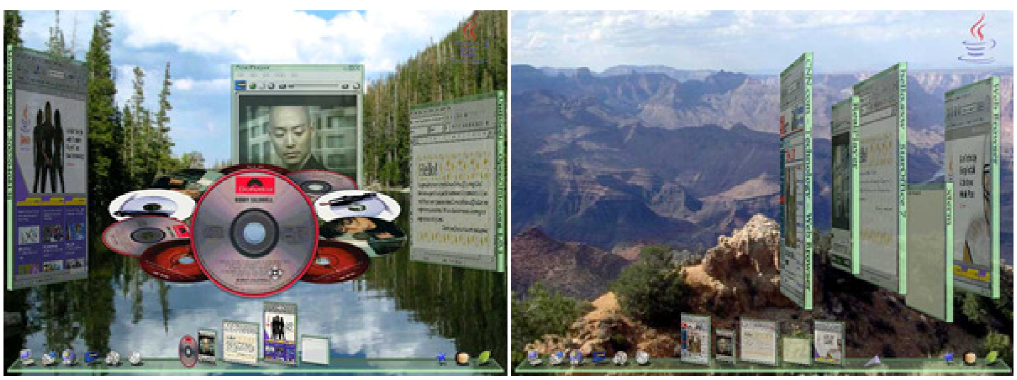


Figure 76. Looking Glass 3D desktop
(Sun_Microsystems_Inc, 2004, CollabNet, 2003)

it was designed for task management, whilst at the same time providing features that are normally exhibited within window management, notably a collection of documents or applications organised around a particular knowledge worker's specific activity. It is suggested by Robertson *et al.* (2000) that this segmenting of the gallery into separate areas, grouping task windows into mounted artworks or using distinctive backgrounds, all contribute towards providing landmarks and spatial cues that act as memory aids at a later date.

Project Looking Glass (Card *et al.*, 2004) is a research system similar to both Media Browser and TaskGallery approaches but instead of replacing the entire 2D desktop, it seeks to adapt it by exploring the use of 3D windowing capabilities across all applications. Looking Glass (Figure 76) allows knowledge workers to both switch virtual desktops and 3D flip through windows or tasks like playing cards within a single virtual desktop workspace by clicking the right edge corner of the screen. The desktop shows the knowledge worker a panning collection view of their entire applications with a label on the side of each task, providing information such as the title, subject or category matter. In addition, meta-content can be added to each task object by flipping the task window over and writing notes or comments on the back. Windows that are not currently in use are still accessible and visible.

Win3D is the final approach to extending 2D desktops through the use of 3D (Cockburn and McKenzie, 2002). It provides a 3D surrogate for the standard flat desktop or remote desktop environment through segmenting common task categories, such as office or Internet into their own respective activity rooms. In the office room a file system hierarchy is accessed through shortcuts that are placed on the walls or on shelves, whilst applications are 3D style icon objects. When a knowledge worker selects a 3D object icon, it launches the 2D application over the top of the desktop replacement.

Figure 77. Win3D desktop replacement workspace manager
(Clockwise_Technologies, 1999)

It is the considered opinion of this author that whilst the concept of activity rooms is useful, it may fall down if a knowledge worker wants to open both an office application and then compare content from an Internet web browser that is available only in a separate room. This approach would be far better suited for segmenting rooms as activity task jobs, where each room contains the task objects, files or applications needed for the activity.

It appears that there is very little consensus on what knowledge workers really want from these 3D office interface or whether there is any real added benefit over 2D Interfaces

(Cockburn and McKenzie, 2001). 3D environments can contain much more information that can normally be visualised in a 2D alternative, through the added z dimension or depth through the increased space or using novel interactive features like flipping tasks to add notes on the back (Chiou, 2000). 3D also can convey a sense of time through the use of the farther away/perspective, and by noting the order/the longer ago the task was accessed or created, such as an Internet history behind a subject walking in a 3D world. Alternatively, the closer a task thumbnail is the more relevance it might have towards the desired search criteria (Chiou, 2000). However, even though it is believed (Chin, 2002) that 3D is the next great advance in workspace design, there is criticism because as the office task workspace is currently 2D it is thought it must always remain so, resulting in debates revolving around monitor screens as highlighted by Chin (2002).

Indeed, fuelling the view that 3D is not really a good idea, objects in a 3D screen workspace are often at a distance or occluded by a wall or other such obstructing feature, preventing a knowledge worker from clearly seeing beyond what is in front of them and thus resulting in them missing certain objects that may be of interest (Supersites, 2001). Other problems occur when knowledge workers use 3D environments either for the first time or on a regular basis, as typically it could take them anywhere between 5 to 10 minutes to move around to orientate themselves in either understanding the display or in finding the required information. Further, the navigation might not necessarily be in the realms of simple point and click, but might also include hand or body gestures, weird mouse movement and key combinations that use six or more degrees of freedom. Therefore, further work needs to be carried out on the exact characteristics of metaphors that should be employed for designing these systems and whether they can extend, with an added benefit, over already existing 2D workspace systems.

5.3 Summary remarks

This chapter suggests, following Cockburn and McKenzie (2002), that it is tempting to believe that 3D is the *fait accompli* mechanism to provide greater spatial flexibility for moving information workspaces from flat 2D environments to that of 3D. Further, that interfaces such as described within this chapter, which employ higher dimensions, are often perceived to be much more cluttered and less efficient than their 2D alternatives in terms of knowledge worker performance of a task; this goes against the assumption by industry that it will optimise space. This is a point also supported by Cockburn and McKenzie (2002), as their results show that for relatively sparse information retrieval tasks (up to 99 data items) 3D hinders item retrieval. However, as this chapter has shown, this view is based solely upon present research attempts at 3D alternatives to the traditional desktop workspace or menu file system metaphor. It is still the proposition (Robertson *et al.*, 1991) that 3D in the right form could improve the management and access of large information spaces if structured in the right way.

Chapter 6: Information-based Architecture

6.1 Introduction

The previous chapters have revealed through the literature a number of issues concerning the management of information. For the purpose of this thesis five such issues have been selected and these are as follows:

1) Linking tasks and associated information (Chapter 2),
2) Lack of current structure for ordering and accessing information (Chapters 3),
3) Automation of indexing of information (Chapter 3),
4) Persisted activity sessions (Chapters 4 and 5),
5) Screen clutter of task documents (Chapters 4 and 5).

The rationale for choosing these five is that they are fundamental to a shift in design paradigm for the system (not the user as such) in order to facilitate the everyday tasks which a knowledge worker needs to complete. When working with tasks in an everyday content a knowledge worker has typically to overcome these five major issues through creative methods which may increase cognitive load. However, this thesis is not concerned with measuring cognitive load as such but focuses the system structure itself which should provide the necessary mechanisms for overcoming these issues automatically, rather than relying upon the user to accommodate these.

This thesis therefore takes the position of attempting to solve these five issues for the user by remodelling the design paradigm of the computer system rather than modifying the presentation layer approaches while leaving the data layer untouched. It should be noted that this thesis focuses on the system structure for the five problems while many other aspects of solutions to information overload are omitted such as searching, intelligent agents, user collaboration, user interface design and cognitive load.

6.2 Partial solutions of the five issues

Previous researchers have attempted to solve the five issues from a systems viewpoint. For example, a common structural approach seen in all 3D workspaces (Chapter 5) or techniques such as that of Necklace (Figure 78) or CyberCity (Figure 79) is that at their heart they facilitate an animation-based interaction architecture termed by Robertson *et al.* (1989) as the '*Cognitive Coprocessor*', where the behaviour of the interactive system can always be described as the product of the interactions of (at least) three agents as seen in Figure 80. The name is so derived from the cognitive assistance it provides for the knowledge worker.

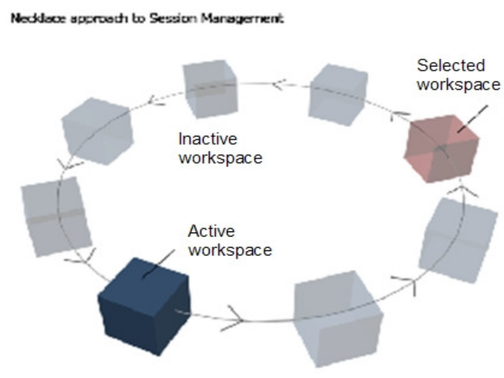


Figure 78. 'Necklace' concept approach to session management (Chalmers_Medialab, 1999)

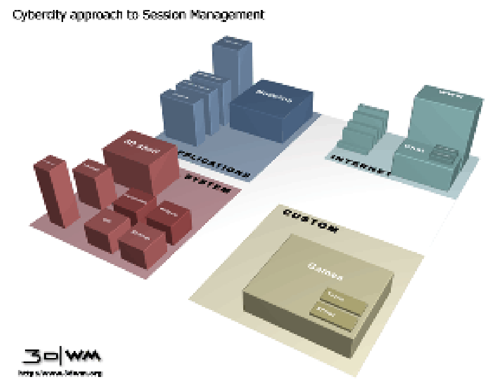


Figure 79. 'CyberCity' concept approach to session management (Chalmers_Medialab, 1999)

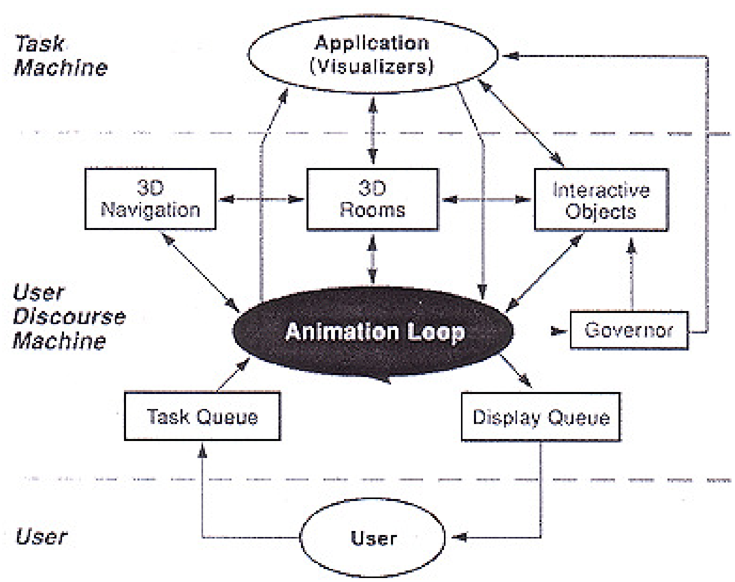


Figure 80. Cognitive Coprocessor interaction architecture (Robertson *et al.*, 1993)

Goldberg (1984) uses this architecture to address issue 5 specifically in the Smalltalk Projects, where each project contains a number of views and, when active, takes up the whole screen. The authors claim this allows clarity of views because it is one screen to one view. In addition, this system goes someway to satisfying issue 1 where icons might well be grouped in each view depending upon the overall view activity, whereby one view contains all icons (applications) related to satisfying a particular task. This system does not address the other two issues in particular as the structural paradigm of the system still remains unchanged because the partitioning of the screen is not mimicked in the underlying storage structure. Additionally, beyond the life of the work session the partitioned screens are not preserved (Hutchings and Stasko, 2002b) - i.e. persisted beyond the life of the session.

Henderson and Card (1986) proposed a structure (Figure 81) involving the use of Rooms. These rooms have shortcut doors for entering or leaving a workspace and action icons for starting a new process when leaving a workspace to go to another, at which point these icons are changed for another set related to a different task. The Rooms manager architecture (Figure 81) overcomes the screen size issue by dividing the knowledge workers' workspaces into a suite of virtually connected workspaces with animated transitions between them. Unlike the previous example, this solves issues 1 and 5 above but again neglects the other two issues. However, the underlying concept of Rooms design (Figure 81) will be used later in this thesis when discussing the design rationale.

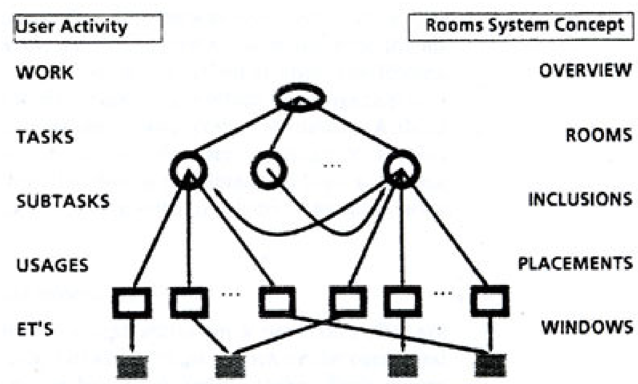


Figure 81. Schematic structure of the rooms system
(Henderson and Card, 1986)

The concepts behind some commercial technologies such as Windows XP, which accommodate session management, involve either an 'Explicit Heavy-weight' or 'Implicit Light-weight' model approach for interaction. Edwards (1994) discussed the differences between these two models which are summarised and clarified in Figure 82. The difference between these two concepts is characterised by a user initiative in the heavy-weight model while the system initiates the light-weight model. The latter model addresses issues 3 and 5 and will be incorporated into the model developed in this thesis since they clarify the characteristics of session management.

Model	Heavy-weight	Light-weight
Type	Explicit	Implicit
Form	Initiator-based Joiner-based	Artifact-based
Characteristics	Participants are required to take some form of action.	Participants know that they are working on the same or similar tasks because of interaction with the same object. A rendervous is therefore based on sharing this common object.
Collaboration	Serendipitous Transient Unnamed	Planned Long-term Named

Figure 82. Summarised forms of Session Management vs. Types of Collaboration

(Edwards, (1994)

Commercial technologies which utilise the light-weight model specifically to address issues 3 and 4 and in a similar way to the Rooms project and the Smalltalk project are Window XP (Microsoft, 2002c), MacOS X (Apple, 2004) and Mandriva Linux (Mandriva, 2007) desktop implementations (further supplementary material can be seen in Appendix 14 section 5).

Two more recent projects which have attempted to address some of these issues in the introduction are the ‘TOWER Theatre of Work’ and the ‘Research Desktop’ (TAGtivity). The ‘TOWER Theatre of Work’ project looked at the relationship between patterns of spatial structure and patterns of behaviour (Stanford-Smith and Kidd, 2000, Prinz and Pankoke-Babatz, 2000) connected to the context, origin and situation. TOWER provided a 3D virtual reality representation of teams (Figure 83) through the use of avatars. According to Prinz and Pankoke-Babatz (2000), these avatars then automatically act out, through walking or other symbolic actions, knowledge workers everyday task activities with real world environment applications. This may be deemed to satisfy issues 1 and 3 of the introduction and some way towards addressing issue 2 through the use of the 3D representation of the interface. This virtual meeting space (3D) is based upon a superimposed architecture of components (Figure 83), which simply provides another layer, rather than improving upon the underlying management of information (issues 1 and 3) as highlighted in the differing approach taken by this thesis and subsequent tool for demonstrating this (Figure 95).

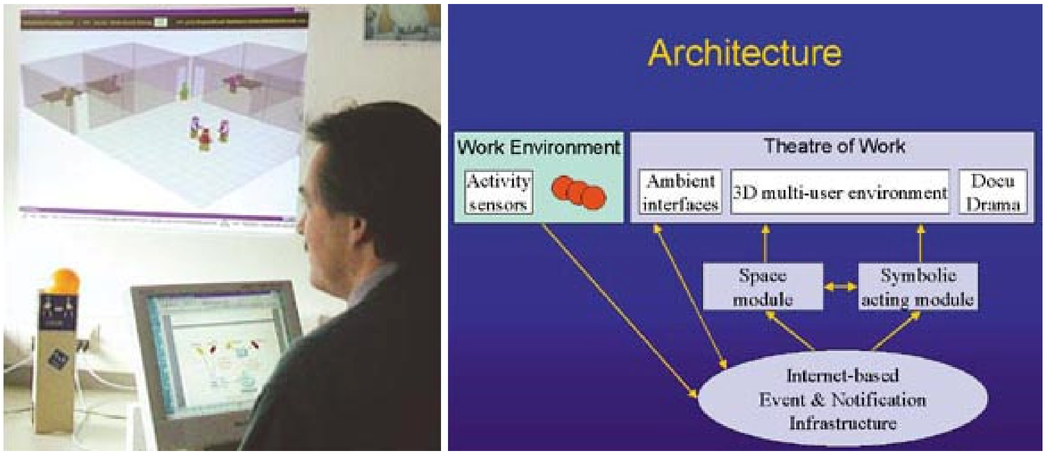


Figure 83. Realisation of the 'Theatre of Work' (left). TOWER architecture (right).
(Stanford-Smith and Kidd, 2000, Prinz and Pankoke-Babatz, 2000)

A more recent (2009) example[1] appears to build upon this work known as the 'Research Desktop' (TAGtivity) which augments the standard office desktop through four keys areas that provide a unified way of storing, interacting or retrieving individual or groups of desired documents. The Research Desktop provides the means for labelling (tagging) related documents, images, e-mails or other items for a given task activity as shown in the arrows in Figure 84 and Figure 85. These assigned labels can then activate particular tasks or provide the means for switching between multiple labelled tasks or micro-switching between label task contents. These task items can then be retrieved, analysed, previewed or added through a variety of tools such as the library or notes viewers. This design which is still in the research phase (2009) appears to satisfy issues 1, 3, 4 and 5.

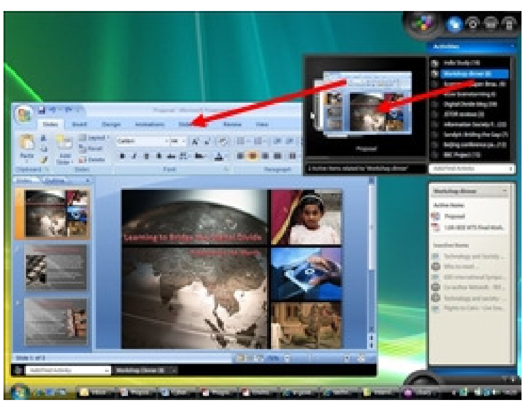


Figure 84. Research Desktop (TAGtivity) showing Activity Categories (Oleksik *et al.*, 2009)

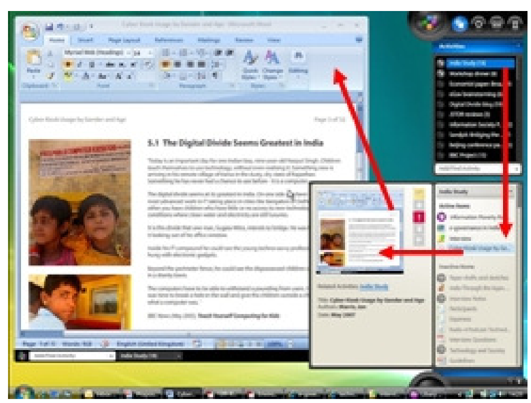


Figure 85. Research Desktop (TAGtivity) showing Activity Document Previews (Oleksik *et al.*, 2009)

[1] This work is associated with the author through his employment on the CFMS project.

As Oleksik *et al.* (2009) describe, the system enables linking of information through the drag and drop tags which associate the document task with a collective label (satisfying issue 1). The system automates the tag creation process through leveraging the Application Programming Interface (API) of the task application hosting the document and retrieving meta-information related to that document (satisfying issue 3) and it then stores this for subsequent sessions (satisfying issue 4). The system satisfies issue 5 by providing quick previews of the store's task documents as seen in Figure 84 alongside the corresponding document properties, to which these documents can be retrieved faster than existing systems. The underlying architecture that focuses on activities is similar to that of the 'TOWER Theatre of Work' project shown in Figure 83.

It is evident that no system appears to exist at present which satisfies all of the five issues. In particular issue 2 above, the ordering, accessing and structuring of information seems to have been a particular stumbling block. A possible solution for overcoming this issue is to use an ontological model within the design of the system to force the knowledge worker automatically to tag the categorisation levels. Consequently, the thesis now proceeds to discuss an ontological model for categorising information within an Information Universe structuring approach. It will be shown that a working prototype of this model satisfies the five issues stated in the introduction.

6.3 Information environment ontology

In order to conceptualise the ontological model a new model, called the 'Generic Management Model' (GMM) (Figure 86), was constructed as a means of explaining and examining the unique categorical relationships (data ontology) that occur within and between computer-based information systems. Figure 86 illustrates a model based upon the work of a single knowledge worker. A rationale will now be given for the terminology used.

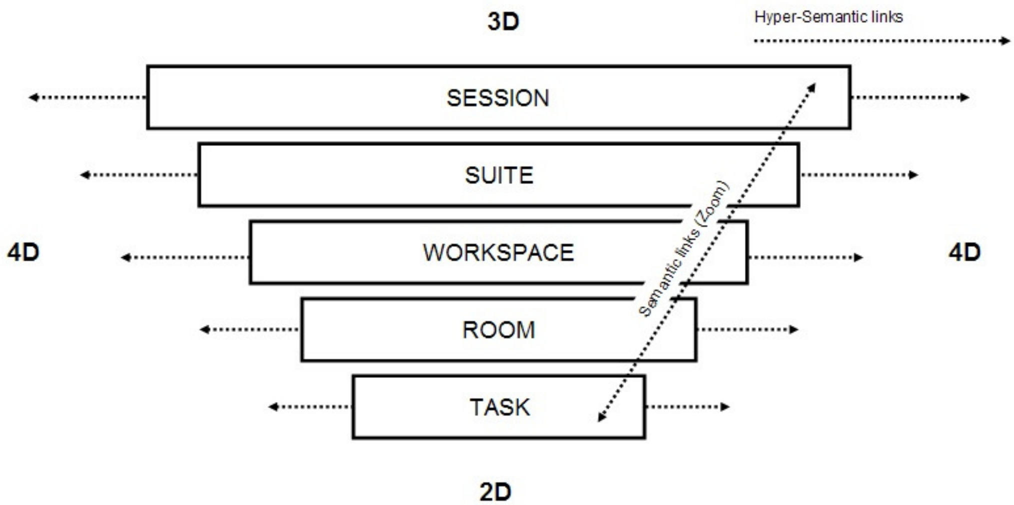


Figure 86. Generic Management Model (GMM)

6.3.1 Rationale for the terminology in the Generic Management Model

6.3.1.1 Task

The use of the model category of 'Task' is well understood in the literature (Henderson and Card, 1986, Card *et al.*, 1996, Robertson *et al.*, 1998, Freeman and Gelernter, 1996) and is applied to either a single or grouped set of actions upon objects (for example, creating a document) that a knowledge worker would typically undertake as part of an activity. In the case of this particular model category it is applied to the storage and retrieval of grouped sets of data that is collectively deemed a document (Chapter 2) pertaining to various activities. According to Freeman and Gelernter (1996), categorising information is the most difficult activity that knowledge workers can encounter as it does not fall into neat methods of categorisation that can be easily implemented through a single label that describes all of the meaning. Thus, since a Task is a universally understood concept it was felt that this was the most appropriate naming terminology for this model category. The reason that a Task is placed at the bottom of the model is that it is the lowest level of categorisation in terms of the knowledge worker's interaction that presently exists upon any filed hierarchical document; a Task normally has a direct association with the actual document in the form of a descriptive label through the way it is saved.

6.3.1.2 Room

The model category of 'Room' appears to have originated from work by Chan (1984) and according to Goldberg (1984), can be seen in Smalltalk through the windows named Project

Views (Card and Henderson, 1987a) which form a tree of workspaces (although the terminology has the same characteristics as that of a Room). Later, as elaborated in Chapter 5, the concept was taken further by Henderson and Card (Henderson *et al.*, 1991, Card and Henderson, 1987b, Henderson and Card, 1986). Essentially Rooms provide a placement mechanism which allows a window to appear in multiple Virtual Desktop instances (Robertson *et al.*, 2004b). In relation to the model category of 'Rooms' at its basic level this provides the facility of grouping related documents together under a specific label. Reflecting back to the Smalltalk example it grouped both icons and windows into different partitioned spaces. In the GMM, a Room has a describing label assigned to it that denotes a collection of associated documents (created through the Tasks) that appear under it. The placing of this in the GMM above that of a Task category, is directly related to work carried out by Freeman and Gelernter (1996) who described a concept called 'Lifestreams' of time-ordered streams of documents, that can be manipulated within the relevant Room.

6.3.1.3 Workspace

In the literature there seems to be a discrepancy between the terminology used for Rooms and that of Workspaces as they are used interchangeably without any regard for any separation between the two distinct concepts, often citing them as the same or similar Of specific note is work undertaken by Henderson and Card (1986) where a proposed system was described in terms of its providing the knowledge worker with '*a suite of roughly screen-sized workspaces called Rooms*' (Henderson and Card, 1986, p.12); these Rooms exhibit the same attributes to that described originally by work undertaken by Chan (1984) and exhibited in the Smalltalk Projects interface. Henderson and Card (1986) state that knowledge workers activities are distributed amongst several Rooms, whereby each Room contains a main assigned Task activity (document) being undertaken and could contain multiple related documents pertaining to that activity. Defining this relationship between an activity Room and Tasks suggests that a Room is part of a separate hierarchical structure that provides a means for switching between different Tasks. Further, it is pointed out again by Card *et al.* (1996) that knowledge workers in environments where Rooms do not exist, constantly rearrange their environment to tune the relative costs of the information so as to make them efficient. This suggests that a layer or category above these labelled Rooms is needed and in the GMM is termed a 'Workspace'; while ideally this could relate to the physical Workspace including the desk that the knowledge worker sits at (including their physical post-it notes or other resources) for interacting with the individual Rooms; for the purposes of this thesis the term Workspace relates to a collection of Rooms within the virtual desktop. This builds upon a concept as highlighted in Card *et al.* (1996) where collections of Task web pages (documents) were stored as named WebBooks (Room) and then these WebBooks (Card *et al.*, 1996) could be stored on a bookshelf that in itself might (although never explored by those authors) well have colour coded or named shelves (Workspace) according to the WebBooks being stored upon it. This layer aggregating these collections of WebBooks or Rooms into the bookshelf itself was called the ‘Information Workspace’. Thus, the central category in the GMM is called a ‘Workspace’.

6.3.1.4 Suite

As previously mentioned in the last category, Henderson and Card (1986) proposed that the concept of a ‘Suite’ category could well be applied to several Workspaces, although this relationship was never fully explored in this context since Workspaces were instead used interchangeably with that of Rooms. A labelled Workspace has already been termed a set of activities (Rooms) that contribute towards a common Workspace goal. These Workspaces are then grouped through a common theme; each of these groups of Workspaces are termed a Suite. A Suite therefore, has a labelled theme which binds the Workspaces together.

6.3.1.5 Session

There seems to be a need for an abstraction layer above that of a Suite, called here a ‘session’, which can consider a group of Suites revolving around a single knowledge worker profile which is unique in labelling and structuring in relation to the other categories. The general term denoting this is ‘session management’ which uses either an ‘Explicit Heavy-weight’ or ‘Implicit Light-weight’ model approach for interaction (Figure 82) and as previously mentioned, refers to the process of starting, stopping, joining or leaving a task (Edwards, 1994) currently being undertaken. These multiple knowledge worker Suites provide the ability for individual knowledge workers to switch between Suites which may or may not be created by themselves. These provide a unique persisted history path per Session that may aid with resuming of Task activities. The technique behind many forms of session management, as illustrated by conceptual drawings (Chalmers_Medialab, 1999) for session switching is the Necklace (Figure 78) or CyberCity (Figure 79) approaches where a knowledge worker could access a Session profile through their own unique login/password and then would be given a personalised view of the GMM categories. The point to note here is that each knowledge worker would see different categories/labels based upon their own created categories based on their own cognitive thought patterns. The documents and resources underneath would remain untouched (duplicated) since they are linked through tags (labels) instead of being copied across multiple knowledge worker Sessions. The GMM category of Session is placed at the very top of the model since it allows named knowledge workers to access different underlying categories and Task activity documents.

6.3.1.6 Semantic Zoom

Figure 86 also indicates that the data between the various categories are semantically linked by syntax and made accessible through the concept of 'semantic zoom'. This is described by Aigner (2007) as a non-graphical zoom mechanism which transforms views of the screen to show directly the underlying meaning (Sawant and Healey, 2007, Gregory *et al.*, 2005, University_of_Michigan, 1996) and type of information contained inside a target object. It does not modify the screen parameters of the graphical representation but instead it modifies the data structure's physical properties (Sawant and Healey, 2007) or selection of the data that is displayed. A semantic zoom can be considered to augment the dimensions of the data (Sawant and Healey, 2007, Gregory *et al.*, 2005, Aigner, 2007) since the addition details exhibited through the zoom mechanism may relate to ad joint information associated with a document but not visible in the document in its initial state. Consequently, data in a document as viewed on a screen can be considered as a two dimensional view; however, through the semantic zoom the ad joint data which is displayed (through the semantic zoom) may be considered as adding a dimension to the original 2D data and consequently is considered as 3D. In the GMM this semantic zoom is considered to operate across the various categories represented but does not add further dimensionality. However, the concept of hyper-semantic links (Potter and Trueblood, 1988) does enable an additional dimension to be added to the data.

6.3.1.7 Hyper-semantic links

Hyper-semantic links extend the dimensionality of data through incorporating knowledge (such as inference) and other meaning associated with data through capturing the objects, operations, flexible constraints, temporal relationships and heuristics (Miller *et al.*, 1990) which are not already captured as part of a semantic data modelling set of links. Suppose data exists in a document which is already linked to other data through a semantic link. This semantic link may contain a number of different kinds of relations between different types of resources (Guha *et al.*, 2003), such as text, images and document version number. The hyper-semantic link will add to these object resources further information beyond actual object linking to include characteristics about the relationships between these objects which may extend beyond the user's documents. For example, a hyper-semantic link would identify an object's membership of a group of objects which may have members from other resources beyond those in use at any one time by the knowledge worker (Potter and Trueblood, 1988). In order to distinguish between the data provided by a semantic link (3D) and that of a hyper-semantic link (4D), the GMM calls the additional information generated through hyper-semantic linking 4D. It is stressed that these dimensions within the GMM are data dimensions and not spatial dimensions associated with geometry. It is accepted that the literature is silent about the dimensionality of data associated with both semantic links and hyper-semantic links but they are added to the GMM in order to clarify the different data characteristics of the resources (further supplementary material can be seen in Appendix 14, sections 1 and 2).

6.3.2 Rationale for the terminology in the Information Universe Model

The ontology of the GMM can be further represented diagrammatically as in Figure 87 and in this thesis has been termed an Information Universe. Generally in this thesis, this is considered to be electronically linked or structured information within categories associated with a particular knowledge worker. The ontological model in Figure 87 has been named the Information Universe Model (IUM) in order to distinguish it from the GMM. This Information Universe Model illustrates the dimensionality of the data associated with the GMM. The five levels of the GMM extend across the four data dimensions discussed above. The semantic linking which provides the generation and aggregation of data through the semantic zoom generates data which may be of 1, 2 or 3 data dimensions. The hyper-semantic linking which provides the extra categories (classification, membership, constraints, heuristics, temporal) over and above those of semantic linking is deemed to generate data of four dimensions..

Whilst semantic linking applies to the Task category and through the semantic zoom to the other GMM categories, hyper-semantic linking through the incorporation of the extra categories means that it not only considers the Task, but also all other GMM categories at the same time. This in turn strengthens the associations between these links and refines the relevancy of the data associated with the Task. The Information Universe Model illustrates this by showing that semantic linking is across 1D to 3D, whilst hyper-semantic linking is across 1D to 4D. Hyper-semantic linking thus can be seen to include the characteristics of semantic linking but refines and adds to the categories covered by semantic linking.

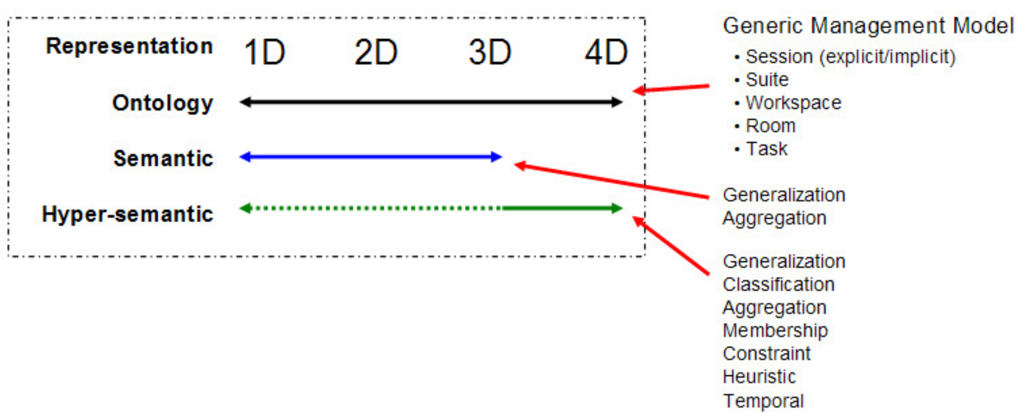


Figure 87. Information Universe Model (IUM)

As an example of a possible representation of the GMM, consider a particular medical doctor working in one hospital who creates three disparate medical report documents as part of their ward round. Suppose each of these documents relates to a gynaecological problem (T1), a gastrological problem (T2) and haematological problem (T3) as tasks, respectively. Each patient report is stored in its own unique Room which is labelled according to the name and patient identifier. Each Room contains a set of document reports that pertain to a full patient history going back, for example, ten years which are all labelled. The set of Rooms are then stored together as a single Suite which is labelled according to the name of the ward in which the patients are registered. A single doctor ward round, covering a number of different wards, forms a Session which thus has a number of Suites (wards) that are assigned to it. All categories, down to the task documents (T1, T2 and T3) may be shared amongst other doctors, or other departments avoiding any duplication of these documents through the model's linking of these documents. These other department staff can all access these documents according to their own unique structural labelling conventions for each of their departments.

The semantic linking provides the added granularity across the different tagging labels assigned to the different categories through understanding the meaning behind each document. For example, the doctor above wishes to find out further information about the haematological problem (T3) of a particular patient. In this scenario, the semantic linking associated with the label tagging will reveal to the doctor all related documents associated with a single patient report, regardless of where they were originally stored in the GMM. This label tagging stretches across any of the higher or lower levels of the GMM. The hyper-semantic linking would extend the information exhibited to the doctor to include similar instances of this patient's symptoms across other hospitals (assuming the hospitals are networked and the records are not confidential) and all other repositories. In addition, the hyper-semantic linking would enable the doctor to refine the retrieved documents according to a choice of categories (which is enabled through the characteristics of hyper-semantic linking - see Appendix 14 section 2).

The GMM satisfied the five issues stated in the introduction in the following ways:

1. Linking tasks and associated information

   The nesting hierarchy provides the ability to categorise different information, while the semantic zoom provides the ability to understand the meaning behind the hierarchy and the information itself. The hyper-semantic linking provides an extra dimension of detail when working across sets of semantically-related information which in turn provides extra granularity.

2. Lack of current structure for ordering and accessing information

   The nesting hierarchy provides an intuitive structural hierarchy alongside semantic zoom which should facilitate accessing information by providing ordering to any finite number of complex datasets (up to system breakdown). This nesting structure provides the knowledge worker with finite number of structured tag-based categories which may be accessed at all levels through the semantic linking. In addition, the semantic zoom allows relevant data to be displayed in greater details as the knowledge worker navigates through the nesting hierarchy. This is achieved by the semantic zoom changing the type and meaning of the information displayed according to the needs of the knowledge worker (Appendix 14). When using semantic linking, a single knowledge worker will already know much of the structural meaning behind data associated with their conceptual model of the system. However, when working with the GMM of another knowledge worker, the meanings are less clear. Therefore, further context and meaning needs to be applied to these additional links and this is achieved through the added data dimensions of hyper-semantic linking.

3. Automation of indexing of information

   Upon insertion of a new document into the GMM at the task category the system model would index the information through the document and its associated metadata.

4. Persisted activity sessions

   At the conclusion of a work session the system model is programmed to record all the activities of that session. Each record of the activity is retained by the system until deleted by the knowledge worker or system administrator.

5. Screen clutter of task documents

   The GMM allows the knowledge worker to choose the characteristics of the information displayed through the use of semantic linking and hyper-semantic linking. The semantic zoom in combination with the categorisation of the data provides the facility to select the level of granularity and number of documents displayed on screen at any one time.

While Figure 86 only illustrates issues 1 and 2 above; the other three issues can be demonstrated through the prototype implementation known as ‘Virtual Gatekeeper’.

6.4 Structural Design of the Generic Management Model

The structure of GMM rests on the nesting principle which was inspired by concentric circles with a central point. One natural occurrence of this concept is that of a cross section of a tree trunk with its age in rings (Figure 88). This natural phenomenon has a marked central point (Figure 88) which the nesting principle does not exhibit so strongly, unless of course the nests happen to form concentric circles. The limit of five levels represented in Figure 86 is arbitrary in the sense that it may be possible to extend the model further to include groups of Sessions etc. However, this is beyond the work of this thesis. While Sessions provide a natural first stopping place for the model, since these Sessions incorporate multiple knowledge workers, the limit of five levels was inspired by the work of Shneiderman (1980) who stated that a maximum depth of six levels was desirable. Although this work related to menu depth the similarity between navigating menus and retrieving information in the GMM pertains (see Chapter 4).

Figure 88. Young tree rings

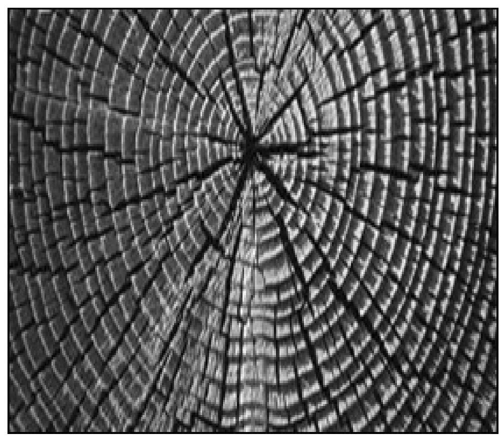


Figure 89. Cracked tree rings through age

Figure 89 is a photograph of a cross section of a trunk of an aged tree that illustrates cracks in the wood emanating from the central focal point. It will be noted that these cracks are not necessarily continuous from the central point to the outer circumference. Some cracks extend from the central point over a small number of the inner rings while others extended between concentric rings within the total radius; however in all cases, the disjointedness of each ring can be clearly seen. This first inspired the incorporation into GMM of partitioning historical data associated with tasks (rings) both within the categories and the tasks themselves. Secondly, those cracks which link rings but do not emanate from the central point suggested the concept of semantic linking since they are independent of the central focal point.

Referring back to Figure 88 the continual growth of the tree can be seen clearly and this inspired the ability of GMM to accommodate variable levels of data within each category. In addition the continually uninterrupted growth suggested the concept of semantic zoom as a smooth continuous process.

Figure 90. Spider Web

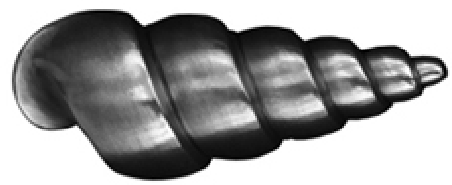


Figure 91. Girdled Horn Shell
(3D representation of 4th data dimension)

A similar but different metaphor is that of the Spider's Web which does not exhibit any concentricity but is considered to be a naturally occurring spiral (Figure 90) emanating from a central focal point. This inspired the concept of hyper-semantic linking since the spiral of the spider's web links the various nodes continuously; this contrasts with the concentric rings of the tree trunk (Figure 88) where nodes on different rings are connected through the cracks (Figure 89). This difference represented through nature, inspired making the distinction between semantic linking and hyper-semantic linking in the following way. A spider's web may be conceived as a ('flat') spiral within 3D; however, if the central point of the web is pulled orthogonally to the rest of the web a spiral akin to a girdled horn shell (Figure 91) is produced. This added dimension produced by pulling orthogonally suggested the added dimension of hyper-semantic linking over that of semantic linking. Thus the GMM represents hyper-semantic linked data as 4D rather than the 3D of semantic linked data.

Another analogy for this was inspired by the Kaluza-Klein theory (further supplementary material can be seen in Appendix 14 sections 3). The Kaluza-Klein theory is a model that seeks to unify the two fundamental forces of gravity and electromagnetism. This unification theory inspired the title 'Information Universe Model' since this model in the thesis attempts to unify the presentation and data layers. Kaluza-Klein theory in modern geometry is tantamount to there being a fourth independent spatial dimension which can be understood as a circle group (Schaar, 2005). This point is also made by Greene, (2003), who suggested that the true thickness of any dimension cannot be seen and could be vast, proposing that there could be multiple wrapped dimensions within four space hyperspace or tetraspace (Jones, 2003b). It suggests that the fabric of the universe could have large extended dimensions, but also very tiny, curled up, packed dimensions found at every point in space. The point to note in relation to this thesis is it could provide limitless space (Feltz, 2005), which a knowledge worker would never actually see, for potentially storing extra information or providing shortcut pathways to traversing (mining) the information in different ways. When/if Kaluza-Klein theory is accepted and it is then possible to view 4D geometry (Banchoff, 1990) in a 3D world, rather than a stereographic projection of it, then it could provide linkages between items or paths, without necessarily cluttering up the three-dimensional view that the knowledge worker is seeing. This aspect of Banchoff's work is discussed further under section 6.6.2.

If the spider sits at the centre of the web it is able to feel all vibrations and changes caused by interference with the web. Because the web is based upon the spiral, the spider is able to deduce the direction and magnitude of the interference (Foelix, 1996, Gore, 2008, Stewart, 2008, Krink and Vollrath, 1997). In the GMM, this is mirrored through semantic and hyper-semantic linking since both are updated as knowledge workers undertake different task activities such as adding documents to the system.

6.5 Implementation of the GMM

In order to test part of the GMM an implementation methodology was needed which would lead to a system architecture which mirrored the GMM as closely as possible.

6.5.1 Multi-tier System Design

Modern business desktop environments employ a '*multi-tier*' (Eckerson, 1995) software engineering architecture (Figure 92) for interacting with software levels, also referred to as the '*n-tier*' (client/server) architecture. Due to the limitations that existed prior to 1990s with the two-tier engineering architecture approach which only accommodated the back-end (data repository) and the front-end (user interface), additional layers were deemed necessary. Consequently, the architecture was extended to include modular flexibility for moving (repartitioning) and scalability as well as an added middle tier between that of the User Interface layer (presentation tier) and the data repository layer (data tier). This three tier approach is now typified through .NET Framework programmed desktop (client user interface) software applications that employ such aspects as Web services. An every day example of this is the Windows Update feature which is initiated and seen through screen prompts to the knowledge worker at system scheduled times throughout the working period. This system behaviour is also mimicked in application updates such as in Adobe Photoshop or in Microsoft Word.

Figure 92 represents a 3-tier generic model of the n-tier architecture based upon the work of Senthil *et al.* (2007) and Hans-Peter (1998). The three layers consist of a Data tier, Logic tier and Presentation tier each of which can be associated with the corresponding tier of the system architecture to be implemented as a prototype (Figure 93). The reader is referred to Figure 92 for formal definitions of these different layers. The data layer of the n-tier architecture becomes the data repository of the prototype, while the logic layer is equated with the GMM. The presentation layer mirrors the interface of the prototype. These three layers are situated within the Information Universe Model. As it has been discussed previously, the Information Universe Model represents the world view of data objects and the associations through semantic and hyper-semantic linking. Consequently, the 3-tier implementation can be considered as sitting within this Information Universe Model where the data object linking is represented in the implementation between the data repository and the GMM and between the GMM and the interface. The GMM acts as a data hub which interrogates and processes the information in both directions utilising the characteristics of the semantic and hyper-semantic linking. Referring to Figure 92, this can be seen as a direct mirroring of the functionality of the logic tier.

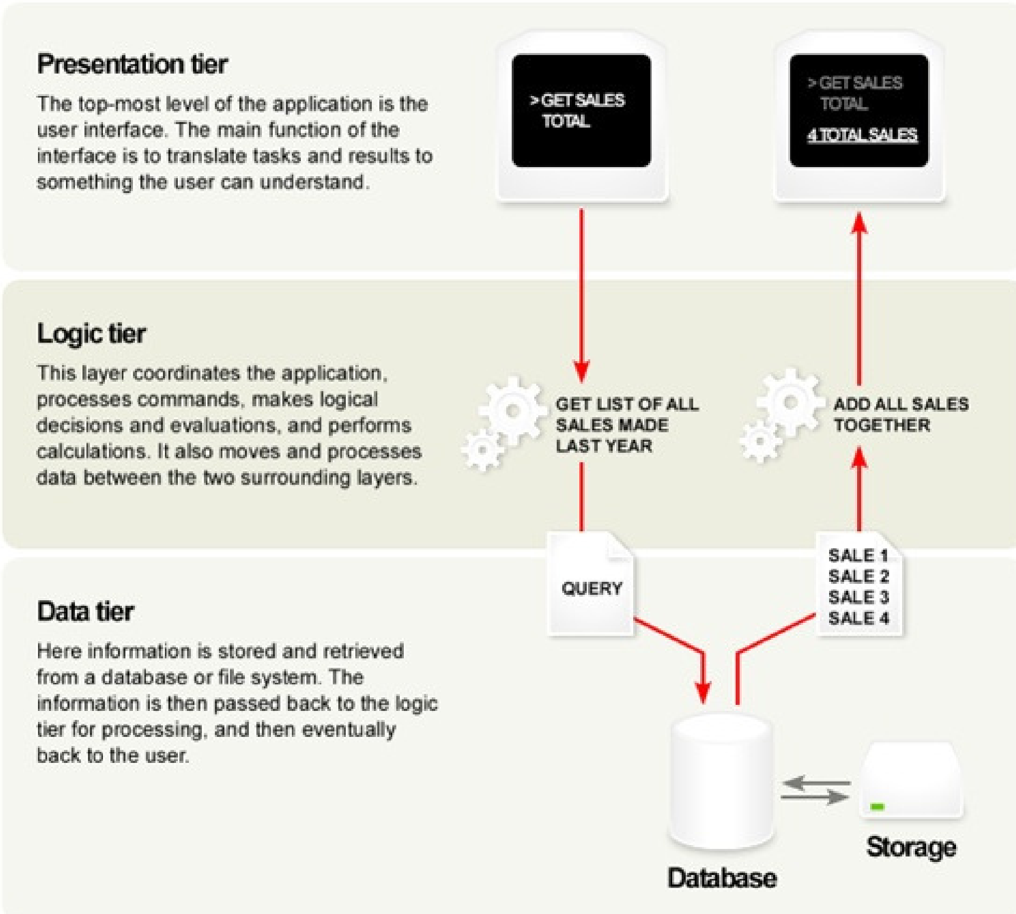


Figure 92. Three Tier Client/Server Architecture

(Senthil *et al.*, 2007, Hans-Peter, 1998)

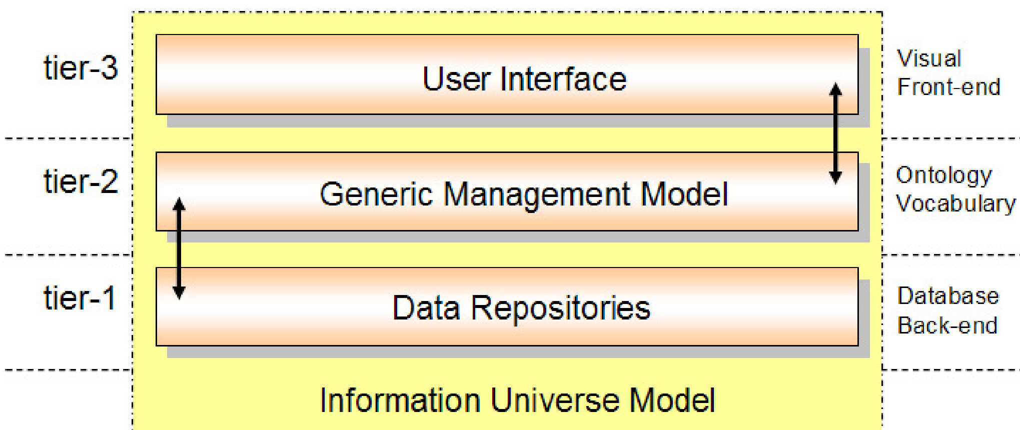


Figure 93. Prototype Architecture

6.5.2 Design of the Prototype (Virtual Gatekeeper)

Due to time constraints and the focussing of the experimental work on the five issues (6.1), it was decided to implement as a prototype only the two upper tiers (2 and 3) of the system architecture discussed in 6.5.1. It was felt that the technical problems of implementing a data repository along with its associated semantic/hyper-semantic linking were beyond the author's present technical capabilities. However, this was overcome by simulating the database through the creation of XML data objects (Appendix 11) where the relationship hierarchy was linked through the XML Schema (Appendix 11). This reflected a typical star or warehouse database as represented in Appendix 11. This also allowed the testing of the GMM categories and is in keeping with the exploratory prototype approach (Harmelen, 1989).

6.5.2.1 Design of the Logic Layer

The GMM (Figure 86) is the central focus of the thesis and was implemented with modifications to the terminology in order to cater easily for knowledge workers in a business domain. For example the top two categories of the 'Session' and 'Suite' were changed to 'User' and 'Project' respectively in order to be more familiar to knowledge workers in the application domain as suggested by two expert advisors (Appendix 9). They also suggested, that 'Workspace' was not changed. However, the researcher changed 'Room' and 'Task' to 'Segment' and 'Slice' respectively in order to remove any ambiguity between the terms that might persist and to show further a partitioning of a 'Workspace' level. All other aspects of the GMM remain unchanged. These changes are shown in Figure 94 for convenience.

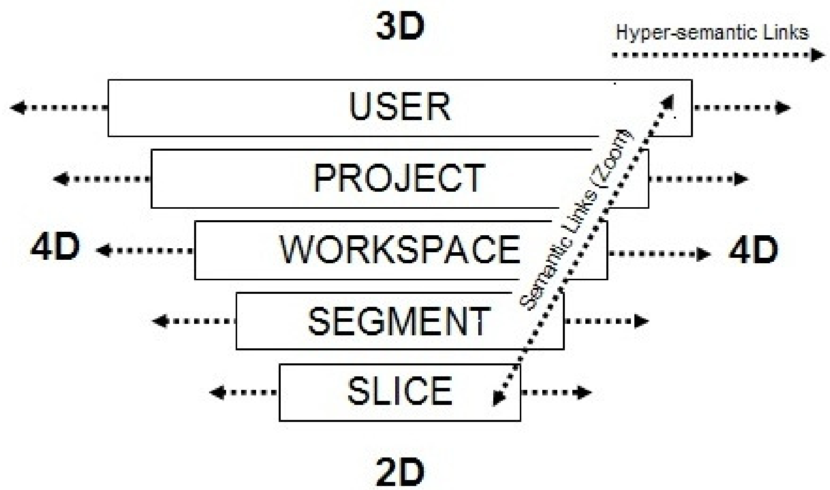


Figure 94. Domain specific Generic Management Model

The presentation layer (interface) was incorporated into the implemented prototype. Through the 3-tier architecture (section 6.5.1), the interface reflects the logic layer (GMM) and was so designed to incorporate the necessary functionality to test the five issues in section 6.1. It should be noted that the resulting interface is clearly one of many possibilities but was designed specifically to reflect the structure of the GMM. It should be noted that the interface has not been designed to be tested specifically for usability issues associated with the interface. These include aspects such as screen navigation (as apposed to system navigation), cognitive load and use of colour to name but a few. More specifically, the prototype was used to ascertain whether the conceptual model (GMM) was usable from the point of view of the five issues of section 6.1.

6.5.2.2 Design of the Presentation Layer

Figure 95 represents the presentation layer as implemented (Figure 96) in the prototype known as Virtual Gatekeeper (VG). The five categories of Figure 94 are visible with the addition of a central core which records use of the system linking into the database (which was not implemented). In addition, search slots are shown; these record the results of searches made by the knowledge worker and recorded by the system. It should be noted that the conceptual model is based around the Workspace which consists of a number of search slots that are tied to it. Each labelled search slot would represent a single search that is useful for the category in which the knowledge worker resides. In this way a search (semantic or hyper-semantic) covers all lower categories that are based either on the local system of the knowledge worker and unique to their session, or search across all lower categories associated with the category which they are in.

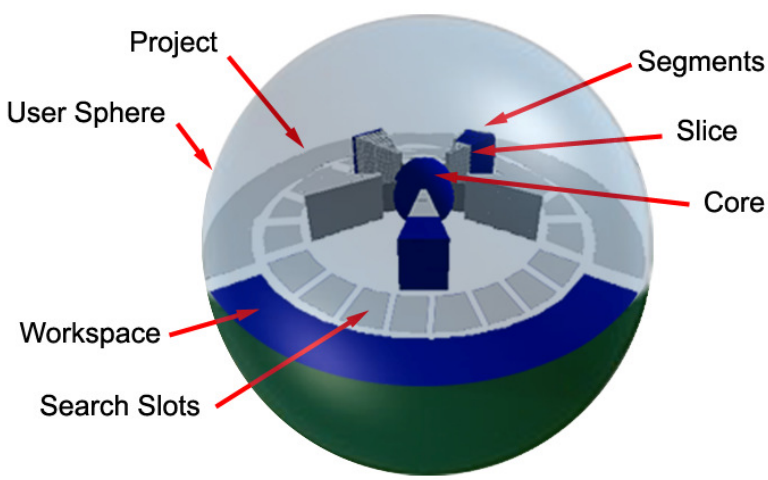


Figure 95. Virtual Gatekeeper 'Manager'

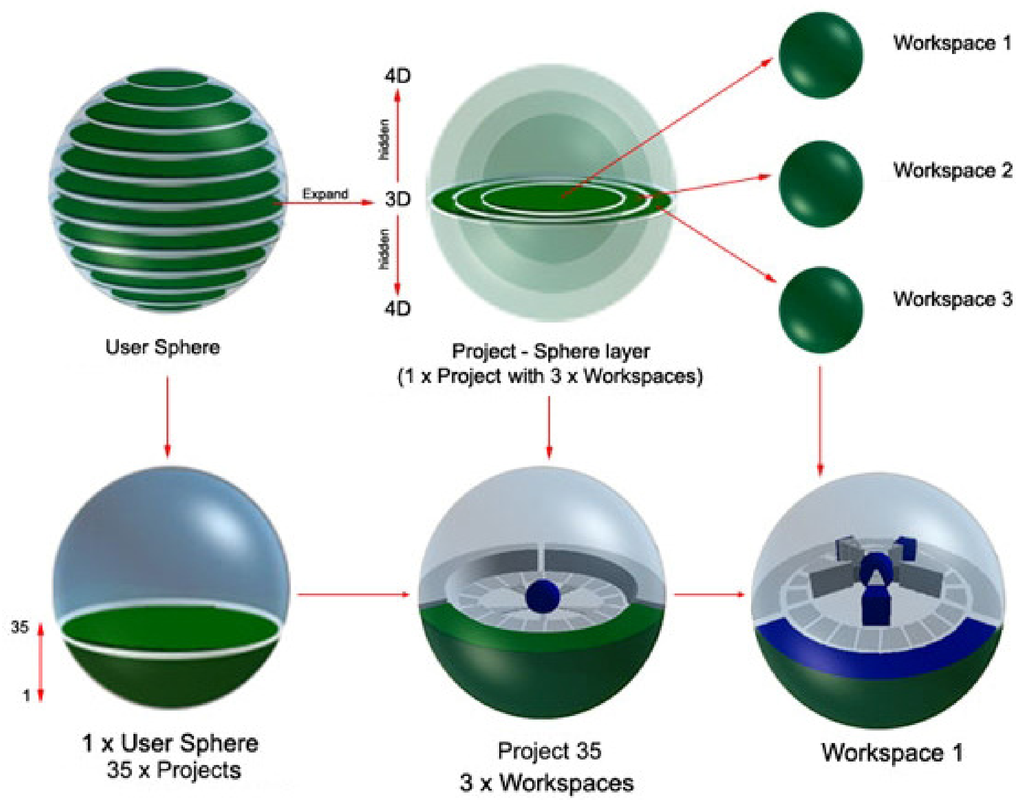


Figure 96. Virtual Gatekeeper Manager Interaction

Searching across documents/categories of their project workspaces or across the entire project workspaces assigned to multiple knowledge workers is facilitated, the results of which are then shown as a search slot workspace as indicated in the inner ring and labelled accordingly. Should this search workspace become further tailored or sorted according to further refinement by the knowledge worker, then this can be promoted to the outer ring as a newly named workspace with the previous search block being cleared. This means that the project will now include dynamically updatable shared documents as part of its structure since these are being changed by other knowledge workers who are associated with that particular project. Due to time restrictions, the core and the search facility were allocated for future development of Virtual Gatekeeper.

A knowledge worker interacts with Virtual Gatekeeper through first logging into the system using a username/password at the level of a Session in the GMM (Figure 97). Once logged in, the system presents a sphere (Figure 96) as seen in Figure 98, although this is a top down view, of project suites. At this point the knowledge worker can add, delete, rename or modify the properties for each of these displayed Projects at the level of a Suite in the GMM. Upon selecting a Project, the screen transitions to an equally sized sphere that resembles Figure 95 but with the inner segments depressed (Figure 99). At this point the knowledge worker can add, delete, rename or modify the properties for each Workspace that is displayed upon the outer ring. This is achieved through the clicking upon the desired workspace and the ring rotating around either left or right to bring the segmented ring to the front. Upon selecting the front ring for a second time it will depress down and the Segment's level then moves upwards from the centre to resemble that of Figure 100. In a similar way the Segments in the Workspace level can be added, deleted, renamed or have their properties modified. Also in the same way by selecting a segment or Room level in the GMM, not already at the front, the segments rotate either left or right until the Segment is close to the knowledge worker. Upon selecting the Segment for a second time the screen will then zoom into the segment and transition to display a pack-of-cards (Slices or Tasks in the GMM) (Figure 101) that are animated in terms of the knowledge worker being able to move them around, add, delete or modify their properties. These Slices initially are empty slots until such time as they are 'filled' with a document. A knowledge worker in this particular implementation could select an empty slot and then open the desired type of document that they want it to be. Upon creating this the screen would transition to display an application tool such as Word or a Web Browser (Figure 102). Once a final save occurs the application would close and reveal the Slice changed to a blue colour and meta-properties added dynamically to the Slice (Figure 103).

