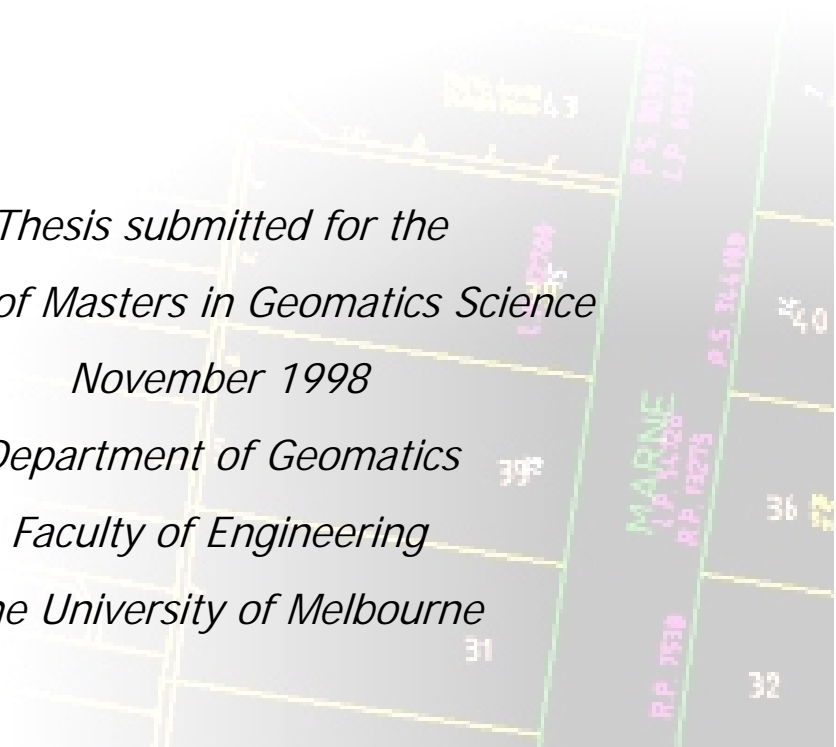


*Facilitating the use of cadastral
data through the World Wide
Web*

Iestyn Polley



*Thesis submitted for the
Degree of Masters in Geomatics Science*

November 1998

Department of Geomatics

Faculty of Engineering

The University of Melbourne

Abstract

Over recent years the cadastral industry has become increasingly reliant on digital data. Many surveyors now submit digital survey plan data to accompany the legally required hardcopy maps and documentation, although it will not be long before total digital lodgement will be possible. In this environment it will be ideal to capitalise on computer networking technology such as the present day Internet and World Wide Web (WWW) to better facilitate the transmission of digital data.

This work provides a study of the current climate in the cadastral industry and further identifies how the Internet and its related technologies can be used to facilitate the transmission of digital cadastral data. The focus is to provide a prototype application that facilitates these data transactions in the most effective manner that benefits both user and data provider. This involves a study of the different underlying Internet technologies and how they can be used within the cadastral context. The work presents how the Internet and the WWW can bring benefits in the form of increased data distribution, and, in data integration and update for data maintainers, who need efficient ways of passing digital data to and from different locations.

The thesis covers topics such as the current cadastral system, the future trends in digital data handling within this industry, current cadastral online applications, a technology review and how this can be combined in the most appropriate manner. One aspect that is presented is the extension of current Internet one way flow of information into a two way flow, allowing selected users to pass digital data on to the data server in addition to the traditional method of receiving data from the server. The study includes the background for the cadastral context, the component technologies and their appropriateness in that context, and the capabilities that such a system would present to users.

The thesis presents a number of conclusions resulting from the research work. The cadastral discipline is becoming more digital and is slowly adapting to the increased need for dealing with digital data. The Internet can provide a medium for dealing with digital cadastral data, because of its vast networking abilities. A

generic model for the general provision of spatial data on the Internet is presented, including user interface strategies and database interaction strategies. The component technologies that make up such a model are also presented and reviewed. A system that provides spatial data on the Internet is designed bearing in mind the generic model, the most appropriate component technologies and the digital cadastral data handling requirements. A proof of concept implementation is presented to illustrate these principles in action.

Declaration

This is to certify that this thesis has not been submitted for a higher degree at any other University or Institution.

This thesis is approximately 30,000 words in length.

Acknowledgments

I would like to gratefully acknowledge the following people for their advice and input into my research (in no particular order);

- Wolfgang Effenberg, Department of Geomatics, The University of Melbourne
- Andrew Phillips, Department of Geomatics, The University of Melbourne
- Katie Falzon, Department of Geomatics, The University of Melbourne
- Tai On Chan, Department of Geomatics, The University of Melbourne
- Bill Robertson
- Dozie Ezigbalike, Department of Geomatics, The University of Melbourne

I would like to thank the following people for their time and for letting me visit their organisations;

- Brian Marwick, DataFlow Pty. Ltd.
- Steve Jacoby, Land Victoria
- Peter Lennon and Graeme Rush at the Department of Natural Resources, Brisbane

I would also like to acknowledge;

- Gunther Birznieks and Selena Sol for their freeware CGI-handler Java Source Code
- Rammi for allowing access to his DXF-viewer Java Source Code

This research was made possible from a collaborative Australian Research Council (ARC) grant jointly funded by Land Victoria and the Surveyor General's Department New South Wales. I would like to thank these organisations for their support.

And last but definitely not least, I would like to graciously thank my supervisor, Professor Ian Williamson, for his advice, experience and help, which without whom, this thesis would never have been completed.

Contents

Abstract	ii
Declaration	iv
Acknowledgments	v
Contents	vi
List of Figures	ix
List of Tables	x
1 Introduction	1
<i>1.1 The Study Context</i>	<i>1</i>
1.1.1 Wider research context	1
1.1.2 Focus of this research	2
1.1.3 Links Into Other Research Projects	3
<i>1.2 Conceptual Framework and Research Design</i>	<i>4</i>
1.2.1 Problem Statement	4
1.2.2 Type of Study	4
1.2.3 Delimitations and Scope of Study	7
1.2.4 Research Methodology	8
<i>1.3 Summary of Thesis Structure</i>	<i>10</i>
<i>1.4 Chapter Summary</i>	<i>11</i>
2 GIS, the Internet and the Cadastre	13
<i>2.1 Chapter Overview</i>	<i>13</i>
<i>2.2 Victorian Cadastral System</i>	<i>13</i>
2.2.1 History of the Victorian Cadastral System and DCDB	13
2.2.2 The Current Victorian System	15
2.2.3 The Impetus for Cadastral Reform	17
2.2.4 Cadastral Data Update and Upgrade Strategies	19
2.2.5 Heading into the Digital Age	20
<i>2.3 GIS Developments</i>	<i>21</i>
2.3.1 Government Initiatives and Spatial Data Infrastructures	21
2.3.2 Commercial Movements	23
<i>2.4 Internet and the WWW</i>	<i>24</i>
<i>2.5 Current State of Spatial Information Provision</i>	<i>26</i>
<i>2.6 Chapter Summary</i>	<i>28</i>
3 WWW Technologies for DCDB Data Transactions	30
<i>3.1 Overview</i>	<i>30</i>
<i>3.2 Review of Technologies</i>	<i>30</i>

3.2.1	Static Files	32
3.2.2	CGI Overview	32
3.2.3	HTML Forms	33
3.2.4	Java / ActiveX	34
3.2.5	Plug-ins	36
3.2.6	Interoperability of Systems	37
3.2.7	Data Encryption, Server and User Authentication	38
3.3	<i>Chapter Summary</i>	43
4	Online Data Applications	44
4.1	<i>Chapter Overview</i>	44
4.2	<i>Why Review Existing Applications?</i>	44
4.3	<i>GIS Vendor Products</i>	45
4.3.1	Assessment Criteria	46
4.3.2	Autodesk MapGuide	47
4.3.3	ESRI	48
4.3.4	MapInfo	49
4.3.5	Intergraph	50
4.3.6	Discussion on Components in Major Products	51
4.4	<i>Online GIS Approaches - Components of Real World Online Cadastral Applications</i>	52
4.4.1	New Brunswick Real Property Service	53
4.4.2	TerraNet Property Information Service	54
4.4.3	Finland's National Land Survey MapSite	55
4.4.4	Discussion on Real World Applications	56
4.5	<i>Model for a Typical Online GIS Application</i>	57
4.6	<i>Chapter Summary</i>	60
5	Components of an Online System	61
5.1	<i>Chapter Overview</i>	61
5.2	<i>Service Components</i>	61
5.3	<i>System Architecture</i>	65
5.4	<i>User Requirements</i>	68
5.5	<i>Data Requirements</i>	70
5.6	<i>GIS User Interface</i>	71
5.7	<i>Java</i>	76
5.8	<i>Security Model</i>	81
5.9	<i>Chapter Summary</i>	83
6	An Online System	84
6.1	<i>Chapter Overview</i>	84
6.2	<i>The Prototype System</i>	84
6.3	<i>User Interface</i>	85

6.3.1	Loading Custodian Data	86
6.3.2	Loading User Data	89
6.3.3	Data Viewing	90
6.3.4	Data Submission	90
6.3.5	Data Download	91
6.4	<i>System Security</i>	92
6.5	<i>WWW Server</i>	93
6.6	<i>Data Server</i>	94
6.7	<i>Cadastral Data Transactions</i>	95
6.7.1	Examples of Use	96
6.7.2	Current Limitations of the System	98
6.8	<i>Chapter Summary</i>	99
7	Conclusions and Recommendations	100
7.1	<i>Basis For Online Systems</i>	100
7.2	<i>Internet Technologies</i>	101
7.3	<i>A Typical Online Cadastral Application</i>	102
7.4	<i>Summary of Conclusions</i>	103
7.5	<i>Future Research</i>	103
7.6	<i>Concluding Comment</i>	105
	References	106
	Glossary of Terms	115
Appendix-1	Perl Script	117
Appendix-2	Java Application	119
Appendix-3	Java Applet	120

List of Figures

Figure 1 - Cadastral Data Flow in Victoria (Effenberg et al., 1998)	16
Figure 2 - DCDB Update Data Flow (Jacoby and Marwick, 1997)	16
Figure 3 - Integrated System reaches mainstream users	27
Figure 4 - Basic Client Server WWW Setup	31
Figure 5 - Assessment Components.....	46
Figure 6 - Generic Model of a Typical Online GIS Application	59
Figure 7 - Three Tier Architecture	66
Figure 8 - Convergent's Spatial Data Manager - (Marwick, 1997).....	67
Figure 9 - The User's View of the System	69
Figure 10 - Basic Window Layout.....	75
Figure 11 - Interaction Flowpath with the Database	78
Figure 12 - Digital Certificate and Encryption Interaction	83
Figure 13 - Applet User Interface.....	86
Figure 14 - Data Load Window.....	89
Figure 15 - Private Surveyor	97
Figure 16 - Spatial Data Customer	97
Figure 17 - Casual User	98
Figure 18 - Flow Chart of Perl CGI program functionality	117
Figure 19 - Flow Chart of Java Application Functionality	119
Figure 20 - Java Applet Source Structure.....	121
Figure 21 - Java Applet Functionality Flowchart	122

List of Tables

Table 1 - Purchasing Options	62
Table 2 - Maintenance Options	62
Table 3 - Data Delivery Methods	63
Table 4 - Submission Mechanisms	64
Table 5 - Update Mechanisms	65
Table 7 - User Characteristics	73

1 Introduction

1.1 The Study Context

1.1.1 Wider research context

The growth of the Internet has been meteoric, and there are predictions that the online commercial market will grow by a factor of ten by the year 2000. The telecommunications carrier Optus has predicted that the value of Australian commerce online will be \$2 billion by 2000, while other sources suggest that the present global figure of \$3 billion will increase to \$150 billion by 2000 (Ministerial Council for the Information Economy, 1998).

The Internet's growth accelerated as a result of the development of the World Wide Web (WWW) in the early 1990's. Introducing a connectionless, stateless client – server paradigm, it allowed users to download information from other computers, typically containing a range of textual and graphic information. With its rich content and potential to reach a global audience, it has demonstrated itself as a valid information gathering and distribution tool. The practical uses and the underlying technologies of this information tool have developed at a great rate to the point where it is now possible to conduct commercial transactions 'online'.

“There is no doubt that the Internet is changing the way in which we get access to information and the volume of data that is at our disposal. The Net affects the way we learn and the way in which we practice our business.”

(Dale, 1998)

The spatial data industry has entered a stage where, economic rationalism has taken a great importance, particularly in government organisations. This has led to organisations and processes undergoing reform to enable the

“... delivery of outputs which satisfy performance standards and targets established in the budget in terms of quality, quantity, cost and timeliness”

(Vertigan, 1996)

This has led to greater commercial roles being played by many government units, which aim to be commercially competitive and recoup a return on the services or products that they provide. An example of this is the Victorian state Digital Cadastral Database (DCDB), which, being a digital representation of the geographic land parcel information across the state, is sought after by many data resellers. The value of the DCDB is such that it now features prominently within the cadastral system itself, as part of cadastral maintenance processes and cadastral operations, and subsequently the increased use of this digital product is perceived to be highly desirable.

1.1.2 Focus of this research

This work provides a study of the current climate in the cadastral industry, and further identifies how the Internet and its related technologies can be used to facilitate the transmission of cadastral data over the Internet, given the needs of both providers and users of cadastral data. While this information is used in the development of a prototype application, the focus is on the appropriateness of different techniques and technologies, and how they can provide services that could bring benefit to the cadastral industry. The work presents how the Internet and the WWW can bring benefits in the form of increased data distribution, and also in data integration and updating for data maintainers, who need efficient ways of passing digital data to and from different locations.

The cadastral data flow process in Victoria will be introduced, noting its current and likely future digital components, while recalling that the cadastral process is still legally hardcopy map based (Falzon and Williamson, 1998). This will result in the identification of a need to facilitate digital cadastral transactions, a need that can be addressed through the use of a digital networking medium such as the Internet. The development of tools that enable that to occur will allow more efficient use of digital data, resulting in improved benefits which come from using that data.

A focus of this research is to study how the Internet can be applied to enable use of cadastral digital data, given current technical capabilities, and the needs of cadastral data users and providers. Transaction security and data authentication

will be reviewed, as will the capability of current Internet technologies to handle these and other needs. In response to this study, a prototype system will be developed and presented to demonstrate the principles associated with conducting cadastral transactions online.

A major contention associated with this prototype is the extension of the Internet's primarily one directional flow model of data, to that which allows data to flow in two directions. This, it will be shown, is important in the cadastral context, where users who download data are often in the position of being able to upload data as well. An example of this is the typical licensed private surveyor, who, after downloading a portion of the DCDB, often is in the position of being able to upload an updated version of that portion of data. This model is a relatively new development for the WWW, which currently focuses on the server serving out information, but rarely receiving it in any non-trivial quantities from the user. The design of such a model, given the needs, background and requirements of all concerned, is a major part of this thesis.

1.1.3 Links Into Other Research Projects

This project is one of several research efforts being conducted in the area of cadastral reform and development. The research effort at the Department of Geomatics at the University of Melbourne is dealing in areas of digital lodgement, spatial data infrastructures, upgrade and update of digital cadastral systems, and diffusion of GIS in management organisations. The focus of each of these projects interlink, touching on areas researched by the others, providing an integrated research effort into the developing cadastral system of today.

Each of these are important works, as they embrace areas of research that are of direct importance to the research presented in this thesis, even though they do not fall within its scope. For example, the project investigating the digital lodgement of survey plan information deals with the issues within a digital lodgement system (Falzon, 1998), and subsequently, is related because of the digital lodgement possibilities raised within this thesis. The project dealing with spatial data infrastructures is related through the data distribution potential of the system described within the body of this thesis. Another project studies a digital cadastral

system's update and upgrade processes (Effenberg, in progress), a topic which is touched on by the potential of the system described in this thesis.

This interlinking of research directions means that this project has a context within a wider research effort. The collective effort means that a much broader and in depth research initiative can be maintained in this particular area and that the potential to cover more intellectual ground is realised while avoiding duplication of effort.

1.2 Conceptual Framework and Research Design

1.2.1 Problem Statement

“Study the appropriateness of Internet Technologies given the current climate in the cadastral industry in Victoria, and show what Internet Technologies can be used for in a cadastral data context, focussing on the effective transmission of digital data, in both directions from the custodian to user and from user to custodian.”

1.2.2 Type of Study

This research is primarily the study of a technical solution to a real world problem. The research deals with the background of the problem, the technical requirements that are essential to the resolution of the problem, and the resolution of the problem itself.

This study can be broken down into a series of components – the background research, case studies, and application design / implementation. These can be further broken down into more logically self contained units, which are:

- cadastral industry background;
- existing applications / systems use of technology;
- assessment of technology as applied to a cadastral role;
- design and implementation of a system utilising the technology;
- an overview of a prototype system.

These form the basis for each of the chapters within this thesis.

Background Research

This project deals with issues such as the present cadastral system, current technologies dealing with data on the Internet, application design and GIS implementation. The project studies the current cadastral system, the cadastral data flow process, the move by the system towards the digital age, the deficiencies in the current system in coping with the digital age, and the latest developments and trends within the system. Background is attained on the Internet technologies and their advantages and disadvantages in general, and more specifically in the context of cadastral data applications. Some research is also performed to get a background in the use of GIS technology in the Internet / WWW contexts, and their use in facilitating online data applications.

The Victorian cadastral system has been largely studied by such persons as Williamson (1994), Hesse (1990), Jacoby (1997), to mention but only a few. This section of the research is capably covered by such literature, and by literature generated by others within the industry and academia.

Most of the background research comes from journal articles, industry magazine articles and essays, and from the WWW itself. Literature in the area of the Internet is essentially limited to journals and conference proceedings as studies of the technology are too new to be included in many texts.

The study of existing systems and implementations draws on similar sources, as there is often little literature associated with many commercial products. This requires the assistance of trade magazine reviews and articles, and in many cases physical testing of such systems is performed, to gain insight into their technical components and capabilities. The study of online systems, such as those dealing with cadastral data, provides insight into how different problems were resolved, and how well different component technologies perform in these situations.

Case Studies

This research involves the use of a number of case studies. These are useful for providing an insight into how digital data systems work, and how they incorporate different technologies into their operation. The case studies included operational cadastral data systems, and commercial WWW intended data systems

and products. The study of the latter were used in the identification of Internet technologies, the proliferation of their use, and provided an insight into identifying the technical components necessary for an online mapping or cadastral data application.

A study of the Basic Land Information Network (BLIN) system, as described in Lennon and Berenyi (1997) and in Department of Natural Resources (1994) was conducted by study of its documentation and by personal communications with some of the people involved in its creation. This included a trip to the Department of Natural Resources building in Queensland to see the system first hand. Although not Internet enabled and at the time of review and at the time of thesis publication, it was perceived that the system was intended to be made available on the Internet in time, and that the system provided a good example of implementation strategy and of the back end components of such data systems.

A study of the Real Property Information System produced by the New Brunswick Geographic Information Corporation and the University of New Brunswick as outlined in Arseneau (1997) and others, was also undertaken. This included reviewing the available literature on the service and using a guest account to actually interact with the system. Use of the service allowed for a study of its front end implementation.

Studies of similar online systems originating from New Zealand and Finland were also conducted.

Commercial products were studied using review literature and commercial literature. In some cases, examples of software were procured and tested. For example, ESRI's ArcExplorer, and the AutoDesk MapGuide plug-in system, were two examples that were procured and tested in this manner.

The role of the case studies in this research context was one of component technology review and identification. These were used to identify and review the appropriateness of technology that would be used in the prototype application.

Application Design and Implementation

The program implementation focuses on showing the design for a WWW application that could facilitate the transmission of cadastral data through the Internet. The implementation deals with issues relating to user interfaces, links with a WWW server and linkages through that server to a database server, and importantly, the cadastral processes modelled within the system.

The research identified a number of technologies that were to be used in the implementation, including Java as a front end programming language, an SQL database server, and others. These were used in order to approximate the needs of such an application, including the data formats supported by the data custodian, the type of users (for example, the private surveyor and others), and the needs for data integrity, security and so on.

This work presents the resulting implementation by showing the design factors that were taken into account, and the capabilities of the resulting application. Low level programming issues were not considered to be within the scope of this research work.

1.2.3 Delimitations and Scope of Study

This research studies the cadastral system, in particular the data flow processes, and identifies limitations and possible improvements, but does not attempt to go beyond what has been identified in current literature in this area. That is to say, this project follows the work of others in the area of cadastral reform, and subsequently provides a technical solution to problems and reforms that are identified. This work is a response to future trends within the cadastral system as identified by others, and provides a technical solution to one part of the system given the current system and those future trends.

The technical implementation applies some processes which potentially have legal and institutional ramifications like, for example, that of digital lodgement. Recent works from other sources, such as industry and academia, demonstrate that a more digital environment is desirable to make the cadastral processes more efficient, however this is impossible under many current legal and institutional arrangements. The institutional and legal issues are for the most part ignored, as

the prototype demonstrates processes that could be useful in a digital cadastral environment which are not yet part of the legal data flow process.

The technical work studies available Internet and WWW technologies, and how to apply them given the cadastral context. It is not intended to provide an analysis of one commercial product over another, but instead identify the processes and practices that may have been adopted by some commercial products and show how they are relevant in the cadastral context. Also, it is not intended to provide a technical implementation to rival commercial products, as this would take the focus away from the model used in the implementation to the specific implementation itself.

1.2.4 Research Methodology

The research began with an examination of the GIS applications that were, at the time, available on the Internet. This provided an insight into the breadth and depth of these applications, and to what uses they were being put. A review of recent literature devoted to the development of particular systems further added to this, and also explained implementation issues and reasons for implementation. Participation in and organisation of a seminar devoted to GIS and the Internet enabled the acquisition of information from the local GIS industry in regards to industry products, online strategies, and general attitudes from both Government and industry sources (Department of Geomatics, 1997).

Examination was extended to include the background technologies that enabled these systems to be created. In this way an idea of the technical composition of these systems was derived, which led to the further review of all available technologies capable of delivering GIS and mapping systems on the Internet. The examination included the study of online examples, literature regarding the implementation of online systems, and the technology itself. Technology literature included reviews and comparisons of technology components, reviews of technology applied to online GIS applications, and critiques of the emerging use of GIS on the Internet.

Attention was now turned to the cadastral discipline, and in particular the processes involving the Digital Cadastral Database and land registration. This

was supported by visits to DataFlow (who at the time was contracted by the Victorian Government to maintain the DCDB) to help understand more about the DCDB, and the Land Titles Office to help understand more about the registration system. Interaction with fellow research students conducting work in areas of digital lodgement, digital cadastral systems and spatial data infrastructures provided extra insight into these areas. Participation in a number of seminars devoted to the cadastral industry were also performed, such as an Internet and Utility Organisation seminar which discussed utility companies attitudes to the ongoing reforms of the cadastral system (Department of Geomatics, 1997), and also a State / Local Government seminar which discussed further reforms to the cadastral system.

At this point the development of an online cadastral application was begun. This meant learning to program in Java, and developing Internet GIS and database applications. This work allowed the establishment of the internal specifics of such a system, and allowed more clarification of the system design itself. A major technical component that was identified was facilitation of two way mapping data flow across the Internet, a concept that to current knowledge, has not yet been implemented anywhere. An appraisal of industry online mapping and GIS applications was made at the vendor displays at the AURISA 97 conference, which demonstrated the latest products and the functionalities they enabled.

The final direction taken was the writing of the thesis, which allowed the formulation and design of an online cadastral application in concrete terms. This included defining the relevant cadastral processes, the processes to be provided in the online application, and the design of the application to handle these processes itself. Attention was also paid to development of variations to the present processes to enable them to be handled more efficiently in a digital environment. Examples of this are that of digital lodgement, which is still only just being introduced in some cadastral jurisdictions, and of the two way flow of mapping data as previously mentioned. The final clarifications and implementations were also made at this point.

1.3 *Summary of Thesis Structure*

The thesis is broken into major components which are each presented in a chapter. The chapters are intended to run together, providing background and information that is applicable to each successive chapter.

The introduction presents the background context of the thesis, the argument focus within that context, and the basic elements that comprise the thesis itself. It details the components of the research and their context to the overall contention, and finally the structure of the report itself, given the logical structure of the research.

The second chapter presents a detailed background of the systems and industries associated with the cadastral, GIS and Internet industries. This overview provides insight into how the proliferation of digital cadastral data has seen the need for reforming of processes in order to deal with this type of data more efficiently and appropriately. The component systems and industries are presented in this context, as are the currently perceived reforms needed to enable the systems to function more effectively.

The third chapter focuses on discovering what goes into a system that provides cadastral data over the Internet through a study of existing applications and systems. This study aims to isolate the different components that make up such systems, and through a process of break downs, identify the general approaches and methods used to provide cadastral data over the Internet. The study concentrates on areas such as system layouts, user interfaces and the user's data handling capability, the ideal usage situations and users for different applications. A differentiation is made between systems produced commercially, or the 'off shelf' vendor systems, and those that are real world implementations. A result of this particular study is to provide a general outline for an online GIS or spatial data application.

The fourth chapter presents a study of the various Internet technologies that could be used in an implementation of a cadastral data application. This study rates competing technologies given the needs of cadastral data users and servers, and the general capabilities of each. This chapter draws on the cadastral background

knowledge and the use of technologies in other applications, as discovered in the preceding chapters, to enable a study to be made. By the end of this chapter it will be apparent which technologies would be ideal to use in a cadastral application.

The fifth chapter, drawing on the results of the preceding chapters where appropriate, describes the layout of a system that allows the transaction of digital cadastral data through the WWW. Sections are devoted to studying projected user type, supported data types, the system layout and architecture, user interface issues and other related items that must be considered in such designs. A system specification is developed, and the components are presented and justified. By the end of the chapter it is demonstrated what could comprise such a system in design and technical components.

The sixth chapter presents a system that was developed to the guidelines presented in the preceding chapter. It textually and graphically details the capabilities of the system, as a 'walk-through' type showcase of functionality and capabilities. It presents the functions and capabilities available from the user's point of view. It also shows the layout and overall architecture of the system, and presents the interactions that occur at the server and database that are invisible to the user. This chapter is the culmination of all the preceding chapters, presenting the system given the background of the earlier chapters.

The final chapter provides a summary of the thesis, bringing together the contentions and conclusions of each chapter in a format that answers the initial problem statement and focus of research. Also presented is a section on how this work can be extended in the future, with future directions and possibilities.

