A Multi-Purpose Cadastre Prototype on the Web

by

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Abstract

The Multi-Purpose Cadastre concept has been discussed over the last three decades. The concept, although idealistic when conceived, is still regarded as visionary in addressing the inherent limitations of most modern geo-spatial systems, especially cadastral systems worldwide. The concept is being used to better disseminate and utilise the increasingly large amount of data contained in many of the geo-spatial databases developed over the last few years.

The utilisation of the World Wide Web has allowed these geo-spatial systems to evolve into online 'virtual' systems that are accessible by most people with the appropriate tools (the computers and telephone lines). This thesis analysed the growing development of these online systems. It describes a review of online cadastral systems that revealed the similarities in moving towards the future vision of cadastral systems of the 21st century, as highlighted by the International Federation of Surveyors document, Cadastre 2014.

The rapidly growing volume of geo-spatial data, which has been attributed by technologies such as remote sensing and Global Positioning Systems, are impacting on the way societies of today, are using, viewing and storing geo-spatial data. Improvements in related areas such as the Spatial Data Infrastructure, the Open GIS Consortium and the Australian World Wide Web Mapping Consortium are described and discussed in this thesis.

Communication technologies such as the Internet, the World Wide Web and other related technologies that are encouraging the development of online geo-spatial systems, that are securing the applicability of geo-spatial information for the future.

This thesis describes the amalgamation of the Multi-Purpose Cadastre concept, the communication technologies and the geo-spatial data developments, into a Multi-Purpose Cadastre model and prototype that utlises the World Wide Web, distributed databases and geo-spatial information standards. The prototype provides worldwide Internet users, the tools to collate, view and update cadastral, title and planning information up to the parcel level.

This thesis recognises the imperfection of the prototype, and delineates the process of identifying the problems and limitations of the prototype. This thesis concludes by discussing future developments and recommendations that are relevant in the online geo-spatial systems arena.

Acknowledgement

I would like to gratefully thank Professor Ian Williamson, my supervisor and mentor for his support and guidance throughout each phase of this research.

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Declaration

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

This thesis is approximately 30,000 words in length.

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List of Abbreviation

DCDB   Digital Cadastral Database – The digital representation of the paper cadastre.

DCOM   Distributed Component Object Model – Mutation of Microsoft's COM.

FIG   International Federation of Surveyors

Geo-spatial Data or information having spatial and/or geographical attributes

IP   Internet Protocol address. Each computer on the web is identified uniquely with a set of IP address.

Map server A generic name given to a dedicated machine that publishes maps on the web.

Metadata   Data about the data.

Middleware A new concept and component that fits in the three-tier architecture.

MPC   Multi-Purpose Cadastre

Packets   A packet of data consists of the body, the destination and the sender address.

PDA   Personal Desktop Assistant

Parcel   A land parcel is usually the smallest parcel having individual ownership.

Scripts   High-level codes that are interpreted (not compiled) upon execution on the web.

Web   Abbreviation for the World Wide Web

Chapter 1

Introduction

The Multi-Purpose Cadastre concept is one of the two fundamental concepts that are used extensively in this research thesis. The concept was introduced in 1983, as a conceptual model that has the characteristics of a system that is capable of meeting the needs of society.

The following chapter provides the necessary understanding of the concept, which contributes to the overall appreciation of the research prototype developed for this research.

Chapter 1: **Introduction**

Historically, geo-spatial information such as cadastral maps, information from registers such as title and valuation, has traditionally been gathered from isolated systems of surveying, title registrations and valuation assessments. In many countries around the world, these systems have existed as isolated, and to a certain extent, independent systems. As a result, gathering complete and up to date parcel information is often time consuming and difficult.

However, in recent times, society has endeavored to bring together data from isolated resources. To date, the success rate has varied according to the nature of the desired data. For example, recent telecommunication advancement has allowed various forms of text and images to be easily collated, using the World Wide Web as a resource pool. This has contributed to the expansion and creation of digital libraries and as a direct result, society are now demanding greater forms of data, especially relating to the land parcel, such as cadastral maps and title information, to be viewed and retrieved just as easily as text and static images.

Using the World Wide Web (hereafter referred to as the web) as a tool, gathering and viewing geo-spatial information from isolated resources is being made possible using web-based systems those functions either as a central geo-resource or as an entry to concealed and distributed geo-spatial resources. Utilising the web, these systems are combining the two central concepts of this thesis, namely the Cadastre 2014 concept and the Multi-Purpose Cadastre concept.

The Cadastre 2014 concept was introduced through a recently published strategy by the International Federation of Surveyors (FIG). Cadastre 2014 outlined the characteristics of a future cadastral system that meets the needs of the users and the providers (Kaufman and Steudler, 1998). For example, the Cadastre 2014 concept anticipates that by the year 2014, the separation between the cadastral maps and other related registers will be abolished.

The Multi-Purpose Cadastre concept (hereafter referred to as MPC), was introduced in 1983 as a conceptual model for a land information system that is versatile, with a multitude of functions and capabilities to serve the society. The MPC concept is expected to resolve weaknesses in current cadastral systems such as the detachment of the cadastral map and the title register, whilst accentuating the strengths and capabilities of current effective systems.

This thesis will demonstrate the development of a MPC prototype that emulates the concepts of the MPC and Cadastre 2014. The prototype embraces the connectivity of the web, to deliver geo-spatial information from various distributed government agencies, in an integrated and accessible manner to the public. In order to do so, the term web is used to represent a simple system that allows users to interact with documents stored on computers across the Internet as if they were parts of a single repository. Although the web is also loosely referred to as the Internet, the Internet on the other hand is a *network of networks* that links computers around the world.

This thesis will also introduce concepts and terms such as *map servers*, *middleware and distributed processing architectures* that form the integral knowledge background for this thesis. Simplistically, a Map Server is a new breed of software that extends GIS and mapping functionality across the web. A Map Server allows live maps, based on user queries to be created. It also promotes the production of rich and integrated geo-spatial information, by gathering geo-spatial data from several sources simultaneously. Middleware and distributed processing architectures, are parts of developing and experimental client/server architectures that treat the web users as the clients with the web and map servers acting as the servers. The middleware is the central component of an online geo-spatial system. It facilitates the communication between the web and the geo-spatial databases, while the distributed processing architecture is a newly introduced concept that facilitates the development of scalable and powerful applications on the web to effectively manage distributed databases and web applications.

1.1   **Problem Statement**

Currently, the geo-spatial information scene is progressing at a rapid rate as it embraces Information Technology with open arms. In the last decade, land-related government agencies around the world have been automating, delivering and presentation their data through the web. Here in Australia, one of the active participants has been in Victoria, where under the administration of Land Victoria, agencies such as the Surveyor-General, Titles Registrar and the Valuer-General reside. Within each agency, various initiatives to value-add and improve the services over the web have been established, with many of them in their final phases of completion (see Chapter 2.5.2).

Users of geo-spatial data and in particular the public, however, still face fundamental problems when accessing geo-spatial systems in Victoria and most certainly, around the world. The services and data provided by land agencies are still isolated, even with common and overlapping information existing between them. Even though some common identifier correlate with most of the data, efforts are yet to be made to sufficiently integrate the data and as a direct result, the public is still faced with isolated services and differing products.

The public's right to know and their rights of access to information is reinforced with the belief that the public has paid, through taxes, for the collection of government information. The U.S President's Office of Management and Budget (OMB) has recently reinforced this belief through a circular that stated:

> *"Agencies should collect only information essential to their mission. They should ensure that they are collecting information only once, not redundantly. They should always look for simpler, easier and faster ways for citizens to retrieve the essential information"*
>
> *(Office of Management and Budget, 2000)*

Therefore, it is vital that accurate, open and accessible geo-spatial information is provided to the public. The providing mechanism however, is still imperfect.

In countries such as Australia, America and Denmark, it has been observed that efforts to remedy such situations are on the horizon (Abdul Majid and Williamson, 1999). Many in Australia and around the world are championing calls for centralised points of geo-spatial information access.

In a recent publication, Jones *et al.* (1999) advocated that

> *"Public interests are often administered by a myriad of public bodies. Increasingly, there will be a demand for a single source of (or gateway to) all land information. A future cadastral system will need to satisfy this demand".*
>
> *(Jones et al., 1999)*

At the Federal government level, The Commonwealth Spatial Data Committee supports efforts to produce better access to geo-spatial information for the public. In its annual report, the Chairman of CSDC, mentioned that:

> *"Economic studies have found that each dollar spent by the Government in collecting data results in four dollars' worth of benefits or savings. This cost:benefit factor is increasing significantly as government geo-spatial data are made more accessible and their quality is improved".*
>
> (Commonwealth Spatial Data Commitee, 1999)

Advancement in telecommunications and developments on the web in the past few years have introduced client/server architectures that are moving away from closed systems to interoperable systems, linking distributed resources and databases, and utilising the growing web environment as the delivery medium. Buckler and McKee of the Open GIS Consortium argued that:

> *"The dominant computing paradigm is moving away from closed systems to open systems, away from isolated systems to systems that*

interoperate in real time, away from tightly wrapped independent applications to application environments equipped with software components that interoperate to provide more flexibility for the user".

(Open GIS Consortium, 2000)

As a direct result, geo-spatial information users are now at a stage where maps and textual records from various government agencies are capable of being delivered across the web. The underlying protocols and infrastructures between the geo-spatial information resources and providers are transparent to the users. Locally, it is expected that Victorian government agencies adopting advanced telecommunication and web technologies will benefit, as their databases will be accessible by members of the agencies, thus able to deliver geo-spatial information aggressively through the web.

The facilitation of Electronic Commerce within an online geo-spatial information environment will also be beneficial as more users and data providers consider the option of providing and purchasing geo-spatial goods and information online. The fusion of traditional geo-spatial information and IT requires the expertise, skills and understanding from a combined surveying / geomatics and IT perspective. The problems and issues arising cannot be treated in isolation (by the respective professions) but treated through a multitude of disciplines and skills. Already organisations such as the FIG and the Open GIS Consortium are combining diverse professions and skills in building frameworks that will direct future geo-spatial systems to show the complete rights, restrictions and responsibilities that exist on land.

Ultimately, the development of such advanced systems is a step towards the concept of a MPC. The MPC concept has been a symbolic slogan used by experts to represent a geo-spatial system that efficiently stores, use and delivers geo-spatial information to its users (Panel on a Multipurpose Cadastre, 1983). It was not until the possibilities the Internet had to offer were seen that the MPC concept was made more possible than ever before.

Problem

The public still faces fundamental problems when accessing geo-spatial systems here in Victoria and certainly most countries around the world. The services and data provided by land agencies are still isolated, with varying degrees of common and overlapping information existing between them. Even though some common identifiers correlate most of the information together, efforts are yet to be made to sufficiently integrate the data and as a direct result, the public are still faced with isolated systems and differing products.

1.2 **What is a MPC**

The MPC is a concept that has been around since the 1970s. The word *multi* is defined by the Longman Contemporary Dictionary (1995) as:

> *Multi*: **more than one; many.**

which also defined *purpose* as:

1. **an intention or plan**
2. **a use; effect result**
3. **steady determined following of an aim**

<div align="right">(Longman Contemporary Dictionary, 1995)</div>

Thus, Multi-Purpose can be used to show one more *or* more use of an item.

Williamson (1999) classified the MPC as one of the three types of cadastres, *i.e*:

- **Legal:** Created to record ownership and all other legal interests in land.
- **Fiscal:** Developed to raise revenue through taxation of land.
- **Multi-purpose:** Developed when additional registers or information were added to the basic fiscal and/or legal components within the cadastre.

Webster's Third New International Dictionary (1995) defined cadastre as

> *"an official register of the quantity, value and ownership of real estate used in taxes".*

<div align="right">(Webster's Comprehensive Dictionary, 1995)</div>

The International Federation of Surveyors (1994) further defined the cadastre as

> *"a parcel based, and up-to-date land information system containing a record of interests in land (e.g. rights, restrictions and responsibilities). It usually includes a geometric description of land parcels linked to other records describing the nature of the interests, the ownership or control of those interests, and often the value of the parcel and its improvements. It may be established for fiscal purposes (e.g. valuation and equitable taxation), legal purposes (conveyancing), to assist in the management of land and land use (e.g. for planning and other administrative purposes), and enables sustainable development and environmental protection."*

(FIG, 1994)

Therefore, a MPC can be thought as a system that is used for many purposes to serve the many uses (such as land conveyancing and land subdivision) of society.

The notion of the MPC is further substantiated when the Panel on a Multipurpose Cadastre Committee on Geodesy conducted a review on land-information systems in governments (Panel on a Multipurpose Cadastre, 1983). The Panel identified the land information systems as being either the traditional title or assessment systems or, more recently land-planning and management systems. It is also reported that these systems inherit problems such as accessibility, duplication, aggregation, confidentiality and institutional structure. It was however agreed that the MPC concept forms the basis for action to remedy these problems.

The Panel also described the Multi-Purpose Cadastre concept as:
> *"a framework that supports continuous, readily available, and comprehensive land-related information at the parcel level"*.

(Panel on a Multipurpose Cadastre, 1983)

Williamson (1985) further described that the major aspect, which delineates a multi-purpose cadastre, is:

> *"the inventory of land parcels and the large-scale maps showing all parcel boundaries are used as a base for many other authorities and purposes"*
>
> *(Williamson, 1985)*

With the MPC designed to overcome the difficulties associated with cadastral systems, the features a MPC should provide, would include a continuous and comprehensive record of land-related information and present the information at the parcel level. The MPC should be designed as a public system with accurate geo-spatial information framework, base maps and cadastral overlays to provide complete legal records such as property boundaries and linking them to land records distributed across many agencies and users.

1.3   **Research Objective**

The objectives of this research thesis can be divided into two parts. The primary objective of this research is to understand the technical operations of current online cadastral and geo-spatial systems. Online geo-spatial systems are now changing the nature of cadastral data delivery by adopting technologies such as the web and distributed processing architectures, to serve multiple, simultaneous users on the web. Consequently, the technical comprehension of the operations of these systems was achieved by a review of twelve online cadastral systems and literature review of existing distributed processing architectures available (see Chapter 3). The outcomes from the review have significantly contributed to the development of the research prototype and the general understanding of online cadastral systems.

The secondary research objective is to evaluate the viability of retrieving geo-spatial data, in particular cadastral data from multiple, heterogeneous databases across the web. This was achieved through the prototype using a multitude of programming languages, web-based scripting, map servers, and distributed processing architectures and presented through the Hypertext Markup Language (hereafter referred to as HTML). The prototype, named the **Victorian Land Information System (VLIS)**, displays parcel-based information, fundamentally utilising the cadastre as the integral component of the system. The results produced by the system consists of interactively generated cadastral maps (see definition of interactive maps in Chapter 5.5.3), displaying graphical location and status of land parcels, with related textual records of title, valuation and planning regulations of the parcels. To use the system, users are required to be on the web and equipped with web browsers.

The prototype developed has solved a number of fundamental inadequacies of using and delivering geo-spatial information, in particular the Victorian Government geo-spatial information to the public. Currently, online geo-spatial systems in Victoria are isolated silos of services, resources and applications. To gather information effectively, the public is forced to learn and comprehend these isolated systems. Precious amount of time and

resources are wasted when considering the information is already fundamentally related by a common entity: the cadastre. Therefore, to utilise the common entity, the research prototype will introduce a new concept called the *middleware*. The middleware bridges isolated geo-spatial databases by supplying applications that retrieve, consolidate and update the data using the cadastre, thus generating custom and interactive geo-spatial maps and textual results.

Primary Objective

To understand the fundamental operations of current online cadastral and geo-spatial systems

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Secondary Objective

To test the viability of retrieving geo-spatial information, in particular cadastral data from multiple, heterogeneous databases across the Internet, through the development of a prototype involving high-level programming, web-based scripting, map servers, and distributed processing architectures, presented using the common Hypertext Markup Language.

1.4   **Research Process**

The research associated with this thesis has been conducted in parallel with other research projects in the Department of Geomatics. The author of this thesis is a member of the Spatial Data Infrastructure and Cadastral Research Group, a multi-discipline assemblage that focuses on the development of Spatial Data Infrastructure. Members of the group are involved in researching issues such as the spatial dimensions of Native Title, Spatial Hierarchy Reasoning, the development of Organisational GIS and the understanding of national and regional Spatial Data Infrastructures, to name a few. All aspects of the research undertaken by group members are interconnected thus complements the knowledge base for future researches.

This research thesis and prototype began in early 1999 with an extensive review of web-enabled online cadastral systems. Because the technology and its implementation were still new, only twelve systems were included in the review. The review was conducted through the web and concentrated on the system implementations whilst searching for evidence of transformation from the traditional cadastral system to the MPC characteristics. These characteristics are compared to the visions of future cadastral system by the FIG publication (Cadastre 2014).

Figure 1 shows a flow-diagram of the thesis, designed to illustrate the flow of knowledge stream structured for this thesis. The triangles denote the main ideas of the chapters while the rectangular boxes represent the chapters. The thesis begins with Chapter 1 that introduces the thesis using problem statements, thesis justifications and research processes. The knowledge flow is then broken down into two components.

The first component covers Chapters 2 and 3, where the background and concept of the MPC, accompanied by a review of online geo-spatial systems to highlight the progression of the cadastre into Multi-Purpose Cadastres. From these chapters, important understanding of the MPC components, user needs and the evolution of the cadastre into online geo-spatial systems are projected to the reader.

The second component introduces the Information Technology (hereafter referred to as IT) path, where Chapter 4 highlights the major geo-spatial development factors that are occurring worldwide. For example, factors such as the Spatial Data Infrastructure, the Open GIS Consortium and Cadastre 2014 are impacting the way geo-spatial data, in The detail breakdown of the development environment, tools and issues of the prototype development are discussed in Chapter 7. In a nutshell, the prototype consists of three major components: the front-end that represents the system on the web, the back-end that represents the databases and the middle-end (middleware), that attaches the two components together. The development of each component, and the developed applications that value-adds the system, are highlighted in this chapter.

The detail breakdown of the development environment, tools and issues of the prototype development are discussed in Chapter 7. In a nutshell, the prototype consists of three major components: the front-end that represents the system on the web, the back-end that represents the databases and the middle-end (middleware), that attaches the two components together. The development of each component, and the developed applications that value-adds the system, are highlighted in this chapter.

Chapter 8 describes the evaluation process and problem identification that lead to the discovery of the prototype imperfections. The prototype was tested against a set of principles. The principles were developed from the understanding of the concepts and trends presented in this thesis (Chapters 2,3,4 and 5) and provided the basis to compare the prototype against current Victorian online geo-spatial systems. The problems and limitations of the prototype were then documented and discussed.

Throughout the prototype and thesis development, several key factors were identified as being contributing drivers in the development of future online geo-spatial systems. This is described in Chapter 9, along with concluding remarks and recommendations derived from the thesis.
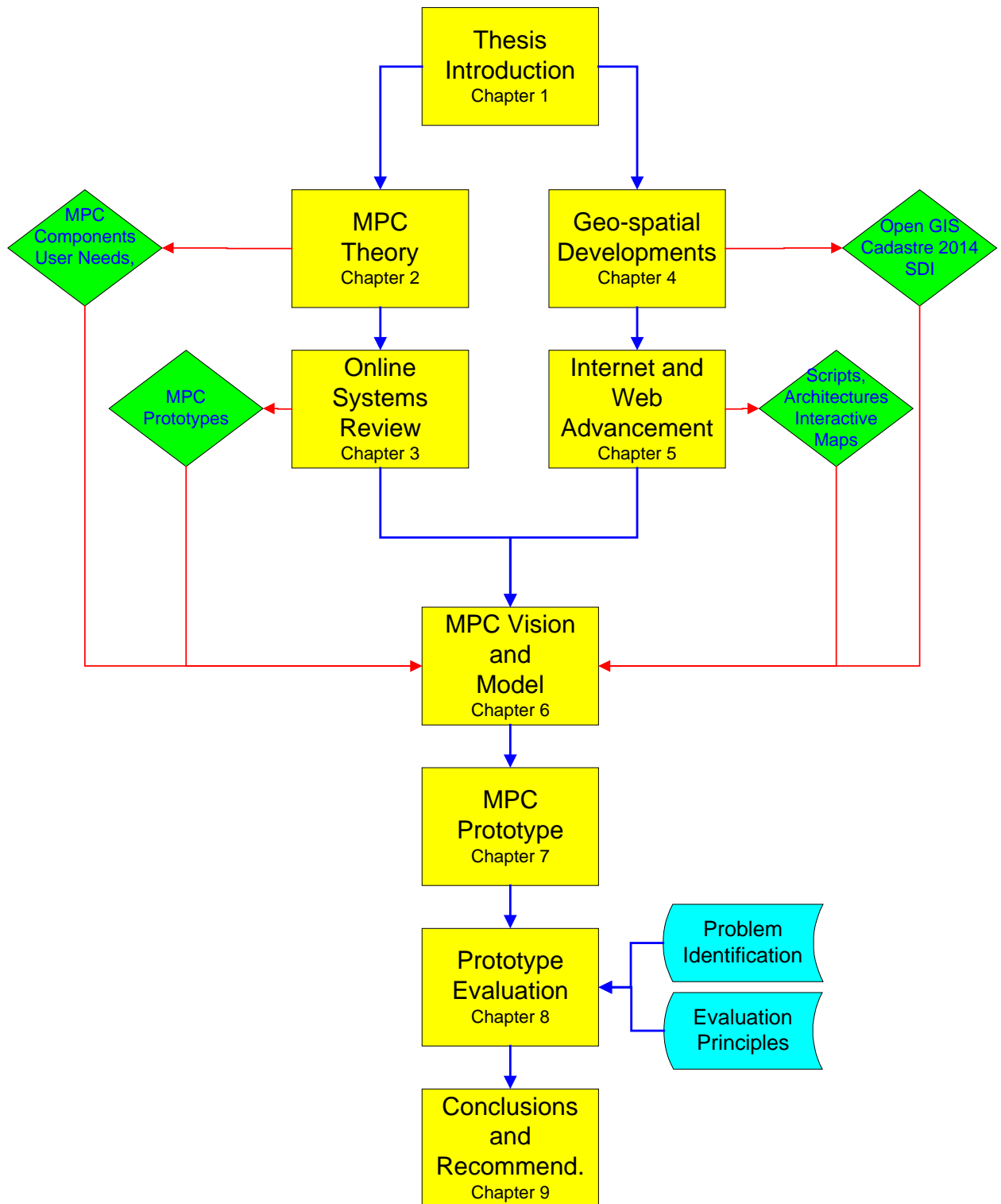
Figure 1: Diagram of thesis flow and main ideas

1.5   **Research Justification**

The rapid developments in the area of IT have lead to increasing demands by the information society for greater access to better information. The delivery of geo-spatial information to the general public still remains unclear, with problems that need to be solved. This research thesis, therefore is aimed at solving these problems, through three main objectives listed below.

The first justification relates to the development of cadastral and title registration systems that use the web as the medium of delivery. In recent years, the geo-spatial information community has witnessed tremendous growth of web-enabled cadastral and title systems that have not only lessened the procedures of obtaining parcel-related information but have eradicated the need for the *over-the-counter* procedures and departmental bureaucracy. The thesis has also supported this finding through a review of online geo-spatial systems that proved that users with access to the appropriate technology, are able to search, retrieve and view cadastral maps and title registers in real-time (see Chapter 3).

The second justification is the exposure of computing, communication and IT that are impacting on future developments of land information systems. It is important to highlight that the most profound creation in the area of information sharing has been the Internet. Alongside it, the web grew as disparate databases containing geo-spatial information such as the cadastral and title information are brought online. Latest computing developments are also providing greater data searching and manipulation power than ever before. These are being implemented consecutively on the Internet. As a result, the world is no longer isolated but is moving towards an interconnected atmosphere of intelligent users and information rich society.

The third justification is concerned with the technical understanding of a MPC system development. It is vital to emphasis that all of the researched online systems are government initiatives with little development documentation out in the open and accessible to the public. Certainly, there exists tremendous opportunity in understanding

the intricacies of an advanced online geo-spatial system. In addition, worldwide collaborations on specifications and implementation that are impacting on the progression of online geo-spatial systems are beginning to alter the way society use geo-spatial information. Therefore this thesis is an effort to shed some light on the technical requirements, procedures and understanding required when building a MPC.

Research Justification

The first justification relates to the development of cadastral and title registration systems that use the web as the medium of delivery

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The second justification is the exposure of computing, communication and Information Technology that are impacting on current and certainly, future developments of land information systems

Research Justification

The third justification is concerned with the technical understanding of a MPC system development.

1.6   **Chapter Summary**

Chapter 1 introduces the research, the research objective, research process and research justification that describes the detailed breakdown of the thesis. The thesis first illustrates the understanding of the MPC concept that has contributed to many Land Information Systems (LIS) around the world. The review of online geo-spatial systems was conducted to evaluate the evolution of the cadastre into Multi Purpose Cadastres and consequently, the role of IT and the changing global geo-spatial information environment were identified as the major contributors to this evolution.

This chapter discusses the problem statement that initiated this research. The problem statement lead to the understanding of the MPC, with Chapter 1.2 representing the investigation into the origin of the Multi-Purpose Cadastre terminology.

Chapter 1.3 discusses the research objective. The research objective is divided into two parts *i.e.* to simulate the viability of retrieving geo-spatial information from multiple, heterogeneous databases across the web, and to understand the fundamental workings of current online geo-spatial systems around the world. The research process is then discussed to highlight the formation of the thesis flow diagram that steps through the flow of knowledge encapsulated in this thesis. Finally, the three research justifications are discussed in Chapter 1.5.

Chapter 2

The Origin of the Multi-Purpose Cadastre

The Multi-Purpose Cadastre concept is one of the two fundamental concepts that are used extensively in this research thesis. The concept was introduced in 1983, as a conceptual model that has the characteristics of a system that is capable of meeting the needs of society.

The following chapter provides the necessary understanding of the concept, which contributes to the overall appreciation of the research prototype developed for this research.

Chapter 2: **ORIGIN OF THE MULTI-PURPOSE CADASTRE**

2.1 **Introduction**

The evolution of the MPC from modern cadastral systems is seen by many as one of most profound changes in the delivery and use of geo-spatial data, in particular cadastral data to the public. To fully appreciate this evolution, some degree of understanding of the origins, components and the possible jurisdictional extents of the MPC will describe an overall approach to the MPC concept.

2.2 **Progression of the Cadastre**

The evolution of the cadastre dated back to 3000 BC where the Romans recorded information about their controlled land for a basic of fiscal records (Larrson, 1991). It was not until the 1870s, when Napolean Bonaparte established the first modern cadastral system. He ordered the creations of maps and cadastral records that eventually established the foundation of the European cadastre. In the 18th and 19th century, the cadastre was used in Continental Europe for taxation and fiscal purposes (Williamson, 1985). Since then, cadastral systems have been used as an important tool for urban planning and service delivery. As taxes evolved over time into complex differential tax-assessment, so did the cadastre to support other land-related arrangements.

Many land-administration scholars have highlighted the importance of the cadastre in the modern cadastral systems in the past decade. For example, Williamson (1990) argued that

> *"Cadastral systems are the foundation and an integral component of parcel-based land information systems (LIS) that contain a record of interests in land. These systems are a central component of the land administration and land management systems in a state or jurisdiction"*
>
> *(Williamson, 1990)*

It is clear that the cadastre, and subsequently the cadastral system have come a long way since their first conceptions with their role continually changing as they are being impacted by drivers such as the land market, societal demands and more recently, environmental factors.

Looking from a Western perspective, Ting *et al.* (1998) in Figure 2, pointed out the cadastral systems have evolved from a tool for wealth resource to indispensable tools that manage the scarce resource and environmental concerns of the public (Ting and Williamson, 1998).