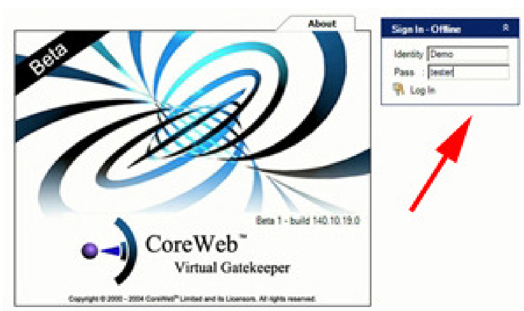


Figure 97. Virtual Gatekeeper 'Session'

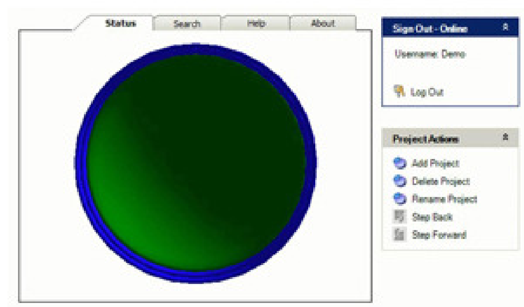


Figure 98. Virtual Gatekeeper 'Projects'

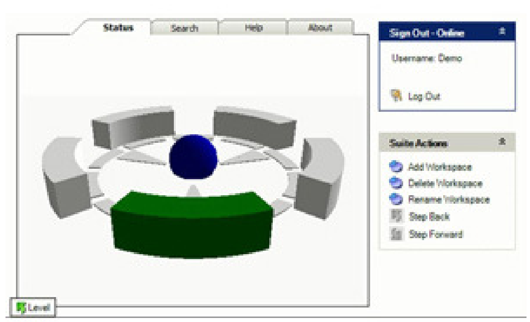


Figure 99. Virtual Gatekeeper 'Workspaces'

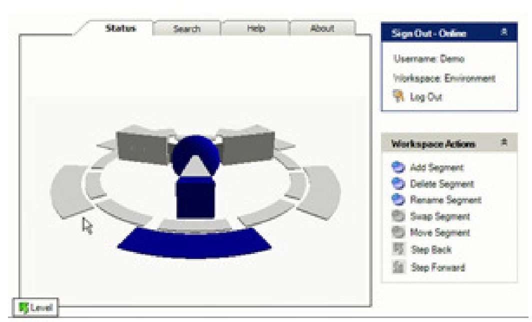


Figure 100. Virtual Gatekeeper 'Segments'

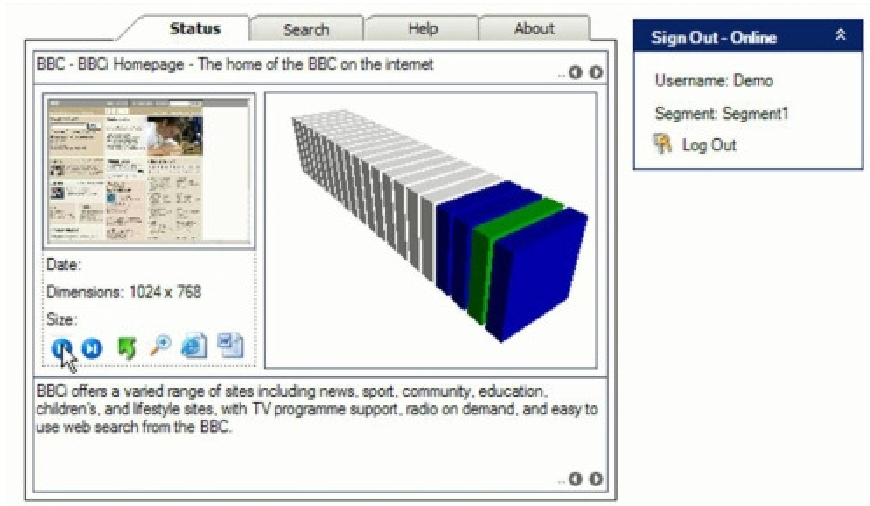


Figure 101. Virtual Gatekeeper 'Room'

Figure 102. Virtual Gatekeeper 'Slice'

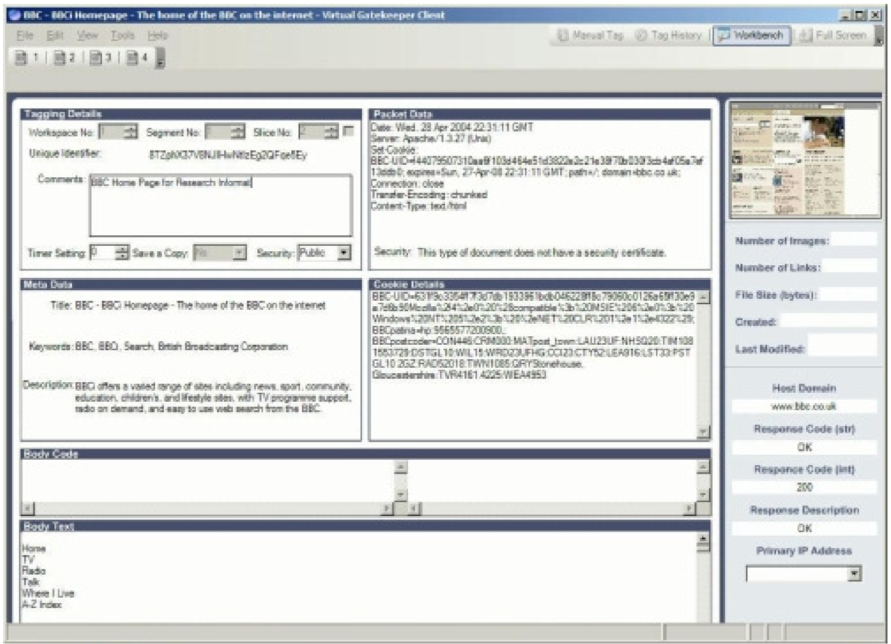


Figure 103. Virtual Gatekeeper Slice Metadata

6.6 Rationale of Design of Virtual Gatekeeper

The rationale for the design of Virtual Gatekeeper naturally falls into two parts, each of which will be discussed separately. The first of these relates to the interaction of the system with the knowledge worker whilst the second part will discuss the theoretical underpinning of the conceptual design. This section also relates the rationale to the five key issues given at the beginning of this chapter.

6.6.1 Rationale for Interaction

Mention has already been made of two previously developed concepts, namely the Necklace and the Lifestreams. Both these informed the implementation of Virtual Gatekeeper. The Necklace approach (Figure 78) inspired the rotational aspects of the interface while the Lifestreams (Figure 104) formed the basis for the segment slicing that represented tasks.

More specifically the necklace approach inspired the animation of the selected workspace to the front of the Virtual Gatekeeper User Interface whereby it then changed colour indicating it had now become the active selection. In Virtual Gatekeeper the selection changes from grey to green (Figure 98, Figure 99, Figure 101) indicating selection or from grey to blue (Fig 100, 101) when the selection is occupied. In addition the necklace approach inspired the linking of workspaces and segments (Figure 99, Figure 100) addressing issues 1 and 2, in a rotational fashion. This linking was extended in Virtual Gatekeeper to include the Central Core rather akin to a wheel with the Central Core mimicking or mirroring a hub.

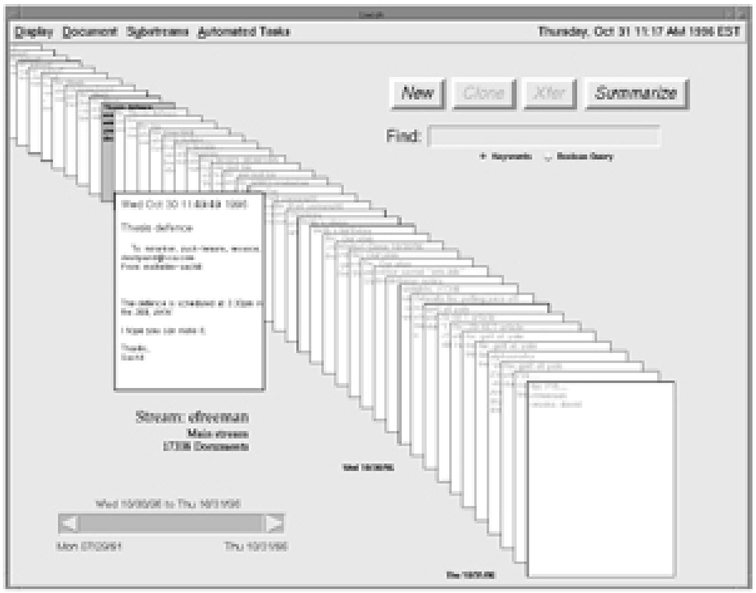


Figure 104. Lifestreams 'Pack-of-Cards' Interface
(Freeman, 1997)

The Lifestreams approach (Figure 104) led to the implementation within Virtual Gatekeeper of Segment Slices (Figure 100, Figure 101) generating the persisted histories through the stream of information characteristic of the Lifestreams' approach addressing issue 4. The tagging of certain preview metadata (Figure 104) has been reproduced in Virtual Gatekeeper (Figure 101) and extended to include the document title that is assigned automatically to the empty slide, date, size, screen dimensions, thumbnail preview of the actual document Figure 102, and brief description. To address issue 5, the Slices are linked directly from the Manager (Figure 101) to the Client Workbench (Figure 103) through number tabs that provide the knowledge worker with task shortcuts to all of the Segment's non-empty Slices so reducing screen clutter and providing comparison capabilities without the need to switch back and forth between Manager and Client whilst working on a task. In addition the Workbench part of the Client (Figure 103) automatically pulls out key metadata describing the document, meeting issue 3. For example for a Web document (Figure 102) this metadata may include data packet, title, keywords, description, cookie details, body code, body text, number of images, number of links, file size, when created, when modified, host domain, response code, response description, primary IP address (Figure 103). The knowledge worker is then able to add further comments that they may wish to describe the document's (knowledge) usefulness and reason for its generation. These characteristics can then be used by the system structuring and indexing of documents in conjunction with semantic/hyper-semantic linking or searching.

It should be noted that the design of the Client itself was inspired by the Sun Microsystems's Looking Glass Project (Figure 76) whereby a document's characteristics could be included on the back of the documents itself through an animated flip (rotation). In Virtual Gatekeeper the flip has been replaced with the transition from the view of the document itself to an equally sized view of the metadata behind it accessed through a single click of the Workbench button. This allows integration of the two sets of information thus removing the need for screen flipping or extra dialogue boxes. This therefore reduces even further screen clutter when working with metadata, in line with issue 5.

While the Necklace and Lifestreams projects provided a basic metaphorical inspiration for the design of Virtual Gatekeeper they were insufficient in themselves to give a complete rational of the design of the Virtual Gatekeeper. In particular, they do not allow for the Central Core, (akin to the hub of a wheel) which would contain the data mining (fourth data dimension). In order therefore to validate the conceptual design, rather than the implemented prototype, of Virtual Gatekeeper it was deemed helpful to utilise some basic geometrical and topological mathematics. In addition, the fourth data dimension, i.e. the hyper-semantic data linking, conceptually happens outside the Central Core, in particular across Projects, Workspaces and Segments accessible to multiple knowledge workers.

6.6.2 Mathematical Foundation of the Design

The basic geometry used to inspire the design of Virtual Gatekeeper followed work described by Banchoff (1990). Figure 105 shows the transformation based on a stereographic projection from four space into three space of successive subdivisions of the polyhedral torus (Banchoff, 1990). Essentially, this uses the property that all vertices of the hypercube are situated on a hypersphere (further supplementary material can be seen in Appendix 14 sections 4). In addition, the vertices of the four by four polyhedral torus lie on a hypersphere since these vertices can be seen as the same 16 vertices of the hypercube (Banchoff, 1990). By successive doubling of the vertices of the four by four polyhedral torus, "*a very close approximation of a surface in four space having the smooth torus as its image under the central projection*" (Banchoff, 1990, p. 127) is produced. Mathematically this torus in known as a Clifford torus.

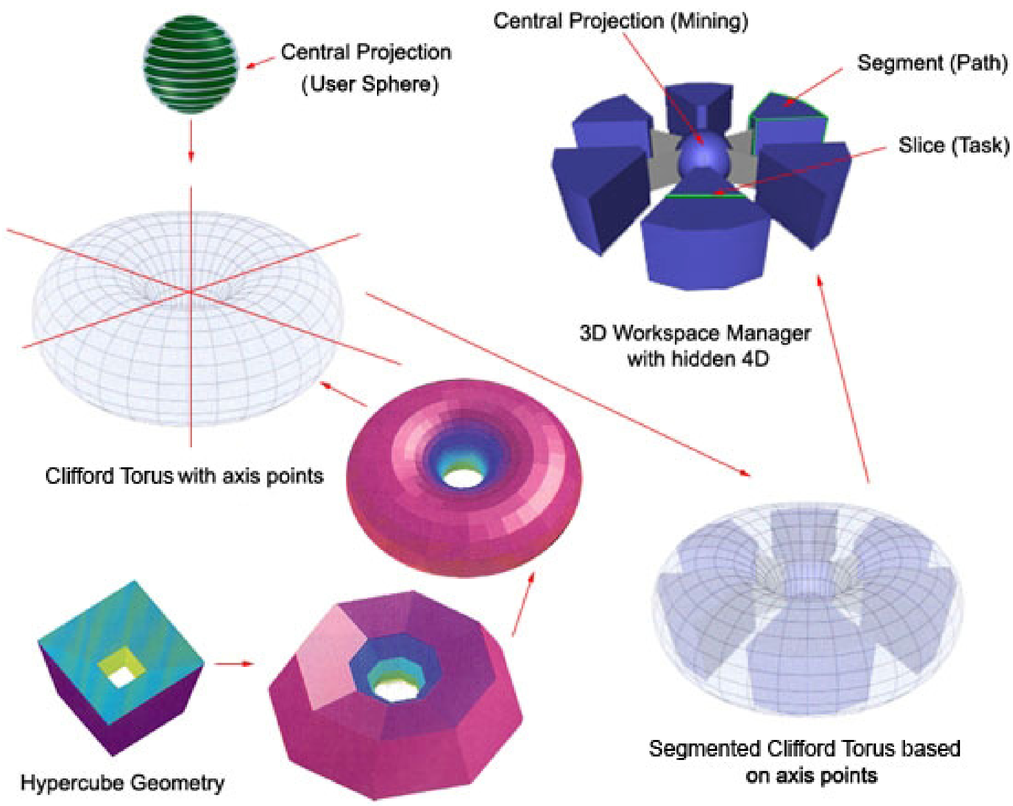


Figure 105. Virtual Gatekeeper Manager with hidden 4D structure
(certain figure aspects are scanned from Banchoff (1990)

Taking the stereographical projection into three space of the four space Clifford torus the design of Virtual Gatekeeper now places within the torus the construction inspired by the Necklace (lower right hand illustration in Figure 105). In addition, into the central empty space of the Clifford torus, Virtual Gatekeeper includes a three space stereographic projection of a hypersphere, in the upper right and upper left illustrations in Figure 105.

In addition, the three space stereographic projection of the hypercube has been used to inspire the internal structure of each segment. Figure 106 shows the relationship between various segments in terms of their hyper-semantic linking. The upper illustration in Figure 106 shows the top down hierarchical structure of a User sphere consisting of 35 Projects. The upper most Project of which has 3 Workspaces.

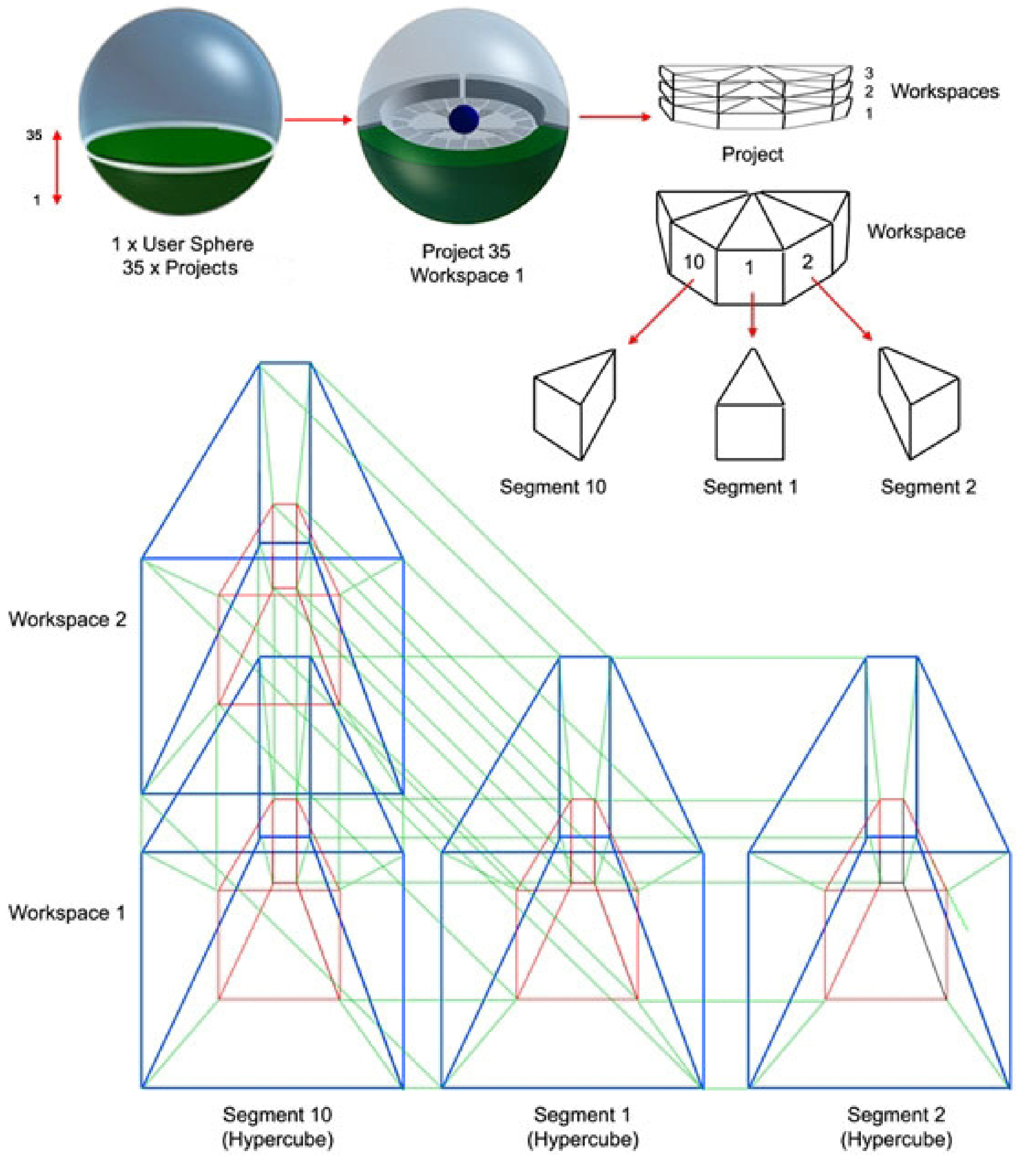


Figure 106. Hypercube structure of the Virtual Gatekeeper Manager

For the sake of illustrations one of the Workspaces is divided into 10 Segments whose data may be hyper-semantically linked. In Figure 106, it is assumed for the sake of illustration that Segments 1, 2 and 10, each belonging to Workspace 1, are hyper-semantically linked. In addition, a Segment from Workspace 2 is hyper-semantically linked, highlighted in green, to Segment 1 and Segment 10 of Workspace 1. In order to represent the fourth data dimension of the hyper-semantic linking each Segment is represented as a three space stereographic projection of the Hypercube where the linking of the vertices represents individual User Spheres or individual User Projects. Thus the fourth data dimension of the hyper-semantic linking is represented in Virtual Gatekeeper by the three space stereographic projection of the four space Hypercube.

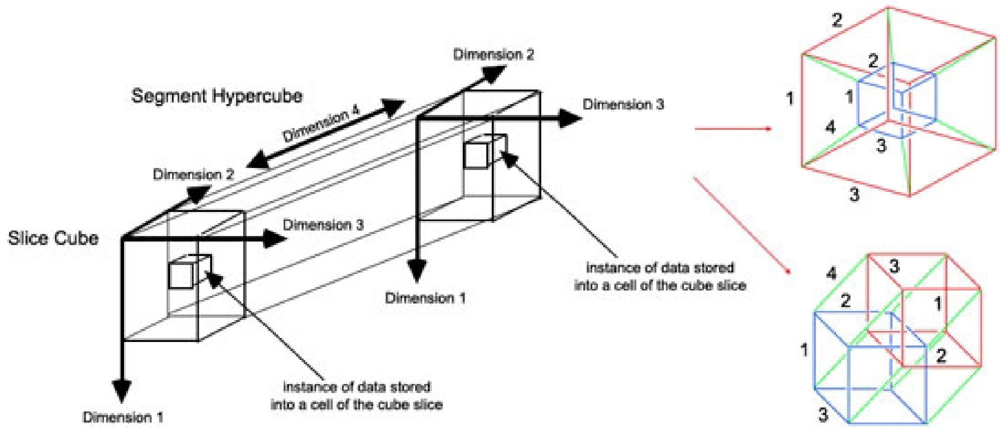


Figure 107. Geometrical basis of the design of a Segment within Virtual Gatekeeper

The concept of the three space stereographic projection of the four space Hypercube is again used within the Segment layer to represent the semantic linking between Slices. In Figure 107, two Slices are represented by the three space stereographic projection of the fourth space Hypercube. Within this three space slice data are stored which may include a document represented in two space together (conglomeration of data objects) with associated metadata properties (three space). Reverting now to the four space Hypercube the hyper-semantic linking of three space data objects (stored as separate tables and fields within a database) is conceptually represented by the fourth spatial dimension within the Hypercube. This linking conceptually may be between the data associated with other Slices both within the same Slice or between Slices and within other Slices anywhere in the conceptual GMM. Thus Figure 107 attempts to show that the data dimensionality is represented spatially within the implementation of the GMM. The nesting principle of the GMM is applied within Virtual Gatekeeper as a nest of hypercubes each of which represents a separate category all sitting within a hypersphere (Banchoff, 1990) which is represented in Virtual Gatekeeper by a User Sphere (Figure 95).

Mathematically, the cubic torus is homeomorphically transformed (Figure 105) into a smooth torus which is represented topologically by S1 x S1 (Hilton and Wylie, 1967) where S1 represents the circle in Euclidean two-dimensional space, R2 and x the topological product. The innermost cube is topologically equivalent to a sphere, S2 (Adler, 1966), and so can be topologically represented in this way. The originality of GMM and Virtual Gatekeeper has been verified through Patent No. GB2414574 **(**Richardson, 2004).

6.7 Original Contribution to Knowledge

Figure 108 illustrates the key claims to the original contributions to knowledge. Essentially, beginning with physical world metaphors (Figure 108) as an inspiration for clarifying the five issues, it has been shown that these metaphors when carried either up (data to presentation layers) or down (presentation to data layers) provide a link or unification between these layers since the approaches are harmonious, unlike with existing systems that do not provide this level of unification.

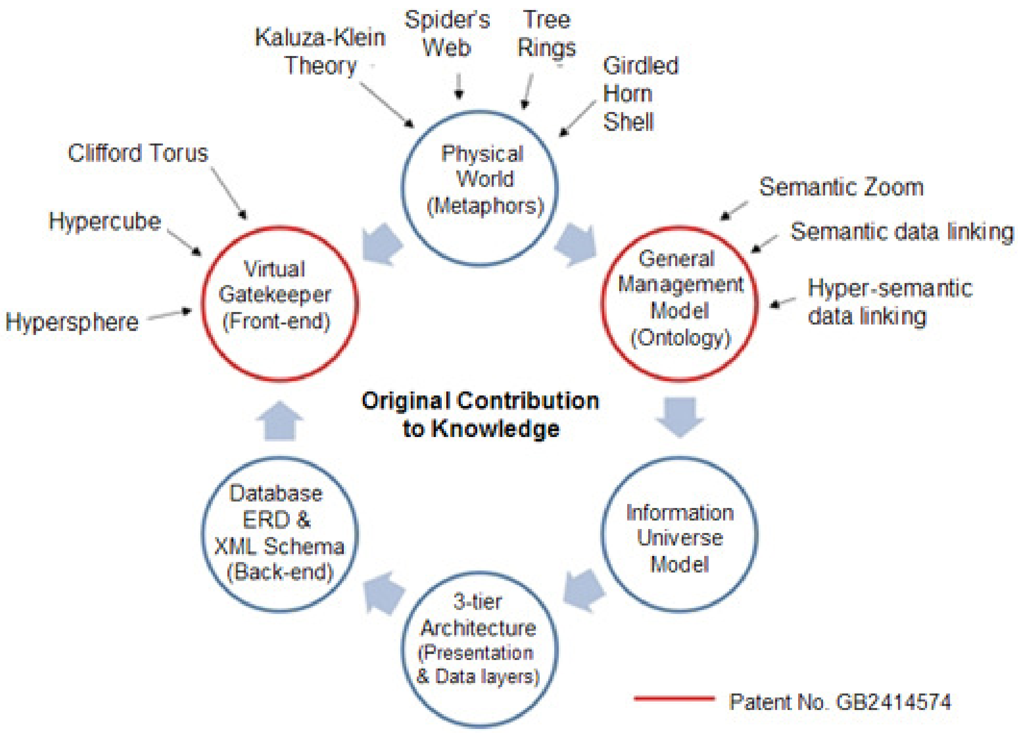


Figure 108. Original Contribution to Knowledge

More specifically, using Figure 108, the following original contributions to knowledge have been identified:

Integration of physical world metaphors

1) Kaluza-Klein
   - This inspired the use of the fourth data dimension in the GMM and in the selection of the geometry for the presentation layer implementation. This facilitated the addressing of issues 1, 2 and 5.

2) Spider's Web
    - The nerve centre of the spider allows sensory data to be captured. This metaphor was used to model semantic linking in 3D and hyper-semantic linking when pulled from the central point of the web. This also inspired the capturing and replay of session specific information. This addressed issues 1, 2, 3, 4 and 5.

3) Tree Rings (smooth/old)
    - The tree rings were used to inspire the modelling of semantic linking across partitions of each level and across data objects in each level. This enabled issues 1, 2 and 4 to be addressed.

4) Girdled Horn Shell
    - This 3D representation of a spiral inspired a 4D spatial representation of hyper-semantic linking. This addressed issues 1, 2, 3 and 5.

Generic Management Model (all items tested)

1) Clarification of Workspace and Rooms in terms of concepts and terminology.
2) Extension of previous work (Appendix 4) to include Suite and Session categories.
3) Clarification of the concept of Session through refining the work of Edwards (1994).
4) Incorporation of the concept of semantic zoom into the GMM.
5) Extension of the concept of hyper-semantic linking across and between categories of the GMM.

Information Universe Model (only tested item 2)

1) Clarification of where and how semantic and hyper-semantic linking fits into dimensional representation of data.
2) Unification of presentation and data layers through the GMM and Kaluza-Klein theory representation.

3-tier Architecture (all items tested)

1) Integrated the GMM as the Logic Layer into the 3-tier architecture.
2) Situated the 3-tier architecture within the Information Universe Model.

Database ERD and XML Schema (only tested item 2)

1) Application of the domain specific Generic Management Model as a Database Entity Relationship Diagram (ERD) for construction of a possible database.
2) Creation of an XML Schema for communication between a possible database and the domain specific Generic Management Model.

Virtual Gatekeeper Implementation (only tested items 1, 3 and 4)

1) Application of the domain specific Generic Management Model in combination with both the physical world metaphors and geometrical underpinnings.
2) Conceptual representation for possible future implementation of semantic and hyper-semantic linking.
3) Relationship between domain specific Generic Management Model and applications (for example a document linked to many categories through tagging).
4) The integration of a nesting principle using three space stereographic projection of four space with the properties of the Kaluza-Klein proposed fourth spatial dimension.

6.8 Summary remarks

This chapter has highlighted five important issues concerning the management of information and has shown how these can be satisfied by a conceptual Generic Management Model which can be implemented in software as a prototype called Virtual Gatekeeper. It has been demonstrated that the domain specific Generic Management Model is able theoretically to meet the challenges of the five issues. This work includes a number of original contributions to knowledge which have been summarised. The key elements of these controbutions include the combination of everyday physical world metaphors, i.e. a spider's web, tree rings and a girdled horn shell, which complement the Kaluza-Klein theoretical approach. Within Kaluza-Klein theory there exists a unification dilemma between very small and very large objects (Appendix 14). This inspired a possible linking between the presentation and data layers of a computer information system. This has enabled an approach to be adopted where the metaphors are used to bridge the presentation and data layers. This allows the combining of the two layers to form a unification which enables data to be linked in both layers in a highly structured and ordered way.

In order to conceptualise the underlying data structure and data linking in was necessary to use techniques which were inspired from geometry and which map spatial dimensions in 4D onto stereographic geometric object representations in 3D. This facilitated the interaction of the underlying data objects which mirrored the data dimensionality. This differs from present day approaches since the user interface is firmly coupled with the data repositories through the Information Universe Model. This Information Universe approach gives the foundation for developing domain specific applications such as Virtual Gatekeeper. It does not however, define the design of the User interface in any way.

Chapter 7: Methodology

7.1 Research philosophy

According to Davison (1998) a research philosophy is a belief about the way in which data concerning a phenomenon should be gathered, analysed and implemented. In order to examine the effectiveness of the proposal embodied in this thesis it was necessary to determine the research strategies and methods to be employed. A branch of philosophy which deals with knowing the methods of obtaining knowledge is termed '*epistemology*' (Bryman and Bell, 2007). Epistemology, according to Davison (1998) examines what is known to be true as opposed to doxology or what is believed to be true. This branch encompasses the philosophical doctrine of positivism, sometimes called 'scientific or interpretivism', also known as antipositivism (Galliers, 1992). These are normally considered to be either qualitative or quantitative in nature, although in reality there is considerable overlap between these clusters of research strategies. Quantitative strategies tend to be deductive, with the focus of the research being the testing of the theories proposed. In contrast, qualitative strategies tend to be the culmination of successive theories building towards the conclusion propounded. This thesis found a primarily positivistic quantitative experimental approach to be the more appropriate to the research questions as identified in Chapter 1. However, as a means of informing upon discussion themes and further research avenues, the interpretivism approach was also undertaken in part with respect to a qualitative interview.

7.1.1 Positivism versus interpretivism

Positivism, according to Bryman and Bell (2007), is a philosophy that states that the only authentic knowledge is scientific knowledge, and that such knowledge can only come from positive affirmation of theories through strict scientific method. Positivism is sometimes associated with empiricism which is further defined as a reliance on observable and quantifiable data (Davison, 1998). Positivists, according to Levin (1998), believe that reality is stable and can be carefully observed without interfering with the phenomena, or described from an objective viewpoint, stressing that all observations made should always be repeatable. This approach involves the manipulations of reality through carefully controlled variables of constituent elements that apply to relationships found within the social world (Giddens, 1974, LeGouis, 1997)

Interpretive researchers start out with the assumption that access to reality, given or socially constructed (Bryman and Bell, 2007), is based on understanding phenomena (Levin, 1998) through the meanings that people assign to them. Interpretivism (sometimes known as

Interactionism) research according to Kaplan and Maxwell (1994 does not predefine dependent and independent variables, but instead focuses on the full complexity of human sense-making as the situation emerges through intervention with reality. Further, it provides an interpretation of events and phenomena in their natural environment in terms of how the people involved perceive and understand their own experience.

7.1.2 Employed research methods

Human Computer Interaction (HCI) research employs a standardised set of techniques, across industry, for assessing a product or user interface in relation to its intended task purpose. The methods traditionally employed include usability testing, contextual inquiry, low-fidelity prototyping and heuristic evaluation (Hom, 1998). HCI research is often undertaken in a laboratory environment, where arguably all variables can be controlled and tweaked in accordance with specific questions at differing stages of the product development life cycle. Typically a set of tasks is devised and participants think aloud (Ludi, 2000) to express their opinions on the given task. The researcher then observes a synchronised broadcast (Figure 109) of how the participants are to use the product whilst taking written notes, adding markers or log event actions to understand what has occurred, such as the time taken to complete a given task or the number of errors made. In the past, these sessions were traditionally recorded on videotape in order to review further at a later date in conjunction with other manually collected data sources. However, today more sophisticated automatic surveillance methods are employed by organisations, such as tracking the computer screen events (Hilbert and Redmiles, 2000 and section 7.3) or recording eye tracked movements (Figure 110) of the participant.

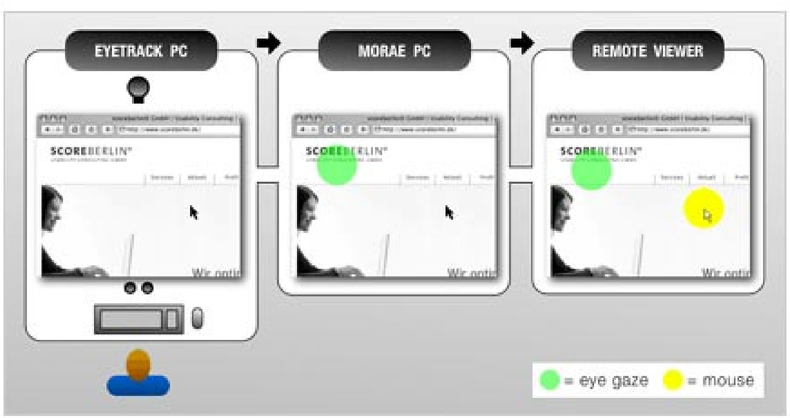


Figure 109. Data is synchronised in real-time to an observation room (Scoreberlin, 2007)

As a further example, one such standard quantitative approach employs the completion of a pre-questionnaire (background) and post-questionnaire (feedback) in order to reaffirm participant observed behavioural response or logged events which occurred during an experimental session and how these reflect back to the participants' prior experience. All of this data once combined and further triangulated (Baulch and Scott, 2006, Foss and Ellefsen, 2002) is used to assess the problem domain in accordance with informing upon improvements in either the product itself or upon the conceptual idea. The final tailored approach as undertaken, follows an adapted Spiral Lifecycle model (SoftDevTeam, 2007, Huq, 2000, Land and Wallin, 2001) and focuses upon combining the framework (Figure 113) and methods (Figure 111) of analysis into a specific simulation phase and a prototyping phase (Hakim and Spitzer, 2000).

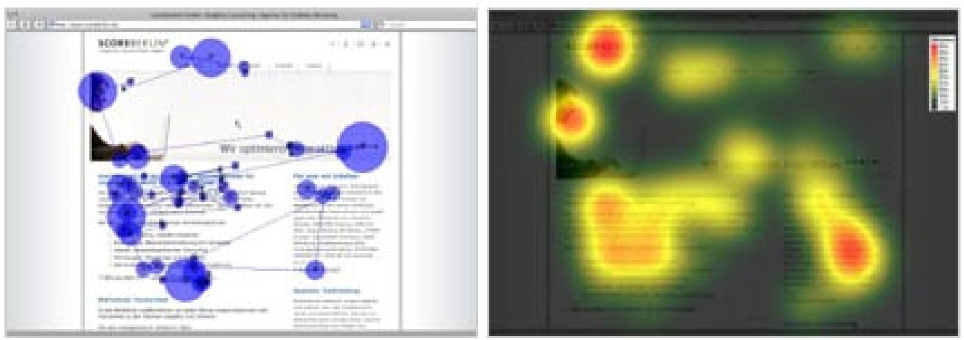


Figure 110. Left: Eye tracked gaze positions. Right: Heat map of a group of participants (Scoreberlin, 2007)

This entire phased strategy approach incorporates three main governing principles (Gould and Clayton, 1985) of design as a way of structuring the methods/activities undertaken into an ordered and coherent approach and includes:

- an early focus on users and tasks
- empirical measurements
- iterative design

As a way of understanding and deciding upon which were the most appropriate research methods, the following table was compiled from work undertaken by Stanton *et al.* (2005), Genise (2002), Jue (2007), Perner (2007) and Pearson_Education (2007) as a unified way of understanding the advantages and disadvantages of each method.

Evaluation Method	**Advantages**	**Disadvantages**
Think Aloud Protocol (Genise, 2002, Jue, 2007)	*Cost effective. Results are close to what is experienced by users.*	*The environment is not natural to the user.*
Remote Testing (Genise, 2002, Jue, 2007)	*Efficiency, effectiveness and satisfaction, the three usability issues, are covered.*	*Additional software is necessary to observe the participants from a distance.*
Focus Groups (Genise, 2002, Jue, 2007, Perner, 2007)	*If done before prototypes are developed, can save money. Produces a lot of useful ideas from the users themselves. Can improve customer relations. Flexible method to gauge consumer response to entirely new products and questions; issues of interest to respondents can be identified without specific prior knowledge of specific questions to ask.*	*The environment is not natural to the user and may provide inaccurate results. The data collected tends to have low validity due to the unstructured nature of the discussion. Expensive; unable to generalise from small sample size; respondents are vulnerable to social influence so that answers are not independent.*
In-depth Interviews (Genise, 2002, Jue, 2007, Perner, 2007, Stanton *et al.*, 2005)	*Good at obtaining detailed information. Few participants are needed. Can improve customer relations. Able to explore consumer feelings in depth; more independent than focus groups.* *Flexible technique that can be used to assess anything from usability to error. Interviewer can direct the analysis. Can be used to elicit data regarding cognitive components of a task.*	*Can not be conducted remotely. Does not address the usability issue of efficiency. Expensive; small sample size; unable to generalize. Data analysis is time consuming and laborious. Reliability is difficult to assess. Subject to various source of bias.*
Cognitive Walkthrough A team of evaluators walkthrough the application discussing usability issues through the use of a paper prototype or a working prototype (Genise, 2002, Jue, 2007, Stanton *et al.*, 2005)	*Good at refining requirements does not require a fully functional prototype. Quick and easy to use involving little training and cost. Allows the analyst(s) to understand the physical actions involved in the performance of a task. Very flexible.*	*Does not address user satisfaction or efficiency. The designer may not behave as the average user when using the application. Subject Matter Experts required. Access to the system under analysis is required. Reliability is subjective.*

Pluralistic Walkthrough A team of users, usability engineers and product developers review the usability of the paper prototype of the application (Genise, 2002, Jue, 2007, Perner, 2007)	*Usability issues are identified faster. Greater number of usability problems can be found at one time.*	*Does not address the usability issue of efficiency because of the number of users.*
Questionnaires including SUMI, QUIS and SUS (Stanton *et al.*, 2005, Jue, 2007)	*Flexible technique that can be used to assess anything from usability to error. Established questionnaire technique. Easy to use, requiring minimal training. Flexible technique that can be used to assess anything from usability to error. Can be used to elicit data regarding cognitive components to a task. Interviewer can direct the analysis.*	*Data analysis is time consuming and laborious. Subject to various source of bias. Development is time consuming and requires a large amount of effort on behalf of the analyst(s). Data analysis is time consuming and laborious. Reliability is difficult to assess. Subject to various source of bias.*
Checklists (Stanton *et al.*, 2005)	*Easy to use, low cost and requires little training. Based upon established knowledge of human performance. Offers a direct assessment of the system or device under analysis.*	*Context is ignored when using checklists. Data is subjective and inconsistent.*
Heuristic Evaluation (Stanton *et al.*, 2005, Jue, 2007)	*Easy to use, low cost and requires little training. Output is immediately useful.*	*Poor reliability and validity statistics. Data is subjective.*
Layout Analysis (Stanton *et al.*, 2005)	*Easy to use, low cost and requires little training. Offers a redesign of the interface based upon importance, frequency and sequence of use. Can be used throughout the design process in order to evaluate design concepts.*	*Poor reliability and validity statistics. Preliminary data collection involved e.g. observations, hierarchical task analysis. May be difficult to use when considering complex interfaces.*
Fieldwork (Stanton *et al.*, 2005, Pearson_Education, 2007)	*Can be used to assess anything from workload to usability. Powerful insight into how the end product will potentially be used. Yields information on personality traits, emotional states, aptitudes and abilities.*	*Can be time consuming. Requires access to end-users. Difficult to construct tests that are valid and reliable.*

Observation (Stanton *et al*., 2005, Pearson_Education, 2007)	*Consumer is in natural environment. Can be used to elicit specific information regarding decision-making in complex environments. Allows description of behaviour as it occurs in the natural environment. Often useful in first stages of a research programme.*	*Cannot get at consumer's thoughts; labour intensive and expensive. Data analysis procedure is very time consuming. Coding data is also laborious. Allows researcher little or no control of the situation. Observations can be biased. Does not allow firm conclusions about cause and effect.*
Surveys (Stanton *et al*., 2005, Perner, 2007, Pearson_Education, 2007)	*Mail: Low cost; ability to show text and graphics. Telephone: Moderate cost; ability to screen select respondents meeting desired criteria. Mall intercept: Able to reach more potential respondents; able to pre-screen respondents for desired criteria. Easy to use, low cost, requires little training. Potentially exhaustive. Provides a large amount of information on a large number of people.*	*Mail: Slow; low response rate Telephone: Cannot show stimuli; can only ask a limited number of questions; question answer options have to be repeated. Mall intercept: Expensive. Time consuming in application. Surveys are dated. Requires operational system. If sample is non-representative or biased, it may be impossible to generalise from the results. Responses may be inaccurate or untrue.*
Experimentation (Perner, 2007, Pearson_Education, 2007)	*Able to limit extraneous influences and identify causes of choice and/or behaviour. Allows the researcher to control the situation. Permits researcher to identify cause and effect, and to distinguish placebo effects from treatment effects.*	*Expensive; difficult to set up; limited information collected in one setting. Situation is artificial, and results may not generalise well to the real world. Sometimes difficult to avoid experimenter effects or other potential confounding variables.*
Physiological Measures (Perner, 2007)	*Able to pinpoint responses to stimuli over time (and thus identify good and bad parts of ads); able to gauge feelings of which respondents may not be aware.*	*Expensive; cumbersome*

Online Research (Perner, 2007)	*Able to take advantage of existing data (e.g., search engine queries; click stream sequences); conditional branching; able to customize questions; recording is usually automatic; often fast.*	*Lack of respondent willingness to follow instructions; concerns about privacy; possible response bias toward those more technically savvy.*
Laboratory Observation (Stanton *et al.*, 2005, Perner, 2007, Pearson_Education, 2007)	*Allows more control than naturalistic observation.*	*Allows researcher only limited control of the situation. Observations may be biased. Does not allow firm conclusions about cause and effect. Behaviour may differ from behaviour in the natural environment.*

7.1.3 Experimental method route chosen

According to Benbasat *et al.* (1987) and Bryman and Bell (2007) it has often been observed very accurately that no single research methodology is intrinsically better than any other methodology, where many authors, including Bryman and Bell (2007), cite a combination of research methods facilitating triangulation (Baulch and Scott, 2006, Foss and Ellefsen, 2002) in order to improve the overall accuracy (Kaplan and Duchon, 1988) of the research.

Benbasat (1984) and Pervan (1994) further highlights this by suggesting that a methodology best suiting the problem under consideration, as well as the objectives of the researcher, should always be employed. The overriding aim therefore are to make the methods chosen both relevant to the research questions as set out in Chapter 1, and to be rigorous in their implementation. With these points in mind, the methods adopted are summarised in the adapted Figure 111 showing research methods by research philosophy. This thesis' actual selected methods are ticked in red and piloted dismissed methods are ticked in blue. The significance of these ticks will be explained in the next section more fully.

Research Philosophy	Mingers' (2003) classification of research methods	Galliers' (1992) classification of research methods)
Positivist	Observation (passive), measurements, and (statistical) analysis ✓ (blue) ✓ (red)	Laboratory experiment ✓ (blue) ✓ (red)
	Experiments ✓ (red)	Field experiment
	Survey, questionnaire, or instrument ✓ (blue) ✓ (red)	Survey ✓ (red)
	Case study ✓ (blue)	Case study ✓ (blue)
		Theorem proof
		Forecasting
	Simulation ✓ (blue)	Simulation ✓ (blue)
Interpretivist	Interviews ✓ (blue) ✓ (red)	Subjective/argumentative
	Qualitative content analysis	Reviews
	Ethnography	Action research
	Grounded theory	Descriptive/interpretive
	Participant observation ✓ (red)	Futures research ✓ (red)
		Role/game playing

Figure 111. Research Methods against Philosophy with selected (red) and (blue) dismissed methods

(Choudrie and Dwivedi, 2005)

Since it is a multidisciplinary subject, HCI inherently incorporates research methods from a variety of sources as shown in Figure 111 (ChiCI, 2007). As mentioned previously (7.1), scientific research is generally undertaken using empirical methods, whilst in the opposing design disciplines (University_College_London, 2007) are more often based upon the development of product prototype, their evaluation, and their subsequent refinement. In direct reference to this thesis' research questions (Chapter 1), it was therefore important that a marriage was struck between these two opposing approaches and bridged, since what was being studied was an implementation of a conceptual approach, formulated upon a model. However ChiCI (2007) subsequently provided this bridge by highlighting work undertaken by Mackay and Fayard (1997) where they combined these areas into a framework (Figure 112).

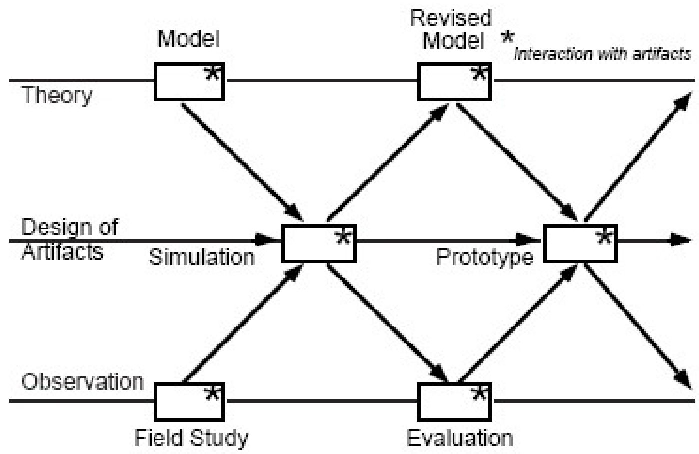


Figure 112. Interaction of people with artificially-created artefacts

(Mackay and Fayard, 1997)

This thesis' researcher then further extended this framework (Figure 113) through complementary approaches (NITEworks, 2008a, 2008b) and research findings from both theory/observation, whilst at the same time developing a concept prototype. Figure 113 illustrates the refined selected methods (ticked in red) and piloted or dismissed methods (ticked in blue). Thus, the final elaborated approach (Figure 114 & Appendix 2) is a combination of applying this adapted framework (Figure 113), the previously highlighted research methods (Figure 111) and a literature based foundation.

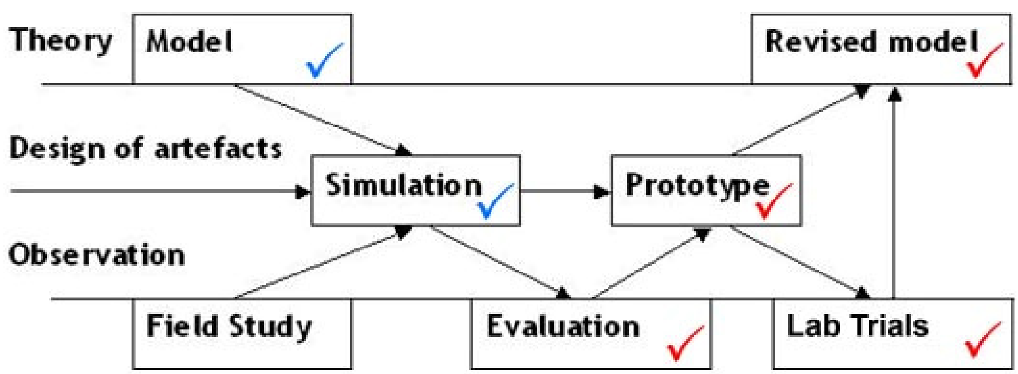


Figure 113. Adapted and extended through colour coding the Integration of Science and Design

(Mackay and Fayard, 1997)

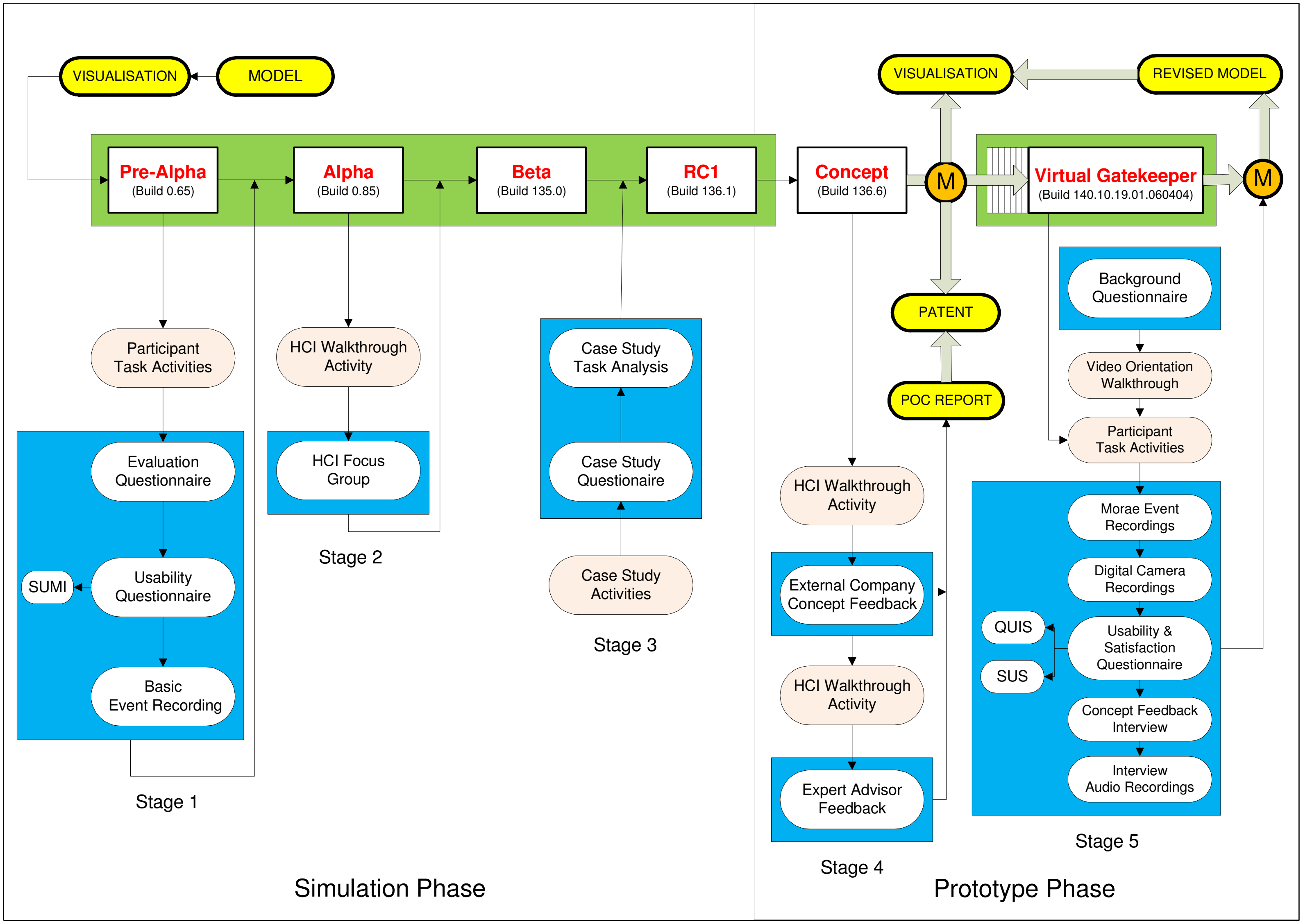


Figure 114. Thesis methodology flow diagram as described in sections 7.2 through to 7.4

7.2 Procedure

The simulation phase, referring back Figure 113 and Figure 114, was used as a strategic approach towards visualizing (piloting), over time, various complementary research methods with differing scenario implementations, which it was thought the prototyping phase (manipulation experiment) might eventually employ. The simulation phase (visualisation) is further described by NITEworks (2008a, 2008b) as an information practical event which relies entirely on subjective participant feedback and provides a rapid means of exploring the problem area prior to conducting an experiment or empirical study.

The key point of note is the focus in this phase is upon obtaining an understanding of the right tools, instruments, techniques and technologies required, where it mitigates against later erroneous results and the selection of the wrong or inappropriate methods. In the simulation phase any feedback obtained from these activities, informed upon the eventual software iterations only if major issues were encountered (so called show stoppers) such as the software crashing at irregular points, always emphasising the successfulness of the methods used and not the results obtained.

As seen in Figure 114 and Appendix 2, the simulation phase is separated into two streams which focus upon distinctly different aspects, these being the developmental software iteration builds of the realised concept model and the experimental research methods used for assessing them. Specifically, milestone iteration builds (code which was considered stable at certain points) was identified, which was then used as a means of informing upon the method(s) which were later to be used.

7.2.1 Stage 1

As an initial experiment it was decided to try out an entirely exploratory approach (Welie, 2001, Creswell, 2002) in relation to a set of tasks that consisted of milestones routing a participant around the features of the software. The aim was to facilitate exploration of the interface by providing only minimal structural tasks that corresponded with the desired functionality of the product. What was subsequently discovered was that this minimal approach meant that participants very quickly became lost in the software and one participant who did not know what to do to start undertaking the tasks, refused to continue. The evidence suggested that the tasks needed to be restructured appropriately.

As a vehicle for rapidly prototyping the ‘Generic Management Model’ (Chapter 6), Macromedia Director (Adobe, 2007) was chosen as the authoring development tool. The original justification for using this tool came from work carried out by Ludi (2000), which suggests that Director provides a visual animated development environment, requiring only marginal programming input, whilst at the same time providing extensive means for exploiting different forms of multimedia and text files. The benefit over alternative authoring methods was that the interface design could then be rapidly iterated, rather than worrying about any of the underlying programming logic, as this would be automatically generated. As mentioned previously, whilst this particular tool (build iteration 0.65) was initially very good for prototyping the interface, it was not sufficiently robust enough for providing an adequate level of realism, scalability or mathematical dynamics which were later required. Other aspects were that it frequently ran out of memory, was slow to respond on occasions and often crashed, resulting in an entire computer reboot.

The questionnaire (Appendix 6) was designed with open style questions (Creswell, 2002) so as to enable participants to provide some detailed degree of response to the Usability questionnaire. However, the largest problem was that the questionnaires were not probing enough in their phrasing or design, concentrating too much on the interface of the implementation and not upon the underlying model or what the concept was actually achieving. This constantly frustrated the participants as they frequently made comments regarding the questionnaire structure and that it did not capture what they wanted to say. Participants also wanted to elaborate further upon certain questions, and they would often suggest splitting up a single question into multiple ones for clarity. These changes to the questionnaire were made in order to give stronger validity to its use in the main study (stage 5).

The usability part of the questionnaire (Appendix 6) utilised an instrument called 'SUMI' (Software Usability Measurement Inventory). According to Veenendaal (1998) it is described as a rigorously tested and validated method for measuring software quality from the participants' perspective in relation to their perceptions. It provides a means for comparison of (competing) products and differing versions of the same product, as well as providing diagnostic information on future developments. SUMI consists of 50 questionnaire items devised in accordance with psychometric practice where participants answer a Likert style scale (Likert, 1932) with either agree, undecided or disagree. SUMI according to Veenendaal (1998), provides a global usability and is based upon five subscales:

- efficiency: degree to which the user can achieve the goals of his interaction with the product in a direct and timely manner
- affect: how much the product captures the user's emotional responses
- helpfulness: extent to which the product seems to assist the user

- control: degree to which the user feels he/she, and not the product, is setting the pace
- learnability: ease with which a user can get started and learn new features of the product

It was subsequently discovered from the results and other sources (Veenendaal, 1998) that a minimum number of ten participants with the same background was required for the results to be truly representative. In addition, participants found the phrasing of the questions far too general, with the accuracy and level of detail being limited and quite often were unable to relate what was being asked of them back to the actually tested software. The largest single area of criticism from participants was the use of this particular type of usability questionnaire, so it was therefore decided to investigate alternatives to this method.

As mentioned previously (7.1.3), in order to measure how long participants took to undertake certain task activities, it was necessary to record their events whilst interacting with the software. Unfortunately, software such as Morae (discussed later), did not exist at this point, so what was therefore undertaken were video screen captures of the participant activities in addition to directly logging their interactions with the software. The issue found was that in order to accomplish this, a separate application needed to be programmed in the background which logged information every minute on aspects such as session time, current movie clip, frame marker, mouse location (x/y) and mouse selected. However, what was discovered was that processing this information into something meaningful was incredibly difficult and relating it back to the separate video recording was utterly impossible. Apart from processing issues it was found that this intrusive recording caused the software to slow down considerably, to the extent that some operations did not function for a delayed period of time. Finally, based upon the problems with setting up and implementing this with participants, it was decided to abandon this technique.

7.2.2 Stage 2

According to Carnegie_Mellon_University (2007) and IEEE 1028 (I.E.E.E._Standards_Association, 2004), a walkthrough is a form of software peer review in which a designer or programmer leads a selected team of developers or other interested parties through an early iteration of a software product so as to facilitate understanding of the physical actions which would be involved in performing the task. During this walkthrough (section 7.1.2 methods table) session participants were allowed to ask questions and make observational comments at any point. This specialised technique were applied with a specific focus group (Morgan, 1997) of ten computer science academics and ten business managers of similar backgrounds at a British university in a single integrated session. The broad objectives of these sessions were to gain feedback about the technical quality of the product (build iteration 0.85) concept and underlying model therein without expending time on training, inform upon the presentation or the interface, or to familiarise the audience upon the features or intended use of the product.

In the case of this focus group the walkthrough was presented as a live demonstration of the software and frequently had problems as it was subject to crashes at certain points, which sometimes detracted from what was intended to be achieved. In addition, feedback suggested that the product was interesting but that perhaps a walkthrough that was video recorded would have been better than a live demonstration and a suggestion was made of investigating typical usage scenarios rather than just explaining the product features.

7.2.3 Stage 3

Based upon the feedback from the focus group which had referred to understanding case studies of how participants currently use information, it was decided to further investigate a hospital case study in order to get a real world perspective of typical daily tasks that participants might undertake when working with information. To this end, a questionnaire was adapted in order to understand the task analysis (Stanton *et al.*, 2005) of these activities. This questionnaire (Appendix 7) was adapted from Commonwealth_Government_of_Australia (2007) and focused upon Current Duties, Job Analysis and a Task Analysis log of events during a typical working day. This was then completed by two participant doctors in the same hospital. However, it was found that this technique, on its own, without any follow up, did not provide enough depth of information for the level that was required, where many aspects required either further investigation to clarify the participant's answers. In addition, the varying approaches taken to creating the logs meant that in both cases information was not full enough, was missing, and in a form which was not understandable to the researcher. It was therefore decided that whilst this approach was useful, it was much too time consuming for what was actually required. The decision was therefore made to adapt some of these questions into a background questionnaire instead.

7.3 Industrial feedback

According to Shneiderman (Fertig *et al.*, 1996, Freeman, 1997, Freeman and Gelernter, 1996) it is unacceptable to rely solely upon the programmer's intuition for developing a software tool, as software systems require to be validated via methods such as prototyping, usability and acceptance testing in a highly ordered, methodical and structured manner. As seen in Figure 114, the prototype phase merged two separated streams (software development and methods development) and focused instead upon understanding the responses to the model concept idea. However, feedback from the simulation phase suggested that the conceptual prototype (Figure 115), as developed (build iteration 136.1) using Director (Stage 1 & Stage 2), was not robust enough (build iteration 135.0), through continued crashing and inadequate feedback mechanisms, as a fully testable application for any participant trials. It was additionally thought that since the interface was entirely artificially simulated (six animated segments) and only had a finite number of routes that a participant could take, this inflexibility gave rise to an unrealistic and artificial view of the underlying concept model which was not consistent or comparable enough to real life applications, thus biasing the participants' responses.

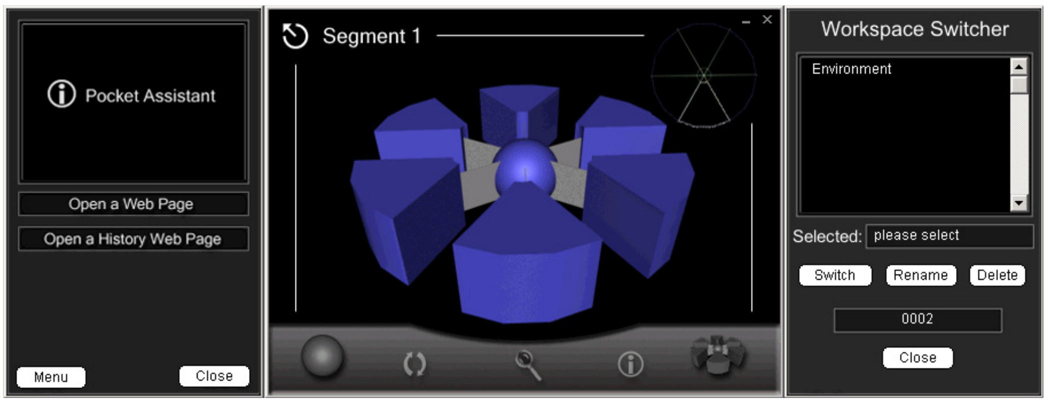


Figure 115. Proof of Concept build iteration 136.1 implementation

7.3.1 Stage 4

To further validate the final version of the model concept as developed using Macromedia Director (build iteration 136.6), it was presented under confidentiality agreements at seventeen HCI walkthrough presentations to specifically targeted industrial companies (a selection of comments are found in Appendix 8) which target products aid in the management or storage of information. As previously identified in the simulation phase (Stage 2) this type of technique at that point required better refinement. Therefore, the model concept was screen recorded as a video prior to these walkthroughs in accordance with a scenario of a participant writing a report and finding online resources that would aid them with that task. This task example was taken from the output provided from the simulation phase (Stage 3) where doctors typically write reports and obtain medical information from a plethora of online journal sources. However, the difference between these new presentations and Stage 2 was that the participants could only give their feedback at the end of the walkthrough. The main comments of their reactions to the concept are available in the Appendix 8. The suggestion was also forwarded that more business experienced advisors should be approached who knew the industry and who could then help refine the idea further; their main criticism was that the software as prototyped was not mature enough for them as yet.