1.4 Chapter Summary

This chapter introduced the context of the thesis, by presenting the wider context the thesis sits within, the problem statement, the types of study, background research and research methodologies, and the structure of the thesis itself.

The context for which this thesis is appropriate was presented, defining the current situation within the world, then within the cadastral discipline itself. The situation and the pursuant issues that relate to it were also briefly introduced as a basis for a research work that would address some of these issues. A problem

statement that encompasses the aim of the research work in one sentence was generated in response to these issues and the context for the work in general.

The type of research conducted was presented, including background research, the case studies performed, and application design and implementation. The background research section basically described the types of literature reviewed during the course of the project. The case studies were used to ascertain information about currently existent systems and added depth to the research work done through literary channels. The culmination of this research was that of an application design and implementation.

Also presented were the limitations and extent of the scope of the research work. This described the areas of research that were not going to be researched but which were of direct relevance to the topic of the thesis. The research methodology was presented, which described the processes and the order of research events that occurred during the course of the work.

The final section of the introduction described the structure of the thesis document itself. The major topics for each chapter were introduced, as was their relevance to the thesis overall and with each other.

2 GIS, the Internet and the Cadastre

2.1 Chapter Overview

This chapter provides a background on the GIS, Cadastral and Internet industries, and the directions that each has been moving in recent times. It demonstrates the existing situation and presents the context for which an online cadastral application is desirable, appropriate, and possibly, even necessary. Discussed will be the contention that while each industry has been a discipline in their own right, recent developments have seen the emergence of a combined spatial data industry, composed of what currently are separate disciplines, to produce an integrated paradigm in spatial practice and thought.

2.2 Victorian Cadastral System

2.2.1 History of the Victorian Cadastral System and DCDB

A look at the cadastral system in Victoria is instructional, as it demonstrates the development of the Digital Cadastral Database (DCDB) in that state, and the background to the issues that are key elements in contemporary discussions involving the DCDB. It is interesting to note that before the creation of the DCDB's around Australia, states such as Victoria did not have a cadastre in the pure sense of the word, as there was no jurisdiction wide cadastral map. However, it was accepted that the system that was in place could be described as a cadastral system (Williamson, 1983).

In Victoria, as in the rest of Australia, land titling follows the Torrens System of land registration (Larsson, 1991). The cadastral system could be split into two major sections, that of the Surveyor General, which dealt with unalienated crown land and that of the Land Titles Office (LTO), which dealt with alienated, privately held land. The influence of the LTO grew as more and more land became alienated and privately held, simultaneously heralding the decline of the Surveyor General's influence (Williamson, 1994). Land Titles defined each parcel to survey accuracy, but in isolation from other parcels, and as such, no state wide cadastral map was ever developed (Williamson, 1994). Land Titles

Offices have specifically only ever been concerned with individual land transactions, with the result that the Australian states lacked a complete cadastral map which could be used for land administration purposes (Williamson et al., 1997).

Whether it was because of a lack of a cadastral map or because of a need for customised mapping, many organisations maintained their own stores of hardcopy maps of parcel or property based data, often in duplication with map bases held by other organisations. One organisation that maintained their own parcel based map base was the precursor to Melbourne Water, whose mapping was derived from survey and survey data submitted as part of the land titling process which was eventually digitised and became the DCDB for Melbourne metropolitan Victoria (Hesse and Williamson, 1990). Because of its hardcopy origins, the Victorian DCDB consists of untopologically structured ‘spaghetti’ data. The graphical accuracy of the DCDB data reflects that of the maps they came from, for which 1mm at map scale can lead to accuracies of only about $\pm 2.5\text{m}$ for 1:2500 map scale data (Effenberg and Williamson, 1997). The isolated nature of title plans contributes to further inaccuracy as plan boundaries do not necessarily meet in some cases due to survey errors (Hesse and Williamson, 1990).

Currently, users of DCDB data receive updates as blocks or tiles of data by either disk or through email. These tiles replace the relevant sections of old data. Because many users value add their datasets, they prefer to abstain from applying updates because of the workload it implies on their own data in order to integrate it. An incremental update system would reduce this problem as it is a change only approach to updates (Jacoby, 1996). The Victorian DCDB custodian, Land Victoria, has recognised that many spatial data users maintain their own spatial datasets in duplication at great cost, and that providing better access to an improved DCDB would provide a means for many of these users to reduce their costs by using the new format DCDB as a base for their own data (Geographic Data Victoria, 1997). These users would greatly benefit by reducing their database maintenance workload.

2.2.2 The Current Victorian System

The traditional role of the current system has been to support the land market (Williamson, 1994), while more recently it has fulfilled a role in the developing Spatial Data Infrastructure as a contributor to land related data (Williamson et al., 1998). The DCDB plays a large part in this function, although it is more of a byproduct of the current cadastral process than an integral component.

Cadastral Data Flow

The DCDB is a digital representation of the parcel based titles register. It is not a legal record of title plans or boundaries, but merely a facsimile of what is recorded at the LTO. The cadastral data flow process can be described thus (also, see Figure 1):

1. Licensed Surveyor submits plan to Council for planning approval.
2. Councils refer plan information to utilities for approval. The plan information is also forwarded onto the DCDB custodian for integration into the 'proposed' layer.
3. Upon approval by the Utilities and upon Council certification, the plan can be submitted to the LTO.
4. Upon registration, the plan is submitted to the DCDB custodian for removal from the 'proposed' layer and incorporation into the database proper.

In Victoria, all surveyors submitting subdivision plans containing more than ten parcels are required to submit a digital copy for incorporation into the DCDB.

A 'proposed' layer is maintained within the metropolitan DCDB for the users who require the new information often within the timeframe commonly allotted for plan registration. These users can include utility companies who need new subdivision information for laying new infrastructure etc. The proposed layer provides a mechanism for the DCDB to include the latest lot information while allowing the registration system to run its course in its own appropriate timeframe.

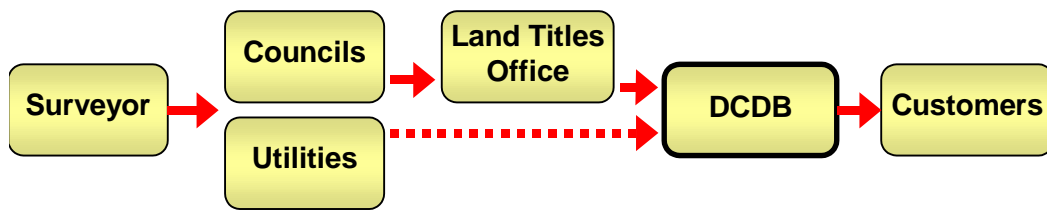


Figure 1 - Cadastral Data Flow in Victoria (Effenberg et al., 1998)

In practice, the DCDB update system (as opposed to the cadastral update system) is a little more complicated, given that it now supports property data as well as cadastral parcel information. In many cases, the property information is more important to some DCDB customers than the parcel data, given that property information indicates the occupation of the land as opposed to a cadastral parcel which simply indicates the land actually owned. The update process for the DCDB, is summarised in Figure 2.

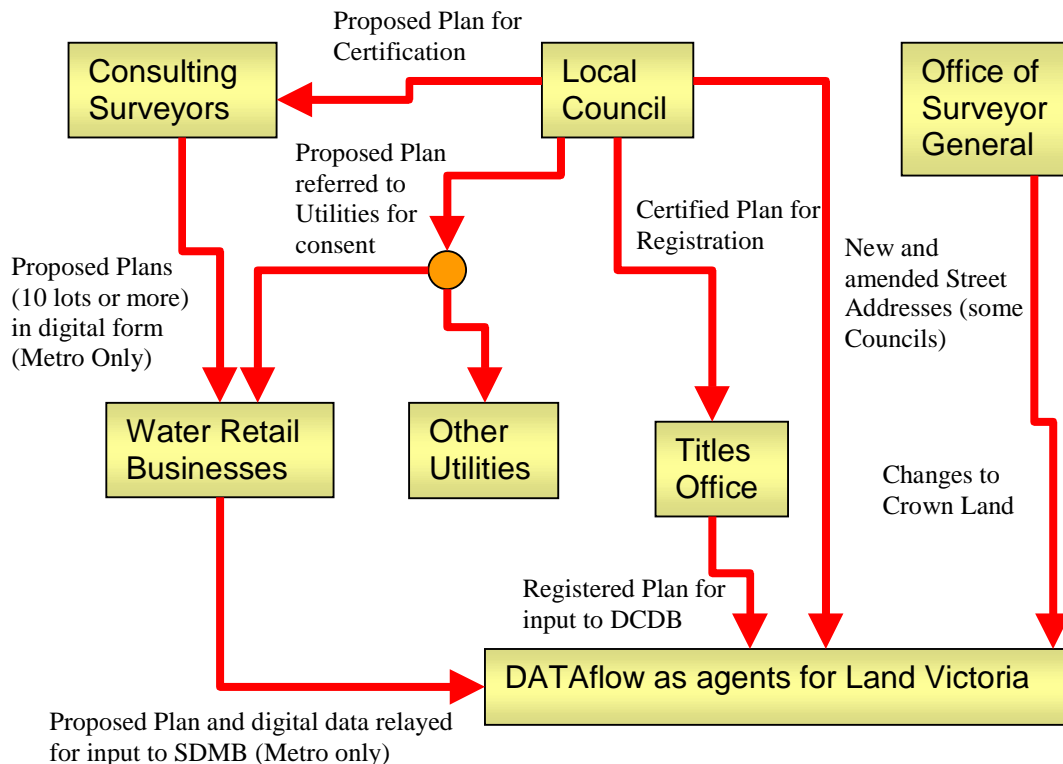


Figure 2 - DCDB Update Data Flow (Jacoby and Marwick, 1997)

The flow of cadastral information is poised to make big inroads into a wholly digital paradigm, given that a lot of information is digital at some part of the data flow process, and that in many cases the information is born digitally at the private surveyor at the very beginning of the process. Investigations into modifying the existing plan transfer process between Local Government and utilities are being undertaken (Jacoby and Marwick, 1997), while digital lodgement as a part of the cadastral process is also being seriously studied.

2.2.3 The Impetus for Cadastral Reform

The International Federation of Surveyors defines the cadastre as a system put in place to enable social and economic development in a region, supporting legal or fiscal purposes and land administration (FIG, 1995). As such, the cadastre and the environment in which it operates must be one that allows it to perform at its most efficient. In the days of Torrens, and even until recently, this was achieved by the hardcopy maps and its supporting infrastructure, and before Torrens, through survey plans and charting maps (Williamson, 1983), as it was the most appropriate or available technology of the time. Birrell et al. (1997) point out that the Torrens system should change as society changes, and that it had survived for more than a century without major modifications.

Our society is indeed changing, and has entered what must be the most revolutionary time with the introduction of real time electronic communications systems to complement the rapidly maturing computing technologies that have made hardcopy mapping databases all but obsolete. This is generating an environment where up-to-date data is desired more or less as it develops in the real world. A cadastral system that has a turnaround more often measured in weeks and months in an age where parts of the DCDB itself are updated in close to real time in some jurisdictions (Geographic Data Victoria, 1997) is certain to come under scrutiny as it is no longer as efficient as it could be.

Effenberg et al. contended that the

“... maintenance of the digital cadastral map must account for the needs and processes of all the entities in the cadastral system to

realise the goal of a single, survey accurate and multipurpose digital cadastral map”

(Effenberg et al., 1998).

In order to effectively service everyone’s needs and in order to keep it relevant in today’s environment, cadastral changes are inevitable. There are well known historical examples of large businesses developing their own spatial datasets when clearly the cadastral dataset was the most logical choice to use, but was not available at the time. Hesse and Williamson asked;

“Why, for example, should road construction authorities have to spend resources on a complete new boundary survey for a proposed road extension, why cannot they use the digital data base as the foundation for their planning?”

(Hesse and Williamson, 1990)

Changes are coming about, or have come about, in order to make sure that such inefficient solutions do not occur in the future.

Various organisations have recognised that substantial infrastructural changes are going to take place because of new technologies, such as the Internet, as a result of the improved efficiencies that they enable. The infrastructure in place to date is not ready for these technologies. In the case of the Internet, the technology and its uses appeared before the appropriate infrastructural changes could be made.

Dale noted back in 1992 that;

“A cadastral reform program that is driven by the data producer rather than the data user is out of tune with modern needs.”

(Dale, 1992)

And that;

“All too often the producer has provided a system that satisfies professional interests and does not necessarily meet the requirements of the user community.”

(Dale, 1992)

The impetus for cadastral reform has become user driven. Users have embraced the digital age, they have initiated their own spatial data bases using base layer DCDB data, but are being hindered by the relatively slow reform of the cadastral system, which, for reasons of its own, has not kept up with technological change. Cadastral systems will need to be able to react better to such changes in order to effectively and efficiently service the needs of the community at the time it is needed.

2.2.4 Cadastral Data Update and Upgrade Strategies

A review of DCDB data and users of that data across Australia in 1995 found that some state DCDBs had shortcomings in spatial positioning accuracy, data integrity, data structure, data accessibility and problems associated with updates and upgrades. The review also identified that it was widely thought that to be 'good', a DCDB had to meet certain requirements, which were (in order of importance);

- 1. Completeness - the ability to provide a complete coverage.*
- 2. Currency - information must be up to date.*
- 3. Data quality and data integrity - data should be clean, correct and consistent.*
- 4. Data structure or topology - the provision of unique identifiers for all points, lines and polygons.*
- 5. Timeliness - information must be provided in a timely manner.*
- 6. Accuracy - survey accurate information is required by some but not by all.*
- 7. Additional attributes such as location of easements are required by many.*
- 8. Data access and exchange method - a consistent and standardised exchange format is necessary. Online data access is preferred.*
- 9. Meta data is highly desirable - an accuracy indicator and historic information are the most important.*

(Wan and Williamson, 1995)

Some of the state DCDBs had experienced problems with spatial positional accuracy, data structure, integrity and accessibility, and in problems associated with updates and upgrades of DCDB data (Wan and Williamson, 1995). Some of the users of the DCDB products disclosed their desire for better update and upgrade mechanisms for DCDB data than the then current whole file replacement strategy. More recently, the private contractor involved in maintaining the DCDB itself has put in place moves that introduce upgrades of the structure of DCDB data, introduce an incremental update and upgrade mechanism, and other moves that improve the quality and completeness of the data (Jacoby and Marwick, 1997).

Effenberg (1997) identified a number of issues relating to the DCDB including data transfer, data update and upgrade and a review of the specifics of these issues relating to Australian (and to a lesser extent, the Victorian) DCDBs. These issues illustrate a complex area influenced by infrastructure limitations and policies, hardware and software, economics, transfer capabilities and DCDB structure and data structures.

2.2.5 Heading into the Digital Age

Much work has been conducted in the area of reforming the cadastral system to enable efficient use of the digital age. Work has been done to allow for improving the completeness of cadastral data, and of its accuracy and timeliness. Digital Lodgement of survey data would bring multiple benefits, although there are many issues that must be addressed properly within this scenario if maximum benefit is to be gained (Hayes, 1997). Effenberg (1997) documented the existing DCDB and possible and real improvement strategies to allow a more efficient electronic system, such as digital lodgement of survey data and upgrade strategies. The Surveyors Board of Victoria has noted in the Survey Practice Handbook, in its section on 'Digital Data and the Future', that digital lodgement of data will become mandatory (The Surveyors Board of Victoria, 1997). In Denmark this year digital lodgement of cadastral survey data becomes mandatory for all surveyors. Digital Lodgement is being addressed by the Survey Departments in most states of Australia, and some, such as Western Australia, have introduced digital lodgement systems to some extent (Falzon, 1997). These works,

particularly those that address upgrade of cadastral data and digital lodgement, have set up the platform for change and indicate that the cadastral industry is about to, or already has, moved in the right direction for the future.

The DCDB is a valuable source of information for a number of users, commonly as a base layer in other information systems. Jacoby noted that the volume of new users of cadastral datasets became smaller and the focus shifted towards dataset maintenance and update (Jacoby, 1996), and, that work was being done to allow datasets using DCDB data to be updated more easily and efficiently. It appears that the spatial information industry is moving towards maturity, in that the user is beginning to get information in a manner that allows its most appropriate and desired use. This fact is supported by the development of government initiatives like the Victorian Government Geospatial Information Strategic Plan, which identifies the importance of such information for the community and provides an impetus for developing the necessary infrastructure to make it available in an efficient and timely manner (Geospatial Policy And Coordination, 1997).

These final developments signify cadastral data as a viable source of information and that its more widespread use is driving a desire for the cadastral industry to adapt. As data becomes more accessible, users are beginning to want to know more of ownership data, planning data, valuation data and others. In future, users will be demanding up to date, complete and more accurate data, and that this influence will prompt changes in itself. Cadastral change is coming and, while perhaps it is not in as advanced state of change that is the case with the GIS industry, for example, it is beginning down the right track at the very least.

2.3 GIS Developments

2.3.1 Government Initiatives and Spatial Data Infrastructures

Governments have recognised the need to reform the way geoinformation is managed, by a combination of streamlining resources and outsourcing. This is in addition to the government realisation that provision of spatial information not only provides considerable financial benefits to the economy, but it also has substantial uses by the community, especially in the private sector. In recognition of this, a number of governments have made a whole-of-government commitment

to the provision of information, thus eliminating duplication of effort and equating the standards at which they are provided across their organisations (Grant and Mooney, 1997).

Grant and Mooney have further stated that reforms in government that foster a competitive market for service provision are

“more likely to lead to the optimal allocation of resources rather than political directives issued in a command economy”

(Grant and Mooney, 1997).

These moves provide a framework for a favourable development of government owned spatial information within the private sector, leading to the benefits that come from more efficient commercial operations (Williamson et al., 1997). In light of these developments it is reasonable to expect that the quality of the provision of geoinformation products will not only conform to government requirements but be suitable for commercial use in a broader setting.

The Victorian Government has identified that a trend that signifies GIS as becoming more mainstream will continue, and has further suggested that spatial data will become less of a single entity and more of a component of more generic information systems, some of which have spatial characteristics (Geospatial Policy And Coordination, 1997). Government has drawn on the importance of geoinformation and has subsequently put in place strategies to ensure that its use becomes widespread and more efficient. The Victorian Government has estimated that about ninety per cent of all government information has spatial characteristics or attribute data, and as such, has benefit to a large audience (Geospatial Policy And Coordination, 1997).

Utility use of GIS in Victoria varied in extent from not being used, to being installed but not upgraded over time, to being fully implemented, as revealed at a recent seminar (Department of Geomatics, 1997). Issues included the fact that State Digital Map Base (SDMB - the logical dataset that includes the DCDB) data at the time was unsuitable in its raw form for many uses, because of unsuitable data quality or lack of completeness. Other issues included the need for proposed parcel data, better dataset update methods, and the need for some utilities to

maintain datasets even though it was not core business. The SDMB has undergone dramatic modifications in response to these problems in order to make it more marketable to such organisations (Department of Geomatics, 1997). Such works are illustrative of the desire by many to boost the use of GIS and spatial data. The benefits from such systems are well accepted within this context, and work is being done in order to facilitate the implementation, efficient use and maintenance of such systems.

2.3.2 Commercial Movements

With time, GIS is evolving from a product oriented to a customer / user oriented profile. A study by Marr and Benwell (1996) of the implementation of GIS in New Zealand in 1995 showed that, in most areas, the levels of use had not reached that which was intended, and then contended that this could have been due to unfamiliarity with the technology and a lack of skills in the area. The need to substantially train users for the use of the technology is indicative of the size and complexity of such systems, and is one factor in its slowness to gain overall acceptance as a business tool in the workplace.

Latest vendor products have included lightweight GIS-like tools that remove some of the complexity in the pursuit of user-friendliness. Products like MapInfo ProViewer and MapInfo Mapplets for Microsoft Excel (MapInfo Corporation, 1998), Latitude (Aussoft Solutions Pty Ltd., 1998), ArcExplorer (Environmental Systems Research Institute, 1998), and other similar packages like these are customer / user oriented products that allow GIS data to be used more readily by relatively inexperienced users. Tools that make GIS more or less transparent to the user will become more widespread because of their useability and hidden or limited complexity which makes them more attractive to casual users and subsequently a mass market.

Examples of these lighter weight products are appearing across the board. The Basic Land Information Network (BLIN) is the Queensland Department of Natural Resources internal GIS. BLIN Enquiry, which is a lighter, user friendly version of the BLIN GIS, as described by Rush (1997) and Lennon and Berenyi (1997), was designed specifically for use by anyone within the Department of

Natural Resources or of the public through over-the-counter public enquiry, at low cost to the Department itself. Terranet New Zealand's Property Information Service (TerraLink, 1998), provides easy access to property information, as does the University of New Brunswick's Real Property Information Service (New Brunswick Geographic Information Corporation, 1998), both of which are accessible over the Internet. Health sector applications are also appearing, (Escobar et al., 1998), and also applications for natural resources management. The simple nature of the software makes its use by a larger, more untrained audience possible.

The GIS industry has rapidly identified that Internet technologies and the use of light weight GIS client technology is a component of future products. The speed at which the industry has moved lies perhaps within its commercial nature. The commercial drive, or the need to meet needs of customers, is probably a major reason the GIS industry has advanced much quicker than, for example, the cadastral industry, which has been slowed by institutional and other issues preventing it from moving to take advantage of the latest developments.

2.4 *Internet and the WWW*

The rise in popularity of the Internet on the back of the World Wide Web (WWW) has caught more than a few unawares. Black wrote that

“If it [the Internet] had been anticipated, the Internet and its requisite languages, codes and protocols would most certainly have been designed differently. The problem is that the technology was well-established before the most compelling applications had been envisioned”

(Black, 1997)

The pace of technical development in this area has been such that a far greater range of applications and uses are now possible, and are continually appearing. It would be appropriate to note that by the time this thesis is published the WWW industry will have progressed significantly. The popularity and level of development of the technology has helped it to find its way into homes, workplaces and information ‘kiosks’, facilitating the existence of the mobile

office through mobile phones and generally reaching into most sectors of developed society.

In its earlier years, the WWW was marked by its lack of complexity and ability to facilitate more complicated operations, such as those complementary to online GIS applications. However, these early problems were well known and have been documented elsewhere, such as by Li (1996). Commercial vendors have been quick to realise the potential of the WWW and have made efforts to overcome these problems and make the provision of online spatial information or mapping systems possible.

The World Wide Web specialises in providing graphic presentation and provides an attractive and presentable medium for geospatial information. At the present time it is possible to set up a GIS like front end from within a web browser and allow users to perform queries to some remote database. The geospatial data itself resides somewhere on the remote database, which is often a pre-existing database or GIS that has been extended to allow users on the WWW to query it. The result, in many cases, is a lightweight front end linked to a GIS-like back end that produces an information tool that is powerful yet relatively intuitive to use for a variety of purposes.

The uses for which such tools are of most benefit are those of the information 'kiosk' or enquiry services, where users make enquiries for certain information without the need for heavy GIS functionality. The volume of data is small enough such that it can be presented relatively quickly to the user, who may or may not be GIS-educated. Examples of this sort of service exist in the University of New Brunswick and Terranet services mentioned earlier, and also in the Victorian Government's Land Channel service (Government of Victoria, 1998), which combines a number of information sources on the one web site.

Problems that still exist with the WWW are the limitations imposed by network bandwidth, or the amount of data that can physically be transferred in a period of time across the Internet. Although this problem is one belonging as much to the communications industry as it does to the Information Technology industry, it does limit the practical size of the data that can be pushed around the Internet, meaning that for applications which provide large datasets the Internet is not as

efficient as other methods. Peng (1997) discusses this more in his assessment of current Internet GIS technologies.

The Internet at this point in time specialises in providing functional yet lightweight GIS like tools that may or may not look a GIS at all, providing a level of information distribution that requires little in technical capability to extract. Applications of this type can be remarkably cheap and easy to set up - the cost of constructing the University of New Brunswick's online Real Property Service consumed only a small fraction of the time and cost of development that went into building the database and collecting the data itself.

2.5 Current State of Spatial Information Provision

The evolution of the three disciplines is proceeding to make them more mainstream and available to the average user. GIS technology, the cadastral industry, and WWW developers are moving to make their wares more accessible and more useable by a wider audience. These moves have been driven by the user - the expanding industries are beginning to tap into the mainstream market which is fuelling user demand for more products.

The underlying concept that each is moving towards is the one and the same - the geoinformation system, one that has a multitude of information that is either spatial or aspatial and that when put together, provides a user with information that is useful in a number of contexts. Each of the technologies provides their own individual component to such a concept - the GIS industry provides the database technology, the cadastral industry provides its data components, and the Internet provides the communications technologies and facilitates the presentation technology required to bring the data to the remote user (see Figure 3).

The state of each of the disciplines in its move to providing for an integrated system is varied, and for different reasons. The bottleneck is that of the Internet, where only after it is capable of providing the required functionality through browsers, or allowing use of technologies such as Java to allow GIS vendors to develop interfaces that run inside the ordinary web browser, is it possible to provide an online information system that contains the necessary functionality. Other considerations to this point are network transfer rates, or security of

transmissions such as in protecting credit card details or proprietary data. GIS is becoming a 'popular commodity', but issues such as proper use of data and the quality of data remain (Barr, 1996). Perhaps it is essential to either educate the mass market on how to use such 'commodities' properly, or to make it so that the software prevents inappropriate use or places warnings or guidelines on the use of data. The pace of development in this industry is considerable, and web browsers that can handle these concerns, particularly those to do with inline browser components or security for example, are being continuously developed.

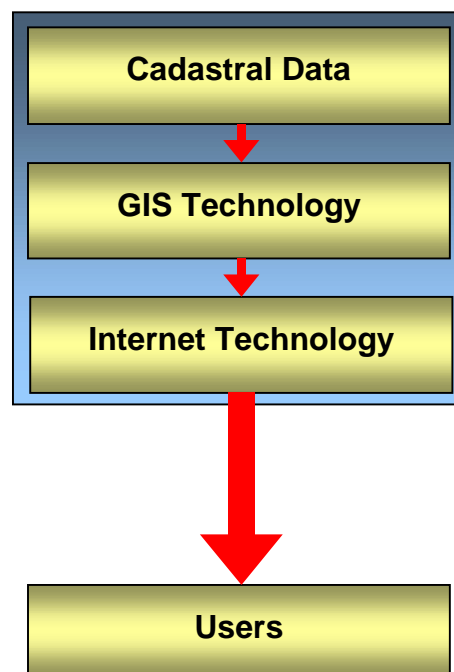


Figure 3 - Integrated System reaches mainstream users

The GIS industry has moved just as quickly, providing web access extensions for their GIS software, as well as developing the interfaces and linkages to allow users to interact with the GIS through the browser. In these cases, the linkages are becoming transparent, and the user does not know or need to know how the data is served to them. The cadastral industry has also been quick to provide cadastral data for use in such systems, but the pace at which the system has been undergoing reforms to allow it to provide data in the best manner and at a quality that is desired by users, is not the same. These changes have to come at the digital

lodgement and update levels that maintain the DCDB itself, and are beginning to be addressed only of late.