SKETCH OF EVOLUTION OF WESTERN LAND ADMINISTRATION SYSTEMS
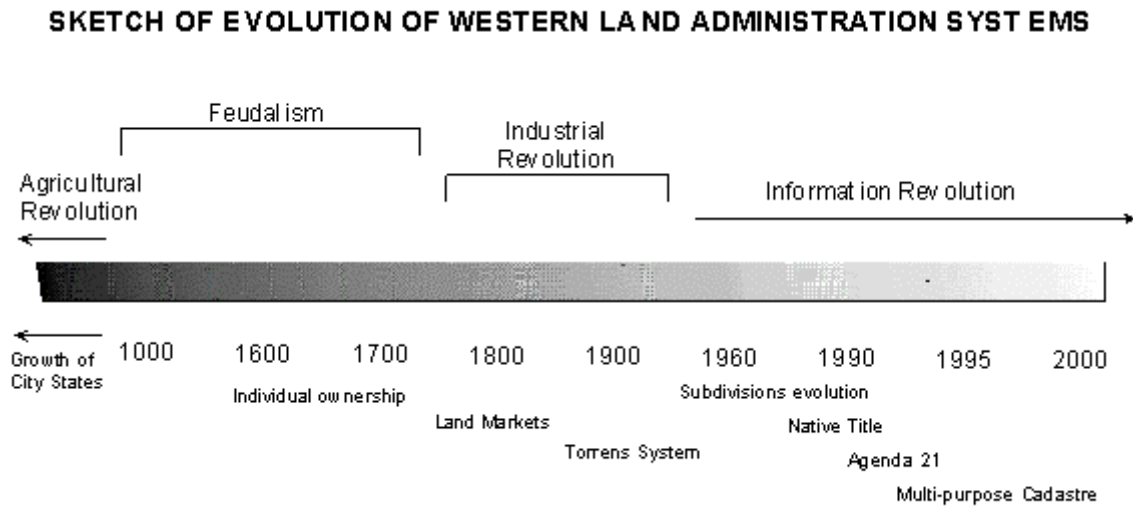
Figure 2: The evolving cadastre (Ting *et al.*, 1998)

Williamson (1996) presented the cadastral system as two critically important components, namely the cadastral map and the title register (see Figure 3). In Australia, the cadastral map has gained the most attention, as massive data migration of many Australian state owned cadastral databases was seen in the 1980s, with the first introduction of the Digital Cadastral Databases (DCDB) that represents the traditional cadastre in a digital form. In Victoria, a pioneer move to develop the DCDB was spearheaded by the Land Title's Office through the LANDATA project in 1984 (Williamson *et al.*, 1998).

The international community has also embraced efforts towards a better cadastral system. For example, the collaboration between organisations such as the United Nations and the International Federation of Surveyors (FIG) has for many years, organised meetings and conferences, which have resulted in numerous documents containing guidelines and specifications that has and will enable current and future cadastral systems to develop. These documents are highlighted in table 1.

The Cadastral Concept
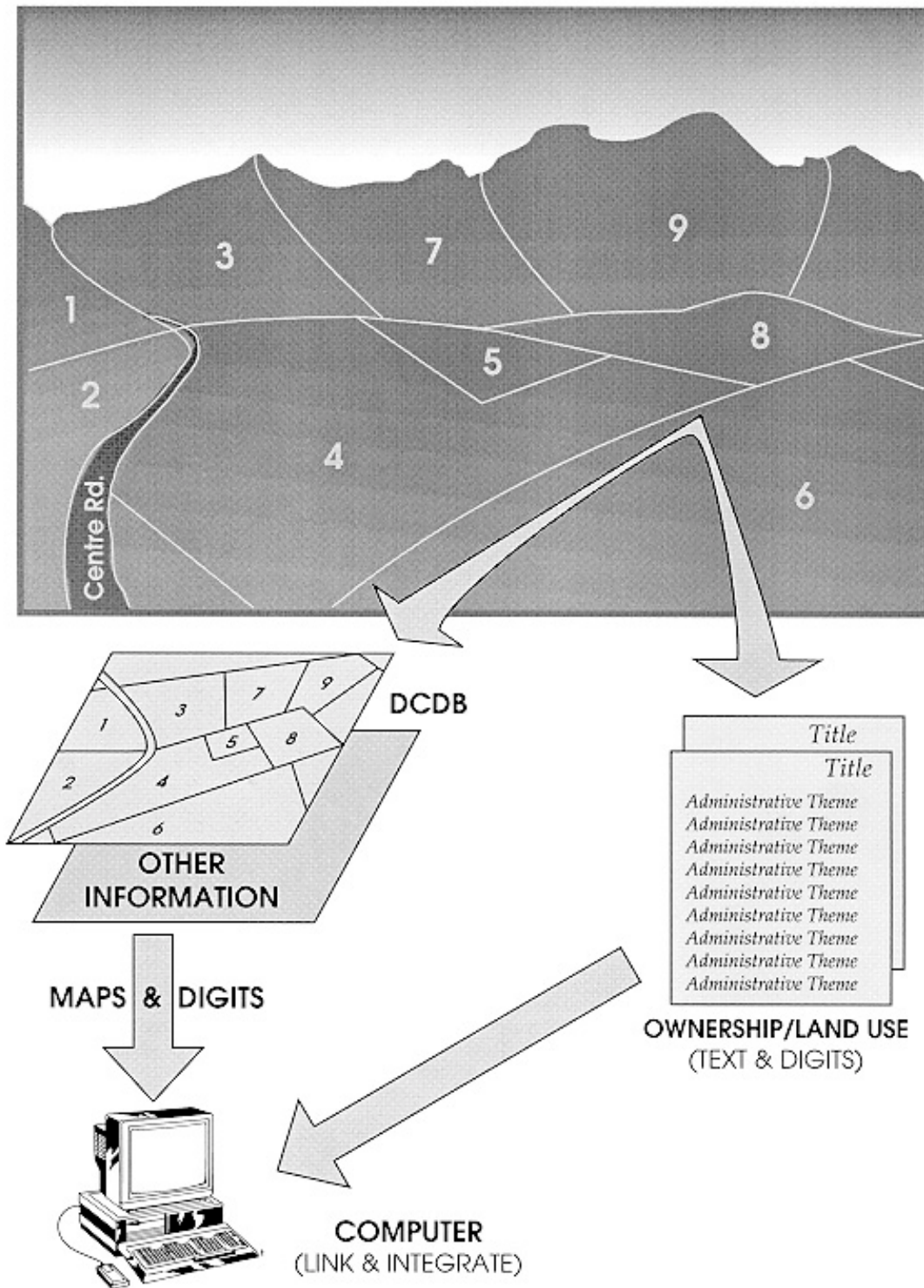
Figure 3: The Cadastral Concept (Williamson, 1996a)

Table 1: International declarations and documents

Document	Year	Objective
Statement on the Cadastre (FIG, 1998)	1994	Highlights the importance of the Cadastre as a land information system for social and economic development
Bogor Declaration (UN/FIG, 1996)	1996	To develop modern cadastral infrastructures that facilitate efficient land and property markets, protect the land rights of all, and support long-term sustainable development and land management.
Cadastre 2014 (Kaufman *et al.*, 1998)	1998	Provides the characteristics of future cadastral systems that supports sustainable development, political and economic stability and omit conflicts of public and private interests.
Bathurst Declaration (UN/FIG, 1999)	1999	Identifies the need for the promotion of institutional reforms to facilitate sustainable development and for investing in the necessary land administration infrastructure.

These evolutions from the first conception of the cadastre in 3000 BC have been significant and largely constitute the role that the cadastre has played in fulfilling the developments of the land registration, land administration and land markets of a country.

2.3   **The need for a MPC**

Geo-spatial data in a typical governmental framework is involved in numerous operations of creating, duplicating, manipulating and delivering for decision-making processes. In many cases, the use of geo-spatial data spreads across organisations with varying extents of overlapping responsibilities. For example, the surveying profession in Victoria manages the creation and management of the geodetic and topographic framework. The courts and the legal profession are concerned with the legal implications of land while the planners are concerned with the planning and zoning status of land. With all these professions interested in some form of geo-spatial information, there have to be mechanisms that deliver geo-spatial information without being held up in the inherent problems of present land information systems.

These are further substantiated by the findings of the Panel on a Multipurpose Cadastre Committee on Geodesy in 1983 that problems inherent in the present land information system be categorised as follows:

1. Accessibility;
2. Duplication;
3. Aggregation;
4. Confidentiality and
5. Institutional structure.

<div align="right">(Panel on a Multipurpose Cadastre, 1983)</div>

The Panel suggested the MPC concept forms the basis for action to remedy these problems that exist in current systems. The committee had also constituted the essential requirements for the development of a MPC. These are as follow:

1. The development of technical standards and specifications and the means to enforce these;

2. The development of linkage mechanisms in order to relate other geo-spatial data to the basic components;

3. An emphasis on gradual, phased re-organisation and quality control of existing government functions, rather than the creation of new functions and agencies;

4. A focus on the municipality level as the place where much of the work in developing and maintaining a MPC will occur, with appropriate support by state and federal government; and

5. The development of qualified personnel through encouragement and support of university research and education.

(Panel on a Multipurpose Cadastre, 1983)

The MPC should be designed to record, store and provide not only land-tenure and land-valuation information but also a wide variety of land-related facts. The Panel further supported that if a MPC is truly multipurpose, it does not only receive information and data from many sources, but it also provides services and products for many purposes and to many users.

Therefore, in many ways, the MPC is designed to address the inherent problems in the geo-spatial industry by:

1. Providing comprehensive records of land-related information and;

2. Presenting this information at the parcel level.

Simplistically, the MPC should maintain the current availability of geo-spatial information to the public. With a comprehensive mechanism such as the web, members of the public and the concerned professions will be able to access geo-spatial data at a touch of a key.

2.4 Fundamental Components of a MPC
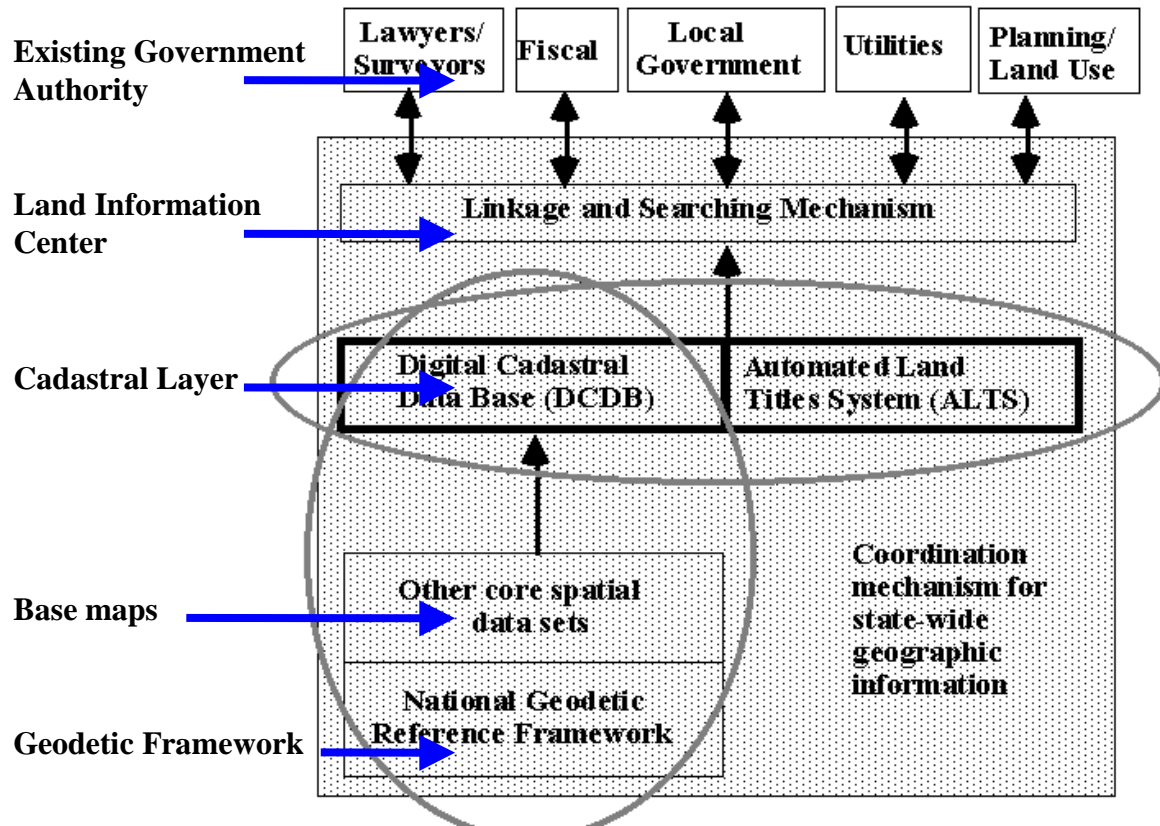
Figure 4: Fundamental Components of a MPC – Adapted from (Williamson, 1996b)

A MPC consists of public inventories that support and overcome the difficulties associated with traditional and in some aspects, limited capabilities of the modern cadastre. The Panel on a Multipurpose Cadastre in 1983 proposed that the fundamental components of a MPC should include the geodetic framework, the base map and the cadastral layer. However, the proposed fundamental components are seen as inadequate for the scope of this thesis. Therefore, a combination of the models from the Panel on Multipurpose Cadastre (1983) and Williamson (1985) was adopted as the approach to understanding the critical and fundamental MPC components that are applicable in this research thesis.

The proposed model should contain essential elements that would enable continuing progress and efficiency (see Figure 4). These elements include:

- Large scale maps;
- Registers;
- Cadastre must be complete;
- Each parcel must have a unique identifier;
- Cadastre must be dynamic;
- Information must be correct;
- Information must be public;
- Cadastre must be supported by a coordinated survey system;
- The cadastre must include an unambiguous definition of parcel boundaries both in map form and on the ground *i.e.* cadastral surveys.

To achieve fulfill these elements, the combined model should be made up of five components that are described below.

2.4.1   Geodetic Framework

A geodetic framework forms the geo-spatial foundation for the creation of a MPC (Panel on a Multipurpose Cadastre, 1983). A geodetic framework would consist of monumented points that have been accurately determined by one or more precise surveying methods. The geodetic framework should also be carefully designed to fit the specific needs of the particular maps created.

The Panel on a Multipurpose Cadastre suggested that for a multipurpose application, if the maps are to be effective planning and management tools, it is essential that the framework satisfies two basic criteria. These criteria include:

- First, the framework must allow for the correlation of cadastral boundary-line data with topographic, natural resources and other land related data;

- Secondly, the framework must also be permanently monumented on the ground so that the lines on the maps may be reproduced in the field when land-use development and management projects reach the regulatory or construction stage.

2.4.2 Base maps

A functional MPC receives data from many sources. To present the information meaningfully, there has to be a framework where all information can correlate. Like a painting on a canvas, geo-spatial information has to relate to a base map in order to be useful for others to use. In a MPC environment, the canvas would be a base map. A base map is a graphic representation at a specified scale of selected important map information.

The nature and accuracy of the base map dictates the overall accuracy representation of the MPC. In a typical mapping environment, the base map may be a line map or an ortho-photographic map. Recent technologies such as remote sensing and GIS have introduced digital maps that are becoming an increasingly popular choice for base maps.

2.4.3 The Cadastral layer

The business systems that rest on the MPC begin with the cadastral layer. The cadastral layer forms the basic overlay to delineate the current status of property and parcel ownership. Parcel ownership is determined graphically by the cadastral parcel that forms the basic entity of the cadastral layer. The cadastral layer therefore consists of a series of cadastral parcels within a given jurisdiction.

Although information coming from activities such as climate demography relies on some basic base layer, almost every other geo-spatial information is related to the cadastral layer. The cadastral layer has notably attracted the most attention from the legal, economic and social perspective (Williamson, 1997). Because the cadastral layer is made up of cadastral parcels, the cadastral layer represents land ownership and interests in land. With legislations covering anything from ill-defined property boundaries to the validity of ownership by a proprietor, the cadastral layer is of significant interest to the legal community.

From a social perspective, the cadastral layer may be thought to be of a Western paradigm in dictating a way of life. Indigenous cultures have unique procedures, laws and processes in denoting land boundaries (Brazenor *et al.*, 1999). This has often caused some degree of difficulty in establishing the physical boundaries of indigenous territories.

Nevertheless, research and progress are continuing in combining the Western and the Indigenous land tenure systems. Specifically, works and research within the Spatial Data Infrastructure and Cadastral Research Group in the Department of Geomatics, such as (Brazenor *et al.*, 1999; Iatau and Williamson, 1997; Rakai *et al.*, 1995) are examples of solving the complex arrangements between the land tenure and cadastral layer of the two cultures.

2.4.4   **The Land Information Centre**

The Land Information Centre will be the linking and searching mechanism that connects the cadastral database to the individual database of the MPC. Williamson (1985) suggested that the Land Information Centre should have an independence and overall responsibility for the MPC.

2.4.5   **Existing Government Authorities**

Williamson (1985) and the Panel on Multipurpose Cadastre (1983) both agree that land-related government authorities involved in future or current MPC developments, should develop their own sets of databases according to their respective uses and specifications, but adopt the cadastral database as the base layer. Each authority should manage and own their data, with the MPC facilitating the access to other authorities databases.

2.5   MPC: User Requirements

Maintaining databases of title records and cadastral layers in a MPC is expected to fulfill most of the needs from the various jurisdictions, levels of government and the end-users. However, it is difficult to determine the exact requirements as the requirements from mission-critical projects are rising. There is also the risk of developing a *state-of-the-art* geo-spatial system that will be hailed as the pinnacle of geo-spatial delivery but is a vendor or technology driven endeavor that is under utilised and misused. The geo-spatial information community needs to realise that the ultimate benefits of producing a MPC will be for the users of the MPC. Despite of these, it appears that the user requirement and needs of a MPC have not been rigorously investigated.

In his 'Land Information Vision for Victoria', Williamson (1996b) stated the possible users of geo-spatial information, to include users such as local governments, property owners, land managers and utilities (Williamson, 1996b). These users fall into one of the categories listed by the Panel on the Multipurpose Cadastre. These categories include the geo-spatial and temporal interest, coverage and subjects of the MPC (Panel on a Multipurpose Cadastre, 1983). What was also recognised that designers of future MPC should explore each of these areas in light of fulfilling at least, the majority of the user requirements plus the appropriateness of technology applied.

2.5.1   Geo-Spatial Information Interests

The users of a MPC may be assumed to have an interest in parcel-related information, but they may have other important interests. User interests may include information of the areas within the parcels, or the buildings that stand on the parcels. Frequently, because of environmental awareness, users may also be interested in the salinity of the soil or the approximate location of the building and the parcel to a particular factory or sewerage dump. Sometimes, the interest is in relating parcels to arbitrary grid cells.

2.5.2 **Temporal Interests**

The existence, configuration and characteristics of land parcels or the buildings that stand on them, change with the passage of time. Ordinarily in Australia, current land parcels originate from bigger land parcels, first allocated by crown surveyors in the early 18th century.

These changes will often fascinate users who may be interested in the situation at specified intervals or the history of the changes of the parcels.

2.5.3 **Coverage**

The requirements of the MPC users change with respect to the coverage of parcels or associated features. Many users will require information on a single parcel but other users may be interested in the parcels or suburbs within a certain radial distance from the parcel. Users may also be interested in parcels that are effected by a particular course of event, such as the frequency of ownership transfer. No doubt, tools such as GIS would assist in extracting the information to a limited number of users, but a well-developed MPC that utilises the web, could provide the same services and information to millions of worldwide users simultaneously.

2.5.4 **Subjects**

The subjects or topics of interest about parcels will vary greatly among users. The obvious interests would be for the physical characteristics of the parcels, buildings and other related improvements. Other subjects of interest would be events such as crime that effect the suburb or the traffic flow within an area.

2.6   **Benefits of a MPC**
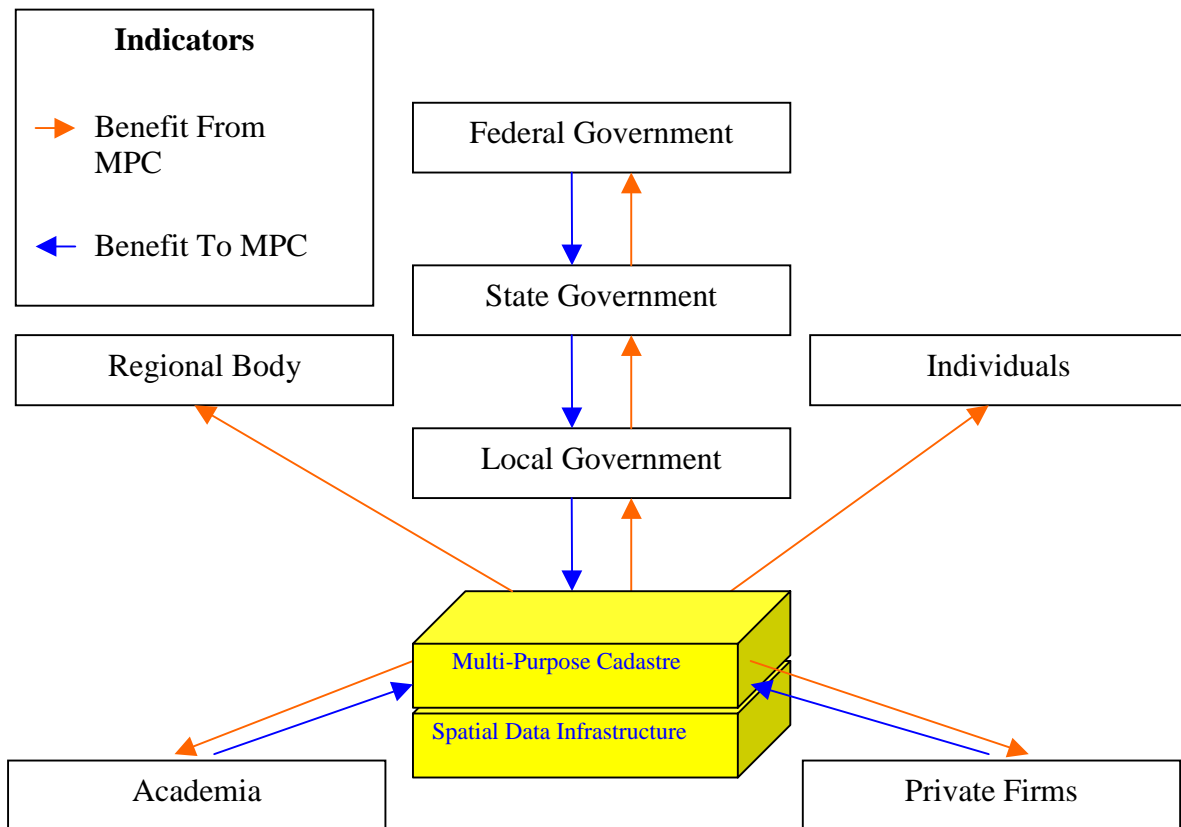
Figure 5: Benefits of the MPC

With most geo-spatial information being produced by various levels of government agencies, the development of the MPC for any country will be dependent on the commitment and contribution from these agencies. It is anticipated that a MPC will benefit a range of potential users such as federal, state and local governments, private firms, individual, academia and regional bodies (see Figure 5). These benefits (detailed below) illustrate the primary purposes of a MPC to users.

Federal governments are the roots of any national administration of land and other resources. Through a MPC, a flow of standardised data for updating federal maps and statistics for use in national-wide census to efficiently manage federal assistance to local programs such as community housing and developments can be achieved. Small-scale national maps and themes can be linked to more accurate databases from state and local governments. Financial and political support from Federal governments towards MPC would definitely improve the use and creation of geo-spatial data. MPC will be the

tentacles of the Federal, state and local governments in better managing geo-spatial information in the country.

State governments are the mechanisms for the administration of state affairs, regulations and interests. Through the MPC, state maps could be related with other detailed maps and databases available from private firms and local governments. State governments could also easily share information between themselves and local governments within them. State ownership or other interests in land can be accurately determined through locational references offered by local governments.

The Panel on MPC Committee suggested that one of the biggest users of MPC would be local governments (Panel on a Multipurpose Cadastre, 1983). This is because a MPC allows for better data to be used in any public transactions with the local governments. Local governments in turn have access to other related geo-spatial data using a MPC. Higher accuracy data when needed, is available through existing connectivity with other geo-spatial data repositories. The production of new themes or data may not be necessary because local governments and government authorities may collectively agree to share land related resources through the MPC. As a result, a MPC will dramatically reduce costs of maintaining separate geo-spatial information repositories.

The participation of private conglomerates in the geo-spatial information industry has contributed to the development of specialised tools for geo-spatial data creation and development. Private sectors will also benefit through efforts such as the production of standards and regulations, sharing of themes and data and large-scale maps, amongst others. Most importantly, the private sector will benefit the manner of which the MPC speeds up administrative actions and reduces the costs in dealing with government authorities.

Academic institutions will play a vital role in ensuring that the purpose and creation of the MPC serves the demands of society. Benefits of the MPC to the government and its people can only be achieved from a neutral and balanced perspective. Academic institutions will continue to contribute through extensive research in areas such as human interaction with the MPC, feasibility studies and the data transfer formats.

Traditionally, one of the biggest bottlenecks of any government administration is the lack of response and action towards the needs of individuals seeking information. However, the ultimate end-user would be the members of the public who are involved with cadastral and geo-spatial data in their everyday lives. Individuals as the end-users would greatly benefit from efficient manner of delivering cadastral and geo-spatial data by the MPC.

The MPC will allow members of the public more access to government geo-spatial data than ever before. Faster access to records affecting individual rights, such as planning controls, native title and land title issues could be achieved. The MPC is also hoped to clarify minor boundary disputes through simultaneous access to planning, cadastral, title and customary land title databases. Individuals seeking duplicates of titles or maps may easily reproduce them through the MPC. Ultimately, the public's attitude towards the administration of local governments programs may improve.
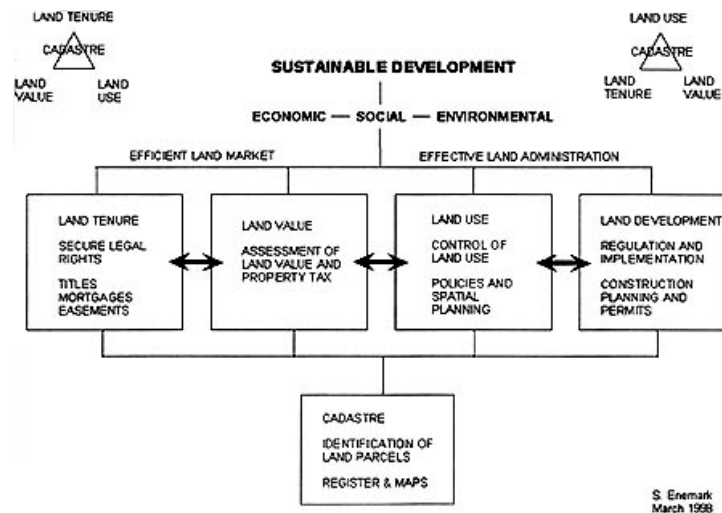
Figure 6: MPC towards sustainable development (Enemark and Sevatdal, 1999)

A future MPC system should be able to support continuing progress and evolution of current systems. In Figure 6, a cadastral model highlights the importance of a MPC in

promoting economic, social and environmental conditions, that contribute towards the sustainable development of a nation. Ultimately, a successful MPC can lead to an improved conveyancing system, cadastral survey system, land use planning, land management and environmental management, management of publicly owned lands, reduction of duplication and control of land transactions (Williamson, 1999a).