Thus, through researching this through South West Angel and Investors Network (SWAIN), LinkedIn (online contacts network), Business Link/DTI and Oxford Innovation, a businessman, Mr. Andrew Ive was recommended (Appendix 9), who also happened to be a member of the DTI Council in 2004. After various communications, an initial presentation meeting was set up to be given, under a confidentiality agreement, to him and an associate, Mr. John McNulty (Appendix 9) who was a CTO for a technology company in London. After this similar walkthrough presentation, their decision was to back the idea fully in whatever ways they could. Their feedback, as seen in the Appendix 9, shows that they liked the concept idea but also wanted to see it further refined/extended, which confirmed the comments made earlier by the other seventeen companies approached. In addition, Andrew and John offered to help refine the idea further through advising specifically on a detailed Proof of Concept (POC) report (Appendix 10) showing how the idea could be developed in the future from just a concept. Concurrently to this, it had also been suggested by the University of Gloucestershire that the original ideas should be protected and so concurrently to the POC report, a Patent (Appendix 3) was written and subsequently published (Richardson, 2004) as original ideas in a pending published state.

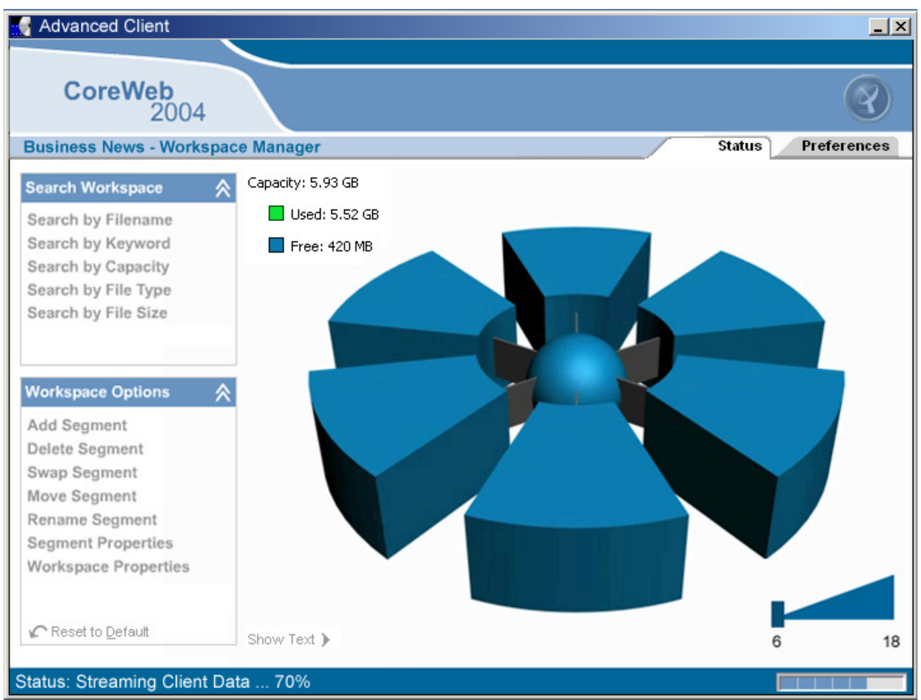


Figure 116. Virtual Gatekeeper build iteration 140.1 early implementation

The decision was therefore taken, after writing this POC report (Appendix 10) and from all the feedback from these specialised industrial organisations (Appendix 8) and advisors, to rapidly redevelop the software (Figure 116 shows an early iteration) using a commercial programming (C# .NET) language and game development technologies (DirectX 9).

The advantage over the Director build (iteration 136.6) was that everything on the interface would be entirely mathematically generated (dynamic), rather than being displayed based upon static predefined routes, in turn based upon participant defined action routes. In comparison to the Director build, this previously had to use pre-rendered animations for certain sequences and totalled 800+ differing generated animations in order to anticipate all possible routes that a participant could use for the interface. It also meant that the interface could not go above or below a certain number of segments due to scalability issues of rendering so many files. This was also the reason for the previous crashes, since many of the animations had to be loaded into memory prior to the participate taking that route - making a seamless transition. In a dynamically generated interface, these routes would be rendered mathematically at runtime and thus could take into account more permutations than could ever be designed using the Director build. Also, unlike the Director interface, the C#.NET version (build iteration 140.10.19) allowed for direct manipulation of the 3D visualisation,

Figure 117. Virtual Gatekeeper build iteration 140.10.19 implementation

which the Director version could not, such as selecting certain areas of the interface, whilst others were not selectable. This software therefore reacts to participants like any other application on their desktops, i.e. it provides comparable feedback like screen tips which they are familiar - something that was artificially created in Director and looked artificial. Upon early demonstration to the expert advisors (Andrew Ive and John McNulty) it was suggested that this presented a much better refinement of the model concept and should be taken forward further. The final iterated robust version (Figure 117) of the management model was therefore taken forward to Stage 5 participant trials (7.4.1).

7.4 Experimental procedure

The prototyping phase (manipulation experiment), referring back to the framework in Figure 113, Figure 114 and other complementary approaches (NITEworks, 2008a, 2008b), assessed the 'Generic Management Model' (Chapter 6) through a carefully controlled event conducted with participants at the Systems Integration Facility (SIF) laboratories situated in Bristol at MBDA UK Limited with state of the art experimental digital logging facilities. The phase investigated cause-and-effect relationships, which assessed, in quantitative terms, the effect of changes to one or more (independent) variables, whereby it specifically investigated the completeness of managing information (Chapter 1).

Specifically, a prototype (Virtual Gatekeeper) was used to trial the following key concepts behind the 'Generic Management Model' (Chapter 6) within the software. These concepts encompass the five issues as described in section 6.1 in the following way as shown below These concepts were tested using the following methods:

- Management model approach (issues 2, 4 and 5)
    - Post Experimental Questionnaire and Interview
- Management model interaction (including usability) (issues 2, 3, 4 and 5)
    - SUS/QUIS, Activity Logging, Observations
- Use of screen space for interaction (issues 1, 4 and 5)
    - Post Experiment Questionnaire, Interview
- Comparisons with other computing environments (issues 1 to 5)
    - Background Questionnaire, Post Experiment Questionnaire, Interview

It should be noted that issues of scalability and searching have not been included for trialling since these issues are seen as secondary concerns to the trialling of the 'Generic Management Model' as a workable paradigm shift in line with the thesis aims (Chapter 1).

During the prototype phase experiment (Figure 113, Figure 114), nine representative MBDA employee participants, matching specific participant profile(s), were asked to spend two hours either commenting or using the prototype tool (Figure 117). Prior to this, two extra participants piloted the procedural implementation of these trials, in order to facilitate understanding of the exact time taken between activities or if there were any further discrepancies that needed to be ironed out. The exact methods/instruments employed were taken from the work undertaken in the simulation phase, but specifically focused on the combination of complementary method areas as highlighted in red (Figure 118).

Usability Indicators	UI Event Recording	Audio/Video Recording	Post-hoc Comments	User Interview	Survey/ Questionnaire/ Test scores	Psychophysical Recording
On-line behavior/ performance	X	X				
Off-line behavior (nonverbal)		X				
Cognition/ understanding	X	X	X	X	X	
Attitude/opinion			X	X	X	
Stress/anxiety						X

Figure 118. Adapted data collection techniques and usability indicators (Hilbert and Redmiles, 2000)

The areas that the simulation phase focused upon previously are highlighted in blue and show how the simulation phase complemented the work undertaken in the prototyping phase.

During the prototype phase participants:

- completed a participant background questionnaire alongside a data logging consent form
- passively reviewed a 10 minute training video on the software system focused on a specific case scenario study
- actively performed up to 15 minute physical world set of task walkthroughs of the system while thinking aloud
- completed a usability and overall satisfaction questionnaire of the system
- answered interview questions about the overall model concept

7.4.1 Stage 5

The prototyping phase looked at accessing the completeness of the experiment in managing information. During this phase, participants were asked to complete three scenarios or real-life task walkthroughs using the management model with a standard hierarchical website as the source material for the tasks. This website used content which was unrelated to the employees' jobs, so that they had to actively hunt for information. These tasks were presented in consecutive order and participants were instructed not to use any search features either on the task website or within the management model, as this was not within the scope of this particular trial evaluation. The following representative tasks were then identified from case study analysis carried out in the simulation phase as typical ways of working with information in relation to applying them to the management model looking at similar situations. These tasks went from being highly directive and totally instructional in task 1, to partly instructional with some exploration in task 2, to finally totally exploratory in task 3. This approach, unlike in the simulation phase (Stage 1), assumed that after each task the learning of the management model features had been reinforced from undertaking both the training video and from undertaking each feature again under task instruction. These tasks were:

- orientation walkthrough of the management model
- filling the scenario workspace
- slicing up and identifying segment tasks

Following the feedback from the simulation phase (Stage 3), a background questionnaire was redesigned (Appendix 12) and structured based on combining work as carried out by Reffell and Waterson (2001) and Lang (1996). These authors had undertaken studies in the use of information and person profiling in relation to this. It was therefore thought that instead of redesigning from scratch untested questions, this would provide an adapted tried and tested approach for finding the information required from the participant. Specific adaptations were made to elaborate certain questions or rephrase them in accordance with the context of the research study's objectives (Chapter 1). The use of an already validated questionnaire helped to minimise bias whilst increasing reliability of the questions.

The video orientation walkthrough was provided to participants as a means of getting the participants up to speed quickly with the concept behind the software (Generic Management Model) before undertaking the trial task activities. This video was an updated version of the material provided to the advisors in Stage 4. However, audio was specifically removed from the learning material so that participants were forced to understand the visuals on screen in their own way and not be biased by the voice over at this stage. It was recognised that this might cause some participants to get annoyed, but since it was the visual understanding of the concept that was under examination, and that in the real world they would have no such help when working with such an operating system filing system, it was something that would have to be tolerated during the trials. Therefore, participants passively reviewed a ten minute training video on the software system, which focused on demonstrating a study of a specific case scenario.

As mentioned in the simulation phase (Stage 1) participants experienced considerable problems when using the default SUMI questionnaire for measuring the usability of the software; it was so general that participants did not understand many of the questions which were asked of them and so considerable tailoring would therefore be required (Stanton *et al.*, 2005). Thus, it was decided to opt for two alternative usability measurement instruments with a view to comparing their findings, so providing a more accurate rating result for the management model. The two approaches taken were System Usability Scale (previously used by Freeman (1997) and Tullis and Stetson (2004) and Questionnaire for User Interaction Satisfaction (previously used by Tullis and Stetson (2004) and developed by Brooke (2004).

According to Stanton *et al.* (2005) SUS is a measurement tool first developed in 1986 (Brooke, 2004) at Digital Equipment Corporation in the UK. SUS consists of ten questions with a Likert style one to five scale ranging from 'Strongly Disagree' to 'Strongly Agree'. It is used to measure the overall usability of a system or indeed a physical device such as a car cassette player (Stanton and Young, 1999). SUS provides a high-level subjective view of usability and thus is often used in carrying out comparisons of usability between systems (Brooke, 2004) SUS yields a rating score between one and one hundred which means it can be used to compare systems which may well outwardly be dissimilar in different domains. The drawback is that SUS is very general and also one-dimensional having only a small set of questions and should therefore be used in combination with other measurement techniques so as to achieve a holistic view of the usability of the system.

According to Laboratory_for_Automation_Psychology (2007) and Shneiderman and Norman (1992) QUIS version 7 is a measurement tool first developed in 1985 at the University of Maryland in the United States and attempts to capture the overall subjective participant acceptance (satisfaction) when working with an electronic system. According to Stanton *et al.* (2005) it is designed to elicit participant opinions in relation to ease of use, system capability, consistency and learning. QUIS has specifically targeted questions under these categories which are then rated on a Likert style one to ten scale. According to Stanton *et al.* (2005) once an operational system is available, the speed and ease of use means it can be employed repeatedly to modify the design concept. The output rating which is gained from each category or the overall rating is then immediately useful for offering an insight into the management model in relation to participant attitudes to using the interface under analysis.

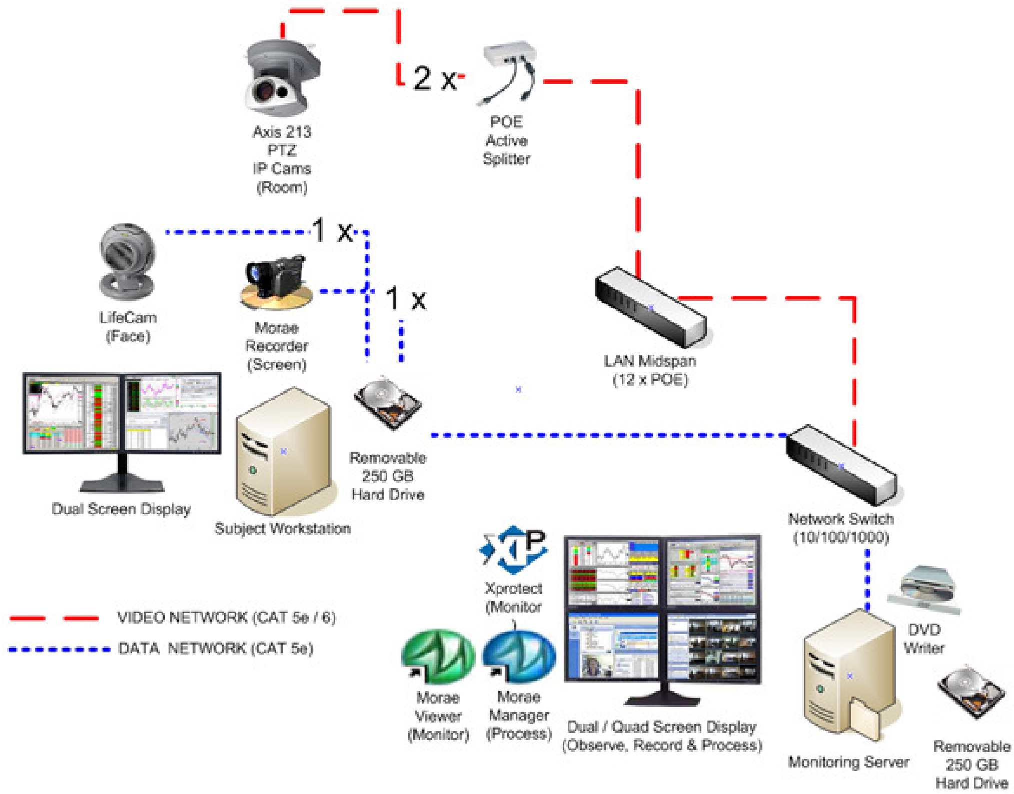


Figure 119. Architecture diagram of logging networked approach used for participant trials

As per the architecture diagram (Figure 119), the Techsmith Morae suite (Figure 120) of tools was primarily used for providing the logging of the participant trials. This technology had three main integrated components, known as a Recorder, a Remote Viewer, and a Manager.

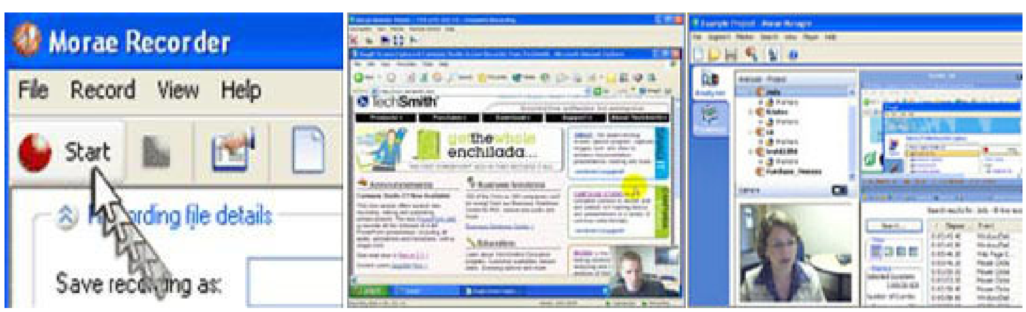


Figure 120. Morae usability testing for software illustrating the recorder, viewer and manager (Techsmith, 2007)

These components synergistically record, log, observe, analyse and share the participant experiences in a better way than previously used within the simulation phase (Stage 1), where separate custom applications were used. Specifically, the Recorder component creates a complete chronicle of management model event activity alongside the video of the screen and face video/audio of the participant using a LifeCam. The key point of note is that the Morae software runs silently in the background, thereby never disturbing participants when they are undertaking tasks or slowing down the software or activities on screen. The Remote Viewer component connects directly over a network with the source screen streamed from the participant recorder, thereby providing the ability to collaboratively observe and log with markers the live trial sessions from a remotely connected computer that synchronizes these notes back to the participant screen recording.

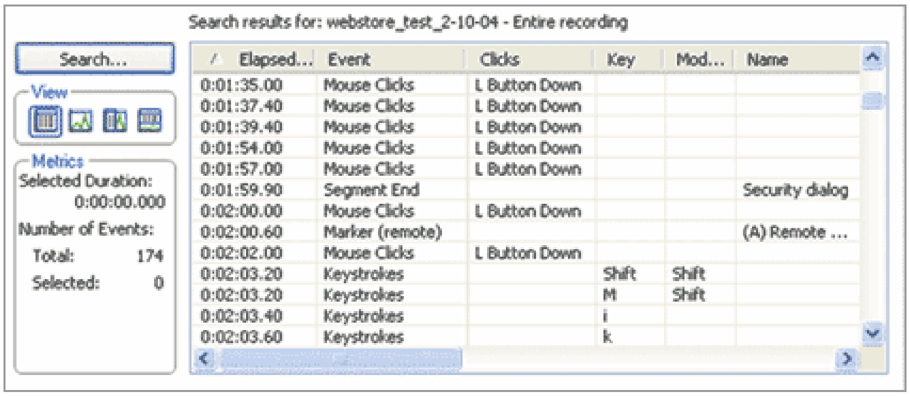


Figure 121. Morae manager analysis results
(Techsmith, 2007)

Finally, the Manager component (Figure 121) provides a tool which scans the screen video automatically, detecting event types or text entries that appear onscreen. The Manager visualises these search results in a time-stamped list view, or as an interactive graph, synchronised with the screen video. Through selecting any event in the list, the video recording of the screen and face camera of the participant, it is possible to instantly jump to the point in time when the event happened. For each event, the results provide detailed information such as when the event occurred, what type of event it was, the title of the window in which the event happened, a description of the event and the application name in which it occurred. The Manager provides an inbuilt graph view that displays the consolidated event results as a density graph, in either a line or histogram format, depending on the options chosen. The graph illustrates the distribution of search results over time showing where activity occurred and where there was no activity at all. The x-axis of the graph is Time, which is the duration of the entire recording or the section of the recording searched in, whilst the y-axis shows Density, which is the number of events that occurred at any point in time. These results can then be exported in comma-delimited test format in order to import into statistics applications such as SPSS or Excel for a more detailed breakdown, such as looking at performance measures like time on task or delays over time.

In combination with this, the XProtect remote client tool (Figure 123) was used to provide remote access to live and recorded video image feeds from two Axis Pan Tilt Zoom 213 digital camera feeds. These cameras were specifically used to observe participant body expressions and/or keyboard actions during the task walkthroughs. As a result this tool provided a unique insight, for post trial analysis, of selected video areas of motion thereby enabling the observer to identify moved, added or removed objects/keyboard actions.

Figure 122. IPOD 80GB with Belkin TuneTalk audio recorder

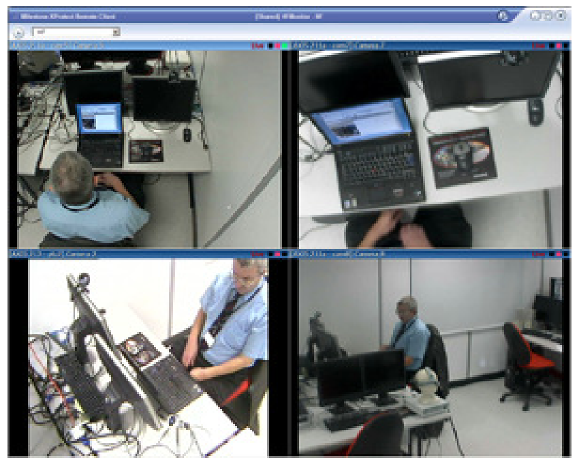


Figure 123. XProtect remote client

In a similar way to that of the background questionnaire, a set of interview questions (Appendix 12) was devised and adapted based upon Freeman (1997). In this earlier thesis, Freeman had specifically focused on a similar aim of understanding the concept approach in relation to Lifestreams. Therefore, since these were again tested questions, they were used as the initial basis for structuring these questions, and they were adapted further to suit the research questions (Chapter 1) by being elaborated in certain areas as indicated, based upon the feedback in the simulation phase (Stage 1). This debriefing interview was conducted and recorded using an adapted IPOD that included two combined high-quality omnidirectional stereo microphones (Figure 122). This tool provided a backup method if anything went wrong or was missed during these interview sessions. The tool also provided another form of material evidence for analysing and gauging the reactions of the participants upon the management model such as listening to the speed of response or any uncertainty in the audible responses.

7.5 Summary remarks

This chapter analyses the research philosophies and methods employed in testing the physical implementation of the model in a highly structured way. Specifically, it focuses on the differences between that of positivism and interpretivism through understanding the merits of the methods which fall into each of these categories. Since Human Computer Interaction is described as a multi-disciplinary, diverse subject, the chapter argues that the final methodology should incorporate both scientific research, which is generally undertaken using empirical methods, along with the opposing design disciplines, which are often based upon the development of prototype products, their evaluation and their subsequent refinement. A marriage was therefore struck between these two approaches through incorporating and extending the Mackay and Fayard (1997) Framework (Figure 113), which describes a simulation and prototyping phase, in which the simulation phase was used as a strategic approach towards visualizing (piloting), over time, various complementary research methods with differing scenario implementations. The prototype phase then merges these two separated streams (software development and methods development) and focuses upon understanding the responses to the ‘Generic Management Model’ through specific key concept areas of focus. As a consequence, the chapter concludes with an elaborated approach (Figure 114 & Appendix 2) and a final set of chosen methods, along with a detailed breakdown of each stage, the prototype implementation designs and the logging technologies which, when combined (Figure 118), provide the necessary triangulation of results.

Chapter 8: Results

8.1 Introduction

It can be seen from Chapter 7 (methodology) that some early trials were conducted for stages 1-4 of the development process. These trials can be seen as piloting possible methods to be used for the main study (Stage 5), the results of which are contained within this chapter. In addition these trials were used to test the actual implementation process of the 'Generic Management Model', particularly in terms of software robustness and reliability. As discussed in Chapter 7, these trials were useful in that they demonstrated that the initial implementation process was unsuccessful and if the management model were to be tested in a meaningful way, then a different implementation software and methodology must therefore be used. For more information the reader is referred back to Chapter 7.

The results as processed within this chapter were collated as part of the stage 5 (Figure 114) trials which were designed to investigate the completeness of managing information (Chapter 1) against the concept model (Chapter 6). In order to achieve this aim a tailored version of the model (Figure 94) was embedded into the architectural foundation (Chapter 6) of a tool known as 'Virtual Gatekeeper' which served merely to inform upon the underlying 'Generic Management Model'. The trial activities were carried out in strict laboratory controlled conditions and wherever possible, facilities were provided to mimic the participant's computer desktop office environment such as distractions through telephone calls, and the layout of the facilities, such as the telephones or printers that would normally be at their disposal. In order to focus the participants'' attention on the task and to minimise external errors, a non-related task activity website was constructed and entirely hosted on a self contained standalone network in order to reduce the risk of outside interference, or extraneous variables, such as slowness of the Internet network at certain times of the day. The trials approach provided a uniform network speed/set up throughout the day, where all variables could be carefully controlled and logged with less chance of external influences on the trials data collected.

The logged data within this chapter was collected under consent agreements (Appendix 12) which were signed by each and every trial participant prior to undertaking any activity. The questionnaire content was agreed in advance with the participating organisation and Staffordshire University Ethics Committee. The trials (Prototype Phase) were split into a pilot that consisted of only two participants of opposite sexes and a full experimental session run that used a combination of participant sexes. The pilot was used for reference purposes and served as a means of informing upon any minor refining of questionnaire phrasing necessary, and to test all the recording technologies combined in a real participant activity situation. The careful selection of the methodology process activities as documented (Chapter 7), the transparency of all logging methods, alongside the provided tailored instruments (such as QUIS, SUS and the questionnaires) were designed to mitigate, wherever possible, any perceived bias that may have potentially influenced the trials as the investigator was also the trials experimenter.

This chapter presents all logged data obtained during these trials with the aim of demonstrating that the management model, as applied, manages information very well and that this is directly supported through all experiments being successfully completed by participants. It will provide further justification for this conclusion through the fact that 80% of participants undertaking the trials wished to continue to use the management model beyond the trial studies and would even recommend it to others.

8.2 Participants' background

Due to the nature of the organisation and the employees' occupations, some personal identifiable information along with any organisational branding, was removed/suppressed at the request of the organisation's security department, such as employee badge details being blurred in photos, information removed on the length of service in the organisation, or main fields of interest. However, some special dispensation has been granted over the use of certain trials results/quotations (a sample is in Appendix 13) under the condition that these were not personally identifiable either to the individual or the organisation. Sample representativeness restrictions were necessarily imposed as only highly skilled employees from the organisation were used in customising the management model. It must be noted that this is unlikely to affect the overall bearing of the results as processed, although greater freedom/scope would have provided further richness and a wider set of experience from each participant.

The full trial consisted of nine participants, 82% male and 18% female, carefully selected based upon their occupational background (omitted by security) from a variety of levels in the organisation similar to a study undertaken by Boardman (2001) into multiple hierarchies in workspaces. This studies participants ranged in age from 45% of 25-34 years, 45% of 35-44 years and 10% over 45 years. In relation to their visual acuity, none declared any form of colour blindness, but 91% required visual correction devices (contact lenses or glasses). In relation to educational background, over 81% had a degree or higher, a higher ability in reasoning and comprehending the complexity of the concept being trialled. Indeed, over 91% of participants had a computer at home and were familiar with Windows (73%), MacOS (18%) or Linux (9%). This was an essential factor if they were to compare their experience (over 24 mean years across the entire sample, with a mean total of 36 hours per week) against the concept model. It was reassuring that whilst 73% of participants regularly used a Windows-based computer, 18% also used MacOS-based computers as well. This was helpful as it meant that the experience from which they would be drawing upon would not be limited by the use of one specific type of presentation level (Figure 92), such as Windows.

Since the trials consisted of task activities that worked with Web pages, it was essential that participants had a good level of understanding and experience of working with the Internet. In terms of the sample, participants used the Internet about 6 mean hours per week with most (55%) using it both at home and at work, while 36% others only used it at work. Crucially, it was asked what type of connection participants used for their Internet access, specifically tailored to what they had at home. It was noticeable that 73% had broadband Internet connections, suggesting that the Internet was always on and so that would not be an inhibitor to the amount of time that they spent online. In order to understand participants' experiences with Internet Web browsers, something again crucial to the overall functionality of the management model, it was asked what browsers they used and whether they had experience of using tabbed-based methods in these. It was very surprising that only 55% of people used Internet Explorer, with 36% using Firefox and 9% using Safari. However, it was of specific note that 55% of participants said that they had experience with tabbed Internet browsers at some point, which implies that they used a browser such as Firefox even if it were not their primary browser as at the time of the trials Internet Explorer 7 which includes tabbed browsing, was yet to be made available. Essentially, it was not the browser which was of interest, but whether participants had used tabbed based session management techniques, something crucial to both the manager (Virtual Gatekeeper Management Model) and the client in the trial tool. It suggested that whilst not every participant would understand the switching of workspaces initially, at least over half would pick up the concept and be able to compare against a feature that they were used to employing.

A further significant factor was to establish the methods by which participants distribute information in the workplace. This was collected by the participants answering several questions in an attempt to establish which format information was received, in which format they would prefer it to be received in and how they subsequently distributed it themselves. This question was also essential to the trials as it attempted to determine how useful a management model would be for the participants to utilise in their everyday occupations.

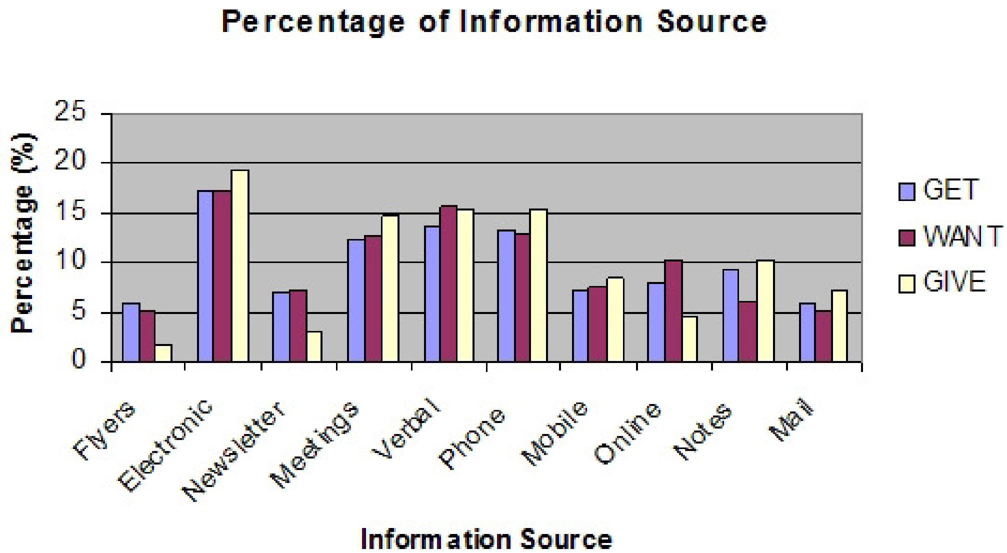


Figure 124. Distribution of information in the workplace

The results as graphed (Figure 124) show that the benefits of a management model approach would be considerable as the highest ranked method for obtaining, wanting or giving information to others is through electronic means. If one compares the participants' mean of 41 hours per week spent at work against the 36 hours mean per week that they used computers, there is a general suggestion that participants spend 88% (36 mean hours using a computer/41 mean hours a week people work) of their time either processing (getting) or generating (giving) electronic information. This high level of activity puts considerable pressure on a management model to accomplish the tasks efficiently. Interestingly, when this is broken down even further, it was found that 63% of participants spent over half of their remaining time using a computer reviewing electronic information and thus 28% of this time seems to be spent generating electronic information. In terms of the other 12% of participants' hours spent at work (out of 41 mean hours in total) they spent on average between a quarter to a half of their time reviewing other non-electronic information. However, the quality of information which participants received seems to have dropped as between 25-50% was suggested as being useless or immediately deleted despite the amount of information doubling in the last two years. According to nearly 64% of participants, they do not review any of this work related material at home and if they did (36%), it was in terms of supporting materials only (such as unclassified emails or web pages) rather than the actual documents themselves. In addition, this extra work never exceeded the mean value of 3 hours per week.

In considering the sorting of information received at work, participants used a variety of methods which are detailed further in Appendix 13. Some participants would '*review items* *within an email inbox quickly*' then '*prioritise or order*' the emails through techniques such as '*coloured flags*" etc., whilst others would '*print off important messages and immediately delete*' (scan, prioritise, delete). Alternatively, others would use an approach of prioritising using flags or grouping in a named folder, take action (through undertaking the task or answering the item) and then complete by deleting or archiving the items in different named folders. Others still '*ordered and sorted these items*' in terms of title, sender or importance but would always open the items first to assess the priority level. Those who opened the items first or placed items in sub-folders in their inboxes would also '*make directories on the desktop with the same named folder title*'. This behaviour was mimicked by those who printed these items as typically they '*placed correlated items into piles*' and it was reported (Appendix 13), that some placed sticky notes on top of these piles to reflect the title of the folder in their inbox or simply to categorise. This suggested a background of specific participant categories with those who developed no hierarchies, developed one hierarchy or were experienced at using multiple hierarchies either physically or virtually through processing a variety of information sources simultaneously (Boardman, 2001) across many desktop applications.

Surveyed participants reported that even though they used manual methods for sorting and prioritising incoming information, they still '*experienced frustrations with the information received*'. These frustrations were born from the lack of participants' understanding who would be the '*right person to assist with the task received*' or having to potentially search across a '*multitude of flat results through Internet search engines or file storage hierarchies*' when asked to research a given task, in addition to aspects such as not being able to access the search result due to a lack of available technology (software runtime) on their computer. Some participants cited that folder hierarchies on shared team areas were often so deep that they were an inhibitor to finding the latest document; something that was also observed when it was noticed (Boardman, 2001) that when deep categories were present the locations of particular categories varied. Also, due to the deluge of other unwanted documents within email inboxes it was costly in terms of time when answering emails or if they needed to sift through these to ascertain whether an important document had arrived. Nearly all participants reported that many '*emails were deleted without being read or never responded to through a lack of time*'. Often the already included filtering technologies did not perform as expected as they did not discriminate between what was required and how this data should be stored (in terms of legitimacy or format). Indeed, search technology, which is apparently available for finding documents, was cited as a way of finding a sender email or subject but due to the number of documents accumulated over the years this search would take too long.

Participants were asked which methods, techniques, or equipment they believed would help them further sort or sift through this information to increase the quality viewed, compared to current manual methods which they presently employ. The majority of participants (Appendix

13) expressed a preference towards methods such as '*filters/pre-filters (based on heuristics), automatically summarising documents into abstracts, smart folders or finding reports/presentations/spreadsheets in a fast and easy manner*', without having to plough through myriads of folders on a computer or shared drive, as well as a system that tracked when items are moved and so locations are automatically updated. Further, some participants expressed a requirement for tighter integration between applications, data generated, formats of documents stored and that this should be entirely accessible from within a single Interface rather than a myriad of differing tools interacting with the underlying operating system desktop.

Participants were then asked to bench mark these suggested improvements against their best experiences with information retrieved. They reported aspects such as '*finding out information that no one else had discovered*' due to using a novel way of finding it and having positive feedback provided over document changes or updates. Indeed, it was reported that when extra third party software was installed, it highlighted clear sections, titles and links to related or relevant sections which otherwise would have been missed. Participants also liked it when certain mundane tasks were automated through integrating named author created macros as a means of online help when generating a document.

Participants were subsequently asked to envision a situation where if they could invent something to sort through the information without present day technology constraints or limitations and describe what they believed would be the ideal gadget or technique. This was designed to reveal whether participants were thinking creatively and to investigate whether they were susceptible to change or not, especially since they were about to trial a management model that was a conceptual vision of the future. The responses reported in Appendix 13 are summarised as the following guideline points:

- summarise all information into a meaningful product so that I'd then be able to decide whether or not to continue further
- organise information by project importance for me, where it would pull out project or subject specific data that's relevant, complete and current
- some way to locate a file on my laptop or shared drive which finds exactly what I wanted inside it
- something which automatically sorts on topics/domain/file names into particular folders/areas or relevant groupings with clear cross referencing within the information when it was received
- something to identify what was wanted rather than what was asked for through instant finding, tagging, manipulation and prioritisation
- a way that allowed for multiple spellings of the same search term

- make me more productive - I need to switch tasks from one problem space to another quickly
- use an open standard for storage, so that documents were not at the mercy of specific tools or software versions
- provide templates of commonly undertaken document tasks which include styles, formatting and cross referenced resource links of previously completed examples to aid in the production of the new document
- provide automatic understandable named files without the need to populate with summary metadata as this is intelligently done for you

8.3 Concept training observations

The first phase of activity after completing the background questionnaire was for participants to review a 10 minute silent training video showing the management model in action. Whilst this was being undertaken, participants were monitored (Figure 125, Figure 126) remotely through the overhead digital cameras to obtain a record of their physical behaviour towards the material. Summarising from the notes made by all participants (a sample of which can be seen in Appendix 13), it was noted that participants expressed frustration at the length of video, and complained that there were no audio or annotated bubbles highlighting areas of interest. It was noticed that within 6-8 minutes on average the participants became visibly irritated through actions such as folding their arms, tilting their heads down on one side,

Figure 125. Training observation screens 1

Figure 126. Training observation screens 2

slumping in posture, putting one hand in their pocket, closing their eyes on occasions or putting both hands on their hips. At least three participants repeated the last 2 minutes of the video and at the same time put one hand on the desk fairly relaxed with their hand open. It was also noticed that over half the participants moved forward when they were more interested and rested both hands on their knees at intervals. One participant skipped on screen through the video at various points at the start of the activity before finally rewinding and watching it in one go whilst making written notes. At the end of the activity the participant then rewound, paused and played the video again until satisfied that they understood the concept with their notes.

8.4 Concept activity observations

After the initial training activity, participants were then provided with a task sheet (Appendix 12) and were instructed to start the three exercises. The participants' behaviour during this period was then monitored (Figure 127, Figure 128) without interference in the same manner through the overhead digital cameras and was studied along with the notes made from all participants (a sample of which can be seen in Appendix 13).

Participants would often select the software (Virtual Gatekeeper Management Model) icon and double click it many times as they expected the application to load instantly - on some occasions this caused frustration as multiple versions of the application appeared. It is of note that participants quickly worked around this issue by selecting the icon with the mouse and then pressing the enter key on the keyboard to open the application rather than double clicking. During the activities all

Figure 127. Trial observation screens 1

Figure 128. Trial observation screens 2

participants would type in the URL address and then hit the enter key on the keyboard first before using the mouse-driven interface, such as clicking the 'go' button to initiate a search for a URL address. It was assumed therefore that if participants preferred keyboard shortcuts, that they would also use others such as 'ctrl +x' and 'ctrl +v' thereafter to duplicate URL addresses. However, it was observed that only a quarter of participants ever undertook this while the rest typed out each address in full every time. Often participants moved the task sheet around the desk and expressed a requirement that they would have liked a stand to hold the sheet as some had at their office computers. It was also expressed by participants that they would have liked to have had a goal per exercise as they did not like to explore themselves but instead be directed.

It was observed that over half of the participants found the last exercise difficult when they were required to apply the skills learnt earlier, in the first exercises, rather than simply follow relevant instructions. On several occasions participants felt they had failed the last exercise when the outcome did not meet their personal expectations. It was observed that when participants became frustrated they used the ‘enter’ key more and also clenched their fist (left hand).

Participants initially had difficulty with selecting anything other than the menus in the management model visualisation and did not like to click the 3D objects as they reported that they were unused to clicking pictures. There was often confusion from some participants with regard to where they were in the management model visualisation and this was often remedied through participants making unnecessary jumps up or down from a workspace or segment level.

Application window placement was studied and it was found that most participants would insist on centring everything instead of maximising the application and using up the full screen space - they would then work in the opened screen instead of optimising their workstation environment. It was noticed that only two participants ever optimised the placing of items on screen and were also the ones, it must be noted, that in the previous training activity studied the training video the most by taking notes or jumping back or forward through it. The facility of dropping the management model visualisation into the system tray of Windows instead of appearing on the task bar often confused participants and they would frequently wonder where the menu had gone though after some hunting would find it. One participant even mentioned under their breadth the words ‘*so that is what a system tray is!*’

At the beginning of the exercise participants were instructed not to interact with the researcher or ask questions, but often they would seek clarification over problems they experienced. The researcher would simply say ‘*please continue*’ to avoid causing bias in the results. It was noticed that participants would have liked to have reassurance for actions they considered different to the norm when working with the management model. On one occasion a participant directed expletives (Appendix 13) at the interface due to what they considered to be irritation with the animations. They expressed a preference towards switching these off perhaps through a control panel feature.

8.5 Concept event logging

It must be noted that during these trials, the Morae screen recording software crashed silently for two participants. In these cases, the sample that were analysed using screen recordings was reduced in number to only the successfully completed participants. In the subsequent questionnaire analysis, these two particular participants were again included as they had completed each and every trial task, but just lacked the screen recording to reflect the activities.

During the trial task activities, participants were recorded with a view to monitoring whether the number of windows/dialogues and mouse clicks increased over time as a direct result of the tasks becoming less directed/instructional and more exploratory. Figure 129 and Figure 130 summarise the results gathered from screen activity logs for all participants and show that the number of events (windows and mouse clicks) are clustered roughly around the mean value. However, in Figure 131 for task 3, it shows a large variation in results around the mean, with no clear clustering pattern and thus confirms that participants' events varied widely depending on how well they had understood the management model. It is suggested that this is because task 3 was an entirely exploratory exercise and relied upon the learned experience of working with the management model from the previous tasks and training. Task 3 does show that all participants successfully completed the task, even with varying experience of using the management model in a relatively short space of time and thus shows it could satisfy the aim of managing participant information across different project to workspaces hierarchies without much difficulty. This observation does share some accord with work reported by Boardman (2001 whereby the flexibility of a management model, such as the one undertaken successfully in Task 3, allowed participants to organise their resources by whatever categories, titles or terminology that they wished within a carefully controlled project-to-workspace-to-slices hierarchy of relationships. This following on from Boardman (2001 who suggested that structures of this type could indeed provide consistent, collaborative structuring that would facilitate access to remote resources across the workspace and goes some way into further validating this work.

Task 1

Participant No.	Elapsed Time	Window/Dialog Events No.	Mouse Click Event No.
1	00:06:24	41	35
2	00:06:05	46	45
3	00:08:11	70	65
4	00:11:52	59	66
5	00:07:46	46	43
6	00:07:04	44	48
7	00:05:17	39	39
8	00:09:19	84	72
9	00:11:27	55	62
Mean:	00:08:09	53.8	52.8
STDEV:	-	15.0	13.5
Error of Mean:	-	5.0	4.5

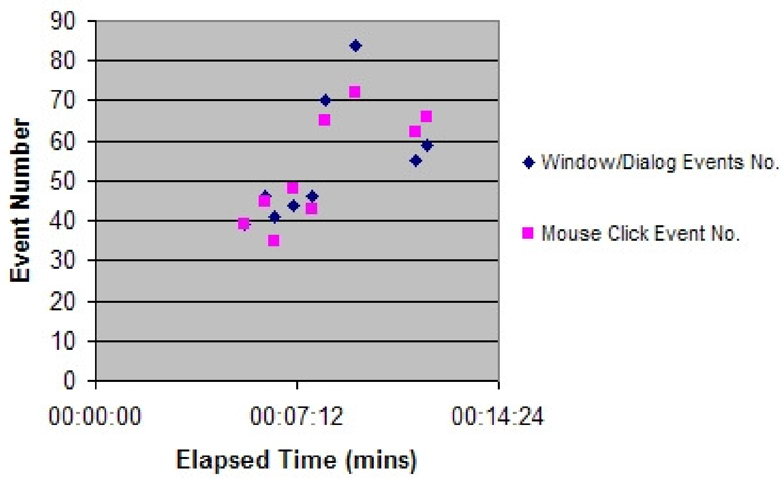


Figure 129. Task 1 Event Logging Results

Task 2

Participant No.	Elapsed Time	Window/Dialog Events No.	Mouse Click Event No.
1	00:08:29	86	72
2	00:05:23	91	71
3	00:20:44	211	182
4	00:07:28	57	76
5	00:09:35	119	98
6	00:27:53	257	278
7	00:06:30	92	92
8	00:05:53	118	68
9	00:16:54	141	137
Mean:	00:12:05	130.2	119.3
STDEV:	-	64.5	70.5
Error of Mean:	-	21.5	23.5

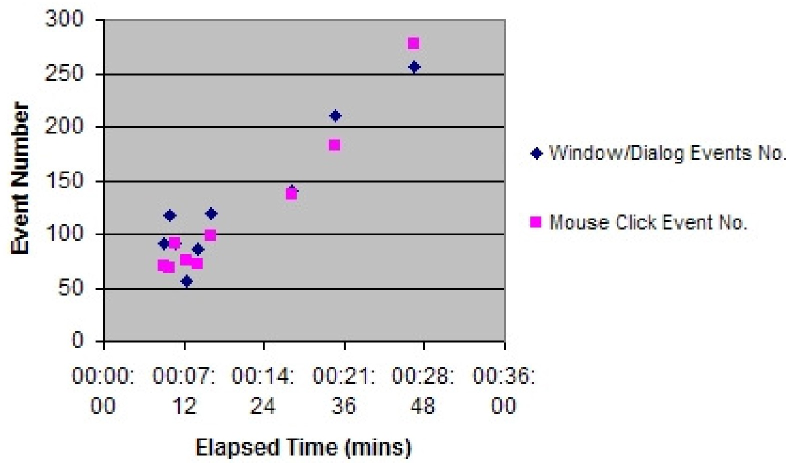


Figure 130. Task 2 Event Logging Results

Task 3

Participant No.	Elapsed Time	Window/Dialog Events No.	Mouse Click Event No.
1	00:02:03	7	23
2	00:10:49	100	169
3	00:15:21	149	178
4	00:09:03	115	75
5	00:08:17	87	76
6	00:19:59	157	196
7	00:11:50	37	41
8	00:08:51	79	104
9	00:15:24	134	163
Mean:	00:11:17	96.1	113.9
STDEV:	-	50.2	64.1
Error of Mean:	-	16.7	21.4

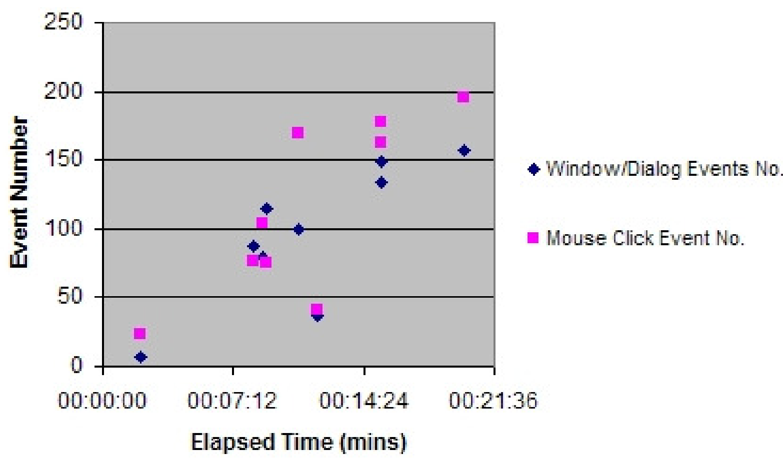


Figure 131. Task 3 Event Logging Results

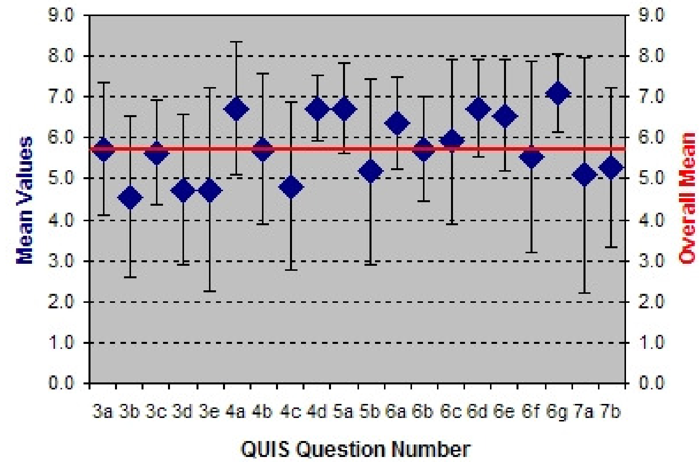
8.6 Usability & satisfaction

In order to understand whether participants found the management model usable, in their opinion, a questionnaire (Appendix 12) was given to them directly after the completion of all task activities whilst their new experiences were fresh in their minds. Concerning whether the management model was easy or difficult to use, 57% of participants said that it was moderately easy to use. This response directly correlated against the ratings processed from various sets of questions for QUIS (Figure 132) and SUS (Figure 133) usability tools, as QUIS showed a rating of 63.3 and SUS a rating of 64.5. This was a good result as it correlated against the results from task 3 (section 8.5), since it was expected that the overall

Question No.	Mean	STDEV	Error of Mean
3a	5.7	1.6	0.5
3b	4.5	2.0	0.5
3c	5.6	1.3	0.4
3d	4.7	1.8	0.5
3e	4.7	2.5	0.6
4a	6.7	1.6	0.5
4b	5.7	1.8	0.5
4c	4.8	2.0	0.5
4d	6.7	0.8	0.4
5a	6.7	1.1	0.3
5b	5.2	2.3	0.3
6a	6.4	1.1	0.3
6b	5.7	1.3	0.3
6c	5.9	2.0	0.3
6d	6.7	1.2	0.3
6e	6.5	1.4	0.4
6f	5.5	2.3	0.4
6g	7.1	0.9	0.4
7a	5.1	2.9	0.4
7b	5.3	2.0	0.4

Overall mean: 5.7 + - 1.8 0.3

QUIS overall usability rating: 63.3



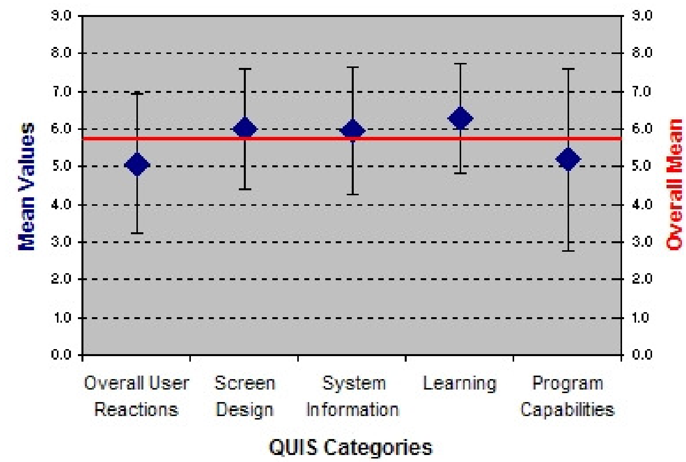
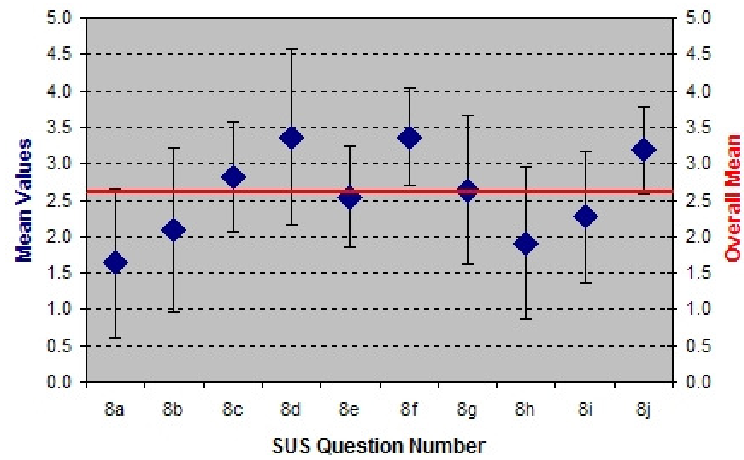


Figure 132. Rating for User Interaction Satisfaction (QUIS)

ID		8a	8b	8c	8d	8e	8f	8g	8h	8i	8j
1	Result	3	2	4	1	4	2	4	3	3	3
	SUS	2	3	3	4	3	3	3	2	2	2
2	Result	2	3	2	1	3	2	4	3	3	2
	SUS	1	2	1	4	2	3	3	2	2	3
3	Result	4	2	4	1	4	1	2	4	4	2
	SUS	3	3	3	4	3	4	1	1	3	3
4	Result	3	1	4	5	3	2	5	2	2	2
	SUS	2	4	3	0	2	3	4	3	1	3
5	Result	2	4	5	1	5	1	5	2	5	1
	SUS	1	1	4	4	4	4	4	3	4	4
6	Result	4	2	4	2	4	2	4	2	3	2
	SUS	3	3	3	3	3	3	3	3	2	3
7	Result	4	3	4	2	3	2	3	3	4	2
	SUS	3	2	3	3	2	3	2	2	3	3
8	Result	2	5	4	1	3	1	3	4	2	1
	SUS	1	0	3	4	2	4	2	1	1	4
9	Result	2	3	4	1	3	1	4	4	3	1
	SUS	1	2	3	4	2	4	3	1	2	4
10	Result	2	3	4	1	4	1	4	5	4	2
	SUS	1	2	3	4	3	4	3	0	3	3
11	Result	1	4	3	2	3	3	2	2	3	2
	SUS	0	1	2	3	2	2	1	3	2	3
	SUS Mean:	1.6	2.1	2.8	3.4	2.5	3.4	2.6	1.9	2.3	3.2
	STDEV:	1.0	1.1	0.8	1.2	0.7	0.7	1.0	1.0	0.9	0.6
	Error of Mean:	0.3	0.3	0.2	0.4	0.2	0.2	0.3	0.3	0.3	0.2



SUS Rules:

- For items 1, 3, 5, 7and 9 the score contribution is the scale position minus 1
- For items 2, 4, 6, 8 and 10, the contribution is 5 minus the scale position

	Mean	STDEV	Error of Mean
Overall mean:	**2.6**	+ - 0.9	0.3

SUS overall usability rating: **64.5**

Figure 133. Rating for System Usability Scale (SUS)

rating would have been much lower for both usability tools. As detailed in the QUIS technical notes, any QUIS rating above 5 is '*perceived as being better than an arbitrary, mediocre value*' (Slaughter, 1994) which suggests a mean value higher than this for the whole surveyed group is a very good result indeed. QUIS also highlights the expected failure of the tool in its current form as corroborated in the follow up interview responses (Appendix 13) through the deficiencies with the program capabilities (Figure 133). Indeed, triangulating this result with the previous results to 8.5 task 3, the management model was above the mean rating in areas such as screen design, learning and system information profile categories, despite only being a concept prototype for leveraging the 'Generic Management Model'. Indeed with QUIS and SUS providing such a similar result it does appear to validate the results obtained since they used differing measuring approaches which were corroborated with participant responses and event logging task results.

8.6.1 Management model questionnaire major themes

Participants were asked (Appendix 12) to provide some general comments (Appendix 13) relating to the overall usability of the management model. Participants in the majority stated that they liked the idea of a 3D file management style concept. However, they thought that it was very complex for inexperienced knowledge workers to learn/comprehend in its present level of maturity as conceptualised in the tool. Participants also suggested that the graphical portrayal of the model terminology of projects, workspaces, segments and slices were a very good idea, but that the implementation in the tool was at present far '*too slow when revolving around*' the different hierarchical levels. Participants then offered suggestions on how to improve and make the management model more accessible. Some participants expressed a wish for '*entire segments to be context sensitive*', not just the front face, as it would provide a greater surface area for clicking as they said sometimes they clicked the wrong segment when there was more than a certain number. They further extended this by indicating that they would like to directly pick up ('*drag and drop*') and move segments or workspaces around the hierarchical levels using a mouse or finger, as well as rotating them, where the name would then be present on the object itself as it was picked up. This was interesting as it indicted that participants were getting to grips with the dimensionality aspect of the management model and further reinforces aspects highlighted by Boardman (2001).

Participants were then asked to identify and describe the specific difficulties that resulted from using the management model in relation to the task activities. The first criticism (Appendix 13) was that segments were indistinguishable ('*graphical portrayal…good….should be labelled with titles*'), where participants did not like having to click on individual segments in order to rotate them to the front in order to retrieve the name or other meta-information. Thus, an initial suggestion was made that a simple, customised, visual colour coding of segments/workspaces would help speed up the location of currently active information within the hierarchical levels. Alternatively, an option could be provided to store further comments about different levels like workspaces, segments, or slices to make it '*more intuitive*'. This relates again to, as it was suggested that extra dimensionality would afford the identification of information in a more structured way.

In terms of the hierarchical structure one participant suggested a switchable alternative tree-view where the management model could be customised in the same way as a 2D file manager in windows with different views but would automatically flip back to a 3D view afterwards (where this would be the primary view). Participants liked the idea of the '*blocks*' representation for workspace search collections but would have liked to have seen how this search capability would enhance traversing the hierarchical levels in the management model. A suggestion was made that perhaps a fast shortcut alternative between hierarchies or across segments/workspaces could perhaps be a text style address bar that would always be visible, as apparent in similar file hierarchies such as explorer for file directories, to give an indication of where they were in the hierarchical structure. This suggested that participants were really engaging with the model fundamentals. In addition, some participants found the '*use of terminology* (such as project, workspace, segment and slice) *a little confusing*' at first, but admitted later that they had not fully appreciated the terms as identified in their training activity until they were using the management model approach themselves.

The most requested improvement was to include '*multiple segments/workspaces and clients open*' simultaneously where these were linked back to a single workspace of segments i.e. 1 x workspace with 4 x segments would equal 4 x open centrally managed client windows if required for comparing document contents. This is also represented since the dimensionality of the management model was designed to record this flexibility with all associated resources (Boardman, 2001). The participants that had a negative perception suggested that they '*could not see any benefit in the use of 3D aspect over existing tools*' or what Windows or the Linux operating systems already provided and one opined that '*3D visualisation was a waste of time*' citing their preference for command line interfaces or traditional hierarchies. However, this response was in the minority, with others wanting further integration with other existing tools such as Microsoft Outlook or Microsoft PowerPoint and suggested that the model's management structuring approach was something participants could really engage with in the everyday workspace environment.

8.6.2 Management model questionnaire minor themes

Participants expressed a wish to have a '*right click context menu*' to allow access to rename, delete and copy functions when working with segments, including the ability to highlight a segment using the mouse so that they knew what was selected. A majority of the remarks (Appendix 13) made in relation to the navigation, focused on the level selector icon, as it was suggested that this was '*unintuitive to the rest of the Interface metaphor*' and was confusing. Occasionally, participants went up a level rather than down (or vice versa). A further criticism was that there were no screen tips, or any way to govern the animation speeds, so increasing memory load when hovering over projects, workspaces, segments or slices. Indeed, it was suggested that the interface would be more fluid by having fewer navigation buttons directly on the interface such as up, down, forward or back arrows, and by having more natural gesturing movements using the mouse. It was also suggested in 'throw away' comments that perhaps these aspects could be pre-configured or tailored within some form of '*settings screen*' for changing aspects like speeding up or slowing down the animations as necessary. It was then suggested that the 3D interface should have the facility to scale dimensionally such as full screen or use different views on the management model so that it could be made larger or smaller or twisted to reflect the participants' eyesight or task requirements. It was suggested that '*prompts or maybe expert wizards*' could be used that prompt for actions at certain points, on behalf of the knowledge worker, such as '*name your workspace*' if not already named.

Finally, the last question asked of all participants at the end of the trials was that if the 'Generic Management Model' (expressed in terms of Virtual Gatekeeper) was developed into a robustly supported tool, based upon both their present experiences and their comments for enhancement, would they then continue to use it? The responses suggested that 80% of participants would continue to use it (Appendix 13) and even suggested that they would recommend it to their own departments in the future if it could be shown to cover the suggestions that they had already made (see section 8.2 guideline points and section 10.3 suggestions). A few participants suggested that they would like to test it against other commercial alternatives, but struggled to see which other comparable tools could be chosen as the management model was in their opinion different to what was presently commercially available. They believed this would provide an advantage in the office environment in the future. All this showed that whilst the implementation might have its flaws, in general the management approach based upon the model was something that participants could relate to.

8.7 Relationship of the results to the four key concepts

The data collected came from a number or experimental instruments each of which yielded useful information across the four key concepts (section 7.4) being tested. These will be specifically discussed further in Chapter 9.