The information industry that results from the amalgamation of these disciplines has the potential to provide great benefits to the community through the range of uses that can be derived from it. The ease of use and the transparency of the underlying technologies will provide a potentially global audience with the capability to retrieve information that is of great use to them. The resulting product will not be a GIS, but more of a generic information tool that has more general use, including those of a spatial nature. The GIS will lose the 'G' that identifies specific technology oriented systems and become more user-oriented Information Systems. The development of the WWW as an information tool that can seamlessly and easily handle georeferenced information as well as it handles static information is one that will improve, even more, its usefulness to the world.

2.6 Chapter Summary

In this chapter, three major components have been identified. The cadastral industry, GIS industry, and the Internet, are the components that make up the core of this work. The review of each of these disciplines has provided an insight into the workings of each, and how they relate to each other or are beginning to relate to each other as time progresses. This information provides both a background and a base from which the remainder of the thesis is built.

The cadastral system in its current form is not the most effective for handling digital data. The cadastral industry has recognised for the most part its role in the geoinformation industry, having begun to take measures that will make the collection, maintenance and transacting of cadastral data more efficient.

GIS vendors are seeking to satisfy the needs of a mass market, in the process producing a range of products that are easier to use by casual users. This idea is shown to full extent by the fact that some government organisations have started developing spatial data infrastructures, recognising that geoinformation is being demanded more.

The Internet has developed with great speed, and now is capable of delivering GIS functionality from within the WWW browser. There are some limitations

with regard to network data transmission bandwidth, and some issues including security that also need to be taken into account. However, it is generally possible to create information services that seamlessly integrate spatial and non-spatial data that can be used for a variety of purposes, including public information and also to support business.

We are moving into a brave new world as large amounts of information are suddenly becoming available to large audiences that may otherwise not have had such access. The influence of the user cannot be underestimated either, as they are the ones driving the commercial organisations to develop these technologies, and ultimately they will benefit the most from them. It is unclear what effect that large quantities of readily accessible data will have on society, but it is possible that it could considerably impact the way with which land is perceived and dealt.

3 *WWW Technologies for DCDB Data Transactions*

3.1 *Overview*

This chapter provides an in depth study of each of the technologies that comprise an Internet accessible database system. The study identifies for each, the advantages, disadvantages, and an indication of what roles they would be suitable for in a generic context. Also, in each section, the cadastral context is briefly considered, given a simple model for provision of cadastral data over the Internet. In some cases reference is made to the Victorian cadastral system, to help highlight issues which are relevant to particular technologies.

3.2 *Review of Technologies*

The Internet has

“... beckoned information technology managers to create services for both internal and external customers over the Internet and Intranet in whatever business they happen to be.”

(Black, 1997)

The advent of plug-in, Java and ActiveX technologies have provided WWW administrators a capability that has yet to be fully tested without the limits of network bandwidth. This chapter attempts to explain what technologies are best suited to the provision of an online Digital Cadastral Database (DCDB) service which provides viewing and download access to DCDB data and facilitates update transactions.

A review of user needs in relation to some of the DCDBs in Australia revealed, among other items, that better access to the DCDBs was desired. Online data access was a preferred option of the utility authorities surveyed at the time (Wan and Williamson, 1995). Improved access would bring new users, quite possibly including those which may have previously not had any contact with cadastral data before. Tile or file based update services have been available through the

Internet for a while (in Internet time scale). As incremental update technologies appear and mature, more sophisticated services will also be created.

Many of the major GIS vendors have released a variety of products designed to extend Internet functionality to their existing GIS products. The Internet has experienced extraordinary growth in the last few years, and will continue to do so as more and more services become available. Conversely, as more people use the Internet, demand will bring more services online.

The Internet is ideal as a ‘narrowcast’ medium (ie sending information to specific single groups or persons) (Black, 1997). In this respect, it becomes an ideal medium to implement automated distribution services specialising in digital products such as digital map or dataset updates. The Internet has proved itself as a data delivery and viewing medium (Wilson, 1997), and as such, it could become a key component to any spatial data viewer and update service.

There are a variety of tools and technologies that could implement a data viewing and update service on the WWW. Each has strengths and weaknesses, and some are more suitable than others in particular situations. A typical WWW user / server connection is illustrated in Figure 4. Of the following subsections Static Files, Java / ActiveX, HTML Forms, and also plug-ins apply to interface technologies, while Common Gateway Interface (CGI) and interoperability of systems is devoted to providing access to GIS and server side databases, and the

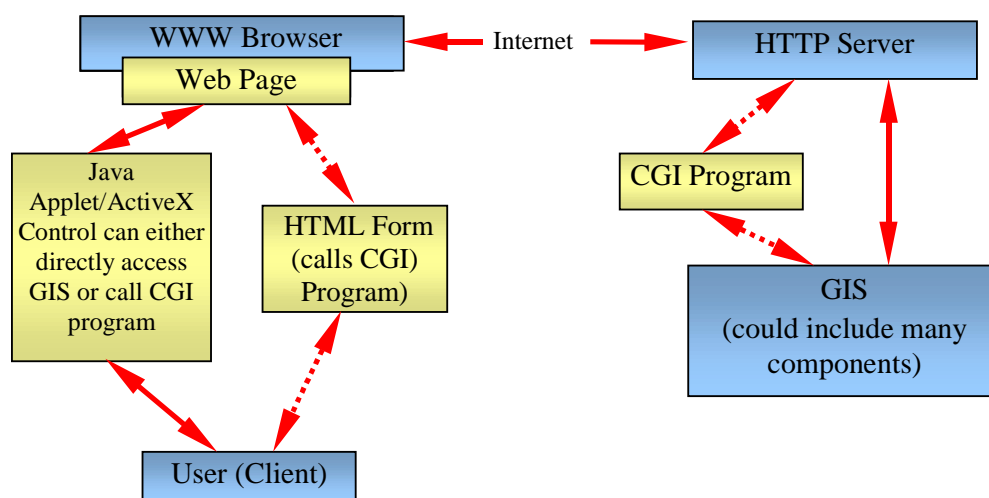


Figure 4 - Basic Client Server WWW Setup

last subsections address some of the available security technologies.

A major consideration is that the WWW emerged from the Internet using protocols that were initially suited to only a small hypertext related role. Many tools and products have since been created to allow WWW sites and services to incorporate more extended capabilities.

3.2.1 Static Files

There is the possibility of providing a service based on static HyperText Markup Language (HTML) files that themselves are updated on a regular basis, an approach taken in the publishing of metadata by Cowen (1996). This approach constitutes the simplest of implementations by which display of data is constrained to a regularly updated collection of HTML documents. The GIS involved with the display generation then has little or no contact with the outside world, making it the most secure, which relieves administrators of the workload of maintaining interface application software, as in CGI and Java implementations.

However, the ability to communicate with the custodian to purchase data is limited to either email or by non Internet means. Also, the HTML files need to be updated often, ideally each time the dataset changes. This approach lacks query capability, so is not ideally suited to data viewers where customizable views and database interrogation is essential.

3.2.2 CGI Overview

Common Gateway Interface (CGI) is a provision within the HyperText Transfer Protocol (HTTP) to allow WWW clients access to select server programs. It was originally added to HTTP to provide rudimentary interactivity, as the early WWW was a purely static file environment. The CGI is probably the most predominant way of providing interaction with server programs at this time, simply as it has been available the longest. An illustration of the CGI model can be seen in Figure 4. The model can be broken into two components, the interface and the CGI program itself. The CGI program (which can be written in any language as long as it is executable) is executed at each user request, using any information that the user sends to it. The user interface is distinct from the CGI

itself, but is vital as it provides the user with the power to execute the CGI program. The user interface can be implemented using either HTML Forms, or through the use of Java Applets or ActiveX Controls.

The CGI program on the other hand is ideal as an intermediary to the GIS itself. In this way the GIS is not directly accessible from the Internet giving added security. Also the requested data can reside in a number of locations - the CGI program acts as a broker, retrieving data from the required data stores. This is especially useful for a DCDB that may be composed of distributed layers.

3.2.3 HTML Forms

HTML forms provide only for single click operations on images, so that rectangular areas cannot be chosen or selected (Fortunati, 1996). Such capability is important for many GIS operations. The functionality of the CGI program and the underlying GIS in this respect is reliant on the capability of HTML forms, which were never designed for spatial or graphical information requests. The simplistic nature of the HTML forms interface is a 'bottleneck' and thus prevents easy to use, powerful GIS functionality (Li, 1996). The advantage is that forms are simpler and faster to implement than the alternatives Java and ActiveX (Bertazzon and Waters, 1996).

In addition, Chopra identified that these WWW mapping interfaces and regular GIS interfaces are stark contrasts of each other in speed and complexity / useability because of the forms interface, especially in areas of:

- latency between information requests;
- lack of state between requests;
- lack of native vector display format;
- [initial] lack of security at server side.

(Chopra, 1996)

The WWW (the HTTP protocol and, as such, browser and server software) provides for only two different image types (GIF and JPEG), both of which are raster based. Mapping outputs, which are commonly vector based and need to be converted to raster format for display in a browser, lose the manipulative power

that vector information has. The WWW can only provide for vector display through Java / ActiveX or through browser plug-ins such as ActiveCGM from Intergraph (Black, 1997) and (Crisp, 1997).

The lack of capability for rapid, multiple query operations on mainly vector data means that forms would not be ideal for an online GIS style application.

3.2.4 Java / ActiveX

Java

Java was created by Sun Microsystems in 1991 as an attempt to create a platform independent programming language, but was developed further to make it useable through the WWW. Java is a C++ like object-oriented programming language that employs partial compilation and machine translation to achieve platform independence. Because it is translated, Java is relatively slow when compared to other fully compiled programming languages (Chappell, 1996).

From a security point of view, Java is ideal as security measures were built into it from its beginning. Java Applets are Java applications developed specifically for running inside WWW browsers on the user's machine. Java Applets are forbidden access to the user's hard disk and other sensitive areas, making it impossible for a malicious Applet to attack the user's computer. This is a compromise as there are times when it is ideal to write information to the user's computer. Future implementations of Java intend to relax this restriction in certain situations and move the security measures into server and Applet authentication. The leading browsers have introduced these features into their own latest browser implementations in order to allow this fine grained access control to Applets (Wallach et al., 1997). Java is a completely new language, and as such, its use is still maturing.

More complex functionality can be achieved through the browser using Remote Procedure Interface calls (Java) to a server GIS (Parent, 1997), or through CORBA ORBS, or DCOM objects. A detailed appraisal of Java used in integrating GIS to the Internet is found in Wang (1997). An application providing all data viewing functions could be constructed, one which is able to directly

interact with a server GIS (or database software), or, interact with a CGI program that then performs a similar role.

ActiveX

ActiveX is the development of Microsoft's Object Linking and Exchange (OLE) technology for sharing objects between applications, with extensions for use on networks including the Internet. ActiveX Controls are pieces of precompiled binary code that run on the user's computer, offering performance advantages over Java. This means, however, that ActiveX controls are currently only operable on Microsoft Windows platforms. Security was not one of the original design considerations in OLE, and ActiveX, its successor, suffers as a result. The Microsoft response has been to make use of server authentication using digital certificates to prevent users loading 'untrusted' programs and the encouragement of 'trust' mechanisms that monitor which Internet sites are allowed to do what on a user's computer. On the other hand, the lack of security means that ActiveX programs can provide functionality (for instance, access the user's computers hard drive or memory stacks) in a way that isn't easily possible in Java.

The big advantage of ActiveX is that it capitalises on the large base of Windows programmers that exist today. Existing applications can be converted to ActiveX controls without embracing new programming languages, which in turn can potentially lower development costs. ActiveX controls are suited to the PC LAN environment within departments and organisations behind firewalls, where security concerns are not so great, and where Windows based personal computers are more widespread.

Java / ActiveX Discussion

Either of Java or ActiveX have the potential to provide the functionality that allows data viewing on the user's computer. Both can lower the use of network bandwidth by storing data in the user's computer memory instead of making successive requests across the network to the server. Each can also provide superior data viewers. Java's platform independence makes it a favourite for a pure WWW application, as DCDB users can come from a variety of PC or workstation environments across the Internet.

The C-Class unreliable networks that form the backbone of the Internet are a drawback (Jankowski and Stasik, 1996) and contribute to relative slowness and a bandwidth limit that users and services can consume. The physical network technology is being addressed by service providers and telecommunications companies worldwide in an attempt to speed up the data transmission rates. Use of Java / ActiveX potentially reduces this problem by carrying out many tasks within the user's computer and limiting network transmissions.

3.2.5 Plug-ins

Plug-ins are applications that provide extra functionality to WWW browsers and are an alternative to Java and ActiveX for providing full functional user interfaces.

When a browser detects a particular type of content in the page that it is downloading, it redirects that content to the plug-in, which is then capable of dealing with it as required. The plug-in is used extensively in other disciplines providing browsers the capability of presenting multimedia over the WWW.

A drawback is that it has to be installed before trying to download pages with special content, and the software resides on the user's machine afterwards as well. Another problem is that there are many different plug-ins to cater for the many different types of content that are now available on the WWW. It is a considerable task to have them all installed and is impractical for the average user because of the non-trivial system space they consume.

The advantage is that if a type of special content is common, then having the plug-in already loaded prevents the download time associated with Applets and ActiveX components. Plug-ins, however, are platform dependent and browser dependant, which increases development costs and limits deployment across different platforms. Because the browser starts the plug-in when a particular type of content is loaded, that content will typically reside in the publicly accessible space on the WWW server. This could present security problems for commercial database data, however, if the plug-in software was smart enough to retrieve data from more protected areas, this problem is overcome.

Plug-ins exist that provide vector image display, for example, the Autodesk Mapguide is a plug-in that performs all the functions of a vector map viewer application (Autodesk Inc., 1997).

3.2.6 Interoperability of Systems

Interoperability is defined as

“... a user’s or device’s ability to access a variety of heterogenous resources by means of a single unchanging operational interface.”

(Schell et al., 1995)

A review of the interoperability capabilities of different GIS products can be found in Aybet (1996). The principles of such interoperability allow various systems to share data and / or functionality.

Distributed applications development to date has used either of the Distributed Component Object Model (DCOM) and the Common Object Request Broker Architecture (CORBA). DCOM is significantly a Microsoft product, while CORBA was developed by the Object Model Group, a consortium of major IT corporations and companies.

DCOM is a development of the OLE technologies that have been a major component of Windows applications for many years, but is still currently platform dependant. CORBA, on the other hand, was designed for distributed operations from the start, but suffers from its relative newness by a lack of programming environment support. Netscape Corporation announced that the CORBA and Java remote procedure interface was not yet incorporated into the then latest Netscape Browser product (in mid 1997), but would in the succeeding products (Moeller and Montgomery, 1997).

ActiveX applications are able to interact with any GIS supporting the DCOM protocols. In the near future it will be possible to achieve similar results using Java Applets through CORBA in Netscape, or Java and DCOM in Internet Explorer.

OpenGIS is an open standard being developed by the Open GIS Consortium Inc., and is envisaged as being an umbrella specification that describes interoperative

behaviour for distributed platforms such as CORBA and DCOM and others. It is intended to produce a standard allowing OpenGIS compliant applications to interact with other OpenGIS compliant applications to reduce the effects of a proliferation of proprietary software and data formats. In this way, each of the major distributed computing platforms can be used to talk to others (Buehler and McKee, 1996).

3.2.7 Data Encryption, Server and User Authentication

It could be said that Victorian cadastral data is readily available at the Land Titles Office for anyone to see and as such that there is no real need to implement security measures. Because of the state guarantee on the title, however, there is a need for the source of the data and the data itself to be guaranteed. This guarantee can theoretically be fulfilled using a combination of encryption and digital signature technology. These are also suitable for digital lodgement, where the data needs to come from a reliable source and be kept safe from interception and modification while in transit. Also, the DCDB data is valuable data and should be prevented from being pirated and resold by unauthorised parties, not only to protect financial interest, but to also to maintain individual privacy.

Internet Security

Information about Internet Security can be found at the CERT website (CERT Coordination Centre, 1998). The CERT Coordination Center is part of the Networked Systems Survivability program in the Software Engineering Institute, a US funded research and development center at Carnegie Mellon University, which maintains a database of reported security incidents on the Internet. Howard (1998) as part of a PhD dissertation, performed an in depth study of security incidents on the Internet reported to CERT, and made a number of findings:

- the rate of growth of Internet security incidents was less than the rate of growth of the Internet;
- the average Internet server and Internet host was not likely to be involved in a security incident, but that it was still possible.

He further recommended that the following precautions should be sufficient for most users:

- "1. Back up important files;*
- 2. Use a good password for network access controls;*
- 3. Ensure permissions are set properly on files that can be accessed by others;*
- 4. Encrypt, or store offline, files that are particularly sensitive;*
- 5. Do not send sensitive user identifications, such as a social security number, address, phone number, personal data, or credit card number across the Internet unless it is encrypted at the source (prior to being sent across the Internet);*
- 6. Use an encryption program, such as Pretty Good Privacy (PGP) or S-MIME, if you want e-mail to be private."*

(Howard, 1998)

The line of reasoning was that the chances of suffering security breaches were small, although it was still possible, and that all practical precautions should still be taken to ensure the privacy and safety of systems and data.

Encryption

Encryption prevents unauthorised eavesdroppers from making sense from transmissions that they may have intercepted. Encryption technologies typically refer to the private and public key form of encryption (Netscape Communications Corporation, 1997), a technique that is mathematically robust when used with a suitably sized key. There are other types of encryption, but they have been largely superseded by private - public key systems.

The Secure Sockets Layer (SSL) is a Netscape Corporation product that integrates secure communications between their browsers and Netscape secure WWW server software (Netscape Communications Corporation, 1997). Microsoft has a similar arrangement for their server software, using SSL and Private Communications Technology (PCT) (Microsoft Corporation, 1997).

There are US export restrictions on US made encryption software, limiting the deployment of many US made cryptographic products globally. Fortunately, other products are available in other countries, such as SSLeay (another implementation of SSL from Australia) (Hudson, 1997) which mimics the SSL product. This product basically allows transmissions between server and user to be encrypted. Applications can use SSLeay code libraries or other proven encryption code libraries to provide cryptographic capabilities in Applets or browser plug-ins.

A typical encrypted session between a server and a user would proceed as follows:

1. The user would receive the server's details, such as its public key. It may already have these, or be able to derive these from a digital certificate. At this stage, the user would ordinarily perform authentication of the server's details in order to ascertain that it is who it actually says it is.
2. A server would encrypt transmissions using its private key and send it to the user.
3. The user would use the server's public key to decrypt the transmission.
4. The user would encrypt any transmissions with the server's public key and send them on to the server.
5. The server would decrypt the user's transmissions using the server's private key. Only the server could make sense of the transmissions, since only the server has access to the private key.

This scheme means that anything that the user sends, can only be understood by the server, however, anyone with the server's public key can decrypt data that the server sends. This setup would be sufficient if, for example, the user wanted to transmit confidential information, such as a credit card number, to the server, and the server did not need to transmit confidential information back to the user.

Another option which is often provided for, is for the user to send its own public key details to the server, so that both parties have the other's public key. This allows both parties to encrypt all transmissions with the other's public key. These transmissions can only be deciphered with the relevant parties' private key,

essentially meaning that both server and user transmissions can only be understood by the other. This process is used in SSL sessions between browsers and SSL enabled WWW servers, a process that is explained in more detail at the Netscape WWW site (Netscape Communications Corporation, 1998).

Digital Certificates

A digital certificate, or the practice of digital signing using digital certificates, provides a way of authenticating parties and digital content, for use across the Internet. The certificate contains vital user information including the user's public key, which is encrypted by a Certification Authority's (CA) private key. A CA is a reputed organisation that registers users and their public keys and generates digital certificates. Hernando (1998) explains the different framework concepts and implementations that allow CAs to be trusted by users and regulating bodies in the appropriate generation and maintenance of digital certificate technology and products.

Use of the digital certificate proves that the user is bona fide, and also, provides the user's public key. A piece of content that is digitally signed cannot be tampered with without being detected. A digitally signed piece of content can then be encrypted to provide privacy for the object while in transmission across the Internet. Digital certificates are an important part of the authentication process that is performed at the start of a SSL encrypted session between a user and a WWW server (Netscape Communications Corporation, 1998), and are an alternative authentication method to the more traditional username and password method for user authentication.

A first party, knowing the CA's public key (both Netscape and Internet Explorer browsers keep a list of recognised CA details), can decrypt a second parties' information and public key contained in their digital certificate. The first party can now decrypt any transmissions that are encrypted with the second parties' private key. Using the second parties' public key, the first party can also encrypt transmissions that can only be deciphered by the second party, with the second parties' private key. In this way, encryption sessions can be initiated using digital

certificates to both authenticate the two parties, and to pass around essential user and key data useful in the initiation stage of the encryption session.

Digital Signatures

Besides authentication, digital certificates can be used to digitally 'sign' objects to both provide authentication on the authorship of an object, and provide tamper detection on that object. The certificate is used to generate a digital signature, which contains a digest of the object, using some known and documented hash function. This ensures that each digital signature is different, and thus, cannot be copied and used by others. Hash functions have the advantage of not being easy to invert, making retrieval of the original document from the digest impossible (Verisign Inc, 1997).

Once a signature containing the digest is generated, it is attached to the object which is sent across the Internet. The object with its signature can be encrypted before transmission to provide privacy for object. A recipient user receives the object, extracts the signature, digest and original object, and performs the same hash function on the object. If this result is the same as the digest, then the message is guaranteed to be intact. Digital signatures can be used in combination with data distributions to ensure the origin of the data and that data integrity has been preserved in transit over the Internet. Objects that can be signed can include, but are not limited to, email transmissions, digital files, and Java Applets for example.

Security Discussion

A very detailed description of how digitally signed Java Applets provide their security features is described by Wallach et. al. (1997) who also rates the security of these solutions. Balfanz (1997), however, points out that these models suffer as they are software based solutions, and can be exploited through bugs and implementation errors. Early Netscape browsers suffered from security 'holes' because of software bugs and implementation errors (Goldberg and Wagner, 1996). Goldberg also points out that the ideal way for testing a security based application is to release it to security experts who can then try to breach the security features. A insecure piece of software only needs one security breach to

prove it to be insecure, and conversely, secure software is proven by a lack of security breaches over time.

There are other methods besides digital signing of code that allow Java Applets to step outside the sandbox security model. The trust model that allows Applets to step out of the sandbox depending on the source is one that is adopted in Internet Explorer Browsers, and is also proposed by Balfanz et. al. (1997). This model can potentially suffer from IP spoofing, whereby a source can fake its IP address and subsequently gain access privileges to a user's computer.

It seems that most methods of providing security have advantages and drawbacks, and that all need the test of time to be proven and to gain acceptance in the community. A required level of security can be achieved using a combination of methods, and although the risk of suffering a security breach is reduced quite considerably, some risk still remains. Until a proven foolproof system is developed which can be universally adopted, it is necessary to accept the relatively low levels of risk that are associated with the existing security methods.

3.3 Chapter Summary

The technology is available to provide the WWW user with a online DCDB service that provides a vector display of map data with tools for customising views of that data. The use of Java Applets can provide this service on any machine with a Java capable browser throughout the WWW. ActiveX can be used to provide a similar service but with the advantage of using existing software development practices for ideal application deployment over a corporate or departmental Intranet or LAN.

HTML forms provide a technically simpler tool for providing simple map query services to the WWW, but loses out when more advanced viewing functionality and increased user interactivity is needed. Digital Certificates prove the identity of a party, be it a data provider or user (such as a private surveyor), while digitally signed documents enable detection of unauthorised tampering. WWW components can be constructed that can interact with GIS software provided that each is using the same distributed component scheme, to which there are a number of alternatives.

4 Online Data Applications

4.1 Chapter Overview

The use of the Internet gives many data custodians a way to disseminate digital information. Providers of cadastral information can benefit from the ability to deal with digital information, especially as digital processes within the cadastral system become more widespread. Before designing a system that deals with cadastral information, it would be ideal to examine the specifics of what can be done and what is being done by others in terms of online applications, and in particular, cadastral applications.

This chapter will review a number of online GIS related applications and their components from an operational and technical perspective. The focus will be on the components that make up these systems and the perceived purpose of those components. To this end there is both a review of commercial products, and a review of a small number of cadastral applications. The commercial review will provide a snapshot on the direction that vendors are heading, while the application review will provide an overview of how these technologies have actually been used in the real world. The study is not in itself of any individual product or system, but more of what comprises the average system.

Using this knowledge, it will be possible to design a cadastral application that follows this average concept by designing into it the components that would be typically expected, and to build from that concept any extra functionality that is needed. The analysis of each of the technical components and the design of the system follow in subsequent chapters.

4.2 Why Review Existing Applications?

A commercial vendor will have at its disposal industry experience and industry resources from which to construct a product. They will have a knowledge, to some degree, of what will sell and what will not, and can devote many person hours to a project. The objective of the commercial vendor is to create a properly working product that will satisfy the needs of a consumer audience. They are

unlikely to produce, except in rare occasions, products that are not going to be adopted by a mass market.

The WWW has moved out of the domain of academia and amateur users, and into the domain of the commercial developer. A look in this direction, by looking at products that are under development or are being currently released, should provide an illustration of what is to come from online systems in the near future.

4.3 *GIS Vendor Products*

The appearance of the WWW as a medium for data presentation, distribution and communication, with its immediate popularity, caught a lot of the industry off guard when it appeared in the early nineteen-nineties. Many commercial vendors provided add on software patches to enable their products to produce WWW useable files (such as Microsoft and its Internet Assistant Series for MS Office Applications) leading to more integrated software in subsequent generations.