2.7   **Chapter Summary**

Chapter 2 looks at the progression of the cadastre, from a simple tool of recording fiscal records in 3000BC that has evolved to an important component for planning and environmental monitoring. Several professions are now taking interests in the information that the cadastre has to offer. For example, the land conveyancing community is interested in the exchange of land as a commodity, thus demands special types of information and products from the cadastre, as distinct to the needs of the surveying profession. As demands for rich, integrated information from the cadastre and other land records increases, the cadastre will continually be shaped into a multi-purpose cadastre, to fulfill the different uses and functions to the community.

This chapter explains the fundamental components of the MPC and highlights the potential users and benefits of the MPC. It can be seen that the MPC jurisdictional initiative could cover various levels of governments and benefit individuals, academia and private enterprises. Regardless of the jurisdictional scope, it is anticipated that a MPC could perform the following tasks for the users:

- Provide a digital base map of connected parcels;
- Provide title information through the digital base map of parcels and parcel identifiers;
- Provide valuation information of the parcel through the parcel identifier;
- Provide planning proposals relating to the parcel through the parcel identifier;
- Provide zoning information through the base map and parcel identifier;
- Provide information relating to any local government regulations;
- Provide information pertaining to the parcels, roads and the environment within and around the parcel in question;
- Provide information relating to Native Title claims or other indigenous related information on the land.

It would be desirable for a MPC to provide these data seamlessly to the users without revealing the resource distribution. Users are just concerned with the availability and usability of the data rather than the protocols, difficulties and procedures in obtaining the data. To facilitate this feature, the MPC requires architectures and standards that will accommodate user queries and a browsing facility through the use of the web that will simplify data sharing and data distribution. Therefore, the developments in the areas of Spatial Data Infrastructures (SDI) and web-based architectures are being observed closely by solutions seekers. Discussions on the impacts of SDI and web-based architectures are discussed in Chapter 4 and 5 of this thesis.
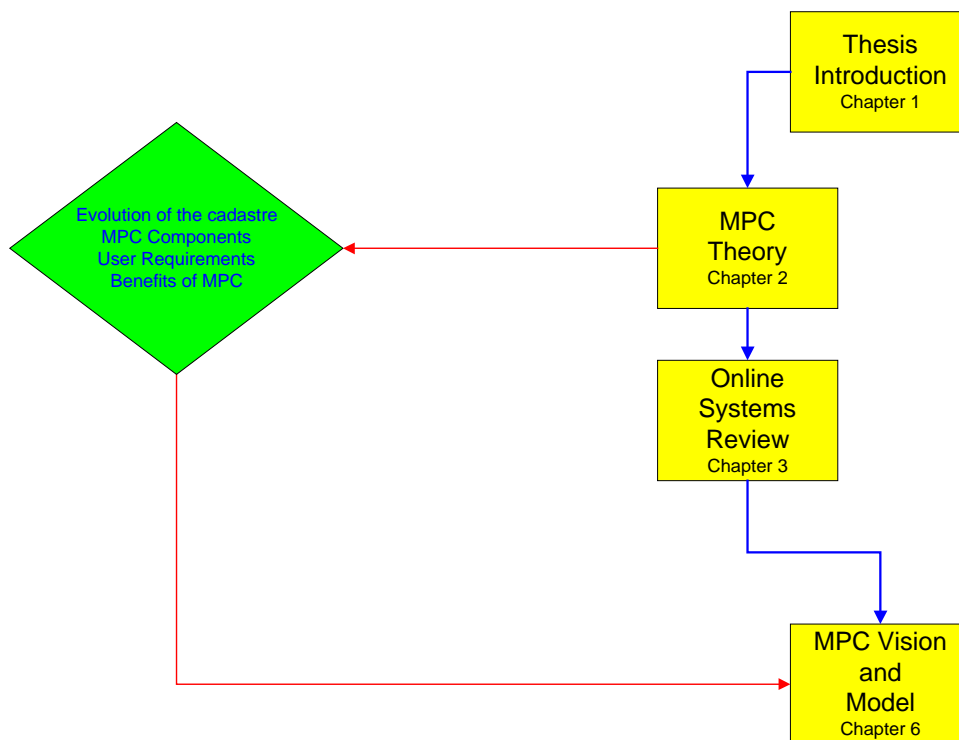
Figure 7: Understanding the MPC Concept Part 1

Chapter 3

Understanding Online Geo-Spatial Systems

The following chapter highlights a review conducted on twelve government initiated geo-spatial systems, in order to identify and compare the features between these systems.

The review was necessary as it captures a snap-shot in time, of the fast moving geo-spatial developments around the world.

Chapter 3: **ONLINE SYSTEMS DEVELOPMENT WORLDWIDE**

3.1   **Introduction**

Digital Earth, a concept first introduced by U.S Vice President Al Gore, has received considerable attention because of its visionary outlook towards the use of geo-spatial information. Al Gore (1996) stated

>"*If we are successful, it [Digital Earth] will have broad societal and commercial benefits in areas such as education, decision-making for a sustainable future, land-use planning, agricultural, and crisis management*"

(Gore, 1998)

In Victoria, the Executive Director of Land Victoria, further proposed that by the year 2002, the public will be able to:

>"*point to a piece of land on a map and have all the information relevant to that piece of land available at their fingertips*"

(Land Victoria, 1999)

The surveying and registration professions reinforced that

>"*Public interests are often administered by a myriad of public bodies; increasingly, there will be a demand for a single source of (or gateway to) all land information. A future cadastral system will need to satisfy this demand*"

(Jones *et al.*, 1999)

These visions by leading public figures and government agencies for better geo-spatial information service to the public, are being materialised by advanced tools. In particular, tools such as cutting-edge geo-spatial systems (typically derived from modern cadastral systems) that are aimed at providing geo-spatial information such as parcel-related

information, title records and resource management relating to land. This evolution has been obvious with the adoption of the web, that have not only increased the rate of geo-spatial information usage but also the intelligent gathering and dissemination of geo-spatial information. Through the web, most of these systems have established actuality in the open communication world. The web has also made modern cadastral systems metamorphose into online systems that are radically impacting on society as tools of information technology.

Various government initiatives to produce online systems have evolved into capable and respected systems offering parcel-based information into the public domain. Current prominent examples include The Land Information System Tasmania and the New Brunswick Internet Server that are significantly contributing towards the use and popularity of digital cadastral data on the web (Department of Primary Industry Water and Environment, 1999; Service New Brunswick, 1999). These systems resemble the Multi-Purpose Cadastre concept and Cadastre 2014, where the singular functions of current land information systems are expanded to include data from disparate sources, and lessening the already obvious division between land related components (Kaufman *et al.*, 1998; Panel on a Multipurpose Cadastre, 1983).

3.2   **Review of online systems**

To understand the characteristics of these systems, a review was conducted on the development of online cadastral systems based on twelve government initiatives in Australia, Europe and America. The review was necessary to understand the technology used, whilst identifying the influence of Information Technologies and other catalysts that have impacted on the operations of these systems. The review was conducted based on a set of criteria. The criteria for an online cadastral system inclusion in this review were:

1. The system must be implemented and operational on the web.
2. The system must be relevant to the concepts of the Multi-Purpose Cadastre and Cadastre 2014.
3. Access to the system must be available to the public through the web using current web browser as the viewing tool.

However, several other online systems were not reviewed because of the following reasons:

1. the systems were not fully completed at the time of the review;
2. access to the systems was restricted to users within the local jurisdiction;
3. access was subjected to establishing physical telecommunication links to the systems.

Table 2 lists the twelve online systems that were accessed and reviewed. Most of these systems fall into the last of the four overlapping categories of web-sites as defined by (Coleman and McLaughlin, 1997) that focused on applications related to the distribution of geo-spatial information and attribute data. These categories include:

1. Advertising – web-sites used strictly for advertising data products and are composed of sample geo-spatial information products without analysis capabilities.
2. Data Distribution – web-sites designed for the distribution of geo-spatial information with the ability to search for specific information.

3. Custom Map Creation and Viewing – special-purpose development projects aimed at the composition, display and downloading of custom maps. These sites may or may not use GIS as the underlying technology but limited in data coverage and variety.

4. GIS/Internet Integration Projects – web-sites designed to integrate limited amount of user query with the capability of database and GIS packages residing in the background. User queries are translated into structured commands and passed to back-end GIS database for processing. The resulting response is passed back through the web server (gateway) to the user. The generated maps are usually translated into graphics or bit-map format suitable for transmission across the Internet.

The systems are grouped into regions with further discussion on these systems later in the chapter.

In Australia, five online systems were reviewed. These were Landata and Vicmap Digital in Victoria, the Land Information System Tasmania, Territory and Canberra By Suburbs Online in the Australian Capital Territory. Landata in Victoria is a text-based system developed by Land Registry in Victoria to allow members of the public to query, track and retrieve titles and dealings of land parcels (Natural Resources and Environment Victoria, 1999). Despite its textual approach, Landata provides a meticulous search on parcel creation with information relating to the status and dealings affecting the parcel. On the other hand, Vicmap Digital generates live maps with parcel identifier attributes, based on address queries (Natural Resources and Environment, 1999). VicMap Digital is the web gateway to the State Digital Map Base in Victoria and is being adopted as an integral component by projects such as the Property Information Project (Jacoby, 2000). Landata and Vicmap Digital are good examples of the collaboration by various geo-spatial information agencies in Victoria, and implemented through a centralised gateway at Land Channel (http://www.land.vic.gov.au) (Natural Resources and Environment, 2000).

Table 2: Lists of online geo-spatial systems

(Note: These URLs were current at 01/08/2000)

	System	**Jurisdiction**	**Uniform Resource Locator (URL)**
Australia			
(1)	Landata	Victoria	http://www.landata.com.au/
(2)	VicMap Digital	Victoria	http://www.giconnections.vic.gov.au
(3)	Land Information System Tasmania	Tasmania	http://www.thelist.tas.gov.au/
(4)	Territory Plan Online	ACT	http://www.palm.act.gov.au/tplan/
(5)	Canberra By Suburbs	ACT	http://www.suburbs.canberra.net.au/
Europe			
(6)	Web-Matriklen	Denmark	http://WWW.kms.dk.
(7)	Mapsite	Finland	http://www.kartta.nls.fi/karttapaikka/eng/home.html
(8)	Jako	Finland	http://www.nls.fi/jako/norm/index_eng.html
North America			
(9)	New Brunswick Internet Service	New Brunswick, Canada	http://caris0.universal.ca/NBGIC
(10)	Greene Internet Map Server	Ohio, USA	http://www.co.greene.oh.us/gismapserver.htm
(11)	Mecklenburg Internet System	North Carolina, USA	http://ntgis_netvs.co.mecklenburg.nc.us/taxgis/
(12)	Nashville and Davidson Property Online	Tennessee, USA	http://www.nashville.org/Multi-Purpose Cadastre/maps/index.html

The Land Information System Tasmania (The LIST) is the initiative by Tasmanian land authorities that provides the overlaying of data themes, which include themes such as contours, water boundaries and title information from various Tasmanian agencies. One of its main strengths lies in the successful integration and management between the survey, title register and valuation authorities despite the apparent jurisdiction and physical database separation between them. Available through subscription only, The LIST includes

a revenue-generator mechanism for the recording and charging of plans and title records transactions (Department of Primary Industry Water and Environment, 1999).

The ACT Land Information Council has recently introduced Territory Plan Online and Canberra by Suburbs Online, two systems that grew out of the existing ACTMap database. Territory Plan Online delivers land use information alongside the cadastre. Although presented in a non-intuitive bitmap format, the map layer is informative as detailed information such as land use regulation and policy statements, are included with each map (ACT Land Information Council, 2000). Canberra by Suburbs allows the user to locate parcels based on the street name and suburb of Canberra (ACT Land Information Council, 2000). Both systems represent the transformation of existing geo-spatial information in ACTMap into a web-enabled environment.

In Europe, the systems reviewed include the Web-Matriklen of Denmark and Finland's Jako and MapSite. Web-Matriklen is a product of the government of Denmark (National Survey and Cadastre Denmark, 1999). Web-Matriklen offers in-depth title information and dynamically generated vector maps, with associated attributes such as boundary names and survey benchmark numbers. The digital map base includes survey benchmark identification while the textual components include forests and water body information. The government of Finland is also delivering geo-spatial information through Jako and MapSite. MapSite functions as a live map server, capable of fetching maps of various scales through customisable interfaces. MapSite also includes facilities for purchasing maps by utilising electronic commerce technologies (National Land Survey Finland, 1999b). Jako on the other hand, provides title and cadastral map information of Finland (National Land Survey Finland, 1999a).

In North America, the reviewed online systems are more likely to be classified as Land Information Systems (LIS) because of the legal status and the diversity of the information presented. Most of these systems are held under the responsibilities of county (local government) authorities. Apart from parcel-based information, the Greene, Mecklenburg, Nashville and Davidson systems deliver information ranging from census to housing assessments (Greene County Ohio, 1999; Mecklenburg County North Carolina, 1999;

Nashville and Davidson County Tennessee, 1999). Access to these systems is freely available without subscription base, and the information available is easily downloadable and viewed through the web. On the other hand, the New Brunswick Internet Services is only available to subscribers of the system. Seen as one of the pioneers and front-runners of digital geo-spatial information delivery by Polley (Polley and Williamson, 1999), the New Brunswick Internet Services requires minimal browser modules (such as Java and ActiveX) for it to work. The system also provides services such as web queries through name and parcel search (Service New Brunswick, 1999).

3.3   Comparisons of reviewed systems

Each of these systems is unique with features that distinguish one system from another. To fully appreciate the differences between the implementation and operations of these systems, several features of these systems are compared. These features include:

- government guarantee on the information;
- freedom of access and user-pays policies;
- integration of the cadastre and database layout;
- breadth of information;
- data overlay;
- functionality;
- processing architecture.

Although there are clearly several other features (technical and institutional) that are comparable, the few features compared are sufficient in presenting an overview of the differences between the online systems.

3.3.1   Government guarantee on the information

The reviewed systems were a mixture of title and deeds based systems. The reviewed systems in North America are based on deeds whereas systems in Australia, Denmark and Finland are based on title. The major difference between a deeds and title-based systems lies in the government guarantee. With the deeds based systems, less importance is placed on the accuracy of the base map or the cadastre. Thus the implementation of these systems

are more likely to be highly graphical, with elaborate property and utility information attached to the parcel-based information. Most title systems on the other hand, offer accurate spatial aspects of the cadastre (to fulfill the cadastre accuracy and government guarantee on parcel and title information) and extensive title searches based on the elaborate title-based information.

Table 3: Overview of online geo-spatial systems characteristics

Systems	Map Type	Access Method	Browser Specific	Property Dimensions Included
Australia				
(1)	Text	Subscription	All Browsers	N/A
(2)	Raster	Free	All Browsers	YES
(3)	Raster	Subscription	Internet Explorer Only	YES
(4)	Raster	Free	All Browsers	NO
(5)	Raster	Free	All Browsers	NO
Europe				
(6)	Vector	Subscription	Internet Explorer Only	NO
(7)	Raster	Subscription	All Browsers	NO
(8)	Raster	Subscription	All Browsers	NO
North America				
(9)	Raster	Subscription	All Browsers	NO
(10)	Raster	Free	All Browsers	NO
(11)	Raster	Free	All Browsers	NO
(12)	Raster	Free	All Browsers	NO

1	Landata	7	Mapsite
2	VicMap Digital	8	Jako
3	Land Information System Tasmania	9	New Brunswick Internet Service
4	Territory Plan Online	10	Greene Internet Map Server
5	Canberra By Suburbs	11	Mecklenburg Internet System
6	Web-Matriklen	12	Nashville and Davidson Property Online

3.3.2   **Freedom of Access and User-Pays Policies**

Acquiring access to the systems is largely dependent on the current access policies and commercial considerations of the implementing authority. A few of the reviewed systems such as the North American deeds-based systems, have policies that heavily subsidise costs of data production, thus providing access and retrieval at no charge (see Table 3). Other systems are based on active collaborations by the private sectors to produce data, interfaces and data delivery with strong emphasis on quality and user-pays policies. In Victoria for example, the cooperation between DATA*Flow* Ltd. and Land Victoria in maintaining the Digital Cadastral Database (DCDB) for Victoria symbolises the active participation between the government and private industries (Jacoby, 2000).

3.3.3   **Integration of the cadastre and database layout**

The most significant feature in all these systems is the seamless integration of the cadastral layer and the title register. In reality, databases containing the cadastral layer and title registry may be distributed or centralised in the same institution or in separate institutions altogether. However, the use of the Intern*et* allows the formulation of integrated information, which from the user point of view, is derived from centralised resource centre.

The physical layout of the databases in these systems plays an important role in the maintenance and operation of an efficient online system. From the review, it was noted that the topology of the databases from these systems is found to be grouped into two categories (see Figure 8) *i.e.*:

- Distributed;
- Centralised.
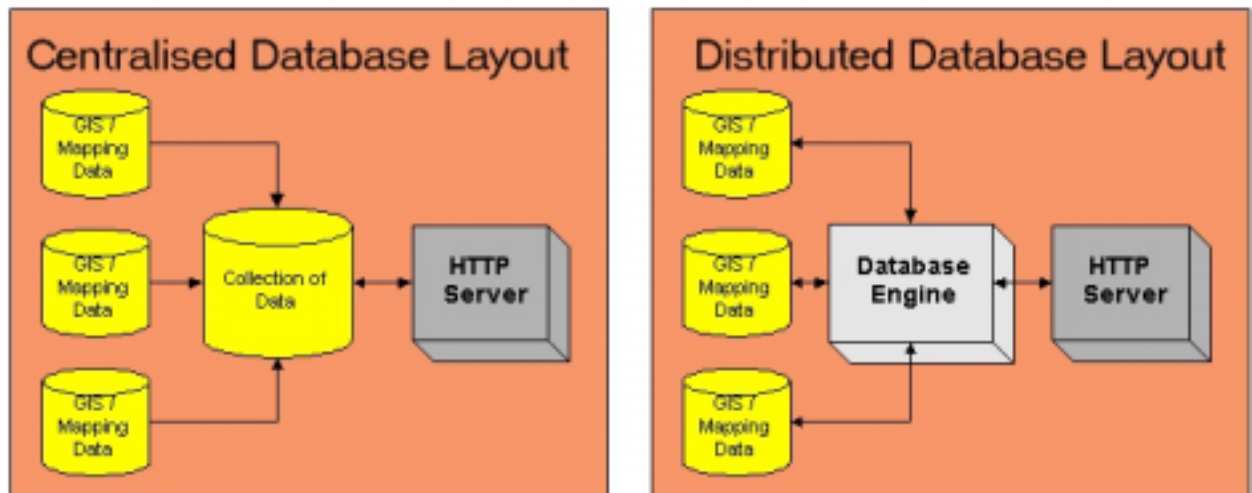
Figure 8: Centralised and Distributed Database Layout

There are several issues concerning the layout of these databases. A centralised database layout permits a physical storage unit to be used where the data that has been replicated, are stored. It is ideal in systems with a fixed quantity of data or as an immediate solution for a complex database layout. A growing volume of data in a centralised database may result in major upgrades and unnecessary expansions to the system. However, a centralised database is easier to manage and uses fewer computing and networking resources. Moreover, from a security and access perspective, it is often desirable to supervise a collection of data in a single location than over several repositories. On the other hand, the distributed database layout is ideal for the expanding system *i.e.* for the Multi-Purpose Cadastre concept, where related themes from other resources are integrated within a common environment. The distributed databases layout allows participating agencies to efficiently manage, maintain and produce the data. As demand for better data increases, additional databases from other agencies are simply connected via the distributed database layout.

From this review, it was understood that The Land Information System Tasmania (LIST) incorporates the distributed database topology. Access to each database was transparent with seamless flow of data from the distributed databases of participating custodians (Department of Primary Industry Water and Environment, 1999).

3.3.4 **Breadth of information**

Another notable feature of these systems is the impression of a one-stop shop for all related geo-spatial information. Apart from the cadastral map and title registers, other data that are regularly found in these systems include building footprints, land use, contour details and land-value assessment data. Table 4 lists examples of parcel-related data that complements the cadastral layer in these systems.

Table 4: Availability of data themes and layers from online systems

Systems	Title / Deed Search	Survey Records	Land Value Assessment	Building Information	Easement	Flood Plain	Parcel History
Australia							
(1)	YES	NO	NO	NO	NO	NO	YES
(2)	NO	LIMITED	NO	NO	YES	NO	NO
(3)	YES	NO	YES	YES	NO	NO	YES
(4)	NO	NO	NO	NO	NO	YES	NO
(5)	LIMITED	NO	NO	NO	NO	NO	NO
Europe							
(6)	YES	LIMITED	NO	NO	NO	NO	NO
(7)	NO	NO	NO	NO	NO	NO	NO
(8)	YES	YES	YES	NO	NO	NO	NO
North America							
(9)	YES	LIMITED	YES	NO	NO	NO	NO
(10)	YES	YES	YES	NO	NO	YES	NO
(11)	YES	YES	YES	YES	NO	YES	NO
(12)	YES	NO	YES	YES	NO	YES	NO

1	Landata	7	Mapsite
2	VicMap Digital	8	Jako
3	Land Information System Tasmania	9	New Brunswick Internet Service
4	Territory Plan Online	10	Greene Internet Map Server
5	Canberra By Suburbs	11	Mecklenburg Internet System
6	Web-Matriklen	12	Nashville and Davidson Property Online

The table shows the diverse populated data and map themes available in these systems. The American deeds-based systems offer the most diverse and populated themes available

(such as building and flood plains) while most of the title-based systems boast parcel and title information that are meticulous and detailed.

3.3.5 Data Overlay

Online systems are usually made up of large relational or object-oriented databases with spatially enabled routines or programs that treat each of the themes listed in Table 3 as a layer of data. Each of the systems provides interfaces to allow users to include the layers directly onto the cadastral layer or as tabular title information linked to a register. This is usually performed through selectively choosing the data using menus or queries available by most systems. Features such as Pan, Zoom and Buffering are also included in most systems as the capabilities of web-based scripts and plug-ins are being improved.

3.3.6 Functionality

Online systems make their existence through the windows of web browsers that translate the authored HTML documents into text and bitmap images to the user. For most online systems however, to cater for efficient geo-spatial data delivery such as dynamic mapping, languages such as JavaScript are used to develop specialised web-based scripts (codes embedded within HTML documents) and additional web browser components. Although popular amongst web developers and designers, this approach does introduce some limitations, such as:

- limiting the audience base by demanding the use of non-standard browser components;
- requiring more capable computers to accommodate the additional features;
- creating custom scripts and codes that are interpreted differently by different web browsers;
- lowering the security level when communicating between the web browser and the server through the use of applets and applications that access parts of the memory and disk storage space.

On the other hand, most online systems utilise web-based scripts to accommodate greater and better geo-spatial information use through the web. For example, web-based scripts are often used to translate mouse clicks on dynamic maps, from screen coordinates into real-world coordinates, hence facilitating the generation of newer dynamic maps by the system.

Specialised plug-ins such as ActiveCGM allows vector maps with boundaries and features that could be individually queried by the user (InterCAP Graphics System, 1999).

3.3.7 **Processing Architecture**

The reviewed systems have allowed members of the public to share and manipulate geo-spatial information on the web, due to the successful integration of information from distributed databases. To present this information, a substantial amount of processing resource is needed to integrate the back-end databases and manage them to hundreds of simultaneous web users. As a result, more powerful machines are used and maintained for such purposes. Another solution involves the understanding of existing client/server architecture of the web. The client/server architecture allows for the sharing of processing resource between the web browsers as the users and the servers, but the architecture does not dictate the exact ratio of this sharing. Therefore, a balance between a thin-client configuration, where the web browser is specifically used as a viewing tool, with the web servers handling most of the processing, and a thick-client configuration, where the web browser is given additional processes to lighten the load on the web servers, is needed.
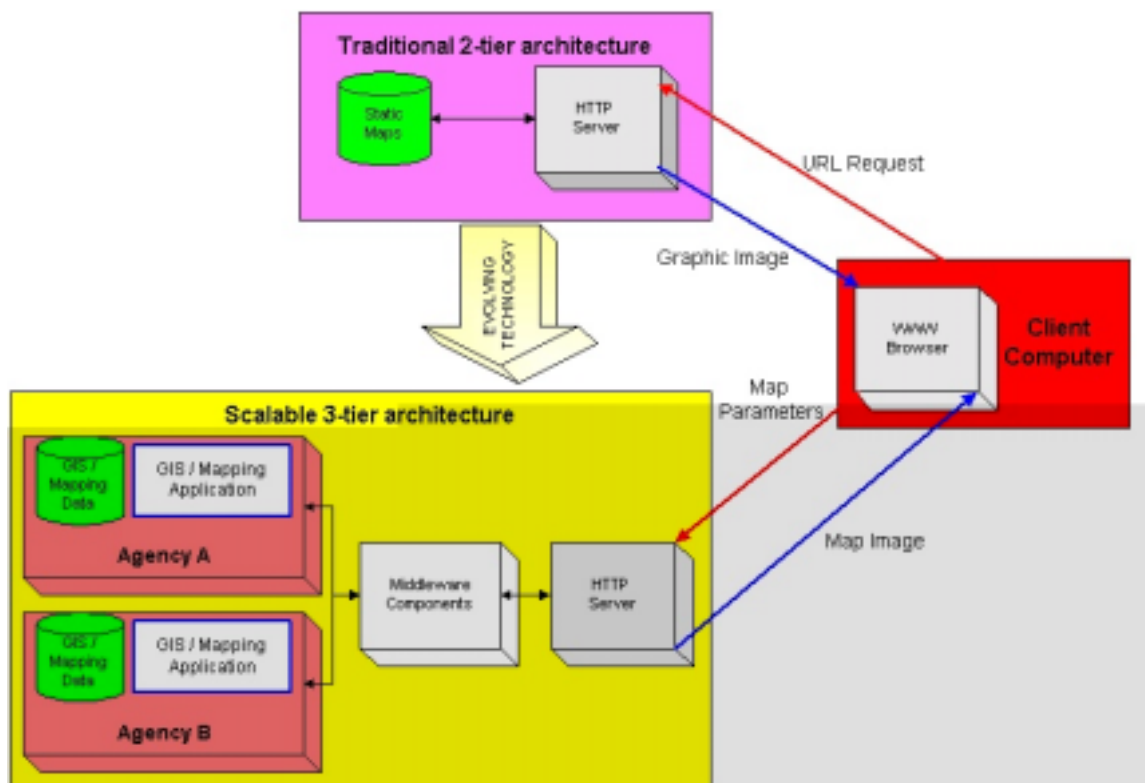
Figure 9: Evolving processing architecture with client/server interaction

Typically the balance between the processing load of the users and the servers are determined by the software used to develop the systems and the mass market of users that the systems are targeted for. A thin client (interacting with a thick server) allows for powerful and complex analysis to be conducted, but would not handle as much network traffic and client requests as expected, thus limiting the response time and the speed of the delivery. A thick client on the other hand, uses considerable amount of bandwidth by sending and receiving pieces of codes to pan, zoom and deliver newer maps to the users. A thin client configuration is favorable for simpler (and most) systems with a wider audience without downloading additional browser modules such as the plug-in.