8.8 Summary remarks

This chapter reports on the results obtained from the prototyping phase of the methodology which mimicked, as closely as possible, the natural office environment. The trials were split into a preliminary pilot and full experimental run. It consisted of nine participants, 82% male and 18% female, who were carefully selected based upon their occupational backgrounds. Out of these, 73% of the participants regularly used a Windows-based computer whilst 18% also used a MacOS-based computer. It was established that the primary method used by participants who wanted, received or distributed information within the workplace was electronic means as 63% of participants spent over half their remaining time reviewing electronic received information. Participants would review items quickly (especially in an email inbox) and prioritise or order these through coloured flags, printing important messages or immediately deleting. Those who first opened or placed items in sub-folders in their inboxes would also make additional directories on their desktops with the same named folder and title. This behaviour was mimicked in the real world as printed items were typically placed into piles with sticky notes on top to reflect the title of the folder in their inbox or desktop.

Participants undertook a silent video training session where it was noticed that within 6-8 minutes some participants became visibly irritated, often wanting some sort of audio commentary. It was also noticed that participants would use a combination of keyboard shortcuts and mouse gestures/actions for interacting with the management model. However, suggestions for other methods of input like gesturing using a finger were highlighted later. Event logging during the trials confirmed that participants' events varied widely depending on how well they understood the management model. In the post trial survey 57% of participants said that the management model was 'moderately easy' to use. This response correlated directly with the ratings processed through QUIS and SUS usability tools, where QUIS showed a rating of 63.3 and SUS a rating of 64.5. Criticisms were identified relating to aspects surrounding the indistinguishable nature or interaction with 3D objects in order to achieve a task. However, participants were very keen to improve the deficiencies identified, often suggesting numerous improvements such as a 2D switchable tree-view alternative with the option to automatically flipping back, quick jump address bars, further meta describing data, or providing colour coding to the 3D interface. All this strengthens the fact that participants were very much engaged with the management models underlying approach and were operating the system within the extra dimensionality aspect.

Chapter 9: Discussion

9.1 Introduction

Having identified the key results of the data collection in Chapter 8, this chapter will discuss how these data inform upon the following four key concepts discussed in section 7.4 and the issues highlighted in Chapter 6; .

- Management model approach relates to issues 2, 4 and 5
- Management model interaction including usability relates to issues 2, 3, 4 and 5
- Use of screen space for interaction relates to issues 1, 4 and 5
- Comparisons with other computing environments relates to issues 1 to 5

Before discussing each of these in turn a short resume of the main general issues will be given.

9.2 General issues concerning the management model

Questionnaire results discussed in Chapter 8 which assessed whether participants could successfully complete the trial tasks placed upon them in their first exposure to the 'Generic Management Model' (Figure 86) envisioned in 'Virtual Gatekeeper', revealed it was easy to use, although initially, some participants were slightly overwhelmed cognitively. The mixed reactions ranged from the fact that some thought it was a '*novel concept for organising information*' (Appendix 13), right through to some stating '*it looked impressive*' (Appendix 13) but with caveats that there was too much emphasis upon memory load and not enough focus upon the interaction (drag and drop) and visible feedback to identify the different levels of screen elements (labelling or colour coding of items). This reaction was important as it suggested that the management model immediately engaged the participants into using it, even with limited training. This justified the background work as covered in Chapters 4 and 5, where it was suggested that participants invariably liked an enhanced presentation level (Figure 92), even if they were unsure of its final intended purpose or efficiency gain over existing already used tools. Chapters 3 and 4 had also suggested that presentation level changes in industry products, such as Windows, are simply a way of extending a product's life cycle by making it seem different, without providing any new considerations towards better management of information and screen space. These interface enhancement tweaks do not address the root cause for aspects such as obtaining information (issue 1) or screen overload (issue 5) as highlighted in Chapter 2. It also seems that these early reactions from the trial observations do confirm this finding, as participants did seem to like the new concept from what they are already familiar with, whether the perceived benefit was immediately evident or not.

Interestingly, it was found that experienced participants who heavily used or foraged (Card *et al.*, 1996) for electronic information seemed to be more curious over the intended purpose of the interface and its features than novice participants who used a computer far less (Wu, 2000, Galitz, 1997, Kim, 2001, Lazonder *et al.*, 2000). It is suggested that the possible reason for this reaction was that these participants could readily understand the intended purpose and thus the advantages gained unlike that of novice participants (Wu, 2000, Kim, 2001, Lazonder *et al.*, 2000). It was also these same experienced participants who wanted the animations (Robertson *et al.*, 1993, Robertson *et al.*, 1991) in the management model switched off after certain period of time. These questionnaire results seem to triangulate against the event task times (being faster), as they became more accurate and thus searched far less through mouse clicks, within the interface (issue 3).

It was also found that some novice participants mentioned that there was a large amount of time required in understanding and becoming *au fait* with the new concepts of a slice, segment and workspace, with some even continuing to wonder, after initial training activities, what these terms or intended relationships were within the management model, citing that they could not see a hierarchical structure as it was not immediately obvious through the 3D visualisation. This was a point strengthened through the observations of the participants undertaking the precursor training, as the results indicated irritation, especially with the level or between level animations (Appendix 13) where they were either too slow/too fast or did not have the relevant hierarchical visual indicators, such as a hand in their pocket or crossed arms, through having to watch the training video. It was observed that this gave rise to clicking erratically around the interface whenever they were unsure with what to do within tasks. It was thus pointed out on more than one occasion by participants that some form of interactive help system or wizards might provided greater benefit in overcoming this problem instead of an initial silent training video running through a typical scenario - even perhaps having a voice over prompt at certain points until the participant was familiar with certain actions on what to do. Overall, the general reaction was much better than was expected, including QUIS usability results (Chapter 8), which showed a 63.3 rating, for the management model, with the tool having far less verbal criticism than activities (Chapter 7) originally undertaken in the predecessor simulation phase.

9.3 General concerning the Management model

The main focus of the entire trials was upon assessing whether participants could successfully complete tasks and understand the underlying ‘Generic Management Model’ concepts. Therefore, the management model trials implementation approach should create a highly ordered information aware universe enabling virtualization (Fried, 2003), so that knowledge workers can organise information based on where it fits logically in an organisational structure, rather than worrying about where, when and how it was stored. It is the assertion from the results up to this point that this goal was achieved, even though participants would have liked to see it developed even further in other areas (as seen in section 10.3).

Deconstructing the model into its constituent parts, participants were asked whether they found the workspace concept, built on evolving the Rooms multi desktop metaphor and large workspaces as described by Robertson *et al.* (1991) a useful method for storing documents or if they preferred their presently used methods. The most popular answer was that they found present single screen workspaces easier, but that they could get used to the multiple workspace approach given time. Some participants suggested that, instead of replacing the current desktop approach entirely, this could instead be augmented with the management model approach being incorporated instead of having it as a separate tool. The rest of the feedback from participants expressed that they would like a transitional process into migrating over to the new approach rather than a big bang deployment as they were used to the present hierarchical approaches and did not want the tool to impact upon their every day jobs.

The next part of the model which was then analysed was the use of the conceptual approach of segments where it was asked whether this was a useful method for storing and managing information (issue 2). Overwhelmingly, all participants said that they liked the historical segment concept (issue 4), although some requested that perhaps further sub-categories could be stored under each segment similar to present flexible file management structures (described further in 9.7). Some also stated that any form of partitioning of information would always provide added value for describing or structuring it further (issue 2). However, a small number of participants added the caveat that they could not see any distinction between the management model and traditional file systems. However, it was these same participants who seemed not to like change to their existing ways of working. Others suggested that if segments were made more flexible including sorting and drag and drop techniques then they would become useful for finding information (issue 2) in a similar way to that of Media Browser in Chapter 5. It was stated that segments and the underlying slices did provide useful containers for information which otherwise might have been placed in traditional hierarchical approaches, in inappropriately named files or folder containers, as they avoided clutter in the form of demoting or promoting content (issue 5).

Generally, deconstructing the concept of the client component of the management model, participants were asked whether they liked the fact that they did not have to file or name documents any longer since the management model would do this for them automatically through tagging (issue 3). This was eluding to the use of intelligent agents as described in Chapter 3 and further described by Robertson *et al.* (1991) as a way of delegating parts of workload within an interface. The results indicate a clear split between participants who liked this and others who said they did not. The reasons given by those participants who did not like this approach were that they thought they had lost control (Dix *et al.*, 2003, Shenk, 2003, Nelson, 1995) over their information (Chapter 2), electing instead to place different information versions in differing directories and that the act of finding or naming a file meant it was committed to memory in the form of its location. It is therefore suggested that there is a need for wider education of the benefits that these new automated tagging methods would offer for storing information, especially as present methods invariably lead to duplicated files. Indeed, those participants who already expressed a desire for embracing automation methods even suggested information should be stored as data instead of in a single file format (issue 2). Furthermore, they went on to suggest that automation did not go far enough as they would have liked an automated summarisation feature embedded into the client component so that they did not need to always put meaningful meta data around a tagged document (issue 3).

Participants were then asked whether the management model aided them in respect of finding the information they were looking for during the trials (issue 2). The response from participants was also mixed as they indicated that it was hard to interrogate the 3D interface since the search feature or sorting features were not yet implemented so making it '*incredibly frustrating*'. This is accepted as a limitation of the prototype tool as mentioned in Chapter 7. They again cited the fact that they required tooltips, customised colour coding and highlighting of the interface when the mouse rolled over a 3D object providing feedback. Finally, participants were asked whether they then understood the data ontology category names of project, workspace, segment and slice and their function within the management model interface. Overwhelmingly, every participant was able to understand these. However, it was suggested that there was some confusion visually in terms of segments, slices and the client component and that this should be addressed. Indeed, it was also suggested that perhaps these model names should be more predominantly displayed on the interface so as to show which level they belonged. However, what all the results have shown is that there was a favourable response to the management model compared to the feedback provided in the simulation phase and justified the redevelopment of a more robust proof of concept prototype.

9.4 Management model interaction

It has been identified by the participants that an interactive help system would have been useful. Again, this shows a limitation of the prototyping tool although it could also indicate that the tool was sufficiently 'real' in its implementation to a COTS (Commercial Off The Shelf) tool. Similarly, it was pointed out that if a knowledge worker wanted to compare two or more task documents from a root workspace, they could not currently do this as the prototype was biased to opening only one client slice instance at a time. In addition, it was found that participants wanted to use keyboard shortcuts, such as the enter key, for loading a typed in URL, rather than only using the buttons on the interface - since this feature was not available, it was suggested as being frustrating on many occasions. Other participants wanted a history feature or to have the management model linked directly to Google search as they suggested it would be a '*nice way to store and retrieve data*' (issue 2). Other notable aspects which were missing were things like confirmation prompts for what to do next, linked if required to a more detailed help system. It was also suggested that the closing of the client tool would have been better if it was animatedly merged into the management model main structure like the Genie feature for tasks in MacOSX as seen in Chapters 4 and 5. Also, participants felt they were doing something wrong when closing the client using the exit menu command as they believed they were totally exiting the management model - it was suggested that this was unnatural and simply needed different terminology for certain menu item wording.

The majority of participants confirmed with a single response of '*yes*' that the management model was an effective method for storing multiple documents (issue 2). Specifically the client workbench, although very complicated initially, did provide transparency of what was stored for later use. The aspect of recording notes about what was stored was also considered to be an excellent feature (issue 4), although it was suggested that perhaps this could be automated with some suggestive initial text and perhaps further fields (issue 3). One criticism came from the fact that the management model spawned both a 2D client interface as well as a 3D main interface. It was thought that the client interface could be more in keeping with the 3D look and feel, perhaps sliding out of a segment as the slice and becoming larger, according to one suggestion. It was further suggested that the very fact that items were compartmentalised was in fact a very good structuring feature for organising and managing often very complex sets of documents. Furthermore, it was then pointed out that it would be useful to trial how the management model could handle standard office applications and not just web pages within the client workbench. It was also suggested that perhaps linked to this the 3D interface could have further menu options of copy, move, sort and drag/drop. Clearly, most of these points relate to functionality of the implementation which has already been acknowledged as a limitation of this work. However, these suggestions can be seen as supporting the general concept in that the participants wanted to try a more developed implementation. Thus, the participants have engaged with the management model concept to the extent that they wanted a more rigorous interrogation of it in a more meaningful way.

Chapters 2 and 3 highlighted the challenges faced by managing information in the form of structure (issue 2) and thus the symptoms which occur if structuring techniques have broken down once items get above a certain scalable volume, leading to either information overload or onscreen task clutter (issue 5). Participants seemed divided over whether the management model was less or more confusing in combating these areas in relation to the way they normally undertake working with electronic information. Those who suggested it was more confusing were also the ones who were bored during the training session (hands in pockets) and also these same participants were not as methodical in their approach to tackling the tasks, for they would often jump ahead and have to then come back when they realised that they had missed a vital action. These were also the ones who suggested that 2D file manager hierarchies were much better. However, those who found it less confusing, were the ones who suggested the management model was a '*brilliant way of unifying all applications*' into a single place, stating that the concept was '*very useful*' as it could store emails, documents and so on in a single repository so making searching very much easier (issue 2). These same participants liked the aspect of no duplicate copies of data. Conversely, those who did have confusion with the management model also wanted to put extra copies of these items in separate folders. This seems to suggest that it was not necessarily the management model that was the problem, but rather a change in attitudes towards working with a management model approach compared to what they already knew. Specifically, exemplifying this point was a comment which mentioned that the management model forces knowledge workers to undertake commands, operations or tasks which otherwise would have been overlooked in the past.

9.5 Use of screen space for interaction

The management model was designed to optimise space on screen through managing task and document objects through a highly interactive 3D visualisation interface (issue 5). As pointed out by Robertson *et al.* (1991) there are challenges which need to be considered:

- animation problems in relation to a smooth interactive animation architecture
- visual abstraction problem for speeding up assimilation of information
- interaction problem with 3D widgets alongside application behaviour

- viewpoint problem in relation to simply moving to a given point in 3D space to observe an object
- object movement problem in relation to how objects can easily be moved in 3D space
- small screen space problem in relation to dynamic properties that allows for more screen space

These highlighted points which were alluded to in Chapters 2, 4 and 5, were key drivers behind the dynamic nature of the 3D visualisation. The question was therefore posed to participants as to whether the management model satisfied these drivers through providing adequate interaction and animation techniques. Apart from the already mentioned additions, participants suggested that specifically the 3D visualisation itself, the use of animated workspaces and zooming in or out of segments at different levels were all much better visual techniques than presently exist in operating system interfaces. They also suggested that more of these techniques coupled with the existing 3D visualisation would be highly beneficial. Over 90% of participants from the results suggested that the drivers above had been satisfied in a '*very clear way*', although with the caveat that there should be a toggle mechanism for increasing the speed (such as a meter) or alternatively a customisation panel to turn off certain animations once the participant became familiar with the interface. It was suggested that perhaps the interface could somehow record the path of where a participants had been visually, such as a history (extension to issue 4), as it was suggested that if a participants eyes were taken off the screen due to a distraction and then looked back, everything might have dynamically changed and they might not remember why this was the case - what was the last action they were doing prior to the interface changing. However, overall, participants considered that the 3D visualisation was an excellent way of saving screen task and document storage space whilst maintaining relationships between items.

Again the limitations of the prototype tool may have played a part in these suggestions as it is envisaged that a fully implemented system would include much of this functionality. Even so, the enthusiasm of the participants for the further development of the prototype tool shows that the underlying design concept of the management model is robust and supportive of activity tasks (issue 1).

9.6 Comparisons with other computing environments

As mentioned in Chapters 4 and 5 information screen space within the presentation layer or structuring through storage hierarchies as discussed in Chapters 2 and 3 are becoming increasingly important as storage capacities increase. Specifically, Chapter 2 highlighted a significant flaw within present file hierarchical structures (issue 2) or screen layout methods in the form of too much information (issue 5) alongside unique cognitive patterns for each knowledge worker in organising or structuring information documents or screen tasks (issue 1). The results therefore indicate two specific themes which came from trials with the management model which again highlighted these aspects when comparing it to other computing environments. These included cognitive issues when interacting with tasks or information structures and more visual methods for finding information.

Participants liked the dynamic nature of the interface in that it moved and altered in accordance with their screen actions - specifically they liked the options being provided depending on the hierarchical level or path that had been taken. One aspect of note was the use of segments as participants indicated that these moving elements stimulated memory recall (Robertson *et al.*, 1998, Robertson *et al.*, 1991, Robertson *et al.*, 1993). It was suggested that this was a huge improvement over the more traditional static hierarchical structures of file system managers, thus validating a key aspect of the 'Generic Management Model' (issues 1 and 2). Some participants indicated that they could see how the logic of the management model approach worked by drilling down into items, but also suggested that this structure was not useful for everyday use for quick access to frequent information as it placed structure on things when none was necessary. It was suggested that perhaps an option could be provided to bypass the 3D structure. However, this verbal observation was not supported by other participants' comments, for they suggested that the ability to store information in different areas, as in Internet Explorer Favourites, but at the same time to force a hierarchical structure, was very useful as it stopped long linear lists of shortcuts being created that soon become unmanageable (issue 2). It was suggested that the interface did not go far enough in automating this process (issue 3).

As seen in Chapter 3, intelligent agents could possibly automate this process and insert folder names or other meta-information without participant input. It is suggested that this as pointed out by knowledge workers, coupled with the linking of the presentation/file hierarchy layers, would have a benefit in the long term for the knowledge worker when undertaking tasks (issue 1). Specifically, some participants suggested that should more dynamic automation (intelligent agents) be placed in the management model approach (issue 3) as this would give rise to rapid access of files (Chapter 3) and manually unify what they do on a regular basis (issues 1 and 2). Participants verbally commented that the 3D layout was quite logical, like a tree structure, in that it forced better ways of organising content. They cited it was easier for preventing them from creating '*slap dash*' folders with erroneous names, and compared them once again to flat lists of files within web browser favourites or a file system hierarchy on their computer. However, one criticism was that the 3D interface did not go far enough if it was mimicking and improving upon present hierarchical file managers as certain features such as search, cut, copy or paste were missing. The single most important point which was raised across many of the research gathering methods employed was that participants liked the ability to store information documents instantaneously through one single click (Tagging - issue 2) which meant they could focus on the task itself and not worry about where to store the item, what name to give it or what describing information should be included with it or indeed in what format it would be stored (issue 4). However, some participants expressed that they would have liked to trial the management model further with over 100+ stored items from their own desktops and to use the unimplemented search facility in the management model to really understand the power behind the 3D dynamic nature of the visualisation as they could see great benefits to its visual way of '*drag and drop*' organisation and linking of tasks with documents more directly. However, as stated in Chapter 7, searching and scaling are beyond the scope of this thesis. Even so, this tool might not necessarily be a total replacement for an operating system, but instead it could become the means for controlling various sources of data with this dashboard style approach. In order to facilitate this aspiration it would thus be necessary to combine a manual drag and drop and an automatic import facility for items previously created beyond Virtual Gatekeeper into prenamed or pregrouped levels of the management model. What was interesting was that these suggestions would leverage more directly the extra fourth spatial dimension underlying the model levels to store/search these meta-based relationships and meant that whilst participants might not reflect upon its existence, the very fact that they could understand and see the relationship potential alongside the hierarchical levels of the management model does suggest a high level of engagement with the concept.

The concept of 'Pack of Cards' thumbnails was highlighted first in Chapter 4 with Windows Vista, Chapter 5 with TaskGallery, Data Mountain, Media Browser and Chapter 6 with the Lifestreams approach. The management model employs this concept to a limited extent with the segment being cut up into slices where each represents individual information named instances, such as a web page. Although, the intention had been to design a more dynamic animated segment which mimicked aspects seen in the Media Browser and the management model main animations, due to time restrictions a more static version of this concept was implemented which instead mimicked Lifestreams. This specific approach was criticised as being too static compared to that of the rest of the management model, but surprisingly was then complimented as providing an excellent way of previewing tagged task documents (issue 3). The future aspiration is that the meta-content, internal text, images, relationships and associations for an item could then be previewed or extracted without even opening the entire saved document, leveraging the extra dimensional space. This also mimicked aspects as described in Chapter 3 where knowledge workers, typically at the present time have to open a document in order to see to what it pertains. Participants also could see how the benefit of this pack of cards approach, coupled with the main interface concept could enhance visual search, although again they expressed their wish to trial this further to see if it helped search or index large volumes of data in a more visual way. It was also suggested that the segment slice screen and the main interface screen should not be specifically separate when implemented, so segments would show actual thumbnails and could then be named/colour coded in such a way so that it would hover over the segment if required. As it presently stands, participants regularly expressed their verbal annoyance at having to click on a segment or workspace in order to find out what it was called, also citing the fact that they would have liked to have seen a tree structure alongside it so that they could determine where they were in comparison to other segments or workspaces.

9.7 Summary remarks

The chapter has discussed the nuances of the trial results which indicated that participants found the management model envisioned in 'Virtual Gatekeeper' easy to use, making statements such as it was a '*novel concept for organising information*' (issues 1 and 2) and specifically supporting the 2D/3D approach. Participants who heavily used or foraged for electronic information seemed to be curious over the intended purpose of the hierarchical interface and its features, recognising a potential advantage of the new features over existing methods (issues 1 and 3). The chapter then emphasised the importance of information screen space (issue 5) and highlighted that participants liked the dynamic nature of the interface where specific options are only displayed at certain hierarchical levels or paths. One aspect of note is the use of segments as participants indicated that these moving historical elements stimulate memory recall and force better logical ways for organising content (issue 4). However, it is pointed out that on occasions it might be beneficial to bypass the 3D hierarchy entirely for more common tasks or alternatively to automate certain functionality, like storing describing metadata using intelligent agents. Participants as a whole said they liked the idea of a 3D graphical portrayal for projects, workspaces and segments when working with documents, but did think that the management model was very complex for inexperienced knowledge workers at its present level of maturity.

The chapter suggests that a requirement towards tighter integration between applications, the data generated, and the formats of documents stored, is needed within the management model. This should be entirely accessible from within a single interface rather than through a myriad of differing tools interacting with the desired underlying operating system. The conclusion is that 80% of participants said they would continue to use the management model and would even recommend it further as it allowed participants to organise their resources by whichever categories, titles or terminology that they wished within a carefully controlled project-to-workspace-to slice hierarchy of relationships. This supported Boardman's (2001) work which suggested that hierarchies of this type could thus provide consistent collaborative structuring that would facilitate access to remote resources across the workspace.

Chapter 10: Conclusion

In this thesis it has been shown that it is possible to extend information space from its traditional representation in 2D/3D through the use of a hidden fourth-dimension which allows information to be better organised and managed through the use of structured categorisation. To test this theoretical approach, a conceptual tool was constructed (Chapter 7) from the ground up using an adapted version of the 'Generic Management Model' along with a 3D geometric visualisation (Chapter 6) for interaction. This tool consisted of a Manager and a smart Client component, which facilitated the monitoring and extraction of actionable knowledge value (Chapter 2) from cubed clusters of task-based documents through automated tagging and direct knowledge worker input.

10.1 Satisfying of the aims and objectives

The aim of the thesis as given in Chapter 1 has been satisfied as detailed below:

- To explore the possibility of expanding information space dimensionality from traditional 2D/3D to 4D as a means of structuring/categorising meta tagged information with a view to assessing whether participants can successfully complete task activities through understanding these underlying concepts.

This was accomplished through fully understanding the multi-tier software engineering architecture as applied to present office desktop environments and augmenting them through the addition of an information ontology - 'Generic Management Model' for data categorisation (Figure 86) and an information structure - 'Information Universe Model' for document organisation (Figure 87) (Chapter 6). More specifically, the objectives of the thesis have been satisfied in the following ways:

1) To examine in detail existing modelling of information space within a 2D/3D environment:

Chapter 2 introduced the foundations of information-based environments, where information is described by organisations as a commodity of grouped data objects. Further, it suggests that once information is transformed through information workers' tacit knowledge becoming explicit, it then becomes more than just a collection of data objects, but a knowledge document in itself. Highlighted are the problems and issues from the literature which focuses on either information or knowledge management, for it was proposed that an entirely new title of Knowledge Fusion with knowledge workers should instead replace and encompass both domains since there seems to be so much ambiguity in the literature over the term's use. It then suggested the major issue which affects organisations is the topic of information overload. Chapter 2 further pointed out, that this is a real problem for knowledge workers, as it is physical in nature and attributed to health symptoms, culminating in stress, frustration and a feeling of helplessness due to both physical and electronic workspace deficiencies. Specifically, the chapter highlighted significant flaws in file hierarchical structures in the forms of too much information and unique cognitive patterns for knowledge worker profiles in organising these. The main emphasis was the point that full unification of the activity space would provide closer integration between tools that are used in the generation of information and those which are used in the management of information documents.

Chapter 3 then moved on to discuss a layer in the form of search technologies which is often used between the presentation and file hierarchy layers in order to try and overcome deficiencies that occur in both of these layers. 3D radical solutions were discussed and their possible advantages highlighted, although they often did not seem dissimilar, or provide a significant efficiency gain, over 2D approaches. It also suggested that aspects from present and future search engine technologies, such as intelligent agents, path modelling and content aggregators might all be possible ways of redefining the way that present day file systems are defined. In conclusion, it claimed that two aspects needed to be considered for a future approach to combating information overload. These are, first, the cognitive issues relating to using the 'Generic Management Model' approach in a physical sense - providing added knowledge value - and secondly, the information-based structuring/management issues in relation to the holding of the data.

In satisfying this objective, the following original contributions to knowledge (Chapter 6) have been made:

- Generic Management Model
    - Clarification of Workspace and Rooms in terms of concepts and terminology.
    - Extension of previous work (Appendix 4) to include Suite and Session categories.

2) To investigate possible extensions of present 2D/3D representations of information in order to facilitate information management:

Chapter 4 suggested that, prior to the information technology revolution, many traditional office workspaces included specific features which can now be attributed to the metaphorical foundations of present-day computer information desktop interfaces. Arguments were discussed concerning whether an information workspace that exists inside a computer based interface in 2007/2008, which utilises metaphors, really does improve task efficiency over the traditional physical working environments. The chapter further highlighted that the main cause for multitasking between tools, differing devices or screen notes, which is the root cause for screen clutter (Boardman *et al.*, 2003), is that knowledge worker production activities are distributed across a wide range of data sources for completing a project. It was demonstrated that the lack of integration between devices and tools culminates in multiple windows being open at the same time promoting screen clutter. This introduced the concept of space, where the restrictions of 14 to 24 inch desktops or palm style devices, mean that space is always at a premium and promotes switching or multitasking. Further, various operating system examples of techniques which were devised to overcome these restrictions and the associated problem of scalability were highlighted. The chapter then introduced the techniques presently used for extending space through techniques like direct manipulation, increasing the physical display screen size, utilising immersive 3D space, providing novel interaction methods such as drag and drop wall surfaces, or using augmented reality techniques. However, in every case these techniques are still not really solving the problem, but just making more space, which compounds the scalability issue. Chapter 5 then went on to suggest as Cockburn and McKenzie (2002) conclude, that it is tempting to believe that 3D is the *fait accompli* mechanism that will provide greater spatial flexibility from moving information workspaces from flat 2D environments to those of 3D. Further, interfaces such as described within this chapter, which employ higher dimensions, are often perceived to be much more cluttered and less efficient than their 2D alternatives in terms of knowledge worker performance of a task. This is a point also supported by Cockburn and McKenzie (2002) as their results showed that for relatively sparse information retrieval tasks (up to 99 data items), 3D hindered item retrieval.

In satisfying this objective, the following original contributions to knowledge (Chapter 6) have been made:

- Generic Management Model
    - Clarification of the concept of Session through refining the work of Edwards (1994).
    - Incorporation of the concept of semantic zoom into the GMM.
    - Extension of the concept of hyper-semantic linking across and between categories of the GMM.

3) To develop a conceptual model of a possible extension from 2D/3D information space to a higher dimension:

From the ever-increasing demands being placed on an information universe to respond with multifaceted ways to access, organise or store data, Chapter 6 identified five important issues which concern the management of information. The chapter advanced a formulated 'Generic Management Model' as a means of governing an information universe when specifically applied to a single knowledge worker's business desktop. In doing so, it has shown how these issues can be satisfied and implemented in a software prototype called 'Virtual Gatekeeper' This prototype incorporated a domain specific implementation of the Generic Management Model which demonstrated that it is theoretically able to meet the challenges of the five issues. This work included a number of original contributions to knowledge which have been summarised.

In order to conceptualise the underlying data structure and data linking it was necessary to use techniques which were inspired from geometry and which map spatial dimensions in 4D onto stereographic geometric object representations in 3D. This facilitated the interaction of the underlying data objects which mirrored the data dimensionality. This differs from present day approaches in that the user interface is firmly coupled with the data repositories through the Information Universe Model. This Information Universe approach gives the foundation for developing domain specific applications such as Virtual Gatekeeper. It does not however, define the design of the user interface in any way.

In satisfying this objective, the following original contributions to knowledge (Chapter 6) have been made:

- Information Universe Model
    - Unification of presentation and data layers through the GMM and Kaluza-Klein theory representation.
    - Clarification of where and how semantic and hyper-semantic linking fits into dimensional representation of data.

- N-tier Architecture
    - Integrated the GMM as the Logic Layer into the 3-tier architecture.
    - Situated the 3-tier architecture within the Information Universe Model.

- Integration of physical world metaphors
    - Kaluza-Klein Theory - this inspired the use of the fourth data dimension in the GMM and in the selection of the geometry for the presentation layer implementation. This facilitated the addressing of issues 1, 2 and 5.
    - Spider's Web - the nerve centre of the spider allows sensory data to be captured. This metaphor was used to model semantic linking in 3D and hyper-semantic linking when pulled from the central point of the web. This also inspired the capturing and replay of session specific information. This addressed issues 1, 2, 3, 4 and 5.
    - Tree Rings - the tree rings were used to inspire the modelling of semantic linking across partitions of each level and across data objects in each level. This enabled issues 1, 2 and 4 to be addressed.
    - Girdled Horn Shell - this 3D representation of a spiral inspired a 3D spatial representation of hyper-semantic linking. This addressed issues 1, 2, 3 and 5.

- Virtual Gatekeeper Implementation
    - Conceptual representation for possible future implementation of semantic and hyper-semantic linking.

- Database ERD and XML Schema
    - Application of the domain specific Generic Management Model as a database Entity Relationship Diagram (ERD) for construction of a possible database.

4) To test the developed conceptual model in terms of its ability to manage information:

The final Chapters of 7, 8 and 9 focused upon the methods employed in testing the developed 'Generic Management Model' (Figure 86) in terms of its ability to manage documents within an information universe (Figure 87), with the aim of exploring the possibility of expanding information space dimensionality from traditional 2D/3D to that of higher dimensions. Specifically, these chapters focused on the trials which were designed to investigate the completeness of managing information (Chapter 1) against the concept model (Chapter 6). In order to achieve this aim a tailored version of the model (Figure 94) was embedded into the architectural foundation (Chapter 6) of a tool known as 'Virtual Gatekeeper' which served merely to inform upon the underlying concepts. Chapter 7 develops a methodology that was suitable for testing the 'Generic Management Model' and includes a simulation and a prototyping phase, based upon the literature reviewed and demonstrates a procedure that was proven to satisfy this objective. Various methods were used to show that the management model does indeed facilitate information management. The main results recorded a usability rating of over 60 (63.3 QUIS and 64.5 SUS) in two separate usability tests and demonstrate, alongside the triangulated questionnaire material and subsequent follow up interviews, that such a management model does produce a usable approach for completing task activities (discussed further in Chapters 8 and 9). Criticisms were identified relating to aspects surrounding the indistinguishable nature or interaction with 3D objects in order to achieve a task. However, the chapter suggested that participants were keen to improve the deficiencies identified, often suggesting improvements such as a 2D switchable tree-view alternative with the option to automatically flip back, quick jump address bars, further meta describing data, or providing colour coding to the 3D interface. All this strengthens the fact that participants were deeply engaged with the 'Generic Management Model' and were getting to grips with the extra dimensionality aspect. The conclusion was that 80% of participants said they would continue to use the management model and would even recommend it further as it allowed participants to organise their resources by whichever categories, titles or terminology that they wished, within a carefully controlled project-to-workspace-to-slice hierarchy of relationships.

In satisfying this objective, the following original contributions to knowledge (Chapter 6) have been made:

- Information Universe Model
    - Unification of presentation and data layers through the GMM and Kaluza-Klein theory representation.

- Database ERD and XML Schema
    - Creation of an XML schema for communication between a possible database and the domain specific Generic Management Model.

- Virtual Gatekeeper Implementation
    - Application of the domain specific Generic Management Model in combination with both the physical world metaphors and geometrical underpinnings.
    - Relationship between the domain specific Generic Management Model and applications (for example a document linked to many categories through tagging).
    - The integration of a nesting principle using three space stereographic projection of four space with the properties of the Kaluza-Klein proposed fourth spatial dimension.

To summarise, the key contributions to knowledge of this thesis are:

- A unique 'Generic Management Model' for data categorisation as shown in Figure 86. leading to a unique ontology being generated.
- A unique 'Information Universe Model' for document organisation as shown in Figure 87 leading to a unique structure which incorporates a fourth dimensional aspect.
- Creating a conceptual model for future implementation which allows hyper-semantic linking based upon a 3D stereographic projection of a 4D hypercube (as in Patent No. GB2414574).

The obtaining of a double grant from the South West Development Agency for proving the concept with industry and in the published patent (Richardson, 2004) under a strict confidentiality clause, are clear indications of this originality. This work was completed prior to the more recent Research Desktop (TAGtivity) work of Microsoft Research Cambridge.

In addition, the Generic Management Model has been tested and found to be implementable and supportive to knowledge workers within their office environments.

10.2 Limitations of the study

The results in Chapter 8 clearly showed that there were two major limitations to the implementation tool namely scalability and a search facility. While it was not possible to implement these within the thesis' timeframe it must be noted that these facilities were conceived within the management model. However, it is recognised that whilst it would have been desirable to implement these two aspects of the management model the experimental work undertaken in this thesis was primarily to test the underlying ontology and structure. Further limitations of the prototype tool were caused through operational issues, resulting from time constraints, lack of knowledge of certain technologies and the difficulties of programming a robust tool that would integrate with a variety of systems.

Due to the methodology incorporated throughout the lifetime of this thesis, many of the experimental instruments chosen were robustly tested prior to the actual trials taking place. However, it must be noted that the final prototype phase trials whilst consisting of eleven participants in total, in actuality only had nine participants fully taking part throughout since two extra participants instead piloted the prototype phase implementation procedures. Therefore the combination of this along with the time and cost associated with working individually with each of the participants mean that the surveyed results were reduced. Thus, statistical analysis could not be undertaken with any degree of confidence when applying it to the population as a whole due to the small sample of participants. It is suggested that perhaps in the future, the results could be replicated on a much larger scale with a follow up version of 'Virtual Gatekeeper', in which the experiments are devices with multiple participants in mind.

The other limitation of the study was that it required highly skilled volunteers from different levels of a business organisation in order to test fully the conceptual idea. Again, unfortunately, it relied upon the availability of employees and the author's current occupational time in order to work with them for the trials. However, whilst the study was limited in its numbers of participants, the backgrounds and skills of the volunteers (although removed due to security restrictions) did provide a comparable view against any other organisation. Thus, even though security restrictions had been put in place by the trial company for confidentiality purposes, this did not impact upon the trials' findings or their validity as presented in this thesis.

Since the trials were performed in a laboratory environment, with numerous logging technologies, to mimic the office environment as much as possible, this did mean that it was semi-artificial in the way participants interacted with the tasks. In addition some tasks were disrupted when one of these logging technologies crashed during the experiment causing the participant to restart the activity. Unfortunately, due to the restriction upon the software allowed on the organisation's networks, this limitation could not be avoided. In addition, the laboratory environment did not have Internet access, and as such an artificial website was created for the purpose of the trials. Although this would have had a minor impact, it is suggested that it would be better in the future to undertake the trials *in situ* within the office environment in a more relaxed and less security sensitive organisation to obtain a comparison e.g. to allow participants to use the software over a week in the course of their everyday duties. In addition, since the organisation chosen for the trials had highly skilled people who regularly use complex software, it is suggested that maybe a certain level of bias was introduced. Therefore, arguably it would be interesting to compare the trial results with a similar organisation that had a different employee skill set for comparison where a wider range of different results might arise. Finally, it is acknowledged that perhaps the perception of need may be based upon the age of the tested participants, so it would be useful to test not only different skill levels of people in differing organisations but also to test different age ranges across different job areas for a truer comparison.

Despite these limitations it is the assertion of this author that the trials of the Proof of Concept implementation of 'Virtual Gatekeeper' within the incubator laboratory environment was the best possible method that could have been used for the required achievement.

10.3 Future research

Concerning the conceptual Information Universe Model, it may be possible to incorporate further dimensional categories or repartitioning as part of the information universe (Figure 87). Based on the theory contained in Appendix 14, it may be possible to utilise M-theory (Greene, 2003) to extend the number of dimensions within the Information Universe Model. Briefly, it is now conceivable that there are eleven possible mathematical dimensions, according to M-theory. An exploration of the possibility of trying to implement these within an extended 'Generic Management Model' (Appendix 14) could be attempted. These added dimensions could be implemented through the incorporation of aspects such as hyper-semantic search engine algorithms or the use of intelligent agents within an application domain such as an office environment context. A small start in this direction has been recently made in new research being undertaken into the Research Desktop (Oleksik *et al.*, 2009, Microsoft, 2009). This research focuses on activities within a 2D environment using the underlying context of multiple tagged categories. Whilst this thesis only examined whether participants undertaking the trials could complete them within the limitations of Virtual Gatekeeper, new trials could take place on a larger scale with a wider range of complex hypotheses looking at the more holistic usability issues.

The completed trials in this thesis showed clearly that the 'Virtual Gatekeeper' conceptual prototype could be developed further in terms of the system's functionality as the vehicle to explore these responses through wider and more in depth usability trial investigations. Apart from the improvements, as already mentioned, participants would also be given the chance explicitly to suggest further enhancements or changes to the model which they would like to see considered as part of the envisioned 'Virtual Gatekeeper' tool in the future. Unsurprisingly, many participants at the moment highlight a requirement for a search/sorting feature, along with animation speed customisations, further screen feedback such as tool tips, object labels, colour coding and highlighting objects, as an immediate improvement to enhancing the tool's usability. Further to this, more detailed functionality requirements were suggested, which were captured and summarised here for the future:

- To annotate 3D graphics so that names are displayed on segments or above them with a toggle to turn them on and off.
- To improve workbench intuitiveness through making the tagging in the Client simpler e.g. upon closing a viewed window, page or document 'Virtual Gatekeeper' automatically tags the items and inserts in auto-summarised text if none was originally inserted.

- To provide an interactive help system with audio, notification messages like 'are you sure?', screen tips and perhaps a brief introduction to the management model along with annotated video/audio as an initial welcome screen.
- Provide the ability to move data around quickly e.g. multiple segments so a knowledge worker can move a slice from one segment to another - an extension to this would also be the ability to have multiple segments/workspaces open and to move sets of data.
- Provide an arrow for up a level icon to be changed instead to an aerial view of segments, projects or workspaces depending on the level so that a knowledge worker could click on any level quickly and jump straight to it; in addition more animated sequences merge the levels better, especially between a segment and the slices.
- Provide right clicking on a 3D object to provide a context for an actions menu to appear - that is suggesting actions like renaming the workspace, segment or slice.
- Provide the ability to keep the Client open as well as 'Virtual Gatekeeper'. An extension to this would be to have multiple client windows available from the system tray icon and customised based upon the number of segments, slices or upon a knowledge worker suggestion.
- Having the ability to version/baseline documents.
- To provide standard file system activities e.g. move, copy, sort.
- Provide smart slices/smart segments e.g. smart folders on MacOS so the operating system structure is automatically based upon the data.

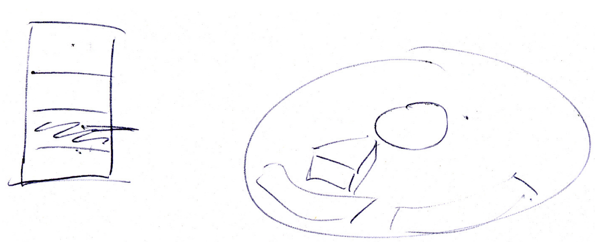


Figure 134. Virtual Gatekeeper sketch 1

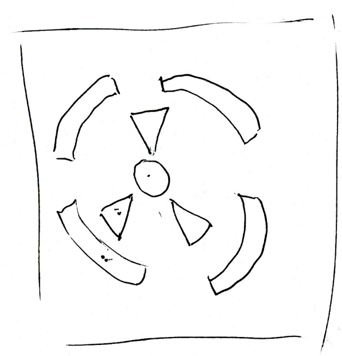


Figure 135. Virtual Gatekeeper sketch 2

Indeed, some participants were so motivated in wanting to see 'Virtual Gatekeeper' developed to support them in their own job area that they even drew illustrations depicting different enhancements to the 'Virtual Gatekeeper' interface which they would like to see included. Figure 134 shows a horizontal thermometer graphic as a means of jumping to different levels in the 'Virtual Gatekeeper' interface. Alternatively, another participant drew another illustration (Figure 135) which shows a plan view of a graphic also suggested as a means of jumping to different levels in the 'Virtual Gatekeeper' interface.

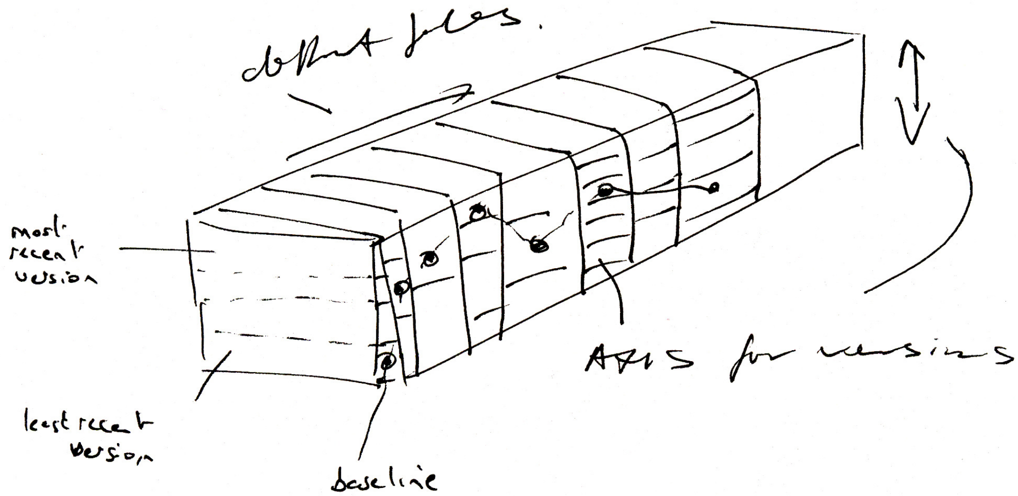


Figure 136. Virtual Gatekeeper sketch 3

Finally, a different participant drew the illustration (Figure 136) depicting a versioning mechanism for slices indicating the multidimensional nature of the information and where a baseline could be drawn. It was suggested that the slice containers themselves might fill up like sand in an hour glass and a baseline might be a single black line at a certain level. Individual slice versions might be the layers of this single slice itself, truly utilising, in the participant's own opinion, the visualisation to its fullest potential. Such practical suggestions demonstrate clearly that the participants found the Generic Management Model an exciting innovation with tremendous potential.

These suggestions focus mainly on the interface of Virtual Gatekeeper with which the knowledge workers interacted. In many cases, the suggestions are cosmetic to the interface and do not reflect upon the underlying models of the GMM and UIM. Such practical suggestions, however, demonstrate clearly that the participants found the Generic Management Model an exciting innovation with useful potential.

10.4 Final remarks

This thesis has formulated a new model approach to knowledge working which has resulted in a unique geometrically-based model for the managing of information. It is to the project's credit that contemporary designers are contemplating similar strategies although these utilise different underlying information management structures; thus, it may be that the 'Generic Management Model' may achieve fuller implementation than has been possible in this thesis in the future. The thesis has postulated that, due to the enforcement of an underlying fourth spatial dimension, every data point or object now has the capability of touching each other. Potentially, this could provide additional space for data categorisation whilst maintaining a highly ordered, three-dimensional interaction structure. This, however, is in the future but it is hoped that the present thesis has made a small start towards providing a firm foundation for this future development.

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Appendices

Appendix 1

Historical timeline of space-time theory

A historical timeline of space-time theory

1905 - Albert Einstein publishes his simple, elegant Special Theory of Relativity, making mincemeat of his competition by relying on only two ideas: 1) The laws of physics are the same in all inertial frames, and 2) The speed of light is the same fro all inertial observers.
Source: The_Physics_Time-Line, 2007, The_Official_String_Theory, 2003

1907 - Hermann Minkowski publishes Raum und Zeit (Space and Time), and establishes the idea of a space-time continuum.
Source: The_Official_String_Theory, 2003

1908 - Hermann Minkowski, geometric unification of space and time.
Source: The_Physics_Time-Line, 2007

1912 - Albert Einstein, curvature of space-time.
Source: The_Physics_Time-Line, 2007

1913 - Niels Bohr publishes his Quantum theory - a model of atomic structure introducing the theory of electrons travelling in orbits around the atom's nucleus.
Source: The_Physics_Time-Line, 2007

1914 - Splitting of five-dimensional space-time into the Albert Einstein equations and James Clerk Maxwell equations in four dimensions was first discovered by Gunnar Nordstron, in the context of his theory of gravity, but subsequently forgotten.
Source: Wikipedia_Encyclopedia, 2007

1915 - Albert Einstein, with David Hilbert in stiff competition, publishes his stunning General Theory of Relativity, and is lucky enough to be able to find observational support for his theory right away, in the peripheral advance of Mercury, and the deflection of starlight by the sun.
Source: The_Official_String_Theory, 2003, The_Physics_Time-Line, 2007

1921 - Theodor Kaluza follows Albert Einstein’s advice and publishes his highly unorthodox ideas about unifying gravity with electromagnetism by adding an extra dimension of space that is compactified into a small circle.
Source: The_Official_String_Theory, 2003, The_Physics_Time-Line, 2007

1926 - Oskar Klein, “Kaluza-Klein“ theory.
Source: The_Physics_Time-Line, 2007

1938 - Oskar Klein, new field equations from higher dimensional “Kaluza-Klein” theory.
Source: The_Physics_Time-Line, 2007

1968 - “String theory”, was proposed by Gabriele Veneziano.
Source: Truephysics, 2003

1970 - Yoichiro Nambu, Leonard Susskind, and Holger Nielsen independently discover that the dual resonance model devised by Veneziano is based on the quantum mechanics of relativistic vibrating strings, and string theory begins.
Source: The_Official_String_Theory, 2003

1973 - Quantum field theories with space-time supersymmetry in four space-time dimensions are discovered by Julius Wess and Bruno Zumino.
Source: The_Official_String_Theory, 2003

1974 - Stephen Hawking combines quantum field theory with classical general relativity and predicts that black holes radiate through particle emission, behave as thermodynamic objects, and decay with a finite lifetime into objects that we don't yet understand.
Source: The_Official_String_Theory, 2003

1981 - Michael Green and John Schwarz develop superstring theory.
Source: The_Official_String_Theory, 2003

1984 - Michael Green and John Schwarz show that superstring theory is free from quantum anomalies if the space-time dimensions is 10 and the quantum gauge symmetry is S(32) or E8 times E8.
Source: The_Official_String_Theory, 2003

1995 - Edward Witten and Paul Townsend introduce the idea of Type IIA superstring theory as a special limit of 11-dimensioal supergravity theory with quantized membranes. This begins the M-Theory revolution in superstring theory, and leads people to ponder the role of space-time in string theory.
Source: The_Official_String_Theory, 2003

2002 - Raphael Bousso, from the University of California, Santa Barbara and Fotini Markopoulou-Kalamara, from the University of Waterloo, Canada shared the top prize at Science & Ultimate Reality symposium and presented work that seeks to unify classical relativity and quantum theory.
Source: Gefter, 2002

Dr. Bousso works in the area of black hole physics, string theory and cosmology. Using constructs called light-sheets, he has discovered a fundamental limit on the information content of the universe (measured in bits and bytes). This improves upon similar previous methods derived from black hole physics. It underlies the so-called holographic principle, considered a guide to quantum gravity
Source: Kaplan, 2002

Dr. Fotini Markopoulou-Kalamara was recognized for a new formulation of quantum cosmology in which quantum theory is applied to a system that contains its own observers, such as the whole universe. She has also explored the role of

causality in the quantum theory of gravity and developed methods to study the relationship between the quantum and classical theories of gravity.
Source: Kaplan, 2002, Planetpreterist, 2000

2003/04 - Dr. Fotini Markopoulou-Kalamara and Lee Smolin first publishes a v1 paper called “Quantum Theory from Quantum Gravity” which provides a mechanism by which, from a background independent model with no quantum mechanics, quantum theory arises in the same limit in which spatial properties appear. This was updated as v2 in 2004.
Source: Cornell_University_Library, 1996

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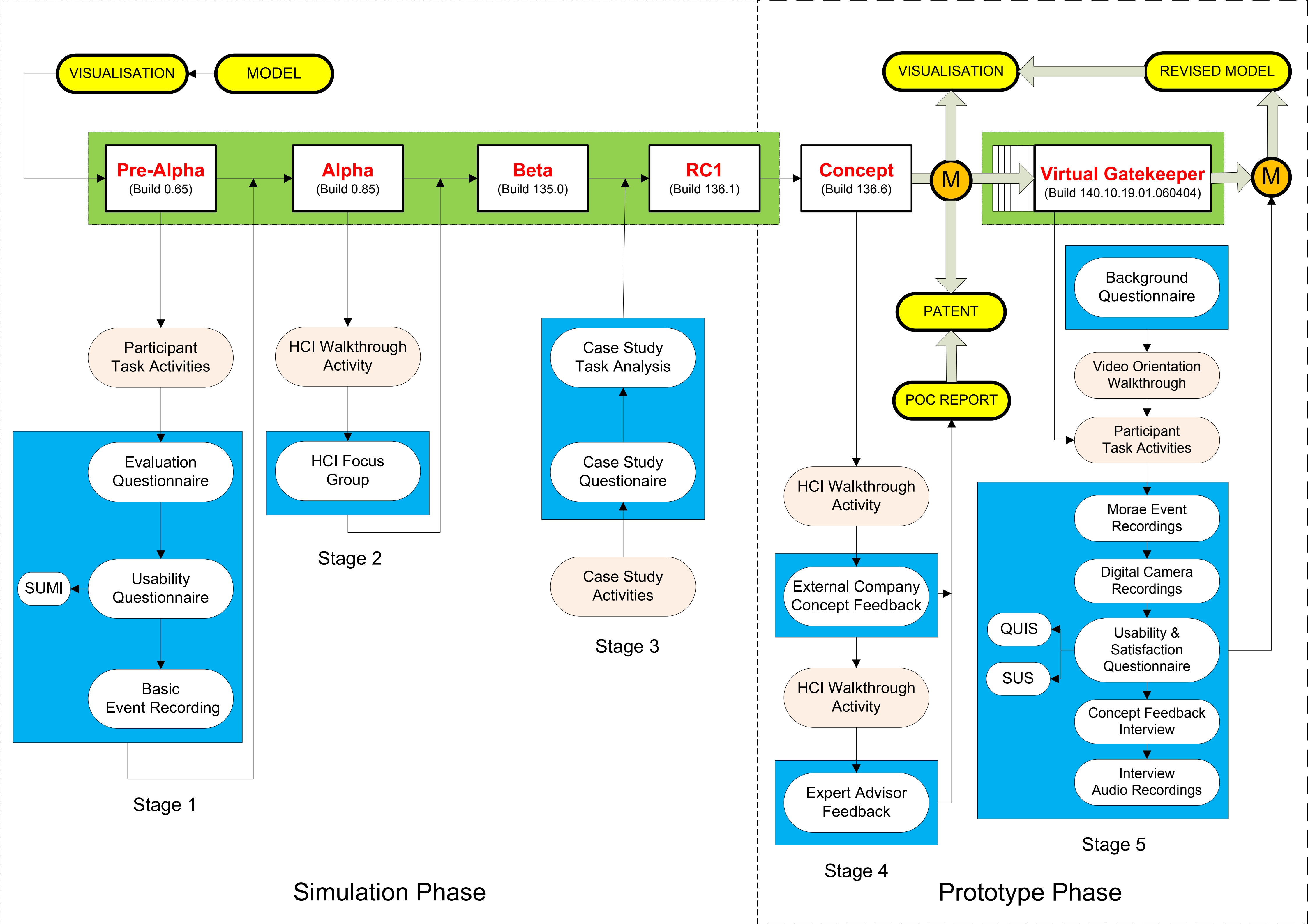
Appendix 2

Methodology flow chart


VISUALISATION
MODEL
Pre-Alpha
(Build 0.65)
Alpha
(Build 0.85)
Beta
(Build 135.0)
RC1
(Build 136.1)
Participant Task Activities
Evaluation Questionnaire
Usability Questionnaire
SUMI
Basic Event Recording
Stage 1
HCI Walkthrough Activity
HCI Focus Group
Stage 2
Case Study Task Analysis
Case Study Questionnaire
Case Study Activities
Stage 3
Simulation Phase
VISUALISATION
REVISED MODEL
Concept
(Build 136.6)
M
Virtual Gatekeeper
(Build 140.10.19.01.060404)
M
PATENT
POC REPORT
HCI Walkthrough Activity
External Company Concept Feedback
HCI Walkthrough Activity
Expert Advisor Feedback
Stage 4
Background Questionnaire
Video Orientation Walkthrough
Participant Task Activities
Morae Event Recordings
Digital Camera Recordings
Usability & Satisfaction Questionnaire
QUIS
SUS
Concept Feedback Interview
Interview Audio Recordings
Stage 5
Prototype Phase

Appendix 3

Managing shared data patent

PATENTS STATUS INFORMATION

FULL DETAILS

Please click on button below to view the published patent application via esp@cenet.

ESP@CENET

REGISTER ENTRY FOR GB2414574

Form 1 Application No GB0411938.4 filing date 28.05.2004

Title DATA MANAGEMENT SYSTEM

Applicant/Proprietor
DAVID SETCHELL AND PATRICK BROOKE ACTING AS NOMINATED TRUSTEES OF THE UNIVERSITY OF GLOUCESTERSHIRE TRUST INCORPORATING THE CHURCH OF ENGLAND FOUNDATION, Incorporated in the United Kingdom, The Park, CHELTENHAM, Glos, GL50 2QF, United Kingdom [ADP No. 08877862001]

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Classified to
G4A
G06F

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New Enquiry

Managing shared data

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Publication date:	2005-11-30
Inventor:	RICHARDSON DAVID EDWARD (GB)
Applicant:	DAVID SETCHELL AND PATRICK BRO (GB)
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- international:	G06F17/30 ; G06F3/00 ; G06F9/44
Application number:	GB20040011938 20040528
Priority number(s):	GB20040011938 20040528

Patent Status Enquiry

RESULT LIST
1 result found in the GB database for:
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(Results are sorted by date of upload in database)

1 **Managing shared data**
Inventor: RICHARDSON DAVID EDWARD (GB) **Applicant:** DAVID SETCHELL AND PATRICK BRO (GB)
Publication info: **GB2414574** - 2005-11-30 **IPC:** G06F17/30 ; G06F3/00 (+1)

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EP 0339220 A2	**WO 2001/037120 A2**
US 6636246 B1	**US 5982374 A**
US 20030135512 A1	**US 20020174105 A1**

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Other: **EPODOC, WPI, PAJ, , TXTUS1, TXTUS2, TXTUS3, TXTEP1, TXTGB1, TXTWO1, Internet.**

(54) Abstract Title: **Managing shared data**

(57) A data management system comprises:
a user interface system enabling a user to create at least one project suite and subsequently select one of said at least one project suites to permit working in said selected project suite, each project suite including at least one container for storing data;
means for extracting core data from a data source; and
means for tagging the data source, such that the core data extracted from the tagged data source is automatically placed into a container located within the selected project suite.
The user interface used may be formed as a represention of a segmented sphere.

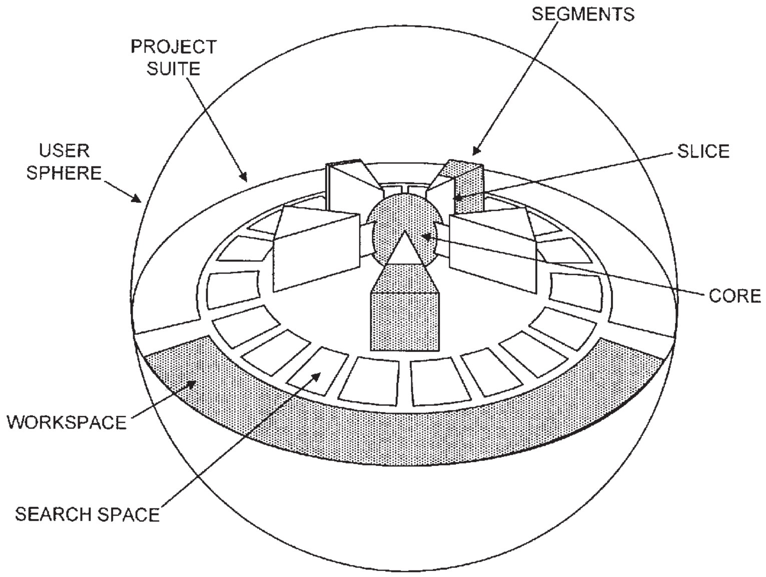


FIG. 1

GB 2 414 574 A

This print incorporates corrections made under Section 117(1) of the Patents Act 1977.