The GIS industry is another example of this move, with a flurry of WWW products designed to present GIS data on the WWW. For the most part, they included software that converted output from native GIS into WWW content destined for WWW pages, allowing the use of existing operational GIS. Subsequent generations saw refinement of these packages into standalone products, providing more mature services than earlier implementations.

Limp (1997), identified that the major GIS WWW software products differed in:

1. the use of image graphics vs. graphic objects;
2. using map prepublishing vs. direct data access;
3. client level requirements;
4. the amount of geographic analysis accessible from the Web;
5. data and platform restrictions.

Limp (1997) also reviewed the major individual products and discovered that no one product was better than the other, rather, that each seemed to be suited to particular user situations, including the type of system the user owned and the

format of the user's data. There were also other considerations that weighed for and against each of the products in turn.

The review will focus on the components that comprise these systems. The major parts of these systems will be assessed on their suitability for satisfying an online DCDB model, and for the types of components that they have. A result of this is a perspective on the major technological components that have been incorporated by commercial vendors, possibly leading to a justification for the use of particular technologies / techniques in the online model.

The product review will differ from those that appear in trade magazines in that there will be no recommendation of one product over another, instead, this will present the major products, and identify the trends in the use of technology as it is applied in bringing GIS data onto the Internet.

4.3.1 Assessment Criteria

By examining certain components of each product or suite of products, it should be possible to see how typical systems are comprised. The components examined are what could be construed to be the major components of any online database system. The components are (also, see Figure 5):

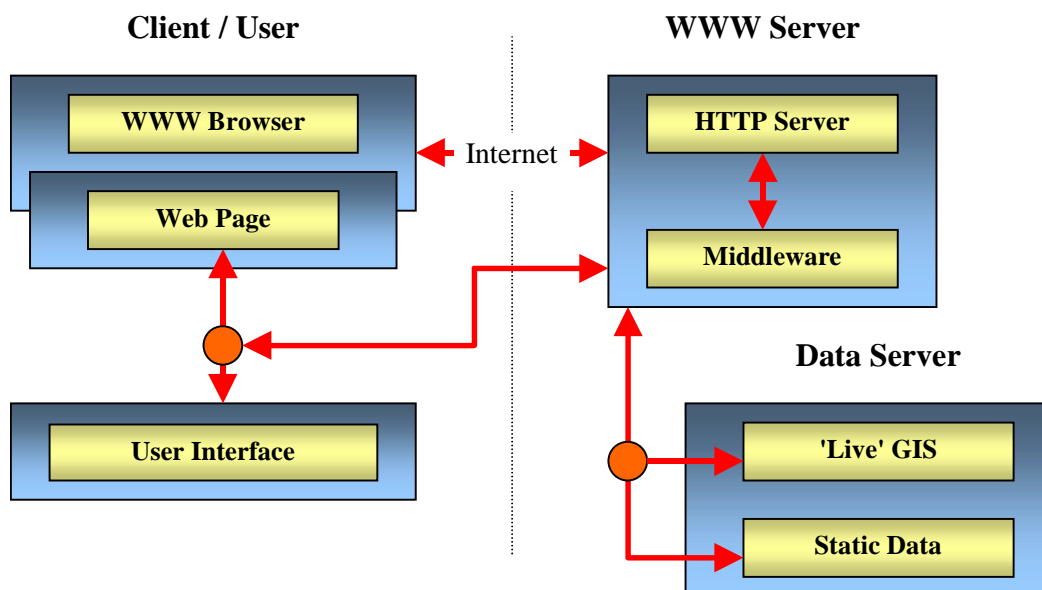


Figure 5 - Assessment Components

- User Interface, including supported platforms, interface methodology, etc;
- WWW Server, including any extensions to normal HyperText Transfer Protocol (HTTP) WWW servers, Common Gateway Interface (CGI) etc.;
- Data Server, platforms, data formats, restrictions etc.;
- Overall Comment, including miscellaneous comments.

4.3.2 Autodesk MapGuide

The Autodesk suite of products includes the MapViewer, MapServer, and MapAuthor. A more detailed description of this product can be found in Limp (1997), and at the Autodesk WWW site (Autodesk Inc., 1997). MapViewer represents the user interface, it is the component that interacts with users from a WWW browser. The MapAuthor is the component used to create Map Window File (MWF) maps viewable with the MapViewer, and the MapServer is the WWW server component which supports HTTP requests for MWF files as well as ordinary WWW content.

User Interface

The MapViewer represents the user interface of the system, which is a WWW browser plug-in that is executed by the user's browser when MapGuide MWF maps are loaded from a server.

The MapViewer plug-in contains the capability to zoom, pan, and issue reports in selected areas. Also provided are layer toggles which allow display of user selected layers of information. The images displayed are 'intelligent' images that are generated from the information in the MWF file. Layers of information are displayed according to constraints such as current scale, etc, which are defined by the MWF file's author. Report generation includes the capability to access server databases through Object DataBase Connectivity (ODBC) drivers.

The use of a plug-in allows fairly complicated functionality to be incorporated, as well as allowing the use of non WWW standard data and image files as opposed to simple Graphic Interchange Format (GIF) and Joint Photographics Expert Group format (JPEG) raster images.

WWW Server

The MapServer provides a WWW server that is also extended to allow the use of MWF files in normal HTTP transactions. The drawback is that MWF files are not dynamic files, and must be generated by MapAuthor prior to publishing on the WWW server.

Data Server

The data server in this system is limited to an ODBC compliant database server that is called from the MapServer in response to a user request for a report, which is an extra function from the map serving function.

Overall Comment

The use of plug-ins have advantages and disadvantages for users and data providers alike, but in this case its biggest strength is the ability to load complex data file formats such as MWF files and to provide functionality on those files. The biggest drawback is that the plug-in must be installed on the user's machine before MWF files can be viewed. A MapServer is required to be installed on the server before MWF files can be served through the Internet.

4.3.3 ESRI

A brief review of Internet GIS products from ESRI are reviewed by Limp (1997) and also presented by ESRI (1997). The ESRI product incorporates the MapCafe or ArcExplorer data viewer, the Internet Mapping Server (IMS), and optionally, the MapObjects development tools.

User Interface

The choice is to either use the ArcExplorer data viewer, or to use MapCafe, or even to implement a user interface in a HTML page using HTML, Java or ActiveX.

The ArcExplorer is unique in that it is a standalone application that functions as a browser by accessing Arc-Info data over the Internet. It cannot view HTML or other conventional WWW files however. It provides full GIS like functionality and includes all the usual display manipulation functions.

The MapCafe Applet is provided with source code in order to allow developers to implement their own user interfaces while still being able to interact with the IMS.

WWW Server

The IMS provides the WWW data server requirements for users, accepting requests for data from users and subsequently making requests of a data server. It receives requests from web pages through the HTTP server. Subsequently, it interacts with a data server, then passes the retrieved data back to the users computer.

Data Server

The data server is provided by a MapObjects application. MapObjects is a developer environment with a number of ActiveX components that allows developers to build their own data server, based on the MapObjects components. This allows standard basic functionality but with custom implementation to suit the developer's needs.

The alternate product is an ArcView application that the IMS interacts with to retrieve data.

4.3.4 MapInfo

The MapInfo Proserver is reviewed in Limp (1997) as MapInfo's Internet GIS product, yet the online documentation presently indicates that the MapXSite is now the software that fulfils this role (MapInfo Corporation, 1997). It comprises the MapXSite components that work in conjunction with both WWW server and a MapInfo MapX program that serves data on request. An OCX (short for OLE Custom control) component and a Java Applet are provided for the implementation of a user interface. An OCX component is an independent program module that can be accessed by other programs in a Windows environment. OCX components are the predecessor to ActiveX controls.

User Interface

The use of a Java Applet or an OCX allows developers to create a user interface that best suits the needs of the developer and user. The Java Applet is best suited in the Extranet / Internet role, where user platform and browser version cannot be guaranteed. The applet provides the basic viewing functions, along with query functions that allow interrogation of the MapInfo server. The OCX component is useable by developers in Windows applications to add map viewing capability to applications, or in ActiveX applications for use in browsers. This is useable for Internet Explorer browsers over the Internet but is more ideal for Intranets where the browser that all users use are commonly controlled through some client server setup.

WWW Server

The WWW server contains a middleware application that provides the 'bridge' between the WWW server and the MapX application. This administration software is invoked by a user through CGI, Netscape Server API (NSAPI - the Netscape version of CGI used only with Netscape Server WWW software) or Internet Server API (ISAPI - the Microsoft version) through the WWW server. The administration software then invokes an instance of MapX with a request for information.

Data Server

The data server is a MapX application. Since it is an ActiveX component itself it can only run on Windows and NT platforms.

4.3.5 Intergraph

The Intergraph product is comprised of the GeoMedia Web Map application, and ActiveCGM ActiveX map viewer components (Limp, 1997; Intergraph Corporation, 1998).

User Interface

The user interacts with server data through an ActiveX component that consists of a map viewer that displays Computer Graphics Metafile (CGM) data files.

Users need to install the ActiveCGM plug-in before they can load CGM files. The combination of plug-in and CGM file allows users to view, zoom etc and to query data sets from within the browser.

WWW Server

CGM files are served from the WWW server itself. These are created using the GeoMedia Web Map and published on the WWW server.

Overall Comment

CGM files are static files, needing to be created initially, and published on the WWW server at a later stage. The plug-in is only available for Windows and NT platforms, restricting the ideal usage of this system to the Intranet role, although Internet / Extranet usage is certainly possible.

4.3.6 Discussion on Components in Major Products

Starling (1997) points out a number of different approaches in front end user interfaces to GIS data. He describes four major ways of providing systems through:

1. *“Plug-ins by which functions are downloaded into the browser environment and are executed as linked modules on the client, the data is also held locally eg Automap from Autocad;*
2. *Functions invoked from the browser are executed on the server (HTML / CGI model) with the results being sent back to the browser in the form of a gif file eg Genasys, ESRI, and Smallworld;*
3. *Hybrid model where certain functions are executed on the server delivering a gif and an API delivers specified vector data to a Java client for local processing eg Genasys and MapQuest;*
4. *A Java based viewer and querying environment where the data is downloaded to the client for local processing eg Genasys, CSIRO and IDGIS.”*

(Starling, 1997)

While not all the systems described in this reference were reviewed, those that were support the assertions of this last quote. Systems that use only ActiveX or Windows / NT technologies are more suited to the Intranet or Corporate setting, where PC / Windows environments are more widespread. The wider platform support of Java makes it more ideal for Internet use, and to this end, it is also fairly well supported. More user friendly interfaces are those of the ActiveX / Java / plug-in variety, which share processing duties with a server, especially in the case of dynamically retrieved data from a live database. Middleware applications that provide a bridge between the WWW server and the Database server are important for dynamic databases that need to be located away from the WWW server for security reasons. Middleware applications are less important for static data that can stored on the WWW server itself.

In general it can be seen that:

1. Systems that access dynamic data from 'live' databases require a user - WWW server - Data server setup (3-tier architectures), while systems that access static data that is periodically updated are not required to reside in 'live' databases, and as such can reside on the WWW server itself.
2. User interfaces are required to interact with server software either through standalone applications that connect through the Internet to a database server, or through a WWW server to a database server, commonly through CGI.
3. User interfaces that deal with mapping data with non trivial basic display or query functionality require either Java, plug-in or ActiveX technology to operate on the user's browser. The use of HTML forms is possible with some of these systems, but is for the most part, inefficient and comparatively user unfriendly.

4.4 Online GIS Approaches - Components of Real World Online Cadastral Applications

These following examples are those of online cadastral data systems that provide user access to digital cadastral datasets. Their roles are limited to data distribution and data enquiry only (there are no input or online data maintenance facilities at

this stage). Again the review will focus on overall layout and major components and the roles they fulfil.

4.4.1 New Brunswick Real Property Service

The New Brunswick Real Property Service is an online cadastral data service intended to provide;

“the public with fast, convenient access to snapshot copies of accurate land and land-related information from anywhere in the world.”

(Finley et al., 1998)

It is available online through subscription only, and provides users with cadastral land information linked to land gazette information (New Brunswick Geographic Information Corporation, 1998).

User Interface

The interface consists of WWW pages with HTML forms which interact with the WWW server through CGI requests. This requires all functionality to reside at the server, reducing user friendliness, as every little function requires a network transmission (and thus, increased network traffic and time delays) between user and server. The forms are combined with images functioning as buttons and imagemaps to provide the user functionality that includes data retrieval and image manipulation.

WWW Server and Data Server

At the WWW server sits the Caris Internet Server, which contains a series of programs which provide GIS functionality to users over the WWW. The data is currently updated every two to three months and sits on the WWW server, but it is hoped that datasets will reside at their decentralised departmental locations and be updated more regularly in the future (Finley et al., 1998).

Overall Comment

Universal Systems, which developed the Caris Internet Server, has since developed Java interfaces that will work with a Java enabled server product

(Universal Systems Ltd., 1998), although this may be an independent vendor product with no intentions for the New Brunswick system.

The service distributes data to users, but there is no online input provision. Update and maintenance processes are separate entities, and are left to the data providers. This service is purely intended as a data distribution tool, and no online maintenance mechanisms or tools are envisioned at this time.

4.4.2 TerraNet Property Information Service

TerraNet Property Information Online is the New Zealand equivalent of the New Brunswick service. It provides subscriber access to land information data (TerraLink, 1998).

User Interface

The user interface is also HTML forms based, providing textual data retrieval from a variety of datasets. There are no images or graphic output, thus there is no map manipulation functionality.

WWW and Data Server

At this time there is little in the literature about what comprises the back end of this system, but it is known that the data originates from a variety of databases. It is not known if it is kept on the WWW server or not, but the data is only periodically updated so it is reasonable to assume that it is kept on the WWW server and not in the 'live' land information database that services these jurisdictions.

Overall Comment

The interactions in this system are different to others discussed in this chapter, as currently there are no map components to the interface for viewing. For the text based role that it fulfils, HTML forms are more than adequate as the functionality to manipulate maps is not required. Network transmissions, the large number of which are needed to service a graphical interface, are kept to a workable minimum.

4.4.3 Finland's National Land Survey MapSite

The National Land Survey of Finland has introduced a digital system for handling its cadastre (containing about 4 million parcels), allowing complete digital processing of cadastral data. In addition to this, Internet access to the cadastral map base has also been provided to Finnish and other subscribed users. The new digital cadastral system is described more in Schofield (1998) and also Tuomaala and Uimonen (1998). The Internet site also contains information about the service in addition to the service itself (National Land Survey of Finland, 1998).

User Interface

The initial user interface is forms based, and contains a map 'pane' and a control 'pane'. Using a combination of the two panes it is possible to find map data based on address, coordinate or parcel identifiers. The control pane also includes usual zoom, move functions, and also allows selection of map scale. Access to the system is through a user / password facility. A prototype Java interface has also been developed that allows more types of querying and map selection, but it is not yet available for review.

WWW and Data Server

The cadastre resides on a bank of server computers, and while the system is decentralised in concept, there is one master copy of the cadastral map base that is stored in a central location and maintained from the decentralised locations. The Object-Oriented Land Information System (JAKO), is built on top of Smallworld GIS software, and can be edited through a hypertext based editing system. This hypertext system also provides the basis for Internet access.

Overall Comment

Since a Java interface is under development, it is presumed that the HTML forms interface is not adequate for general use. The ability of the Java interface to perform some functionality without deferring to the server allows more efficient querying. The developers of the system have noted that subscriber access is provided only to "customers with a service agreement, since the NLS [National Land Survey] has not yet transferred to using 'netcash' on the Internet" (Tuomaala

and Uimonen, 1998), although any users within Finland are also able to procure access. While access is free for Finnish users, subscribed users can attain access to more detailed datasets for an access fee.

4.4.4 Discussion on Real World Applications

Many real world applications are combinations of different systems. Often they include custom or off the shelf systems and sometimes they are combinations of both. The Victorian DCDB, while not yet fully online, combines ORACLE RDMBS with Convergent Spatial Data Manager system software, with Microstation user interfaces (Marwick, 1997). The Queensland BLIN system, which is planned for online use, combines a number of RDMBS, with TUXEDO as a middleware, and an inhouse user interface (Lennon and Berenyi, 1997). The New Brunswick and TerraNet systems also have preexisting databases, although the New Brunswick system is being progressively upgraded to allow better decentralisation, data serving and to allow better maintenance of served data (Finley et al., 1998).

Data Transfer formats such as OpenGIS, and others become important when dealing with data across networks, especially in those where database and WWW server are not necessarily on the same platform. While the reviewed commercial systems from the previous section concentrated on dealing with (often) proprietary data formats, the systems mentioned above had less of such a focus, often using non-heterogeneous components (in a proprietary sense) to produce desired functionality.

One aspect that was dealt with by all the real world applications was that of user access. All three of the reviewed systems restricted access to subscribed users only, and all three utilised user / password schemes to let the subscribers into the system. A pricing scheme and access fee were a part of this restricted access also, partly to make a return on the services provided, but also to enable privacy protection. Interestingly, encryption of network transmissions was not performed, although the reasons for this are not clear at this stage.

In all cases, the Internet access component to cadastral data systems were small components to the system overall. This is possibly because of the desired

requirement for providing Internet access to preexisting systems while limiting disruption to the system overall. It is also indicative of the size and complexity of the cadastral systems compared to the relatively small mechanisms needed for providing Internet access to those systems. The major aim for these Internet services is that of data provision, or of providing users with the ability to view and download data. There were no other provisions for user data submission for instance, or to enable dataset maintenance over the Internet.

In summary, these systems featured:

1. Text / attribute data searching for specific data;
2. Simple web based user interfaces which contained the basic map manipulation functions (zoom, move etc.);
3. User / password mechanisms to restrict access to authorised persons, often in conjunction with fee charging for some services;
4. Web based services were limited to user viewing / downloading of data (no data submission, no dataset maintenance mechanisms).

4.5 Model for a Typical Online GIS Application

By combining the conclusions drawn from these reviews, it is possible to piece together what a typical online GIS application would comprise. This provides a base from which a cadastral online application can be designed, using the base as minimum from which we can incorporate functionality more suited to the solution of more unique cadastrally related problems.

In general, the configuration of most systems are remarkably similar, although they differ in areas such as specific technical functionality, and in specific software components. The general model for an online GIS is summarised in Figure 6. The following is a summary of the most common traits that an online GIS is likely to contain, using the main classifications used in reviewing each of the applications.

User Interfaces

These are either loaded into the user's computer over the network (interfaces built in Java, ActiveX, HTML forms) or from the user's hard drive on instruction from the browser (interfaces built on plug-ins, stand alone applications). The interface usually consists of basic map / graphic manipulation functions, plus functions to search for data to be retrieved from the database.

WWW Server

More often than not, the WWW server performs the task of maintaining contact with the user's browser and the user interface. All data and HTML pages requested by the user are normally served through the WWW server. An exception to this are a very small number of user applications that make direct connections through the Internet to a data server itself (ArcExplorer for example).

Data Server

Data is either stored in static files or in some storage structure, or served from a 'live' database. Live databases are often located elsewhere to the WWW server and could be distributed (ie. reside on a number of different databases). Static files tend to be snapshot copies of data contained in some live database, and are updated at periodic intervals.

Overall Comment

Access to databases are restricted to subscribed users, who are subscribed beforehand. It is possible to consider online subscribing, but there is a general lack of confidence in the still newly emerging online commerce procedures. Access to databases is restricted using user / password mechanisms.

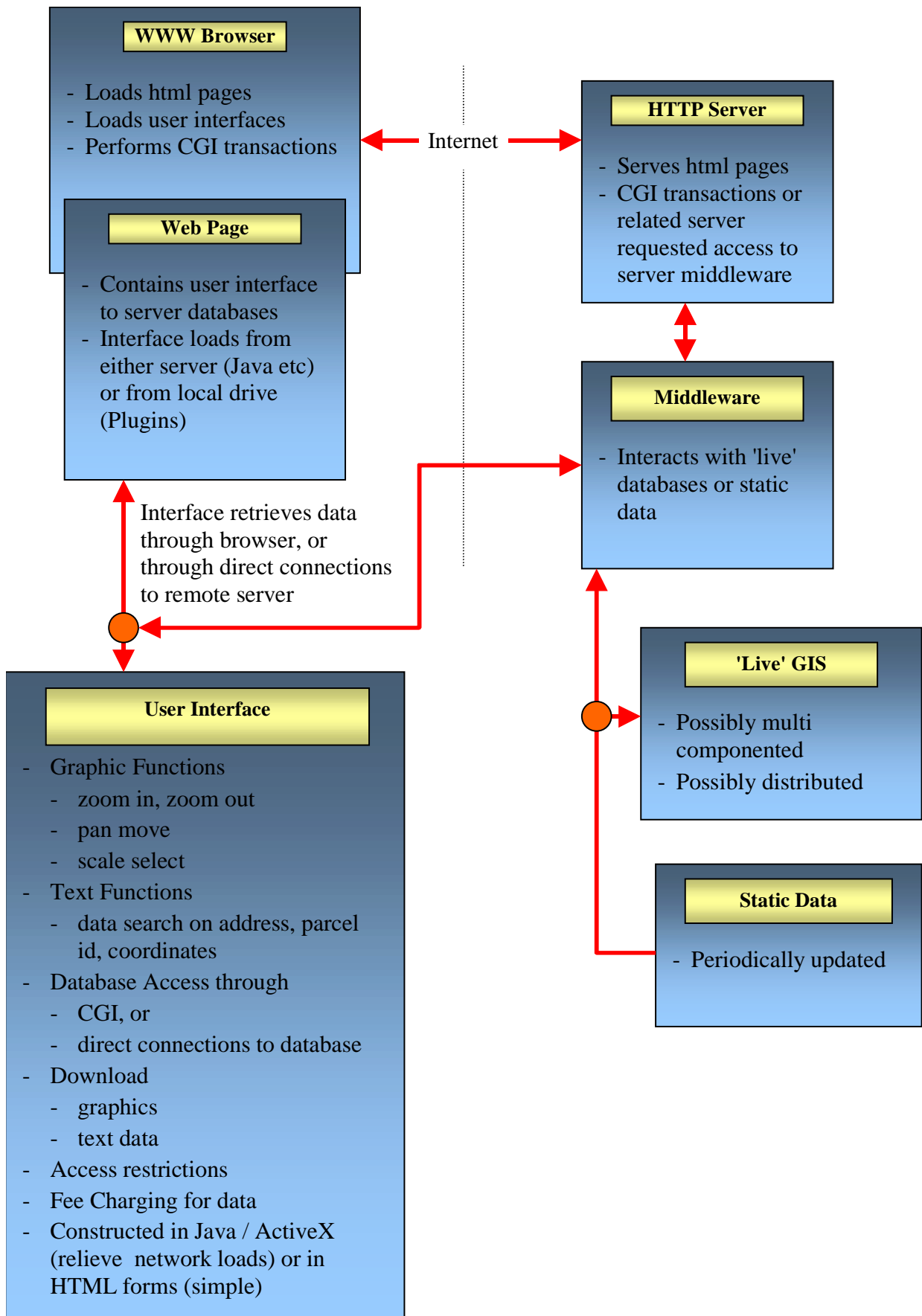


Figure 6 - Generic Model of a Typical Online GIS Application

4.6 Chapter Summary

This chapter reviewed the components of some online GIS. A number of common traits were identified in both commercial / vendor products and real world online applications. The commercial products demonstrated the latest available technology, and what the GIS companies had identified as necessary in web GIS products. The real world applications demonstrated practical solutions and the concepts used in those solutions, with less focus on the technologies themselves. The final section of the chapter outlined a general model for an online GIS application given the components identified in the reviews.

5 Components of an Online System

5.1 Chapter Overview

This chapter documents the actual design and implementation of the prototype system itself. It documents the cadastral data needs, the service needs of the likely users, and the interactive needs of the user in general. Also documented is the set up and layout for the system, the user interface, the database interface and the internal linkages required to bring the data to the user.

5.2 Service Components

Service components are the system components which together provide a particular level of service, the processes and mechanisms of which make up the interactions between data provider and customer. The following sections address each of the major mechanisms that allow user and data provider to perform data transactions.

Initial Data Purchase

Currently, users purchase data from the custodian through a simple ordering process by listing the areas and types of data required and the digital format it is required in. This process can be easily automated by creating a mechanism that acquires the user's data requirements and either processes them or sends to them to another location that processes them (for instance, for manual processing of an electronic request). A summary of these mechanisms are listed in Table 1.

Dataset Maintenance

Often a customer that purchases data will desire to maintain contact with the data provider in order to procure dataset updates on some regular basis. Deciding when updates are needed can be performed a number of ways. The custodian may be able to keep track of when changes to its data occur and automatically generate an update for a user once a particular number of changes or a particular time has elapsed between user updates. Another method sees the user entering into a

periodical update contract that enables updates to be purchased at regular intervals, whether they are needed or not.

A last possibility is that the user determines that an update is necessary on their own accord, by checking the custodian dataset and comparing the differences and deciding if an update is warranted. The advantages of this method are that the customer gets updated information when it is best desired, although customers must take the time to determine this themselves.

Purchasing Systems - Existing
1. Credit Card, Cheques etc. through mail, fax, or in person
2. Acquire user's data requirements through a paper form which is faxed, mailed, or submitted in person (over the counter)
Purchasing Systems - Online System Should Provide For
1. Existing options (augmented through online forms etc)
2. Online Credit Card system (through a secure online transaction)

Table 1 - Purchasing Options

Maintenance Options - Existing
1. Custodian issues updates on a periodical (perhaps contractually determined) basis
2. Custodian monitors changes and issues update after a particular amount of changes have occurred.
Maintenance Options - Online System Should Provide For
1. Existing options
2. User keeps track of changes, and orders update when desired, or alternately, upon user initiation, the system compares user and server data and automatically generates update

Table 2 - Maintenance Options

Table 2 lists the different ways of deciding when to generate updates for a customer. An online system should make use of all or either depending on the customers existing data maintenance contracts, or on the method that best suits the customer.

Data Delivery

The customer can take delivery of the data in a number of different ways. For instance, the user may desire the data to be burnt onto a CD ROM and sent through mail or by courier, or alternatively, may desire to receive the data through email, or, through the WWW (typically through a web browser).

Receiving data through the web is only ideal at this point in time for small datasets, as the transmission time of large datasets can be impractical. It would be the best idea to again cater for each of the scenarios in the hope of letting the customer choose the most appropriate for their needs. For CD ROMs the custodian could be notified of the data order and thereupon make the appropriate actions, just as in the current over-the counter system. Data Delivery methods are listed in Table 3.