Most reviewed systems are also evolving from monolithic systems that represent static web fronts of these systems to intelligent query and retrieval systems that integrate data from various agencies across networks. Instead of just tools for searching cadastral records or title registers of specific agencies, most online systems integrate data and layers from disparate resources, using scalable three-tier processing architectures. This permits databases from other agencies to be connected behind the web servers.
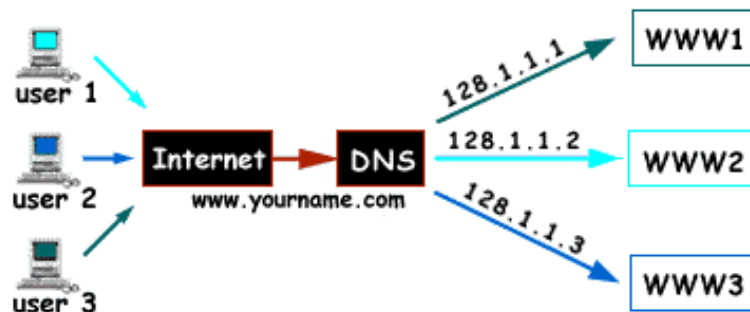
Figure 10: Using Load Balancing Techniques in Handling High Internet Demands

Most systems concentrated on the ability to provide all day access and service to multiple users simultaneously. There are a number of techniques in doing so. The first technique requires the use of dedicated communication lines (such as the Integrated Services Digital Network (ISDN) and T-3 lines) that offer up 44,736,000 bits of transfer per second (approximately transferring a megabyte of data in less than one second). The connection is permanent between the servers and the Internet, but are charged on the amount of data transferred. Examples include Optus@Home and Telstra Big Pond (Optus, 2000; Telstra

Corporation Limited, 2000) The other technique uses multiple identical web servers registered under the same Domain name *e.g.* www.yahoo.com.au, that intelligently manage client requests across the system servers (see Figure 10). Often termed Load Balancing, it minimises delays, maximises response time and ensures reliable connection to service.

3.4 **Benefits of online systems**

Current distributed computing trends and the wide adoption of the Internet have profoundly affected the nature of geo-spatial information processing and delivery. The development of current web-based geo-spatial systems relies heavily on computing architectures such as DCOM and CORBA, where geo-spatial systems are built on the three-tier distributed processing architecture (see Figure 9). For the deployment of geo-spatial data, the distributed architectures have several advantages over the existing client/server architecture of the Internet.

The distributed architectures will promote efficient online delivery, electronic sharing and transfer. Architectures utilising web-based scripts allow users to navigate through databases and resources using menus and toolbars, and easily select different data from the distributed but connected databases. The interfaces could also be used as an entry point to a portal site where several similar systems can be grouped under a common theme. An example is Land Victoria's Land Channel web-site (Natural Resources and Environment, 2000).

Online geo-spatial systems allow databases that reside in isolated government agencies to be connected. This will abolish the major concern of data custodianship *i.e.* who is responsible for the data. As the data is retrieved directly from the providing agencies, the agencies will still retain ownership of the information in databases, thus the upgrading, updating and maintenance process will be on the respective agency onus.

By utilising the distributed database layout and multiple-tier processing architectures, web users are always ensured of getting the latest versions and updates of the data since there is little duplication or replication that exists between data providers and users. This is in contrast to having related copies of the data themes stored in large and centralised

databases, that require additional procedures to update the concurrency and versioning between the databases.

3.5   Impact of online geo-spatial systems

The online systems reviewed exemplify the visions of the respective governments to suitably equip the public with the tools to easily search, locate and retrieve cadastral, title or other parcel related geo-spatial information. Already the impacts of these systems are immediate and are generally well observed from these systems. The impacts include:

- the public's view towards land and geo-spatial information, and land authorities in general will be significantly improved through greater access to better geo-spatial information;

- the public could easily retrieve information from a single point of entry or gateway instead of hassling through various government agencies. See the Victorian Land Channel web-site at http://www.land.vic.gov.au.;

- most systems are equipped with revenue-generating mechanisms and Electronic-Commerce that facilitate online geo-spatial information transactions;

- geo-spatial information used in online geo-spatial systems will be widely used and embedded in other related applications and wireless devices. Recently revealed technology such as the Wireless Application Protocol (WAP) and Wireless Markup Language (WML) will facilitate geo-spatial information delivery from online systems to wireless devices (Google Inc., 2000).

3.6   **Chapter Summary**
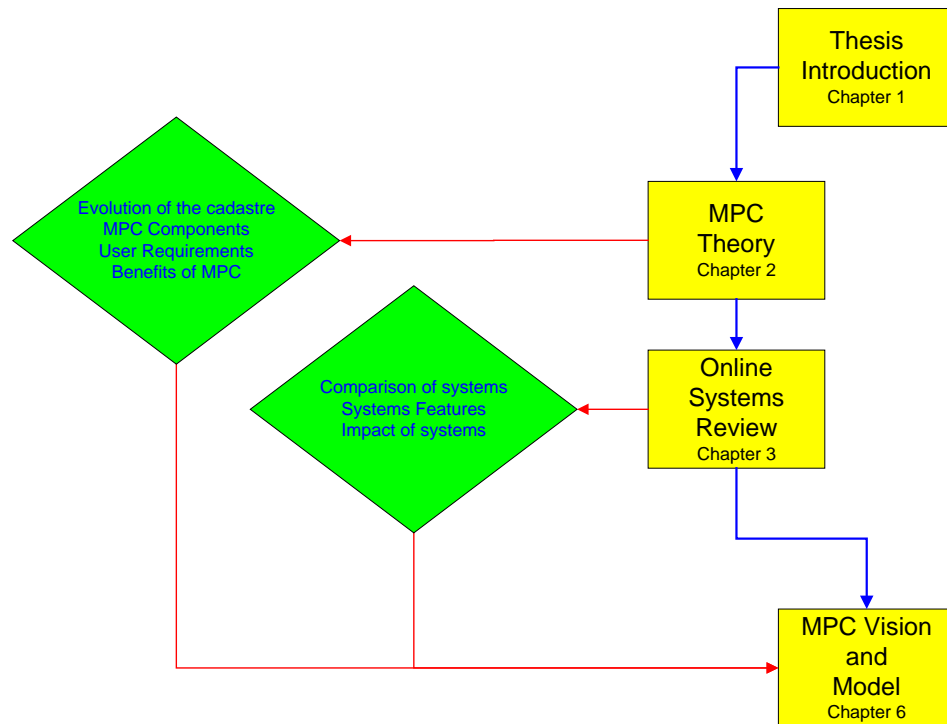
Figure 11: Understanding the MPC Concept Part 2

This chapter discusses the awareness of the MPC concept through the review of twelve online systems in Australia, Europe and America. The review proved that the MPC concept discussed by the Panel on the Multipurpose Cadastre and the International Federation of Surveyors is being implemented in most of these systems. For example, Cadastre 2014 document by the FIG, pointed out that the separation of the cadastral map and the title records will disappear by the year 2014. The review proved that this trend is occurring as web users are treated with online geo-spatial information, in particular cadastral and titles data that are integrated as one product but originate from isolated resources.

This chapter also identifies some major differences in the operations and structure that exists in these systems. Of importance, the information available to users, access and payment for access to these systems differ between systems, thus demonstrating the

policies that are in place to better suit the varying uses from society. The systems themselves are not identical in structure and architecture, but the clever use of technology and the web, has permitted more people to view and use the geo-spatial information made available to the public. These differences are healthy and illustrate the viability of different system approaches to the MPC concept.

Chapter 4

Worldwide Geo-Spatial developments towards the Multi-Purpose Cadastre concept

Recent initiatives by geo-spatial information organisations are now realising the Multi-Purpose Cadastre concept. The International Federation of Surveyors has released a visionary specification for a cadastral system that would satisfy the needs of tomorrow, while geo-spatial producers and developers are collaborating to fulfill a standardised geo-spatial information environment that would facilitate unambiguous communication in the geo-spatial information world.

This chapter will highlight the significance of these developments to the Multi-Purpose Cadastre context.

Chapter 4: **WORLDWIDE DEVELOPMENTS TOWARDS MPC**

4.1 **Introduction**

Integrating title and cadastral entities has helped to support land markets in many developed and developing countries by providing a sound and undisputed resource on legal rights, interests, ownership and position of land parcels. The establishment of such integration must not be an end by itself. There seems to be a move by many countries worldwide towards linking other information relating to the cadastre, specifically the land parcel. Decision-makers are no longer satisfied with the desegregated information that still requires efforts in putting the information together. It has also seen by many, that the current geo-spatial information is inadequate to sustain increasing developments. The recent Bathurst Declaration was the pivotal period where experts around the world acknowledged the need for better information for sustainable development (UN/FIG, 1999).

In the past few years, several notable factors and initiatives were seen as the driving force in the rapid development of online geo-spatial systems. This chapter is aimed at highlighting the role and impact of these initiatives whilst extracting the relevant concepts that are pivotal in the overall understanding of this research thesis.

4.2   **Growth in Volume of Geo-spatial Data**

Recent surveys of practitioners in the geo-spatial information community indicated that geo-spatial data volumes through the 1990s would continue to increase dramatically (Newton *et al.*, 1992). This has contributed to the significant reduction in geo-spatial data costs whilst increasing the price-performance ratios through the use of satellite, scanning and storage technologies.

Newton *et al.* (1992) also argued that several of the biggest contributors in the creation of geo-spatial data of today include:

1. Remote-Sensing techniques that have produced data volumes in excess of 1000 Gigabytes per day. Fortunately, advanced image compression such as MrSID (see below) reduces high-resolution satellite imagery to a factor of 10 to 20 with little loss of information while it reduces storage requirement, information transfer time and processing time.

2. The geo-spatial information communities are storing paper plans and maps through raster scanning. The results are digital copies of maps and papers that contribute to the creation of geo-spatial data.

3. The design and drafting community is embracing the availability of commercial products in Computer-Aided Design (CAD) format. A CAD product for example, includes libraries of predefined designs that would considerably decrease drafting time.

4. The large availability and price-drop of the Read-Only Memory Compact-Disc (CD-ROM), hard disk and optical disc with capacities in the Gigabyte range are now being used across the geo-spatial community to store and archive images and plans.

Despite the obvious increase in data volume, its impact on the limited Internet bandwidth and speed, especially on dial-up and home connections are remedied using technologies

that reduce transfer time and bandwidth. For example, the Multiresolution Seamless Image Database (MrSID) format is being utilised by the United States Library of Congress, to publish an image of 208 megabyte in size, that has been compressed into a 6.9 megabyte on a 30:1 compression ratio (LizardTech, 2000).

How MrSID Works in a Web Browser
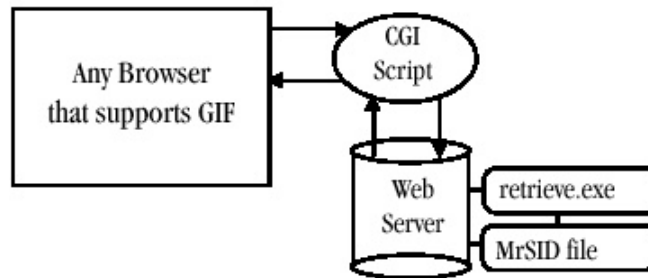
This "full" image is a 514 by 396 pixel screen image generated from the actual MrSID file stored on the server. MrSID dynamically extracts -- from within the compressed space of a single file -- the requested view as a GIF file. In this case, the file "served up" to the browser is about a 160k GIF. Using a simple CGI script, this can be easily configured for your particular Internet implementation.

Figure12: An abstract taken from MrSID Application Brief (LizardTech, 2000)

Together with the continuing reduction in price/performance ratio of desktop and mainframe storage and memory, the growth in volume of geo-spatial data and the intelligent compressions techniques are being managed and used by more people now than ever before.

4.3   **Cadastre 2014**

In 1994, the FIG Commission 7 decided to create Working Group 7.1 to study the automation of cadastres and the increasing importance of the cadastre as part of a larger land information system. Based on the trends analysed, the working group produced a 20-year vision of where cadastral systems are headed with emphasis on the technology used to implement this vision. The vision named "Vision Cadastre 2014" became significant as it was substantially developed based on a rigorous understanding of problems, needs and futures of 31 jurisdictions around the world. The justification of the Cadastre 2014 includes:

- Cadastre 2014 is needed to support sustainable development. Cadastre 2014 provides the security and complete documentation of legal and physical land objects that support the efforts of sustainable development. This is done through efforts such as the guarantee of ownership and security of land tenure, security for credits and the reduction of land disputes.

- Cadastre 2014 creates political stability through strong legal and fiscal guarantee of the cadastral system.

- Cadastre 2014 provides the necessary public documentation and contributions that omits conflicts of public and private interests.

- Cadastre 2014 is aimed to support the economy through complete documentation about the situation of a certain piece of land. A standardised and complete cadastral system can help companies to easily deal with matters relating to land thus leading to money and time saved. The saving is passed to the customers, making products and services less expensive.

- Lastly, Cadastre 2014 with its concept of complete area coverage and straightforward information structure will meet the diversity needs of modern society that requires cadastral systems that should be simple, effective, adaptable to rates, provide access and security to land and be part of a national spatial data infrastructure

(Kaufman *et al.*, 1998)
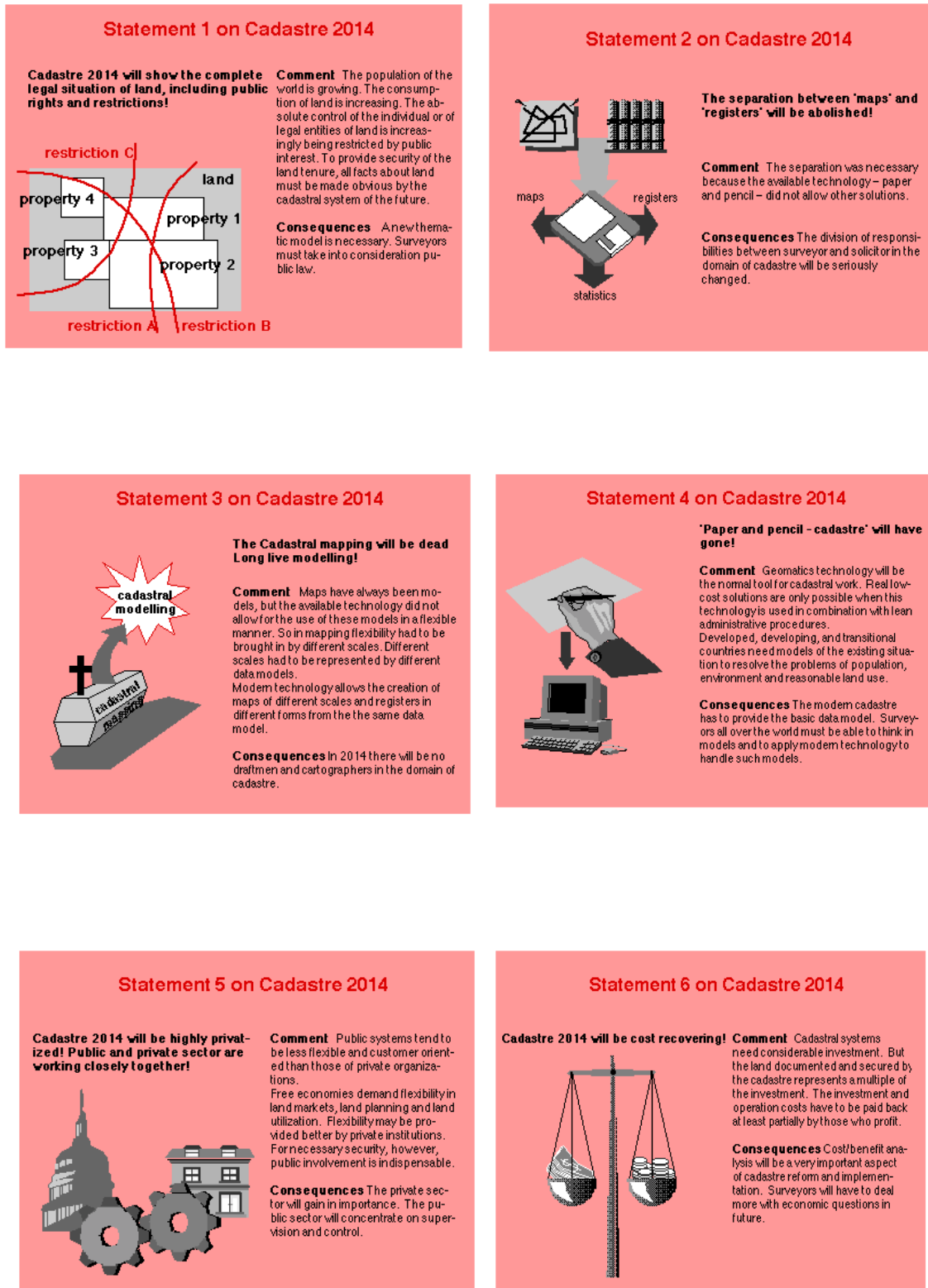
Figure13: Features of Cadastre 2014 (Kaufman *et al.*, 1998)

Figure 13 illustrates the six key statements of Cadastre 2014 about the development of the modern cadastral system. These are:

1. Cadastre 2014 will show the complete legal situation of land, including its rights, restrictions and responsibilities.
2. The separation between maps and registers will be abolished.
3. Traditional cadastral mapping will be replaced by modelling.
4. The paper and pencil cadastre will have gone.
5. Cadastre 2014 will be highly privatised.
6. Cadastre 2014 will be based on cost recovery.

The six key statements and the justifications for Vision Cadastre 2014 are contributing towards the MPC concept.

These registers might include databases with planning and valuation information. Figure14, taken from (Williamson, 1999b) depicts the role of the MPC in revealing the complex rights, restrictions and responsibilities on land.

Schematic of overlapping rights, restrictions and responsibilities in a modern multi-purpose cadastre

Native Title Claim
Heritage Protection Area
Protected Species Habitat
Flood Zone
Proposed Road Widening

Land Use
Zone

A Land
Parcel

Noise Buffer

Mining Lease

Transmission Line Easement

Restrictions on Use
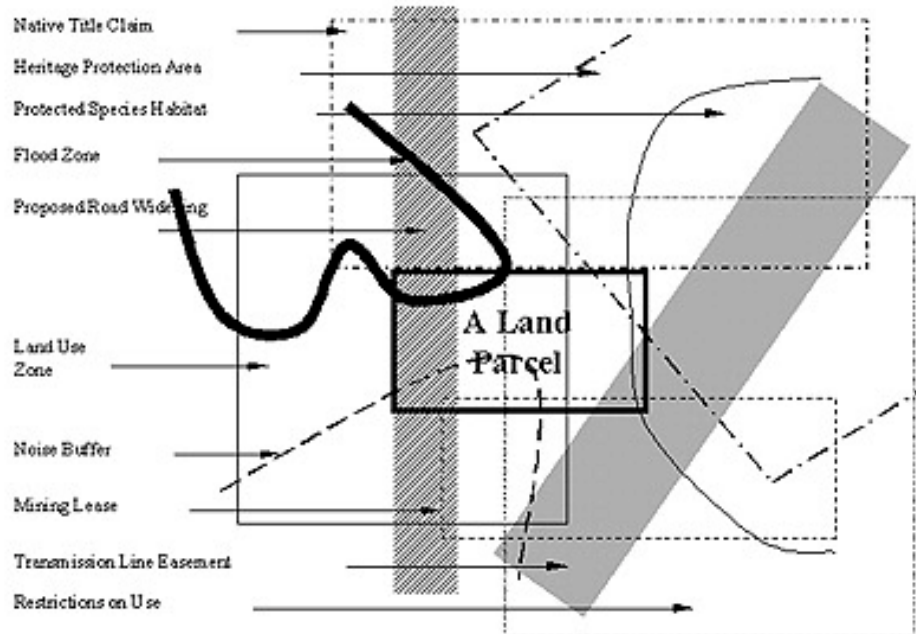
Figure 14: Rights, restrictions and responsibilities of a MPC (Williamson, 1999b)

Clearly, the modern cadastral system is adapting to changes in order to meet increasing demands. As part of these changes, the modern cadastral system has gone through improvements such as digitisation, automation, database integration and many more technological changes that have in many ways transformed paper maps and documents into the digital form. A good example is the modernisation of the Title Registrar office that lead to the development of LANDATA (McMahon, 1998)

4.4   **Global Technological Initiatives**

Globally, there has been a rise in the adoption of information technology standards in order to promote and regulate the use of geo-spatial data. Currently, there exists several key initiatives that are pushed forward by technologically adept nations. These initiatives include:

- the adoption and promotion of Spatial Data Infrastructure (SDI) in the national, regional and global environment (Rajabifard and Williamson, 1999).
- The unification of commercial and academic institutions in researching and promoting the Open GIS Specification. The Open GIS specification is being championed by several software developers in pursuit of producing a compatible, interoperable geo-spatial environment across multiple data formats, operating platforms and delivery environments (Open GIS Consortium, 2000).

Each initiative will be described in the following sections, with the intention of highlighting the geo-spatial information convergence in these areas.

4.4.1   **Spatial Data Infrastructure**

For efficient and unambiguous use, the geo-spatial data in a MPC environment must conform to regulations and structures that permit sharing across government agencies. Inevitably the creation of a MPC itself forces the collaboration and cooperation between several disciplines and an appropriate strategic plan for the maintenance of the distributed geo-spatial data is needed. The general community on the other hand, expects the geo-spatial data to be operational and readily available through transparent network technology such as the Internet. If the geo-spatial data is used as a GIS resource, then the geo-spatial data has to evolve into an infrastructure that is ready to serve its users.

In this context, SDI is an infrastructure of standardised geo-spatial data, through the use of metadata and metadata engines in the overall scheme of data flow in a MPC. The Australian and New Zealand Land Information Council (ANZLIC) defines metadata as *"data about data" (ANZLIC, 1999).* A metadata engine (see Figure 15) is an application

that is used by a database management system (DBMS) to extract and display the metadata queried to the user. Metadata engines work in the background, with no direct interaction with the user of the database. Although the computing industry has already embraced the concept of metadata in almost every computing activity such as software development, it is crucial to classify the two types of metadata that exists in operation.

The first type of metadata that is commonly used in the software development arena commonly refers to the under-laying set of rules that instructs a software how to handle data (Phillips, 1998). Database Management Systems (DMS) generally use metadata to locate the results of a particular database query.

The second type of metadata primarily concerns the geo-spatial information community. Metadata is being used to describe the characteristics of the data. These may include the description of the data, custodian rights, age and quality of data, geographic extent of the data, currency of the data and contact information to inquire about the data. Currently in Australia, ANZLIC has developed guidelines for the collection of geo-spatial metadata that will be used in the Australian Spatial Data Directory (ASDD). The ANZLIC Guidelines: Core Metadata Elements, provides a model that defines the core metadata elements that ANZLIC believe should be recorded for all geo-spatial data. To facilitate this movement, ANZLIC has also introduced a software product that assists users in developing the proper metadata. The Metadata Entry Tool (MET) supports the collection of metadata and to ensure consistent description of core metadata elements. It can be downloaded free of charge from http://www.lpe.nt.gov.au/info/met/runtime.htm. (ANZLIC, 1999)

Currently, SDI itself is being used and implemented in many levels across governments (see Figure 16). At the lowest level, the SDI exists at the local level where SDI is used by local governments and corporate organisations for decision-making processes. ANZLIC further classify SDI at the national level to consist of the institutional framework, technical standards, fundamental datasets and the clearinghouse network (ANZLIC, 1999). Regionally, the work to develop regional SDI has been initiated by groups such as the Permanent Committee on GIS Infrastructure for Asia Pacific (PCGIAP) and the European Umbrella Organisation for Geographic Information (EUROGI) (Rajabifard *et al.*, 1999).

The progress of SDI has also crept to the global scene, with active participation by experts in the 4th Global Spatial Data Infrastructure Conference in Cape Town, South Africa (GSDI, 2000).
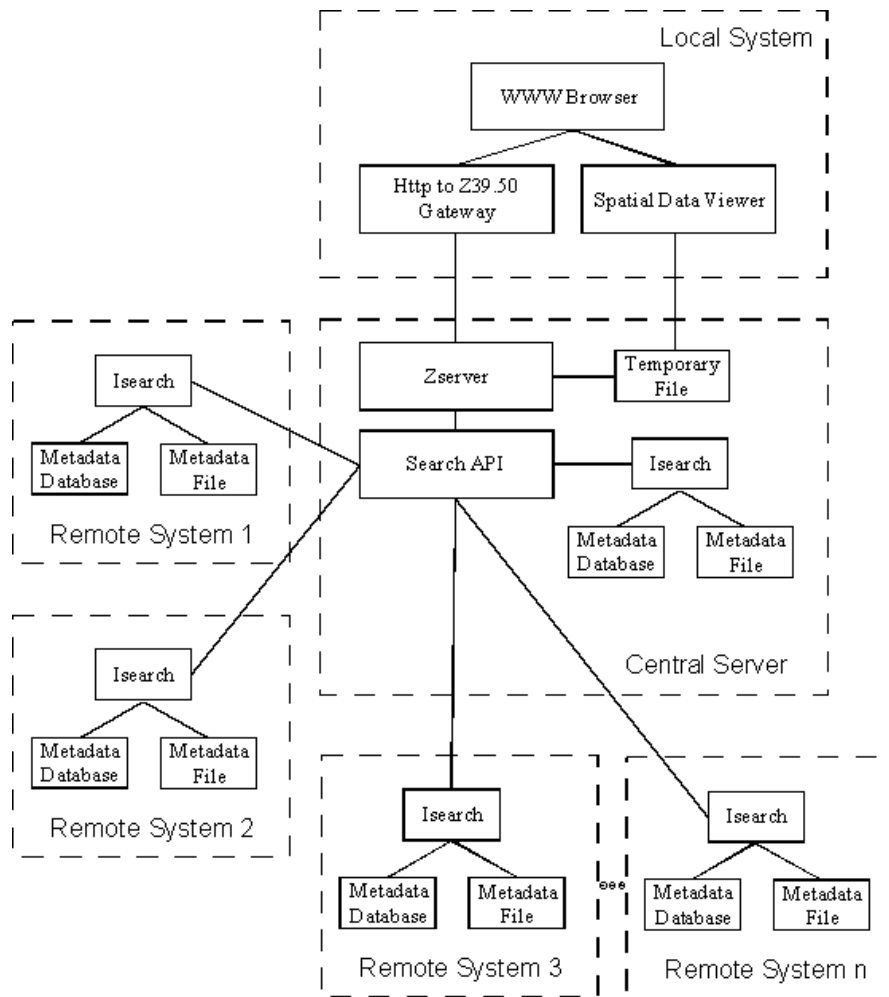
Figure 15: Architecture of a metadata engine (Phillips *et al.*, 1998)
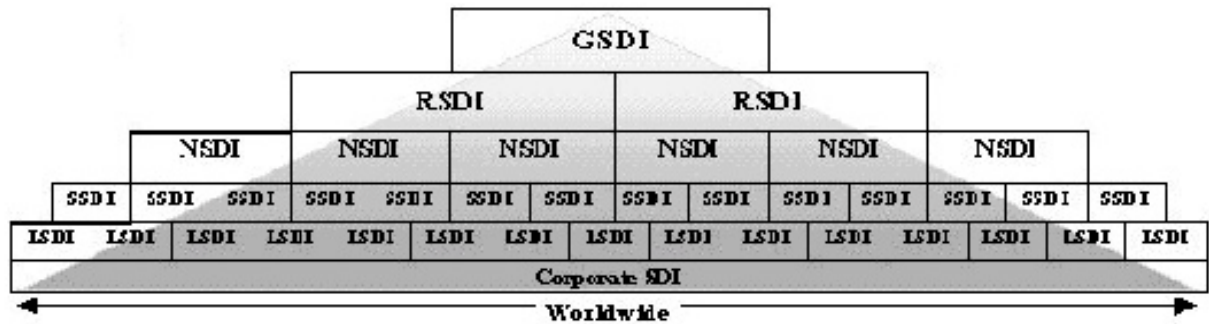
Legends
 GDSI – Global Spatial Data Infrastructure   **RSDI**– Regional Spatial Data Infrastructure
SSDI– State Spatial Data Infrastructure   **LSDI**– Local Spatial Data Infrastructure

Figure 16: The Building Block of SDI (Rajabifard *et al.*, 1999)

(Rajabifard *et al.*, 1999) argued that SDI environment is still far from perfect. There exist issues such as the lack of metadata and common standards, and political issues such as the intellectual property that hinder greater collaboration between participating members (Rajabifard *et al.*, 1999).