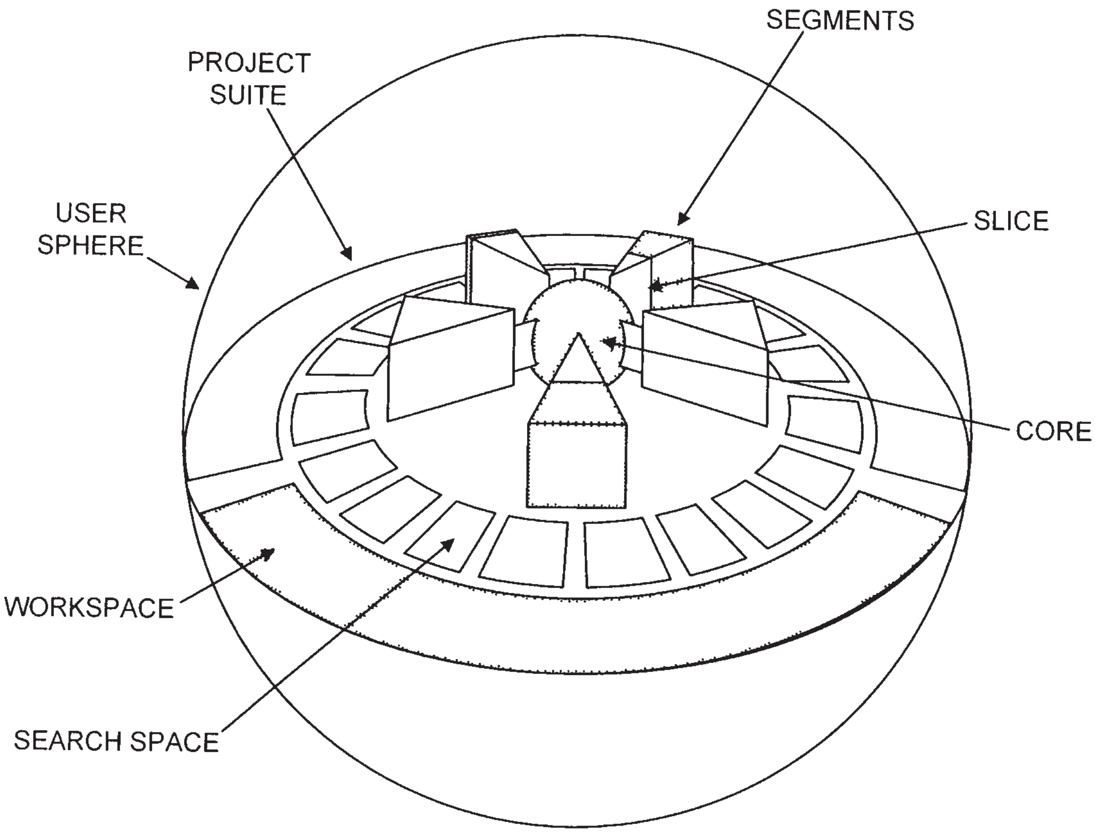

SEGMENTS
PROJECT
SUITE
USER
SPHERE
SLICE
CORE
WORKSPACE
SEARCH SPACE

FIG. 1

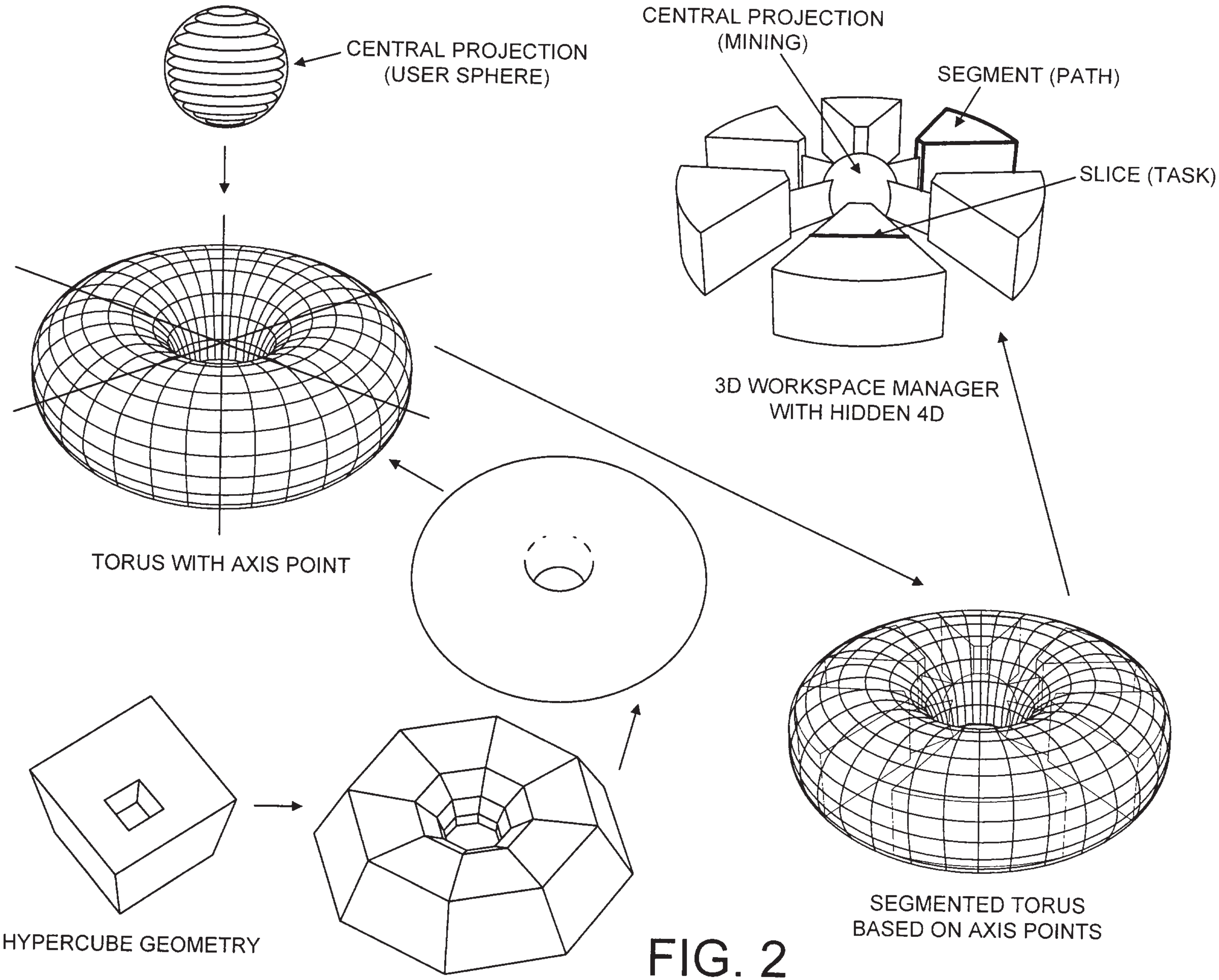
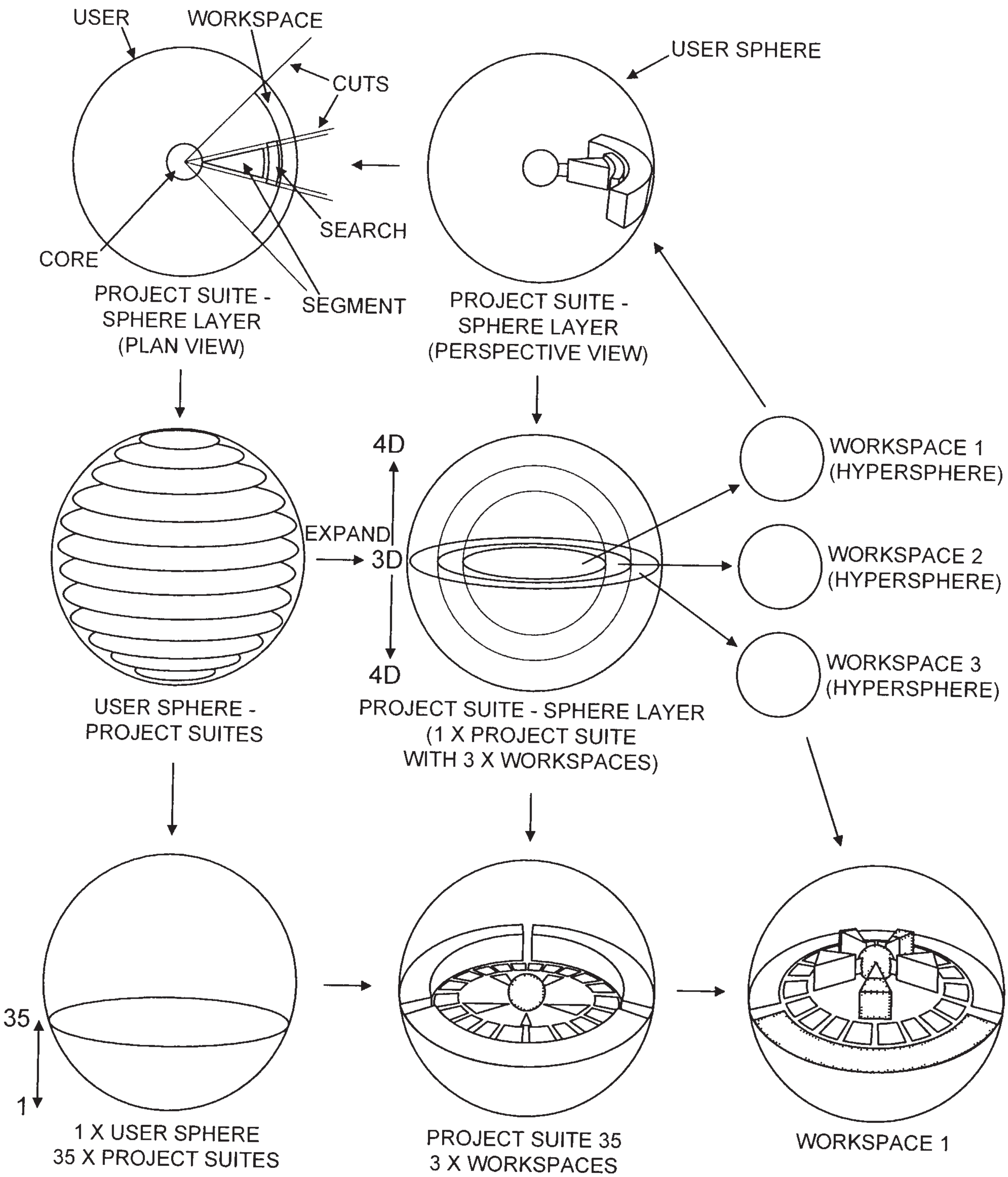

CENTRAL PROJECTION
(USER SPHERE)
CENTRAL PROJECTION
(MINING)
SEGMENT (PATH)
SLICE (TASK)
3D WORKSPACE MANAGER
WITH HIDDEN 4D
TORUS WITH AXIS POINT
HYPERCUBE GEOMETRY
SEGMENTED TORUS
BASED ON AXIS POINTS

FIG. 2



CENTRAL PROJECTION

FIG. 3

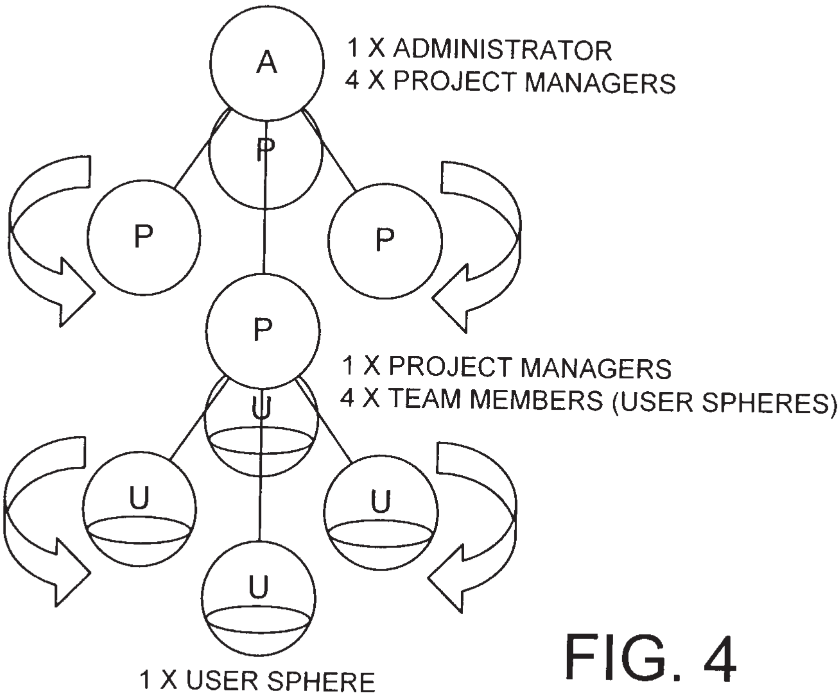

A
1 X ADMINISTRATOR
4 X PROJECT MANAGERS
P
P
P
P
1 X PROJECT MANAGERS
4 X TEAM MEMBERS (USER SPHERES)
U
U
U
U
1 X USER SPHERE

FIG. 4

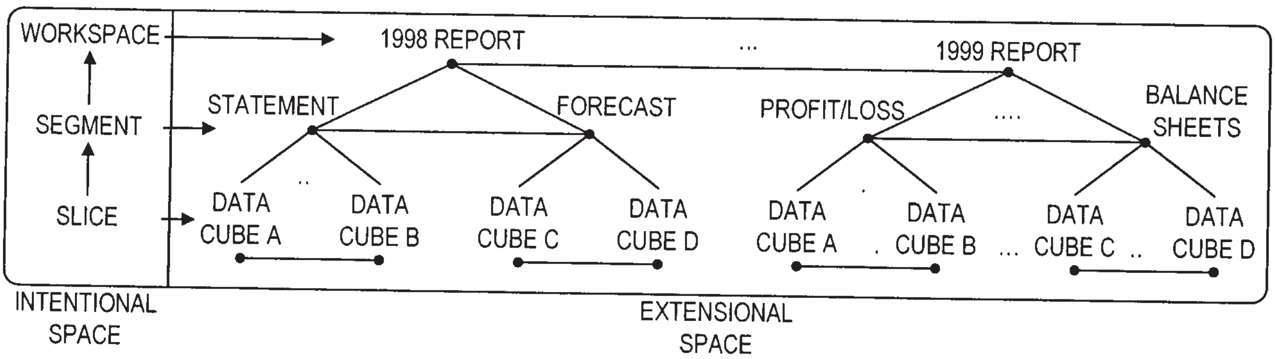

WORKSPACE
SEGMENT
SLICE
1998 REPORT
...
1999 REPORT
STATEMENT
FORECAST
PROFIT/LOSS
....
BALANCE SHEETS
DATA CUBE A
DATA CUBE B
DATA CUBE C
DATA CUBE D
DATA CUBE A
DATA CUBE B
DATA CUBE C
DATA CUBE D
INTENTIONAL SPACE
EXTENSIONAL SPACE

FIG. 5

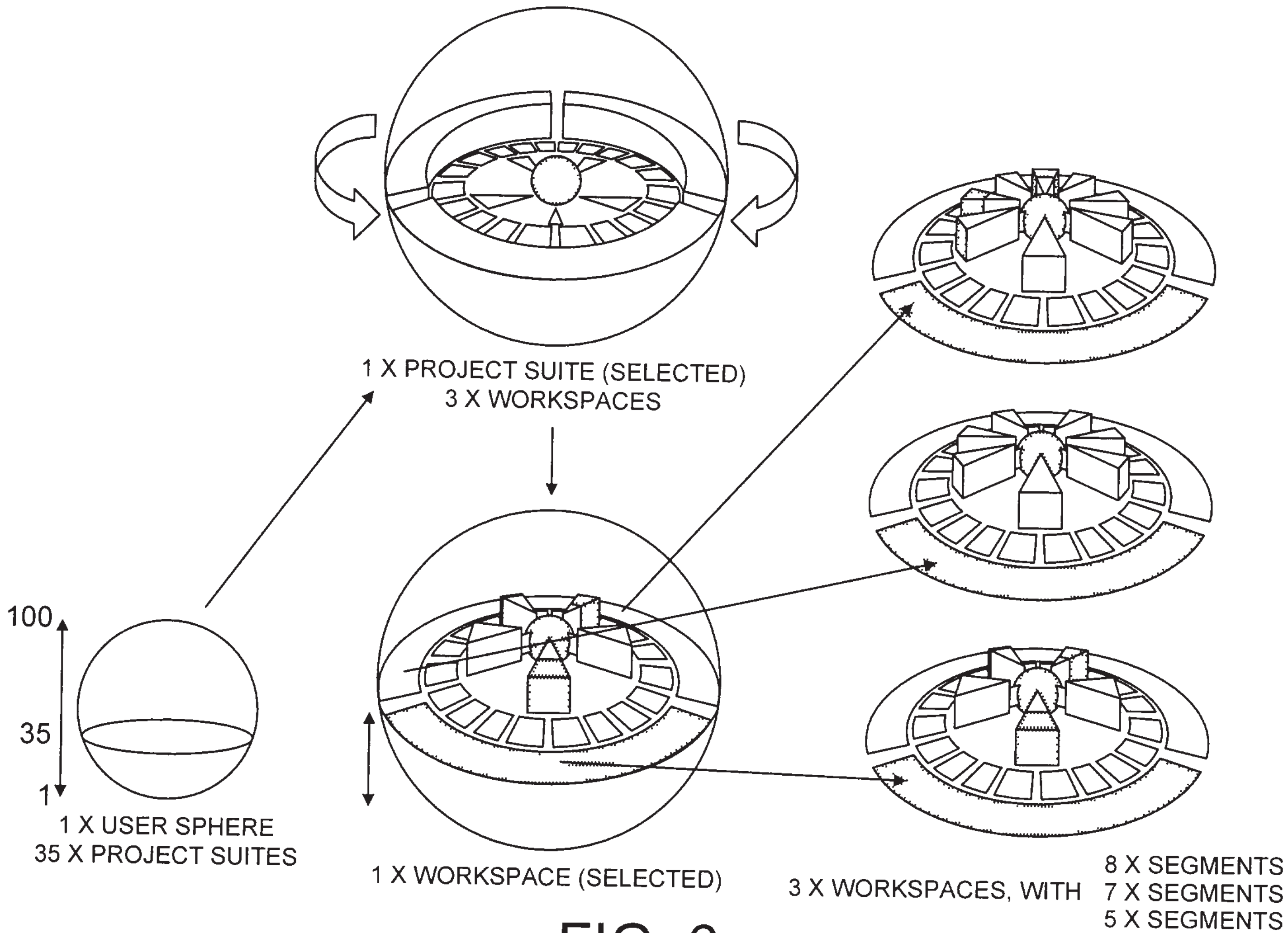

1 X PROJECT SUITE (SELECTED)
3 X WORKSPACES
100
35
1
1 X USER SPHERE
35 X PROJECT SUITES
1 X WORKSPACE (SELECTED)
3 X WORKSPACES, WITH
8 X SEGMENTS
7 X SEGMENTS
5 X SEGMENTS

FIG. 6

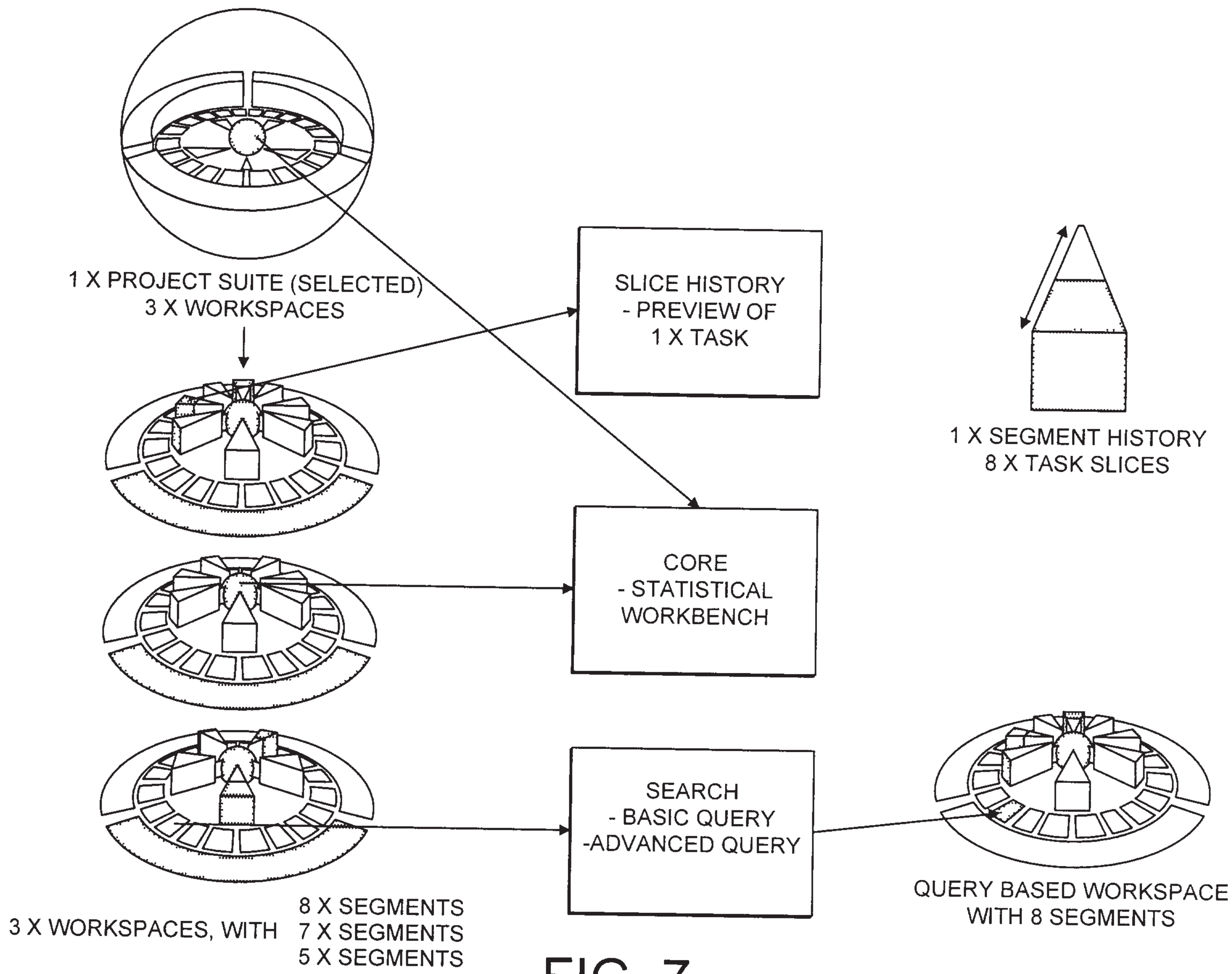

1 X PROJECT SUITE (SELECTED)
3 X WORKSPACES
SLICE HISTORY
- PREVIEW OF
1 X TASK
1 X SEGMENT HISTORY
8 X TASK SLICES
CORE
- STATISTICAL
WORKBENCH
SEARCH
- BASIC QUERY
-ADVANCED QUERY
QUERY BASED WORKSPACE
WITH 8 SEGMENTS
3 X WORKSPACES, WITH
8 X SEGMENTS
7 X SEGMENTS
5 X SEGMENTS

FIG. 7

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Data Management System

This invention concerns a data management system for implementation on a computer or network of computers.

Typically, within desktop file systems, stored data is represented graphically (the so-called "presentation layer") using two (x, y) or three (x, y, z) dependent spatial dimensions. This data is typically stored as miniature icons or lists of files within a structure of folders and sub-folders. Many documents may be opened on screen (presentation layer) together, which could relate to one state in time of a particular project. However, unless the user of the computer knows how the documents have been organised then it is impossible to know that these are related documents. One presently used solution is to create duplicates of these documents and to place all these into a single folder. This would be highly organised, but depends on the efficiency of the user. Generally, a mixed set of documents are saved in one folder and then others are opened up in new folders when required. Difficulties may occur if the user changes occupation or if multiple copies are made at different times, as differing versions in different places. A new person taking over a previous user occupation will need to spend time working out the previous user's filing system and replacing it with their own system. Even then they may not be able to find all the required stored documents related to one single project. It may be possible through understanding the folder name, file name, extension, internal document data or randomly previewing the file required, but it is likely that some knowledge about how the original user undertook that project and the thought processes involved would now be lost.

It is an object of the present invention to provide a data management system which overcomes the problems outlined above. This is achieved by providing a new user interface whereby users can navigate through, interact with and organise data through a cognitive project-based front-end which integrates directly with a back-end data mining and searching / categorising system.

In accordance with a first aspect of the present invention there is provided a data management system comprising:

a user interface enabling a user to create at least one project suite and subsequently select one of said at least one project suites to permit working in said selected project suite, each project suite including at least one container for storing data;

means for extracting core data from a data source; and

means for tagging the data source, such that the core data extracted from the tagged data source is automatically placed into a container located within the selected project suite.

The at least one project suite preferably includes at least one workspace which may be selected by the user, each said workspace including at least one container. The at least one workspace may include at least one segment which may be selected by the user, each said segment including at least one container.

Each said project suite is advantageously represented visually by a layer of a sphere. Each workspace may be represented visually by a circumferential section of said sphere layer, each segment may represented visually by a segment radially within said circumferential section and each container may be represented visually by a slice of said at least one segment.

Preferably, the data source may be tagged upon selection by the user.

The extracted data may advantageously be additionally stored within a core area, which may be represented visually by an inner sphere at the centre of the spherical shell. The extracted data may be viewed or analysed within the core area.

Means may be provided for searching through the data by entering search request information via the user interface system. The search request information may be automatically stored within a search data container within the selected project suite and the search data container may be represented visually by circumferential section, radially inwardly of the workspace circumferential section. Data found as a result of the search may be automatically stored within a container within the selected project suite.

Preferably, a plurality of user interfaces are provided to permit a plurality of users to access data. The plurality of user interfaces may be personalised to allow access to different data depending on the authority of each of the plurality of users.

The data source may be automatically tagged when the data source is accessed. Core data extracted from the automatically tagged data source may only be accessible to a user with a predetermined level of authority.

Advantageously, the data source is a web document, text document, spreadsheet or other computer-based application.

Means may be provided for viewing or performing statistical analysis of the stored data.

According to a second aspect of the present invention there is provided a method of organising data, comprising the steps of:
a) creating a virtual project suite;
b) creating a virtual task space within said project suite, said task space including a container for storing data;
c) entering said virtual task space;
d) accessing a data source from within said task space;
e) extracting core data from said data source; and
f) providing means for tagging said data source, such that extracted data from a tagged data source is automatically placed into the container.

There may be a further step of creating a virtual workspace within the project suite, and creating the task space within said workspace.

According to a third aspect of the present invention there is provided a computer program for implementing the data management system on a computer.

According to a fourth aspect of the present invention there is provided a computer when programmed with the program.

The invention will now be described by way of example with reference to the following figures, in which:-

Figure 1 shows a visual representation of the data management system according to an embodiment of the invention;

Figure 2 shows the geometrical transformations used to construct the data structure used in the inventive data management system;

Figure 3 shows various representations of the data structure used within the inventive data management system;

Figure 4 shows an example of an authority level structure;

Figure 5 shows the effect of hyperpath linkage between data within the data structure;

Figure 6 shows the user interface for navigating between projects and workspaces according to an embodiment of the invention; and

Figure 7 shows the user interface for navigating within workspaces and segments.

A visual representation of the data management system is shown in Fig. 1, with its construction described with reference to Figs. 2 to 5. Fig. 1 shows a three-dimensional representation of the hierarchical data levels within the system. The outermost sphere 1 is termed the "user sphere". Each user of the system will be able to access their own user sphere, so that the sphere defines the identity of the user. The sphere contains a number of project suites, which in the figure shown are arranged as vertically arranged layers of the sphere. For simplicity, only one such project suite is shown in its expanded form. Circumferentially arranged around the outside of each project suite is at least one workspace, three such workspaces being shown in the figure, with the frontmost workspace shown as being selected. Within the selected workspace are a number of segments, with five of these being shown in the figure. Each such segment includes at least one slice, each slice being a container for data. Also shown in the figure are a number of search slots, which are used for holding information relating to data searches, as will be explained in detail later. At the centre of the user sphere is the core, in which all of the data within the system is stored.

This structural geometry is a three-dimensional ghost projection of the underlying hidden four-dimensional mathematical structure of a "hypersphere", although it is considered synonymous (topologically equivalent in mathematical terms) to that of a "hypercube". The geometric structural visualisation provides a means by which interaction can take place within a three-dimensional n-space environment, the statistical results of which can be viewed from within the central core hypersphere. Consider three cubes, each centrally placed inside each other. The outer and middle ones are joined at their vertices to produce a tesseract or hypercube, as shown in Fig. 2. The top and bottom faces of the middle cube are then cut and removed, leaving a cubic torus around the inner cube. The tesseract is then topologically transformed into a smooth torus while the inner cube is similarly transformed into a sphere. The radius of the sphere is slightly less than that of the inner diameter of the torus so that it fits into the central space but is distinct from the torus itself. The cubic torus is homeomorphically transformed into a smooth torus which is represented topologically by S^1 x S^1, which, through the induced topology of S^1 in R^2, can be considered as a subset of R^4. Here S^1 represents the circle in (real) Euclidean 2-space, R^2, while R^4 represents (real) Euclidean 4-space. The innermost cube is topologically equivalent to a sphere S^2, and so can be topologically represented in this way. This structural geometry greatly assists the interaction with the complex multidimensional data and / or levels.

Everything that a user undertakes within the system is based upon the premise that data is being stored within the single central hypersphere core that denotes their user identity. This sphere is then split into multiple layers, i.e. project suites which have an infinite number of multiple cells of multi-dimensional information stored within them. The limit to the volume of information stored is determined by the constraints of the external physical storage media used.

Figure 3 shows various representations of the data structure. The middle row of the figure shows the mathematically derived structure, and its limitations as the detail of the structure cannot be easily viewed. The bottom row of the figure shows representations of the structure in a form more accessible to a user of the system, which form the basis for the user interface. The upper row shows further detail of the structure in plan view and perspective view for clarity. The layers when viewed as a three-dimensional structure can only be seen as flat layers appearing within 3-space, as shown in the "User Sphere - Project Suites" image in the middle row of the figure. The complexity of the structure is therefore hidden from someone viewing it in three dimensions as the rest of the structure exists in a fourth spatial dimension. The design then reflects a number of mathematical transformations based on the topology of the hypersphere / hypercube, in order to provide a means of interaction with this hidden geometric structure. In the example shown, there are thirty-five separate project suites or layers (not all shown in the middle row images). If a single one of these layers or project suites is expanded, it can be seen that a number of workspaces, in this case three workspaces, exist within the layer. These are shown as concentric circles in the middle row and as circumferential sections in the bottom row. Again, each workspace is a hypershere which includes data hidden in segments as described with reference to Fig. 1. As shown in the bottom row for example, "workspace 1" includes five segments.

The segments and workspace layers which make up a single project are connected by four-dimensional joins. This means that any workspace hypertorus can touch others at any point, and also that the segment hypercubes can also touch each other at any point. This provides the flexibility to infer distant relationships or patterns between or within datasets. If the system used relational database architectures within the visualisation then disparate data could not physically be joined within a three-dimensional environment. The analogy is that a three-dimensional environment will allow data to be bent in order to touch each other, but if that data is from a distant dataset then this would not be possible. Hence it is necessary to use four dimensions, where the analogy is that disparate datasets can be ripped within 4-space and then a relationship can be derived from joining these new datasets for the purpose of complex analysis or data mining. It also provides the gateway to hyperbolically connected paths which can be searched for or manually connected according to user storage patterns or requirements.

As stated earlier, each segment contains a number of slices, which essentially act as containers for data. Since the hypercubic structure is hidden (in Euclidean three-dimensional space), what an end-user visualises via the interface is a single slice, with the most recent slices being closer to the centre of the structure. In reality, behind the visualisation are many multi-dimensional cells of stored information which are linked through the geometric structural relationships provided by the hypercube and multi-dimensional database architectures. This is illustrated in Fig. 5, which shows two related report documents which are stored in separately named workspaces, i.e. "1998 Report" and "1999 Report" within one project suite. The segments are named according to sections of the report, for example "statement", "forecast" in the first workspace and "profit / loss" and "balance sheets" in the second workspace. Each segment therefore contains slices of data which are relevant to the segment, such as tables or pages. In the figure, dotted lines show that there is a hyperpath link between these documents, and thus that a new relationship exists. For example, 1998 Report forecast is linked to 1999 Report profit / loss. Incidentally, hyperpath relational links also exist within a report, such as profit / loss being linked to the balance sheet.

It is an important aspect of the invention that many users can access the same data, to allow joined-up working on a project for example, or to avoid duplication of effort. Generally, data will either be linked to by another user, or, if it is altered in some way then it is automatically copied into the new user's environment. Alternatively, a user may designate that some information is private, in which case it will not be available to other users. If for example a workspace is made private by a user, then even though a slice or segment within that workspace remains public, then due to the hierarchical structure of the data the slice or segment still cannot be accessed by other users. In addition, users may be assigned different access rights to the data depending on the authority of the user. For example, an administrator may have authority over a group of project managers, who in turn have authority over groups of team members. Such an arrangement is shown in Fig. 4. In this case, although a user of a certain authority may mark information as private, it may still be viewed by users of a higher authority level.

The operation of the data management system in a preferred embodiment will now be described with reference to Figs. 6 and 7. When entering the data management system, the user must be determined. If the user has a computer terminal of their own then it may be configured so that only the user's sphere is available for selection. Alternatively, if several users have access to a terminal then they may select their own user sphere by selecting, e.g. by clicking, the correct sphere of a "user map" similar to the authority diagram of Fig. 4, or by entering log-in details into the interface, in which case the correct user sphere is automatically selected. Once the correct user sphere has been selected, a representation of the sphere showing the available project suites is shown on screen. The project suites may be shown as individual layers of the sphere, which may be vertically arranged as shown on the left hand side of Fig. 6, or alternatively as concentric layers of the sphere in an "onion-skin" arrangement. The user may add new project suites or rename or otherwise edit individual suites at this stage. In the example shown, there are 35 project suites available, with total space for 100 suites, although this is determined by the limits of the external storage medium.

A particular project suite is then selected and entered, for example by clicking on a layer. The visual representation then changes to that shown at the top of Fig. 6. In the example shown, there are three workspaces available. The user may add new workspaces, or rename, edit or delete existing workspaces as required. The workspace at the front of the sphere is the one currently selected, the others may be selected by clicking on them for example. An animation may be triggered so that the selected workspace spins round to the front, as shown by the arrows. A workspace may be entered by further clicking.

Once a workspace has been entered, the visual representation changes to that shown directly underneath the previous image. In the example shown, the workspace selected has five segments available. The images to the right indicate that the other two workspaces have eight and seven segments available respectively. The amount of data held within the segments is indicated by the shading applied thereto, so that each full slice is shaded.

Fig. 7 shows some of the options available to a user through the interface. If a segment is selected, for example by clicking, then a slice history area, for example a window, appears on screen. The slice history area enables the individual slice containers, holding various multivariate releated document data, to be previewed. The window would include a visual representation of the segment with individual stacked slices, and the content of a slice viewed by moving the mouse pointer over a slice. The slices may also be flicked through in a "pack of cards" manner. Slice histories may be displayed with the oldest task documents being at the front of the "pack" and the newest being towards the centre of the segmented structure (following the inverse ghost projection out from the central core). The window also contains means, for example icons, to allow the user to access a variety of applications. These may include internet browsers, word processors, or spreadsheet applications for example. This means that the application is only accessible from within a segment of a workspace. Therefore any data taken from the application, as will be described later, is automatically associated with a particular task of a particular project, leading to an efficiently organised data structure.

If the core is selected, for example by clicking, then a "statistical workbench" is entered. The central hypersphere core is the place where all the "hidden" four-dimensional data can be analysed. Note that the core may be selected from inside or outside a workspace. The statistical workbench allows the user to carry out and display various multidimensional level specific statistics, for example the time spent on a various task or project. Single user or multiple user statistics may also be provided.

Selecting a search slot, for example by clicking, will pull up a search screen or window. This search visualisation interface front-end provides a means for previewing basic or advanced filtered queries placed upon the multi-dimensional database Essentially, key content which is stored in the database is then made available through On-Line Analytical Processing (OLAP) queries. This allows the user to search, for example by keyword, for data contained in slices. The search may be limited to, for example, the active segment, current workspace or entire project as appropriate. These queries can be used multiple times and are stored alongside the workspaces as temporary search blocks for the lifetime that the user is logged into the current project or session. This means that when a user does another search, the previous search data is also included, increasing performance or refining search results to the key content required. Should the user wish to keep the created search block workspace, then it can be upgraded or promoted to the outer ring, i.e. becoming a single project workspace which can be entered and viewed as any other workspace. This frees the search block which may then be deleted or overwritten.

As mentioned above, applications such as internet browsers and word processors are accessed from within a segment. These task applications are data sources, providing the data which is stored in the individual slice containers. The data management system includes an embedded, expandable set of tools or agents with hooks and / or links directly into task applications which compress, reformat, dissect or extract all related document content, whether hidden or visible. In addition, control is provided over data categorisation by facilities to customise or to view certain meta-content fields. For example, suppose the task application entered is an internet browser, and the user visits a web-page. The data management system will automatically extract all the data about that page, which may be previewed in a separate "workbench" window. The data may include aspects such as the number of page links, the Internet protocol address of the server it came from and vital meta-data information. As well as this visible extracted data, the system will also collect in-session statistics, with regard to areas such as origin, content, time-frames or whether the data is sensitive or protected. Also, a unique hash identity is given to the page container upon loading which helps prevent duplication of content. The user may edit the extracted data from within the workbench as needed, for example the user may add a custom comment about the web-page.

In addition, a "hidden" log is made of every document that is visited alongside spatial and selected information about it. This goes towards prohibited content analysis This log is created as an Extensible Markup Language (XML) file and is synchronised with the database using a Web Service through a "Search and Scan" module, so that the user knows that this document is being recorded. These statistics go beyond simply watching for prohibited content, but enable the system to predict options or locations that a user might like to take. If a user wants to bookmark a document page for off-line inclusion inside the system, they can manually tag the page, for example by clicking a taskbar button. At this point two things happen: firstly, all vital information is collected from the workbench and is recorded to a local XML index file using a Schema, and secondly text content is processed into keywords, body text and a description regarding the content. If a user had provided custom comments about the page then this would additionally be saved. Lastly, a screenshot of the document page at the time of saving is made, as well as a copy of the document as a compound MHT file or in its original format, should those options be selected by the user. These files are retained on the hard disk until the user closes the application and returns to the slice history interface. When this happens, the data is synchronised with the database using the Search and Scan Web Service as used previously for the "hidden" log file. Depending on file size, MHT files or backup documents are synchronised with a content management server, and index / content XML files have their data extracted into the separate server database fields. When this data is needed again, the XML is generated and the content files are pulled back as packets off the content server.

When the slice container is viewed within the slice history window, an image of the document page will be shown, and the workbench data will be available for viewing if desired. The web document page may then be returned to by selecting that slice.

The hidden log of every page visited allows the user's actions to be tracked. This information can be used for example to determine the user's activity and efficiency, and whether they have been viewing prohibited content. Such hidden information about the user's activities may be inaccessible to the user, but may be accessed by a user of greater authority. This promotes greater accountability and reduces unprofessional practice.

Although the invention has been described with reference to the embodiments above, there are many other modifications and alternatives possible within the scope of the claims. The visual interface is exemplary only as a method for interacting with the four-dimensional data structure used by the system.

Claims

1. A data management system comprising:
a user interface enabling a user to create at least one project suite and subsequently select one of said at least one project suites to permit working in said selected project suite, each project suite including at least one container for storing data;
means for extracting core data from a data source; and
means for tagging the data source, such that the core data extracted from the tagged data source is automatically placed into a container located within the selected project suite.

2. A system according to claim 1, wherein the at least one project suite includes at least one workspace which may be selected by the user, each said workspace including at least one container.

3. A system according to claim 2, wherein the at least one workspace includes at least one segment which may be selected by the user, each said segment including at least one container.

4. A system according to any preceding claim, wherein each said project space is represented visually by a layer of a sphere.

5. A system according to claim 4, wherein each said workspace is represented visually by a circumferential section of said sphere layer.

6. A system according to claim 5, wherein each said segment is represented visually by a segment radially within said circumferential section.

7. A system according to claim 6, wherein each said container is represented visually by a slice of said at least one segment.

8. A system according to any preceding claim, wherein the data source is tagged upon selection by the user.

9. A system according to any preceding claim, in which the extracted data is additionally stored within a core area.

10. A system according to claim 9, wherein said core area is represented visually by an inner sphere at the centre of said spherical shell.

11. A system according to either of Claims 9 and 10, wherein the extracted data may be viewed or analysed within the core area.

12. A system according to any preceding claim, comprising means for searching through the data by entering search request information via the user interface system.

13. A system according to claim 12, wherein the search request information is automatically stored within a search data container within the selected project suite.

14. A system according to claim 13, wherein the search data container is represented visually by circumferential section, radially inwardly of the workspace circumferential section

15. A system according to any of claims 12 to 14, wherein data found as a result of the search is automatically stored within a container within the selected project suite.

16. A system according to any preceding claim, wherein a plurality of user interfaces are provided to permit a plurality of users to access data.

17. A system according to claim 16, wherein the plurality of user interfaces are personalised to allow access to different data depending on the authority of each of the plurality of users.

18. A system according to any preceding claim, wherein the data source is automatically tagged when the data source is accessed.

19. A system according to claim 18, wherein core data extracted from the automatically

tagged data source is only accessible to a user with a predetermined level of authority.

20. A system according to any preceding claim, wherein the data source is a web document, text document, spreadsheet or other computer-based application.

21. A system according to any preceding claim, comprising means for viewing or performing statistical analysis of the stored data.

22. A method of organising data, comprising the steps of:
a) creating a virtual project suite;
b) creating a virtual task space within said project suite, said task space including a container for storing data;
c) entering said virtual task space;
d) accessing a data source from within said task space,
e) extracting core data from said data source; and
f) providing means for tagging said data source, such that extracted data from a tagged data source is automatically placed into the container.

23. A method according to claim 22 further comprising the step of creating a virtual workspace within the project suite, and creating the task space within said workspace.

24. A computer program for implementing the data management system of any preceding claim on a computer.

25. A computer when programmed with the program of claim 24.

26. A data management system as herein described with reference to the accompanying figures.

27. A method of organizing data as herein described with reference to the accompanying figures.

28. A computer program as herein described with reference to the accompanying figures.

The Patent Office

INVESTOR IN PEOPLE

Application No:	GB0411938.4	**Examiner:**	Mr Philip Osman
Claims searched:	1, 22	**Date of search:**	29 October 2004

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A	-	US2003/135512 A1 (MORGAN JR et al)
A	-	US2002/174105 A1 (DE LA HUERGA)
A	-	EP0339220 A2 (HEWLETT PACKARD)
A	-	US6636246 B1 (GALLO et al)
A	-	US5982374 A (WAHL)
A	-	WO2001/37120 A2 (ANWAR)

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application

Field of Search:

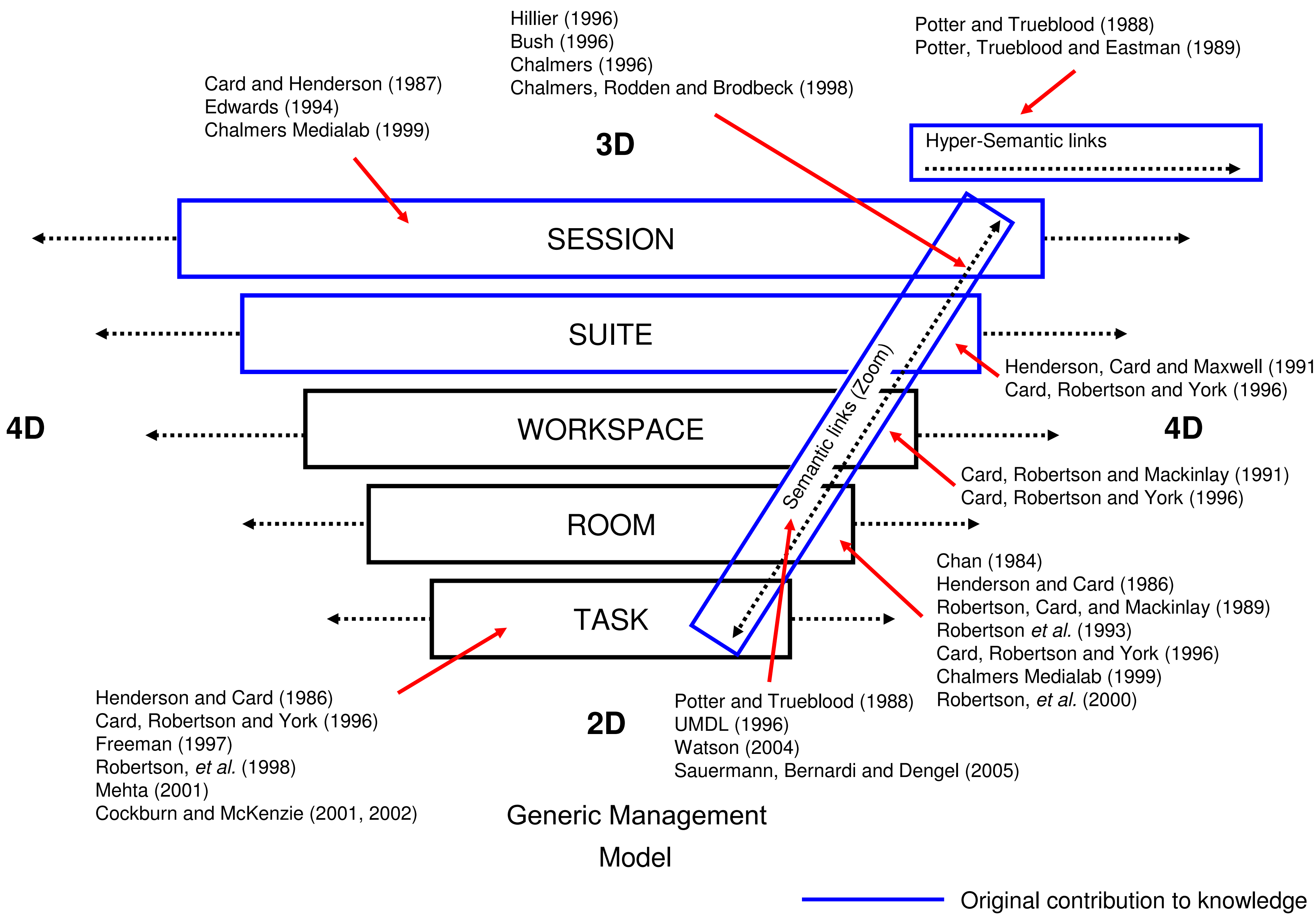
Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{W} :

Worldwide search of patent documents classified in the following areas of the IPC^{07}

The following online and other databases have been used in the preparation of this search report

Appendix 4

Generic Management Model

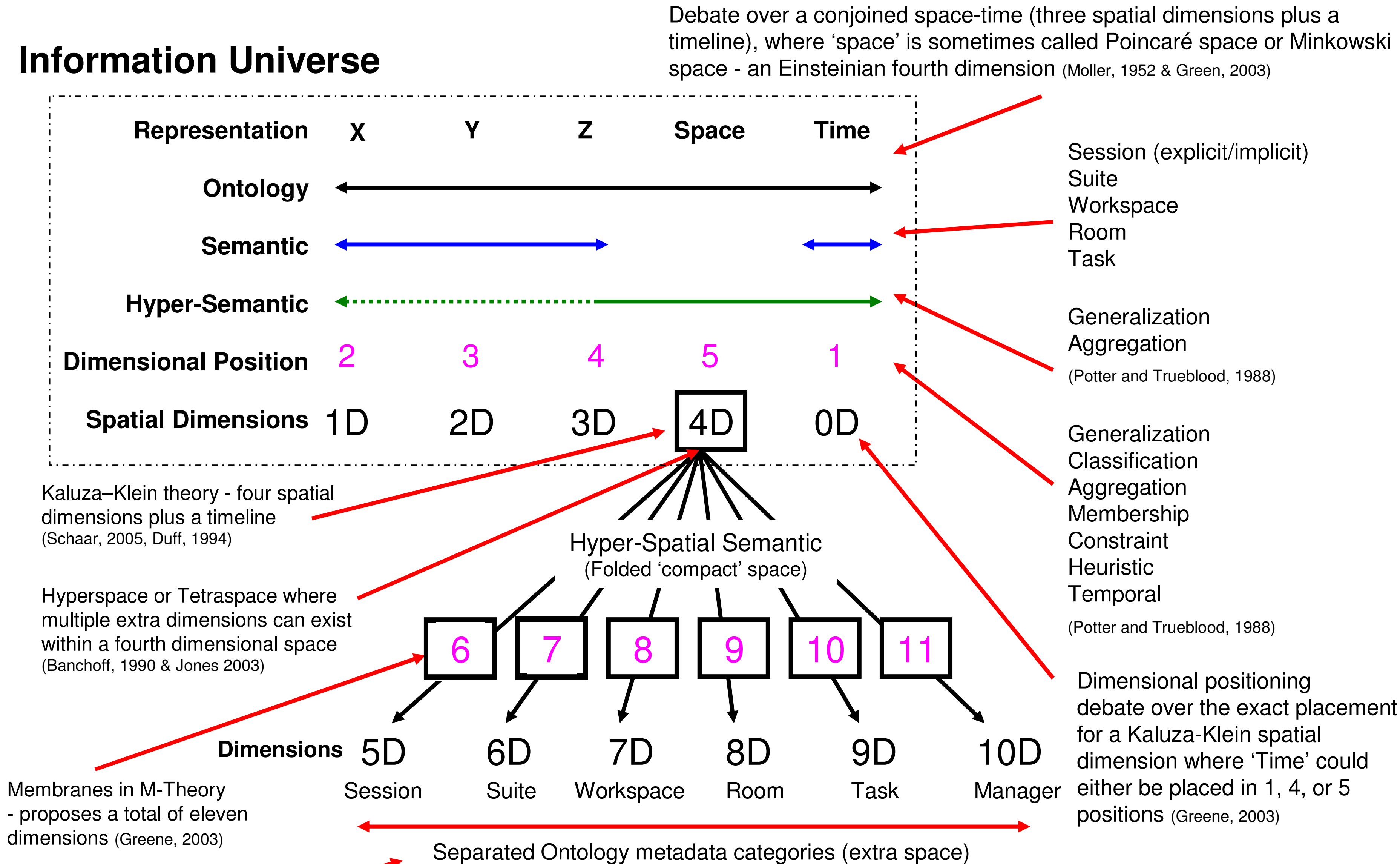


Hillier (1996)
Bush (1996)
Chalmers (1996)
Chalmers, Rodden and Brodbeck (1998)
Potter and Trueblood (1988)
Potter, Trueblood and Eastman (1989)
Card and Henderson (1987)
Edwards (1994)
Chalmers Medialab (1999)
3D
Hyper-Semantic links
SESSION
SUITE
Henderson, Card and Maxwell (1991)
Card, Robertson and York (1996)
4D
WORKSPACE
4D
Semantic links (Zoom)
Card, Robertson and Mackinlay (1991)
Card, Robertson and York (1996)
ROOM
Chan (1984)
Henderson and Card (1986)
Robertson, Card, and Mackinlay (1989)
Robertson *et al.* (1993)
Card, Robertson and York (1996)
Chalmers Medialab (1999)
Robertson, *et al.* (2000)
TASK
Henderson and Card (1986)
Card, Robertson and York (1996)
Freeman (1997)
Robertson, *et al.* (1998)
Mehta (2001)
Cockburn and McKenzie (2001, 2002)
2D
Potter and Trueblood (1988)
UMDL (1996)
Watson (2004)
Sauermann, Bernardi and Dengel (2005)
Generic Management Model
Original contribution to knowledge

Appendix 5

Information Universe Model Extended

Information Universe



Extra dimensions:

- provide further task activity, content information and knowledge metadata-based logging categorisation space
- enable traversable wormholes (Visser, 1989) between semantically linked paths or datasets
- enable bridging through parallel space membranes (Kaku, 1995, Green, 2003) between hyper-semantically linked paths or datasets
- nature of dimensional operator categories are yet to be defined - subject of further work

Appendix 6

Simulation phase questionnaire

18h February 2002

CoreWeb Pre-Alpha Build 65 Testing

Instruction Sheet

Dear Participant,

Thank you for agreeing to assist with my postgraduate research. You should find enclosed the following materials:

- 1 x Experiment Tasks sheet (attached).
- 1 x Critical Error report sheet.
- 1 x Questionnaire booklet (stapled).

Please read the following instructions fully before you start the experiment.

General Instructions

1. You will be provided with an IBM compatible laptop PC with Windows 2000 and Internet Explorer 6 pre-installed.

2. There will be a link available on the PC desktop called "**CoreWeb Install & Start**" so that you can initiate the test software for use during this experiment.

3. Please read carefully the license agreement during the installation process and select "**Next**" if you agree.

   →**Note:** You are specifically accepting to keep all information undertaken during this experiment confidential **(refer to confidentiality).**

4. After installation please wait for your **Tester ID number** to be provided by the researcher, so that you can continue with the experimental tasks.

   →**Note:** This information is used for monitoring your actions during the use of the test software and that it is merely used to differentiate you from other users.

5. During the experiment please follow the "**Experiment Tasks**" sheet only.

6. If the software stops for any reason or you cannot / partially complete a task, then please fill out the "**Critical Error**" sheet.

7. Once you have completed all the tasks, please fill out the "**Questionnaire**" booklet.

8. Each "Questionnaire" booklet should take approximately 5 - 20 minutes, although this time may vary depending on participant.

9. When the "Questionnaire" booklet is complete, please return all sheets to the researcher.

Thank you for your cooperation and assistance.

.   18h February 2002

CoreWeb Pre-Alpha Build 65 Testing

Experiment Tasks

Instructions

- **Login Details**

Tester ID: testerX (lowercase) X = your allocated number)

Password: cwb2001 (lowercase)

- **Tasks**

1. Log into CoreWeb as a "New" tester type.
2. Using the options provided, navigate to a simulated web page screenshot.
3. At a web page screenshot select "go into link" three times and then select "come out of link" once.
4. Navigate back to an opening CoreWeb screen.
5. Exit the CoreWeb Browser.
6. Log into CoreWeb as a "Returning" tester type and then "resume" back to your previous position.
7. Using the options provided, navigate back to segment 1.
8. Using the options provided locate: -

   a) How to view the history of a segment.

   b) How to select and navigate to a previous Web Page screenshot that the one currently available to you.

18h February 2002

CoreWeb Pre-Alpha Build 65 Testing
Critical Error Report

Instructions

Please fill out this sheet **ONLY** if you had a problem during testing e.g. you could not / you could partially complete a task, or the software crashed on you. If multiple problems occurred during testing then more “Critical Error” sheets will be provided.

Tester ID: __________________ (please specify)

Name of Software: CoreWeb 3D Web Browser - Build 65

Date: ___/___/___ (please specify)

1. Task number: ____ (please specify number)

2. Please specify the level of severity of this problem according to the following:

   Level 1: I was unable to continue with the task due to the problem.

   Level 2: I had considerable difficulty completing the task but was eventually able to continue

   Level 3: I had minor difficulty completing the task.

   Your response: __________ (please specify number)

3. Description of Problem (please write one sentence)

   ____
   ____
   ____

4. Please specify the results of problem based on the following:

   Consistency: Did the problem claim that an aspect was in conflict with some other portion of the system or not?

   Recurring: Is the problem one that only interferes with the interaction the first time it is encountered, or is it always a problem?

   General: Did this problem point out a general flaw that affects several parts of the interface, or was the problem specific to a single part?

   Your response: ____________________ (please specify one word)

Recommendation(s) - administration use only

Should this be addressed or not: YES / NO

18h February 2002

Experiment Questionnaire

Tester ID: ________________ (please specify)

Name of Software: CoreWeb 3D Web Browser - Build 65

Computer Experience:

1. Novice

2. Intermediate

3. Expert

___ (please specify number)

Test Date: ___/___/___ (please specify)

Note: The information you provide is kept completely confidential, and no information is stored on computer media that could identify you as a person.

- ### Section 1

Instructions:

- There are 50 statements.
- Please answer every one of them.
- Mark the first box if you generally AGREE with the statement.
- Mark the central box if you are UNDECIDED, can't make up your mind, or if the statement has no relevance to your software or to your situation.
- Mark the right box if you generally DISAGREE with the statement.
- In marking the left or right box you are not necessarily indicating strong agreement of disagreement but just your general feeling most of the time.
- To respond please ☑ the box by your desired answer.

1 This software responds too slowly to inputs.

Agree ☐ Undecided ☐ Disagree ☐

2 I would recommend this software to my colleagues.

Agree ☐ Undecided ☐ Disagree ☐

3 The instructions and prompts are helpful.

Agree ☐ Undecided ☐ Disagree ☐

Please continue overleaf

4 The software has at some time stopped unexpectedly.

Agree ☐ Undecided ☐ Disagree ☐

5 Learning to operate this software initially is full of problems.

Agree ☐ Undecided ☐ Disagree ☐

6 I sometimes don't know what to do next with this software.

Agree ☐ Undecided ☐ Disagree ☐

7 I enjoy my sessions with this software.

Agree ☐ Undecided ☐ Disagree ☐

8 I find that the help information given by this software is not very useful.

Agree ☐ Undecided ☐ Disagree ☐

9 If this software stops, it is not easy to restart it.

Agree ☐ Undecided ☐ Disagree ☐

10 It takes too long to learn the software commands.

Agree ☐ Undecided ☐ Disagree ☐

11 I sometimes wonder if I'm using the right command.

Agree ☐ Undecided ☐ Disagree ☐

12 Working with this software is satisfying.

Agree ☐ Undecided ☐ Disagree ☐

13 The way that system information is presented is clear and understandable.

Agree ☐ Undecided ☐ Disagree ☐

14 I feel safer if I use only a few familiar commands or operations.

Agree ☐ Undecided ☐ Disagree ☐

15 The software documentation is very informative.

Agree ☐ Undecided ☐ Disagree ☐

Please continue overleaf

16 This software seems to disrupt the way I normally like to arrange my work.

Agree ☐ Undecided ☐ Disagree ☐

17 Working with this software is mentally stimulating.

Agree ☐ Undecided ☐ Disagree ☐

18 There is never enough information on the screen when it's needed.

Agree ☐ Undecided ☐ Disagree ☐

19 I feel in command of this software when I am using it.

Agree ☐ Undecided ☐ Disagree ☐

20 I prefer to stick to the facilities that I know best.

Agree ☐ Undecided ☐ Disagree ☐

21 I think this software is inconsistent.

Agree ☐ Undecided ☐ Disagree ☐

22 I would not like to use this software every day.

Agree ☐ Undecided ☐ Disagree ☐

23 I can understand and act on the information provided by this software.

Agree ☐ Undecided ☐ Disagree ☐

24 This software is awkward when I want to do something which is not standard.

Agree ☐ Undecided ☐ Disagree ☐

25 There is too much to read before you can use the software.

Agree ☐ Undecided ☐ Disagree ☐

26 Tasks can be performed in a straightforward manner using this software.

Agree ☐ Undecided ☐ Disagree ☐

27 Using this software is frustrating.

Agree ☐ Undecided ☐ Disagree ☐

Please continue overleaf

28 The software has helped me overcome any problems I have had in using it.

Agree ☐ Undecided ☐ Disagree ☐

29 The speed of this software is fast enough.

Agree ☐ Undecided ☐ Disagree ☐

30 I keep having to go back to look at the guides.

Agree ☐ Undecided ☐ Disagree ☐

31 It is obvious that user needs have been fully taken into consideration.

Agree ☐ Undecided ☐ Disagree ☐

32 There have been times in using this software when I have felt quite tense.

Agree ☐ Undecided ☐ Disagree ☐

33 The organisation of the menus or information lists seems quite logical.

Agree ☐ Undecided ☐ Disagree ☐

34 The software allows the user to be economic of keystrokes.

Agree ☐ Undecided ☐ Disagree ☐

35 Learning how to use new functions is difficult.

Agree ☐ Undecided ☐ Disagree ☐

36 There are too many steps required to get something to work.

Agree ☐ Undecided ☐ Disagree ☐

37 I think this software has made me have a headache on occasion.

Agree ☐ Undecided ☐ Disagree ☐

38 Error prevention messages are not adequate.

Agree ☐ Undecided ☐ Disagree ☐

39 It is easy to make the software do exactly what you want.

Agree ☐ Undecided ☐ Disagree ☐

Please continue overleaf

40 I will never learn to use all that is offered in this software.

Agree ☐ Undecided ☐ Disagree ☐

41 The software hasn't always done what I was expecting.

Agree ☐ Undecided ☐ Disagree ☐

42 The software has a very attractive presentation.

Agree ☐ Undecided ☐ Disagree ☐

43 Either the amount or quality of the help information varies across the system.

Agree ☐ Undecided ☐ Disagree ☐

44 It is relatively easy to move from one part of a task to another.

Agree ☐ Undecided ☐ Disagree ☐

45 It is easy to forget how to do things with this software.

Agree ☐ Undecided ☐ Disagree ☐

46 This software occasionally behaves in a way which can't be understood.

Agree ☐ Undecided ☐ Disagree ☐

47 This software is really very awkward.

Agree ☐ Undecided ☐ Disagree ☐

48 It is easy to see at a glance what the options are at each stage.

Agree ☐ Undecided ☐ Disagree ☐

49 Getting data files in and out of the system is not easy.

Agree ☐ Undecided ☐ Disagree ☐

50 I have to look for assistance most times when I use this software.

Agree ☐ Undecided ☐ Disagree ☐

***** Check you have ticked each item *****

Please continue overleaf

- **Section 2**

Instructions:

- There are 14 open questions.
- Please answer all of them as fully as possible.