Data Delivery Methods - Existing
1. Data stored on CD ROM etc. and sent by mail / courier
2. Data sent through email
Data Delivery Methods - Online System Should Provide For
1. Existing options
2. Data sent through WWW (as part of a HTTP or File Transfer Protocol (FTP) transaction)

Table 3 - Data Delivery Methods

Data Upload

Historically, cadastral data has always been submitted as a hardcopy plan - the provision for a digital lodgement facility is a new concept in this category of

online data applications. Digital lodgement itself is a developing concept that has been studied by people such as Hayes (1997) and Falzon (1998). The integration of mechanisms that allow the user / customer to upload data in addition to those that allow download through the WWW are new concept, and are a major component of the system design.

There are a variety of strategies that allow data upload. These focus principally on what occurs to the data after it is submitted, since the uploading of digital data is relatively trivial compared to the task of updating a digital database (which is often subject to rigid update procedures).

The most automated approach would be to enable direct update / upgrade of the DCDB by a private surveyor online, but institutionally and legally this is currently impossible (Effenberg et al., 1998). The DCDB can only be updated by the custodian at this time, and survey plan data is examined by the Land Titles Office before it is legally integrated into the cadastre. With the introduction of quality assurance, and with professional liability moving towards the surveyor along with the reduction of plan examination practices in many jurisdictions, the environment that would allow an online system that allows private surveyors to directly update the DCDB could become possible in the future.

Another approach would be to provide for online submission of data that is subsequently conventionally processed. In essence the submission would parallel existing options of submitting data, for example by mail, or over the counter submission.

A summary of submission and update mechanisms is presented in Table 5 and Table 4 respectively.

Submission Mechanisms - Existing
1. Hardcopy Plan Submitted, sometimes with Digital Copy
Submission Mechanisms - Online System Provides For
1. Digital Lodgement of Digital Plans

Table 4 - Submission Mechanisms

Update Mechanisms - Existing
1. Custodian enters plan data into proposed layer as the plan data is received from utilities or LGAs
Update Mechanisms - Online System Provides For
1. Existing Option - enabled through online submission of data in a manner that replicates the existing process ie submitted to custodian for further processing
2. Private Surveyors plan data entered directly into the appropriate DCDB layer. Plan examination replaced with Quality Assurance practices and random auditing of plans by the LTO.

Table 5 - Update Mechanisms

5.3 *System Architecture*

Online GIS are inherently client server applications, given the client server nature of the WWW. For this next section discussion will focus on the components of the system and making particular reference to the client / server approach to network applications. The client / user runs server resident applications or interface components loaded from the server, allowing the server to be the one access point for all application software and data needs. The client software distributed by the server in this context can include HTML pages, Java or ActiveX components, data, or images (in this section it is all referred to as client software for simplicity).

The client server paradigm allows for the latest in backend and client interface software (eg Java), as it is downloadable from the server as it is needed. The exception to this idea is that of plug-ins, which need to be installed on the client's hardware before data downloading through the WWW is possible. Otherwise, the client downloads the required interface software as needed. The advantage is that the client gets the most up to date version of the software each time, and also that the client does not need to have to know anything about the software or need to

install it, etc. The disadvantage is the network bandwidth that must be used each time the client downloads application software from the server.

Online GIS systems usually follow a 3 tier client / server hierarchy, the type of which is illustrated by (Alexander and Warwick, 1997), and also mentioned by (Strand, 1997) in his overview of online GIS components.

The first tier is the client / user interface, which includes the WWW browser, the HTML Pages that provide the GIS interface (which is handled by either Java, ActiveX, or even plug-in technology). All, with the exception of plug-in software, is loaded as needed from the server. The first tier contains software or components that are used by the user which interacts with the other tiers of the system (see Figure 7).

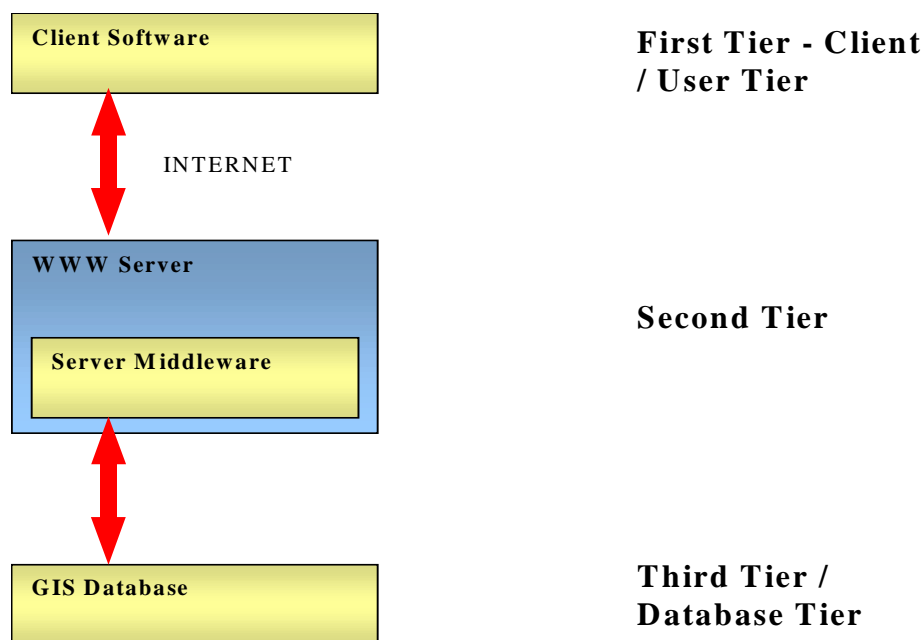


Figure 7 - Three Tier Architecture

The second tier is the middle component that serves as an intermediary between the client / first tier and the database / third tier, providing the user with the link to the database, while simultaneously protecting the database from the user, and serving data in a meaningful way.

The third tier is the back end component that is not only hidden to the user but combines all the database technology needed to serve data to an enquiring

application. Often separate from the WWW server and often located on a different machine or in a guarded location, it is only available to the WWW through the second tier. It provides the regular database technology and can, in some cases, serve as the GIS in regular non networked or local area network applications. In this respect it is not very much different from regular GIS software, except that it has the added functionality required to handle requests from the second tier applications.

A real world example that illustrates this tier architecture is the data base system in place to serve DCDB data for Victoria that is maintained by DataFlow on behalf of the Victorian Government (Jacoby and Marwick, 1997) in which the tier system is evident (see Figure 8), although it lacks Internet capability. The client tier is replaced by a Microstation terminal operating with a spatially extended SQL on top of a RDBMS GIS tier, based on an ORACLE RDBMS. The second tier is replaced by a series of components that manage and retrieve database data, while the third tier is the RDBMS itself.

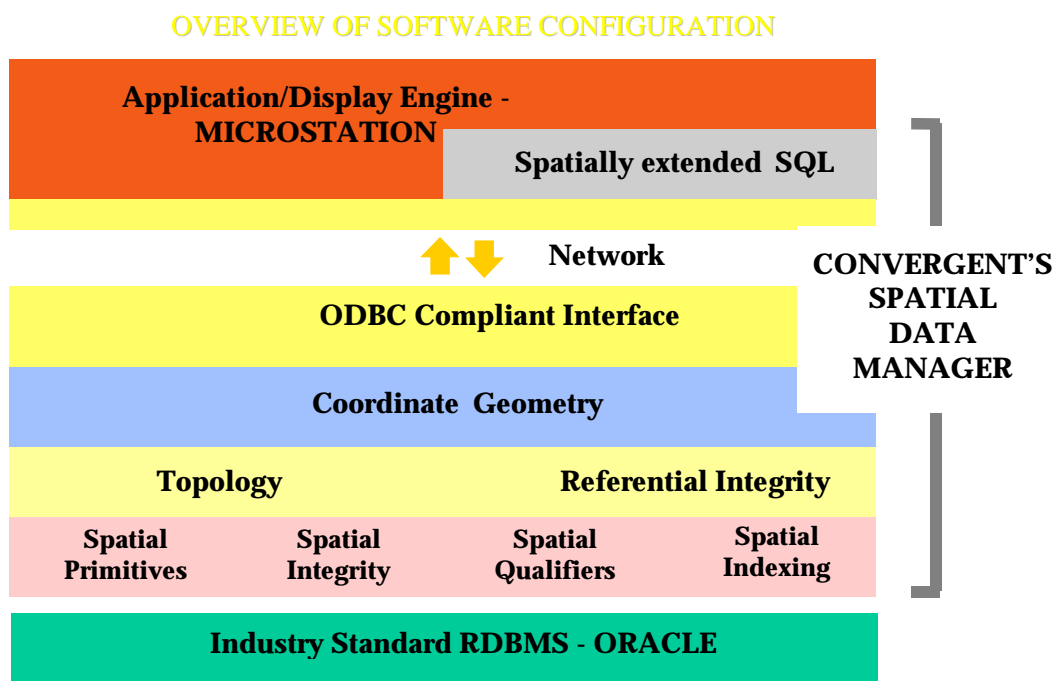


Figure 8 - Convergent's Spatial Data Manager - (Marwick, 1997)

The online system architecture would replace the Microstation application with a browser with a GIS interface, while the second tier would be modified to provide linkages to the browser over the Internet and to the RDBMS. While it could be possible to directly connect the RDBMS to the browser, it would not be wise as extra linkages would need to be added to the RDBMS itself. This would both introduce non core functionality to the RDBMS, and would also present a security risk as the data could be subject to attacks from the Internet.

5.4 *User Requirements*

Functional Requirements

The user's view of the system includes operations that include data viewing, download, upload, and submission. The breakup of user functionality can be described (also see Figure 9) by the ability to:

1. The ability to view a defined extent of the geospatial data;
2. The viewable extent to be predefined;
3. The ability to locate to a specific area using zoom, pan and locations based on coordinates or Melways type specifications;
4. The ability to build a view by adding / subtracting features;
5. The ability to download information (what you can see you can download);
6. The ability to configure and save viewing criteria;
7. The ability to load locally resident data into the view area;
8. The ability to display differences between local and downloaded data;
9. The ability to upload local geospatial data accurately tied to view data;
10. The ability to register and purchase on line.

(Effenberg, 1997)

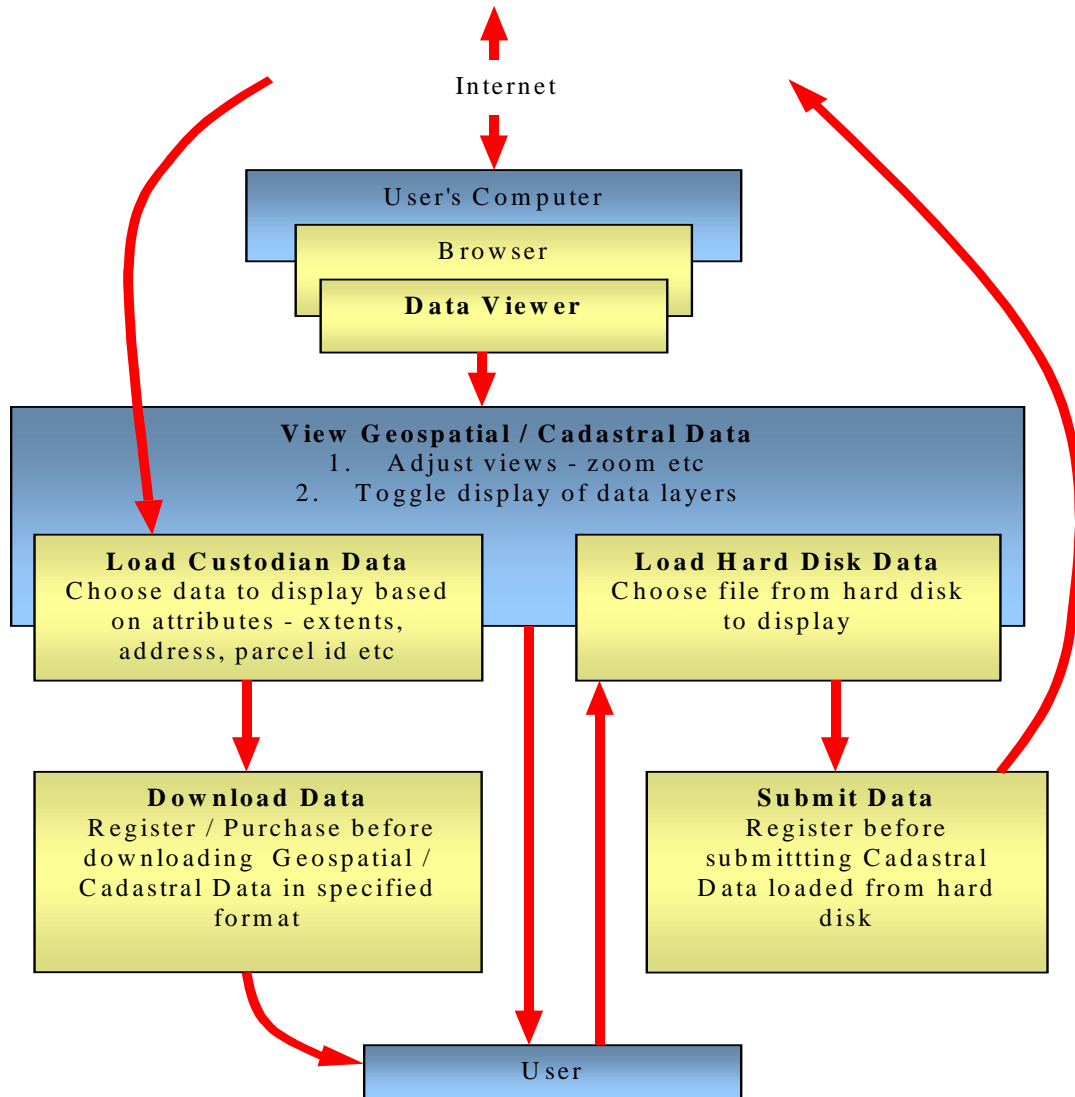


Figure 9 - The User's View of the System

Cognitive Requirements

An interface can be designed that combines these elements, and in the most appropriate manner for the sake of ease of use and for other similar concerns. In fashioning a design for the interface, it is appropriate to note two principles in user interface design:

- reduce complex ideas to combinations of simple ones;
- model ideas as close as possible to experience and intuition.

Sometimes it is necessary to compromise between these if for example, the idea that closely resembles experience is overly complex and cannot be easily

simplified (Richardson, 1995). The design that is the focus of this chapter models the real world problem as close as possible, making it easy for users to identify with the data flows and processes, while keeping it as simple as possible so that it remains easy to use. This may sound obvious, but it has to be considered that novice users may need to be able to use the system as well as users that may have more experience with digital geospatial data. The ideal system to cater for both will need to balance complicated functionality with ease of use.

5.5 *Data Requirements*

Database Data Format

Database data formats refer to either the format of the data as it is stored within the database itself, or the format of the data that is supplied to an enquiring application. For many databases, the issue of data format selection is trivial, for instance, an RDBMS database will store its data in table format and supply data to enquiring applications in what is analogous to table format. Many RDBMS databases also require SQL queries to retrieve data for example, and some databases provide vendor data formats (eg Shapefiles etc). Such system specific factors will have large bearing on the technical interactions that an interfacing application will have to provide.

User Data Format

User data refers to the data that the user deals with, whether it is the data that is being uploaded to the server, or data that is being downloaded to the user's computer. Users will generally expect to download data in some recognisable data format, such as Data Exchange Format (DXF) for example. A user interface will need to cater for at least one and possibly many of the more popular digital storage formats for data that is either downloaded or uploaded.

Integration of data or submission of data, would be achieved using typically data in some known format. This data would be redirected to either a relevant authority for further processing, or could be automatically dropped into the database itself (there are obviously legal and institutional ramifications from this latter option). Data redirection could be achieved using a form of email or upload

(eg using FTP for example) to some data depository. The responsibility of performing these actions would become those of the WWW server application, or the middleware software. Data conversion duties could either occur at the user interface, or at the middleware software, depending on efficiency.

5.6 GIS User Interface

"One of the difficulties in designing GIS user interfaces is in accommodating the diversity of mental models that exist with regard to spatial phenomena."

(Keast, 1995)

Keast explains that the use of task analysis and modelling, and of mental modelling, is essential to the design of a GIS interface. In this context, mental modelling accounts for the perceptions and expectations of users, which is necessarily different for each person because of their different personalities, while task modelling is the outcome of task analysis, which:

1. documents the purpose of the work task;
2. documents how the task is done and how manipulation of information occurs, and;
3. documents the skills capabilities and needs of users.

Also pointed out was the important concept that the Graphic User Interface (GUI) was often confused with the User Interface (UI) itself, which while an important part "of the human computer interface" is still just a part (Keast, 1995). Judging from this piece of knowledge, it would be appropriate to postulate that the interactions that occur between user and the GUI are an important component of the broader interface itself. But how does one implement something that can be difficult to quantify such as the user attitudes or user interactive capabilities with different GUI components?

In his section on "Measuring User Characteristics", Sutcliffe discusses the need to build an interface to suit the likely user and to that end, classifies users according to:

- frequency of use - frequent users will build up skills more quickly than infrequent users;
- discretionary usage - users that are not forced to use a particular system will choose the system that is easiest, more attractive to use;
- computer familiarity - will affect the ability of a user to learn a system;
- user knowledge - some users may wish more complexity to suit their skill levels;
- general abilities - the general knowledge of the user affects the level of sophistication in a system that they can be expected to learn;
- physical abilities and skills - the physical interaction of the user with a computer and its peripherals.

(Sutcliffe, 1995)

Intended Users

The primary user for a system that incorporates geospatial data viewing and submission is the geospatial professional, including data custodians and the private surveyor, as these are those that are most likely to deal in such data. The geospatial professional is likely to be computer literate and capable of dealing with digital data, because of the current state of the geospatial industry and its reliance on computer assistance for dealing with large data sets. Private Surveyors are likely to be computer literate but may not necessarily have the computing experience of the geospatial professional. Because of their professional backgrounds, Private Surveyors are likely to learn about digital dealings with digital data relatively quickly. In a recent survey, about eighty percent of the private surveying industry in Victoria currently submitted digital plans, while about 70 per cent of respondents used modems to transmit digital information while 89 per cent used floppy disk as communication means. About half of respondents had email and Internet access (Falzon and Williamson, 1998).

Because of its presence on the WWW, the system is likely to have a large number of other users which are initially much harder to classify. In this scenario, the secondary user would be those that are interested in viewing geospatial data

online, and from this perspective they would likely have some concept of land titling or of parcel or property databases. This would include casual users to more advanced users such as land dealers. An interface for such a system would need to accommodate both, since they are both likely to pay for services provided, although data custodians are likely to have a larger proportion of the use of the service due to the amounts of data and / or the frequency of use. A profile of user characteristics is provided in Table 6.

<i>User Type - Spatial Data Professional</i>	
Frequency of use	Data Maintenance, Data purchase - relatively often
Discretionary usage	No, as cadastral data system is government specific
Computer familiarity	Ideal
User knowledge	Ideal
General abilities	Good all round
Physical abilities	Good all round
<i>User Type - Private Surveyor</i>	
Frequency of use	Data submission, data purchase - potentially often as part of work environment
Discretionary usage	No, as cadastral data system is government specific
Computer familiarity	Good, some surveyors have more knowledge than others
User knowledge	Good, but not necessarily in digital lodgement
General abilities	Good all round
Physical abilities	Good all round

<i>User Type: Casual User / Other</i>	
Frequency of use	Any one user would use it occasionally to rarely
Discretionary usage	No, as cadastral data system is government specific
Computer familiarity	It is probable that the casual Internet user will have average computer skills
User knowledge	Average
General abilities	Average
Physical abilities	It is probable that the casual Internet user will have average physical skills

Table 6 - User Characteristics

User Interface Design

The way to provide complex functionality while still maintaining a simplicity that facilitates casual users is to implement an interface that provides a simple initial layer but also incorporates more extended functionality for the more advanced user. The intention is to provide a simple data viewing platform that is intuitive, and to provide more complication like data submission and data selection separated into subwindows. This breaks the more sizeable components into separate subcomponents that are easier for the user to work with if needed.

"A golden rule is to minimise the total amount of information by presenting only what is necessary to the user"

(Preece, 1993)

The data viewing window is segregated into areas of usage that include the data display, an operational buttons area and an area that contains a progress or 'busy' icon that shows program activity. The break up of the window into areas provides the user with a set of areas that the user can identify with and ultimately, find more intuitive. Extra information and functionality is contained in other windows that are called up by the user on demand. This way, unwanted functionality is

hidden until it is needed and avoids swamping the user with too much information at once (see Figure 10).

In the earlier discussion on task analysis, it was stated that the analysis leads to a task model which provides a picture of what interactions the user must contend with and conversely what interaction is required of the user. Based on the above layout design, the user type and the required functionality, the following model results:

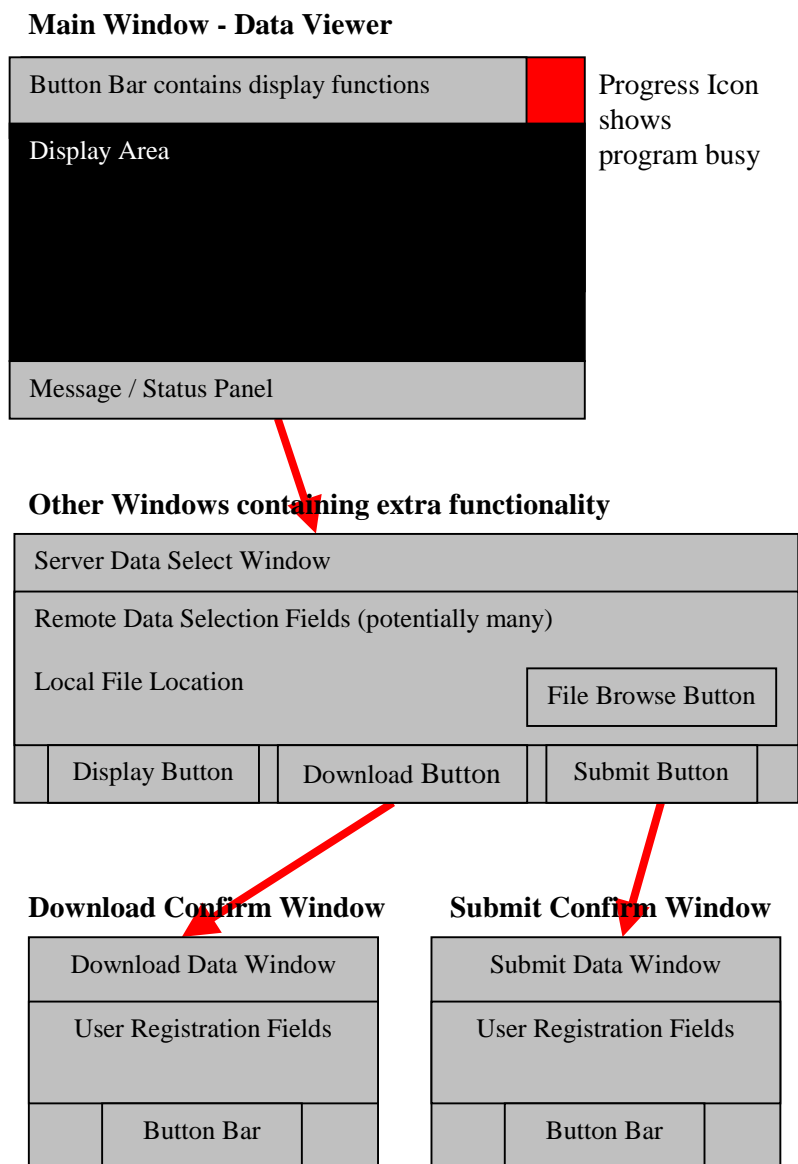


Figure 10 - Basic Window Layout

1. Purpose of the tasks -
 - a) View Digital Data
 - b) Visually compare local digital data with remote digital data
 - c) Download Digital Data
 - d) Submit Digital Data
- 2) How the task is done and how manipulation of data occurs
 - a) Display operations such as zoom, move, etc initiated by button press followed by mouse movements and clicks
 - b) Button presses from main button bar on display window bring up windows containing extra functionality
 - c) Data Selection occurs through file choice for local data files, or through a field entry with certain qualifications followed by button press submission
 - d) Help Buttons bring up relevant information about the window the button is attached to
- 3) Skills capabilities and needs of users
 - a) Need to be connected to WWW
 - b) Need to have capable browser
 - c) Need to have or be able to quickly learn, basic understanding of spatial data viewing and manipulation

5.7 *Java*

This section builds on the section on Java / ActiveX reviewed in Chapter 3.2.4 Java / ActiveX, and provides a detailed analysis of the language and justifies its use.

Java is an object oriented byte interpreted programming language created by Sun Microsystems in the early 1990's. Object oriented languages are the latest in the programming paradigms and offer some advantages over older procedural languages offering code reuse through inheritance and potentially for improvements in program flow and structure. Java is a combined interpreted and

compiled language - while it is compiled to a file of byte code for a saving in size and interpretation speed, it is interpreted to allow it to run on any platform that has appropriate interpreter software installed. The Java model sees raw Java code compiled to byte code, which can then be run on any platform that has the interpreter (or Java Virtual Machine - or JVM) installed (Lemay and Perkins, 1997).

The most important development from an Internet point of view, is the use of Java programs as 'Applets' which are Java programs that are tailored to run inside a WWW browser. Java Applets are incorporated into web pages in the same way as images or text. The HTML page will make a reference to the Java Applet in an analogous way to how images are referred to, and so when the HTML page is loaded into the browser, the Java Applet is likewise loaded into the browser. The difference is that while images are displayed on the HTML page's screen display, the Applet is actually run as a program, and its output is directed to the HTML page's screen display. The browser will have an integral JVM inside it, so that it can interpret Java Applet byte code within its own runtime context (Lemay and Perkins, 1997).

Java Applets are useful for providing content in WWW pages that are not possible through HTML alone. For instance, Java Applets have been used to provide animation in web pages, also to provide complex navigation tools within a web page, or to provide online games. The applications of Java Applets are bounded only by creativity and the security limitations imposed by the JVM used in browsers. The JVM creators have provided some limitations to Java Applets so that the security of users or others is not compromised by malicious Applets.