4.4.2 **Open GIS Consortium**

The Open GIS Consortium (OGC) is a non-profit organisation dedicated to promoting new technical and commercial approaches to interoperable geo-processing environment. It was founded in 1994 in response to industry-wide problems with interoperability and the effects of this on industry, government and academia (Open GIS Consortium, 2000). OGC recently released the OGC Specifications which detail a comprehensive set of specifications to coordinate the software framework for distributed geo-spatial data and geo-processing resources. The specification provides software developers with a detailed and common set of template for writing software that will be interoperable with other Open GIS-conformant software. From the Open GIS Guidebook, the Open GIS framework includes:

- A common means of digitally representing the Earth and its phenomenon, mathematically and conceptually.

- A common model for implementing services for access, management, manipulation, representation and sharing of geo-spatial data between communities.

- A model for using the Open Spatial Data Model and the GIS Services Model to solve technical and institutional non-interoperable problems.

<div align="right">(Open GIS Consortium, 2000)</div>

Developments of future geo-spatial systems and MPC should adopt the Open GIS specification to enable the users to share a potentially huge networked data space, even the data may have been produced at different times by unrelated groups of people using different production systems and tools for different purposes. The OCG is pushing hard for the Open GIS specification to be widely adopted by commercial software makers and users. Ultimately, the end users of this specification would receive real time access to more geo-spatial information with more applications taking advantage of geographic information. The specification also provides for the ability to work with different data formats and types with a single application environment within a continuous workflow. To facilitate the uniform understanding, usage and further research into the Open GIS specification, the OGC maintains a record of consensus that forms the Open GIS Abstract Specification. The Abstract Specification contains 14 topics, which include Overview of the Specification, Feature Geometry, Geo-spatial Reference System and Locational Geometry.

Since its first conception, OCG has successfully tested the Open GIS specifications in many areas of geo-spatial information. As part of the on-going development, OGC has introduced the Australian World Wide Web Mapping Consortium Testbed that allows users and the public to sample a few of the OGC's prototypes.

4.4.3   Australian World Wide Web Mapping Consortium

In Australia, the Australian World Wide Web Mapping Consortium (AWWWMC) represents the Open GIS Consortium. The AWWWMC is led by the Australian Land Information and Surveying Group (AUSLIG) and supported by major Australian geo-

spatial stakeholders such as CSIRO and Geomatics Technology. AWWWMC has been in the forefront of producing state-of-the-art geo-spatial online solutions to further promote the use of geo-spatial information across governments and private bodies.

The consortium began developing standards that would extend existing commercial and public sector capabilities on the web. This lead to an attempt to demonstrate the real-world applicability of web-mapping technologies of accessing multiple geo-spatial resources simultaneously. The consortium succeeded in demonstrating the possibility of interoperability between agencies as data providers and further led to the development of the Australian cyclone and hailstorm disaster scenario. Both scenarios can be accessed at http://203.111.113.5/webmap/awmc.

4.5   **Amalgamation of traditional geo-spatial environment with IT**

While current GIS products are useful tools for analysis of geo-spatial data, they do not necessarily provide the environment for integration of geo-spatial data from external resources. The trend to achieve this connectivity is apparent in Chapter 3, where many governments around the world are expanding their geo-spatial systems to include connectivity capabilities across the Internet.

IT has introduced concepts such as Object-Oriented Programming and Relational Databases that have enabled geo-spatial data such as points, lines and polygons to be stored in a non-spatial storage environment and used with legacy and current geo-spatial systems. Most GIS systems can now be interfaced with objects such as Application Programming Interfaces (API) and sockets, which allow connectivity with databases containing a mixture of geo-spatial information and standard data. For example, the South Australian Department of Environment Heritage and Aboriginal Affairs, through the implementation of InfoShop.SA, has successfully integrated legacy Land Title and Valuation systems with an online web-environment (DEHAA, 1999). This was achieved using a Common Object Request Broker Architecture (see Chapter 2.6.3 for detailed explanation of this architecture), that facilitates data transfers between modern database applications (using ESRI's Spatial Data Engine) and the legacy system.

Mixing spatial and non-spatial data in a proprietary database in recent innovations can be polarised into two different approaches. The first is the use of Object Relational Database Management System (ORDBMS), which provides the use of plug-ins modules such as InfoMix's Datablade, into the engine of the database, hence providing integrated, native support for geo-spatial data types (InfoMix, 1998). The second approach builds on this concept by introducing an external but integrated layer which communicates with the database engine. An example is Oracle8I Spatial (Oracle, 2000b).

4.6 **Chapter Summary**

This chapter represents the beginning of the second knowledge flow encapsulated in this research thesis (see Figure 17). Throughout this chapter, it has been demonstrated that changes in the current geo-spatial information environment are gradually converging towards the Multi-Purpose Cadastre concept.

It is expected that future geo-spatial systems resembling MPC systems would reflect the influence of the worldwide geo-spatial developments discussed in this chapter. Examining each factor on its own merits, the current (and certainly future) growth of geo-spatial data will be a catalyst in building MPC systems that would be the central point of contact for the storage, analysis, dissemination and use of the acquired data. The developed MPC would be expected to the Internet and possibly in the future, the wireless environment where the MPC system would be accessed by a wider scope of users.

The FIG, through technical oriented documents such as Cadastre 2014, has contributed towards shaping future geo-spatial information. The characteristics of Cadastre 2014 are certainly gaining momentum at the moment, and future online systems will eventually realise all of the characteristics in the near future. Even though technology may not be the sole solution in realising the Cadastre 2014 vision, it has and will significantly contribute towards the shape of future systems. Already, it can be seen that the separation of the cadastral map and related registers are made seamlessly, which is made possible through the intelligent use of the web and technologies of the Internet.

SDI will also shape the MPC system of tomorrow. As the SDI issues are being resolved across the various levels (corporate, local, national, regional or global), the importance of SDI and the use of SDI in future MPC systems are inevitable. SDI will further ensure the proper flow of geo-spatial information across agencies and users. SDI will also ensure that the same information viewed at one level of the MPC is the same piece of information on the other side of the MPC, all through the use of metadata and SDI standards.

The most prominent impact towards the MPC of the future will come from the contributions and work of the OGC together with the AWWWMC. Both of these groups are striving towards collaboration of geo-spatial information agencies in adopting common communication protocols and environment that will ensure future MPC systems that are stable and unambiguous. Most of the projects initiated by OGC and AWWWMC are state-of-the-art systems that harness the web, and break down the barrier that has existed between government agencies when sharing and delivering geo-spatial data.
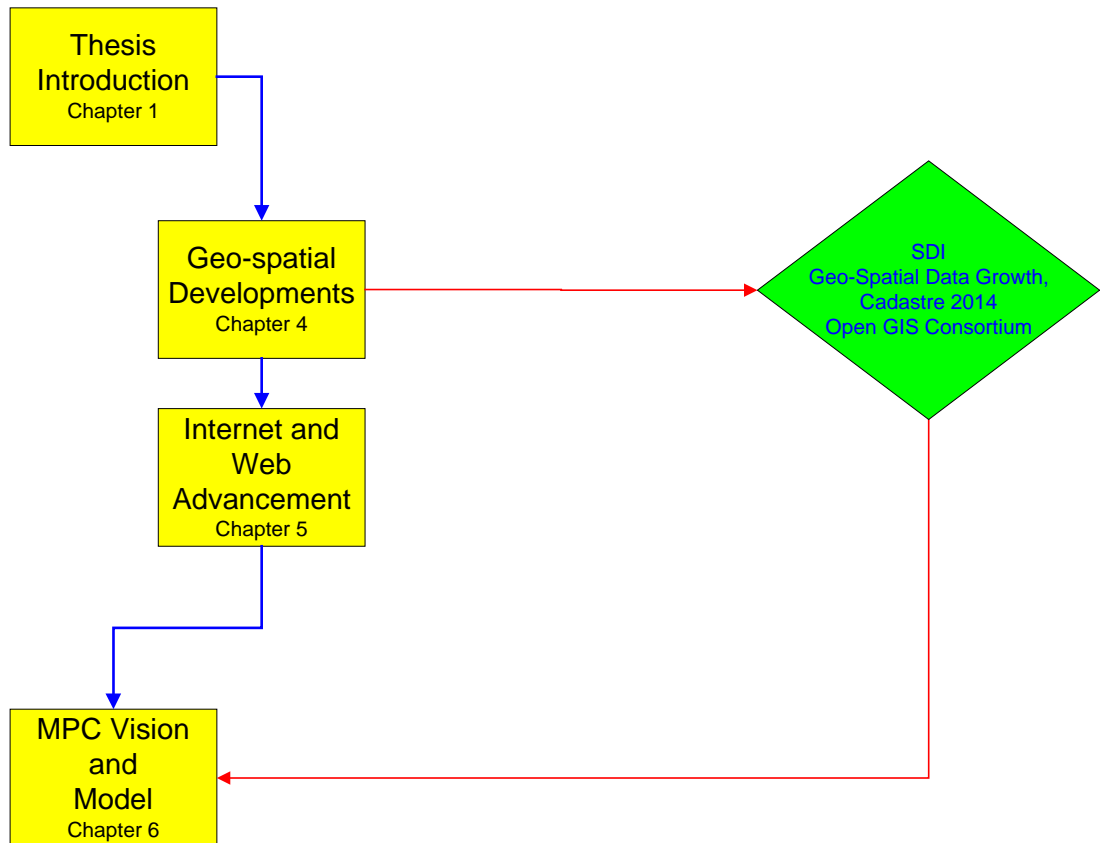
Figure 17: Knowledge Flow of Geo-Spatial Information Development encapsulated in this thesis

Chapter 5

The Internet and Other Contributing Factors

The Internet and the web are two contributing factors in the development of the MPC prototype. In recent times, the web has been the focus of information seekers and information publishers. As a result, the web has been tested by geo-spatial developers as a disseminating medium to an audience base wider than ever before.

The new tools for geo-spatial information publishers have been web-based scripts, plug-ins and distributed processing architectures, which are highlighted in this chapter.

Chapter 5: **THE INTERNET AND OTHER CONTRIBUTING FACTORS**

5.1   **Introduction**

The review of the online systems, conducted to pursue greater understanding of the modern cadastral systems has identified several technological factors that have influenced, impacted and shaped geo-spatial online cadastral systems. Greater understanding of these factors is central in identifying future developments and outcomes of online systems. The first factor, which has the most profound impact on the online systems, is the Internet. The success of the Internet can be attributed to many factors but within the scope of this thesis, the success factors include the web and the scalability of the Internet.

The second factor is the advancement of the Internet technologies that have elevated the use and presentation of geo-spatial information beyond the realm of the standard HTML presentation. In addition, these technologies are also producing digital geo-spatial maps that have progressed beyond the static bitmap images used on the web, to vector maps that deliver interactive and dynamic results and responses in real-time.

The architecture of the Internet itself is being tampered with new architectures that promises the distribution of geo-processing across several machines over the Internet. The consequence of such architecture has so far been nothing short of remarkable. The architectures are also playing an important role in contributing towards the OGC-compliant specifications that will ensure future geo-spatial systems to be scalable and compatible for communication.

5.2   **The web**

The conception and popularity of the web has been the major contributing factor for the increased growth of the Internet. The web sometimes is known as the Internet but the need to highlight some basic design structures of the web and the contrast between the two is important to be distinguished. The web is made up of a client/server architecture that is based on several concepts that apply to various abstraction levels. These concepts are the Hypertext Transfer Protocol, the Hypertext Markup Language and the Uniform Resource Locator.

The Hypertext Transfer Protocol (HTTP) is basically used to send queries to a web-server and to transmit the query-result back from the server to the client. The ease of implementation together with the freely available specifications quickly led to the release of HTTP browsers (web browsers) and web servers for use on most platforms and operating systems.

The Hypertext Markup Language (HTML) is a language used to create hypertext documents that are platform-independent (operational on various types of operating systems). Most importantly, HTML allows embedded links called hyperlinks to be incorporated within images and text. Hyperlinks define the relationship between a text / image fragment and another document. The new document is retrieved when the user clicks on the hyperlink on the HTML document.

A Uniform Resource Locator (URL) is a compact name to represent a particular resource location on the Internet. A URL consists of a part identifying the method to be used to access the resource and the part containing the description of the resource (Vckovski, 1998). The use of URL as an identification mechanism in hyperlinks made the web a very successful integration technology. Users are able to retrieve documents via several retrieval methods such as HTTP, electronic mail, news or FTP by using the web browser. The retrieval method is almost transparent as hyperlinks are used to guide the user to the information.

The HTTP protocol, HTML documents and the URLs form the basis for the HTML success on the Internet. Almost any machine with operating systems capable enough of running network interfaces could support HTTP protocols, and are able to view HTML documents based on its URL address.

5.3 **Scalability**

The ability to scale is an important concept in the design of interoperable and distributed geo-spatial systems. To be able to scale, the system must be independent on the number of nodes or components that exist in the system, yet maintaining the exact manner on which the system is supposed to function. The Internet has proven that it is very scalable. Starting as a small network of universities in the United States, the Internet grew enormously to include millions of permanently or temporarily connected nodes at the same time (Vckovski, 1998). The basic underlying protocol – Transmission Control Protocol/ Internet Protocol (TCP/IP) that is used remains the same during this expansion. Such phenomenon is possible because of the addressing, routing and naming issues of the Internet.
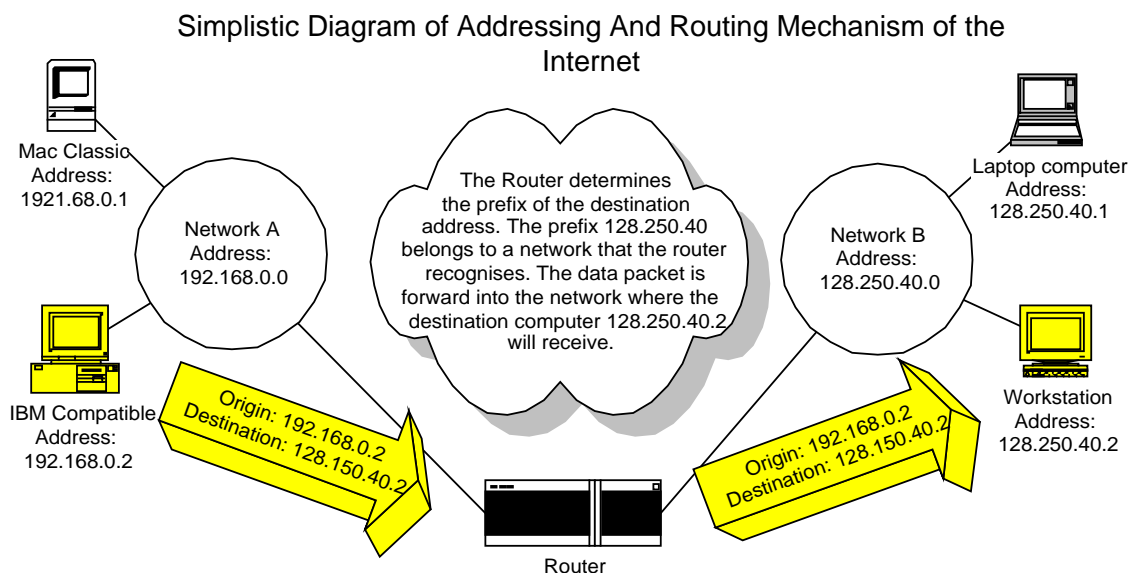
Figure 18: Address and Routing Mechanism of the Internet

The addressing issue of the Internet enables communication on the TCP/IP network to happen by transmitting data packets (IP Packets) between nodes. Each node has a unique address which is a 32-bit integer (IP Address). The data packets carry both the sender's and receiver's IP address and the payload of transmission.

There is no explicit routing information in every data packet to reach the destination system. The determination of a communication path between A to B is called a routing (WhatIS.com, 2000). In the TCP/IP network, routing is established by special nodes (routers), which connect two or more networks together (see Figure 18). Based on a previously programmed routing table, the router knows where the data packets should be forwarded. The routing table is based on a prefix-scheme similar to the routing in public telephone networks. It works by interpreting part of the destination address as the prefix for the network address. The remaining address defines the exact location of the destination host on the network.

The naming issues of the Internet allow access to resources in Internet networks based on IP-numbering systems. Access to IP-numbers usually takes place via a directory service that associates symbolic names with IP numbers. The naming system used is the Domain Name System (DNS). DNS allows a *n-to-n* mapping of IP numbers to symbolic names *i.e.* every IP-number may be assigned to several symbolic names and every name may be associated to several IP-numbers (Salamon, 2000). The design of the DNS was a result of the tremendous growth of the Internet and because it was no longer possible to manage the database of numbers and associated names in a single database. The same DNS name is also used for the management and resolution of electronic mail addresses. In this case, the part following the "@" character denotes the network or domain that the main was sent or destined for.

5.4   **Overcoming the limitations of HTML**

Hypertext Markup Language (HTML) is the de-facto language for producing documents on the web. Currently, HTML offers limited capabilities to geo-spatial users as it only allows raster format (bitmap) images, usually GIF and JPEG formats. Furthermore, HTML was not designed to include complex instructions for handling geo-referenced data, or a conglomerate of GIS functionality such as Zoom and Vector-based maps.

Therefore the industry is overcoming the limitations of HTML, and has progressed significantly in the past years with the introduction of Vector data plug-ins and web-based scripts.

5.4.1   **Plug-ins**

The lack of standards of the current HTML features and its inadequacies for vector image support have introduced many different approaches to managing vector image formats on the web.

One of the approaches is the use of plug-ins. Plug-ins are designed to extend the web browser functionality to support new data types such as vector images. Popular plug-ins available for free download includes Macromedia Shockwave, Autodesk MapGuide Viewer and ActiveCGM Browser (AutoDesk, 2000; InterCAP Graphics System, 1999; Macromedia, 1999).

The drawback of plug-ins is that the vector image can only be viewed through the browser, where the plug-in is located. Plug-ins have also known to interfere with the general operations of the browsers, and forces the use of specific browsers to view the images.

5.4.2   **Web-Based Scripting**

The problems of overcoming the limitations of HTML can also be resolved by utilising web-based scripting. As mentioned, plug-ins are inserted into web browsers to view the vector images on the web browser. Web-based scripts on the other hand, offer a different solution. Web-based scripts come in two types *i.e.*server-side scripts and client-side scripts.

Both types provide solutions that are specifically targeted at the changing client/server environment of the web.

5.4.2.1 **Server-side Scripting**

The codes that reside and execute on a web-server are termed server-side scripts. The most popular server-side script is the Common Gateway Interface (CGI). CGI allows back-end applications *e.g.* isolated databases, to talk to the Internet via the web-server. CGI has also been used to connect a web server with GIS servers with the help of a gateway. The gateway will manage all requests and replies from the users and GIS servers. The Gateway works by parsing queries from users into a format that the GIS servers understand. Replies from the GIS servers will be arranged into HTML documents for the web server to deliver. Most importantly, the growth of web databases has escalated since web developers are able to link storage of databases using CGI. CGI has also been used widely to deliver geo-spatial data across the Internet. However, the delivery of geo-spatial data has been as static files of data and images. Vector-based maps could also be used but only as files, not as maps.
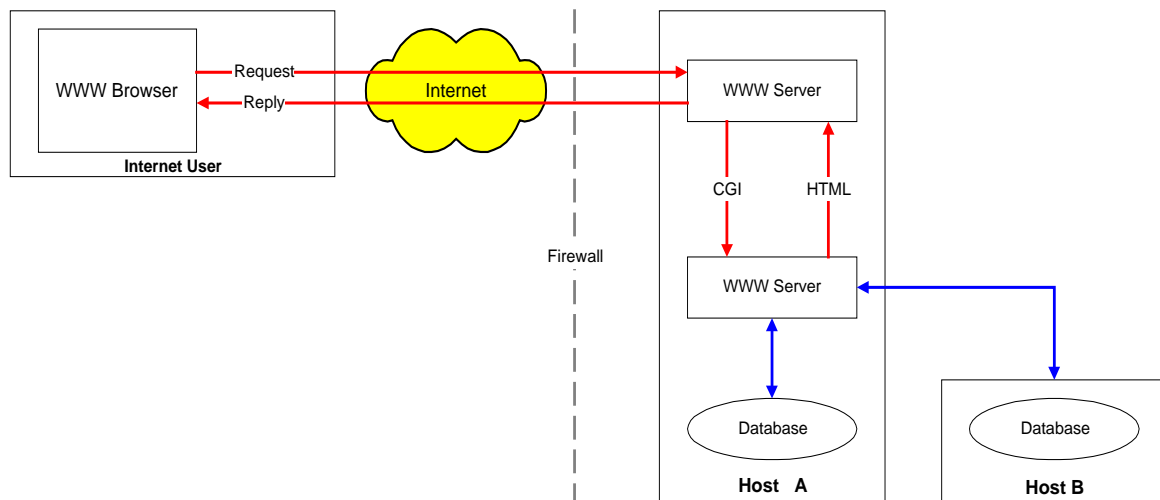

Figure 19: Schematic data-flow of the Common Gateway Interface (CGI)

The disadvantage, however, is the amount of server time and resource consumed to manage user requests. In a MPC environment where the servers are expected to handle thousands of requests per day, server resources are critical factors in determining response time.

Server-side scripts have been used to generate interactive maps. As users send out a request for maps, the web-server will divert the request to the server-side script responsible for the requests. For most server-side scripts to generate maps in return, user requests will usually include the coordinates of the four corners of the web-browser window or some predefined area of the map. The server-side script then *cuts* the map according to the viewing areas and delivers the map down the Internet and waits for acknowledgement from the user browser.

Figure 20: VicMap Display utilising server-side scripts to produce dynamic maps

Examples of server-side scripts used in the production of geo-spatial data online includes the digital cadastral data from VicMap Display (http://www.land.vic.gov.au) and the ICMISS project by Social Online (http://www.socialonline.com.au).

5.4.2.2 **Client-Side Scripting**

Codes that are embedded in HTML documents, downloaded by the web browser and executed or interpreted on the user machine are called client-side scripts. Client-side scripts enhance the web experience by delivering server applications and functions right down the Internet to the user desktop. The advantage of this arrangement is that

applications can be written and operated on almost any operating systems, *e.g.* Linux or Windows, and processor architectures *e.g.* Intel or Motorola. Client-side scripts also utilise minimal bandwidth as applications and scripts are executed on the client desktop. Furthermore, with the processor and computing power of desktop computers increasing, client-side scripts are maximising server performance by reducing processor intensive routines from the web-server.

Examples of client-side scripts include JavaScript, VBScript, Java and ActiveX. Java is a programming language developed by Sun Microsystems that is portable across operating system platforms. JavaScript and VBScripts on the other hand, were developed to address the limitations of HTML in addressing customisable web documents and database access and functionality. Nowadays, Javascript is used extensively to add navigation buttons, scrolling banners and simple querying of GIS data to otherwise static images and texts on a web documents. Both JavaScript and VBScript are being used in conjunction with HTML to include executable programs and functions to the user. JavaScript and VBScript have also allowed greater control and expandability of GIS data on the web.

ActiveX is a product from Microsoft in a bid to facilitate the execution of applications within a web-browser. ActiveX, however, is not portable across platforms but through the ActiveX technology, GIS and other functionality that are served by the web server can now be executed on the web browser.

ESRI's ArcExplorer HTML is an example of a simple GIS application that utilises a combination of client-side scripts, and runs on the user machine. Figure 21 illustrates the use of ArcExplorer HTML in the MPC prototype developed for this research thesis (http://128.250.171.204).
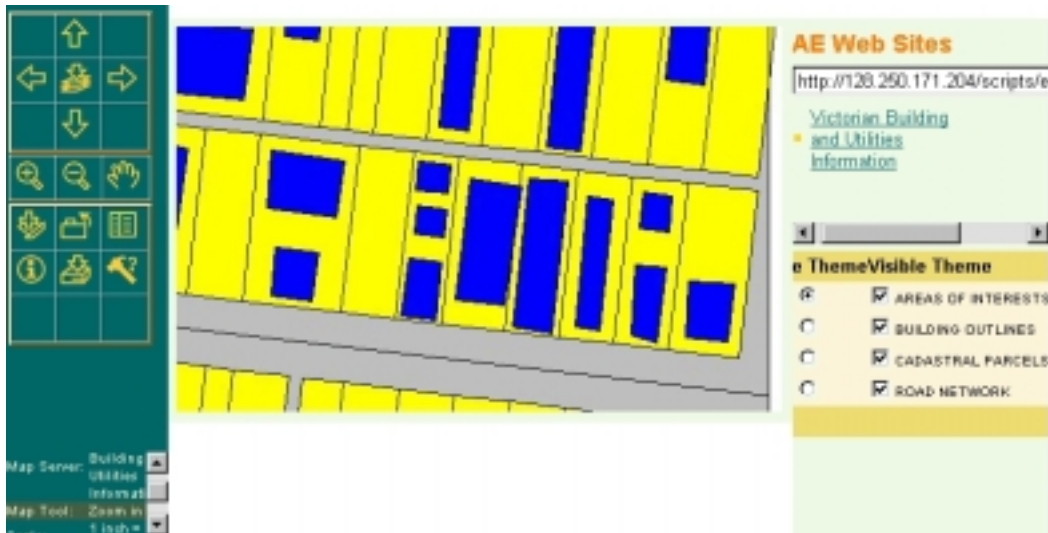
Figure 21: An example of a client-side application from ESRI – ArcExplorer HTML

5.5 Maps on the web

The web has provided a number of choices to deploy maps over the web. Most of the reviewed systems utilise several methods of delivering maps across the web. The choice depends on the purpose of the map, the amount of Internet bandwidth available to the user and the applications to deploy the maps. This section will describe the various types of map delivery that have been used on the web.

5.5.1 Static Maps

Static maps are the easiest method of online map publishing. Static maps are adequate to show the location of a particular area, without the need to frequently update the maps. If an update is needed, the whole map piece is replaced with a newer map. Static maps are produced from scanned or digitally produced maps.

In terms of complexity, static maps are the easiest to maintain, requiring minimal technical programming expertise. On the other hand, static maps are often not replaced regularly but expected to be of higher screen resolution with greater cartographic detail. As a result, static maps are commonly large in size (more than 100 kilobytes) in size which consumes considerable time to download. However static maps require very little browser and server resources to be viewed. An example of static maps includes figure 22 of a static map generated by the Youth Hostels of Australia (http://www.yha.com.au).

Figure 22: A static map developed by the Youth Hostels of Australia

5.5.2 **Dynamic maps**

Dynamic maps were created as a solution for greater mapping capabilities and emphasis on latest details. Dynamic maps are usually used to show a gradual change of information that cannot be shown easily on static maps without requiring tedious cartographic updates and changes. When needed, dynamic maps are refreshed over the web with newer dynamic maps that are either generated beforehand or generated *in real-time.*

Typically, the digital and cartographic representations of dynamic maps are similar to that of static maps but with less emphasis on screen resolution, image quality and cartographic detail. The file size of dynamic maps is smaller compared to static maps, commonly less than 50 kilobytes to ease the transfer over the web. Examples of dynamic maps includes the residential maps produced online by Telstra's WhereIS (see Figure 23) (http://www.whereis.com.au) and the lightning tracking service by Florida Media Communication (http://www.flamedia.com/lightning/light.htm)

Figure 23: Example of a dynamic map from WhereIS.com

5.5.3 **Interactive maps**

The latest, and increasingly the most popular, type of map delivered over the web are the interactive maps. An interactive map is usually a map that is generated based on distributed processing architecture of back-end database systems and mapping applications that integrate map layers and textual information together. Commonly, these systems facilitate a web-interface that allows the users to input map queries on specific maps themes and

layers. The system will then return reproduced maps drawn either on the size of the browser window or specific size and scale as requested by the user.