1. What improvements would you like to see in the interface?

____
____
____

2. Were there any button names that were misleading or confusing?

YES / NO ____________ (if yes, please specify name)

3. Is the colour scheme clear?

YES / NO ____________ (if no, please specify alternative scheme)

4. Was the visual feedback as expected?

YES / NO (if no, please specify why)

____
____
____

5. What other visual feedback elements would you like to see?

____
____
____

6. Are there any other "3D style" features that you would like to see?

____
____
____

7. Are there any other "2D style" features that you would like to see?

____
____
____

8. Were there any specific sections that you would like to see improved?

YES / NO (if yes, please specify)

____
____
____

9. Did the interface perform as expected?

YES / NO (if no, please specify why)

____
____
____

Please continue overleaf

10. Do you feel that the interface might enhance task retrieval of information?

YES / NO (if no, please specify why)

____
____
____

11. If you had to rate this test build of software, what percentage would you give it?

    ___ % (please specific a number)

12. Compared to similar systems that you may have used, do you prefer this software?

    YES / NO (please specify why)

    ____
    ____
    ____

13. Did you understand the full purpose of the software?

    YES / NO (if yes, ring the following to what you believe was the intended purpose)

    1 Creation of a new web browser

    2 Make tasks easier to accomplish through better navigation

    3 Analyse multiple session workspaces

    4 Extend web browser functionality

14. Is there any other suggestions or information that you would like to add?

    YES / NO (if yes, please specify)

    ____
    ____
    ____
    ____
    ____
    ____
    ____
    ____
    ____

***** end of questionnaire *****

Appendix 7

Simulation phase case study questionnaires

Organisation's Name:

General

1. Are you a new employee or a long-standing employee of the organisation? ....

2. How long have you been in your **present** job? ....

Confirmation of Current Duties

3. Do you have a duty statement for your job? Yes (please attach) No (Go to Q 6)

4. Are your job information tasks accurately described in the duty statement? Yes (Go to Q 14) No

5.A If no, what extra duties / information tasks do you do that need to be added to your duty statement?

....

....

....

....

5.B What duties / information tasks are no longer part of your job and can be deleted from your duty statement?

....

....

....

....

Job Analysis

6. Describe the information tasks you regularly perform that are critical to carrying out your job effectively (continue on the back if necessary).

....

....

....

....

....

....

7. Describe the types of equipment you are required to use, for example a keyboard, notepad, forms or specific software programmes (continue on the back if necessary).

8. Do you require a high degree of specialist or computing-based knowledge for your job? Yes No

9. How do you work? Please circle

Alone Part of a team Other (specify below)

10. If you work as part of a team, do you perform the same function or different functions from other members of your team?

11. To what extent does your job require you to work closely with other people, such as customers, clients or people in your own organisation? Please circle.

Very little Moderately A lot

12. How much autonomy is there in your job, i.e. to what extent do you decide how to proceed with your work? Please circle.

Very little Moderately A lot

13. How much variety is there in your job, i.e. to what extent do you do different things at work, using several skills and / or talents? Please circle.

Very little Moderately A lot

Task Analysis log

14. In order to better understand your typical job function in comparison with its specific information tasks, please can you complete a log of your typical day at work covering the following categories:

- **Task undertaken** (whether it is paper or an electronic task) e.g. type a client letter and email it to secretary, or fill in form using a pen and take it to postal room
- **Time taken** to undertake task
- **Any reference / resource documents** used at the same time (electronic or paper)
- If an electronic task, **what software packages were used** (Word, Excel, IE6 or other)
- **Is this a repetitive task** (yes / no) **AND** Was the **task completed** (yes / no)
- What are the **communication channels for this task document**?

Appendix 8

Prototype phase industrial feedback

Industrial Feedback

Under Non Disclosure Agreements

"Extremely powerful and valuable product solution which ambitiously could sell in multiple markets" - PocketThis Limited

"Very interested in the innovative visualisation concept and extraction client" - IBM

"We like the visualisation concept and workbench idea ..would be interested to learn of future progress" - GCHQ

"The client XML extraction technology idea has multiple marketable possibilities" - Factiva

"We like the visualistion solution and would be glad to endorse the idea" - Istante Software

"We are very interested in the visualistion side" - Semagix

"We think that the technology has a lot of potential possibilities and are happy to endorse the idea" - Parthenon Computing Ltd

Appendix 9

Prototype phase expert advisor feedback

Profiles

Andrew Ive: Interested in active participation with early stage companies. Specialities in entrepreneurism, team building, alliances, brand development, product development, business models and venture capital.

Andrew Ive has been the CEO/founder of two companies. X-IT Products which was named one of United States' 'Top 10 Start-ups in 1999' by a top Entrepreneurial magazine. X-IT also won a 'Business Week' product design award for its first product sold through international retail companies. Andrew then began a data management company in Silicon Valley. While CEO, Andrew worked with the investor and venture capital community, negotiated partnerships and establishing customer relationships. Andrew has helped a number of entrepreneurs at the early stages such as Blazent Founders (real time IT intelligence) & PocketThis. Andrew has a Harvard Business School MBA and worked with Siebel Systems (USA), Procter & Gamble (Europe) Ltd., and IBM (World Trade Asia). Andrew focused on building businesses, often from the early stages. Currently Andrew is on the Board of the Small Business Council (Department of Trade & Industry); an advisor to an early stage company in the telecom sector and is at the formative stages of developing his third company spanning the business services/hotel sectors.

DTI Council Member - (www.sbs.gov.uk/default.php?page=/sbc/members.php)

X-IT Products - (www.escapeladder.com/article1.htm)

Lawyers Weekly
http://www.lawyersweeklyusa.com/usa/6verdict2001.cfm

Virginia Business, Media General Operations Inc.
http://www.virginiabusiness.com/magazine/yr2002/jun02/mybladder.shtml

LeClair Ryan
http://www.flippindensmore.com/news/technology/10-08-01-1980.html

Inc.com Hot Start-Ups, Gruner + Jahr
http://www.inc.com/magazine/19990701/821.html

John McNulty: For five years now John has been co-founder and CTO of wireless start-up PocketThis, Inc; prior to that was involved for more than year building and launching Microsoft Passport; Passport which was acquired by Microsoft by purchasing Firefly Inc, a Boston, MA startup. John served a dual role as a lead software engineer and as researcher developing collaborative filtering algorithms for Firefly's recommendation products. Prior to that John received his Master's in AI from UMass/Amherst (reinforcement learning subfield of AI), developed sonar signal analysis software and weather forecasting software for The Analytic Sciences Corporation and received by BS from MIT in EE/CS.

PocketThis, Ltd. / Inc (Silicon Valley) - (www.Pocketthis.com)

Meeting Feedback (written via email 06/09/04)

This summarises much of what Mac (John) and I (Andrew) chatted about over the last few days since we met. Let me know what you think.

Positives:

I think David is targeting an important area from a promising angle: the area as, I see it, is a more intelligent collection of tools for accessing information and structuring access to information. Those tools will be more intelligent about the information the user is accesses and the purpose of that access. The promising angle is that the keys to making the tools more intelligent are:

(a) making them silent and comprehensive (they track everything behind the scenes) and
(b) structuring them in accordance with user tasks (for example I might access two documents in a row but each document is part of a separate task)

The value of the tools I believe really comes to the fore on repetitive tasks and interrupted tasks. With repetitive tasks the tools can assist the user shortening the time and effort required to access a given piece of information. With interrupted tasks the user can close a related collection of resources and open them all again as a unit (compare with windows today where I have 20 windows open 5 of which are part of a given task but I have no way to indicate that so that I can close those five together and reopen them all again to resume that task).

The good news and bad news is that this sort of task-oriented organizational metaphor for desktop software is becoming more popular.

Negatives:

While I think the particular UI chosen by such tools will be important, I think it will be based on a more-or-less visual metaphor perhaps 3D and I'm not sure that the UI David has proposed is the final solution.

TBD how big the niche is between fully general operating system and task-specific automation software like that employed in call centres (the task has been automated by developers rather than an intelligent tool).

I think there is a bit of a gap between the potential and the reality of the tools today. This is understandable given the stage of CoreWeb Virtual Gatekeeper. At the same time I think that a concrete demonstration of a common workplace task being significantly improved by the beta version of CoreWeb Virtual Gatekeeper is within reach and in fact would go a long way toward improving David's chances of success.

Summary:

My recommendation at this stage is to demonstrate concretely the application of the ideas and tools David has developed to a common workplace task. Something along the lines of:

- an uninitiated user sits down at a desktop
- the user is given the following task:
- open an existing spreadsheet
- access a first web site and copy and paste an up-to-date stock quote into a specific cell of the spreadsheet
- access a second web site and copy and paste another up-to-date stock quote into another specific cell
- email the spreadsheet as an attachment to a specific email
- following this the tool should either automate or significantly assist the user in repeating the task

- the user should be able to reopen all of the previous documents as a unit
- the user should be able to proceed in as many places as possible by indicating "yes do that again" when prompted something along those lines would indicate that the tools are
    (a) capable of producing real bottom-line value today and
    (b) technically sophisticated enough behind the UI to provide that value with that sort of demonstration in hand I believe David will progress much further and more quickly with investors and customers

Appendix 10

Prototype phase proof of concept report

CoreWeb Technologies

Virtual Gatekeeper

(Subject of UK Patent Application No. 0411938.4)

Software Requirements Specification (Proof of Concept Report)

Author: David Richardson

Date: 24 09 04

Version: Revision 1.7

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1. Target Market

Today, businesses are under pressure from all sides to compete, through the advent of the globalised information economy. Aspects such as cluttered desktops, remote storage repositories, cognitively different file systems, or a multitude of presentation devices are making it increasingly hard to find or locate the necessary knowledge information to undertake a given task. There is a need therefore, to retain information and store it in an easily accessible manner to exploit knowledge as a strategic organisational resource. Today's information workers face several challenges as highlighted in a Gartner Group 2004 report, to finding the right information at the right time. Currently information is stored on multiple systems, requiring duplication of effort to recreate search parameters numerous times and / or with slight differences in the data dimensions.

As reported by CNET on the 31st March 2003, companies are starting to introduce a preference towards better software methods for managing or searching information stored deep within data repositories, as although the hardware is cheap, the work force needed to maintain it is not. The utopian vision is that management applications become so advanced that the software will enable various policies to be set on types of data and will automatically find the appropriate hardware, whilst ensuring that data space is available but, in addition, the data intelligently knows about itself. This problem is growing as it was determined by CNET that corporate storage data needs are growing by 80% a year. In addition, commercial statistics by IBM first reported on 5th December 2002 and later reinforced by a BBC commissioned report by Workshare on the 13th November 2003, suggest that as much as 85% of information currently flowing through organisations is unstructured, providing little or no characteristics that make it searchable.

The essence of the argument is that information workers can often spend inordinate amounts of precious work time, accumulating hours of lost time per year, "hunting and pecking" around, trying to locate their previous or most recent documents, due to a "deluge" of other stored versions, folders, file names or document formats. To compound matters, constant changes to visual interface objects or task system methods, found in areas like operating system environments or software applications, often lead to expensive re-education through training, as these companies alter their products for the sole purpose of extending sales within the product life cycle.

In essence, graphical visualisation, storage and manipulation techniques need to rapidly evolve, due to present-day inadequacies, by structuring or representing data in a more meaningful way to the end-user. Thus, it is apparent, that there is a need for "smart" business interface systems, which intelligently anticipate work behaviour, manage or adapt to the increasing demands placed upon them by today's end-users. Aspects such as providing timely information or at least re-ordering the information visually should now be considered, whilst constantly maintaining a highly ordered structured storage back-end. Indeed, by extending this further, the more work undertaken on such a system, the more accurate the interface or system, through its methods or agents, should become, by providing accurate timely information. Previously visited search patterns, paths or documents could then be used as a foundation template for predicting end-user datasets or task destinations, based solely upon a selected image, file, page link or keyword entry; the interface could then immediately adapt by suggesting feedback or options which an end-user might like to select.

This innovation for making end-users more productive is proposed at a time when research commissioned for the BBC indicates that as much as 90% of finished documents originally started life as something else, and have led to concerns over "hidden" sensitive information being embedded deep within company data files. Any additional "feature" that locates the exact file required or makes transparent any sensitive "hidden" metadata, would increase the information workers productivity levels by eliminating wasted time through reuse of sensitive documents or undertaking erroneous / frequently used data search paths.

To compound this problem further, since this data is stored as miniature icons or lists of files and many documents are opened on screen (presentation layer) together, pertaining to one state in time of a project, how then could an end-user know that these are related documents? One solution, presently used, is to create duplicates of these documents and to place all these into a single folder. This would be highly organised, but exists only with efficient computer end-users, the majority saving a mixed set of documents in one folder and then opening up others in a new folder of documents when required. Difficulties occur if the end-user changes occupation or multiple copies are made at different times, as differing versions in different places. Alternatively, a new person taking over a previous end-user occupation, will need to spend inordinate amounts of time creating a new logical file system that is unique to their own cognitive way of thinking, and even then may not be able to find all the required stored documents related to one single project. It may be possible through understanding the folder name, file name, extension, internal document data or randomly previewing the file required. However, whatever happens, some knowledge about how the original person undertook that project and the thought processes involved (paths that an end-user undertook) would now be lost.

In addition, the speed at which managers are required to make decisions have continued to increase since the advent of computers, leading to a greater dependency on technology to deliver or organise the appropriate volumes of information, allowing more time for higher value tasks. The combined methods and system platform outlined, have been formulated to meet the challenges of keeping pace with these demands and to utilise effectively vast amounts of scalable information to provide a valuable resource for faster and more informed decision-making. In essence this means turning disparately gathered data into actionable information, thereby adding value.

The "Virtual Gatekeeper Activity Centre" monitors and extracts all actionable knowledge value, from clusters of task documents, thereby capturing or discovering any thought processes or patterns which were involved within their creation. Discussions with industry professionals and consultants have highlighted the following target market areas:

- Call centres: cross-selling opportunities (Customer Relationship Management)
- Financial services: auditing and document control
- Police services: document discovery and tracking content
- Defence: reporting and mining data patterns or trends
- Hospital trusts: patient records tracking and retrieval
- Commercial sectors: project management of employees, tasks or documents
- Record Offices: archiving sections of the Internet
- Risk Management: Auditing and tracking decisions

In summary, the business benefits from such a product are clear, in that organisations can:

- Access information patterns more effectively
- Visualise or share large amounts of complex data
- Quickly search or find any information required
- Navigate / interact with the data more effectively
- Recognise / monitor patterns or trends
- Provide a better overall cognitive understanding

2. Features and Capabilities

The system, whilst retaining all spatial relationships, uses a combination of mathematically formulated visual geometry, dynamically generated semi-structured XML and a multi-dimensional OLAP database architecture, for the purpose of tracking, categorising / filtering the required knowledge information into manageable units of data. In addition, functionality through “drill-down”, “drill-across”, “pivot”, “slice”, “dice”, “sort, “filter” and “group” are applied to the multi-dimensional data, enabling pattern discovery, support for decision-making, detailed statistical reports or providing path predictions. These are collectively described as the symbiotic “visualisation” / “storage” methods and serve as the definition for the “Manager” component of the system.

The method for direct extraction and interaction with the task data is defined as the “Client” component. This Client provides an embedded, expandable, set of tools or agents with hooks and / or integrated links, directly into task applications which compress, reformat, dissect or extract all related document content, whether hidden or visible. In addition, more control is provided over data categorisation by facilities to customise or view certain meta content fields. In-session statistics are also collected, with regard to areas such as origin, content, time-frames or whether the data is sensitive or protected.

The following summarises the “Manager” and “Client” feature sets, with reference to the Gartner 2004 report areas, as mentioned in section 1 and then individually describes these in more detail.

Extract

Feature	Manager	Client
Internet Explorer and Office 2003 Integration		✔
Internet Explorer and Office 2003 Extraction tools		✔
Manual tag capture		✔
Commenting, annotations, an sticky notes		✔
Personal video / audio notes		✔
Intelligent cataloguing		✔
Customised extraction filters		
Key content	✔	✔
Archive dynamic / static content		✔
Digital image fingerprinting		✔
Data transparency workbench		✔
Automation macros		✔

Browse

Feature	Manager	Client
3D approach	✔	
Multi-functional tab interface		✔
Tasks document browsing	✔	✔
Dynamic Interface	✔	✔
Document preview	✔	✔
History and item selection	✔	
Always relevant auto update whilst working	✔	✔
Organisational checker	✔	
Rank or flag by relevance or date	✔	
Highlight search results	✔	
Multifunctional containers	✔	
Profile import / export	✔	
Profile management	✔	
Thumbnail previews	✔	✔
Integrated search engine	✔	
Statistical analysis	✔	✔
Device and platform accessibility		
Intelligent categorisation	✔	✔
Stealth monitoring / tracking	✔	✔
Pinning	✔	✔
Activity centre	✔	
Fast switching	✔	✔
Session resumption	✔	✔
Natural input	✔	✔
Key content	✔	✔

Search

Feature	Manager	Client
Fast content searching	✔	
Search memory	✔	
Split second search	✔	
Keyword, Boolean and conceptual search	✔	
Customised extraction filters		✔
Automatically generated result summaries	✔	
Automatic linking and related suggestions	✔	✔
3D visual representation of web searches	✔	
One stop multi-search	✔	✔
Characteristic matches	✔	
Digital fingerprint	✔	

Share

Feature	Manager	Client
Report publishing	✔	
Collaboration tools	✔	✔
Anywhere capture		✔
Collection sharing	✔	
On-the-fly automatic learning and linking	✔	✔
Virtual file system	✔	

Preferences

Feature	Manager	Client
Customisation	✔	✔
Interface templates	✔	✔
Scheduling	✔	
Market extensible		✔

Extension Add-ins

Feature	Manager	Client
Core statistics modules	✔	
Search and scan modules		✔
Popup or virus protection	✔	✔
Extra application integration		✔
Interface templates	✔	✔

2.1 Manager Component

The Manager utilises a structural geometry that is a 3-dimensional ghost projection of the underlying "hidden" 4-dimensional mathematical structure of a "Hypersphere", although it is considered synonymous (topologically equivalent in mathematical terms) to that of a "Hypercube". The geometric structural visualisation provides a means by which interaction can take place within a 3-dimensional *n*-space environment, the statistical results of which can be viewed from within the central core hypersphere.

2.1.1 Prototype Features

The 3D projection provides a structural geometry, that without, would provide no intuitive means by which an end-user could interact with the complex multi-dimensional data and / or levels without getting lost within the complexity of the information. Therefore, everything that an end-user undertakes within the system is based upon the premise that data is being stored within a single central core (hypersphere) that denotes their end-user identity when joining the organisation. This sphere is then segmented into multiple sphere layers and these layers would have an infinite number of multiple cells of multi-dimensional information stored within them. In essence the volume of spatially aware information being stored using such a structure is immense, with the only limits being the constraints of the external physical storage media. Projects when viewed as a 3-dimensional structure, can only been seen as flat layers appearing within 3rd-space. The complexity of the structure is therefore "hidden" from someone viewing it in 3-dimensions as the rest of the structure exists in a 4th "spatial" dimension. The visualisation design then reflects a set of ingenious mathematical transformations based on the topology of the hypersphere / hypercube, in order to provide a means of interaction with this hidden geometric structure.

Thus, the power of the system is the ability to record all spatial relationships and then to provide 3-dimensional mechanisms for interacting with this data. This can be seen in the three key features of the system, the multi-dimensional inner sphere for statistical analysis through data mining, the search or query blocks which represent temporary workspaces (available for the lifetime of a session) and finally the visual history as represented as a "pack of cards" of slice containers.

The slice container history provides a visual means by which multivariate data can be previewed. The interaction can take place by directly moving the mouse over the slice which results in a preview screenshot alongside data which the Client component originally selectively extracted. This animated sequence is consistent with the other levels of the system whereby animation takes place through zooms or rotating of the interface, providing the illusion of "drilling" up or down into the information.

The search interface front-end provides means for previewing basic or advanced filtered queries placed upon the multi-dimensional database. Essentially, key content which is stored in the database is then made available through OLAP queries. These queries can then be used multiple times and are stored alongside the workspaces as temporary search blocks for the lifetime that the end-user is logged into the current project (session). This means that when an end-user undertakes another search, the previous search data is also included, increasing performance or refining search results to the key content required. Should the end-user wish to keep the created search block workspace, then it can be upgraded or promoted to the outer ring, thus becoming a single project workspace. Again, this gives only the very basic functionality of this mechanism, as at a later date aspects such as viewing the original contents around a sorted search slice, will also be available through the same historical interface or “pack of cards”.

The main power behind the system is the direct inclusion of data mining capabilities into the interface. Up until now, data mining technologies have been separated into unique applications from the data, not wholly integrated into a single interface. The central hypersphere core is the place whereby all the “hidden” 4-dimensional data can be analysed. This is deemed a “Statistical Workbench”. In the current iteration most of these features are yet to be included; it is expected that these will cover areas as suggested in section 2.1.3. It must also be noted that the queries will also use the OLAP method of extraction, as it plugs directly into the powerful database backend. In addition statistics will be displayed based upon the dimensional operator levels of the system. Depending upon the role of the end-user, it will provide single end-user or multi-user statistics. It is expected that third party extension technologies will be developed to meet specific markets at which this software will be targeted. However, the visualisation method for interaction with the data will always remain the same.

The system terminology for dimensional operators relates to a single user or project team and are, therefore, as follows: -

- Slice - a single application based task
- Segment - a path history or “room” of related tasks
- Workspace - a named “group” of related task rooms
- Project Suite - a single “project” of related multi-dimensional workspaces
- User Identity - a user “session” of related multi-dimensional project suites
- User Sphere - a Managed team member who belongs to multiple project teams

In essence, the Manager component provides a cognitive mind-map of the documents and / or task data that support specific task related decisions. Individual task documents are therefore saved only once within the system and duplicate usage is provided through instance links. In addition, end-user work areas remain uncluttered through the use of high level hierarchical approaches, which utilise 4-dimensional geometry, where these are defined as dimensional operators. Unlike existing computer based architectures, the system and methods automatically tag, track and update data as required, allowing task documents to be found more easily. Therefore, in addition to its numerous other functions, the visualisation not only provides a dynamic file system, but also anticipates and adjusts to specific system related behaviours, like a dynamic storage repository for document tasks.

2.1.2 Extended Features - Version 1.0

- **Visual Interface** - relates and clusters documents according to a single task (slice), path history (segment), a named task group (workspace), a single multi-dimensional group collection (project suite) and relates to a single user or project team (sphere). Can be customised by adding, deleting, moving, sorting, renaming, swapping or duplicating workspaces, segments or slices.
- **Tasks document browsing**- can be sorted according to specified filtering criteria such as filename, keyword, capacity, file type and file size.
- **Multi-functional interface** - highly customisable, dynamic and purports a task-based approach.
- **3D history and item selection** - makes it easy to find anything already tagged and provides a more intuitive visual result to searches. In addition, it provides the ability for colour coding, adjusting heights or speeds of the interface to provide immediate feedback.
- **Integrated search engine** - provides quick access to searching large amounts of data with an integrated full text search engine that uses exact phrase / full Boolean.
- **Fast content searching** - anything that has been stored, whether an image file name, links, keywords, text, blocks of text or hidden attributes.
- **Search memory** - ability to save visual search results and to customise or promote as a new workspace, with the ability to share with others.
- **Highlight search results** - automatically highlights search keywords in document workspace results when opened in the Client.
- **One stop search** - the search feature will search all publicly available (internal) documents and online documents through traditional online search engines. In addition it searches several search engines at once, as well as organisational repositories of employee knowledge.
- **Split second search** - will provide split second search of privately owned files.
- **Characteristic matches** - provides further suggestive search results based on previous or other uses searches matching the characteristics of your current search.
- **Document preview** - provides the ability to preview comments written for a slice container item. Static or animated screenshots of slice containers enhance memory retention.
- **Virtual file system** - whilst the interface may change, all data is indexed so that anyone can access the data without having to understand the cognitive structure or how a user uniquely tagged the documents. In addition, it stores and manages virtually, any type of document into a searchable database that can be mined for statistical patterns or trends.
- **Animated history** - browse items captured like a “pack of cards”, which slides out a preview of an item which will show as a static or animated preview.
- **Collection sharing** - view documents associated with a single slice by going into the owners’ original workspace and seeing the files linked to it. In addition other associated documents not included in the original search can then be promoted to an end-users’ own workspace including all the link associations. An end-user can share the information once captured, by making slice containers, workspaces or projects publicly available for organisational searches.
- **Dynamic Interface** - in workspace mode inside the Manager, any document can be selected as the host Client document and then the workspace interface will alter so that all associated segment / containers are then linked / filtered to the document. This changes once edit mode is deselected in the Client. Thus, on entry a workspace has a core, but once a host document is selected for editing this core disappears to becoming a primary document preview at the centre of the segments. Once edit mode is turned off the interface readjusts back to a workspace now consisting of segments and a central core.
- **Statistical analysis** - at the workspace or project levels the central core provides statistical analysis of "Client scraped" information. The report complexity will change depending on the authority level of the end-user.

- **Device and platform accessibility** - provides a platform independent interface that will enable easy access with a finger, pointer, stylus or mouse, and does not limit the device screen size used - view items within a single click!
- **Report Publishing** - can be generated with links to slice containers / comments to send team members informing them of useful information / developments. Dynamically generated result summaries and reports are available for printing, if required. Detailed statistical knowledge about performance, time allocation and problematic areas in your work can be identified by managers through "hidden" tracking.
- **Customisation** - bypass the animated sequences or other elements through customising the interface to fit an end-users' needs.
- **Always relevant auto update whilst working** - fast indexing and synchronization with the server database ensures that all organisation information is constantly up-to-date and employees have access to the latest facts. Just-in-time indexing of needed data reduces start-up times, ensuring unimpaired work.
- **Intelligent categorisation** - searched relevant data is always brought to the front, based on specified criteria. Therefore, no longer is data mixed up, but sorted into segments based on file times or keywords.
- **On-the-fly automatic learning and linking** - the more work undertaken by a user the more intelligent the system will get at predicting usage patterns or patterns per document type, based on organisational patterns.
- **Stealth tracking** - can trace patterns between data types, between users or track intrusions back to its source.
- **Digital fingerprint** - search for a fingerprint within image files to see if they were from the same camera, same way processed or have similar data characteristics.
- **Organisational checker** - builds a spell checker and thesaurus based on the words from read / written documents, so that the system learns end-user / organisation grammar for correcting Client documents.
- **Rank or flag by relevance or date** - results to searches can be flagged, or ranked based or specified criteria.
- **Pinning** - pin frequently used containers so that they are not updated, deleted or overwritten.
- **Automatic suggestions** - provide links to frequent paths or on-the-fly linking to relevant document news articles, web site pages research notes and gives predictive suggestions which can be accepted and thereby promoted to a end-users' workspaces.
- **Total integration** - seamless integration with the Client and associated applications, increases scalability, improves workflow and reduces screen clutter.
- **Activity centre** - inductive user interface approach for working with documents. Thus, instead of opening word to write a report, the interface will suggest a template for writing a report and will then open word. Thereby, one screen for a multitude of operations.
- **Profile import / export** - will retain all knowledge value within the organisation, thus if an employee leaves, then their documents and thought processes could easily become another persons' workspace.
- **Synchronisation and backup** - when a new file is added, the interface immediately synchronises with the server so that there is always an automatic backup and data is up-to-date and relevant. If a connection to the server is lost the server records the hardware device hash ID where the fault occurred and the next time an end-user logs in, whether on the same device or elsewhere, it will synchronise that devices data prior to resuming.
- **Preferences** - pre-select the applications that an end-user wishes to use with the system under a preferences tab. This can be changed, but means that only templates which are relevant to an end-users' everyday work are available, thus customising the inductive interface to respond with greater efficiency.
- **Scheduling** - provides the ability to schedule a selection of slice containers for automatic updating.

- **Profile Management** - project managers can organise profiles (edit, rename and delete) of a team of end-users who are associated with their project. A project manager can see a project of workspaces which are the active workspaces of that Users' project. Thus can obtain immediate feedback on project progress or status.

2.1.3 Manager Component: Core Statistics Module (default)

- Classification (classification trees, discriminate analysis, logistic regression, neural networks, naïve bayes, k-nearest neighbours)
- Prediction (multiple linear regression with subset selection, k-nearest neighbours, regression trees, clustering algorithm - predicts a segment path based on workspaces saved)
- Affinity analysis (association rules)
- Data reduction and exploration (principal components, k-means clustering, hierarchical clustering)
- 3-dimensional and 2-dimensional visual data graphical analysis such as chart and report creation exportable to Excel spreadsheets
- Path tracking graphical statistics
- Hierarchical data mining features to enable zooming exactly to the piece of information required
- Mining association rules discovered from multi-dimensional or relational data
- Lift analysis (curve) added to the prediction module
- Behaviour profile of a segment task path e.g. content-category, visitor-category, count, time-span, document type
- Segment task paths compared over time e.g. segment 1 of workspace 4 with segment 14 of workspace 12
- Display document retrieval paths e.g. server node to server node to content server
- Proportion of time spent per document, per day, or a group of project files
- Organise cluttered workspaces into a new organised workspace based on segments, document tasks time, or other factors.
- Buried patterns within databases are found, and reports act on those findings
- Most frequent interaction document items listed
- Click-stream information is available as a history of tasks that a visitor has clicked through (invisible core)
- Per-session, segment, slice, workspace or project suite comparisons of day, week month or year characteristics, such as total time documents viewed
- Efficiency levels, total times, volume of files, total page views, number of visits per month, last visit, etc.
- Document IP address identification to compare server routes
- Capacity stored, duplicate documents, number of documents, unique paths, duplicate trails, auto-tagged paths verses manual-tagged documents
- Workspace, segment and slice access frequencies
- Frequently visited or speed / times to frequently visited documents
- Health summary: monthly health report, top five causes for problems, desktop stats (connection rates, speed, CPU load, call failure rate), server statistics (retrieval time, page size, load level, delay, speed, access errors, timeout errors, HTTP errors) Internet (delay, speed, traffic level), Intranet (delay, speed, traffic level), service usage (times of day by usage in megabytes) service failures (times of day by network / calls / DNS), traffic report by day (Intranet, server, network)
- Online document visual node paths

2.2 Client Component

The Client provides an embedded, expandable, set of tools or agents with hooks and / or integrated links directly into task applications which compress, reformat, dissect or extract all related document content, whether hidden or visible. In addition, more control is provided over data categorisation by facilities to customise or to view certain meta-content fields. In-session statistics are also collected, with regard to areas such as origin, content, time-frames or whether the data is sensitive or protected.

2.2.1 Prototype Features

Currently, the Client has been implemented inside a Web browser which provides a traditional viewing panel, as well as a panel termed “Workbench”. Aspects such as favourites have been removed and replaced with a “Manual Tag” and “Tag History” options, whilst unwanted screen controls can easily be removed through the “Full screen” option. On the surface this looks similar to a traditional Web browser; however, the power really is apparent when a Web page is viewed. Once an end-user selects a Web page, all data about that page is then “scraped” out of it using methods built into the streams connected with the Manager. This data is then displayed in the Workbench panel and includes aspects such as the number of page links, the Internet Protocol address of the server it came from and vital meta-data information. Also a unique hash identity is given to the page container upon loading to stop duplication of content.

What an end-user does not see is that a “hidden” log is made of every page that is visited alongside spatial and selected information about it. This goes towards prohibited content analysis. This log is created as an XML file and is synchronised with the database using a Web Service through the “Search and Scan” module (2.2.3). Otherwise, an end-user would never know that this document was being recorded. These statistics go beyond simply watching for prohibited content, but enable the system to cleverly predict options or locations that an end-user might like to take. If an end-user wants to bookmark a page for off-line inclusion inside the Manager, then they simply click “Manual Tag”. At this point two things happen; first, a stream collects all vital information from the Workbench and records this to a local XML index file using a schema. Second, text content is processed into keywords, body text, and a description regarding the content. If an end-user provides custom comments about the slice container, then this would additionally be saved. Lastly, when these streams are done, a screenshot of the page at the time of saving is made, as well as a copy of the document as a compound MHT file or in its original format, should the options be selected. These files are retained on the hard disk until the end-user closes the Client and returns to the Manager “history” interface. When this happens, the data is synchronised with the database using the Search and Scan module, as used previously for the “hidden” log file. Depending upon file size, MHT files or backup documents are synchronised with a content management server, and index / content XML files have their data extracted into the separate server database fields. When this data is needed again, the XML is generated and the content files are pulled back as packets off the content server.

It is anticipated in the future that these features will be reengineered and extended (2.2.2), to include more sophisticated tools / hooks which exist as controls or tool bars embedded inside desktop related applications.

2.2.2 Extended Features - Version 1.0

- **Two modes** - toggle easily between a “viewer” and an “extraction / edit” mode. The editor mode provides the means whereby a document can be changed by the child application, but in addition can be linked to other resource documents. The viewer mode provides data capture / extraction tools and collaborative features.
- **Integration** - integrates with Microsoft Office 2003 / Internet Explorer 6 or above as embedded toolbars and / or by nesting the application.
- **Multiple formats** - can extract and index Web pages, Word documents, PowerPoint presentations, Excel worksheets, Adobe Acrobat documents, HTML pages, Text documents.

- **Manual tag capture** - a “single click” manual tag button enables capture of content from any single document being browsed. Alternatively, it can enable the capture of multiple page levels if an option is selected and it identifies the file as a web linked document.
- **Extraction (Web)** - extract hidden attribute information such as source code, title of document, number of images, number of links, original size (KB), last created, last modified, primary host domain, code responses, primary IP address, packet data, cookie data, image names, all links, all text, URL address, document title, time spent on page, document type, prohibited page (yes/no), number of times previously viewed, category, keywords, description, user comments, picture preview (JPG), whether the original file is stored (yes/no).
- **Extraction (Office Suite)** - extract hidden attribute information such as version number (times accessed dependent), title, subject, author, manager, company, document type, category, keywords, all links, all text, comments, picture preview (JPG), modified (date/time), size (KB), attributes (if any), time created and whether the original file is stored (yes/no).
- **Archive all content** - saves dynamic content (asp / jsp) and static content (html / doc). Will convert all text to XML and images to binary strings for transfer to the central Manager / database.
- **Single file storage** - can compress and convert all electronic documents into formats such as compound MHT files.
- **Dynamic interface user filtering** - add custom fields which can be searched at a later date, but provide optional flags to make certain content private / non-searchable.
- **Digital fingerprinting** - scan header signatures of image files (JPG) for unique attributes and records all data.
- **Customised extraction** - extract only specified information from electronic documents.
- **Intelligent cataloguing** - categorise and indexes documents based on content and automatically creates searchable keywords.
- **Data transparency** - view all extracted data as a “workbench” panel behind the viewed document.
- **Dynamic linking** - select an element like an image or block of text and to then import then into a editable destination document location, whilst retaining all links to the original parent document - a flag can be clicked in the destination document which provides immediate “one click” entry back to the original parent resource.
- **Ease of viewing** - scroll through workbench content using a gallery for images, statistics / graphs and text content boxes.
- **Commenting, annotations or sticky notes** - add custom comment notes to auto extracted content within the workbench so as to record reasons why it was captured or simply to summarize.
- **Predictor** - can predict user paths based on previous usage or similar users recorded in the system, which used the same path before e.g. node diagram or prompted suggestions.
- **Second guessing** - intelligently preloads or “caches” future documents whilst monitoring or utilizing system memory to maximize performance in respect to anticipated usage patterns.
- **Flexibility tools** - tag text / screenshots by entire screen, a specified region or a scrolling region.
- **Multi-functional tab interface** - open multiple links through select highlighting and then to open each of these as potential tabbed windows - each having their own workbench.
- **Stealth tracking** - silently tracks, monitors and extracts authority level specific data from every viewed document, whether tagged or not.
- **Visual history** - tight integration with “Manager” to provide a “visual” 3D tag history.
- **Personal Video notes** - record a video sequence of entire screen or region showing a path visited, links clicked or a collaborative discussion, which can then be named and further comments added.
- **Personal Audio notes** - record audio notes which can then be attached to a single element or an entire document of elements and further comments added.

- **Automation** - record named macros of frequently undertaken child application tasks and to save these as a library of action operations. These "actions" can then be shared with other users.
- **Collaboration** - share client tab screens with multi-users, with the ability to edit / tag content at the same time through toggling modes or exchanging text messages in real time. When two or more people are viewing the same document, icons are displayed inviting them to conference.
- **Fast switching** - minimise the client to the system tray, whereby all tab windows associated with a single segment are then visible through a "right-click" popup menu.
- **Session resumption** - resume all client tab windows within one click from opening the "Manager".
- **Natural input** - supports natural "stylus" device input if using a Pocket / Tablet PC.
- **Thumbnail previews** - provide mini, zoomable, size or resolution adjustable previews, of all open client screens. The number of previews is dependent upon the "Manager" allocation of slice slots. All thumbnails enlarge slightly when rolled over. When viewing content as a thumbnail previews, the same tag operations are available. Thus, each thumbnail displays a red boarder to show if the slice slot container is filled or a grey boarder if it is untagged.
- **Multifunctional containers** - group / or group link tab windows under a specified container name, known as a slice. If multiple tab windows are selected and have a container name, then a mini animated preview of all window previews is displayed as the container in the Manager.
- **Customisable** - ability for a user to customise what is auto-extracted and the layout of the workbench including the look and feel through "skins" and / or adding corporate identity materials.
- **Market extensible** - customise the workbench for pre-selected markets e.g. workbench layout templates, third party extensions or additional application support.
- **Protection** - popup blocking of unwanted online content, virus checking as the document is processed, but with the option for allowing certain access if required.
- **Key content** - provide "spotlight style" content regions by annotating items with smart tag comments, colour highlighting, priority / linking flags or by dimming all parts of the document except the selected region of interest.
- **Best guess** - auto-complete functionality applied on all workbench fields, thereby providing appropriate suggestions.

2.2.3 Client Component: Search and Scan module (default)

- Agent based upon the functionality used within search engines
- Scans documents for title, address, keywords and other related information
- "Search and Scan" can be invoked after a specified amount of time and can be customised
- Filters and finds common data paths / patterns based on item characteristics
- Artificial Intelligence profiles organiser (automatic filtering of most frequently accessed paths / documents by count / type / name)
- Average document views to accomplish or to obtain desired information
- Finds target paths for certain filtering variables
- Like Minds - the emphasis of automatic real-time selection of suggested items
- Text analysis - associating words and context with high-level concepts such as prohibited flagged pages
- Documents that have been tagged by a human with the relevant concepts - the system then builds a pattern matcher for each concept. When presented with a new document, the pattern matcher decides how strongly the document relates to the concept
- Sorts incoming documents into predefined categories
- Automatic summaries of key points, and cross-references documents to related material
- Finds new documents that contain words and context also contained in articles which have been read before in previous workspaces or segments e.g. finds a similar document to the one selected if publicly available

- Search and scan algorithms are used to perform estimation and prediction
- A decision tree is created that is essentially a flow chart of data points that ultimately lead to a required decision, by trying to create optimized paths, ordering the questions so a decision can be made in the least number of steps
- Sorting scenarios based on user profile algorithms

2.3.4 Manager / Client Components and Database Rights / Privileges

Given below is an example of these policies. It is anticipated that these will be adapted or extended when dealing with various task specific scenarios.

1 x Administrator: -
ability to assign Team or User specific policies or privileges
ability to view advanced level statistics and / or reports
ability to view, modify, assign or delete Project Managers access
ability to view, modify, assign or delete Project Analysts access
ability to view, modify, delete User “hidden” log files
ability to view, assign, modify, or remove Team Users’ access
ability to view, modify, create or delete Users’ access
ability to search, link, delete or promote public / private slices
can override / reassign all security privileges or access rights
ability to assign private security privileges, access rights
unilateral control over the whole system

3 x Analysts: -
ability to view high level statistics and/or reports
ability to view, modify, delete User “hidden” log files
ability to search, link, delete or promote public / private slices
can override / reassign all security privileges or access rights
ability to assign private security privileges, access rights
ability to assign private security privileges, access rights
ability to view, add, delete, modify project suites
ability to view, add, delete, modify workspaces
ability to view, add, delete, modify segments
ability to view, add, delete, modify slices

* x Project Managers:-
ability to view medium or level specific statistics and/or reports
ability to view, User “hidden” log files
ability to view, assign, modify, or remove Team Users access
ability to assign Team or User specific policies or privileges
ability to search, link, edit or promote Team User workspaces
ability to search, link, edit or promote Team User segments
ability to search, link, edit or promote Team User slices
can override / reassign all security privileges or access rights
ability to assign private security privileges, access rights
ability to view, add, delete, modify project suites
ability to view, add, delete, modify workspaces
ability to view, add, delete, modify segments
ability to view, add, delete, modify slices

* x Users:-
ability to view level specific statistics and/or reports
ability to search, link and promote a public slice
ability to search, link, edit or promote privately owned slices
ability to assign security privileges, access rights on project suites
ability to assign security privileges, access rights on workspaces
ability to assign security privileges, access rights on segments
ability to assign security privileges, access rights on slices
ability to view, add, delete, modify project suites
ability to view, add, delete, modify workspaces
ability to view, add, delete, modify segments
ability to view, add, delete, modify slices

3. Business Process Description

The Business Process Description is described according to the key technology areas identified by the Gartner group in 2004.

3.1 Introduction

The only software systems in pace with information generation is the capacity of technology to store - a powerful fact that is central to the strategy of Virtual Gatekeeper. The retention and storage of data, in an easily accessible manner, positions Virtual Gatekeeper for wide market penetration across markets, industries and applications.

3.2 Structure & Navigate

Users agonise over their inability to prevent file systems spiralling into chaos. By incorporating consistent data management technologies across the enterprise and organisation, employees and ultimately customers benefit. Administrators can monitor information flow within the organisation, production managers can use this to analyse and compare team and individual employee productivity. At board level, information pathways can be expressed as spider graphs utilising the statistical core. Directors can use the informal structure for more intuitive restructuring, in contrast to decisions based on impressions and a published formal organisational structure.

3.3 Search & Retrieve

The concept of Virtual Gatekeeper is built on the synergetic relationship between search and data mining technologies, delivering information to the desktop. The search function is the main feature of Virtual Gatekeeper - users interact with the data using the search function, instead of manually browsing through folders and sub folders to find the right document.

Graphical visualisation of storage and manipulation techniques presents information in a more meaningful way. Doctors on ward duty can access patient records on hand held devices not restricted by miniature icons dictated by classic 2D windows environments. A finger or stylus is sufficient to initiate search, with routine command actions being predicted from previously visited documents, dynamically formulating a foundation or template.

3.4 Dispersal

The dispersal of information across the organisation is essential, but not necessarily for the personal motives of individual employees. For example, solicitors are employed for a specific expertise. Recording how a solicitor sources and delivers information is part way to accessing information previously made impossible to access, formally residing in their head.

The same is true for sales representative who protect information to benefit their own agenda and targets, sometimes at the cost of another sales person or by missing an opportunity for cross selling.

3.5 Share & Collaborate

Document sharing needs to be managed with mechanisms in place for preventing mistakes. Organisations reproduce documents, people will ‘dust down’ former proposals and provide standard pricing documents created from existing templates. If saved incorrectly, confidentiality is compromised, for example, when differentiated pricing is revealed to customers and Police authorities inadvertently provide information on witness locations.

Administrators can monitor information flow within the organisation, production managers can use this to analyse and compare team and individual employee productivity. At board level information pathways can be expressed as spider graphs utilising the core. Directors can use the informal structure for more intuitive restructuring, in contrast to decisions based on impressions and a published formal organisational structure.

3.6 User Case 1: NHS Doctor

3.6.1 Current Problem

- Ward round:

  - write blood test results from preceding day into medical notes.
  - write any radiological tests reported on from previous day in medical notes.
  - review each patient under consultant's care: documenting patient' health, any examination finding, observations e.g. blood pressure, temperature, management plan
  - request any additional tests required.
  - chase outstanding investigations / results.
  - rewrite expired drug charts (often disappear to the black hole known as pharmacy)
  - review any patients deteriorating during the day.
  - writing initial discharge summary - brief diagnosis, investigations, follow-up with consultant and list of medication. Duplicate document to pharmacy for medication to be issued.

- Other Tasks (depending on whether clinic days or have free time):

  - Clinic (usually twice a week)

    - reviewing patients or clerking newly referred patients.
    - document discussion and management plan in medical notes.
    - request investigations.
    - dictate letter to GP regarding consultation and letters to any consultants referred to for advice/opinion.

  - Discharge summaries

    - dictate letter to GP on any discharged patients regarding hospital stay.
    - letter then typed by secretary and has to be signed by doctor and duplicate saved.

- Oncall:

  1. 9am-5pm: receiving medical referrals from A&E doctors. Involves taking a history and examining patient, reviewing x-rays and ECGs, documenting these in notes, documenting blood test results in notes and management plan, requesting any additional investigations, writing drug chart. Not to mention trying to see pre-existing patients on the ward
  2. 5pm-10pm: post-take ward round of any admitted patients (see above ward round for tasks), reviewing sick patients, x-rays, ECGs and blood test results on wards and documenting in notes, rewriting drug charts, prescribing medication, requesting investigations, attending cardiac arrests

- Requesting investigations

  - hand written forms for all investigations
  - then hand delivered by doctor/nursing staff/ward clerk to department (except blood test results)
  - reviewed by department
  - date awaited for requested test
  - test performed then have to wait for formal report to appear on computer
  - referrals faxed to consultants secretary

- Current computer programmes

  - internet based site very slow, but available to GPs.
  - prints ward lists and consultants patients lists.
  - access results for all investigations (dependant on waiting for report to be inputted).
  - access patient's details including previous admissions, GP details, outpatient appointments.

3.6.2 Virtual Gatekeeper Solution

- All information is stored in a central hospital database repository which is automatically updated and accessed as and when information is required.
- A hospital doctor can access the repository from home using their office computer with an installed copy of Virtual Gatekeeper.
- The doctor can then organise their patients for the forthcoming day by searching for the IDs of the patients and creating a workspace customised to each ward. Thus, the ward is the workspace and the segments are the patients.
- The segment will then contain a history of all interactions with that patient, which could be shared documents with multiple doctor workspaces. Thus, if a patient record is edited, it is then promoted to that doctors' workspace, including all document links such as x-rays, prescriptions and notes.
- Once the workspace is then built, the doctor can then access the 3D structure on there PocketPC device, using a stylus or finger. If they are on a ward round then they could even colour code these to make things even faster.
- On an interaction with a patient the doctor puts their finger to the appropriate segment on their Pocket PC, and opens up the "pack of cards" of documents. Once open they can create a new document or open, read and edit a previously recorded record.
- In this case the doctor wants to have an interaction with a patient, so selects a template for an interaction. Virtual Gatekeeper will then replace the Manager with the Client which will embed the appropriate application with the correct template inside.
- All the doctor has to do is naturally write on notes on the Pocket PC screen, and these will be translated into typed notes in the template boxes. Once the document is complete i.e. the interaction with the patient is finished, all data, such as drugs, and prescriptions raised, are automatically requested to the relevant department.
- Virtual Gatekeeper upon closing the Client will automatically and silently synchronise with the hospital server, flagging actions needing to be addressed, such as sending a template requisition for a prescription, or sending links to the relevant department. Whilst this is happening the doctor can continue their ward round as all this would occur in the background, not interfering with the tasks they are doing.
- When the doctor gets home they can access the days ward rounds and can then look at statistics on the patients from the core of the workspace. They could search for drug rates compared to how successful they were with similar patients, or see how responsive the pharmacy was in receiving prescriptions to processing them. Alternatively, Virtual Gatekeeper could suggest similar drugs with better response rates, or show them based on cost. Thus a report could then be printed and allow the doctor to make high value judgements based on both the hospital and patients health interests.
- In regards to managers, they could then see how long doctors took on their ward rounds, or see if patient beds were being economically utilised. Also, problems bad decisions could be recognised early, such as a drug causing harm or frequent accidents.

3.7 User Case 2: Police Officer - Illicit Material Division

3.7.1 Current Problem

At the moment when analysing Web sites which contain prohibited or illicit material of a criminal nature, the police has officers who painstakingly write reports / fill in forms, about the images, content, access methods and how it is displayed amongst many other aspects. These have traditionally been written down on paper-based forms, which are then transcribed at a later date. These officers normally need to take extended leave every few weeks due to the nature of the material which they are exposed to. In addition the Internet is dynamic, so the content might change the next day, or routes to accessing it are switched. Thus, a previous days report becomes ephemeral as it bares little relation to the new updated Web site.

3.7.2 Virtual Gatekeeper Solution

- All information is stored in a central division database repository which is automatically updated and accessed as and when information is required.
- Virtual Gatekeeper is installed on a Police Officers' PC as a means of extracting custom template information in one selection.
- The template used is custom built by CoreWeb Technologies and provides a Client workbench that extracts into the fields, the information normally written into the Web site reports. In addition, it analyses the image headers for comparison information, such as whether it lists the camera which the image was taken from, whether all images are of similar resolution or naming conventions, as well as other digital fingerprinting aspects. It then takes a copy of the entire page or Web site in one click and stores it as an animated slice in the Manager, whereby a preview are the pages.
- This process reduces the time that a Police Officer is exposed to the material and provides detailed categorisation of the content. In addition, similarities between content, authors or other aspects like images, can immediately be discovered. Thus, if the site changes, the original layout and content will still be stored as evidence, including its hidden origins like IP address or the server.
- The Officer can then extract reports from the Manager central core in response to specific filtered queries. Alternatively, the content could be catalogued as workspaces of suspected crime rings who constantly write the illicit materials.
- Also, once the site is stored, using the synchronisation features, the site address or links could be constantly monitored, thus updating if certain content changes.

3.8 User Case 3: Project Manger, Lawyer or Government Employee

3.7.1 Current Problem

Whenever a person in an organisation undertakes writing a document, such as a report, they may go through several iterations of the document. This leads to several versions of the document being saved as a single file or as multiple files. Often when updates are made the last available document is located and then work is undertaken. When two or more individuals are working on the same document, there is a need to share or swap versions of the document. This leads to expensive server based solutions, whereby the file is saved on the hard disk of the users' machine and then copied to a server based solution. The difficulties arise if two people work at the same time on the document and make different changes. Thus, discovering which document is newer is always a problem. Also aspects such as origins of supporting materials are also a problem. Often the main report is shared, but the research and materials pertaining to that section often reside on the originators computer. Thus, it is hard to see where some conclusions came from, without some type of reference. Even then, some thought processes might not entirely be recorded. In addition, when working with multiple research documents at once, the screen can get cluttered, leading to "switching" between documents in order to refer to an element paragraph. Lastly, some resource documents by virtue of them being on the Internet, might disappear or be updated. Thus, it is hard to find what resource elements were used where and when.

3.7.2 Virtual Gatekeeper Solution

- All information is stored in a central organisation database repository which is automatically updated and accessed as and when information is required.
- When an project manager, or employee wants to create a documents that has significant knowledge value, they create a workspace for that purpose.
- The workspace will initially have a central core and several segments, which could be colour coded or named according to their purpose.
- The employee then selects a template document for the workspace, such as an annual report from the interface menu, and accordingly the interface adapts itself so that the core disappears and the template document icon / graphic sits at the centre of the workspace. The document is then automatically put edit mode.
- If the employee clicks on the template graphic then the Client will open up in edit mode and with word nested inside it.
- The employee can use the system tray icon to jump back to the workspace or open up tabs that correspond to segments in the workspace or further containers in a single segment. When a segment tab is opened, it opens another Client workbench instance of say a Web page at the same time. This Web page could be an Intranet document that has a paragraph required or perhaps an image or logo.
- The employee can select the item by highlighting it with the mouse - drawing a transparent square over the item. At this point the rest of the document darkens so that only the elements selected are bright.
- The employee can then tab to the host report document and then select where the content will go and either right click and send it to the document. Alternatively, they can go back to the Web page and right click the selection and send to the host report document. At this point the content appears in the report and a flag appears which holds a shortcut link to the original content.
- Therefore the report will contain flags to multiple files as links. However, if the document is printed, these links are invisible.
- Once the employee has finished the report or saves it for the day, they deselect edit mode in the Client, and the interface readapts back to that of the original workspace, showing the segments and core. In other words, whenever a document is selected for edit, the interface goes into a temporary edit mode, showing linked documents off a central document like that of a spider web. Should another segment document be edited, so that document would then be processed in a similar way.
- Thus, with each new saved version becomes a slice container inside a segment and each container could be edited or viewed.
- If the employee then searches for some new content, the search will look at organisational cached information first and then multiple Internet based sources second. Matches are displayed as temporary search block workspaces. Upon selection a workspace appears whereby segments are intelligently categorised based on their content.
- If there is an element in this workspace that an employee wants as a new source for their work, this document can then be promoted, including its entire links to the new workspace.
- Alternatively, if this document selected was the wrong version, but the right content, they can then view the owners workspace associated with this in a view mode. Should they select or want to edit, it will then be automatically transferred to their workspace. At the same time the owner’s workspace registers it as being sourced.

4. Competitors and Similar Commercial Products

Whilst the following examples could be considered viable competing products, Virtual Gatekeeper provides features, previously found in specialised tools, which target a multitude of industry sectors (see section 1) through combining key concepts into a single unified platform. Therefore, these examples are listed according to their strength within their respective niche markets. They should not be viewed as an exhaustive list, but as suggested technologies from the markets that Virtual Gatekeeper could potentially slot into or dominate. Unlike all these examples or similar technologies based upon these, Virtual Gatekeepers' integration across the board provides a more attractive option for organisations as a one-stop all-inclusive solution.

Accordingly, the analysis provided shows how important these products are in comparison to Virtual Gatekeepers' features. Thus, as mentioned previously, the new niche market for Virtual Gatekeeper is its cross market applications, by combining normally specialised or disparate solutions into a single Knowledge Management Activity Centre product.

Product: Notes 7
Details: Collaborative database / email system.
Price: Domino Server ($1753), Client ($73)
Company: Lotus (IBM Corporation)
URL: http://www.lotus.com/lotus/
Analysis: Medium level threat assessment
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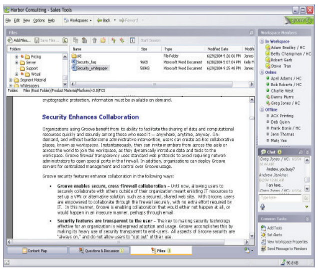
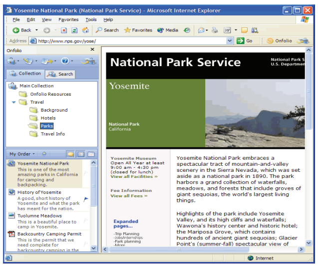
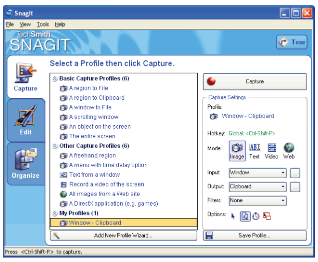


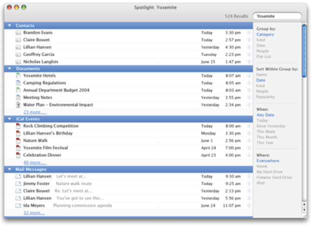
Product: Groove Virtual Office
Details: Share information, manage projects and conduct meetings.
Price: Project Edition ($229), Professional Edition ($179) File Sharing Edition ($69)
Company: Groove Networks
URL: http://www.groove.net
Analysis: Medium level threat assessment



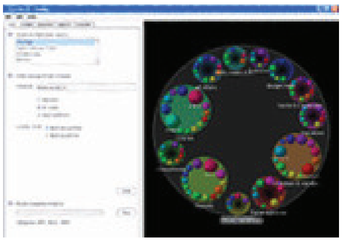
Product: Onfolio 1.03 Professional
Details: Captures a wide range of content including links, text snippets, images, web pages, and documents. It includes a catatalogue organiser.
Price: $99.95
Company: Onfolio, Inc.
URL: http://www.onfolio.com/
Analysis: Medium level threat assessment



Product: Snagit 7.1
Details: Captures a wide range of content including links, text snippets, images, web pages, and documents.
Price: $39.95 & Contact Us
Company: Techsmith, Inc.
URL: http://www.techsmith.com
Analysis: Medium level threat assessment

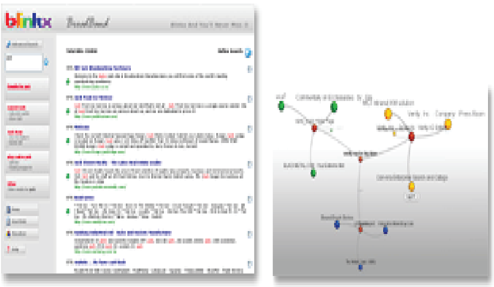


Product: MacOS X Tiger: Spotlight
Details: Lightening fast intelligent search engine based on metadata.
Price: Under Development
Company: Apple Computer, Inc.
URL: http://www.apple.com
Analysis: Low level threat assessment



Product: Groker 2.1
Details: Organises visually and web searches top search engines.
Price: $49.00 & Contact Us
Company: Groxis Inc.
URL: http://www.groxis.com/
Analysis: Low level threat assessment

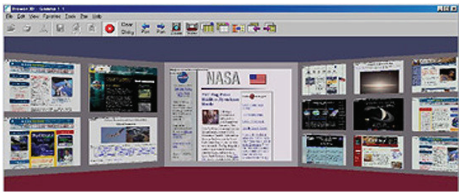
Product: Google Desktop Search
Details: search the full text of your email, files, viewed web pages, and chats.
Price: Under Development
Company: Google, Inc.
URL: http://desktop.google.com
Analysis: Low level threat assessment



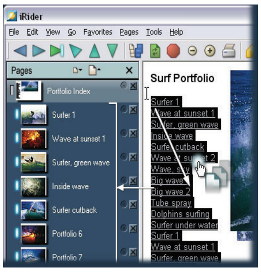
Product: Blinkx 2.0
Details: Finds web pages, news articles and documents related to content of an active window. Actively search web pages, news articles and documents on your machine that are related to a query you enter.
Price: Under Development
Company: Blinkx, Ltd.
URL: http://www2.blinkx.com/
Analysis: Low level threat assessment

Product: A9
Details: Virtual access to bookmarks, search results, your history and diary entries as well as custom searches.
Price: Under Development
Company: Amazon.com
URL: http://a9.com
Analysis: Low level threat assessment

Product: CubicEye Viewer
Details: Web Browser that lets your preview multiple pages at once.
Price: $19.95 approx & Contact Us
Company: 2ce, Inc.
URL: http://www.2ce.com/
Analysis: Low level threat assessment



Product: Browse3D 2.5
Details: Web Browser that lets your preview multiple pages at once.
Price: $29.95
Company: Browse 3D Corporation
URL: http://www.browse3d.com/
Analysis: Low level threat assessment



Product: Irider 2.1
Details: Web Browser that lets your preview multiple links or pages at once as well as pin them or save collections of linked pages.
Price: Under Development
Company: Wymea Bay
URL: http://www.irider.com
Analysis: Low level threat assessment

5. Feature Comparison Guide

To illustrate the power of Virtual Gatekeeper as an Activity Centre solution, below is a comparison of a selection of competing technologies (section 4) and shows how they compare against the Virtual Gatekeeper suggested feature set (section 2).