Java Applets are useful in the context of this research in that they can provide the interface functionality needed for an online WWW GIS application. Examples of online GIS applications have been demonstrated in a previous chapter. The limitations, advantages, disadvantages, and competing technologies to Java have also been documented in a previous chapter. Considerations for using Java in online GIS applications have also been documented by Wang (1997) and Peng (1997). Java was used in the interface in this research as it was free, widely documented, and was supported more widely than its main competitor ActiveX.

Interacting with the Database Server

When the user requests remote data, for example that held by a data custodian such as DataFlow or Land Victoria, the Java Applet that the user was interacting with would make a request to a remote server for data. A remote machine is used to serve spatial data to the Java Applet and thus the user. The Java Applet makes connections to the server making particular requests for data, which subsequently through a series of operations, returns data to the calling Applet (see Figure 11). The interaction process can be broken into a number of linear stages which mark particular parts of the process.

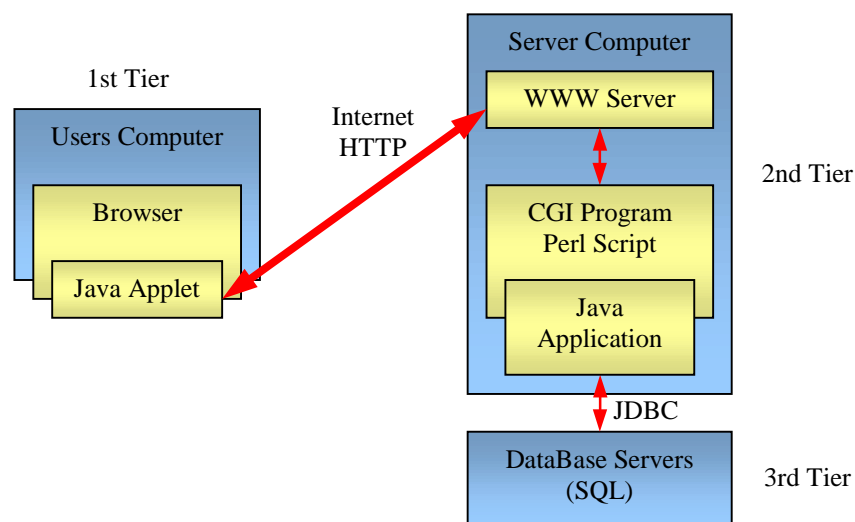


Figure 11 - Interaction Flowpath with the Database

Java Applet - WWW Server

Because of the security restrictions on Java Applets, the typical Applet can only make connections or requests for data only through the WWW server that the Applet was loaded from. Once the request has been made to the WWW server, the request can be processed further or redirected to the appropriate place as necessary. The initial contact that the Applet has with any server resources across the Internet, is subsequently through the WWW server and computer that the Applet was loaded from.

Applets can communicate with WWW servers in a number of ways, including through socket connections, through Common Gateway Interface (CGI) connections, through Remote Method Interface (RMI) procedures, and others. Unfortunately, many users of geospatial data, especially commercial users, may only have access to the Internet through a firewall. A firewall is a type of gateway that sits between an Intranet or Local Area Network (LAN) and the Internet, and allows only HyperText Transfer Protocol (HTTP) connections or email transactions to go through. Firewalls are a security mechanism that prevents users on the Internet from gaining access to any machine behind the firewall that may compromise the security of the machines and data contained behind the firewall. For this reason many corporate LANs are placed behind a firewall, to give them Internet access without allowing outsiders access to the protected computers.

Only HTTP or email connections are typically allowed through the firewall as these are construed to be unable to do anything other than perform the WWW or Internet functions they were intended for. This means that most of the Java Applet connection mechanisms such as sockets or RMI, will not work, as the firewall will not allow them. CGI on the other hand, is a connection mechanism that is an integral part of the HTTP, thus it is the only connection method which can be guaranteed to work anywhere on the Internet for users behind firewalls. A Java Applet that communicates with the server using CGI can be guaranteed to work across all firewalls. The use of CGI guarantees that any commercial geospatial data users sitting behind firewalls can use the Applet's intended functionality.

Thus the Java Applet communicates to the WWW server it was loaded from using CGI, a request / receive type connection method, where the Java Applet makes a connection to the WWW server, runs a designated program with particular arguments, and receives the output from that program. The Java Applet should be able to package information into a CGI request, make the CGI connection to the WWW server, run the designated program, receive the output from the program, and subsequently act on the received output.

The designated program that is run from the CGI request, is located on a protected area on the WWW server for the sake of security. The program receives

its input from the Java Applet and then executes, in this case making a connection to the spatial database, requesting and receiving data, and then sending it in a particular format back to the Java Applet. The Java Applet will be expecting data in that particular format so that it can then process the data and present it to the user on screen.

The CGI program is a Perl script which acts as a wrapper to a Java application that performs the actual connections to the database. Java applications are similar to Applets, except that together with a standalone JVM interpreter, they execute by themselves from the command line. Java has no standardised way of dealing with environment variables, which is how CGI programs receive their input, so the Perl script is started instead, which processes the environment variables and starts the Java application with the environment variables passed as command line parameters. The Java application uses Java DataBase Connectivity (JDBC) to make a standardised connection to the SQL database that contains the spatial data.

CGI Program - Database Server

This component of the interaction is set up so that the database server can be located anywhere on a network. The database software is split over multiple networked machines, away from the WWW server itself. This way users can only access the database through the CGI program. Internet users cannot access the database other than through the Applet and its CGI connections for example.

The Java application as discussed in the previous section makes connections to the database server through the JDBC interface. The JDBC interface is a documented part of the Java distribution that allows a standardised way of interrogating JDBC enabled SQL database servers such as the PostgreSQL database (PostgreSQL Organization, 1998) that was used in this system. It also allows interrogation of such databases across networks so that database data can potentially be situated in distributed locations.

The intention was to set up the interaction between CGI program and database server such that it would work across different machines. The benefit of this approach was that if the system is extended to cater for multiple databases, the

CGI program would become the arbiter of information from a variety of sources and then pass it back to the Applet. This functionality - the ability to work across different platforms and machines - was one of the touted capabilities of JDBC and one of the reasons why Java was chosen for WWW server interfacing in the first place.

5.8 Security Model

The system deals with data that conceptually has proprietary interest attached to it, be in financial or legal or other. It is desired that these interests be protected and as such the data, users and the server are likewise protected. To this extent, it was necessary to protect the data from unauthorised access and copying. There are two ways in which such protection can be offered, through digital signing of data and through encryption of transmissions.

Digital Certificates are used, which are issued by Certification Authorities and contain a user's public key, to generate digital signatures. The user can digitally "sign" documents in order to prove that they were indeed generated by the user. If the user is a trusted user, then the data signed with the user's private key can be decrypted using the user's public key as contained in the user's digital certificate. In this fashion the data and the author of the data are guaranteed, as it is impossible to tamper with a signed object without the tampering being detected.

Digital certificates are also used to sign the Java Applet which provides proof of the author and origin of the Applet. A further benefit of using digital certificates is that specifically signed Java Applets can be allowed to operate outside the JVM security restrictions (or outside the Java 'sandbox') in special cases. Netscape and Microsoft both have differing systems on how this works [see (Microsoft Corporation, 1997) and (Netscape Communications Corporation, 1997)], and either system has both its merits and disadvantages.

The need to allow Applets to operate outside the sandbox has not been fully implemented in the latest versions of Java and the JDK, however, later versions of Java and the Java Development Kit (JDK) will incorporate support for this and for the X.509v3 certificates that are needed for these techniques. The browser manufacturers are expected to adopt the JDK approach once it becomes available,

because the current situation limits a Java Applet's operability to a particular certificate scheme and the particular browser that supports it. As such, Applet signing has not been widely adopted by developers as would have been liked by the browser companies.

This system uses the Netscape technique, which requires a particular type of digital certificate for signing applets, and requires Java libraries that are used only by JVMs in Netscape browsers. This was chosen because it was more familiar and provided a quick solution. The problem with this is that the Java Applet only works properly on Netscape browsers, and the latest releases at that, and is a problem that must be borne until digital signatures are fully supported within the JDK and that the latest JDK is fully supported by the major browsers.

Using the digital certificate to sign the Java Applet, it was possible to allow the Applet to read and write files on the user's local hard disk, a task that is impossible in the traditional JVM security model. The use of the certificate guarantees the source of the Applet to the user. The user is prompted by the Netscape browser when the Applet tries to step out of the security restrictions, in order to make sure that the user is aware that this potentially dangerous action is about to take place. This functionality is useful, and with it, implementation of user data upload and submission is possible.

The other use of digital certificates is to sign data files that the user uploads to the server. This is essential in order to prove the author of the data and the validity of the data. This becomes especially important if at some stage, the data is used to update some database, as accountability must be attributable to someone if bad data is put into a database.

Encryption is ideally used to encrypt the data transmission so that the data cannot be copied without authorisation. By encrypting the data that flows between a user and server, even if the data is copied by some third party while it is in transmission, it cannot be decrypted without the private key of the receiving party, which is, of course, not available to anyone other than the receiving party.

The encrypted session is set up with the use of the digital certificate which contains the public key that the other party will use to encrypt data to be transmitted (see Figure 12).

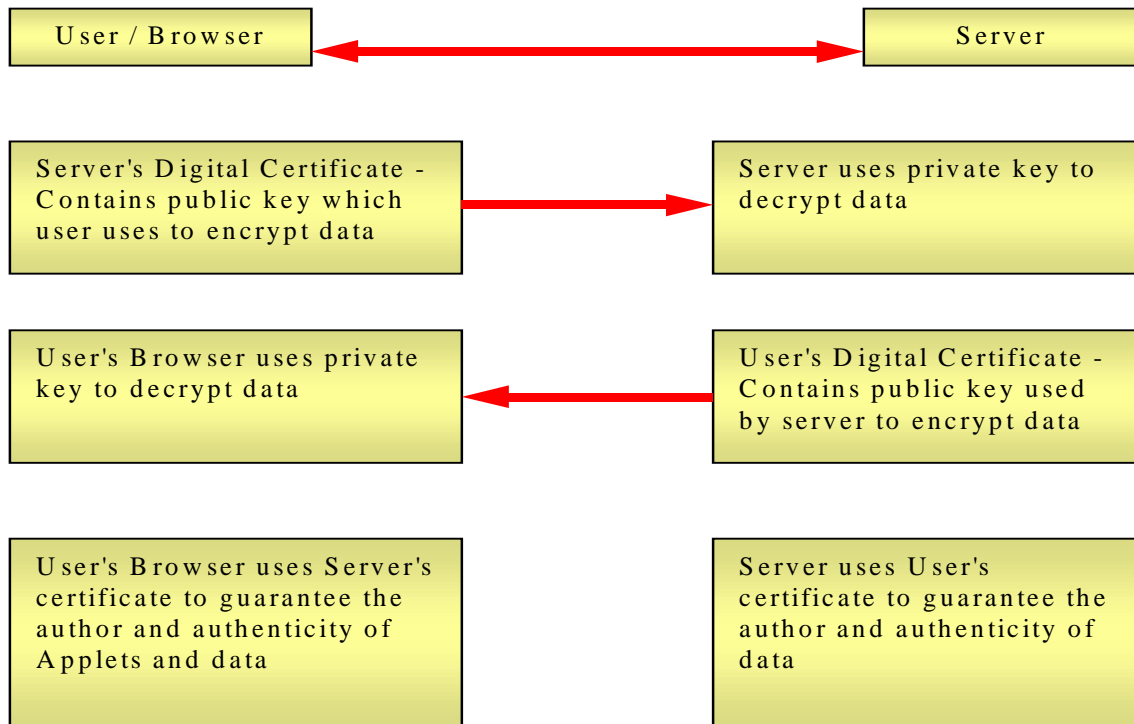


Figure 12 - Digital Certificate and Encryption Interaction

5.9 Chapter Summary

This chapter provided a design for a system that provides online access to cadastral data from a server database. It covered the processes that were intended to be included in the system, the intended user and the interface design considering the intended user, interface specifics, database data specifics and the security measures that would be ideal in such a system.

6 *An Online System*

6.1 *Chapter Overview*

A system was implemented, as a result of the perceived need to facilitate online transactions of cadastral data in both directions between the legal data custodian and the private server. The system took into account the technical components and design factors studied in previous chapters, and the needs of the digital cadastral processes to be facilitated online. This chapter outlines the resulting system, focussing on the functionality provided rather than the programming practices used. Some space is devoted to explaining the uses for the system by describing some of the situations for which the intended users can utilise the system.

The prototype adopts many of the principles described in the previous chapter, which outlined a design for a system with particular requirements. The implementation described in this chapter takes the principles and applies them in a real sense, providing a platform from which to demonstrate the concepts of the use of cadastral data through the WWW, including two way flows of data from server to user and from user to server.

6.2 *The Prototype System*

The system follows the model proposed in the previous chapter, the overall flowpath model in Figure 11, and the user's view of the system in Figure 9 (from the previous chapter). The user interacts with a Java Applet Graphic User Interface (GUI) from within a web page on a web browser, which in turn interacts with a CGI program located on the WWW server which the web page originated from. The CGI program is a Java application with a Perl script wrapper that, together, interacts with a server database through JDBC and SQL queries.

The CGI program is designed to interact with distributed databases, and as such, the user can retrieve data from a cadastral database which happens to be located on the same computer as the web server. The user can also retrieve data from another database located on a completely different computer through a local

network. The CGI program handles this through the JDBC interface and through server metadata files which describe the databases and their locations. These databases are accessed through the JDBC interface using the SQL information indicated in the metadata file.

The user has the ability to download server data to the Java Applet interface, and also upload local disk data to the Java Applet for display. The user can display both local and remote data simultaneously for graphic comparison. The user can download server data to a local disk file, or alternately, submit local drive data to the remote server. The following sections describe these processes in more detail.

6.3 User Interface

The user accesses the system through the WWW using a recent, popular browser that is capable of running Java Applets. A user wishing to submit data must use a late version of the Netscape browser, and although for this prototype system only the Netscape browser was catered for (a result of the specific digital certificate scheme used to sign the Java Applet), there is no technical reason why all major browsers cannot be supported.

Using the browser, the user connects to the custodian's WWW site, downloading the system HTML files, and subsequently, the Java Applet. The Java Applet brings up a simple button on the web page. When the user clicks on this button, the Applet brings up a separate window, which contains a toolbar, data display area, a message bar, and a status indicator. The data display is initially blank – data must be selected for display by the user (see Figure 13 for a view of the display with data on it).

The toolbar contains buttons that manipulate the display – zoom in, zoom out, pan, fit, etc. There are also buttons which bring up a data display dialogue window, which facilitates the loading of custodian data from the WWW server, and for the loading of user data from the local hard drive (see Appendix-3).

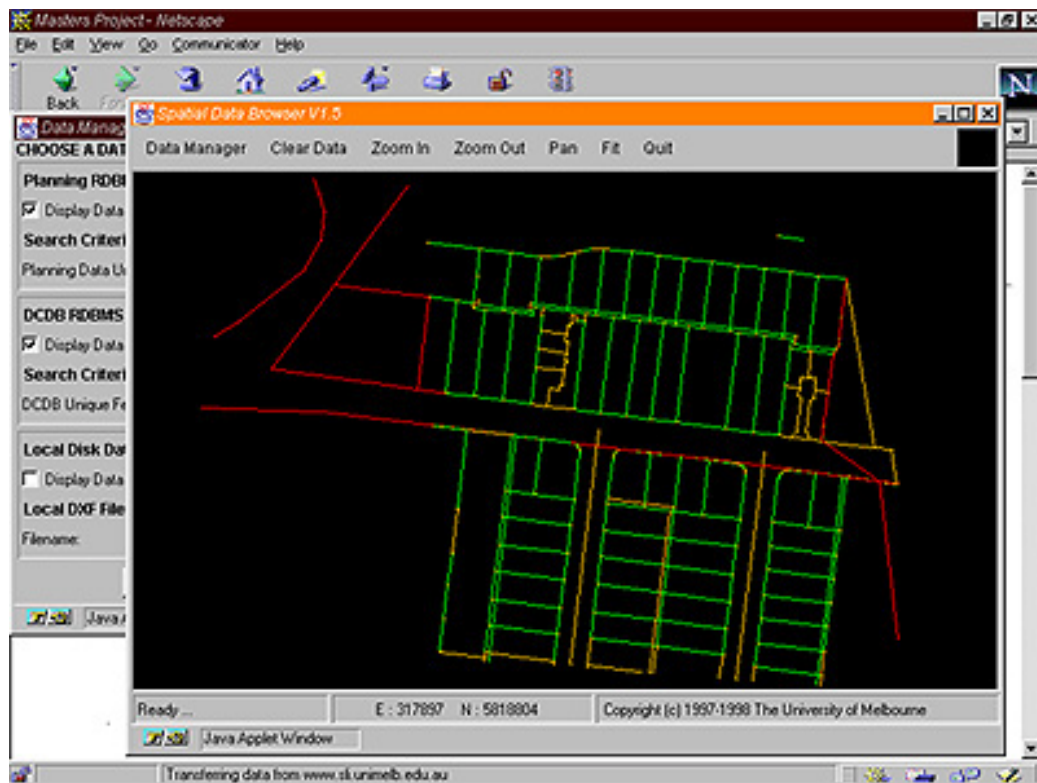


Figure 13 - Applet User Interface

6.3.1 Loading Custodian Data

The user presses the button on the toolbar of the main window to call up the dialogue window which handles the loading of server data (see Figure 14). The dialogue window is generated on the fly, using information loaded from the server about which databases are available. When the user clicks on the load button on the main Applet window, the Applet calls a CGI program which reads a metadatafile which contains information about each of the available databases including network location, available data, dataset information and basic query information. The metadatafile contains one or more records, one for each database. A record contains record entry identifiers, followed by a piece of metadata on the following line. A record looks like the following:

DataRecord

DataDescription

<Dataset Name>

DataDescriptor

<a one word descriptor for this dataset, used as an index in data


```

structures>
DataLocation
<URL of the database>
DataBaseCallString
<command line to use to make queries to the database>
LocatorName
<name of a data type that can be queried on>
Textfield
<name of the data type that can be queried on>

```

The CGI program processes this information and sends it back to the Applet, which uses the information to create a dialogue window, enabling the selection and loading of all data to be displayed within the Applet display area.

This window contains a panel for each available dataset, which includes components that allow the user to specify search criteria for data retrieval, or for data display (see Figure 14). A Unique Feature Identifier (UFI) is used as a search criteria. There is scope for other search criteria, such as street address, or geographic location for example. Search criteria such as street location would require street address information to be resident in the database.

A UFI is taken as being a single numeric identifier which all entities within the database have. When selecting data, the user enters a UFI of some entity, which, could correspond to a point, line or polygon. All objects within a certain radius of the selected UFI are returned. For each remote dataset that is returned, a display layer is created that can be displayed or hidden independently from other layers.

Upon pressing the 'Display Data' button within this dialogue, the Applet attempts to retrieve data, whether it be remote database data or a local file. The Applet only attempts to return data for which the relevant field has been selected and a search criteria has been entered by the user. For remote data, the Applet makes a request to the WWW server to retrieve the data from the data server. The data is sent back to the Applet as a stream of data, which is promptly displayed in the display area of the main window. The data stream consists of graphic instructions which the Applet recognises. All data that is retrieved from server databases is

converted by the CGI program and passed back to the Applet in this format. The format consists of:

1) Point Data:

POINT x1 y1

2) Line Data:

LINE x1 y1 x2 y2

3) Polygon Data:

POLYGON

LINE x1 y1 x2 y2

LINE x1 y1 x2 y2

LINE x1 y1 x2 y2

LINE x1 y1 x2 y2...

ENDPOLY

Where (x1, y1) and (x2,y2) are the 2 dimensional coordinates of the start point and end point respectively, and each polygon contains one or more lines. This data is incorporated in a data structure within the Applet and requires less processing time than other data formats. More object types are possible, such as text object types, or more complicated graphic types such as arcs for example.

The data stream is used to avoid caching on the user's computer, which ordinarily occurs if a file is sent to the browser. This approach means that the user cannot retrieve the data or save it to disk without the explicit intervention of the Applet, and means that access to the data can be controlled. Access controls can subsequently be implemented to restrict access to authorised users.

The Applet uses CGI requests to the WWW server, which is an attempt to allow the Applet to retrieve data through firewalls, which usually (depending on how system administrators set them up) prevent all extraneous communications except selected HTTP requests such as CGI.

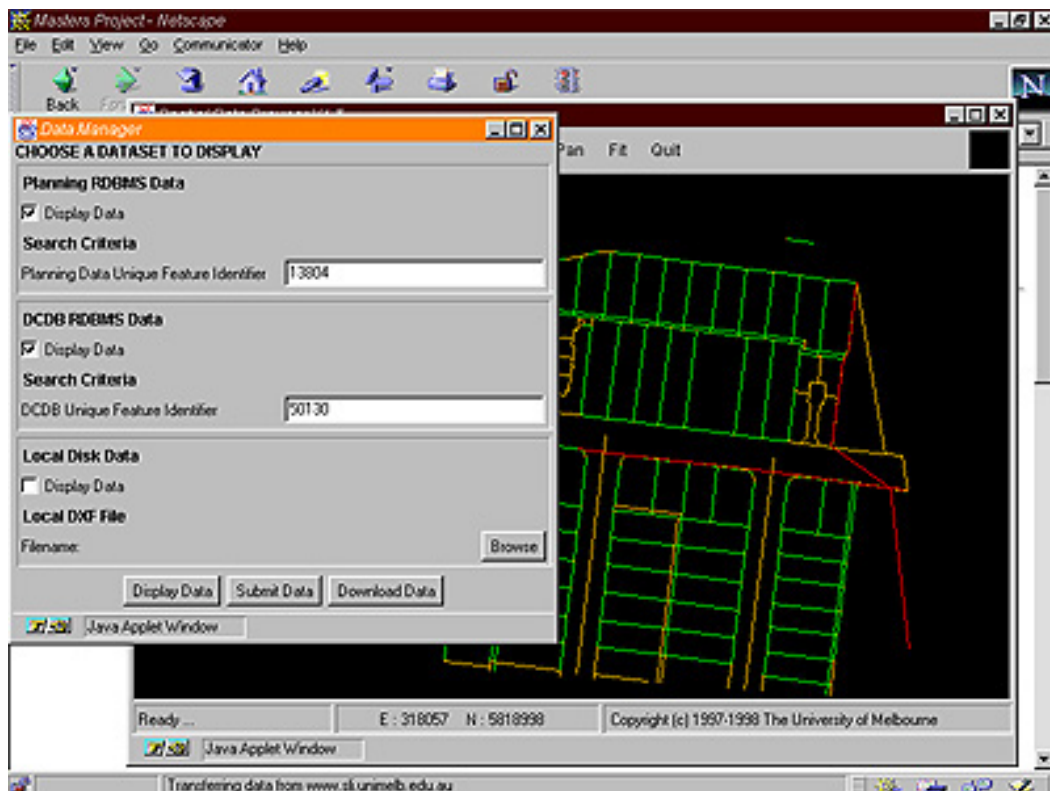


Figure 14 - Data Load Window

Loaded data is stored in the Java Applet's allocated memory. This approach allows the Applet to be able to perform most viewing functions in its own program space, reducing the number of network transmissions to a bare minimum. Approaches such as HTML forms require all interfacing functionality to be performed at the server, increasing the number of server requests, leading to increased network activity and latency between requests. If the user does not select 'clear' (which disposes of the data in memory space) before the end of the session, the loaded data is discarded from memory space along with the Applet.

6.3.2 Loading User Data

Upon pressing the data button on the main window toolbar, the user is immediately prompted with a dialogue window asking to choose a file to load. While many data formats could be supported (all that is needed is the relevant conversion software), for simplicity only the DXF format was catered for in this prototype. Upon selection the file is loaded into the Applet's memory space, using the same internal data structures as for loaded server data. The DXF data format

is lost at this stage, as is any other formatting information that is not used by the Applet. This data is a separate layer to the server data that can be toggled on or off as needed. Multiple files can be loaded into the Applet at once.

One aspect that has been ignored to this point is that of the Java sandbox, which restricts the operations that are available to Java Applets. The restrictions can be relaxed when the Applet is signed with an object signing digital certificate (specifically generated for signing object code), and provides Applets with the capability of file loading from a local drive. On top of using the digital certificate, the Applet must specifically request the user for permission to relax particular restrictions, and only those that are requested are relaxed. This approach means that no unauthorised access to the user's machine can occur, and that all operations that request a relaxation in restrictions do not occur unless the user approves.

When the display data button is pressed for the first time, the Netscape browser notifies the user that the signed Applet is about to perform an operation that is normally prohibited. The user then can view the downloaded certificate and then either grant the Applet access or deny it – the permission must be granted to allow the Applet to access the file on the hard drive.

6.3.3 Data Viewing

The data is displayed in the data display of the main Applet window. The display is a vector display, catering only for the vector style data that categorises cadastral mapping. Typical view manipulation is supported, with zoom, pan and fit functions. Toggle of data layers is also supported, principally with each server data layer and user data layers. Support for layers within datasets is not planned at this stage.

6.3.4 Data Submission

Data submission has been incorporated to facilitate the online submission of digital map files. This is envisioned to augment the current practice of submission of digital files along with legally required hardcopy maps and documentation. In the future, when the digital lodgement of cadastral plan data becomes the major method of plan data submission, the prototype should be extended to include the

particular lodgement strategy. This prototype proves that the process of digital submission of documents is possible, and only requires an institutionally sanctioned procedure to follow to allow its formal implementation in an online system.

Upon pressing the 'Submit Data' button in the load data window, a new dialogue window appears asking if the user wants to submit a local file. Upon user approval, the file is read from the user's hard drive and sent to the server through a CGI request, whereupon it is redirected through an upload process to the data custodian. This strategy is simple and does not incorporate automatic database updating, although technically the implementation of this is possible.

The most logical extension to this paradigm is to allow the submission of data to be automatically integrated into a digital database. This would allow the automatic update and upgrade of databases through the Internet to become a reality, although technically it is already possible. For this to become part of the cadastral system, major changes to the land registration system would need to come about, including user quality assurance of the submitted data, and processes to allow the handling of digital data within the plan approval process (Effenberg et al., 1998). This prototype could be extended to allow all parties with an interest in downloading and passing on digital plan data to do so, although it is not a design feature at this time.