Interactive maps are hailed as the most advanced form of map reproduction and are catered specifically for use over the web. The size, usually limited to no more than 50 KB, allows speedy delivery speed. It also facilitates the need of users to regularly request newer interactive maps as the focus or emphasis of map themes or features changes while viewing the maps.

Examples of interactive maps include the maps of the Australian World Wide Web Mapping Consortium Test-Bed – http://www.auslig.gov.au (AUSLIG, 2000) and the maps produced from the MPC prototype (http://128.250.171.204) - see Figure 24.

Figure 24: Example of an interactive map taken from the MPC prototype

5.6   **Towards Distributed Processing Architectures**

From technological point of view, the MPC is simplistically a collection of geo-spatial information databases spread over several government agencies but connected by web-based technologies. The notion of spreading databases across governmental agencies actually originated from the roles each government agency plays in handling specific tasks for the government. As tasks and responsibilities increase, access and security become an issue when government agencies require data located in another government agency databases.

Even through Internet and the web, there still remain the technological issues that determine the effectiveness of sharing data across government databases. These technologies take the form of distributed processing architectures where the traditional client/server environment of the Internet is further extended to include processing components that are distributed across organisations. The term architecture defines how pieces of an organisation's computing system work together.

The architecture does not refer to how an individual process happens but where this process fits in relation to the rest of the system, application or product. Microsoft defines Distributed Processing as:

> *"a form of information processing in which work is performed by separate computers that are linked through a communications network"*
>
> (Microsoft® Encarta® Online Encyclopedia 2000, 2000)

Together, Distributed Processing Architectures can be categorised into groups of multiple-tier architectures, where each tier is responsible for specific tasks within the architecture. (I-Kinetics, 2000) explained that Distributed Processing Architectures can be categorised as below:

- 2-tier architecture. Presentation, application logic, and data are distributed between client and server, and connected across the network. The 2-tier architecture harnesses the power of multiple systems and supports greater functionality, but it can be complex and costly to scale and change because the three key areas of functionality must be forced into two platforms.

- 3-tier architecture. Presentation, application logic, and data are distributed across three levels interconnected across the network. The common benefit is that 3-tier architecture enables scalability and flexibility. The frequent disadvantage is that 3-tier architecture implementations can result in increased complexity in coordinating and managing if many different languages, middleware solutions, applications and operating systems are required.

Currently, these architectures are being used to address the requirements for sharing and distributing geo-spatial information over the web. In recent times, several commercial and experimental architectures that offer solutions utilising Distributed Processing Architectures are being tested on the web. It is anticipated that the deployment of a future MPC will be based around these architectures. The following is a list of distributed processing architectures that are used on the web.

- ActiveX – DCOM

- Java – RMI

- Java – IIOP (CORBA)

- HTML – HTTP

The following sections will describe the major features of these architectures.

5.6.1 **ActiveX – DCOM**

The origin of the ActiveX model comes from the OLE (Object Linking and Embedding) concept introduced by Microsoft. OLE –2 later introduced the COM (Component Object Model). COM is the basis for inter-software interaction in most of Microsoft's programming environment. Example of common OLE / COM is the ability to copy a piece of text from a Microsoft product, say Microsoft Word into another Microsoft product, say Microsoft Excel. DCOM (Distributed COM) is only an enhancement, which introduces the concept of physical separation of the object model. The implication of DCOM is the ability to distribute components between various computers. As long as a platform supports COM services, DCOM can be used on that platform. DCOM is now heavily used on the Windows platform.

5.6.2 **Java RMI**

 A Java/RMI client acquires an object reference to a Java/RMI server object by doing a lookup for a Server Object reference and invokes methods on the Server Object as if the Java/RMI server object resided in the user's address space. Java/RMI server objects are named using URLs and for a user to acquire a server object reference, it should specify the URL of the server object (see Figure 25). Since Java/RMI relies on Java, it can be used on diverse operating system platforms from mainframes to wireless devices as long as there is a Java Virtual Machine (JVM) implementation for that platform.
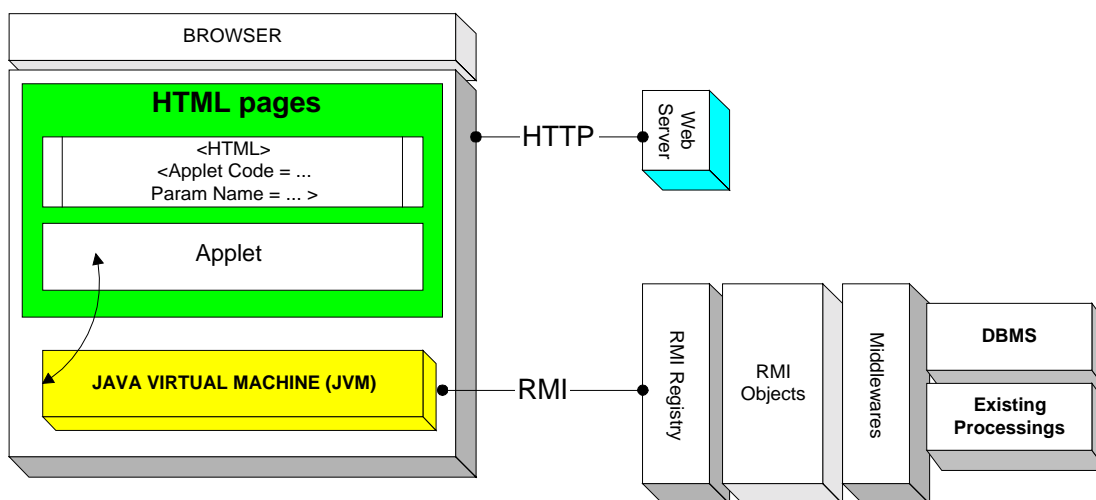

Figure 25: Java-RMI Architecture

RMI (Remote Method Invocation) provides a communication infrastructure for Java applications or applets. RMI is a middleware and is totally linked to Java. The architecture is based on *stubs and skeletons.* The stub, loaded on the user machine, plays the role of the server's proxy. Therefore, a remote method call is performed through the stub and the server's location is made transparent to the developer. The server-side counterpart of the stub is the skeleton, which behaves like a client for the server.

5.6.3   **Java – IIOP (CORBA)**

CORBA (Common Object Request Broker Architecture) is a specification that was developed to facilitate the distributed object environment. CORBA is still in its infant stage with some software developers implementing their own CORBA ORB (Object Request Broker Architecture). However, the internal operations of each of the ORBS are proprietary. The role of the IIOP (Internet Inter ORB Protocol) is to allow communication between these various ORBS.

As shown in Figure 26, each of the computers involved in a CORBA application will have to run an ORB. For the servers, the installation is the same for any piece of standard software. For the users, one may choose between a traditional installation or the unloading of the ORB client through an applet during each application initialisation.
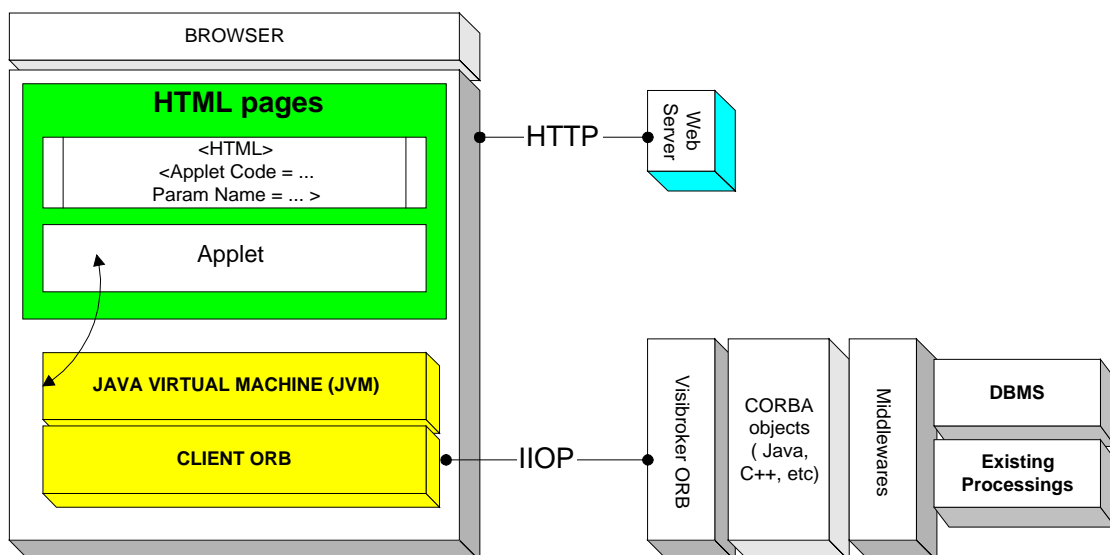

Figure 26: CORBA Architecture

Similar to RMI and DCOM, the communication architecture between objects is based on the principle of stubs and skeletons (or proxy and stub in DCOM terminology). The stub is loaded on the user machine and plays the role of the server's proxy (see Figure 27). Again, similar to RMI, a remote method call goes through the stub and the server's location is made transparent to the developer. The server-side counterpart of the stub is the skeleton which behaves like a client to the server.
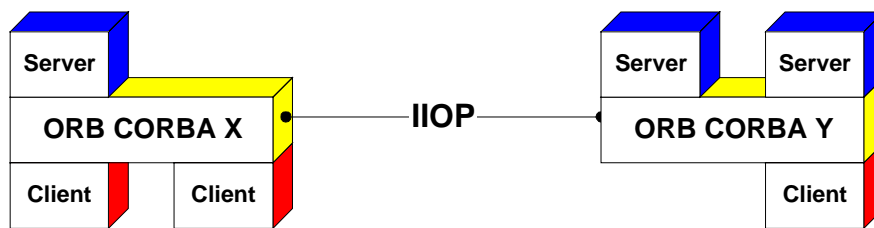

Figure 27: CORBA Object Request Broker Architecture

5.6.4 **HTML – HTTP**

In its simplest form, the web is characterised by the presence of a web server, a browser to interpret the HTML pages and the HTTP communication protocol.
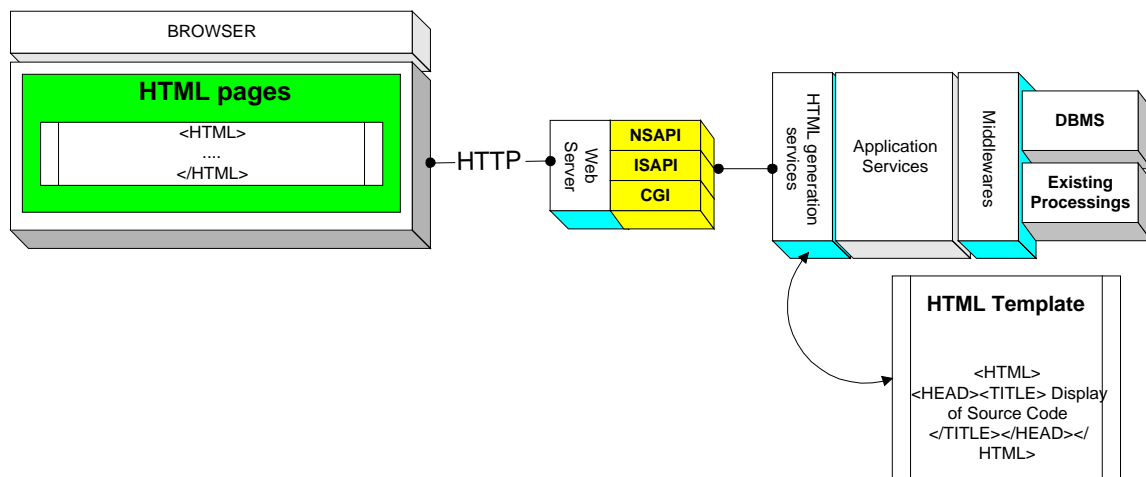

Figure 28: HTTP / HTML Architecture

The browser relies on the HTTP protocol to communicate with the servers. This communication protocol is simple and is implemented over TCP/IP. The HTTP communication protocol operates in disconnected mode: the browser is only connected to the server during page download. Once the download is completed, the browser will disconnect itself from the server. This principle allows savings of network bandwidth and costs.

A web/HTML application is based on dynamic pages. The dynamic pages (applications) are called through a gateway. The result cannot be anything other than HTML page (unlike ActiveX-DCOM where event-driven interfaces are brought to the client machine). The way web/HTML application obtains the result depends on the HTTP server and the development tool used. The applications may be called via the following gateways:

- CGI (Common Gateway Interface)
- ISAPI (Internet Server Application Programming Interface)
- NSAPI (Netscape Server Application Programming Interface)
- WRBAPI (Oracle Web Request Broker Application Programming Interface)

The main asset of the CGI gateway is its portability. All HTTP servers are able to run CGI modules. These executable modules are loaded in the server's memory while the application server is generating the page.

The NSAPI and ISAPI gateways (the HTTP-Server API of Netscape and Microsoft) operate similarly to CGI but are actually libraries (DLL on Windows Platforms), which take up less resources and are loaded directly on the server's memory. Therefore, the library's code is loaded in the memory once. However, the only drawback is that the NSAPI and ISAPI gateways operate on HTTP server from Netscape and Microsoft respectively.

5.7   **Chapter Summary**

This chapter features one of the two knowledge flow of the Information Technology concepts used in this thesis (see Figure 29). One of the biggest technological factors is the availability of the Internet and the web. The Internet and the web are often loosely used to represent the digital information world that has existed in the past several years. Contributing factors such as scalability and openness that have popularised the Internet and the web were described in some detail in the early parts of this chapter.

The web has also been regarded as large digital libraries, with images and text being widely used to represent valuable resources and information for the world to view and retrieve. Newly developed technologies such as the client-side scripts have been introduced that permit the combination of images, text and dynamically generated maps over the web. More importantly however, are the effects of these technologies on the changing nature of online maps, be it cadastral or weather maps.

More profound is the growing development of distributed processing architectures on which several of the reviewed online cadastral systems were built. These architectures have permitted greater geo-spatial information connectivity across the web by promoting the use advanced client/server interactions between the web environment and databases. Together with web-based scripts, these architectures are becoming more prominent in the delivery of GIS tools and subsequently geo-spatial information across the web.
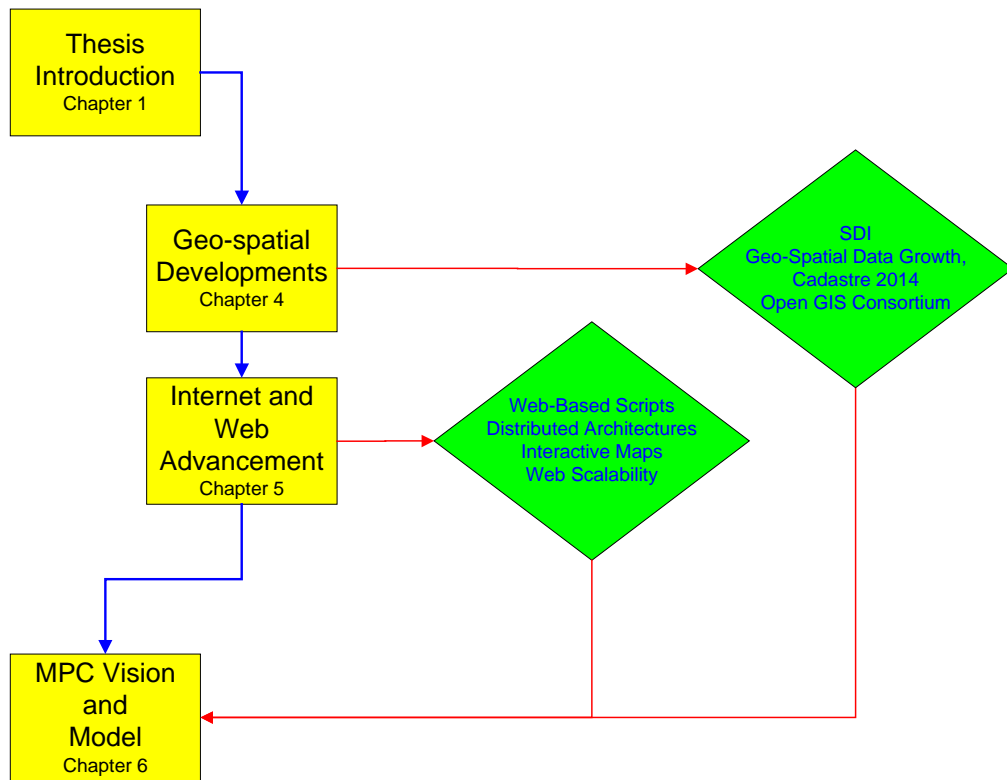
Figure 29: Knowledge flow of the Information Technology concepts used in this thesis

Chapter 6

Merging the Multi-Purpose Cadastre and the web

This chapter discusses the MPC prototype model that was developed based on the understanding of the MPC concepts and the convergence of Information Technologies and recent geo-spatial information developments around the world.

An appreciation of the prototype uniqueness when compared to other similar systems such as metadata engines and web-based GIS systems, is highlighted. The benefits and features of the model are also discussed.

Chapter 6: **MERGING THE MULTI-PURPOSE CADASTRE AND THE WEB**

6.1 **Introduction**

This chapter expands the understanding of the dissemination of parcel-based geo-spatial information, especially the awareness of online systems, its development issues, problems and limitations.

Online geo-spatial systems are usually developed from the amalgamation of cadastral maps and the associated registers of modern cadastral systems. Both of these entities represent the graphical and the textual components of these systems. However, with the modern cadastral systems continually evolving to meet the demands of the land market, other geo-spatial information resources containing information such as the planning control and the land-value assessment are being progressively added. Together with the geodetic, topographic and road networks, the modern cadastral system is evolving and becoming a MPC that provides crucial and overall information relating to land.

The merging of the MPC concept and the web is not unique, and has been developed by governments around the world. This was demonstrated in Chapter 3, where the review highlighted the evolution of current geo-spatial systems towards the MPC concept. However, it is important to outline that this evolution did not transpire overnight, but it was through various pressures and factors, but mainly from the two discrete knowledge streams that have been encapsulated in this thesis. This chapter is aimed at describing the fusion of these two streams and the resulting models and prototype that were used to address the development of a MPC prototype.

6.2 **The merging of the MPC and the web**

A step towards the future has been the adaptation of the web by geo-spatial systems, as the medium of integration, dissemination and presentation of geo-spatial information. As a result, the web has allowed the aggregation of the cadastral systems with other registers seamlessly. Already, projects and researchers are utilising the web to integrate geo-spatial data from diverse sources, satellite imaging, monitoring instruments and GPS receivers for better geo-spatial temporal analysis.

Table 5: Similarities between the vision of Cadastre 2014 and trends of reviewed systems.

Cadastre 2014 Key Statements	Features of Systems
The MPC will show the complete legal situation of land, including its right, restrictions and responsibility.	Coming together of databases and overlaying of data themes facilitate the complete view and understanding of the situation of the land.
The separation between the maps and the registers will be abolished.	Map and web servers allow distributed databases to be connected and presented seamlessly to Internet users.
The paper and pencil cadastre will have gone.	Digital recording of coordinates in field-work and directly feeding into computer databases for geo-spatial processing contributes to development of the cadastre.
Cadastre 2014 will be based on cost recovery.	Electronic-Commerce technology is being used to generate revenue for maintenance of online systems and data.

The comparisons of the twelve online cadastral systems have led to the resolution that aspects of the MPC are evolving in these systems (Abdul Majid *et al.*, 1999). Certainly, each of the systems is unique but the obvious trend is that these features are moving towards the Cadastre 2014 vision. This is shown in Table 5 where similarities between key features of Cadastre 2014 and those of the reviewed online cadastral systems are highlighted. The similarities are generally attributed to the possibilities provided by Internet and the global geo-spatial information trends that are encouraging the creation of integrated geo-spatial information. This also gives rise to the proposal of a prototype for visualising the concept of a MPC with particular emphasis in understanding its development issues and problems.

6.3   **The prototype model**

Most governmental initiatives in developing online geo-spatial systems can be represented by the model in Figure 30. The model outlines the current geo-spatial environment, where geo-spatial systems are being built to cater for the demands of specific professions and industries with geo-spatial data to suit their particular needs. As a result, most geo-spatial systems tend to be data specific, with specialised tools, and limited scope of data available to the users. To gather sufficient evidence and materials on a parcel situation, the public is then forced to use these isolated systems by learning and familiarising the different environments, requirements, limitations and the tools that exist in each system. More often than not, the public is still faced with a segregated geo-spatial information environment.

To remedy the situation, the MPC prototype was developed. The progression towards the conception of the prototype followed a distinct path, which has been described throughout in this thesis (see Figure 1). The prototype represents an amalgamation of the two discrete knowledge base encapsulated throughout this thesis *i.e.* the MPC concept and its advancements toward online systems, and the trends and developments of global geo-spatial information environment and Information Technology.

The prototype was developed according to a model devised from the fusion of the two knowledge streams. The model (Figure 31) focuses on the delivery of geo-spatial data from

disparate databases, through the implementation of map servers, web servers and the web, for the identification and amalgamation of the complex rights, restrictions and responsibilities that exist on land, within a common environment. Through the prototype, the emerging acceptance of online resources as digital libraries, plays an important role in the popularisation of geo-spatial data, especially parcel-based cadastral data from across the web. The prototype moves away from the common centralised architecture paradigm where the computer is merely a non-intelligent terminal accessing a mainframe to the notion of the computers as integral component of a distributed computing environment.

The specifications for the data, hardware and web environment, used in the development of this prototype is detailed in Chapter 7.
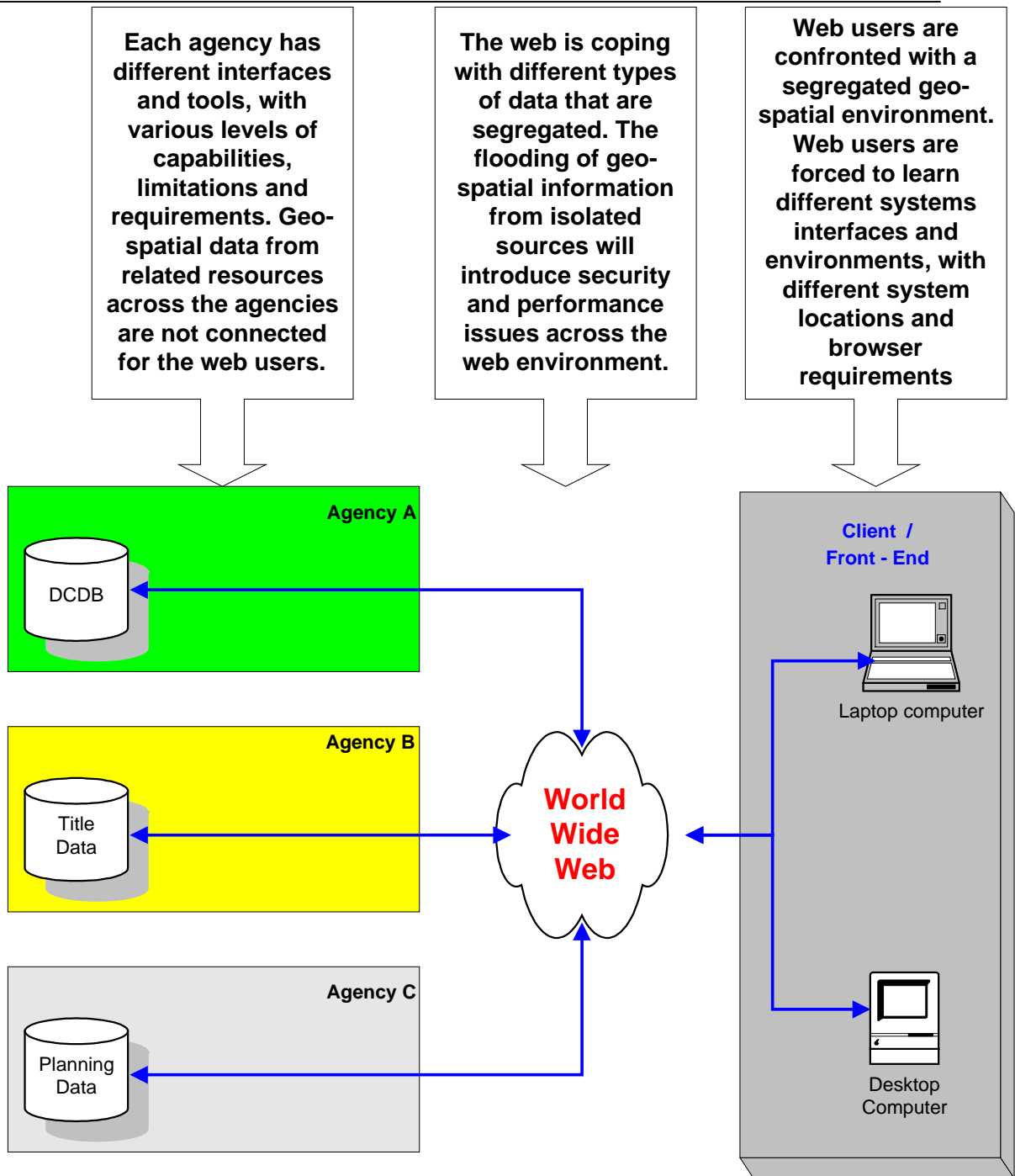
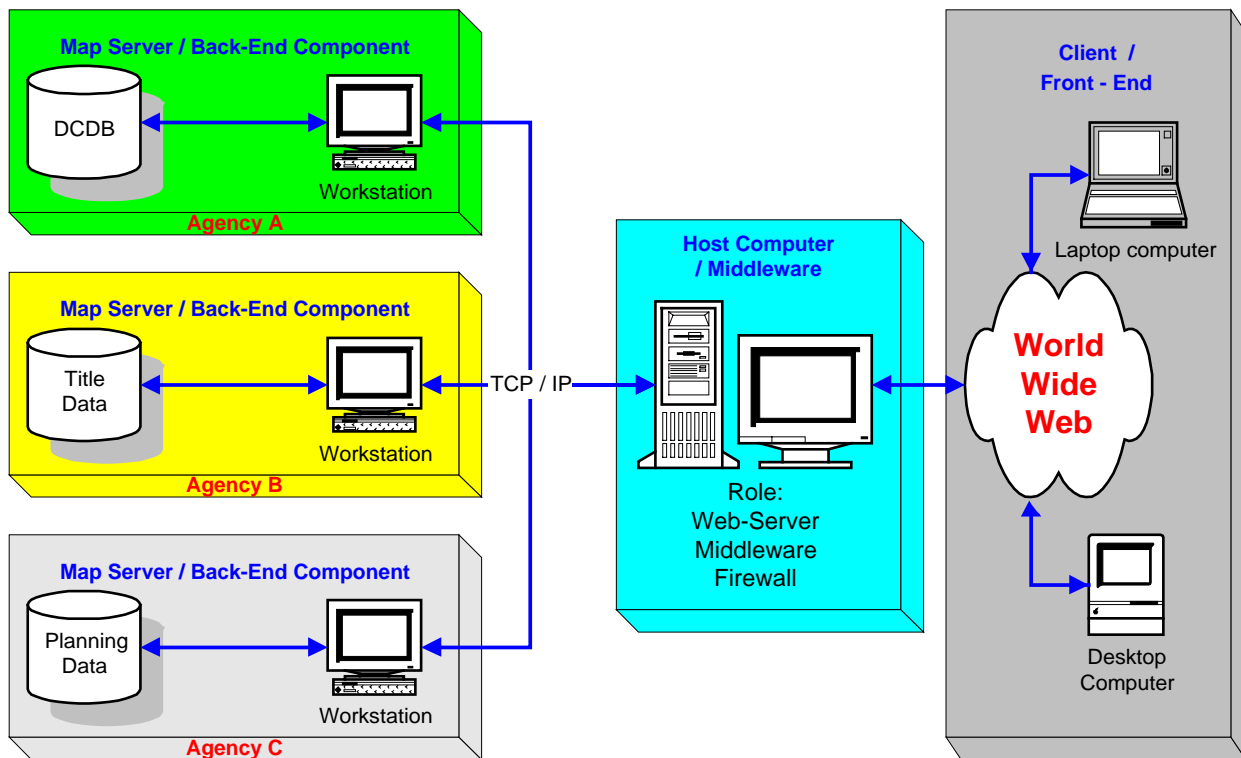Figure 30: Current segregated online geo-spatial information environment

Figure 31: The prototype model

The prototype is designed to allow the aggregation of the cadastral system with other registers seamlessly. This is accomplished through the use of the middleware component, where the web server and a proprietary three-tier distributed processing architecture are combined to respond and reply to user requests. The prototype has also made the aggregation attractive and simplistic. This is because the prototype allows the back-end components and the databases, to be completely controlled by the data provider, hence promoting control over the data and resolving data custodianship issues.