Extract

Virtual Gatekeeper	Onfolio	SnagIt	Blinkx	A9	Irider
Internet Explorer and Office 2003 Integration	✔	✔	IE6	IE6	IE6
Internet Explorer and Office 2003 Extraction tools	✔	✔			
Manual tag capture	✔	✔			
Commenting, annotations, an sticky notes	✔	✔		✔	
Personal video / audio notes		✔			
Intelligent cataloguing					
Customised extraction filters					
Key content	✔	✔			
Archive dynamic / static content	✔	✔			
Digital image fingerprinting					
Data transparency workbench					
Automation macros					

Browse

Virtual Gatekeeper	Onfolio	SnagIt	Blinkx	A9	Irider
3D approach					
Multi-functional tab interface					✔
Tasks document browsing	✔	✔	✔	✔	✔
Dynamic Interface					
Document preview					✔
History and item selection	✔		✔	✔	✔
Always relevant auto update whilst working			✔	✔	✔
Organisational checker					
Rank or flag by relevance or date	✔		✔		
Highlight search results			✔	✔	✔

Multifunctional containers					
Profile import / export	✔	✔	✔	✔	✔
Profile management	✔	✔		✔	
Thumbnail previews					✔
Integrated search engine			✔	✔	✔
Statistical analysis					
Device and platform accessibility					
Intelligent categorisation	✔		✔	✔	
Stealth monitoring / tracking				✔	
Pinning	✔				✔
Activity centre					
Fast switching	✔			✔	✔
Session resumption	✔			✔	
Natural input					
Key content	✔	✔			

Search

Virtual Gatekeeper	Onfolio	SnagIt	Blinkx	A9	Irider
Fast content searching			✔		
Search memory			✔	✔	
Split second search			✔	✔	
Keyword, Boolean and conceptual search			✔	✔	
Customised extraction filters			✔		
Automatically generated result summaries			✔	✔	
Automatic linking and related suggestions			✔	✔	
3D visual representation of web searches			✔	✔	
One stop multi-search			✔	✔	✔
Characteristic matches			✔		
Digital fingerprint					

Share

Virtual Gatekeeper	Onfolio	SnagIt	Blinkx	A9	Irider
Report publishing	✔		✔		
Collaboration tools	✔	✔			✔
Anywhere capture	✔			✔	✔
Collection sharing	✔				
On-the-fly automatic learning and linking			✔	✔	
Virtual file system	✔				✔

Preferences

Virtual Gatekeeper	Onfolio	SnagIt	Blinkx	A9	Irider
Customisation	✔	✔			✔
Interface templates					
Scheduling		✔			✔
Market extensible					

Extension Add-ins

Virtual Gatekeeper	Onfolio	SnagIt	Blinkx	A9	Irider
Core statistics modules					
Search and scan modules					
Popup & virus protection					POPUP
Extra application integration		✔			
Interface templates					

Feature Totals

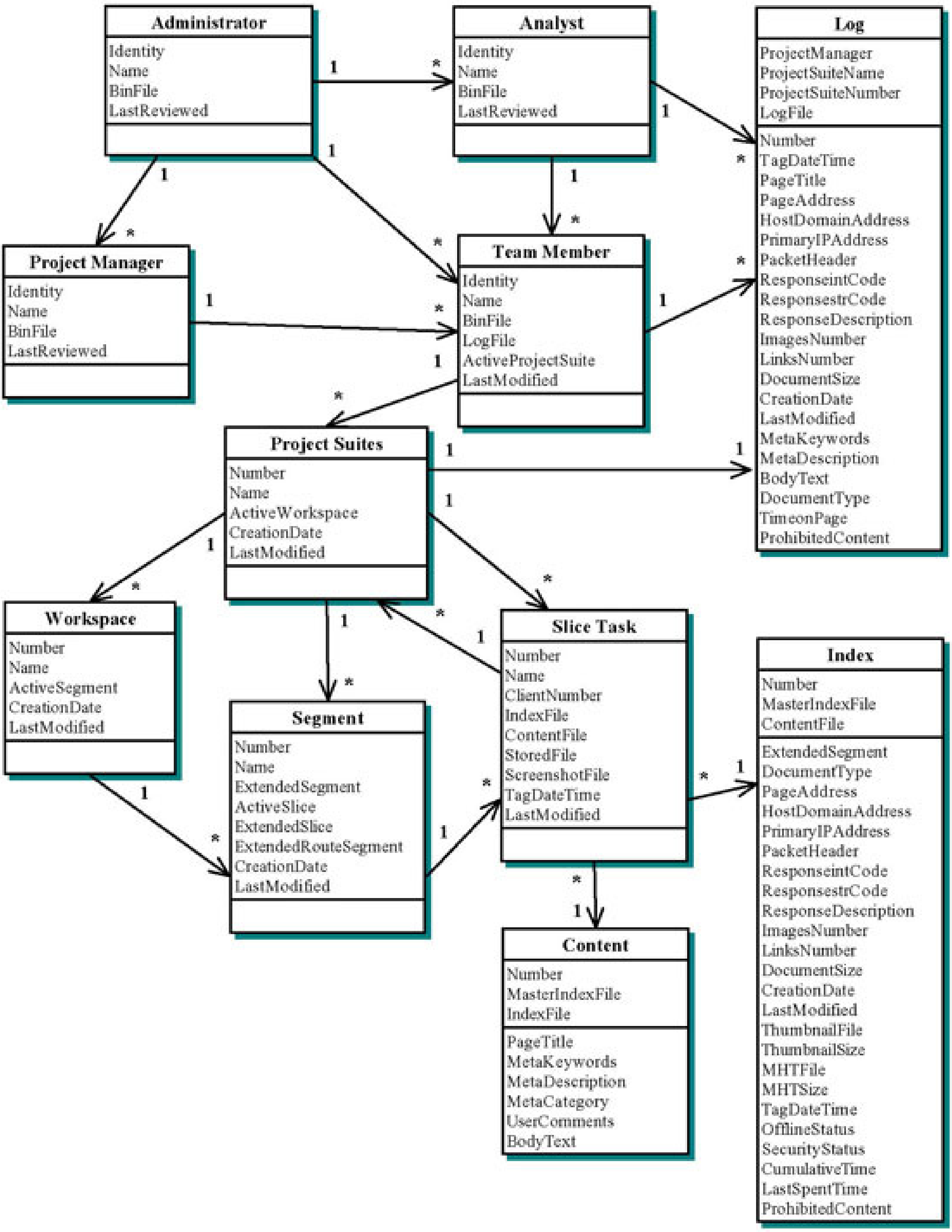
63	22	15	21	22	18

Appendix 11

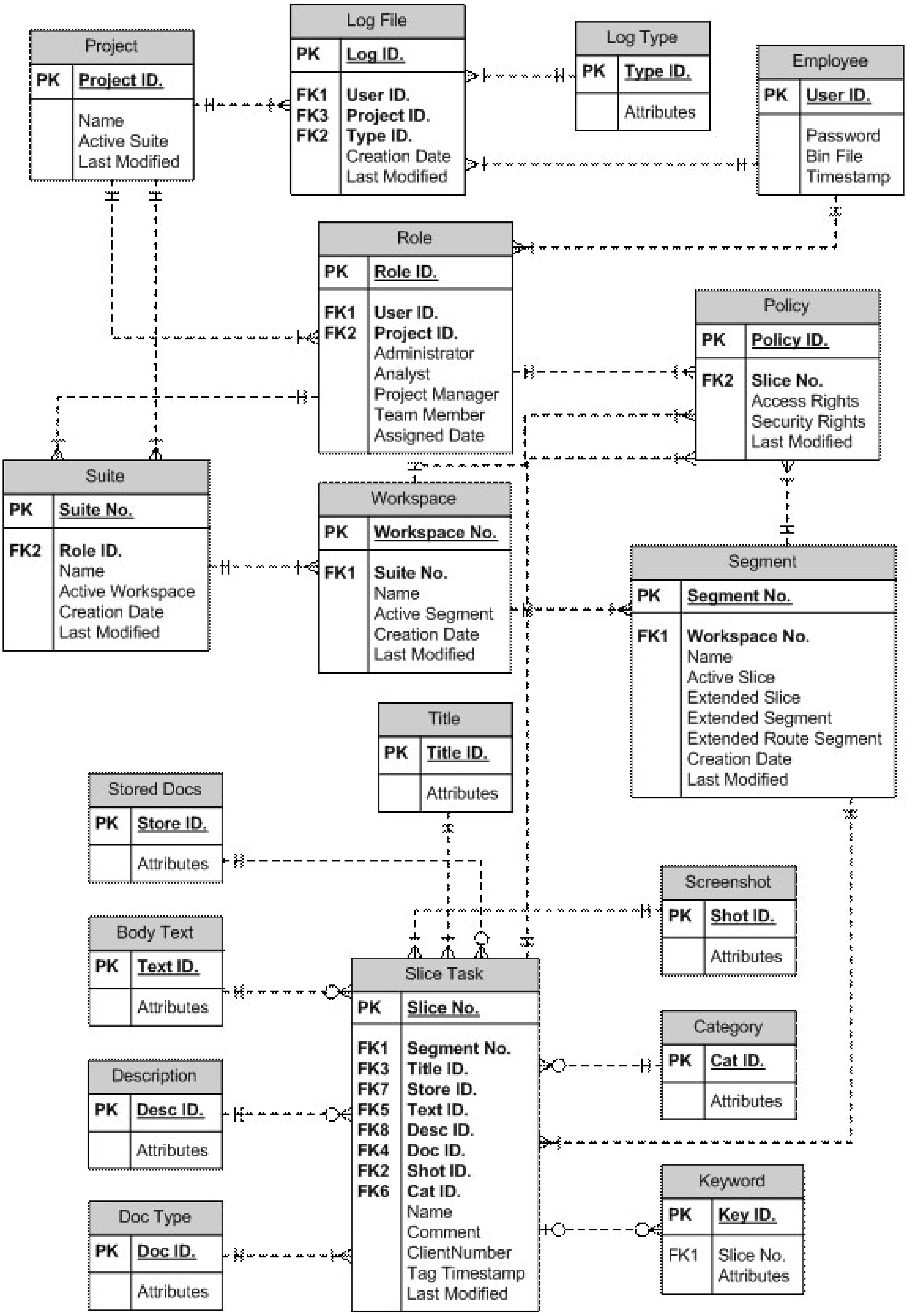
Prototype phase database and XML schema

NB. Throughout these diagrams dual terminology is used in defining the entities.

UML Object Relationships



"3-D Workspace Manager" database ERD view 1



"3-D Workspace Manager" database ERD view 2

Manager / Client Components and Database Rights / Privileges

Given below is an example of these policies. It is anticipated that these will be adapted or extended when dealing with various task specific scenarios.

1 x Administrator: - ability to assign Team or Knowledge worker specific policies or privileges
ability to view advanced level statistics and / or reports
ability to view, modify, assign or delete Project Managers access
ability to view, modify, assign or delete Project Analysts access
ability to view, modify, delete Knowledge worker “hidden” log files
ability to view, assign, modify, or remove Team Knowledge workers’ access
ability to view, modify, create or delete Knowledge workers’ access
ability to search, link, delete or promote public / private slices
can override / reassign all security privileges or access rights
ability to assign private security privileges, access rights
unilateral control over the whole system

3 x Analysts: - ability to view high level statistics and/or reports
ability to view, modify, delete Knowledge worker “hidden” log files
ability to search, link, delete or promote public / private slices
can override / reassign all security privileges or access rights
ability to assign private security privileges, access rights
ability to assign private security privileges, access rights
ability to view, add, delete, modify project suites
ability to view, add, delete, modify workspaces
ability to view, add, delete, modify segments
ability to view, add, delete, modify slices

* x Project Managers:- ability to view medium or level specific statistics and/or reports
ability to view, Knowledge worker “hidden” log files
ability to view, assign, modify, or remove Team Knowledge workers access
ability to assign Team or Knowledge worker specific policies or privileges
ability to search, link, edit or promote Team Knowledge worker workspaces
ability to search, link, edit or promote Team Knowledge worker segments
ability to search, link, edit or promote Team Knowledge worker slices
can override / reassign all security privileges or access rights
ability to assign private security privileges, access rights
ability to view, add, delete, modify project suites
ability to view, add, delete, modify workspaces
ability to view, add, delete, modify segments
ability to view, add, delete, modify slices

* x Knowledge workers:- ability to view level specific statistics and/or reports

ability to search, link and promote a public slice

ability to search, link, edit or promote privately owned slices

ability to assign security privileges, access rights on project suites

ability to assign security privileges, access rights on workspaces

ability to assign security privileges, access rights on segments

ability to assign security privileges, access rights on slices

ability to view, add, delete, modify project suites

ability to view, add, delete, modify workspaces

ability to view, add, delete, modify segments

ability to view, add, delete, modify slices

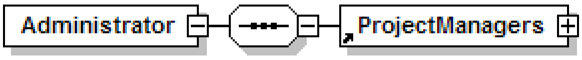
XML Schema

schema location: **cwvg.xsd**

Elements
Administrator
ProjectManagers
TeamMember
ProjectSuite
Workspace
Segment
SliceTask

element Administrator

diagram



children **ProjectManagers**

attributes

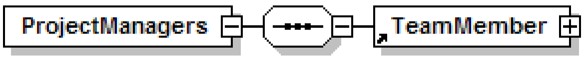
Name	Type	Use	Default	Fixed	Annotation
Identity	xs:string	required			
Name	xs:string	optional			
BinFile	xs:string	required			
LastReviewed	xs:string	required			

source

```
<xs:element name="Administrator">
  <xs:complexType>
    <xs:sequence>
      <xs:element ref="ProjectManagers"/>
    </xs:sequence>
    <xs:attribute name="Identity" type="xs:string" use="required"/>
    <xs:attribute name="Name" type="xs:string" use="optional"/>
    <xs:attribute name="BinFile" type="xs:string" use="required"/>
    <xs:attribute name="LastReviewed" type="xs:string" use="required"/>
  </xs:complexType>
</xs:element>
```

element ProjectManagers

diagram



children **TeamMember**

used by element **Administrator**

attributes

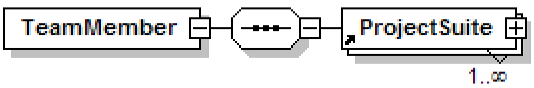
Name	Type	Use	Default	Fixed	Annotation
Identity	xs:string	required			
Name	xs:string	optional			
BinFile	xs:string	required			
LastReviewed	xs:string	required			

source

```
<xs:element name="ProjectManagers">
  <xs:complexType>
    <xs:sequence>
      <xs:element ref="TeamMember"/>
    </xs:sequence>
    <xs:attribute name="Identity" type="xs:string" use="required"/>
    <xs:attribute name="Name" type="xs:string" use="optional"/>
    <xs:attribute name="BinFile" type="xs:string" use="required"/>
    <xs:attribute name="LastReviewed" type="xs:string" use="required"/>
  </xs:complexType>
</xs:element>
```

element TeamMember

diagram



children **ProjectSuite**

used by element **ProjectManagers**

attributes

Name	Type	Use	Default	Fixed	Annotation
Identity	xs:string	required			

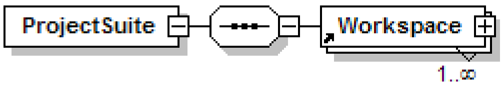
Name	xs:string	optional			
BinFile	xs:string	required			
LogFile	xs:string	required			
ActiveProjectSuite	xs:string	optional			
LastModified	xs:string	required			

source

```
<xs:element name="TeamMember">
  <xs:complexType>
    <xs:sequence>
      <xs:element ref="ProjectSuite" maxOccurs="unbounded"/>
    </xs:sequence>
    <xs:attribute name="Identity" type="xs:string" use="required"/>
    <xs:attribute name="Name" type="xs:string" use="optional"/>
    <xs:attribute name="BinFile" type="xs:string" use="required"/>
    <xs:attribute name="LogFile" type="xs:string" use="required"/>
    <xs:attribute name="ActiveProjectSuite" type="xs:string" use="optional"/>
    <xs:attribute name="LastModified" type="xs:string" use="required"/>
  </xs:complexType>
</xs:element>
```

element ProjectSuite

diagram



children **Workspace**

used by

element	**TeamMember**

attributes

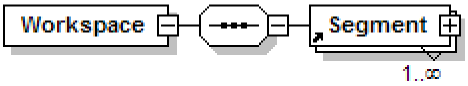
Name	Type	Use	Default	Fixed	Annotation
Number	xs:string	required			
Name	xs:string	required			
CreationDate	xs:string	required			
ActiveWorkspace	xs:string	required			
LastModified	xs:string	required			

source

```
<xs:element name="ProjectSuite">
  <xs:complexType>
    <xs:sequence>
      <xs:element ref="Workspace" maxOccurs="unbounded"/>
    </xs:sequence>
    <xs:attribute name="Number" type="xs:string" use="required"/>
    <xs:attribute name="Name" type="xs:string" use="required"/>
    <xs:attribute name="CreationDate" type="xs:string" use="required"/>
    <xs:attribute name="ActiveWorkspace" type="xs:string" use="required"/>
    <xs:attribute name="LastModified" type="xs:string" use="required"/>
  </xs:complexType>
</xs:element>
```

element Workspace

diagram



children **Segment**

used by element **ProjectSuite**

attributes

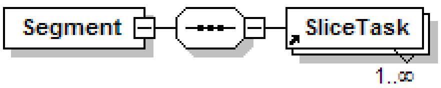
Name	Type	Use	Default	Fixed	Annotation
Number	xs:string	required			
Name	xs:string	required			
CreationDate	xs:string	required			
ActiveSegment	xs:string	required			
LastModified	xs:string	required			

source

```
<xs:element name="Workspace">
 <xs:complexType>
  <xs:sequence>
   <xs:element ref="Segment" maxOccurs="unbounded"/>
  </xs:sequence>
  <xs:attribute name="Number" type="xs:string" use="required"/>
  <xs:attribute name="Name" type="xs:string" use="required"/>
  <xs:attribute name="CreationDate" type="xs:string" use="required"/>
  <xs:attribute name="ActiveSegment" type="xs:string" use="required"/>
  <xs:attribute name="LastModified" type="xs:string" use="required"/>
 </xs:complexType>
</xs:element>
```

element Segment

diagram



children **SliceTask**

used by element **Workspace**

attributes

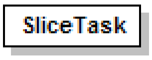
Name	Type	Use	Default	Fixed	Annotation
Number	xs:string	required			
Name	xs:string	optional			
ExtendedSegment	xs:string	optional			
ExtendedSlice	xs:string	optional			
ExtendedRouteSegment	xs:string	optional			
CreationDate	xs:string	required			
ActiveSlice	xs:string	required			
LastModified	xs:string	required			

source

```
<xs:element name="Segment">
 <xs:complexType>
  <xs:sequence>
   <xs:element ref="SliceTask" maxOccurs="unbounded"/>
  </xs:sequence>
  <xs:attribute name="Number" type="xs:string" use="required"/>
  <xs:attribute name="Name" type="xs:string" use="optional"/>
  <xs:attribute name="ExtendedSegment" type="xs:string" use="optional"/>
  <xs:attribute name="ExtendedSlice" type="xs:string" use="optional"/>
  <xs:attribute name="ExtendedRouteSegment" type="xs:string" use="optional"/>
  <xs:attribute name="CreationDate" type="xs:string" use="required"/>
  <xs:attribute name="ActiveSlice" type="xs:string" use="required"/>
  <xs:attribute name="LastModified" type="xs:string" use="required"/>
 </xs:complexType>
</xs:element>
```

element SliceTask

diagram



used by: element **Segment**

attributes

Name	Type	Use	Default	Fixed	Annotation
Number	xs:string	required			
Name	xs:string	optional			
ClientNumber	xs:string	required			
IndexFile	xs:string	required			
ContentFile	xs:string	required			
StoredFile	xs:string	optional			
ScreenshotFile	xs:string	optional			
TagDateTime	xs:string	required			
LastModified	xs:string	required			

source

```
<xs:element name="SliceTask">
  <xs:complexType>
    <xs:attribute name="Number" type="xs:string" use="required"/>
    <xs:attribute name="Name" type="xs:string" use="optional"/>
    <xs:attribute name="ClientNumber" type="xs:string" use="required"/>
    <xs:attribute name="IndexFile" type="xs:string" use="required"/>
    <xs:attribute name="ContentFile" type="xs:string" use="required"/>
    <xs:attribute name="StoredFile" type="xs:string" use="optional"/>
    <xs:attribute name="ScreenshotFile" type="xs:string" use="optional"/>
    <xs:attribute name="TagDateTime" type="xs:string" use="required"/>
    <xs:attribute name="LastModified" type="xs:string" use="required"/>
  </xs:complexType>
</xs:element>
```

XML Files

Manager XML Document


```xml
<?xml version="1.0" encoding="UTF-8"?>
<Administrator xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="cwvg.xsd" Identity="" Name="" BinFile="" LastReviewed="">
	<ProjectManagers Identity="" Name="" BinFile="" LastReviewed="">
		<TeamMember Identity="" Name="" BinFile="" LogFile="" ActiveProjectSuite="" LastModified="">
			<ProjectSuite Number="" Name="" CreationDate="" ActiveWorkspace=""
LastModified="">
				<Workspace Number="" Name="" CreationDate="" ActiveSegment=""
LastModified="">
					&lt;Segment Number="" Name="" ExtendedSegment=""
ExtendedSlice="" ExtendedRouteSegment="" CreationDate="" ActiveSlice="" LastModified="">
						<SliceTask Number="" Name="" ClientNumber=""
IndexFile="" ContentFile="" StoredFile="" ScreenshotFile="" TagDateTime="" LastModified=""/>
					&lt;/Segment&gt;
				</Workspace>
			</ProjectSuite>
		</TeamMember>
	</ProjectManagers>
</Administrator>
```


Client XML Index Document


```xml
<?xml version="1.0" standalone="yes"?>
<SliceIndex Number="" MasterIndexFile="" ContentFile="" ExtendedSegment="" DocumentType="" PageAddress=""
HostDomainAddress="" PrimaryIPAddress="" PacketHeader="" ResponseintCode="" ResponsestrCode=""
ResponseDescription="" ImagesNumber="" LinksNumber="" DocumentSize="" CreationDate="" LastModified=""
ThumbnailFile="" ThumbnailSize="" MHTFile="" MHTSize="" TagDateTime="" OfflineStatus="" SecurityStatus=""
CumulativeTime="" LastSpentTime="" ProhibitedContent=""/>
```


Client XML Content Document


```xml
<?xml version="1.0" standalone="yes"?>
<SliceContent Number="" MasterIndexFile="" IndexFile="" PageTitle="" MetaKeywords="" MetaDescription=""
MetaCategory="" Knowledge workerComments="" BodyText=""/>
```


Log File Hidden Document


```xml
<?xml version="1.0"?>
<CoreIndex ProjectManager="null" ProjectSuiteName="null" ProjectSuiteNumber="null" LogFile="null" Number="null"
TagDateTime="" PageTitle="" PageAddress="" HostDomainAddress="" PrimaryIPAddress="" PacketHeader=""
ResponseintCode="" ResponsestrCode="" ResponseDescription="" ImagesNumber="" LinksNumber=""
DocumentSize="" CreationDate="" LastModified="" MetaKeywords="" MetaDescription="" BodyText=""
DocumentType="" TimeonPage="" ProhibitedContent=""/>
```

Appendix 12

Prototype phase questionnaire

Virtual Gatekeeper Trials

Data logging Release Form

I agree to participate in the study conducted and associated data logging by Dave Richardson.

I understand and consent to the use and release of the data logged materials by Dave Richardson for his PhD work. I understand that the information and data logging materials is for research purposes only and that my name and image will not be used for any other purpose. I relinquish any rights to the data logged materials and understand the materials may be copied and used by Dave Richardson without further permission.

I understand that I can leave at any time.

I agree to immediately raise any concerns or areas of discomfort with the study administrator.

Your signature: ______________________________

Date: __________

Please print your name: ____

Thank you!

Your participation is appreciated.

Background Questionnaire

1. General Information

Name: ______________________________

Gender: *[ ] male [ ] female*

Age: *[ ] Under 18 [ ] 18-24 [ ] 25-34 [ ] 35-44 [ ] 45-54 [ ] 55-64 [ ] 65+*

Job: __________________________________

Years of experience in field: ____________ *years*

2. Sight Impairment

a) Do you use a sight aid when working on the computer?

[ ] none [ ] glasses [ ] contact lenses [ ] other ______________________

b) Do you have any form of colour blindness?

[ ] no [ ] yes ______________________

3. Education

a) Highest educational level attained:

[ ] vocational training [ ] secondary school [ ] university degree [ ] masters/doctorate

b) Please describe your main field of interest:

____

4. Use of Computers

a) Do you have a computer at home?

[ ] no [ ] yes __________________________ *(please specify what kind of computer)*

b) Which kind of computer operating system do you regularly use?

[ ] Microsoft Windows [ ] Apple Macintosh [ ] Linux [ ] Other ____________________

c) When did you first start using a computer?

________ *year*

d) How many hours per week, on average, do you use a computer?

______ *hours*

5. Experience with the Internet and the Web

a) How many hours per week do you use the World Wide Web?

_________ *hours*

b) From where do you normally surf the web?

[ ] work [ ] home [ ] both

c) What kind of Internet connection do you normally use?

[ ] analogue modem [ ] ISDN modem [ ] cable modem [ ] DSL (broadband)
[ ] other ___________________ (please specify)

d) Which web browser do you normally use?

[ ] Microsoft Internet Explorer [ ] Mozilla Firefox [ ] Opera

[ ] other ____________________(please specify)

e) Do you have experience using tabbed-based web browsers?

[ ] no [ ] yes ________________________ (please specify what web browser)

6. Experience with Usability Tests

a) Have you participated in a usability study before?

[ ] no [ ] as a test user [ ] as part of the testing team

If yes, briefly can you give a few lines about what the study was?

____

____

____

7. Domain-Specific Questions

a) Please rank the following common methods of distributing information in the workplace. Each column represents a different ranking of the methods. The first column ranks the methods according to how you currently receive information. The second column ranks the methods according to how you would like to receive information. The third column ranks the methods according to how you send information to others.

Please rank the methods using numbers between one and ten. Zero (0) represents not used, one (1) indicates the method least used and ten (10) the most

Delivery method	Get	Want	Give
Flyers, bulletins, brochures (as needed)			
Electronic mail			
Newsletter or newspaper (periodic)			
Meetings (one to many)			
Verbal (one to one, or one to few)			
Land line phone calls, voice mail			
Mobile phone, Pager			
Online (online help, WWW. CD ROM)			
Notes, sticky notes			
Royal Mail			

b) How many hours do you work in an average week?

______ *hours*

c) In an average work week, what estimated percentage of your time do you spend reviewing electronic information?

[ ] 1-25%   *[ ]* 26-50%   *[ ]* 51-75%   *[ ]* 76-100%   *[ ]* none

d) In an average work week, what estimated percentage of your time do you spend reviewing non-electronic information?

[ ] 1-25%   *[ ]* 26-50%   *[ ]* 51-75%   *[ ]* 76-100%   *[ ]* none

e) What estimated percentage of the information in question 7a do you find useless or just delete?

[ ] 1-25%   *[ ]* 26-50%   *[ ]* 51-75%   *[ ]* 76-100%   *[ ]* none

f) How much information do you receive at work today compared with 2 years ago?

[ ] less   *[ ]* same amount   *[ ]* 2 times   *[ ] 3* times   *[ ]* 4+ times

g) Do you spend time at home reviewing information from work?

[ ] no   *[ ] yes* ______________________________ *(please indicate what type)*

If yes, how many hours per week do you spend (at home) reviewing information for work?

______ *hours*

h) How do you sort through what you have to read (do you prioritize it, make yes / no decisions)?

i) What methods, techniques, or equipment would help you sort through this information more easily?

j) What was one of your most frustrating experiences with information you retrieved?

k) What was one of your best experiences with information you retrieved?

l) If we could invent something to sort through the information you get, what would this ideal gadget or technique do for you?

m) If you develop documentation, what would you recommend that someone new to the profession do to make information easier to use?

n) If you teach or set standards for communication or instruction what would you recommend someone new to the profession do to make information easier to use?

Further Comments:

Participant Tasks Sheet

So that we can assess your responses to using the Virtual Gatekeeper software, please can you complete the following tasks over the next 20 minutes.

Task 1: Orientation Walkthrough

1) Double click “Virtual Gatekeeper” icon shortcut on the Desktop
2) In “User Identity” type your name such as “Dave” and in “password” type “password”
3) Click the “Log In” icon
4) From the project sphere select the middle sphere twice using the mouse pointer
5) From “Suite Actions” on the right, click the name to open the menu options.
6) Click “Add workspace” option
7) Now click “rename workspace” and add the name “Internet” then click “change”
8) Select the furthest workspace using the mouse pointer and then once it revolves around to the front select it again
9) Now click the green “level” icon on the left
10) Now using the actions you have just learned, find your newly created “Internet” workspace using the mouse pointer and select it to bring to the front
11) Click the “Internet” workspace again
12) From “Workspace Actions” on the right click to open the menu options
13) Click “Add segment” option
14) Now click “rename segment” and add the name “Nano-Science” then click “change”
15) Select the furthest segment using the mouse pointer and then once it revolves around to the front select it again
16) Now click the green “level” icon on the left
17) Now using the actions you have just learned, find your newly created “Nano-Science” segment using the mouse pointer and select it to bring to the front
18) Click the “Nano-Science” segment again
19) Now click on the “web browser” blue icon from the left side
20) Type in the following address “C:\TrialSetup\Task Website\index.htm” and click the green “go” icon.
21) Click “Manual Tag” icon at the top
22) Navigation to “Education Introduction” web page from the left menu.
23) Click “Manual Tag” icon at the top once again
24) Now click either the cross at the top right or click File and then close
25) Click on either of the two blue slices once and then click the zoom icon on the left to see a full scale preview.
26) Now click either the cross at the top right or click File and then close
27) Click the green “level” icon on the left
28) Click the “log out” button on the right
29) Finally, click the cross at the top right to close “Virtual Gatekeeper”

Task 2: Fill "Nano-Science" workspace

1) Double click "Virtual Gatekeeper" icon shortcut on the Desktop again
2) In "User Identity" type the exact name "Dave" and in "password" type "password" as you did before
3) Click "Log In" icon
4) From the project sphere select the middle sphere twice using the mouse pointer
5) You should find your previous workspace available to you
6) Select this workspace using the techniques you have already learned
7) Using the techniques you learned in Task 1, please name each of the other workspace segments "Research", "Education", "Application" and then fill these with at least 2 difference web pages from the "Nano-Science" web site at address "C:\TrialSetup\Task Website\index.htm"
8) Once this is done "log out" and close "Virtual Gatekeeper"

Task 3: Slice Knowledge Management

1) Double click Virtual Gatekeeper icon shortcut on the Desktop again
2) In "User Identity" type the exact name "Dave" and in "password" type "password" as you did before
3) Click "Log In" icon
4) From the project sphere select the middle sphere twice using the mouse pointer
5) You should find your previous workspace available to you
6) Using the techniques you learned in Tasks 1 and 2, navigate to the "Nano-Science" web site at address "C:\TrialSetup\Task Website\index.htm" from within the "Research" segment
7) Navigate to the "Research Publication" web page from the "Nano-Science" web site and then click "Workbench" from the top right
8) In the top left hand corner under "Tagging Details" add a comment such as "*this is an academic listing of current documents*"
9) Click the "Workbench" icon from the top right again and then click "Manual Tag"
10) Using the techniques you've learned in Tasks 1 and 2, repeat this new technique to add at least two new web pages from the "Nano-Science" web site at address "C:\TrialSetup\Task Website\index.htm" to each segment with the inclusion of appropriate comments for each slice
11) In the "Research" segment navigate back slice 2 by selecting the slice and clicking the zoom icon on the left
12) On the new bar with numbers on it, deselect number 2 icon
13) Click on "Workbench" icon in the top right
14) Click on slice numbers 3 and 4 and watch the comments change to reflect your custom comments
15) On slice 4 click "Resume" icon to reload the page with the most recent cached copy of the web page
16) Once this is done, close the browser
17) Now "log out" and close "Virtual Gatekeeper"

Virtual Gatekeeper Trials

Usability and Satisfaction Questionnaire

Name: ______________________________

So that I can gain an idea of how easy you found the system to use, please ring, tick or answer the following questions....

1. Did you find using the system easy or difficult?

[ ] Very easy *[ ]* Moderately easy *[ ]* Moderately difficult *[ ]* Very difficult

2. Please describe any difficulties that you specifically experienced.

____
____
____
____
____
____

3. Overall User Reactions

Please circle the numbers which most appropriately reflect your impressions about using this computer software system. Not Applicable = NA.

a) Terrible Wonderful

1 2 3 4 5 6 7 8 9 NA

b) Frustrating Satisfying

1 2 3 4 5 6 7 8 9 NA

c) Dull Stimulating

1 2 3 4 5 6 7 8 9 NA

d) Difficult Easy

1 2 3 4 5 6 7 8 9 NA

e) Rigid Flexible

1 2 3 4 5 6 7 8 9 NA

4. Screen

a) Use of color on the screen was

Poor Excellent

1 2 3 4 5 6 7 8 9 NA

b) Screen layout makes tasks easier

Never Always

1 2 3 4 5 6 7 8 9 NA

c) Amount of information on the screen was

Inadequate Adequate

1 2 3 4 5 6 7 8 9 NA

d) Arrangement of information on the screen was

Illogical Logical

1 2 3 4 5 6 7 8 9 NA

5. System Information

a) Performing an operation leads to a predictable result

Never Always

1 2 3 4 5 6 7 8 9 NA

b) Feedback on operations were

Inadequate Adequate

1 2 3 4 5 6 7 8 9 NA

6. Learning

a) Learning to use the system was

Difficult Easy

1 2 3 4 5 6 7 8 9 NA

b) Getting started was

Difficult Easy

1 2 3 4 5 6 7 8 9 NA

c) Exploration of features by trial and error was

Discouraging Encouraging

1 2 3 4 5 6 7 8 9 NA

d) Exploration of features was

Risky Safe

1 2 3 4 5 6 7 8 9 NA

e) Remembering usage of operations was

Difficult Easy

1 2 3 4 5 6 7 8 9 NA

f) Number of steps per task was

Too many — Just right

1	2	3	4	5	6	7	8	9	NA

g) Steps to complete a task follow a logical sequence

Rarely — Always

1	2	3	4	5	6	7	8	9	NA

7. Program Capabilities

a) General system speed was

Too slow — Fast enough

1	2	3	4	5	6	7	8	9	NA

b) Useful for experienced as well as inexperienced users

Never — Always

1	2	3	4	5	6	7	8	9	NA

8. System Usability Scale (SUS) rating

Statement	Strongly disagree				Strongly agree
a) I think that I would like to use this system frequently	1	2	3	4	5
b) I found the system unnecessarily complex	1	2	3	4	5
c) I thought the system was easy to use	1	2	3	4	5
d) I think that I would need the support of a technical person to be able to use this system	1	2	3	4	5
e) I found the various functions in this system were well integrated	1	2	3	4	5
f) I thought there was too much inconsistency in this system	1	2	3	4	5
g) I would imagine that most people would learn to use this system very quickly	1	2	3	4	5
h) I found the system very cumbersome to use	1	2	3	4	5
i) I felt very confident using the system	1	2	3	4	5
j) I needed to learn a lot of things before I could get going with this system	1	2	3	4	5

9. Do you have any suggestions as to how the system could be made more accessible?

10. Do you have any other comments, criticisms or suggestions relating to the usability - ease of use - of the system?

Further Comments:

Thank you for completing the trials survey

System Concept Interview Sheet

a) What was your initial reaction to Virtual Gatekeeper upon first seeing the system training?

b) What was your initial reaction to Virtual Gatekeeper upon first using the system?

c) What features of Virtual Gatekeeper do you find most useful when compared with your previous computing environment(s)?

d) What features of your previous computing environment(s) do you miss when using Virtual Gatekeeper?

e) Do you find any aspect of Virtual Gatekeeper difficult or confusing?

f) Does Virtual Gatekeeper make any aspect of managing information less (or more) confusing (say, as compared to the way you normally do things)?

g) Does Virtual Gatekeeper in any way change the way you thought about using your computer or managing your information? If so, how?

h) Did you quickly understand the Virtual Gatekeeper user interface?

i) Was the Virtual Gatekeeper user interface an effective way to store documents? That is, does it allow you to carry out the operations you needed to undertake?

j) Do the animations help you to understand the effect of the various operations? For instance creating a new document, storing a document, creating a workspace or segment?

k) Do you like the fact that all your documents were stored in the same workspace? Or do you find it easier to maintain them separately in a traditional file system hierarchy or application store?

l) Do you find segments a useful method of storing and managing information?

m) Do segments allow you to concentrate on current information while older information is moved to the background? Or would you prefer some other default organizational method?

n) Do segments help you locate older information (say, because you remember the approximate time when that document was created)?

o) Do you like the fact that you don't have to file and name your documents?

p) Do you prefer to name documents and store them in a directory?

q) Do you find workspaces and segments useful concept for locating information?

r) Do you find workspaces and segments useful for maintaining collections of information over time?

s) Were you usually able to find what you were looking for? If not, was the system frustrating in that respect?

t) Do the names “project”, “workspace”, “segment” and “slice” make any sense to you?

u) What features or changes would you like to see within Virtual Gatekeeper?

v) If Virtual Gatekeeper were a robust and supported piece of software would you continue using it?

Further Comments:

Appendix 13

Prototype phase sample qualitative feedback

Background Profile Response Sample

7g) Do you spend time at home reviewing information from work?

- Reports & Presentations
- Online World Wide Web not accessible from work network.
- Emails

7h) How do you sort through what you have to read (do you prioritize it, make yes / no decisions)?

- I will review quickly items in my inbox and then delete any irrelevant information before mentally prioritising + reordering again, I do not prioritise electronically, I may make a physical post a note as a reminder.
- Prioritise by project, importance and deadline.
- Try to but more often than not its what interests me at the time.
- Things have to be prioritised.
- Scan, delete and prioritise.
- Prioritise, Act, Finish.
- Title, sender, importance. - but will open and read first few even not all.
- Open files on desktop (electronic) and arrange "piles" on the desk (Hardcopy).
- Transfer important references to a log book after looking/reading the information. Reorganise data items into relevant folders / locations. Generally quickly read through titles / content to establish content and relevance.
- Prioritise
- Lots of ways depending on task - sorting is incidental to the task.

7i) What methods, techniques, or equipment would help you sort through this information more easily?

- The first phase of reviewing the information would be to create an abstract / summary of the document, whereby I would scan other electronic documents to determine their worth.
- Some way of finding reports / presentations / spreadsheets in a fast and easy manner without having to plough through myriads of folders on my laptop or shared drive.
- It's hard to say as different things take priority at different times depending on what's currently going on.
- Filters.
- I know I could do more with outlook to help but I have not yet worked out how to.
- I need consistency in how, prioritise or set reminders. Data not always in the same location or format.
- Application titles, relevant information, clear decisions.
- Depends upon the type of information - pre-filtering (based on heuristics), smart folders etc might help for email etc. - software has more readable/useful search directly within the IDE.
- Home work connectivity. Better integration. Episodic organisation. Non windows system.

7j) What was one of your most frustrating experiences with information you retrieved?

- Not understanding the information or not knowing the right person to assist with it. It's a nightmare web searching for standards as search results are never helpful enough in providing a useful abstract about an item.
- Can't access it as don't have the required technology on machine (i.e. software).

- Working on a project trying to find out where the latest presentation of the system concept was.
- Delays in information coming through via email not reaching you in time for important meetings.
- Filters not able to discriminate between what is wanted and how data is stored.
- People not responding to emails.
- Advisable to retrieve information from an email I know exists but cant remember sender or subject - use search is all but it takes a long time and isn't specific.
- Not knowing the legitimacy / format of the document. Whether or not it was up to date.
- Not being able to get into information to more detail or the information being incomplete. In the case with Microsoft digital information being titles from topic to topic and then back to where it started from without getting more detailed information.
- Poorly written documents - hard to find and extract required information.
- Crashes and formatting issues.

7k) What was one of your best experiences with information you retrieved?

- Most competent system that I use is the newly remade database for car parking - as priorities on age / length or services etc. are automatically calculated making information such as an onsite waiting list easy to now produce.
- Find out information that no one else had discovered.
- Positive feedback such as thanks.
- When I can find what I want
- Not knowing the legitimacy / format of the document. Whether or not it was up to date.
- Manual for 3rd party software, clear sections, titles and links to relevant sections.
- Integrate software and online help.

7l) If we could invent something to sort through the information you get what would this ideal gadget or technique do for you?

- Summarise the information into a meaningful product so I'd then be able to decide whether to go further.
- Organise it into project importance for me.
- “1) Some way to locate a file on my laptop or shared drive which finds exactly what I wanted inside it.
- 2) Something that would inform me where to look and what's new in a key folder."
- Something which automatically sorts file names into particular folder / area when information is received.
- Something to identify what was wanted rather than what was asked for. A way of allowing multiple spellings of the same term.
- Make me more productive - I need to switch tasks from one problem to another quickly - tools able to help with that would be useful.
- Be able to pull out project or subject specific data that's relevant, complete and current.
- Sort by topic / domain into relevant groupings with clear cross referencing within the information.
- Preset information in a consistent, searchable way, without excessive bloat. Use an open standard for storage, so it’s not at the mercy of specific tools / versions. Automatically book writers of rubbish documents onto technical writing courses.
- Instant finding, tagging, manipulation, prioritisation.

7m) If you develop documentation, what would you recommend that someone new to the profession do to make information easier to use?

- Easy to search, always knowing where you are, useful index, decent search results that are distinguishable.
- Templates
- Put it in some form of structured repository rather than the random set of folders that seam to exist.
- To perhaps bullet point information more so than what is currently is to make it easier to locate and quickly.
- Training is hands on and question
- Develop a good searchable help system with wizards - must be context sensitive.
- Consistent conventions, outlining main subject, specifics and date.
- Make documentation which is easy to use / read in combination with other applications being used, prioritising more at a real estate issue.
- Produce documentation for the Participant (not that's easy to write). Determine what the Participant wants. Present it appropriately (again Participant-centric not technical / package centric).
- Use of agreed formats / templates.

7n) If you teach or set standards for communication or instruction what would you recommend someone new to the profession do to make information easier to use?

- Adhere to usability guidelines.
- Process and templates
- Give files more understandable names without the need to populate with metadata property. For projects build web front ends for accessing information rather than folders on a shared drive.
- To have a step by step process that an outsider looking in would be able to pick up and use.
- Show interest and question
- Clear and obvious objectives, summaries and conclusions, avoiding unnecessary abbreviations or technical detail.
- Be concise.

Satisfaction of System Concept Responses Sample

2) Please describe any difficulties that you specifically experienced.

- Workspaces are indistinguishable, you have to click on these to rotate to the front and get the name. I also forgot which workspace I was in whilst searching the web, then didn't seem to be a link back indicating that I was in the "Application".
- Wasn't intuitive - couldn't save comments, following instructions didn't work as the options I needed were not available. Lack of labelling meant I wasn't always sure where I was in the filing system.
- Kept clicking segments incorrectly which took you to next level (i.e. the slices) when wanted to change to another segment.
- Use of terms on instructions, but the system was easy.
- Expected an Internet connection when selecting the web browser.
- Wanted "right click" to give access to rename etc - context menu. Unfamiliar with technology i.e. Workspace / segment so make errors in task 2.
- Understanding the terminology - "segments", "workspaces", and knowing where I was within each.
- Changing back and forward between main topics. Having to use a level selector.
- Occasionally went "up" a level rather than "down" (or vice Versa). Crashed the software a couple of times.
- Memory load, no labels. Often didn't know where I was e.g. what segment an item was in.

9) Do you have any suggestions as to how the system could be made more accessible?

- Differentiating segments / workspaces by e.g., having them moved rather than having to initiate the rotate command. Name on workspaces of the objects themselves. Indication of the workspace / segment you are in whilst on the web.
- Feedback of pages on slices. Names on segments.
- Allow use of "tree-based" navigation. integrated with outlook to store email.
- Being able to view segments/workspace names easier or without having to select them. Being able to leave explorer open. Terminology confusion as everything was a segment or so I thought?
- Instead of having a back arrow for navigating levels have a tower of levels that can be selected. Have the relevant blocks directly selectable - so you can jump back / forward. The blocks should have labels on them not on the info panel to the right.
- When the mouse pointer hovers over a segment/suite, display the name - avoiding on transition and error to find the right one.
- Labels, Indications of where one is. Why link to an image not the page itself?

10) Do you have any other comments, criticisms or suggestions relating to the usability - ease of use - of the system?

- I like the idea of a 3D system - however I think that the concept is very complex for inexperienced Participants. If this is the finished product then it doesn't do what you expect, therefore making it unintuitive. Feedback needs to improve to help navigation.
- Found the graphical portrayal of the project segments etc. to be very good but too slow when revolving around. Felt the graphics should be labelled with the titles - e.g. the project name should be shown.
- Make it full screen. Allow me to move browser out of the way to allow me to know where I am.
- Maybe a "prompt" for actions e.g. are you sure - yes / no. An icon showing levels to take you to different levels rather than an arrow.

- Information when stored as jpg screenshot - this does not allow text / pictures to be extracted for later use.
- Keeping explorer open would help, pressing "close" in the corner intuitive action to get back to gatekeeper.
- Copy functions could be useful.
- It was cumbersome to have to remove the suites / segments compared say with a tree structure - lots of stress.
- Feedback on all buttons required. Spatial movement not very helpful due to rotation.

Further Comments)

- Having to type the URL of the test web site was causing me a lot of time wasting. Would like to give it another go and have a more detailed look at the metadata on each web page that is available to fill in. Not sure on how I would do a search.
- Could be cumbersome if there are hundreds of pages stored.
- It would be nice to see a demo using Microsoft office packages I more regularly use (Word, PowerPoint, Excel, Project etc.) and whether or not it fits with non-Microsoft products e.g. Doors.
- I'm a bit concerned about scalability - potentially cumbersome navigation, potentially cluttered screen area.

System Concept Depth Interview Responses Sample

a) What was your initial reaction to Virtual Gatekeeper upon first seeing the system training?

- "Its 3D - rotates and has a file structure of some sort!"
- 3D was initial reaction.
- Thought presentation of 3D was a novel concept for organising information. Quite liked it but slow on animation.
- What the system could be used for?
- Wondered what it was being used for - did not know if it was a document management system or favourites.
- Allot to take in as lots of new concepts.
- Fairly logical and well laid out. Method for indexing data.
- Was not quit sure what large circles were and how related to substructure - could not see hierarchy as not immediately obvious.
- Straight forward / easy to use.
- Tool was as expected.
- Looks impressive but lack of labels. Too much emphasis on memory load. Looks good but sphere motion was meaningless in trial. Not sure of relationship with segments and workspaces in the hierarchy.

b) What was your initial reaction to Virtual Gatekeeper upon first using the system?

- Seemed ok to use.
- Ok, but did not like feedback as unsure which segment you were in - hard to find where things were as not clear without clicking on segments.
- Did not realise web based - add comments on these. Seen this on similar search etc. Surprised it was web based. Also surprised as it only covered web documents.
- Easy to use - icons moving was good as easier to remember.
- Good but wish full screen for windows (scale larger and smaller depending on eyesight).
- Easy to use.
- Confused over what I saw in the video over the depth of the system.
- It did as supposed to and was straightforward.
- Straight forward and logical but a bit slow.
- Transitions seemed cumbersome as no tooltips so irritating. Worry about scalability issue. Pity it is 3D only.
- Works in a way you expect. Frustration trying to access web pages through the system and unsure if contains certain aspects or were available (features).

c) What features of Virtual Gatekeeper do you find most useful when compared with your previous computing environment(s)?

- When in a segment I very much liked the preview thumbnails of tasks. Tagging data automatically.
- Can see that logically how it can store things and therefore drill down into things. I would not find this structure useful through.
- Method of accessing workspaces and segments. Slices for previewing documents.
- The system moving rather than being still "segments" moving - process was good for sticking in the brain.
- Ability to store information in different areas e.g. Web browser and folders. Was very useful but downside was ability to name folders and then save information anywhere in different areas. No feedback to let me know where I was in the structure.
- It would be a good tool to access files rapidly such as media system. At the moment we use a number of apps all related but this would unify all.

- The ability to "search" and "index" large volumes of visual data.
- Cannot see anything at the moment.
- Quite logical in layout of information. Find things allot easier as not “slap dash” folders.
- If using browser and bookmarks then it is a flat list, Virtual Gatekeeper structure is good as it forces a better way or organising content. Provides a 3D representation of tree structure and imposes structure onto the information.
- Hard to judge. Imagine might be useful but not sure utility of it. Tagging aspects might be good but unsure if time intensive and using / forcing would help or hinder the Participant.

d) What features of your previous computing environment(s) do you miss when using Virtual Gatekeeper?

- Favourites - could not differentiate different workspaces visually until click on them e.g. named folders in explorer and drag / drop icon capability.
- Names of onscreen "blobs" are shown not when cluttered. Found usability difficult. Use a tree structure to show where Participant is and to provide feedback.
- Just see it as another method for accessing information - but hard to tell in such a short space of time.
- No.
- Ability to store data anywhere instantaneously e.g. Like explorer favourites. Ability to move data around into other folders (click and drag). How was information overload controlled over 100+ segments?
- Not that can think of.
- Not as a replacement but as a method to control various sources of data.
- Freedom to open documents and share where you like and navigate away from that.
- Copy / paste in the browser and 3D itself. Keyboard shortcuts not used as am used to Mac, PC and Linux.
- Speed to get to information and shortcuts. Extra access to documents e.g. version control on individual files, baselines and other context information. Other ways of linking element is vital.
- Accessing a copy image rather than the actual web page document. No structure (hierarchical) as unlabeled.

e) Do you find any aspect of Virtual Gatekeeper difficult or confusing?

- As above discriminate visually. Was not sure which workspace in when on the web page.
- Yes, was confusing as had issue with last task - suggests software at fault not me. Input comments were not saved when moved around so why did it not save?
- Bugged me having to type in URL as wanted a history feature. Like to see Google on or with Virtual Gatekeeper. Like to see a search feature implemented in 3D (nice way of storing and retrieving). Accidentally clicking the segment at the front.
- No because easy system to pick up
- No except apparent lack of feedback on segments / slices - some identifies as in a thumbnail picture on actual 3D slices. Minimise amount of data. Use of hot keys.
- Not difficult but with prompts for actions (such as expert wizards or dialogues) such as Yes / No or Are you Sure or in closing Do you want to do this - all would help.
- Navigate from one to other is frustrating as wanted tree hierarchy to quick jump to certain areas.
- Having to close explorer to get back to Gatekeeper screen and dialogues open instead as well.
- No
- Problem with going up or down a level by mistake but this could be cured by familiarity with the system.

- Lack of labelling and feedback on relationships between segments / workspaces and spheres.

f) Does Virtual Gatekeeper make any aspect of managing information less (or more) confusing (say, as compared to the way you normally do things)?

- More confusing as cannot discriminate. At a beginner level as it is more prescribed.
- More confusing as in trying to find information without the need to drill down - difficult to know where things are without drilling down. Also not sure limit of the number of segments.
- Less confusing. Would have liked to click the segment at the front in order to spin as well.
- No
- Make it more confusing as folder and trees make it easier e.g. Like document managers and windows file systems.
- Less confusing as all unified inside one application.
- As a concept very useful. If could also store emails and documents etc. In the file system then you could store all and index search in one place. Liked aspect of no duplicate copies of data.
- Forces you to do things otherwise you would not do e.g. extra comments and that this force is useful.
- More useful but would like labels on 3D like tool tips.
- Versioning and linking things together e.g. more axis than visible for one file (multidimensional versioning of individual slice documents into horizontal versioned layers)
- Images cause confusion. Relationship between entities in segments themselves was confusing.

g) Does Virtual Gatekeeper in any way change the way you thought about using your computer or managing your information? If so, how?

- It would be useful to add comments to files.
- The way you dived into something. Card index and Virtual Gatekeeper structure. Used tabbed based browsing recently.
- In terms of segmenting information in way it shows - different way of storing / filing information. Colour and segmenting easier visually.
- No I manage data very explicitly as in want only one copy of data e.g. versioning also like it hierarchical based on data and use search / sorting methods.
- Strong tool to use as information required would be at your fingertips.
- Make it obvious I must index and store information properly. A flip method for multiple projects would be useful i.e. Virtual Gatekeeper as tool. Sync issue between local store, hard disk and desktop and emails.
- Yes, but not sure what way e.g. associates between tasks and projects and identifying what was doing before it may be confusing.
- Not directly, but depending on integration with other packages such as version management. Hotlinks on the 3D would be nice so as to jump to related files.
- Tend to build deep trees so do not see difference as used to it.
- Annotate your documents e.g. tagging is highly desirable providing it adds value.

h) Did you quickly understand the Virtual Gatekeeper Participant interface?

- Yes, logical.
- Workbench aspects were complicated but understood blobby Participant interface. Two very different Participant interfaces and the problem was the workbench.
- Reasonably quick. Getting used to where on screen e.g. Segment. Criticism would like to see name on segments.
- Fairly quickly.
- Yes.
- Yes.
- Medium to yes understood.
- Yes, however terminology was confusing. Names on items would be good.
- Yes.
- Yes.
- Think so but unsure. Compartmentalisation works for segments workspaces and projects, but not intuitive enough for me.

i) Was the Virtual Gatekeeper Participant interface an effective way to store documents? That is, does it allow you to carry out the operations you needed to undertake?

- Liked to see how Virtual Gatekeeper could be used with standard office applications. It is better for tagging pages for Internet Explorer. Not efficient way as drill down needs more steps which windows file manager does not do.
- No you have to drill down to where you're going - hard to find things!
- Yes it would. Yes to being effective.
- Yes it was effective eventually.
- Depends how you were to use it. If I use it probably not, but if manages data in different ways then yes e.g. On MacOS "Marco Polo" stays at one level. Trade off between Participant Interface and tasks.
- Yes.
- Could do but more options to access data at lower levels.
- Yes, but know what you are doing to start with.
- Yes.
- Need copy/paste/move/sort functionality. Ineffective at present due to versioning, movement and relating this at different levels.
- Effective in technical term. Efficiency/usability could be useful for constrained tasks if labelling included in 3D objects. Would like to see how it handles large datasets.

j) Do the animations help you to understand the effect of the various operations? For instance creating a new document, storing a document, creating a workspace or segment?

- Yes, it is very clear.
- OK, like the idea of 3D and animation.
- Yes but slow, that is to say toggle to increase speed, such as a meter, once I am familiar with the Participant interface.
- Once done a couple of times not particularly hard to remember.
- Yes add value as really good.
- Yes.
- Yes, but over time like to turn off when become advanced Participant.
- No, as did not add much.
- Yes.
- Yes.

- Yes, but once you know animations be good to turn off or skip. Also if you take your eye off the screen and then look back, everything has changed so causing confusion and inefficiency as your not sure where you are or where you were to get there.

k) Do you like the fact that all your documents were stored in the same workspace? Or do you find it easier to maintain them separately in a traditional file system hierarchy or application store?

- Find it easier in windows file manager but could get used to this way of working.
- Not very much difference between either.
- Yes, to the new concept approach. Used Picasa 2 from Google so similar e.g. creates albums. Wiz through rather go into folders - problem with Picasa as not enough metadata description control.
- Trial and error - hard to say as already well organised.
- Prefer old way and "augmenting" with existing systems as that would be useful. Use Virtual Gatekeeper as a retrieval system method.
- In same workspace as quite logical compared to past.
- What stored originally and then indexed for this e.g. Local information such as sits above in the hierarchy. Not clear cut as depends on type of data.
- Prefer traditional hierarchy method.
- Used to old method but could get into Virtual Gatekeeper as could easily adapt and would like to.
- No, as the way I normally do it e.g. file system hierarchy as more depth.
- Was not helpful. Don't see that Virtual Gatekeeper is better than traditional approach.

l) Do you find segments a useful method of storing and managing information?

- Yes, suppose it is useful but did not notice.
- Yes, but add comments.
- Yes.
- Yes.
- Yes.
- Yes.
- Yes, I would. Different workspaces for different projects and Participants as segments. Not hierarchical enough e.g. sub-segments. This flexible approach is traditional file structures do not work but Virtual Gatekeeper is very useful as it forces you.
- Yes, if I could understand more.
- Yes.
- No, due to versioning/baselines that is to say segments are a flat structure
- I don't see distinction between Virtual Gatekeeper and traditional folders.

m) Do segments allow you to concentrate on current information while older information is moved to the background? Or would you prefer some other default organizational method?

- Segments are good but need more information. Find it hard to get head around terminology.
- Did not notice time aspect.
- Have to play a little bit more with software in order to answer.
- Having segments is useful.
- Needs to be alternative defaults e.g. older does not necessarily mean less important or organise on priority rather than time.
- Able to concentrate on current information.
- No as very good as this is useful. e.g. push button and changes such as switching back to what your doing when disturbed.

- Defiantly makes you focus on what you are doing and forces you so frustrating but may help break bad habits.
- Subdivided segments again e.g. more hierarchical based on project elements. On reflection might not want this.
- No, as direct comparison if needed on two or more document types at the same time to establish usefulness.
- Same as Internet Explorer and folders.

n) Do segments help you locate older information (say, because you remember the approximate time when that document was created)?

- Maybe.
- No, as too many segments so unsure where things are.
- Yes, it would as can remember when things were created. Had not appreciated sequence / time until now and would use this allot.
- Yes.
- Could do if 4 to 5 snippets but for 4 or 5 thousand then would not. Graphic in this instance would not help.
- Need to use the system more but yes it would.
- Might do but need more time.
- Yes.
- No, this is not of use to me. Implies a way of careful versioning and organisation with baselines against say date and time as a way of making this of use.
- Cannot answer based on trial.

o) Do you like the fact that you don't have to file and name your documents?

- No, as the act of finding / naming puts these elements into your memory.
- Like having control over documents and also did not save comments.
- Yes, as most irritating part of file systems. Reservation is typing in description of document I am bad at! Possibly an automated summarisation feature.
- Yes, time saving.
- No, at first but would prefer option to edit suggested name on saving.
- Yes.
- I am doing the same actions but in different way.
- Yes, but I like to move things around and create duplicate copies etc. Not sure how to move things around in Virtual Gatekeeper.
- Yes.
- No, as usually like deep trees and versioning.
- Actually naming and storing documents aids memory retention about a document so not naming means cannot remember where item has gone.

p) Do you prefer to name documents and store them in a directory?

- Yes.
- Yes, due to my experience therefore most comfortable with that.
- No, as directly structure can be helpful but often very confusing as structure of folders too deep. Copies in several different folders so duplicates!
- No, but down to trial and error.
- No, don't like them in a directory structure would prefer a document management system.
- No.
- Happy with Virtual Gatekeeper system as prefer it.
- Yes, at the moment.
- Neither for nor against

- Yes - meaningful names.
- Yes.

q) Do you find workspaces and segments useful concept for locating information?

- Could be depending on use case application.
- Yes, but do not see difference between that and a project folder with all information e.g. references, reports, emails etc.
- Have to be convinced if different folder structure or not.
- Yes.
- Yes, good idea - good for several programmers / projects for one person.
- Yes.
- Yes.
- Yes, to workspaces. Segments are a level which needs to be explored further but potentially yes.
- Yes.
- Yes - any form of partition is useful but less useful if have not gotten flexibility of other levels.
- Yes, probably but file structure (hierarchy) also useful.

r) Do you find workspaces and segments useful for maintaining collections of information over time?

- No more useful than standard windows file manager.
- Yes.
- Yes, potentially.
- Yes.
- Yes, really good.
- Yes.
- Yes, I would but would not want to clutter up segments etc e.g. demote or promote.
- Yes, easier over time. Problem I have is making comments over time as a significant challenge to continue doing so manually.
- Yes more useful for collections as you have to drill down to place in appropriate containers. Suggest existing systems (indexing) could be augmented.
- Yes.
- Yes, but hierarchical structures are also useful.

s) Were you usually able to find what you were looking for? If not, was the system frustrating in that respect?

- Hard to interrogate as need further training.
- Yes, frustrating, could not complete tasks so frustrated me.
- Not frustrating.
- Case of learning it but easy to pick up system.
- Yes
- Able to find what I was looking for.
- Yes, but like direct experience.
- Found everything.
- Very easy to find things. However, tool tips and names of segments / workspaces saying already used or something.
- Could find but ordering and search as mean to find thing. Do lots of search on a daily basis as it is natural to me so divide like this would be useful e.g. Google or *.doc.
- Never had a reason to look for complex documents but for easy aspects it was fine.

t) Do the names "project", "workspace", "segment" and "slice" make any sense to you?