Due to the requirements the user must meet in order to be able to submit data, the submission capabilities are restricted to registered users. A registered user is typically a licensed private surveyor as defined in the current cadastral surveying legislation. In order to prevent other users from gaining access to the submission service, a signup window must be negotiated before the user is allowed to submit data. When the user presses the 'ok' button to begin the submission process, the nominated file is read from the user's local drive into the Applet's memory space, whereupon the file is sent down to the server and redirected as required.

6.3.5 Data Download

A facility is provided to enable users to download data to a local drive. It provides a registration window that authenticates the user and provides charging

mechanisms followed by saving of the data in a chosen format onto the user's local drive. There are a number of issues associated with this functionality.

A limited authentication process is provided to ascertain the identity of the user trying to download data. User authentication would involve loading the user's digital certificate and initiating an encrypted session, from which credit card details and private information could be exchanged. The Applet keeps a track of user details and writes what was downloaded by whom etc. to a log file on the server.

The data formats to download data in involve a small number of the most appropriate and widely known. The simplest and easiest to implement was the DXF format, because of widely available DXF resources that allow conversion software to be implemented. However, the DXF format data is not as desirable as some of the more 'intelligent' formats.

The Java Applet is not normally permitted to perform operations such as saving data onto local drives, and can only do so because of the digital signing of the Applet as described previously. A process similar to that of section 6.3.2 occurs to enable the Applet to step outside the 'sandbox' of the browsers JVM.

6.4 System Security

Digital Certificates

The Java Applet is signed with a X509v3 digital certificate, which has extensions on top of the regular X509 structure to allow it to step outside of the Java 'sandbox' within Netscape 4.x and later browsers. By doing this, the Applet not only gains the ability to save and read files from the local drive, it allows the user to authenticate the origin of the Applet and to provide tamper detection on the Applet files that downloaded from the server.

Data files that are loaded into the Applet, or submitted to the server, would ordinarily be digitally signed by the user, using a digital certificate as well. This provides tamper detection and authentication capability on the data file, as would be required on a file of survey plan data for example. This capability is not yet

incorporated into the Applet itself, but it would be ideal in a fully fledged application.

Session Encryption

The entire session, from download of the HTML page with the Applet on it, to when the user interacts with the Applet, to when the page is dismissed, would ideally be encrypted using some accepted encryption capability, such as SSL for example. This procedure would make all data transactions undecipherable to eavesdroppers, and would enable commercial data transactions to be made safely. The encryption procedure itself would require the WWW server software to be cryptographically enabled, and would also require the server to have its own digital certificate. For any download, upload and submission transactions to be made safely, the user must have a digital certificate as well. This would ideally be negotiated at the start of the encryption procedure, to enable the session to be appropriately encrypted. The prototype does not presently have this capability.

6.5 WWW Server

Requests from the Applet to the server are made in the form of CGI requests, which access a CGI program that subsequently performs the extra actions as needed. Since the calling Java Applet performs all other data manipulations, the CGI program is tasked with retrieving data, firstly by retrieving information regarding the available data sets (stored in metadata files), and secondly by retrieving the data itself.

The first contact with the WWW server is to retrieve information from a metadata file that describes the available database data. This allows the Applet to access potentially multiple datasets without having to know anything about how many there are, where they are located, or how to access them. The information is retrieved when the user clicks on the data button in the main Applet window and is used to create the load data window (see Figure 14).

Requests for data from this window go across the Internet and start a CGI program (see Appendix-1) that, itself, starts a Java application sub-process which then accesses the data server through the JDBC interface (see Appendix-2). The Java application ensures that accesses to a data server on a non heterogeneous

system will still work as long as the data server supports the JDBC interface. This enables the WWW server and the data server to reside on different machines, thus increasing the protection offered to the data server from outside. This also enables database servers to be implemented on different platforms, since the JDBC interface is platform independent. If database locations or platforms or database software change, the only requirement is to update the metadata file describing the databases.

6.6 Data Server

The data server is an RDBMS supporting SQL operations and storing of data in a series of tables. This setup is intended to mimic the setup undertaken by DataFlow and Land Victoria (which is still under development and cannot be replicated exactly at this stage), which stores spatial information in tables and uses spatially capable software to access it.

The database itself is a PostgreSQL RDBMS with a JDBC driver that allows Java applications to connect to the database and perform particular operations. A database configuration file specifies which network users are allowed to connect to the database, and what operations connected users are allowed to perform. The database uses this method to restrict access to selected users, one of which is the CGI process on the WWW server.

PostgreSQL was chosen to be the database server as it was freeware, and the source code was freely available. It also incorporated a JDBC driver as part of its standard distribution, and was documented at the WWW site (PostgreSQL Organization, 1998).

Database Data Formats

The database data format was designed to reflect the new UFI (ASCII) based method of storing DCDB data as simply and closely as practical. Since the UFI system is still being developed for the real DCDB, the UFI approach adopted here will inevitably contain some differences from the real system. It was hoped, however, that the concepts of data handling that would come from such a data system would still be addressed.

User Data Formats

The data the user came into contact with, namely the data uploaded into the Applet, was of a particular, defined format. Due to the considerable proprietary nature of most data formats, the only user data format dealt with was the Data Exchange Format (DXF). Dealing with other formats is a simple problem of data conversion, and should not be dwelt on too much, as the concept of handling data in such formats is what is important, not the formats themselves. The DXF format is not as intelligent or ideal for storing spatial relationships in data, but it is probably the most readily acceptable data format to date for spatial data. The DXF format was chosen as it was seen to be widely adopted, have a relatively simple data structure, was well documented and allowed a relatively simple implementation of conversion software.

6.7 Cadastral Data Transactions

The system described has been implemented in such a way as to allow particular users to access particular functionality. The implementation is such that users are able to view data with the option of subsequent download, with viewable data coming from either a server database or the user's hard drive. The traditional WWW model where users are strictly limited to downloading data from a server database is extended so that users can upload data to the server as well.

The system has been implemented to allow transactions in cadastral or spatial data to take place across the WWW. The type of transactions that are accommodated include:

- download of data, possibly to provide data for a GIS like application or maintenance contract;
- viewing of custodian data, possibly as part of a general public information service;
- upload of user data, to allow graphical comparison with custodian data for various reasons;
- submission of data, for use in updating or upgrading a digital dataset, or as part of a digital lodgement component of a land registration system.

The system facilitates the transmission of digital data through a readily available, and increasingly popular, digital networking technology. The provision of the system on the Internet allows a potentially large audience to access the functions the system provides. It also enables users in remote locations to use the functionality it provides in a more real time manner, for example, the digital lodgement scenario.

6.7.1 Examples of Use

A number of projected users for the system include that of the spatial data user, who may periodically purchase data; the private surveyor, who may need access to spatial data but also is able to submit new data as well; and the casual user, who would use the system for its data enquiry services. The most significant example is that of the private surveyor, who potentially has the need for use of a two way flow of data, both to and from a remote data custodian.

Private Surveyor

The second example is perhaps the most significant, as it incorporates the two way flow of data across the Internet. This example is that of the private surveyor being the user, who not only downloads data but also is able to upload and submit data (see Figure 15). The most obvious use for this is for digital lodgement, where the private surveyor submits digital survey plan data as part of the land registration process. After submission, the digital data is either redirected to the relevant authority for processing, or it can be dropped directly into a database, depending on the strategy adopted to handle digital lodgement of survey plan data.

This demonstrates the two way flow of data across the Internet. To date, online services have chiefly been built to supply the users with data. In some cases, like for example the private surveyor or spatial data producer, the user has updated data that can be integrated into the server database. An online service that allows the user to feedback data would be beneficial to a digital data process, and would allow more efficient handling of digital data, especially for users in remote locations.

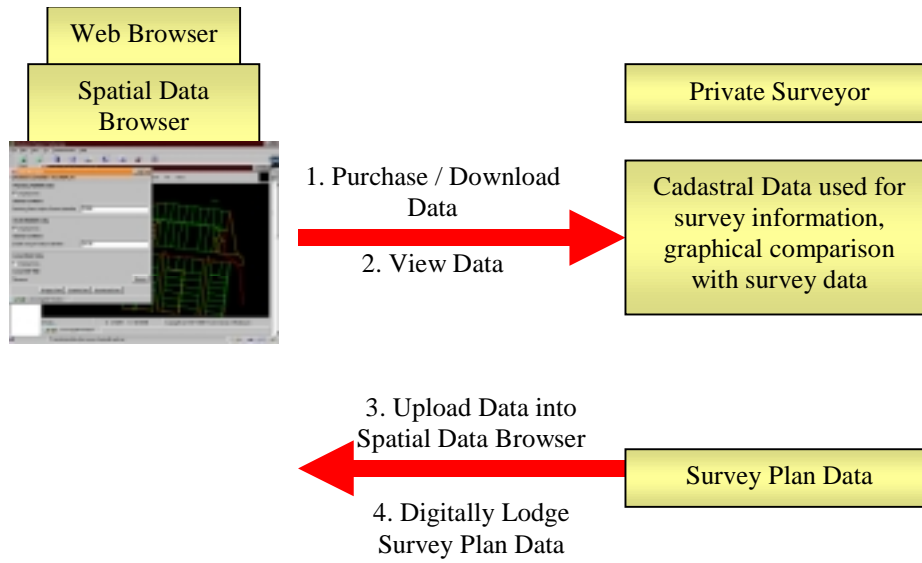


Figure 15 - Private Surveyor

Spatial Data User

This example is that of a user who generally downloads portions of data for use in GIS as a base data set. This type of user will use the system to select and retrieve data from the database. Following this, the user will be able to either view or download the dataset to a local hard drive (see Figure 16). The system would be able to retrieve the data from the relevant database and load it into the Java Applet on the user's computer. The Applet would then be able to save the data into a file on the user's local hard drive in a specified format. Purchasing conditions would normally apply, as would the relevant security measures to ensure data integrity and privacy while in transmission across the Internet.

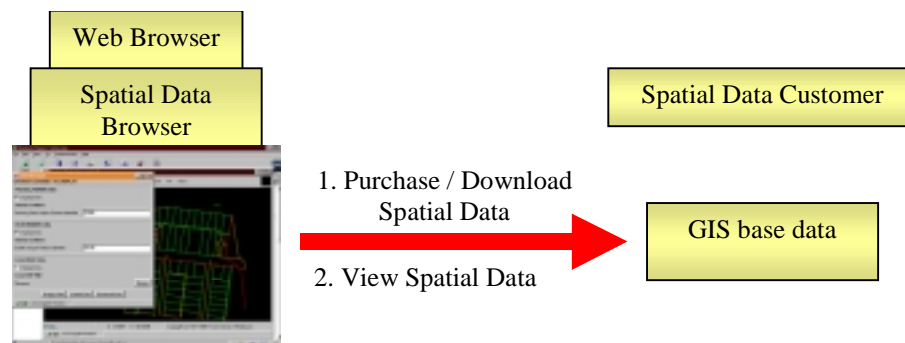


Figure 16 - Spatial Data Customer

Casual User

The casual user would use the system for casual enquiries, mostly for small or single parcel queries. In this case, data download capability would probably not be necessary and submission capability would not be appropriate. Providing for this type of user allows data custodians to disseminate portions of their data into the community. It should be noted that new and unthought of uses for the data will, in all probability, appear, because its availability is likely to attract new types of users and uses. The effect that the availability of such data may have on society in general has yet to be determined.

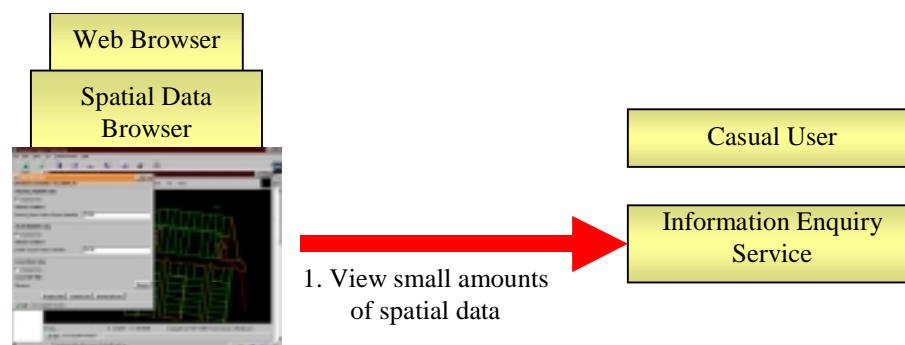


Figure 17 - Casual User

6.7.2 Current Limitations of the System

The prototype is limited generally by time and resource constraints that are reflected in the depth and breadth of the implementation. As it stands, the system shows the potential of the concept in its simplest form without the bells and whistles that say, a commercial application, would be obliged to provide. Some of these limitations include:

- There are a limited number of data formats that the user would use to save data or submit data (there is one - the DXF format). The DXF format is widely recognised and used, yet does not provide for spatially intelligent data, such as those that include relationships between objects.
- The submission component does not implement a hard and fast strategy for lodgement of submitted digital data. The system uses simple redirection of data to some location for further processing, yet future systems may be able to directly update a remote database.

- The security measures are not as strict in the system implementation as should be (as stated in the fifth chapter design requirements). Encryption is not used to protect transmissions across the Internet simply due to resource limitations, which is not to dismiss the importance of these components, just that they were not implemented for this prototype system.
- The database used approximates that of a spatial data custodian, and, for the purposes of this prototype system does so adequately. In a commercial or real world system, the database used would perform similar duties, even if on a larger scale or on slightly different data formats.

6.8 Chapter Summary

An online system that allows the viewing and download of data through the WWW was constructed. A Java Applet provided a GUI that allowed users to select and view data, load local hard drive files, view local data superimposed on other data, and to perform download and submission. Network communications were accomplished through CGI requests to the WWW server which performed the data request and retrieval duties. The CGI program used JDBC to access the data server, thus enabling the data server to reside on a different platform to the WWW server. The use of digitally signed Applets enabled the user to perform operations, such as loading data from a local hard drive, that ordinarily are unavailable to Java Applets. Encryption can be used to encrypt data transmissions in both directions to protect data from prying third parties. The potential users and uses of the system were also briefly explained, keeping in mind the reasons the system was built and the requirements for which it was designed.

7 Conclusions and Recommendations

7.1 Basis For Online Systems

Over time, the cadastral system is one that is becoming more and more reliant on digital technology. The existing hardcopy system is acknowledged to be struggling to efficiently support the existing hardcopy processes given that a large amount of information is digital at many points of its life within the cadastral system. The importance of the DCDB within the system is increasing, especially as it is being used in many contexts as base data for other information systems, and has become a saleable commodity.

Users of the DCDB have demanded increases in data quality and completeness (Wan and Williamson, 1995), demands which have prompted the regulating authorities to rectify the situation. While the DCDB has been reformed of late to improve it as a product, the cadastral system that provides it with data is less advanced in this respect. The introduction of digital lodgement, possibly together with other reforms to streamline the system and make it more efficient, should see the work of maintaining the DCDB, and the cadastre in general, become more efficient in a digital environment.

The use of the Internet allows the easy dissemination of cadastral data to a potentially large audience. This allows the use of an Internet application to provide information that ordinary citizens would previously find difficult to access. In addition to this, the Internet can provide an avenue for commercial users to gain access to purchased data. The advantages of such remote communications are generally understood, although there are concerns about network limitations. The last point is that the Internet can be used to assist in the actual maintenance of the DCDB or of the cadastre itself, as it provides a digital medium that facilitates the transmission of digital cadastral data and can provide for such concepts as digital lodgement.

The pace of movements in the GIS industry and in the Internet industry means that the technology to provide such functionality is available or appearing, and it

will not be long before online GIS and the use of such systems will become more widespread.

7.2 *Internet Technologies*

Online mapping applications have already begun to appear on the WWW, providing users with a range of data viewing and download options. The online cadastral applications that have appeared typically provide user access to cadastral map and attribute data for a fee. The databases that these applications connect to are typically digital cadastral databases that are usually copies of the official cadastre. Some jurisdictions have provided connections to the state DCDB as it is the official state cadastral map in that jurisdiction.

The examples of online mapping applications all have interactive interfaces that include graphic and text-based retrieval of data. The interfaces that deal with graphic data all have a minimum level of functionality, including the basic graphic functions zoom, move etc. The interfaces that were implemented in Java, ActiveX, or as a browser plug-in, provided superior interface functionality and ease of use than the original interface technique of HTML forms. Each of the former techniques have advantages and disadvantages that make their use in some situations desirable. Security measures were limited to user / password authentication schemes to restrict user access to data, although there are other, stricter, security measures that can also be implemented.

The examples mostly interacted with databases through the WWW server, or through an intermediary server, following a three tier architecture commonly used for many database applications. There was a tendency for interfaces to not connect directly to a database over the Internet because of the inherent security dangers involved. The use of the three tier architecture allowed the use of often multipurpose databases that could support wider responsibilities (usually not Internet) such as cadastral operations for example. The Internet functionality in these cases is shifted into the intermediary applications that reside at the WWW server that interact with both the database and the user interface across the Internet.

7.3 *A Typical Online Cadastral Application*

A typical online cadastral application could provide data viewing access for members of the general public, data purchasing of larger quantities of data, and facilities for submission of digital plan data or digital lodgement. Given that the users most likely to use each of these components are, on average, likely to have different levels of computing skills, the interface design must be useable by the beginner, while still providing the functions that more advanced users need for their purposes. The interface should provide functionality typical of lightweight graphic mapping applications, such as zoom, move, and most importantly, data search and retrieval functions. The interface should provide extra functionality, such as data purchasing or downloading options, in extra layers that would be found in separate sub-windows for example.

The interface should interact with a database through the WWW server and an intermediary application, which follows the three tiered approach to providing database interaction capability on the Internet. This approach means that the database does not have to concern itself too much with Internet protocols or processes, and it also means that the database can be stored off the WWW server or even in a number of distributed locations, promoting greater safety and privacy from the Internet. The intermediary application at the WWW server can be responsible for handling interactions with the database and the user interface, thus making it that the interface and database need know nothing about the other to operate.

The user should be able to retrieve data based on certain criteria, be able to view and / or manipulate it, then subsequently download it. Data submission facilities should be provided for the user if the system is to provide for the upload of digital data. Data submission could supplant existing lodgement processes by simply redirecting the user's data to the appropriate authority who then treat it as they would hardcopy plans. Alternately, more sophisticated regimes could be implemented that utilise a more automated cadastral update process. Access to certain functionality may need to be restricted depending if the service attracts fees or requires that users be qualified in certain areas to be able to upload data (eg a licensed surveyor). Adequate security measures should be implemented to

protect the commercial interests in data, the privacy of information that may be attached to the data, and to authenticate users and data providers and transmitted data as needed.

7.4 Summary of Conclusions

1. The cadastral system is becoming more reliant on digital technology, and, in order to become more efficient, needs to continue undergoing infrastructural and institutional reform.
2. Internet systems allow complete digital handling of cadastral data for remote parties.
3. An Internet system can facilitate dissemination of cadastral data, and upgrade and integration of data as well.
4. An Internet system can facilitate digital lodgement of survey plan data.
5. The deployment of Internet technologies for cadastral systems is limited only by institutional and legal arrangements.

7.5 Future Research

There were many areas of interest that arose from the course of this research that could not be covered due to their depth and the detachment from the main context of this thesis.

- 1) Future technical implementations could direct more research on:
 - a) Encryption of transmissions across the Internet. Due to time constraints and resource limitations, this was not implemented although it was deemed to be an important part of the system.
 - b) Internet Security. This research limited itself to using some of the more suitable techniques for providing security for data. Future research could focus on rating the strength and reliability of such techniques. Special work could mention current practices and their suitability for the task in hand given the risks of a security breach. One example of this is the assessment of user / password schemes that transmit unencrypted passwords over the Internet.

- c) Use of OpenGIS, CORBA, DCOM etc. The use of distributed component technology was identified, but not studied in any detail. The impact of using these on the basic online database architecture could be analysed, as well as any benefits or drawbacks that result from using any or either of these.
 - d) Optimise network bandwidth or improve transmission efficiencies for large datasets. The use of the Internet for the transmission of large datasets depends very greatly on the speed of the network connections involved, thus potentially limiting the effectiveness of such systems. Research could focus on the efforts to improve network quality, on the likely improvements and provide an indication of the future situation. Research might conversely focus on how much utilisation a system may get given the current networking infrastructure, and could focus on user attitudes and performance expectations.
- 2) Future research could address cadastral reforms such as:
- a) Digital lodgement processes over the Internet. Digital lodgement in itself is being studied independently, such as by Falzon (1998), and could concentrate on the use of the Internet as a tool for digital lodgement. There are numerous issues such as confidentiality, commerce, and quality assurance that could be addressed.
 - b) DCDB update mechanisms. More automation in the cadastral update process could be the result of complete digital cadastral processing. There is scope for change in the current cadastral model which was ideal for hardcopy cadastres but less so for digital ones. Research could focus on possible efficiencies that could arise from particular changes to the current cadastral model. Research is currently being conducted in this area by Effenberg (in progress).
 - c) Legal and institutional ramifications. This research focussed on the technical side of providing an online cadastral application, without heed to whether it was possible under current legislation and practices. Future research could identify the ramifications that an online application could

have on all concerned in the cadastral discipline, as well as any changes that may be needed legally and institutionally.

- d) Other changes to the cadastral system eg multipurpose cadastres etc. The increased use of the DCDB as an information source could have untold effects on today's society. The availability of a multi-purpose cadastre for example, could have some significant effects on a jurisdiction's economy, or on the way that people perceive land.

7.6 Concluding Comment

The Internet as a medium may have only been available for a relatively short period of time, but its influence is being felt in all bastions of developed society. Many entities are finding that the Internet and the WWW are providing new avenues for going about their affairs. Commercial operators are finding that there are potentially new markets of customers that can be reached, and are subsequently developing ways to profit from it. Users are finding new ways of doing things, such as finding information, or ordering online for example. Development of the technology is going on at a great rate to facilitate the demand for more bandwidth and services. The effect that this new source of information will have on society is yet to be seen, on both those that have ready access to the Internet, and importantly, to those that do not. For these reasons at the very least, study and analysis of the Internet discipline cannot be ignored.

References

- Alexander, J. and Warwick, V. (1997). Writing GIS Applications for the WWW. *1997 International ESRI User Conference*.
<http://www.esri.com/base/common/userconf/proc97/PROC97/ABSTRACT/A543.HTM>
- Arseneau, B., MacLeod, G. and Coleman, D. (1997). The Development of a Land Gazette. *URISA '97*, Toronto, Canada, 19-23 July 1997
- Aussoft Solutions Pty Ltd. (1998). Latitude Geographical Information System, Aussoft Solutions Pty. Ltd. <http://www.aussoft.com.au/html/latitude.html>
- Autodesk Inc. (1997). Autodesk MapGuide.
<http://www.mapguide.com/index.htm>
- Aybet, J. (1996). Interoperability of GIS in an Open System Environment. *Second Joint European Conference on Geographical Information*, Barcelona, Spain, 1996, IOS Press
- Balfanz, D. and Felten, E. W. (1997). A Java Filter, Department of Computer Science, Princeton University. September 1997. p 7
- Barr, R. (1996). Selling Soap. *GIS Europe*. December 1996. pp 16-17
- Bertazzon, S. and Waters, N. (1996). The Use of GIS Applications on the Internet for Marketing Tourist Destinations. *GIS/LIS '96*, Denver, Colorado, 19-21 November 1996
- Birrell, S., Barry, J., Hall, D. and Parker, J. (1997). Is the Torrens System Suitable for the 21st Century? *Administering our Land: An Anthology of Cadastral Issues in Australia*. D. Grant and I. Williamson Eds, Published by the Cadastral and Land Management Commission of the Institution of Surveyors, Australia, Inc.
- Black, J. D. (1997). Disseminating Geodata through Internet and Intranets. *GIM International*. May 1997. 11 (5). pp 6-7

- Buehler, K. and McKee, L. (1996). The OpenGIS Guide - Introduction to Interoperable Geoprocessing - Part 1 of the Open Geodata Interoperability Specification, OPEN GIS Consortium Inc.
- CERT Coordination Centre (1998). CERT Coordination Centre, CERT Coordination Centre <http://www.cert.org/>
- Chappell, D. (1996). Component Software Meets the Web: Java Applets vs. ActiveX Controls, Chappell Associates. May 1996.
<http://www.chappellassoc.com/JavaActX.htm>
- Chopra, P. (1996). Geological Mapping on the Web. *GIS User*. October-November 1996. pp 35-39
- Cowen, D. J., Cundall, A. J., Heimann, P. W. and Richers, D. (1996). Maintaining MetaData Through a Common Web and GIS Interface. *GIS/LIS '96*, Denver, Colorado, 19-21 November 1996. pp 1063 - 1070
- Crisp, N. (1997). Communicating Geographically with Intergraph's GIS. Melbourne.
<http://www.sli.unimelb.edu.au/WWWSymp97/presentations/geowmap4/index.htm>
- Dale, P. (1992). Cadastral Reform '92 - Let the Users Speak. *International Conference on Cadastral Reform '92*, Melbourne, Australia, Department of Surveying and Land Information, The University of Melbourne. pp 1-6
- Dale, P. (1998). What Matters Is What People Do - GIM Interviews Professor Peter Dale, President of the FIG. *Geomatics Info Magazine International*. July 1998. 12 (7). pp 66-68
- Department of Geomatics (1997). GIS and the WWW '97, Department of Geomatics, The University of Melbourne. 1 May 1997
<http://www.sli.unimelb.edu.au/WWWSymp97/Welcome.html>
- Department of Geomatics (1997). GIS, The Utilities and the Internet - Summary. Melbourne, Department of Geomatics. 13 August 1997

- Department of Natural Resources (1994). DCDB Development Project,
Department of Lands. 19 August 1994
- Effenberg, W. (1997). Personal Communication
- Effenberg, W. (in progress). Change Management in Cadastral Systems.
Department of Geomatics. Melbourne, The University of Melbourne
- Effenberg, W. and Williamson, I. P. (1997). Digital Cadastral Databases: The
Australian Experience. *Geographic Information - Exploiting the Benefits:
Proceedings of the AGI '97 Conference*, Birmingham, England, Miller
Freeman
- Effenberg, W. W., Enemark, S. and Williamson, I. P. (1998). Framework for
discussion of digital spatial data flow within cadastral systems. *Submitted to
The Australian Surveyor*
- Environmental Systems Research Institute (1998). ESRI - Geography Connects
Our World. May 13 1998. <http://www.esri.com/>
- Escobar, F. J., Williamson, I. P., Green, J. and Waters, E. (1998). The Use of the
Internet in the diffusion of GIS for General Practices in Victoria, Australia.
INET '98, Geneva, Switzerland, 21-24 July 1998
- ESRI Inc. (1997). Scalable Internet Mapping Solutions from ESRI. *ESRI ARC
News*. Fall 1997. 19 (3). p 6
- Falzon (1998). Digital Lodgement of Cadastral Survey Data in Victoria.
Department of Geomatics. Melbourne, The University of Melbourne
- Falzon, K. (1997). Brief Overview of Digital Lodgement in Other States.
Melbourne, Department of Geomatics
- Falzon, K. and Williamson, I. (1998). Digital Lodgement of Cadastral Survey
Data in Victoria. *Australian Surveyors Congress*, Launceston, Tasmania, 8-13
November 1998

- FIG (1995). Statement on the Cadastre. FIG Bureau, Canberra, Australia, International Federation of Surveyors.
http://sunspot.sli.unimelb.edu.au/fig7/cadastre/statement_on_cadastre.html
- Finley, D. B., Arseneau, B., McLaughlin, J. D. and Coleman, D. J. (1998). The Provincial Land Information Infrastructure for New Brunswick: From Early Visions to Design to Reality. *Geomatica*. 52 (2). pp 165-175
- Fortunati, L. (1996). Geo-Data Server on WWW. *Second Joint European Conference and Exhibition on Geographical Information*, Barcelona, Spain, 1996, IOS Press
- Geographic Data Victoria (1997). LMRI Property Project - Version 6.0. Melbourne, Geographic Data Victoria. 16 July 1997
- Geospatial Policy And Coordination (1997). Victoria's Geospatial Information Strategic Plan - Building the Foundations 1997-2000 - Final Version 3.31. Melbourne, Geospatial Policy and Coordination. June 1997
- Goldberg, I. and Wagner, D. (1996). Randomness and Netscape Browser: How Secure is the World Wide Web? *Dr Dobbs Journal* (January 1996). p 6
- Government of Victoria (1998). Land Channel. <http://www.land.vic.gov.au/>
- Grant, D. and Mooney, D. (1997). The State and the Business of Spatial Information. *CONSAS 97*, Durban, South Africa, 24-28 August 1997, IKUSASA
- Hayes, J. (1997). A Prototype System for the Digital Lodgement of Spatial Data. *School of Planning and Landscape Architecture and Surveying*. Brisbane, Queensland University of Technology.
- Hernando, I. (1998). Security and Confidence in Electronic Commerce: Certification Authorities. *INET 98: The 8th Annual Conference of the Internet Society*, Geneva, Switzerland, 21-24 July 1998.