6.4   **Objective for a MPC prototype**

One of the objectives of this research thesis was to set out and discover the developments of web-enabled or online cadastral and title registration systems that use the web as the medium of integration and delivery. This was achieved by conducting a review of twelve government initiatives in developing online geo-spatial systems with the outcomes documented in Chapter 3 of this thesis. The review proved that most of these systems rely heavily on the web to perform numerous functions for the public. A significant achievement of most of the systems has to be the sophisticated yet seamless integration of the cadastre and other land-related registers. In most cases, the cadastre and these registers do not reside in the same database or agency, but are disparately distributed across governmental agencies. In addition, Chapter 3 of this thesis revealed that the information gathered from the review was consistent with worldwide trends towards better geo-spatial information management. A notable catalyst has to be the explosion of the Internet and the web. Recent statistics show that 40 percent of the Australian population are now capable of hooking up to the Internet (Roy Morgan Research, 2000). Tools and techniques such as Global Positioning Systems and remote sensing, have also accelerated the growth and volume of geo-spatial data. Not withstanding, international and governmental bodies are also pushing forward agendas and commitments for a uniform and consistent manner of handling geo-spatial information. These include:

- the *Cadastre 2014 – Vision for the Future* and the *Bogor Declaration* by the International Federation of Surveyors (FIG, 1996; Kaufman *et al.*, 1998);
- common geo-spatial products and data specifications from the Open GIS Consortium (Open GIS Consortium, 2000);
- and spatial data infrastructure and web initiatives such as the Australian Spatial Data Directory and the Australian World Wide Web Mapping Consortium (ANZLIC, 1999; AUSLIG, 2000).

The second objective of this thesis was to understand the use of current computing, communication and processing technologies with considerable inclination towards better geo-spatial information handling. It was found that the many of the current innovations and advancements are capable of being migrated onto the development of the MPC. Chapter 4 of this thesis further elaborates by describing the progression of map delivery on the web, when static maps were initially used on the web. But considerable improvements in areas such as web-based scripting and plug-ins, have enabled dynamic and interactive maps to be generated in real-time by many geo-spatial software packages. In addition, Chapter 4.5 demonstrates that the computing environment is also going through a paradigm shift. The web is significantly being used and tested by newly developed distributed computing architectures that harness the browser / web server interaction. Together with web-scripts and plug-ins, distributed computing architectures are allowing applications, databases and map generating engines to be used on top of the browser / web server technology.

The third objective of this thesis concerned the technical understanding of building a MPC. The essential understanding of building the MPC was substantiated by the review thus providing the foundation for the technical understanding of the working, structures and operations of the reviewed systems. Further knowledge was supported by the exposure of online map delivery techniques and distributed computing architectures. To put all of the knowledge into practice, a working prototype of a MPC was needed. This was progressively achieved throughout the duration of this thesis. The details of the development, functions and product of the MPC prototype are elaborately discussed in Chapter 7.

6.5   **Differences between the MPC prototype, Metadata Engines and Web-Based GIS**

An important distinction that should be recognised is that the prototype is not aimed at replacing similar applications such as the Metadata Engines and the web-Based GIS systems. Metadata engines and web-based GIS systems are equally crucial in promoting and delivering geo-spatial information, especially on the web environment. Each one of these applications serves unique and specific purposes on the web.

Metadata Engines are applications that exist primarily to search and retrieve metadata from disparate metadata databases. Metadata helps users to ascertain the best use of the data obtained. Usually, there exist some applications that the data is well suited for and others for which it should never be expected to be used or applied. The creation of the metadata itself is governed by standards that are extensive with specifications for exact elements that should or should not be included. An example of a metadata creation standard used is the Content Standard for Digital Geospatial Metadata (CSDGM) from the U.S. Federal Geographic Data Committee (FGDC) (FGDC, 2000).

Because of the thousands of data sets being produced, there exists metadata databases that lists the metadata and the address at which the data can be obtained. As these metadata databases are updated with newer information each day, the size and complexity of the databases warrants dedicated applications such as Metadata Engines to search and retrieve the relevant metadata information based on the user filters and queries. A prominent example is the National Spatial Data Clearinghouse, one of the primary arms of the National Spatial Data Infrastructure of the U.S (Phillips, 1998).

Figure 32 illustrates a metadata engine prototype developed in the Department of Geomatics of the University of Melbourne, that allows web users to enter the desired criteria into a query form on the web browser (Phillips, 1998). The form is sent to the clearinghouse server, where the query is forwarded to all registered database servers using the Z39.50 protocol for database searches. Each of the servers processes the query against

its own database, returning the matching metadata records to the clearinghouse. The clearinghouse server collates and formats the results into HTML and returns the results back to the user.
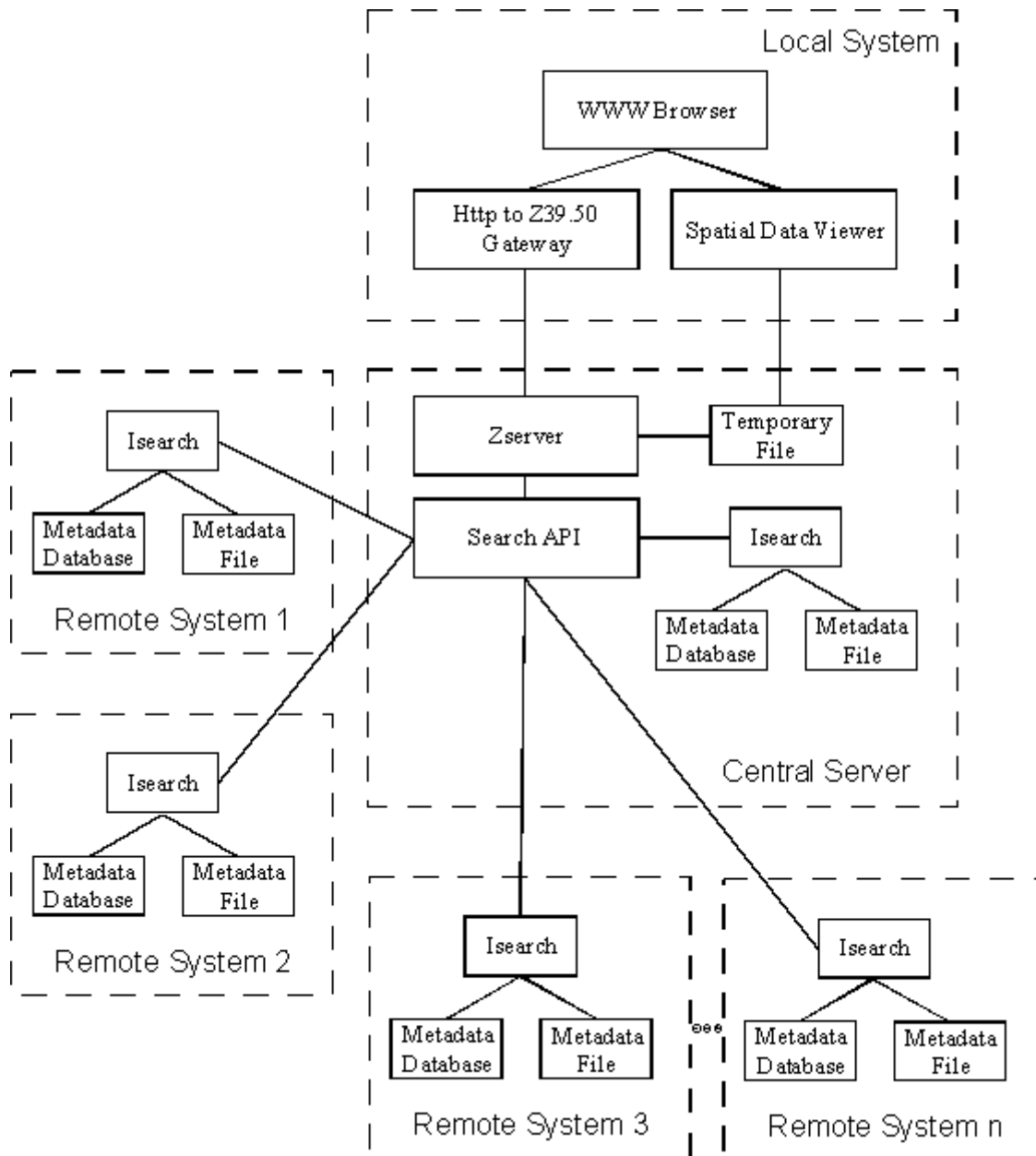

Figure 32: Example of a metadata engine (Phillips, 1998)

The important distinction between the MPC prototype and web-based GIS applications should also be understood. Web-based GIS is an extension of the traditional desktop GIS, with added capability to publish the map and thematic queries straight on the web. Web-based GIS also provides GIS core functions such as network and spatial analysis.

Currently, web-based GIS applications provide users with an interface to perform various queries and analysis against GIS databases on the web (Plewe, 1997). Most web-based GIS require the use of specialised components that are appended into standard desktop GIS software. These components facilitate the conversion between proprietary GIS formats and web-recognised formats, with the appropriate channeling of GIS results through the web server. Figure 33 illustrates the concept of ESRI's web-based GIS system: ArcView Internet Map Server. The product utilises the popular ArcView GIS software by adding libraries of components that allows ArcView to create and display digital bitmap maps through the web server. The disadvantage however, is the requirement for the GIS software to be running at all times during the use of the web-based GIS.
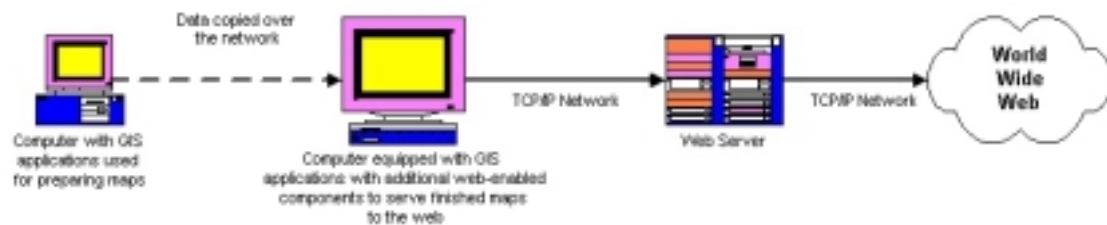

Figure 33: Structure of a web-based GIS (ESRI, 1997)

The running of the MPC prototype would be greatly enhanced if it could incorporate web-based GIS and metadata engines. Table 6 outlines a comparison between the MPC prototype, the metadata engine and a web-based GIS system. It can be seen from the table that web-based GIS systems provide the facilities to perform GIS operations and geo-processing over the web. Therefore, the incorporation of the MPC prototype with a web-based GIS will allow geo-spatial information users the tools to not only view and retrieve geo-spatial data over the web, but also perform specific GIS operations such as network analysis and buffering through the web. On the other hand, incorporating the MPC prototype with a metadata engine would further connect geo-spatial information resources that are isolated but searchable using existing metadata attributes. The user could further locate isolated data and themes from metadata directories, and using the metadata retrieving protocols such as the Z39.50, the user could attach crucial metadata information to the already integrated geo-spatial information from the MPC prototype.

However, it should be recognised that, within the time frame and context of this research thesis, the blending of the three systems was not possible but could be pursued through similar research efforts.

Table 6:Comparison between the MPC prototype, Metadata Engines and Web-Based GIS Systems

Features	MPC Prototype	Metadata Engine	Web-Based GIS
Integration of data from distributed resources	Yes	No	No
Querying data at distributed resources	No	Yes	No
Visualising geo-spatial data *i.e.* cadastral layer and planning information	Yes	No	Yes
Locate data based on metadata	No	Yes	No
Retrieve data sets based on metadata	No	Yes	No
GIS features such as Buffering and Network Analysis	No	No	Yes
Update live information through the web	Yes	No	Yes
Visualising features such as Pan and Zoom	Yes	No	Yes
Development based on International Standards	Open GIS	CSDGM, ANZLIC	No

6.6   **Prototype Features**

The separations between the cadastre and other geo-spatial databases and registers are a hindrance to the flow of data between the government agencies and the users that use them. Therefore, the MPC concept stresses the importance of removing the separations to facilitate an efficient cadastral system that shows the complete legal situation of land, including the related rights, restrictions and responsibilities (Kaufman *et al.*, 1998).

With that in mind, the MPC prototype was developed to understand the Cadastre 2014 concept. The prototype is also envisage to investigate the proposal by Jones *et al.* (1999) that stated:

> *"Public interests are often administered by a myriad of public bodies. Increasingly, there will be a demand for a single source of (or gateway to) all geo-spatial. A future cadastral system will need to satisfy this demand"*
>
> (Jones *et al.*, 1999)

It is important to understand the process of building a single source of geo-spatial information for the public. The process begins with land alienated by the land surveyor and is given a unique parcel identifier in the land registration process and the creation of the cadastral map. The parcel identifier may be numerical or alphanumeric in nature but its uniqueness is critical. This identifier will serve as the linkage between the title register, the cadastral map and other geo-spatial components.

The identifier will also be the basis for linking the databases in the prototype. These will be based on the notion that databases in separate government agencies will be mirrored and scaled using personal computers residing on a Local Area Network (Abdul Majid *et al.*, 1999). For the prototype, the sample data will be taken from the planning, title, cadastral and valuation agencies, and several assumptions were made and adopted to facilitate the database and prototype creation. These assumptions are described in Chapter 7.4.

Each of these data will be hosted by personal computers (each simulating a government database and gateway) running map servers to handle requests from users. The host will be equipped with a web server and serves as the front-end to the web. The host represents the gateway to the prototype and is identified by an URL address. The host will also keep track of the unique URL addresses of the other map servers. Security measures such as the firewall are installed in the host computer to prevent unauthorised access from the web. See Chapter 7.12 for further explanations on prototype security issues.

6.7   **Benefits of the prototype**

Current distributed computing trends and the wide adoption of the Internet have profoundly affected the nature of information processing and delivery today. In recent years, the introduction of new computing architectures have relied heavily on the Component Object Model (COM) structure, where applications subsequently are built on the multiple distributed processing architecture (see Chapter 5.6). The MPC prototype was developed based on a multiple distributed processing architecture that has several advantages over the traditional client/server architecture of the Internet.

The front-end of the MPC prototype interacts with the web users and promotes the use of an online gateway, which in return, provides web users with data from government agencies which are physically distributed in nature. The user is presented with an interface, which presents itself as a gateway to centralised databases. As a result, there will be a perception of data being retrieved and integrated from centralised resources. The front-end can also be designed to represent a portal site where online systems can be grouped together and deliver geo-spatial information through a common environment.

The back-end of the prototype consists of databases that are distributed across government agencies. The databases are connected to the central retrieval servers (known as middlewares) using the Internet's TCP/IP networks. Within the middleware, central servers will act as retrieval mechanisms for retrieving data from the distributed databases. The server is assumed to have established the communication protocols (TCP/IP) needed to communicate with each distributed database in an unambiguous manner. The middleware, however, is not concerned with the updating, upgrading or any form of maintenance of the database as the databases reside in the respective agencies. This configuration introduces advantages such as:

- Abolishes the major issues of data custodianship *i.e.* who is responsible for the data. Since the data used is gathered from databases of the providing agencies, these agencies will remain the respective custodians of the data in their databases.

- Since the data residing in the databases are the responsibility of the providing agencies as the respective owners, any upgrading, updating and maintenance will be the respective agencies' onus.

- By proposing the distributed database architecture, the client is always ensured of using the latest versions and updates of the data since the data itself originates from the data provider. This is in contrast to having data stored in a large and centralised database, where extra efforts are required from either the data providers or the centralised database maintainer to update the database periodically.

- The back-end component will retrieve the data by issuing commands to the database servers for a copy of the data. Since the data being used by the user is a copy of the original, data quality and integrity remains the same in each of the databases. Firewalls will ensure that the users will not be able to directly manipulate the data beyond their Internet browsers (see Figure 29).

Other benefits of the prototype include:

The prototype will promote the combination of geo-spatial data and data layers from several agencies across governments as the prototype hides the multiple, remote heterogeneous data sources from the geo-spatial users, giving the impression of a single web-portal site that delivers Government geo-spatial data and services online. Geo-spatial data, in particular cadastral data, will be made available to the public via the prototype. This will further encourage the distribution of geo-spatial data and online web mapping developments in Australia.

The prototype will demonstrate the viability and importance of the cadastre as one of the fundamental components for a future cadastral system. The prototype will also contribute to further understanding of distributed network of geo-spatial resources and databases that are managed by individual custodians. The results of the prototype will encourage the use of *open-systems* and interoperability solutions, as advocated by the Open GIS Consortium (Open GIS Consortium, 2000). The results from the prototype will provide geo-spatial users all relevant information pertaining to the cadastre and other related registers or

databases. The prototype itself will show the viability of building a future Multi-Purpose Cadastre system.
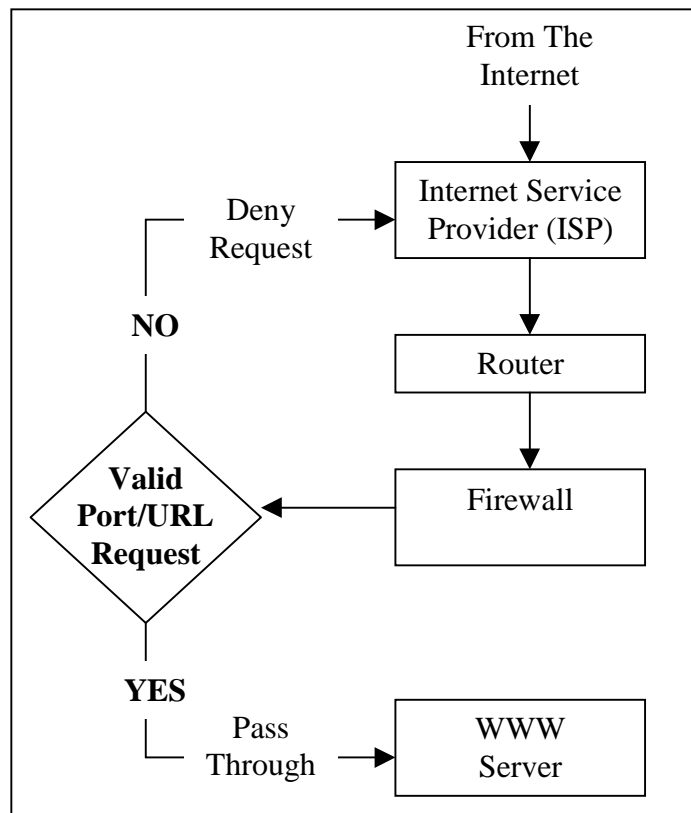

Figure 34: Operations of a firewall

Incorporating "client-pay" schemes across the system will only require the adoption of an Electronic Commerce payment protocol and system onto the existing host computer. Since requests and access are through the gateway, utilising an E-Commerce system, such as the popular SET (Secure Electronic Transaction) will produce a revenue generation system for the government.

6.8   **Chapter Summary**

This chapter represents the contribution of this thesis towards enriching the understanding of geo-spatial dissemination, in particular the awareness of online systems, its development issues, problems and limitations (see Figure 35).

The two knowledge streams encapsulated in this thesis converged in this chapter, which resulted in the model that was used for the development of the prototype. The model is aimed at solving the current geo-spatial environment in most government agencies, where online geo-spatial systems are still isolated systems with differing environment, tools and data. The model proposes the use of a middleware component within a three-tier distributed processing architecture that integrates the geo-spatial data from the heterogeneous geo-spatial resources, through the use of the web and Internet technologies.

The prototype features are also described in this chapter. One of the most prominent features is the use of heterogeneous databases that are connected via a middle component that facilitates data integration.

The important distinction between the MPC prototype, web-based GIS and metadata engines is also described in this chapter. It is anticipated that in the future, these systems should be not be isolated but combined to produce a truly multipurpose geo-spatial system that uses all the possible geo-spatial and geo-processing tools available.

The benefits of the prototype is explained in this chapter, amongst which includes the utilisation of a single entry point to access government geo-spatial data and the ability to allow data custodians the power to control ownership and access to the databases.
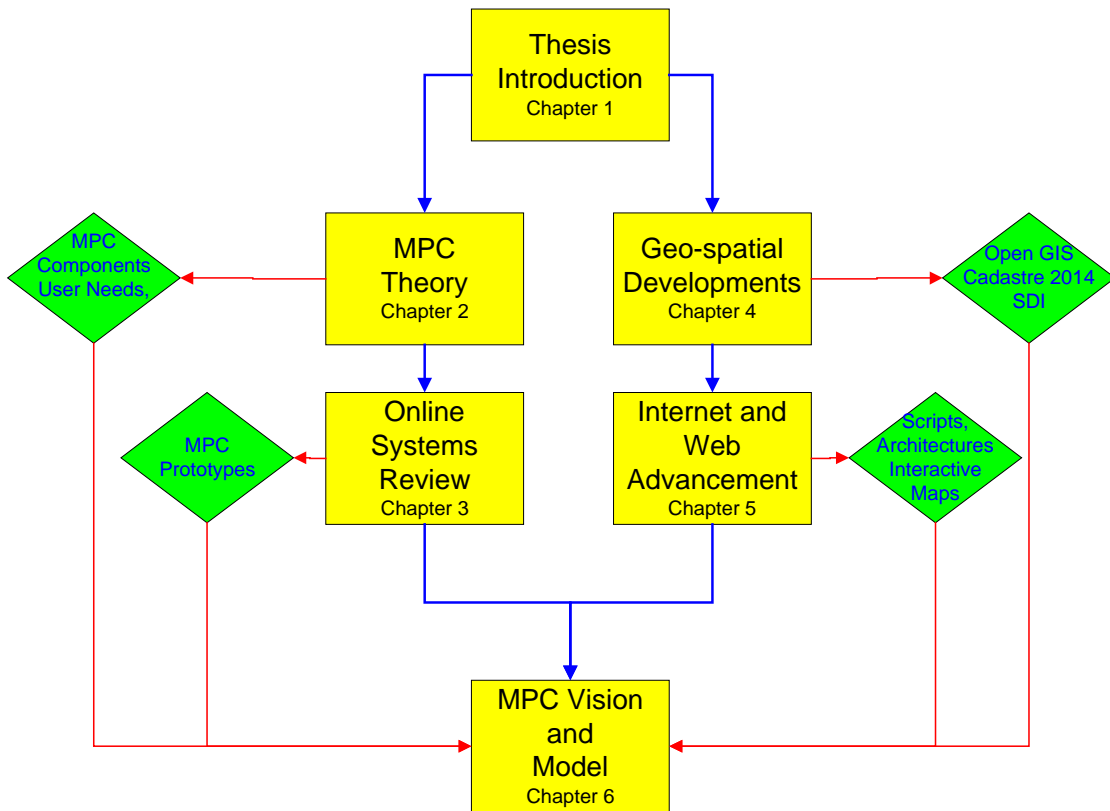
Figure 35: Amalgamation of the knowledge streams

Chapter 7

Prototype Development

The development of the MPC prototype is detailed in this chapter. The development was structured according to a time-line (Appendix A) and discussed in this chapter, based on the specific applications developed within VLIS.

This chapter serves as the realisation of the MPC prototype model presented in Chapter 6, and functions as an owner's manual to work and understand the MPC prototype.

Chapter 7: **PROTOTYPE DEVELOPMENT**

7.1   **Development of the prototype**

The following chapters are technically oriented: aimed to step through the development of the MPC prototype that is based on the model illustrated in Figure 31. The prototype took shape after greater understanding of these following factors:

- the intention of the Victorian government to have all government geo-spatial online by the year 2001;
- concurrent developments of GIS and Internet technologies (Chapters 4 & 5);
- and the birth of other online geo-spatial and cadastral systems around the world (Chapter 3).

It should be recognised that this prototype is not aimed to be the only solution that addresses the Cadastre 2014 vision; the review of other online cadastral systems proved this. Nevertheless, online geo-spatial systems and this prototype share some fundamental similarities. These similarities include:

- Use of the Internet as the prime medium of information delivery;
- Delivery of digital maps and geo-spatial data freely across the world;
- Linking distributed geo-spatial information databases across a local network or a jurisdiction together to serve such information;
- Serving multiple "virtual" users simultaneously.

As the demand for geo-spatial data converges and mutates over time, there is a need to realise these similarities to better serve the geo-spatial information user whilst creating a more robust and truly multi-purpose system. Therefore, through the development, testing and implementing of the prototype, it is hoped that the limitations, problems and advantages of developing and running an online geo-spatial system will be addressed to some detail.

The conceived prototype was named the Victorian Land Information System (VLIS), to give a sense of purpose. The following sections will describe the creation of VLIS.

7.2   Development Platform

Currently, there exist several major players in the world of operating systems that manage all the computer hardware in existence. These include Microsoft Windows, Macintosh Operating System (MacOS) and Unix operating systems. With around 80 percent of the computers in use being desktop computers, Microsoft Windows with its derivatives such as Windows 95, NT and 2000, dominate this end of the market. Software developed for the Microsoft operating system is highly likely to be used by most computer users. As a result, VLIS was developed in the Windows environment.

Currently, the most popular Windows operating system is Windows 95. Windows 95 however is not adapted to the heavy processing and data delivery that VLIS is expected to perform. Windows NT on the other hand, offers better scalability and multi-tasking (multiple simultaneous processing capability).

VLIS was initially developed on the Windows 95 environment but migrated to Windows NT for fine tuning, stability and performance analysis.

Currently, VLIS is operated by the middleware and the web server on the Windows NT Workstation machine, equipped with a Pentium III 450 MHz CPU, 128 megabytes of SDRAM and connected to the Internet via the Fast Ethernet (100 MBit) Ethernet connection through the university network.

The map server and the databases reside on several computers in the Department of Geomatics' networked environment. The number of computers used varies, depending on the user load and computer availability.

Windows NT provides tools to perform server and network analysis that are used extensively through the prototype development. Regular backups of the databases and other components of VLIS are done daily using a third-party automatic back-up utility on the web-server. Access to the web-server is available only to authorised users and

administrators of the machine, using the built-in Windows NT login system. Although VLIS is only a prototype, all possible security measures such as access restrictions and maintained.

7.3   **Development Tools and Components**

Having focused on the choice of operating system platform, the next step was to develop an operational architecture that would link up several distributed databases across the Internet. With the current development software and tools such as Visual C++, Visual Basic and Java, the choice of development was difficult. Fortunately, through the site license of ESRI to the University of Melbourne, a copy of MapObjects and MapObjects Internet Map Server (IMS) were obtained. MapObjects IMS includes modules that permit outflow of digital maps across the web, while MapObjects provided the programming tool box (within a Visual Basic environment) to develop VLIS.