- Understand all except a difference between segment / slice.
- Yes.
- Yes.
- Yes, by end of trial although reversing the training video content would be better.
- Yes.
- Not intuitive. Not sure come up with better naming conventions.
- They do but relationship and displayed graphically are a bit confusing.
- Yes.
- Yes.
- Yes to all.

u) What features or changes would you like to see within Virtual Gatekeeper?

- Feedback - as in hover over 3D objects and get tool tip style feedback.
- As before feedback and navigation. Improve workbench intuitiveness.
- Ability to speed up animation. Annotate 3D graphics so text on segments etc. Tagging made simpler e.g. Close windows and system automatically tags item.
- Brief introduction to system with audio.
- Ability to move data around quickly e.g. multiple segments open so can move 1 slice from 1 segment to another. Ability to have multiple segments / workspaces and clients open and move groups of data to make things scalable. Ability to have labels on 3D graphics.
- Arrow up icon change instead to an aerial view of segments so that could click on any level quickly so as to jump to it.
- Right clicking on 3D which appears to do some action. Light to bring up context menu to rename. Like to see auctioned information stored and latest information on website.
- Keep explorer open as well as Virtual Gatekeeper. Having comments directly on segment / slice objects as well. Names on each workspace and segment directly like tool tips.
- Selecting projects/workspaces directly e.g. Like a jump level guiding shortcut - level up replacement. Notification tools like "are you sure".
- Searching and versioning / baselines. Standard file system activities e.g. Move, copy, sort. Smartslices / segments e.g. Smartfolders on MacOS whereby the OS structure is automatically based on the data.
- Labelling and feedback on buttons. Indication showing where I was all the time. Images of web pages replaced with direct to page itself. Name empty elements not use numbers e.g. "undefined".

v) If Virtual Gatekeeper were a robust and supported piece of software would you continue using it?

- Yes, probably, but would have to see how useful for me compared to other methods like windows files structures.
- Yes very much so!
- Yes.
- Yes, but would like to try it out and compare it with other systems e.g. Filestreams and other managers we use, benefit would be once we could examine further although unsure what to select. There is no low price range document manager systems that are robust / good at certain areas.
- Yes.

- Yes. A number of features e.g. Integration with Outlook etc. Don't necessarily navigate in 3D but could. Tool like this would be highly useful.
- Yes but still unsure yet and would like to see how this worked with PowerPoint and Word documents. Filter access areas according to different criteria.
- Yes.
- No in preference to what I have seen at the moment since it is the same to what Windows Linux already provides. I could not see any benefit in the use of 3D over existing tools.
- No as not consistent with other areas or what I have at home. No advantages over existing tools. 3D is a waste of time as command line is faster.

Comments

- Resume from where last left off if had a problem. Down animation am not sure of that. Access segments / projects and how referenced including security. Perhaps a settings screen for animations?
- Like to log words and snapshot. Recover word documents not as webpage as log and snapshot. Company should consider this tool.
- Participant drew a picture depicting the plan view graphic as a means of jumping to different levels (see scanned graphic).
- Participant drew a picture depicting a horizontal thermometer view graphic as a means of jumping to different levels (see scanned graphic).
- Participant drew a picture depicting versioning of slicing indicating the multidimensional nature and where a baseline could be draw (see scanned graphic).
- Good effort.

Training Feedback Observed Notes Sample

- Participant is frustrated at the length of video and no audio or annotated bubbles highlighting areas of interest.
- Participant is bored after 8 minutes of silent training.
- Passively watches video as instructed. 6 minutes in gets irritated with length as watching with no audio is hard it was reported. Folds arms as watches video thereafter as frustrated.
- Participant remained at all times in the same position and posture.
- Participant statically watched video without change in posture. Participant repeated last two minutes of video for clarification and stated would have liked audio.
- Static position with one hand on the desk fairly relaxed. Did not change position during video training.
- Participant puts hand in left pocket. Makes reference to wanting audio in training. 3 minutes into training the Participant puts both hands on hips whilst watching. Participant moves forward when interested and rests left hand on knee. Participant would jump forward in the video by a few seconds.
- Participant stayed in fixed position reviewing video training.
- Kept a static position whilst watching video training with hands on legs.
- Participant made notes whilst watching video. Actually sitting up straight to watch the video. Participant rewinds, pauses and plays the video until they are satisfied they new the concept.
- Hand was always in pocket or folds arms. Frequently leans on the desk. Seems to close eyes on occasions as if bored.

Trial Feedback Observed Notes Sample


- Participant found an issue with the web browser icon on task 1. Participant types in the URL then hits enter key. Issues with other pages in application side of website. Possible to save website as favourites. Participants types in URL but could have use ctrl +x and ctrl +v if explored. Tasks were ok but loose where on the sheet so larger font needed. Trial needs a goal such as tagging a website to fill a workspace. Needs to be some explanation in regards to what participants should do and not do.
- Participant first hits enter key for the URL. Participant prefers File > Close as to using the X icon for closing application. Often a problem in that the software does not launch between task sessions quick enough so Participant has to click many times on the desktop icon. Second time the participant remembered about clicking with mouse instead of enter key. Participant had problem with last task as unsure of what do at "research" item as already saved it. Solution was not to click on cached page but to add a new one from URL. It shows that the participant is reluctant to type in long URLs as prefers fast links to information - Participant was frustrated but continued on. Body language now shows frustration (hand in pocket / harder typing of the keys) as thinks they have failed the task.
- Participant did not use enter key to go to the URL. Also uses history URL feature when selecting URL address so not having to repeat typing it. Task 1 was completed very fast. Participant did a ctrl C + ctrl V function on the keyboard for the URL but never used the enter key as preferred the mouse. Participant had a personal phone call in the middle of the trial but easily multi tasked using the software. ctrl C + ctrl V function was used by left and right hands. When the participant gets frustrated they would use the enter key on the keyboard for the URL and also clenched fist (left hand).
- Participant had issue initially with selecting anything other that the menus and did not like to click the 3D objects. Participant seems slower than most as did not absorb training material. Participant clicks enter then uses the mouse every time. Closed Virtual Gatekeeper and then double clicked very fast right after and so application did not launch as had not finished shutting down. Participant asked to look back over previous task in order to help instruct on what to do in subsequent tasks. Participant types in URL every time without doing copy / paste function.
- Participant had problems finding green level up icon at segment level whilst looking through slices. Participant presses "enter" key first before clicking go icon. Participant finished tasks 1 and 2 very fast. Participant types in URL every time and remembers not to press enter key second time.
- Participant went into project then came back out on many occasions. System crash when participant did not enter a URL. Participant restarted task rather than ask for help. Participant got stuck on segment slices when opening up an application. Participant typed in wrong URL each time and an error message popped up. Eventually Participant types correct page address. Task 1 restarted twice as Participant was unsure. Participant

uses mouse after twice clicking "enter" key by mistake. Participant had problems but persisted in completing tasks. Participant typed heavily on keyboard. Two instances were open and minimised.

- Asked what was own ParticipantID even after reading instructions. Picked up a ruler and placed on instruction sheet to aid with going through points. Asked about segment being green "selected" instead of two blue - upon further playing Participant realised as already selected. Participant always presses "enter" in URL bar upon typing in details. Participant moved and centred browser window. Participant feels he screwed up task 2 and therefore caused issue with part 6 in task 3 as forgot how to open up web browser window again. Participant copied and selected text in web page "right click" and highlight and then puts in tagging description. Participant liked reassurance that what he was doing was correct. Often asks questions whilst always knowing the answer.
- Participant predominately used mouse for all operations and only used keyboard when needed. Participant used one hand to enter data for URL and then went straight to mouse after clicking "go" instead of enter. Subsequently participant pressed enter key. Participant forgot two instances of Virtual Gatekeeper were running and opened a second copy. Did not remember to use system tray as the navigation method for get back to Virtual Gatekeeper User Interface. Failure of windows operating system was that it did mot launch .NET applications fast enough so leading to the Participant repeating the operation and having multiple copies of the application open - this caused problems as all files still saving were then in read only format and could not be re-launched whilst being written to and thus loss of data occurred when opening several instances of the application.
- Participant used the keyboard whenever possible rather than mouse e.g. "enter" key in URL. Very fast at completing task 1. Participant is very proficient at getting through the tasks and finds little problem with onscreen UI. Problem with Morea as data file was corrupt after recording and did not save the data.
- Participant hits enter and then mouse button participant made notes on task sheet as reminders. System crashed with error messages on slides and killed all of Virtual Gatekeeper. System remembered wrong Participant are log-in as in the fields it came up as David and not Andrew for some reason? Participant looks for reassurance when undertaking tasks e.g. "is that ok to do this" with my response of "please proceed". Ended trial before the conclusion of task 3 as internal error.
- Participant requested to write on sheet in making notes. Participant struggled using the software and looked irritated. Participant likes using the keyboard and "Enter" key. Participant became very irritated and said expletives like "Fxxx sake" when animations occurred. When participant was unhappy as believed an operation had been conducted wrongly the participant hit the keyboard more strongly. Participant was highly irritated in typing in URL every time.

Appendix 14

Supplementary Material

Supplementary Material

1.0 Semantic data modelling

Information overload has led to an explosion of perceived methods (Chapter 2) or novel ways of re-engineering the presentation layer's workspace (Chapter 4/5) through facilitating better management of task space. However, there is still a fundamental need, as seen in Chapter 3, for finding better ways that associate similar or related information, be it based on spatial location, orientation, subject, category, format, word or object type. Computing desktops have therefore ceased to be just simple tools for undertaking infrequent, unrelated or standalone tasks/operations, within the context of the author's own machine, but have instead be come the pivotal portal means for undertaking multiple tasks simultaneously and often in conjunction with other networked members of a project team using a multitude of communication mediums. Thus, connections and relationships between members or information datasets are then accessible by all members of the community establishing a rich information distribution base constructed around a topic, individual document or information embedded within a group of documents (sense making). This, according to Decker and Frank (2004b), now necessitates more finely-grained ways for understanding the context awareness (Stanford-Smith and Kidd, 2000, Gross and Prinz, 2003, Schfer *et al.*, 2002) and continuingly sharing/distributing this networked information, whilst simultaneously safeguarding privacy and establishing trust.

This level of granularity over both information/data presently exists to a limited extent through different sets of applications or through search engine tools that enable the interconnection of separate data items (Decker and Frank, 2004b). The failings of these approaches are clearly evident through the continued generation of unstructured electronic information document formats arriving without trusted metadata inhibiting automatic processing or filing on a recipient's machine and ad-hoc/proprietary file system hierarchies which harbour islands of information that might simultaneously be relied upon for a particular task. As Decker and Frank (2004b) purports, the application folder structure, current Windows-style desktop and document filling system provide limited support for organising or understanding the context of information embedded within documents. The utopian vision for the future can even be seen as far back as 1945 in an article called "As we may think" (Vannevar, 1988, Sauermann *et al.*, 2005), which detailed a system named 'Memex' that allowed an individual to store all books, records and communications and to derive meaning immediately. A follow up article called 'As we will think' (Theodor, 1991, Sauermann *et al.*, 2005), described a system called 'Xanadu' which would later become the predecessor of hyperlinking systems. A more modern day example can be seen in a system called ‘Lifestreams’ (Freeman, 1997) which tracks the thought trails or paths of recourses and builds up a personal information model on a particular category or topic.

The World Wide Web (Web) hyperlink system, as originally conceived by Tim Berners Lee (Sauermann *et al*., 2005, Yee, 2003), was launched in 1992 as a means of linking various sets of information documents. The main problem that was evident with the Internet and is tackled by its new extension called the ‘Semantic Web’ initiative are the failings surrounding aspects of ‘Hypertext’ specifically in the areas of metadata (embedded describing content) and labelled links, whereby information is given more well-defined meaning/links (Guha *et al.*, 2003). According Guha *et al.* (2003), a Semantic Web contains not only a single kind of relation (hyperlink) between resources, but also many different kinds of relations between different types of resources. Unlike hypertext documents, a Semantic Web denotes relations between real world objects such as people, places or events; thus relations are typically interconnected to resources that most pertain to the subject matter being queried and so enable computers to act upon the data more effectively (Bojrs *et al*., 2008).

A method that knowledge workers use for drilling deep into this semantically generated (modelled) set of relationships is via a mechanism approach termed a ‘Semantic Zoom’. It is described by Aigner (2007) as a non-graphical zoom mechanism which transforms views of the screen to show directly the underlying meaning (Aigner, 2007) and type of information

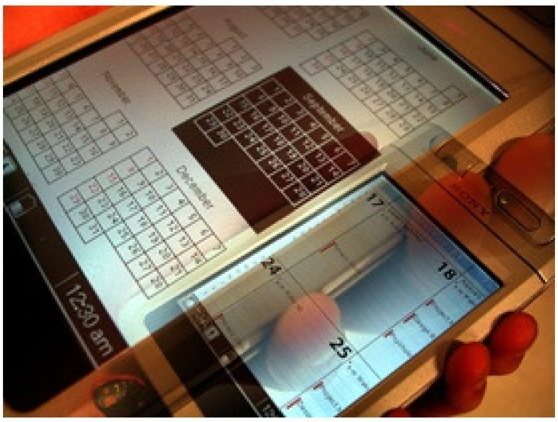


Figure 1. Semantic Zoom
(Yee, 2003)

contained inside a target object without modifying the screen parameters of the graphical representation but instead through the structure, physical properties (Watson, 2004, Aigner, 2007) or selection of the data that is displayed (Figure 1) and seems to be an extension to that of the direct manipulation approach as seen in HomeFinder which was published in a paper by Williamson and Shneiderman (1992).

The Semantic Web effort, according to Decker and Frank (2004b), provide specific standards and tools of XML, XML Schema, RDF, RDF Schema and OWL that are organized (Bojrs *et al.*, 2008) according to the Semantic Web Stack (Figure 2) as a definition for the exchange of semantic metadata based upon ontologies (OWL). These tools then combine to provide descriptions that supplement or replace the content as currently found within original Web documents.

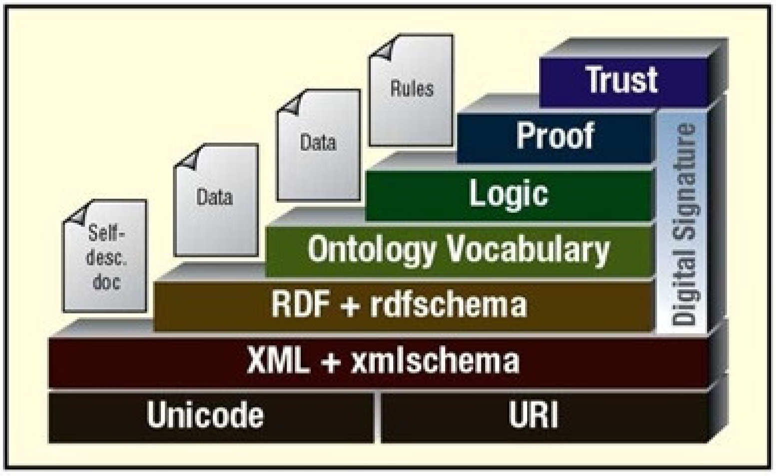


Figure 2. 'Semantic Web' Stack from the Tim Berners-Lee 2000 presentation
(Berners-Lee, 2000)

According to Yee (2003), the difference between Semantic and the non-Semantic Web path links can be illustrated through the following syntax notation:

Non-semantic web pages known as Web 1.0 and Web 2.0 use the following:

<item>**cat**</item>

Semantic web 'page' as described as part of Web 3.0 use the following::

<item rdf:about="http://dbpedia.org/resource/Cat">**cat**</item>

A Semantic link element thus provides more meaningful information about a link than a normal element through the inclusion of extra attributes and thus indicates the external linked relationship behind each item.

The 'Semantics' aspect behind the Semantic Web denotes a method of providing more meaning behind communications whereby it delivers the right information queried by a user rather than having a displayed set of semi-related (Chapter 3) traditional listed results (Yee, 2003). In a semantic data structure of this type, every concept can equally coincide with any other semantic network node which in turn is linked to other nodes (concepts) via specific semantic relationships in a hierarchy/hereditary structure like that of a brain. In this way, a semantic network data model enriches each concept with the characteristics and meaning of all nearby nodes so capturing and deriving more meaning from the knowledge worker application (Potter and Trueblood, 1988). Therefore, query information is viewed in a 'semantic space' of multiple dimensions such as by year, type of document, content or embedded keywords. Semantically queried text retrieval systems thus use mathematical representations of symbols (Schraefel *et al.*, 2005b, Wilson *et al.*, 2005, Wilson *et al.*, 2006b, Schraefel *et al.*, 2006b) in the form of text (words or phrases) in order to capture and compare quantitively the context specific meaning. Further, Wilson *et al.* (2005) continues that these systems reduce individual symbols to vectors within a higher dimensional space whereby the relationships between these vectors within semantic space capture information about the co-occurrence patterns between symbols that convey what the symbols actually mean in a given context known as 'latent semantics' and thereby make it possible to compare the meaning between individual symbols (Gillis, 2003) and/or higher order structures (such as groups of words or groups of word stems, sentences, paragraphs, whole documents, and even large bodies of documents). A recent example that employs this approach is a tool called 'mSpace mobile' (Schraefel *et al.*, 2005a, Schraefel *et al.*, 2006a, Wilson *et al.*, 2006a) that utilises a framework which gathers information according to an information space as a domain with specific awareness context dimensions (Gross and Prinz, 2003) and presents these back to the knowledge worker as a single window. In the mSpace tool prototype it was applied to the city of London as the domain, with the dimensions being locations of interest like Cinemas, Restaurants, Public Transport, Places and History. This tool either automatically queried items based upon the persons' location or alternatively based its queries upon text inputted by the knowledge worker at a given location.

Data models created as part of a Semantic Web of document nodes are characterized as 'derived data' whereby it is created through the instantiation of node relationships at the time of query and thus are not actually stored within a database in any physical form but are produced or derived as required (Potter and Trueblood, 1988). These data models are classified according to three categories of relational, functional, and semantic network and focus on an entity object and associated properties. The subtle differences between these approaches are that whilst the first two are in fact extensions to traditional data modelling approaches, the semantic network approach looks at extending these through the derived data relationship method whereby it provides a powerful abstraction construct such as 'generalization' where similar objects are grouped as a single object or 'aggregation' where models are created based upon abstraction of the intrinsic properties/attributes of an object (Potter and Trueblood, 1988). The core theme behind the Semantic Web initiative is that knowledge workers can use their desktops as a personal semantic web, where individual applications integrate and ideas are equally inter-connected (Sauermann *et al.*, 2005).

The term 'Semantic Desktop' was first coined by Stefan Decker (Decker and Frank, 2004a) and elaborated upon by Leo Sauermann (Sauermann *et al.*, 2005) which eluded to an infrastructure that would enable agents to uniformly access or share data between different applications or tasks. Prior to this Microsoft had announced (2003) a product deemed the 'Information Bridge Framework' (Sauermann *et al.*, 2005) which coincidently provided a means for accessing/connecting various data sources from within office documents using 'SmartTags'. It was the eventual intention that the 'Information Bridge Framework' would become subsumed as an integral part of an operating system codenamed 'Longhorn' where the name was replaced as 'Vista' (2005) and seems to have been where Decker had taken part of his inspiration. The aspiration for Longhorn was that it would incorporate a new file system built upon a relational database (derived from SQL Server 2005) termed 'WinFS' (2003) which would effectively support the management of metadata on all levels through a well defined schema from disk storage to the user interface (Decker and Frank, 2004b) whereby any application could reuse the data; and using the relationships, related data could be effectively organized as well as retrieved. However, the aspiration of 'structured storage' was later shelved before 'Vista' was ever shipped (2007) as a finished product along with many other unrelated features. A Semantic Desktop is thus further defined through a project called 'Gnosis Semantic Desktop' (Sauermann *et al.*, 2005), as a device with a consistent single user interface (Sauermann *et al.*, 2005) where an individual stores their personal information and this is interpreted as a Semantic Web resources and given a Uniform Resource Identifier (URI) whereby all data is then queriable through a Resource Description Framework (RDF) graph. Ontologies and taxonomies then allow the knowledge worker to express personal mental models and to form interconnections between information and systems. Desktop computer applications would then store, read and communicate via these ontolologies using the Semantic Web standards (Sauermann *et al.*, 2005, Potter and Trueblood, 1988). Decker (Sauermann *et al.*, 2005) further extending this approach through a vision of how differing areas, such as social networks and peer-to-peer file sharing services, could eventually evolve to a point where in combination with semantic technologies they provide a 'Networked Semantic Desktop' (Sauermann *et al.*, 2005) which enables social communities to further collaborate directly through the interconnections on their desktop and by leveraging shared views (Decker and Frank, 2004b) of desired information datasets. The experience being that the knowledge worker searches both their own content and the network participant's content combined.

This approach is very much different to today's Information Retrieval (2008) approaches where a knowledge worker must use a separate search application (Chapter 3) to find items based upon the occurrence of words in documents or instead look through an online indexing tool such as a search engine for a result. What is different is that the traditional approach relies on a high degree of accuracy in constructing the right words, sentences or phrases, whilst the semantic network approach automatically associates information based upon leveraging XML and RDF data from semantic networks and pushes the information to the knowledge worker rather than requiring the knowledge worker to pull it.

2.0 Hyper-semantic data modelling

Hyper-semantic data modelling expands upon the techniques already found in semantic network data modelling (aggregation/generalisation) through incorporating an extra 'hyper' prefix which s used to denote objects with more than three spatial dimensions (de Wijn, 2005). Principally, it extends it through incorporating knowledge (such as inference) and even more meaning (i.e., over and above) associated with an application through capturing the objects, operations, flexible constraints, temporal relationships and heuristics (Miller *et al.*, 1990) which are not already captured as part of a semantic data modelling foundation. In this way, hyper-semantic data models proved an even more accurate representation of an object's situation than can normally be captured by semantic data modelling methods alone or other conventional techniques, accomplished by a consistent method for representation, manipulation and multilevel management. Potter and Trueblood (1988) further define hyper-semantic data modelling as including:

- Generalization, where similar object types are abstracted into a higher level object type via the "is-a" relationship
- Classification, where specific incidences are considered as a higher level object type via the "is-instance-of" relationship
- Aggregation, where an object is related to the components that make it up via the "is-part-of" relationship
- Membership, where several object types are considered as a higher level set object type via the "is-a-member-of" relationship
- Constraint, where a restriction is placed on some part of an object, operation, or relationship via the "is-constraint-on" relationship

- Heuristic, where an information derivation mechanism is attached via the “is-heuristic-on” relationship
- Temporal, where specific object types are related by synchronous or asynchronous characteristics and considered as a higher-level object type (Potter and Trueblood, 1988)

In information systems situations, synchronous objects are always directly related to other synchronous object associations by either a predecessor or successor relationship where it can be visualised as a node in a doubly linked list or chain (Potter and Trueblood, 1988). Whilst asynchronous objects are related to other asynchronous objects through a concurrent or parallel notion such as a post condition to initiate another object or the satisfaction conditions that may trigger other related objects. Thus, hyper-semantic data modelling allows for a unified view (Potter and Trueblood, 1988), control of/access to data (values of attributes), metadata (schema), knowledge (constraints or heuristics) and meta-knowledge (constraints or heuristics which apply to objects that are constraints or heuristics). Whilst semantic data models simply look at the top down view of drilling into data objects, hyper-semantic techniques consider the associations and temporal aspects around them.

3.0 Independent space dimension

In the course of expanding the semantic/hyper-semantic underpinnings of an ontological model two false directions were explored namely Albert Einstein’s General Relativity (Walter, 1999) or Niels Bohr’s Quantum Mechanics (Greene, 2003). These proved to be irrelevant since a conjoined space-time (Appendix 1) fourth-dimension does not allow for a separation of space and time in a compacted view of the universe such as a Klein bottle. Often when a reference is made to four-dimensional coordinates using the Einsteinian fourth-dimension notion, it is likely that it is referring to three spatial dimensions plus a space-timeline.

Historically, in 1916 Einstein showed that the force of gravity warps and ripples within the four-dimensions of space conjoined with time. However, four years later in 1919, Theodor Kaluza (Duff, 1994, Schaar, 2005) proposed a radical theoretical model that electromagnetism might also have ripples, occurring within an additional hidden dimension. Kaluza proposed that if General Relativity was extended by an extra separated dimension (Duff, 1994) with an addition of an extra separated set, then Einstein’s theory of gravity with Maxwell’s equations for electromagnetic radiation, could potentially be combined (Feltz, 2005, Schaar, 2005) although he could never actually prove this. The theory suffered from the major constraint that if there were an extra separated dimension why had it not already been seen?

Kaluza sent this proposed theory to Einstein for review (Feltz, 2005, Greene, 2003) who, for two years, wavered over it and held up the publication of the paper. It was finally accepted in 1921 when Einstein wrote back with a belated agreement accepting the possibility of extra dimensions to those which he had originally proposed.

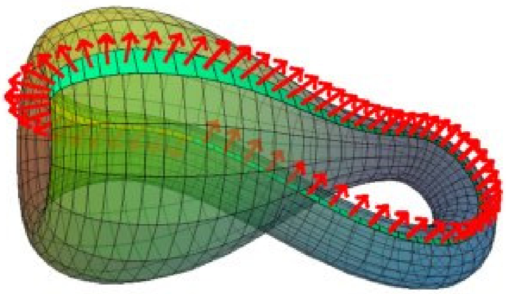


Figure 3. Klein bottle of space-time
(Banchoff, 1990, Polthier, 2003)

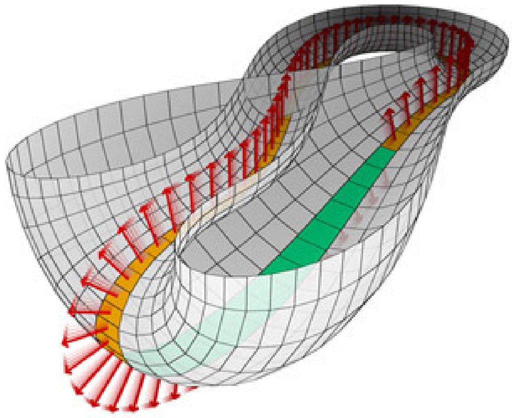


Figure 4. Half of a Klein bottle with Möbius strip
(Banchoff, 1990, Polthier, 2003)

Thus, the possibility of an alternative model theory to a conjoined space-time was established. In 1926, Oskar Klein, further refined this theory (Forsyth, 2001, Finstad, 2002, Greene, 2003, Duff, 1994) by hypothesising that an unseen fourth-dimension, was rolled up into a straw type cylinder or hosepipe (Duff, 1994, George_Mason_University, 1995, Greene, 2003) circle and which from a distance, looks like a straight line. Thus, space has a topology of R^4 x S^1 according to Duff (1994), with a topology similar to a hosepipe: at large distances it looks like a line R^1 but closer inspection reveals that at every point on the line there is a little circle, and the topology of the point is R^1 x S^1 (Duff, 1994). This compacted unit of space (Schaar, 2005) is often termed the '*Klein bottle*' (Feltz, 2005, Banchoff, 1990) as seen in (Figure 3). The Klein bottle (Figure 3) was first postulated in 1882 by Felix Klein (Feltz, 2005, Banchoff, 1990, Polthier, 2003), who described it as a one-sided closed surface that had no border, enclosed interior nor exterior and was deemed very similar to that of the Möbius band in 2D (Figure 4) as postulated by August Ferdinand Möbius in 1958.

The Kaluza-Klein theory is a model that seeks to unify the two fundamental forces of gravity and electromagnetism. In modern geometry this extra dimension can be understood as a circle group (Schaar, 2005). Until recently, any suggestion that there was an alternative to the accepted view of a conjoined fourth space-time dimension was either viewed with complete suspicion or ridiculed by the scientific community (Greene, 2003) and subsequently ignored. Indeed, Kaluza-Klein theory was ignored for many years and did not re-emerge until String theory was formulated (Greene, 2003). String theory, was proposed by Gabriele Veneziano in 1968, and looks at the dual resonance model of the strong interactions between very small particles. Veneziano's idea was that elementary particles, the substance which makes up all universe matter, rather than points, are strings that vibrate or wiggle along with other, higher dimensional geometric objects (Szendrői, 2005). The resonance, or frequency of this vibration, dictates the mass of the particle, and the force carried (Truephysics, 2003). The theory presupposes according to Gefter (2002), that there are up to twenty six individual spatial dimensions. However, whilst the theory describes matter it does not explain the space in which these fine strings 'wiggled' according to the theory. The theory appears to be the first to utilise Kaluza-Klein's work as the fabric foundation of dimensional space, as other research areas, like Quantum Mechanics, follow the Einstein route of a conjoined space-time.

Indeed, this research is ongoing, as a published theory by Edward Witten in 1995, called '*M-theory*' (Greene, 2003, Musser, 2006), sometimes called '*U-theory*', proposes a 'master, membrane, or matrix' theory whereby the universe exists as membranes (branes) of hidden parallel dimensions (Figure 5), much like slicing up a loaf of bread, with vibrating strings at the boundary (Figure 6) which are part of a larger open membrane structure linking membrane universes through a hidden fourth spatial dimension. This unifies the five superstring theories (Weinberg, 1999) by eliciting that the physical world is pinned to a 3D sheet (brane) that is located in higher-dimensional (hyperspace) space, whereby all forces are based around very small vibrating strings, producing eleven dimensions (one of time, three of x y z, an independent space and six curled up dimensions). The six dimensions are folded or 'rolled up' in the String theory approach to below the subatomic level or under the M-theory approach as large, or even infinite, in size higher dimensions that are parallel to the physical world.

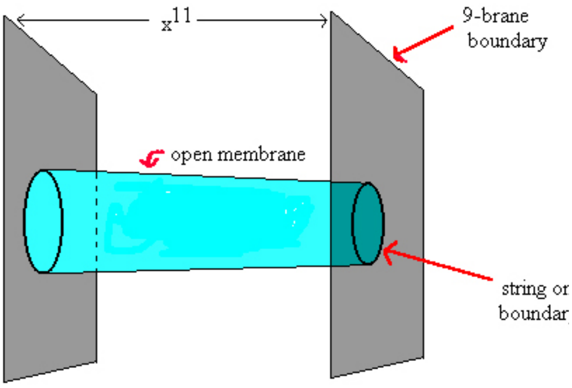


Figure 5. Open Membrane (M-Theory) between hyperspace dimensions showing a string on the boundary
(Pierre, 2006)

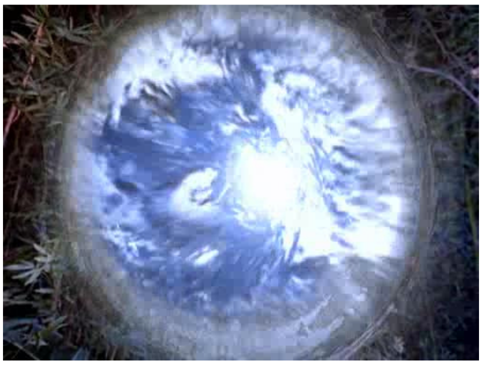


Figure 6. 3-space view of a boundary membrane as envisaged in the Sliders television series
(Tormé and Weiss, 2004)

However, where ‘Time’ is placed in this explanation of the universe is still being debated (Bryanton, 2006, Steffes, 2004, Maudlin, 1988) as if time is considered four-dimensional then the extra spatial dimensions would be ‘five-dimensional’. Depending upon the point of view, a Timeline could be considered paths which twist, turn or branch (choice, chance, influence of others) at any given moment in different directions (Bryanton, 2006) through past events or futures by using a fifth-dimensional level, whereby it might seem as if it is in the fourth-dimension but actually part of the fifth-dimension. Alternatively, time could be positioned as either a zero dimension where all positive-numbered dimensions after that are considered spatial or placed after a fourth-dimension as all previous dimensions could be considered spatial and time could be considered a timeline whereby jumping between dimensional paths or branches is achieved via the zero dimension interacting with the fourth.

Lee Glashow at Boston University points out (Greene, 2003), there is still no known experiment, as yet, that can prove (Gefter, 2002) that these strings or even these extra dimensions even exist, as no part of the theory can be tested in a laboratory or seen in space through a telescope. He additionally argues that science should only be based upon experimentation/observations and that this theory seems only to fit a need/facts which makes it permanently safe, a view also supported by Gefter (2002), from being proved wrong as presently it is totally theoretical. Continuing work, however, into justify M-theory comes from recent work by Fotini Markopoulou Kalamara who has developed a way of connecting General Relativity with Quantum Theory (Gefter, 2002) by proposing that the building blocks of matter are tiny, one-dimensional strings and that various vibrations of these strings play the familiar medley of particles as if they were musical notes (Gefter, 2002). However, more significant recent work (2008/9) at CERN laboratories with a Large Hadron Collider (World_Science, 2008) will look into directly rebutting critics by experimentally testing for extra dimensions by smashing atomic nuclei (gravitons) head-on at nearly the speed of light, creating new, energetic and very unstable particles. These particles quickly disintegrate or ‘decay’ to showers of detectable, lower-energy particles. This experiment will then measure the before and after patterns of this decay. It is hypothesised that this experiment might indicate the shape of unseen dimensions as some gravitons might pass directly into these dimensions through the collision. If this does occur then it is thought it will provide the first significant experimental evidence that these extra dimensions do indeed exist.

This debate is uniquely important for this thesis as a foundation to an information universe, as the conclusive establishment of an independent spatial dimension could lead to higher level parallel dimensions being instilled within Euclidean/*non Euclidean* geometric structures as applied through semantic/hyper-semantic data modelling techniques. This extra dimension could then become the very means for holding vast repositories of extra describing information, over and above existing hyper-semantic data modelling methods in regards to linking object relationships, constraints and associations together, whilst the alternative conjoined space-time approach at present could lead to an ongoing debate on how very large or infinitely small objects could coexist mathematically together, or even be linked, within this view of the universe. If the metaphorical approach for present computer systems is based upon real world objects as seen by a knowledge worker, it is therefore reasonable to assume that any weaknesses or indeed strengths in interacting with these objects would potentially be mimicked or imported in some form into an information universe. Thus, it is proposed that a new combined ontological and presentation approach is required for categorising and interacting with this new information environment, building upon the perceived strengths that an independent fourth spatial dimension can bring - notably more 'space' and better ways of categorising and linking information.

4.0 Geometrically structuring an information environment

Mathematically, the theoretical geometric data structuring methods which allow extreme flexibility of metadata in an information universe are found within the realms of *n*-dimensional geometry (Figure 7 and Figure 8) where descriptive metadata can be stored in a linear (one-dimensional) array fashion, but can then be folded (multidimensional structure) in 4-space (manifold) to be linked within 3-space to any part of a dataset (*n*-dimensional arrays).

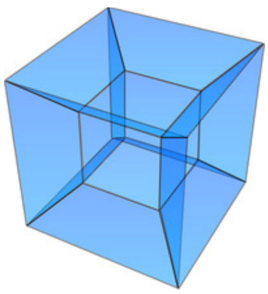


Figure 7. Hypercube
(Weisstein, 2002)

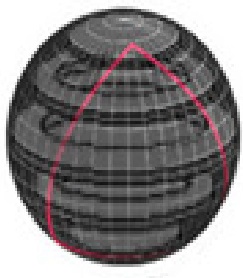


Figure 8. Hypersphere
(Weisstein, 2003)

Non Euclidean n-dimensional geometries can be distinguished by the behaviour of parallel lines, where according to Munzner and Burchard (1995), in Euclidean space only one line passes through any given point which is parallel to a given line, but in *non Euclidean n*-dimensional (hyperbolic) geometry there are many lines. In a famous book entitled '*Flatland*' (Abbott, 2007) an attempt is made to make further sense of this through an analogue of how beings of lower dimensions interact with higher dimensional objects. In a subsequent book called '*Sphereland*' (Burger *et al.,* 1983) it elaborates on the geometric complexities of a hypersphere (Figure 8), where it suggests that a knowledge worker in 3-space observes only slices, as the rest of the object can only be visualised as a whole when viewed from a 4-

space perspective. To elaborate further, in hyperbolic space, the area of a circle grows exponentially in respect to the radius, whereas in Euclidean space the area only grows linearly to the square of the radius (Munzner, 1995, Burger *et al.*, 1983). An alternative modern day metaphor, that illustrates how a person who exists in the real three-dimensional space could interact with this structuring geometry, could be that of the TARDIS (Figure 9) a scenic prop in the BBC television series Dr Who. The TARDIS is famous for being structurally larger on the inside than the outside but it is never explained mathematically how this could be the case with any degree of scientific acumen.

Figure 9. TARDIS hypercube internal structure
(B.B.C., 2003)

If the TARDIS were instead only part of a larger hypercube structure, then crossing the threshold at the doorway would mean that a person was stepping into a fourth-dimensional hidden corridor that exists only in 4D space. Thus the full extent of the TARDIS structure can not be seen fully from 3D space and might simply resemble that of a 19^{th}-20^{th} century police box, disguising the full extent (Figure 10) of the actual fourth-dimensional geometric shape if it were ever rotated.

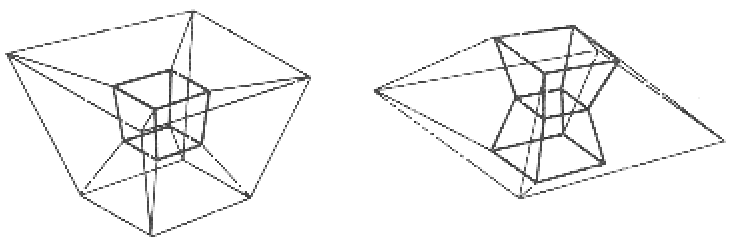


Figure 10. Two views of a hypercube rotating in 3-space
(Peterson, 2001, Banchoff, 1990)

Thus, the prefix of hyper is often used as a means to refer to four or more higher dimensional analogues of three-dimensional objects. In essence, in an information universe, all metadata stored within these mathematical structures can touch each other through the use of an additional dimension of 4-space. The metadata areas of interest would be points within this manifold, where each point is identified by a set of coordinates and each coordinate is a member of one specific dimension.

5.0 Interconnected session spaces that provide pathway linking

When reflecting back to an office desktop workspace where multiple knowledge workers are logged onto the same computer but have different desktops/applications running (Figure 11 and Figure 12), this can be classed as different sessions. A knowledge worker might be

Figure 11. Windows XP showing fast-user switching
(Microsoft, 2002)

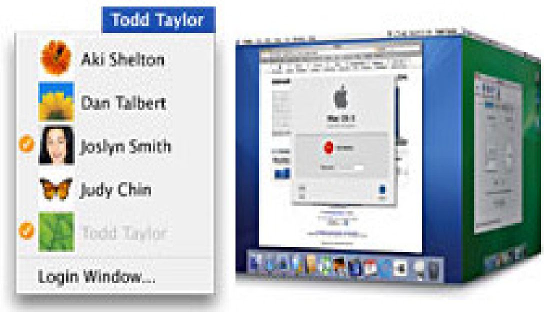


Figure 12. MacOS X showing fast-user switching
(Apple, 2004b)

working at a single workstation which may require multiple knowledge workers wanting to log into it over the course of a day which is not an uncommon requirement in organisations that utilise ‘hot desking’. In this case, these knowledge workers may want to resume uniquely saved locations of files (state in time), but might also want to switch between different day sessions or switch between different knowledge worker account sessions and/or tasks at the same time, without having to close the programs that are currently being run. Organisations presently have this ability, to a limited extent, within standard Window XP (Microsoft, 2002) and MacOS X (Apple, 2004a) desktop implementations, which provides switching/resuming of workspaces (Figure 11 and Figure 12), akin to that of workspace desktop managers. More recently, the conceptual approach of a cube structure for animated session switching as a manager for the traditional office desktop can be clearly seen in both MacOS X (Figure 12) and Mandriva Linux (Figure 13) desktop environments. The very inclusion of this geometric cube into mainstream office desktop environments indicates that organisations are starting to understand the real potential benefits, beyond that of academic research, over the traditional single workspace architectural approach as the small monitor screen size is seen as more of a serious impediment than was once appreciated, as more information becomes increasingly electronic on a wider set of hardware platforms.

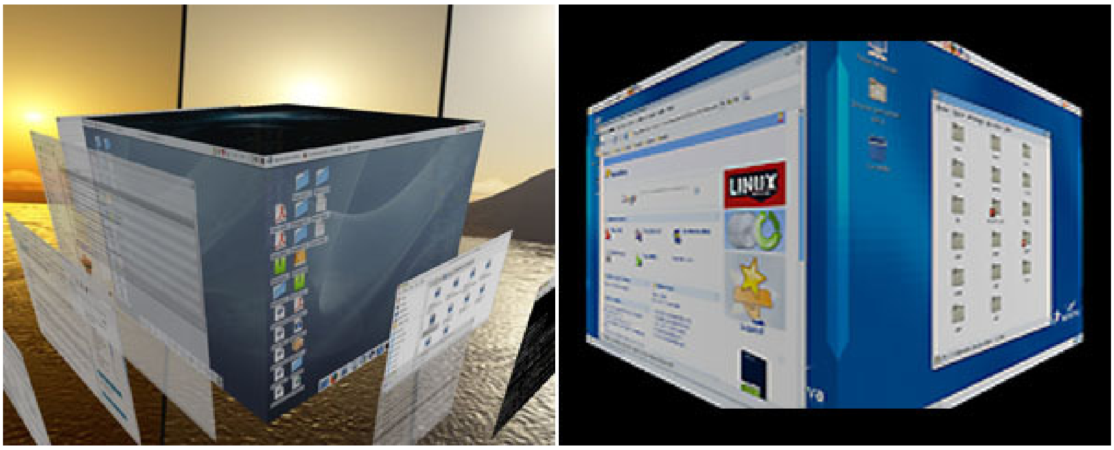


Figure 13. Mandriva Linux showing the 3D cube desktop
(Mandriva, 2007)

Indeed, as seen in Figure 14, small screen device platforms are also utilising the cube approach to overcome the physical limitations of screen size as a way to represent session switching between screens of applications. In the case of TouchFlo, which is the underlying software technology to that of the Touch mobile (Figure 14), screen action space selection is limited to that of a person's finger. It responds to a finger sweeping across the screen and thereby rotating as a 3D object a set of 2D icon menus. Upon selecting an action menu item from one of the screens, the application then takes up the full screen space similar to that of Browse3D (Figure 19) or WebBooks (Figure 18).

Figure 14. HTC Touch mobile device with TouchFLO 3D cube
touch screen experience
(HTC, 2007)

The merits of a touch screen only button interaction approach to navigating 2D menus over traditional tactile buttons is currently being hotly disputed for devices such as the IPhone (Krazit, 2007) and the TouchFLO 3D feature on the HTC Touch phone. According to Henderson and Card (1986), although commenting on envisioned interaction approaches back in 1983, suggested that such systems would provide added value to the knowledge worker as they potentially could overcome the problem of finding information paths without getting lost. Further, they suggested a knowledge worker could then more readily make a mental model cognitively about whether a set of actions are to the right, or to the left. In traditional hierarchical menu systems, when option nesting rises above say seven menu levels (Miller, 1956, MacGregor and Lee, 1987, Lee and Raymond, 1993), a knowledge worker, it is believed, will find it hard to navigate. The strong aspects from both the Touch mobile and the Linux Desktop 3D cube session switching approaches is that they both employ zooming and animation (Robertson *et al.*, 1998) to help increase screen space and to focus the knowledge worker on a given task without cluttering the screen. Indeed, in the case of the HTC Touch mobile it even attempts to remove the need for the knowledge worker to interact with the underlying file system through focusing the knowledge worker's attention on these preconfigured action screens. However, where the Touch mobile approach falls down is that it does not go far enough with these screens and once three actions are undertaken in sequence, the knowledge worker is taken into a finger unfriendly application-based interface where they are required to use an alternative input stylus tool in order to interact with it. The key feature here of note is that the management of sessions and document paths are reduced to a simple geometric Euclidean structure which can be applied in both a small screen and large screen workspace environments.

Since 1995 (Chase, 2002) the World Wide Web has been playing an increasing role in the business workplace with the evolution of integrating operations or services (Turban *et al.*, 2000) and knowledge-based information systems (Clifton and Sutcliffe, 1994). This revolution of changing work practices has brought with it the problem of information overload, as seen in Chapter 2, where even the simplest query is accompanied by a flat one-dimensional results list (Munzner and Burchard, 1995) which can be overwhelming and confusing. These lists provide a means to view many documents at once, but offer no help towards understanding the connections behind, or between, items. Even two-dimensional Web browsers, whilst providing a way to focus on an individual document with all its outgoing connections, do not show incoming links from other documents or mind map overviews of more than one document at once (Munzner and Burchard, 1995). There appears to be (Dumais, 1988, Marchionini, 1995, Shneiderman *et al.*, 1998, Dalsgaard *et al.*, 2005) very limited support provided in helping knowledge workers collect, organise and determine relevancy of items through them being presented textually, as lists of emails, Internet links or news reports

(Czerwinski *et al.*, 1999). The ultimate goal for organisations is to reduce the time cost of information access and increase the scale of information that a single knowledge worker can handle (Robertson *et al.*, 1993) in order to share this distributed data with anyone, anywhere at any time, collectively termed as '*e-business*' (Turban and King, 2003) a broader term employed by IBM in 1999. This has impacted upon the evolution of the graphical office desktop environment, through Internet browser application technologies becoming closely integrated with that of operating system environments as a method for low-cost, immediate accession of objects in use (Robertson *et al.*, 1993). As Robertson *et al.* (1993) assert, a workspace is an environment in which the cost structure of the required materials is turned directly into the requirements of the work process using them.

The state of technology at it exists in 2008, is that knowledge workers can no longer distinguish some processes, operations or tasks, as being unique to their computers alone, as data is shared/updated automatically over the Internet or from corporate disparately connected Intranet databases. In distributed environments such as the Internet, documents would be returned as long results lists, which are not the most efficient way to present large volumes of information to a knowledge worker (Li and Danzig, 1995). Therefore, the Internet can be described as a vast interconnected hyperbolic structure of hierarchical page document nodes which are very difficult to conceptualise as a simple mental model (Munzner and Burchard, 1995). Providing visualisation of connections between links or the reasons why a certain path was taken is therefore very difficult. A knowledge worker may select one node or Web page link element, on one Web site and then move directly to a totally new Web site on a separate computer server, geographically spaced on the other side of the world. To the knowledge worker the path they have taken has a clear reasoning, but this is very unique to him/her, as different individuals may select other, or prior, links to the route undertaken. The value for organisations and individuals may not therefore necessarily be in the destination, but in the shortcut path taken to the required document, as it could give a detailed insight into the reasoning or background of why that path might be important for a specific job function. It is apparent that a clearer mental model or conceptual framework, utilising new innovative visualisation approaches, as seen in Chapter 5, for viewing these path interconnections in relation to the destination data, needs to be established. In these solutions, data is presented using two-dimensional graphical displays systems that arrange documents in two-dimensional space based on their inter-relationship where knowledge workers can move easily between topics or browse topical clusters (Li and Danzig, 1995).

This evolution of integrating Internet technologies seamlessly with computer desktop interfaces can be seen in various levels of knowledge worker-authentication technology (Wilcox, 2001), traditionally only used inside an Internet browser, but this now providing the knowledge worker with the ability to navigate various secure Web sites, without the need to log-in every time. An example is the stored details feature in Mozilla Firefox (Mozilla_Organization, 2004) which facilitates the same experience of navigating files, windows or folders as on found their computer storage repositories. Also, knowledge workers are being encouraged to share data more readily. A knowledge worker at his/her computer is now not only presented with a single set of file system documents, but also views of the file systems or menu levels (Mullet and Sano, 1995, Galitz, 1997) presented through numerous other shared mediums, like other computers or Web sites. This can lead to loss of data as the file system is too large or hierarchically complex to enable recognition of the pathways taken to retrieve as a single task document. Alternatively, due to the rapid pace at which content is updated on remote storage servers, a document required on another subsequent occasion may have been removed or changed. So it is entirely possible that the required content information no longer exists. Indeed, this has become so much of an issue, that libraries (B.B.C., 2004) are trying to store a-state-in-time of certain parts of the Internet, described as a unique insight into life online. In addition, it was also pointed out that there is a real danger that valuable educational, cultural or scientific resources on the Internet could be lost in the future due to increased seamless use of integrated electronic information, as in the past it was archived as book collections which do not rely on any special methods of viewing the information. It is the belief of this author that the hierarchical structure of computer storage repositories, the graphical presentation task interface and the Internet related documents should be considered by organisations as synonymous, or as a single entry portal and not viewed as disparate elements for obtaining or gathering source information.

In the traditional office desktop environment, knowledge workers spawn multiple application windows for the purpose of accessing multiple items of information for reference or comparison purposes. Often these windows overlap and cause task clutter as knowledge workers are often unable to find the root task window in relation to the other linked window items that they have opened around it, so '*sense making'* or '*knowledge crystallization*' (Pirolli and Card, 1999, Wexelblat and Maes, 1999, Card *et al.*, 1999, Russell *et al.*, 1993) is impeded (Card *et al.*, 1996). According to Card *et al. (*2004) this can be further described as a person foraging for information, digesting it, organising it and then finally authoring a product which acts upon it. In the case of conventional Web browsers, knowledge workers are always at a particular page which is at odds with the conventional ways with which they interact with information in the real world. Here they often have multiple opened books, reports or other items available on their desks where they can be simultaneously juxtaposed, rapidly accessed, and structured, through grouping or other layout methods (Card *et al.*, 1996). Current Web browsers try to facilitate methods of alleviating the sense making problem through the use of bookmarks or favourites, wherein knowledge workers can store individual document address in order to construct a personalized information workspace (Czerwinski *et al.*, 1999).

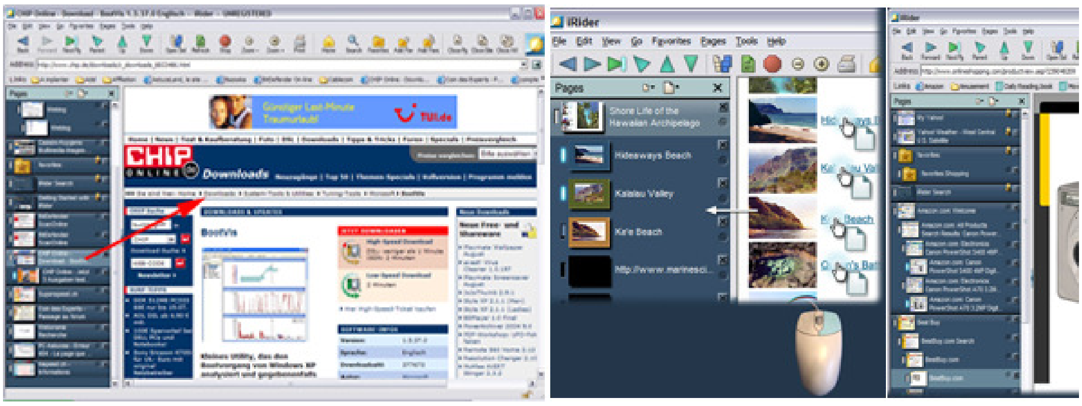


Figure 15. Irider 2.1 Web browser previews multiple links or pages at once
(Irider, 2004)

However, this approach also suffers from the information overload problem, once the numbers of bookmarked items exceed a certain number limit. Other approaches that are being employed to alleviate the sense making problem are to record the page items or documents that were previously visited or potential links that a knowledge worker might like to select such as in the Web browser called Irider (Figure 15).This browser facilities a method to pin together visual collections of pages that a knowledge worker might consider relevant to a given task so that they can go back to them later. This technology also allows for dragging open collections of web pages which a knowledge worker might want to quickly access together and these collections are named based on a given task or some other identifying name. Whilst this approach is solely based on Internet documents, an alternative, which is currently under development, and targeted at the more general office desktop environment, is called Stuff I've Seen (Microsoft, 2004).

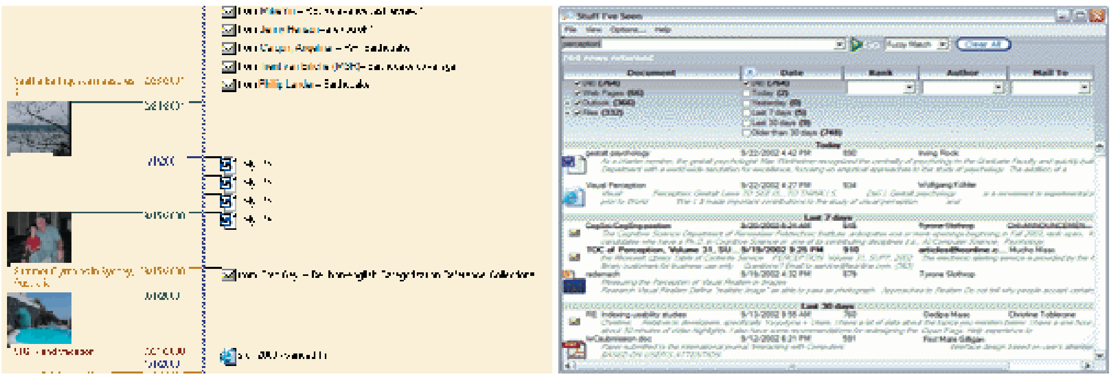


Figure 16. Stuff I've Seen makes it easy to find information seen
(Microsoft, 2004)

This controversial approach (Oiaga, 2007) which harvests knowledge worker information, takes a bird's-eye snapshot view of every electronic conversation or document that a knowledge worker uses over a given day. Stuff I've Seen's (Figure 16) knowledge worker interface is describes as combining both hierarchical and map like views of Web sites and other electronic information observed during a given day as thumbnail graphics. According to reports (Microsoft, 2004) the main theme is to let knowledge workers easily see the whole forest of previously viewed electronic information and drill down to individual trees that are relevant to what they need.

However, whilst both these approaches, although very similar, try to help solve the sense making problem, they are in fact compounding the problem further. The Stuff I've Seen approach creates a mini-screenshot of everything that has been accessed along with a link to that item, but the question remains about what happens if the frequency of documents on any given day for multiple tasks or multiple knowledge workers using the same computer, creates a list that is hard to navigate through? As an example a single workspace might be used for multiple tasks and therefore the screenshots taken might not reflect the ultimate path destinations that the single knowledge worker was actually undertaking, since they might simply be switching between documents due to the high number of application windows open. In the case of the Irider example, this is limited to only Web page documents and whilst the technique of collections with a named title is a good one, it creates a separate hierarchy structure to that which is stored on the computer hard disk in relation to folders. In both cases these approaches do not yet solve the spatial issue, but instead try to optimise the currently flawed approaches.

In order to try and alleviate the sense making problem and to avoid information overload, according to Czerwinski *et al.* (1999), there are a number of cues designed to facilitate spatial cognition, with the most obvious being 3D depth cues of perspective view, accompanying size differences and occlusion, especially when pages are being moved. According to Kahney (2000), there have been a number of different 3D browsers including MIT blocks; however, CubicEye (2ce_Inc., 1999) is a recent commercial browser (Figure 17) that utilises the room metaphor (Card and Henderson, 1987, Robertson *et al.*, 1989) and the ability to save groups of task Web page windows within a single cube.

Figure 17. CubicEye 3D Web browser
(2ce_Inc., 1999)

According to Bergstrom (2001), instead of opening and minimizing separate browser windows, CubicEye shows six pages as if they were on the inside wall surfaces of a cube allowing a knowledge worker to flip the cube to work on a selected page and zoom to full screen for more detailed or extended view. However, although this system seems to provide an improvement in terms of utilising 3D screen space, it really still only exhibits the same characteristics as featured in the Irider Web browser. However, it does mean that windows can be located faster as they do not overlap and are immediately evident based on a wall screenshot of the Web page. The features of this system seems to come from those first developed for WebBook/WebForager (Card *et al.*, 1996) which can also save groups of Web pages as books (Figure 18).

Unlike the CubicEye approach, the WebBook/WebForager appears to be a 3D version of the Irider Web Browser, but unlike the Irider approach, which can appear cluttered or confusing on occasions, WebBook/WebForager could equally be applied to managing documents on the office computer desktop as a way of replacing the traditional presentation system.

Figure 18. WebForager and WebBook an information workspace for the world-wide web
(Card *et al.*, 1996)

What is unique about this approach is that it moves a single document unit of interaction to a higher aggregate utility (Card *et al.*, 1996) or WebBook collection, whilst at the same time preserving screen space through the use of 3D animation. This is achieved by using the clear indication of the relationship between the pages of the book, and a real world metaphor of a bookcase where items are stored through gestures as a filing method for these books. Current Web browsers focus attention, according to Card *et al.* (1996), at the link and page level, whilst WebBooks are a natural abstraction above this layer. WebBooks can be removed from the bookcase through a single mouse click and returned with a gesture of the mouse whist linked book pages are navigated through page flipping. Card *et al.* (1996) go on to say that the book metaphor used for both 2D and 3D applications is not new as it was used in 1987 by Card and Henderson as part of a 2D book simulation called Catalogues as part of a Rooms system.

What is explicitly new about WebBook in relation to Irider and other derivatives is the integration of animated 3D books to show collections of pages within an information workspace manager called Web Forager. The Web Forager manager is an approach for a task-based information workspace where according to Card *et al.* (1991), it is arranged in relation to interactions, into a focus place where a book is open at full size for interaction between knowledge worker and content; an immediate memory space where pages or books can be placed when they are in use, and a tertiary place such as the bookcase where many pages and books can be stored. It is suggested by Cockburn and McKenzie (2002) that any knowledge worker interface that can further exploit the human capability for spatial cognition will greatly improve task performance. It is suggested that the Web Forager is a first step along the route to achieving this (Cockburn and McKenzie, 2002). More recently these WebBook characteristics have been seen in a Web browser called Browse3D (Browse_3D, 2002). It employs both zooming, animation and provides a visual history, within switchable 2D animated windows (Figure 19). This technique appears to be very similar to that of the TaskGallery (Robertson *et al.*, 2000) or Irider approaches, where a knowledge worker can go to a palette and select/retrieve tasks, whilst saving the whole workspace as a single uniquely identifiable name.

Figure 19. Browse3D 3D Web browser
(Browse_3D, 2002)

Whilst all these interfaces appear to be very different in both presentation and description, indeed utilising the 3-space at times, they all seem to share key features whose origins can be traced back to earlier visualisation systems with the principle aim of improving the existing office desktop metaphor. Indeed, previous research (Robertson *et al.*, 1998), has even demonstrated that where a radically new metaphorical approach has been adopted, such as WebBook/Web Forager (Card *et al.*, 1996) or Data Mountain (Robertson *et al.*, 1998), compared to currently available systems, there was a clear performance increase on the part of the knowledge worker when working on everyday task information. However, it seems that the flaw with present systems design is that it relies on a single workspace for multiple knowledge workers/tasks which in itself leads to a standardised presentation approach that potentially is not ideal for everyone concerned with trying to work with information. Indeed, as Henderson and Card (1986) assert, it carries with it a constraint on physical screen space, where only a limited numbers of items can be adjacent to other objects without them overlapping or loosing screen definition through resizing. This puts clear constraints on how the space can be arranged and how densely items can be packed, often requiring knowledge workers to toggle or constantly move things around which in itself can be irritating. Therefore, there seems to be a need for an abstraction layer above that of a workspace, which can consider a group of tasks pertaining to a named workspace and then can consider several named workspaces revolving around a single knowledge worker profile which is customisable. These multiple knowledge worker workspaces provide the ability to switch between knowledge workers or workspaces and provide a unique history path per workspace session that can aid with working again on that task. The technique behind many forms of session management, as illustrated by conceptual drawings (Chalmers_Medialab, 1999b) for workspace task/session switching (Figure 20 and Figure 21), is where a knowledge worker would access a computer terminal profile through a login/password and then would be given a view of named workspaces available only to the individual to allow different tasks to be allocated per workspace.

Figure 20. 3DWM, 3D workspace manager (Chalmers_Medialab, 1999a)

Figure 21. Multidimensional session workspace as envisaged for a Stargate SG1 television episode (Devlin, 2003)

Session workspaces employ characteristics such as being geometrically orientated as different cube faces, or linked to each other in some other way, perhaps non-spatially (Henderson and Card, 1986).

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