- Hesse, W. and Williamson, I. P. (1990). A Review of Digital Cadastral Data Bases in Australia and New Zealand. *The Australian Surveyor*. 35 (4). pp 351-67
- Howard, J. D. (1998). Security Incidents on the Internet. *INET 98: The 8th Annual Conference of the Internet Society*, Geneva, Switzerland, 21-24 July 1998. pp 15
- Hudson, T. J. (1997). SSLeay and SSLapps FAQ. 19 July 1997.
<http://www.psy.uq.oz.au/~ftp/Crypto/>
- Intergraph Corporation (1998). Intergraph GeoMedia Web Map, Intergraph Corporation http://www.intergraph.com/software/geo_map/geo_web.asp
- Jacoby, S. (1996). Incremental Updates and Associated Issues. *WALIS Forum '96*, Perth, Australia, 23 - 24 April 1996. pp 8-20
- Jacoby, S. and Marwick, B. (1997). A New Era for Victoria's Digital Cadastral Data Base. *AURISA '97*, Christchurch, New Zealand, 17-21 November 1997, Australasian Urban and Regional Information Systems Association Inc.
- Jankowski, P. and Stasik, M. (1996). Architecture for Space and Time Distributed Collaborative Spatial Decision Making. *GIS/LIS '96*, Denver, Colorado, 19-21 November 1996. pp 516 - 526
- Keast, C. (1995). Human Computer Interaction and Geographic Information Systems. *1995 New Zealand Conference on Geographical Information Systems and Spatial Information Research incorporating the 7th Annual Colloquium of the Spatial Information Research Centre*, Massey University, New Zealand, 26-28 April, AURISA and Spatial Information Centre. pp 237-249
- Larsson, G. (1991). *Land Registration and Cadastral Systems*. New York, John Wiley and Sons
- Lemay, L. and Perkins, C. (1997). *Teach Yourself Java 1.1 in 21 Days*. Indianapolis, Sams.net

- Lennon, P. and Berenyi, M. (1997). Basic Land Information Network - Capitalising on our Information Resource. *AURISA '97*, Christchurch, New Zealand, 17-21 November 1997
- Li, B. (1996). Issues in Designing Distributed Geographic Information Systems. *GIS/LIS '96*, Denver, Colorado, 19-21 November 1996.
- Limp, W. F. (1997). Weave Maps Across The Web. *GIS World*. September 1997. 10 (9). pp 46-55. <http://www.geoplace.com/gw/>
- MapInfo Corporation (1997). MapInfo MapXtreme, MapInfo Corporation <http://www.mapxtreme.com/mapxtreme/mapxtreme.html>
- MapInfo Corporation (1998). MapInfo - The Information Discovery Company. <http://www.mapinfo.com/>
- Marr, A. J. and Benwell, G. (1996). The Evolution of the Use of GIS in New Zealand Local Government. *New Zealand Surveyor* (286). pp 30-35
- Marwick, B. (1997). Remodelling and Enhancing Victoria's Digital Cadastral Map Base. Melbourne, DataFlow Pty. Ltd.
- Microsoft Corporation (1997). Internet Explorer Provides Advanced Security Features. <http://microsoft.com/ie/ie40/features/?/ie/ie40/features/ie-security.htm>
- Ministerial Council for the Information Economy (1998). Building the Information Economy - a progress report on the enabling legal and regulatory framework, Ministerial Council for the Information Economy. June 1998. pp 18
- Moeller, M. and Montgomery, P. (1997). Web Woes - Netscapers are left to fume as Java/CORBA support falls short. *PCWeek Australia*. nationwide. 4 July 1997. pp 1, 29
- National Land Survey of Finland (1998). Mapsite - National Land Survey of Finland, National Land Survey of Finland. 1998 <http://www.kartta.nls.fi/karttapaikka/eng/home.html>

- Netscape Communications Corporation (1997). How SSL Works.
<http://home.netscape.com/assist/security/ssl/howitworks.html>
- Netscape Communications Corporation (1997). Netscape Security Solutions.
<http://home.netscape.com/assist/security/content.html>
- Netscape Communications Corporation (1998). Introduction to SSL, Netscape Communications Corporation. 10 September 1998
<http://developer1.netscape.com:80/docs/manuals/security/sslin/contents.htm>
- New Brunswick Geographic Information Corporation (1998). Geographic Information Corporation - What We Do. <http://inter.gov.nb.ca/nbgic/infra.htm>
- Parent, P. (1997). GIS and the Internet in New Zealand. *GIS User*. April - May 1997. pp 25-26
- Peng, Z.-R. (1997). An Assessment of the Development of Internet GIS. *1997 International ESRI User Conference*, ESRI Inc.
- PostgreSQL Organization (1998). PostgreSQL. 6 July. <http://www.postgresql.org/>
- Preece, J. (1993). A Guide to Usability - Human Factors in Computing. Oxford, Great Britain, Addison-Wesley
- Richardson, D. (1995). Logic Language Formalism Informalism. Oxford, UK, International Thomson Computer Press
- Rush, G. (1997). Land Information Management in Queensland. *CONSAS 97 Proceedings*, Durban, South Africa, 24-28 August 1997, IKUSASA
- Schell, D., McKee, L. and Buehler, K. (1995). Geodata Interoperability: A Key NII Requirement. USA, National Research Council, Computer Science and Telecommunications Board. April 1995
- Schofield, A. (1998). Cadastre on a clean slate. *GIS Europe*. July 1998 (7). pp 21-23
- Starling, R. N. (1997). Changing the Face of GIS, Genasys II Pty Ltd. pp 6

- Strand, E. (1997). Are You Browsing Browsers, Surveying Servers or Muddling in Middleware? *GIS World*. September 1997. 10 (9). pp 32-33.
<http://www.geoplace.com/gw/>
- Sutcliffe, A. G. (1995). *Human - Computer Interface Design*. London, Macmillan Press Ltd
- TerraLink (1998). TerraNet - Property Information Online.
<http://www.terranet.co.nz/>
- The Surveyors Board of Victoria (1997). Part 1 - Drawing Practice. *Survey Practice Handbook Victoria*, The Surveyors Board of Victoria. pp 2.1-6, 3.1-3
- Tuomaala, J. and Uimonen, M. (1998). Introducing the New Object-Oriented Cadastral Information System (JAKO) of Finland. *Proceedings of the XXI FIG International Congress*, Brighton, UK., FIG, 19-25 July 1998
- Universal Systems Ltd. (1998). Universal Systems Ltd, Universal Systems Ltd. July 1998 <http://caris.universal.ca/>
- Verisign Inc (1997). Digital IDs Introduction.
http://digitalid.verisign.com/id_intro.htm
- Vertigan, M. (1996). Choice and Contestability: Keys to Effective Public Sector Performance, Paper presented to the Institute of Public Administration Australia Leadership Forum
- Wallach, D. S., Balfanz, D., Dean, D. and Felton, E. W. (1997). Extensible Security Architectures for Java. *Internet Besieged: Countering Cyberspace Scofflaws*. D. E. Denning and P. J. Denning Eds. New York, ACM Press
- Wan, W. Y. and Williamson, I. P. (1995). The Users' View of Digital Cadastral Databases in Australia. *The Australian Surveyor*. 40 (1). pp 53-62
- Wang, L. (1997). Network-Oriented GIS: Integrating GIS with the Internet. *URISA '97*, Toronto, Canada, July 19-23 1997
- Williamson, I. (1983). A Modern Cadastre for New South Wales. *School of Surveying*. Kensington, NSW, University of New South Wales. pp 325

- Williamson, I., Chan, T. O. and Effenberg, W. (1998). Development of Spatial Data Infrastructures - Lessons Learned From the Australian Digital Cadastral Databases. *Geomatica*. 52 (2). pp 177-187
- Williamson, I. P. (1994). The Australian Cadastral System. *Cadastral Reform Seminar*, Seoul, Korea, 1 July 1994
- Williamson, I. P., Chan, T. O. and Effenberg, W. W. (1997). Economic Rationalism in Managing Spatial Data Infrastructure - The Australian Experience. *Proceedings of URISA '97*, Toronto, Canada, 21-23 July 1997. pp 15 <http://www.sli.unimelb.edu.au/research/publications/IPW/ERMSDI.htm>
- Wilson, J. D. (1997). Technology Partnerships Spark the Industry. *GIS World*. April 1997. pp 36-42

Glossary of Terms

Cadastral Related

DCDB - Digital Cadastral Data Base

LGA - Local Government Authority

LTO - Land Titles Office

GDV - Geographic Data Victoria (now part of Land Victoria)

GPAC - Geospatial Policy and Coordination (now part of Land Victoria)

LMRI - Land Management Resource Information (now part of Land Victoria)

Internet Related

CGI - Common Gateway Interface

HTTP - HyperText Transfer Protocol

HTML - HyperText Markup Language

LAN - Local Area Network

GIF - Graphic Interchange Format

JPEG - Joint Photographics Expert Group

Computer Programming Related

GUI - Graphic User Interface

RMI - Remote Method Interface (for Java)

JVM - Java Virtual Machine

JDBC - Java DataBase Connectivity

ODBC - Object DataBase Connectivity

OLE - Object Linking and Embedding

OCX - OLE Custom Control

Database Related

RDBMS – Relational Database Management System

SQL – Structured Query Language

Appendix-1 Perl Script

This Perl script is the CGI program which acts as a wrapper for the Java Application that interacts with the database itself (see Figure 11). This script does one of four things at each invocation (see Figure 18). For the first task, the Applet would ideally be requesting information about the available databases. In this case, the script reads a metadata file and returns the information about the available databases to the calling Applet.

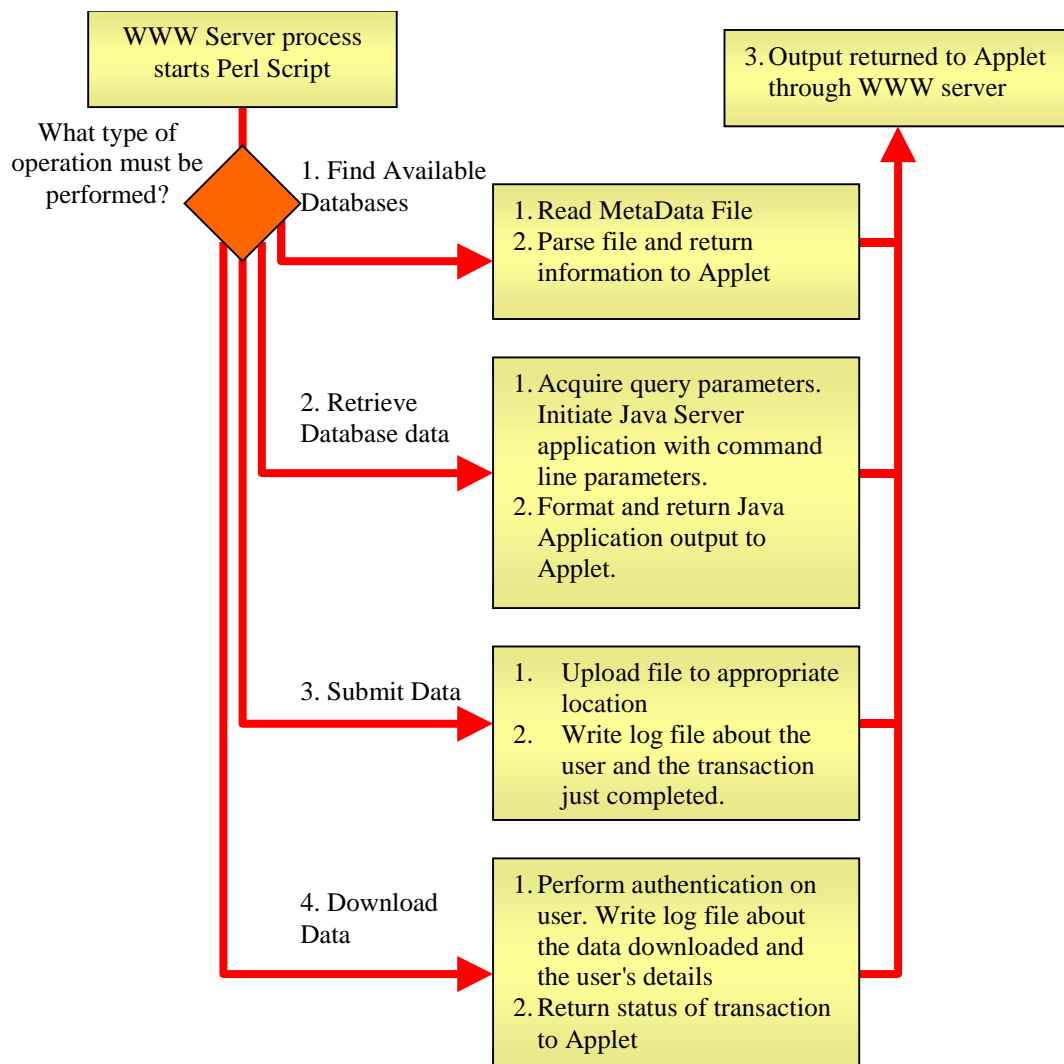


Figure 18 - Flow Chart of Perl CGI program functionality

The second, and more important, task the script performs is that of interacting with the databases themselves. In this case, the script accepts input from the Java Applet across the Internet, processes the input, calls the Java Application, waits

for the Java Application to return, processes and returns the Java Application's output to the Java Applet in a form the Applet is expecting.

The third task is that of handling data submission, whereupon the user would submit a file that would contain mapping information. The script uploads the file to the server, and writes a file with information about the user gathered by the Applet.

The fourth task is that of tracking data download transactions at the Applet. When the user requests to download data, this script is asked to accept user details such as credit card number etc. and log the details to a file. Additional user authentication based on credit card information could be provided at this stage, although it is not at present.

This script resides on a Sun Workstation running SunOS 5.4 running Perl V5.004_04.

Appendix-2 Java Application

This Java Application resides on the WWW server and performs the actual interactions with the database (see Figure 11). This application uses JDBC to communicate with the database, which is an SQL server that supports JDBC. This application is called by a Perl script which serves as a wrapper by starting the application and passing input parameter information to it (see Figure 19). The Perl script is the CGI program that receives its input from the Java Applet across the Internet. This application implements Java Version 1.02 and sits on a Sun Workstation running SunOS 5.4 using a Java interpreter Version 1.1.5.

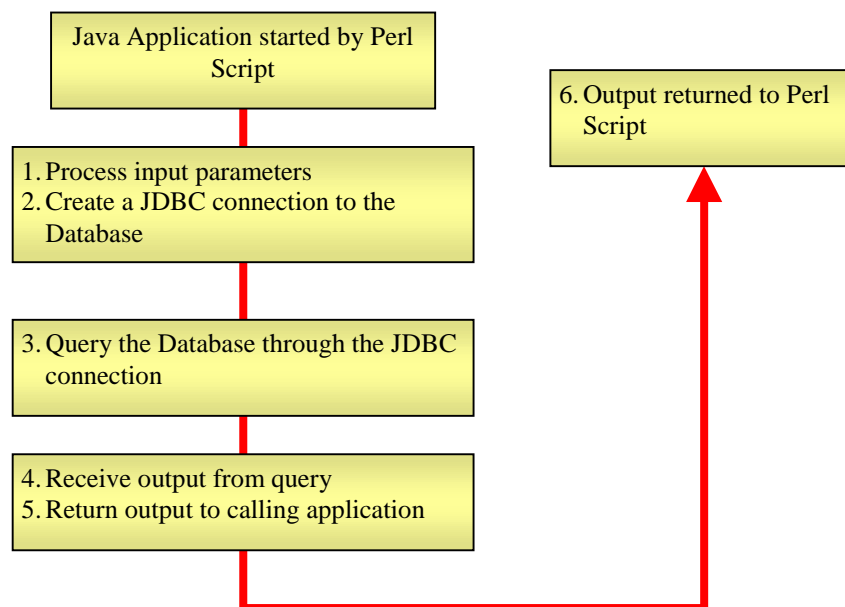


Figure 19 - Flow Chart of Java Application Functionality

Appendix-3 Java Applet

The Java Applet provides the Graphic User Interface that allows the user to interact with the remote database (see Figure 11). The Java class files are packaged into a single JAR file, which is digitally signed with a Netscape Test Signing Certificate. The digital signing of the class files allows the Applet to step out of the security restrictions placed on Applets by a Netscape browser. The Applet was coded in Java Version 1.02, and can operate on Netscape browsers of Version 4.x and later.

This Appendix contains a list of source files that make up the Applet, a class file hierarchy that demonstrates the use of different class files by other class files (see Figure 20), and a functionality flowchart for the Applet (see Figure 21).

List of Java Files that make up the Applet

• DataObject.java	• DCDBFrame.java
• DisplayArea.java	• DXFParser.java
• FlushButton.java	• FrameNode.java
• GraphicObject.java	• LoadedDataFrame.java
• LoadedDataStructure.java	• LoadedLocalDataPanel.java
• Px.java	• SimpleMessageBox.java
• StatusPanel.java	• StatusPic.java
• ToolBar.java	

Other Java Files Used (Freeware Source Code)

• JavaCGIBridge.java	• JavaCGIBridgeTimeOutException .java
----------------------	--

Java Applet Source Code Hierarchy

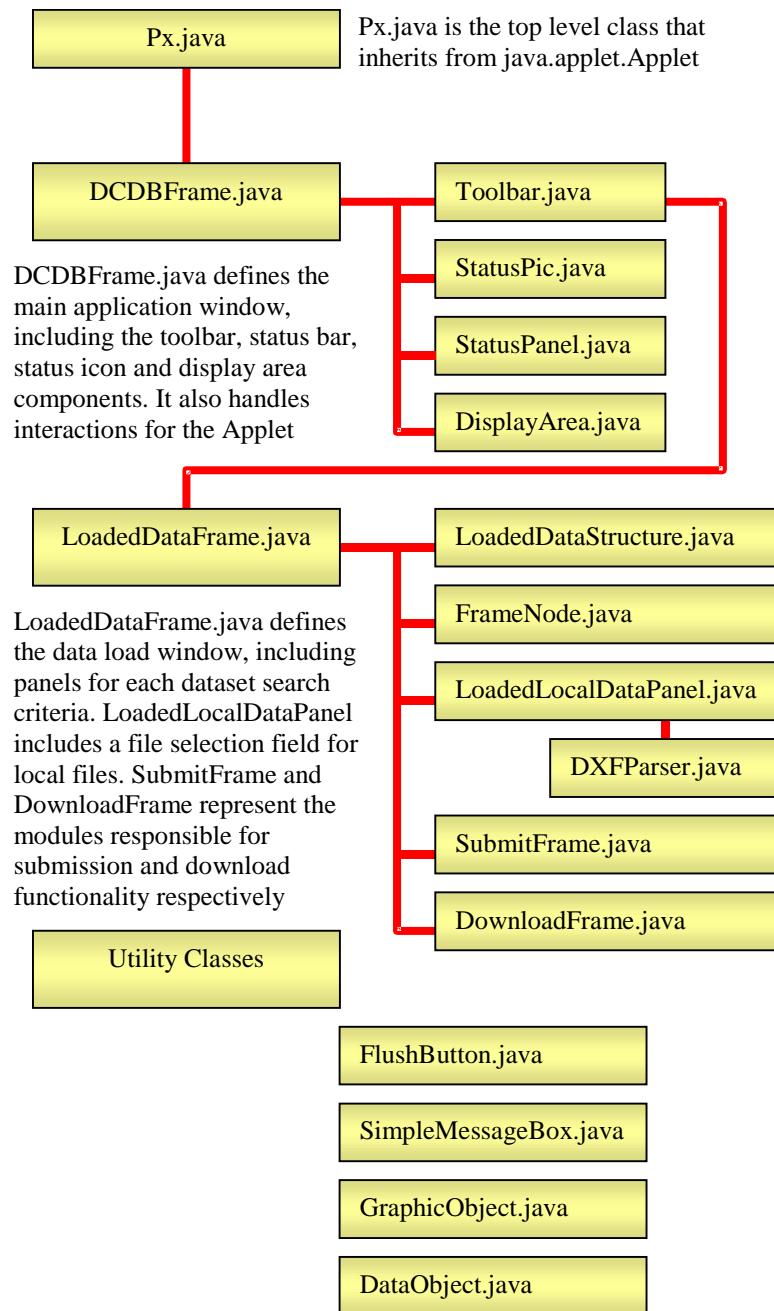


Figure 20 - Java Applet Source Structure

Java Applet Functionality Flowchart

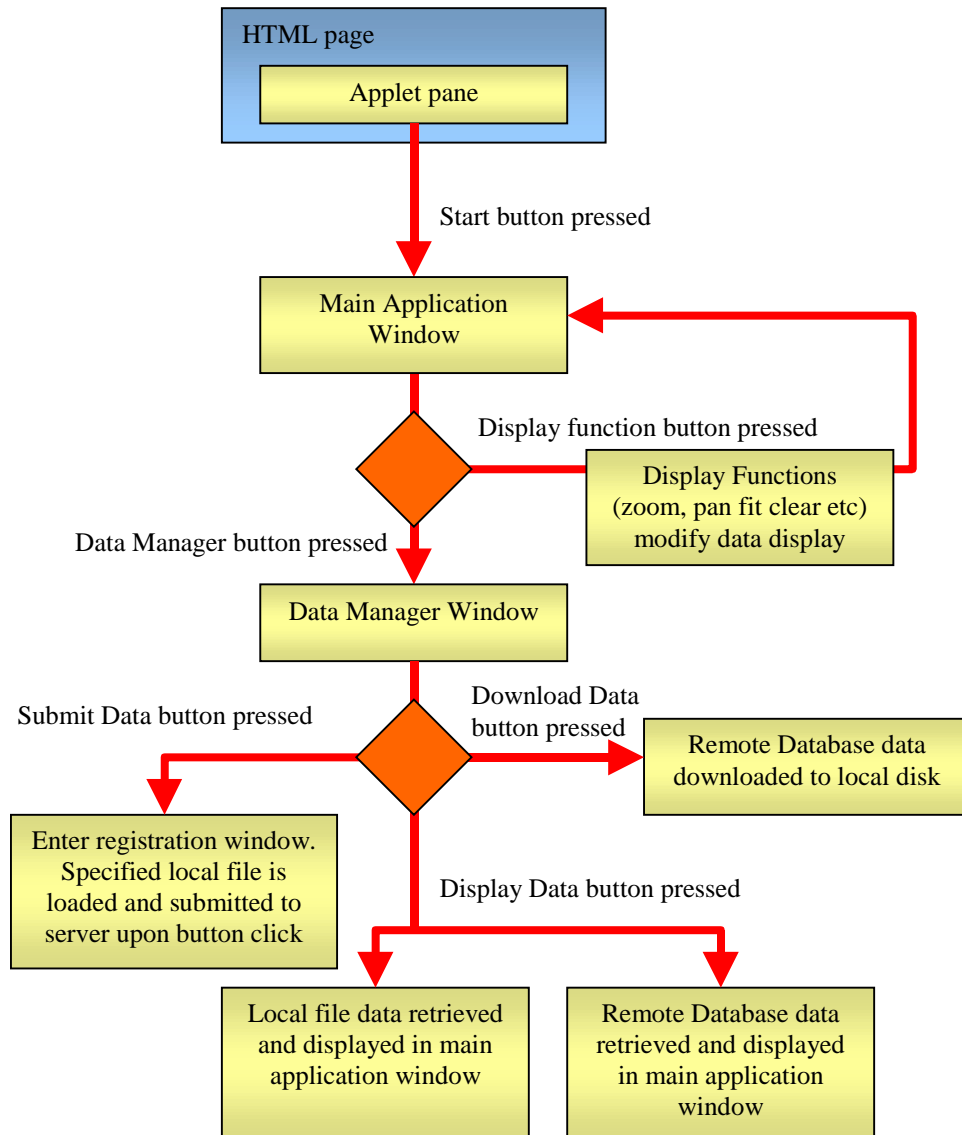


Figure 21 - Java Applet Functionality Flowchart