Several months of development using MapObjects (an Internet mapping development language by ESRI), Visual Basic, Hypertext Markup Language (HTML), JavaScript, Active Server Pages and general Microsoft Windows debugging, were used to developed the VLIS components. Please refer to Appendix A for the prototype development timeline and Appendix B and C for the HTML and programming codes used in the development of the prototype.

VLIS is made up of 3 components. These components are:

- The back-end
- The middleware
- The front-end

The following sections will describe the development and functions of each component in the prototype.

7.4   **Prototype Assumptions**

The prototype was developed under a set of assumptions, that were made to constrain effects from external factors that are beyond the scope of this research thesis. The assumptions are necessary to fulfill the requirement of integrating data easily from disparate resources. Thus, in the development of this research prototype, the following assumptions were made:

1. The distributed databases contained data that were referenced to a common base layer *i.e.* the cadastral layer. The cadastral layer was chosen because of its crucial role as a base layer in many land-related agencies, hence its used in this MPC prototype. The cadastral layer used is made up of an identical subdivision region in Melbourne's North-West region, with approximately 100 cadastral parcels making up the cadastral layer used. This was purposely done to eliminate problems such as such as reference datums, map grids, scale and quality that might exist in different cadastral sources. Other factors include policies and political differences between data providers that would hinder and limit the scope of this prototype.

2. The data custodianship and ownership issues were not considered in the development of the prototype. This was deemed necessary to produce a prototype that was governed solely by technical and conceptual concepts that are within the scope of this research, rather than exposing factors such as management, collaboration and agreement issues between data providers.

3. One of the products of the prototype to web users includes parcel data from the cadastral layer that has already been matched through a one-to-one relationship to the title register. This is to ensure that all parcels in the cadastral layer used are accounted for in the matching process. Although this feature may be taken for granted in some countries, it is often the case where the title registers contain information related to a parcel that has been exhumed.

4. Each parcel and title record has been matched to a postal address *i.e.* address matched. This is to ensure that web users are able to personally relate to the cadastral layer through the use of commonly used postal addresses. In this prototype, address

matching each parcel and title record to a postal address eliminates the real-world problem of inconsistent postal addresses, that result in undefined query results. Address matching for the cadastral layer used in this prototype was necessary but it should be recognised that, having a complete address-matched cadastral layer in a country with millions of parcels is often a time consuming and expensive process.

7.5 **Back-End Component**

MapObjects and Visual Basic were used in the development and assembly of the back-end components. The back-end components consist of the map servers that generate the interactive geo-spatial maps, and the databases containing the title, valuation and planning data. The databases were created on Microsoft Access, which is a popular Windows-based desktop database application. However, there exist far superior and more powerful database packages in the market such as Microsoft SQL Server 7, Oracle 8i Spatial and InfoMix. However, because of the scope of the project and the small size of the database involved in VLIS, Microsoft Access remained the most viable option.

In total, 6 applications were developed to serve various unique services. These applications include

- Victorian Parcel Notification

- Victorian Buffering Service

- Victorian Planning Information

- Victorian Census Information

- Victorian Building Information

- Victorian Querying Service

These applications may reside on single or multiple computers. One or more applications may also reside on the same computer. The computer with one or more applications running on it is called a Map Server. Each Map Server has to be managed by *IMS Launch*. Together with IMS Launch, *webLink.ocx* forms part of the MapObjects IMS that passes query results from the application to the middleware. The sole purpose of webLink.ocx is to listen for requests from the middleware. IMS Launch tracks the location of the middleware (in terms of IP address) and notifies IMS Catalog in the middleware, of the existence of each application. The webLink.ocx and other software components within IMS Launch provide the functions needed by a Map Server to handle requests and

response to users. The collection of the multiple IMS Launch and the associated applications forms the back-end of VLIS.

Detailed explanation of the purpose and relevance, with screen captures of each of the applications is included in the following subchapter. All the applications use a combination of client-side scripts (JavaScript) to provide the basic functionality and interactive maps, TCP/IP and DCOM for the communication between the middleware and the map servers.

7.5.1   **Victorian Parcel Notification**

Purpose of the application: The purpose of this application is to allow web users to locate parcels based on the owner's name, parcel identifier or by selectively choosing the parcel from the interactive generated map. Once chosen, the application will retrieve the relevant title and cadastral information of the parcel.

Relevance of the application: Members of the public who wish to search the title or cadastral information of the parcel could utilise the application, which retrieves the title and cadastral information from the disparate, heterogeneous databases, based on the user queries of owner's name, parcel address or parcel identifier. The user is not forced to use two different systems of title or cadastre to retrieve the same piece of information. The application will collate the information from the disparate databases, and combine them to produce a result that is concise and easy to understand.

Example:

USER QUERY INTERFACE

Please enter the following information

Parcel Id:
11001345   Submit

Please enter the following information

Owner Name:
Smith
Submit
Enter the Owner's name (or the first few letters).

A user could search parcel and title information by entering the parcel number, owner's name or postal address, using one of the three interfaces presented on the left.

Please enter the following information

Street Number:

1510

Street Name:

Francis   Submit

Note: Do NOT enter Street Direction (E,W,N,S) or Street Suffix (St., Ave., Blvd., etc.). A list of potential matches will be displayed.

RESULTS

Figure 36: Victorian Parcel Notification Screen Captures

7.5.2   Victorian Buffering Service

Purpose of the application: The purpose of this application is to allow web users to locate title and cadastral information through a multi-selection by spatial search process (termed buffering in this prototype). The process will return a series of title and cadastral records that the user could save as a file and use for future purposes. The process is based on a radius search that is predefined by the user and collates all the parcels that fall within the radius.

Relevance of the application: Members of the public who wish to search the title or cadastral information of the parcel could utilise the application, which retrieves the title and cadastral information from the disparate, heterogeneous databases, based on a radius search defined by the user. The service is useful in gathering a series of title and cadastral records of surrounding parcels, instead of manually retrieving the records parcel by parcel.

Example:

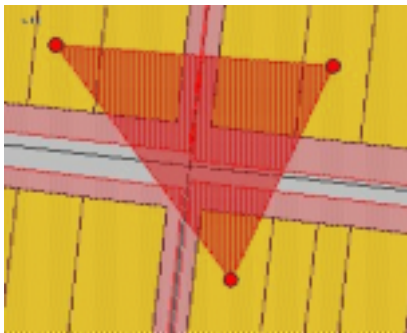To begin the process, the user first defines the shape of the selection area.
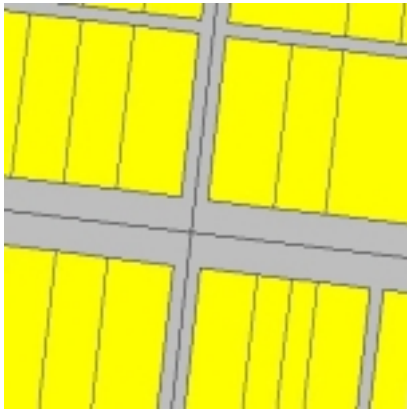
Based on the shape defined, the user then manually trace out the shape on the map.

If the process is successful, the application returns a list of available layers, where the user can selectively choose to view.

RESULTS

If the shape defined was a triangle, the user then traces out the triangle on the map.

If successful, the application returns a table of results based on the layers. In this example, the user has chosen the census layer and the results shows the census details contained within the triangle.

Figure 37: Victorian Buffering Service Screen Capture

7.5.3 Victorian Planning Information

Purpose of the application: The purpose of this application is to allow web users to view and identify the planning restrictions that are imposed on the land parcels. The application provides planning themes that are layered on the cadastral layer. The planning themes contain layers such as flooding zones, development zones and a utility layer that can be queried against the cadastral layer.

Relevance of the application: Members of the public who wish to search the planning, title or cadastral information of the land parcel could utilise the application, which retrieves the information from the disparate, heterogeneous databases based on user choices. Users are not forced to use isolated systems to gather the planning, title and cadastral information, as the application utilises the middleware to integrate the data before sending it through the web.
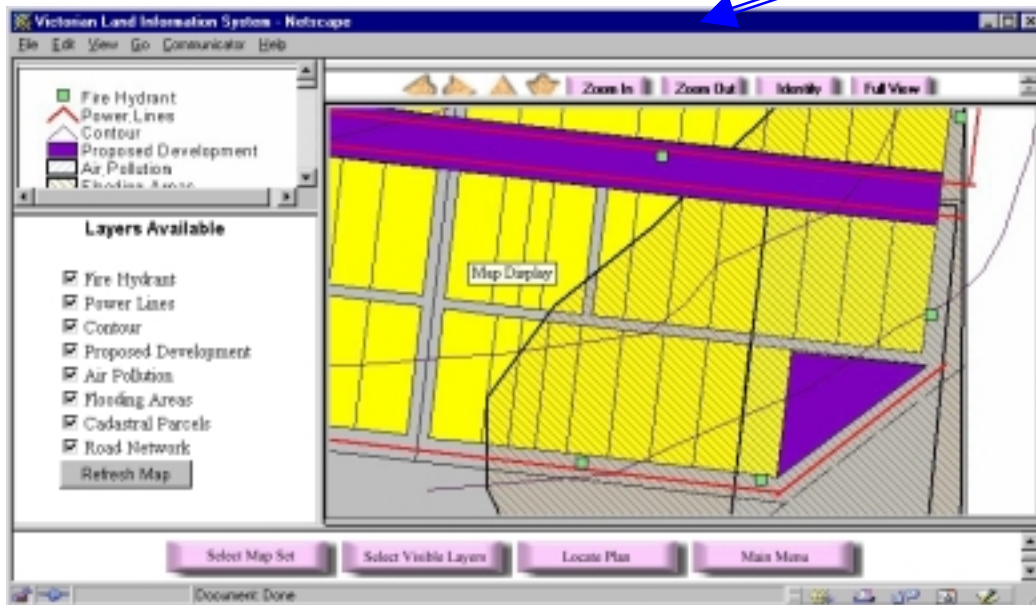
Example:

USER QUERY INTERFACE

☑ Fire Hydrant
☑ Power Lines
☑ Contour
☑ Proposed Development
☑ Air Pollution
☑ Flooding Areas
☑ Cadastral Parcels
☑ Road Network
[Refresh Map]

To begin the process, the user first selects the layers to be queried into.

If available, the application displays the maps, with the appropriate legends, such as the image below.

The user then selects the point in question, by clicking on any point on the map.

RESULTS

OWNER	Thornbury Power
POWER CAPACITY	7505000
LAST SERVICED	140255
Contour	
CONTOUR VALUE	0
Proposed Development	
PROPOSED DEVELOPMENT	Compulsory Acqui
AUTHORITY	Planning and Env
Air Pollution	
AIR POLLUTION RISK	Medium
AUTHORITY	DNRE
Flooding Areas	
PREVIOUS FLOOD DEPTH	0
Cadastral Parcels	
PARCEL ID	11001407
PARCEL AREA	711.60902

Show User Map Set List

If the point selected is valid, the application returns a table of results, that shows the information based on the user layer selection. In this example, the title, cadastral, planning, utilities and pollution data are integrated and presented in a single table, and linked to the cadastral layer.

Figure 38: Victorian Planning Service Screen Capture

7.5.4 Victorian Census Information

Purpose of the application: The purpose of this application is to allow web users to view the census data based on user queries on the cadastral layer. The census data is provided as a separate theme from an isolated database behind the prototype.

Relevance of the application: Members of the public who wish to view the census data could use the application that integrates census data based on the collector districts of the area. The result will show the general census information such as age distribution, income level per annum and population number per collector district. Users are not forced to use isolated systems to gather the census planning, title and cadastral information, as the application utilises the middleware to integrate the data before sending it through the web.

Example:

USER QUERY INTERFACE

To begin the census retrieval process, the user is requested to enter the classification method and classes.

The user is then requested to choose the shape of the selection area.
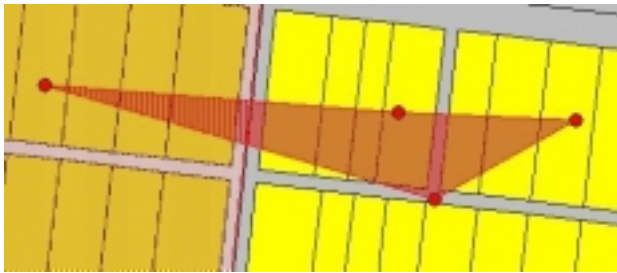
If a triangle is chosen, the user traces out a triangle on the map

RESULTS

If the area selected is valid, the application returns the census details that are contained within the selected area.

Figure 39: Victorian Census Information Screen Capture

7.5.5 **Victorian Building Information**

Purpose of the application: The purpose of this application is to allow web users to view the building information based on user queries on the building theme. Returned results include the building wall type, building price, building height and occupancy rate.

Relevance of the application: Members of the public who wish to view the building information could use the application that integrates building information with the parcel and title information.

Example:

USER QUERY INTERFACE

To begin the building query process, the user is requested to select the layers available.

The user is then presented with a map that contains a combination of the layers selected. The user is then requested to click on any building outline or parcel.

RESULTS

Areas Of Interests
Building Outlines
Cadastral Parcels
Proposed Development

Areas Of Interests	
AREA OF INTERESTS	Museum
Cadastral Parcels	
PARCEL ID	11001316
AREA	1041.91992
X_COORD	317876.8685
Y_COORD	5817675.0545

If the selection is valid, the application returns a table that contains the building information and the underlying cadastral and title records.

Figure 40: Victorian Building Information Screen Capture

7.5.6 Victorian Querying Service

Purpose of the application: The purpose of this application is to allow web users to view the building, and areas of interests in the vicinity, based on the user queries on the themes. Returned results include the type of area of interest, building information, fire hydrant information and powerlines.

Relevance of the application: Members of the public who wish to view the building and other information such as the areas of interest, could use the application that integrates the information with the parcel and title information.

Example:

To begin the querying process, the user is requested to select the search parameters from the menu on the left.

RESULTS

Rec	Parcel ID	Address
1	11001338	520
2	11001376	338

PARCEL ID	11001338
ADDRESS	520
ADD2	520 N QUEEN
STREET	QUEEN
PurchasePrice	476000
OWNER	HINOSTROZA RODOLFO
ValuationPrice	4516221
X_COORD	6675387.5
Y_COORD	1847629.375
SUBDIVISION YEAR	1979
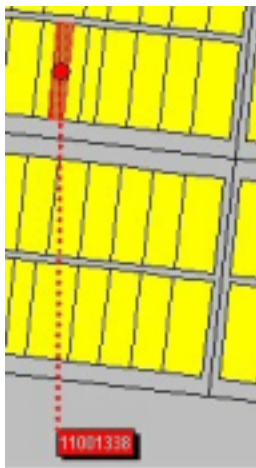
If the parameters are valid, the application returns the parcels that satisfy all of the search parameters selected.

If the parameters are valid, the application will also retrieve the cadastral map to show the location of the parcel and a table of records that contains the cadastral, title and valuation details of the parcel

Figure 41: Victorian Querying Service Screen Capture

7.6   **Middleware Component**

The middleware that forms part of the VLIS components consists of:

- IMS Catalog

- IMS Admin

- ESRIMap.dll

- web server (HTTP- Server) software

- Upload.exe (modules for the uploading of plans)

- Microsoft Transaction Server (MTS)

7.6.1   **IMS Catalog**

All of the Map Servers register their existence and status (upon initialisation) to IMS Catalog, through IMS Launch. IMS Catalog keeps track of map server locations and the applications that are available. IMS Catalog also serves as a registry that is assessable by web-based applications such as the ArcExplorer modules and the IMS Admin.

7.6.2   **IMS Admin**

IMS Admin is the administration module for the map servers. IMS Admin is responsible for configuring the parameters to allow the queries from the web to the applications via the middleware (and vice versa). IMS Admin is loaded into memory and retrieves the list of Map Server locations (from IMS Catalog) based on the IP address of each Map Server. These parameters are also crucial in determining replies from each application are made successfully and delivered through the middleware. For each Map Server, IMS Admin assigns a unique port range (ports are dedicated channels where information packets are delivered, to ensure each Map Server gets a path to the Internet. IMS Admin also allows the administrator to:

- Start and stop map services on one or more map server computers

- Administer map services remotely

- Check the status of map services

IMS Admin can be executed on the web-server machines or any of the machines used in VLIS.
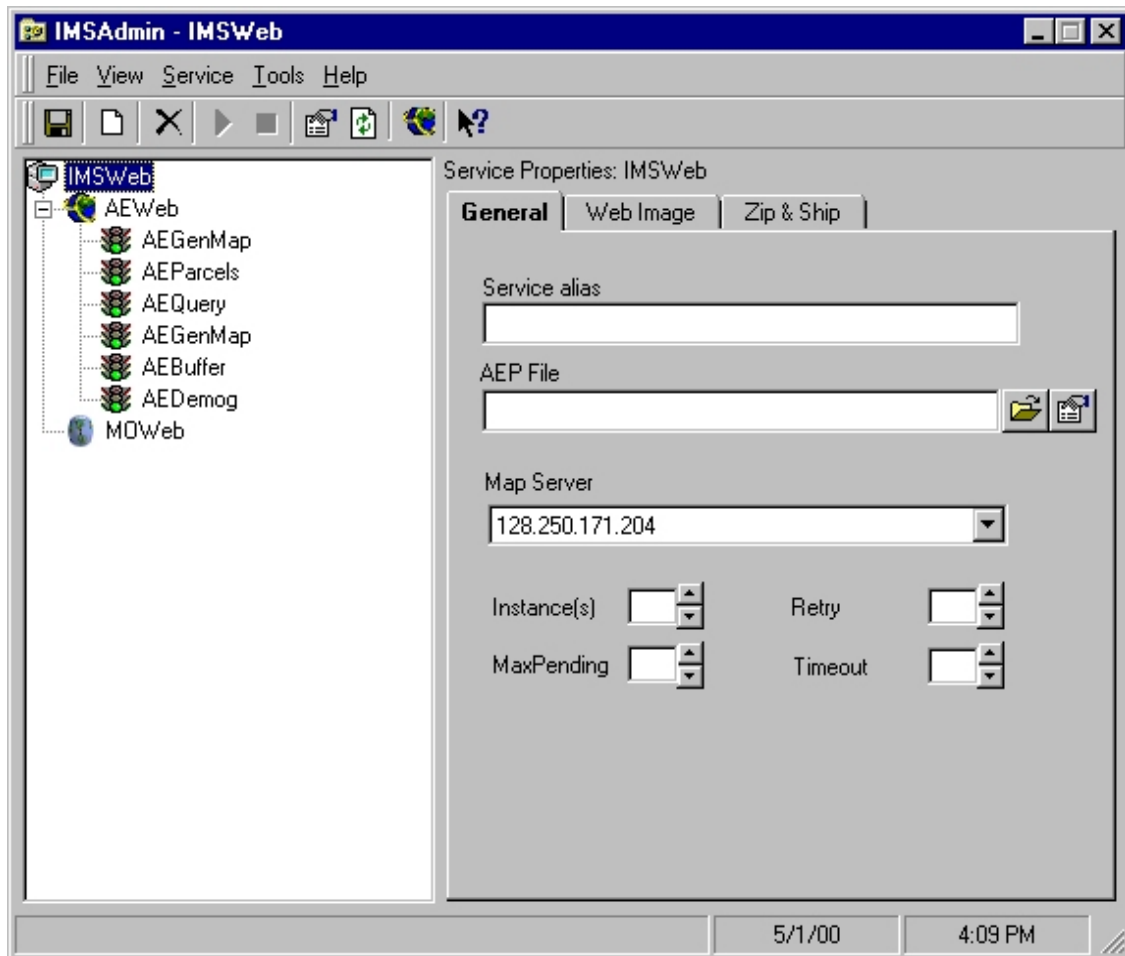
Figure 42: IMS Admin

7.6.3   **HTTP Server**

The web server is responsible for publishing each application from the Map Server to the web. There are various types of web servers available on the market. To avoid programming and future complication to the performance of the prototype, Microsoft's Personal Web Server (available through Windows NT Option Pack) was chosen as the web server. Through a uniquely assigned Internet address (IP address) given to the web server (thus the middleware inherits the same address), the web server is able to mark its presence on the Internet. User queries are received by the web-server and where appropriate, the dynamic link library (ESRIMap.dll file) passes the query to IMS Admin. From the query, IMS Admin is able to narrow down the destination of the query and passes the query to IMS Launch on the specified map server. The responsible application will receive the query from IMS Launch and generates a reply. The reply will flow along the same path back to the user.

Figure 43: Personal Web Server Manager

7.6.4 **Dynamic Link Library**

ESRIMap.dll file is a dynamic link library (dll) component that allows the web-server to manage requests and responses to and from the Map Server and IMS Admin. ESRIMap.dll communicates with the web-server through the Internet Server Application Programming Interface (ISAPI) of the web-server.

7.6.5 **Uploading module**

Residing in the middleware is the module (Upload.ini) for uploading graphical and textual files to the web server. Upload.ini is an initialisation file that passes the location of the web server and the uploading directories to the Upload application. A Common Gateway Interface (CGI) script that retrieves the file using the HTTP-protocol via the web-server manages the Upload application. The purpose of such a facility was to permit surveyors and referral authorities to store plans or maps that need approval by other referral authorities. By assigning a unique number to all documents and plans submitted online, the preservation and version control of files can be instituted easily.

USER QUERY INTERFACE

Choose File:

| | Browse... | Upload file |

To begin the process of uploading files to the central server, the user is requested to choose the file at the local machine and click on the *Upload file* button to upload the file.

RESULTS

128.250.171.204 - /isa/submit/graphics/

[To Parent Directory]
```
    2/9/00   9:35 AM      <dir>  vti_cnf
  11/15/99 12:34 PM        6259  310a.jpg
  11/15/99 12:34 PM           0  310a.jpg.dsc
  11/15/99 12:34 PM        7160  50year.gif
  11/15/99 12:35 PM           0  50year.gif.dsc
```

128.250.171.204 - /isa/submit/text/

[To Parent Directory]
```
   3/27/00   1:49 PM       36092  docs.html
   3/27/00   1:49 PM           0  docs.html.dsc
```

> If the process is successful, the uploaded file will be stored in either the graphics or text directory, which can be viewed and retrieved by other users.

Figure 44: Uploading Facility Screen Capture

7.7 Middleware Functions

Apart from MapObjects IMS modules, the middleware is also responsible for various other services. These services are grouped under the development environment used for their creation. The environments include the Active Server Pages (ASP) and Common Gateway Interface (CGI).

Detailed description of the purpose and relevance, with screen captures of each of the applications is included in the following section. The application provides a searching facility on parcels without using the graphical-based applications that were described in the previous sections. The application does not utilize a heavy network load as it uses only textual query and textual results. The application utilises ASP, with connection through the ODBC gateway to the title records contained in the Access database. The underlying operating system used is Windows NT Workstation, with the Personal web Server acting as the HTTP Server to the Internet.

7.7.1 **Active Server Pages (ASP)**

General Data Flow Within The ASP Environment
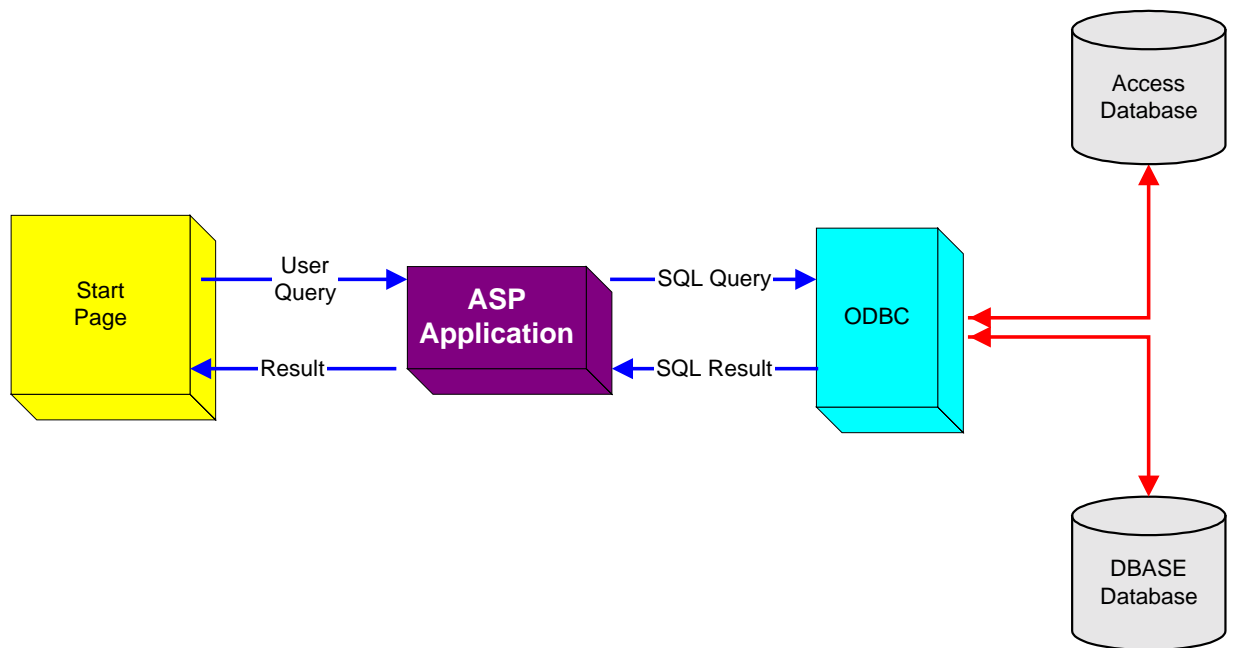
Figure 45: General ASP Work-Flow within VLIS

Each of ASP applications performs similar functions. The common attribute between them is their role of connecting the title, valuation and Native Title databases to the middleware. ASP was chosen because of its strength in database connectivity over the web. The applications will nest the ASP and HTML codes within the same HTML document which are ready to be downloaded. Being a server-side script (see Chapter 5.4), ASP is executed on the server by establishing a connection to the relevant database via the Open Database Connectivity (ODBC) protocol. ODBC ensure that ODBC-compliant databases are communicating with the system processes of the prototype. This is conducted through the use of universal protocols and SQL that hides the different characteristics of proprietary vendor-based or commercial databases underneath the cover of ODBC. Upon successful connection, the ASP application will display a series of choices on HTML documents for the users to choose or input (see Figure 45). When the user responds by clicking the

appropriate buttons, the application will parse the response into SQL queries that are
returned through the web server for the appropriate ASP application to respond. The
application will then open a connection to the ODBC where the appropriate database will
respond and return the results.

7.7.1.1 Function: Locate parcels based on coordinates

Locate Parcels by Coordinates in VLIS

Figure 46: Diagram of Locate Parcel by Coordinates application

Purpose of the application: The purpose of this application is to allow web users to locate
parcels on the cadastral layer based on the centroidal coordinates of the land parcels. The
application uses a drop-down menu that lists all the parcel coordinates contained in the title
register. Once chosen, the application will retrieve the relevant title information of the
parcel based on the user selection of the parcel coordinates (see Figure 46).

Relevance of the application: Members of the public with the knowledge of the parcel
centroidal coordinates are able to retrieve the title information from the title registers. The
user is not required to know the geographic location or address of the parcel.

Example:

USER QUERY INTERFACE

To begin the process, the user selects one of the coordinates of the parcel centroid from the list of available coordinates.

If available, the application will return the parcel that corresponds to the coordinates

RESULTS

The user then clicks on the parcel number (APN) to view the postal and area details.

Figure 47: Locate Parcel by Coordinates Screen Capture

7.7.1.2 **Function: Locate the plans of parcel (Certificate of Title) based on the parcel number**

Locate Plan of Parcel in VLIS
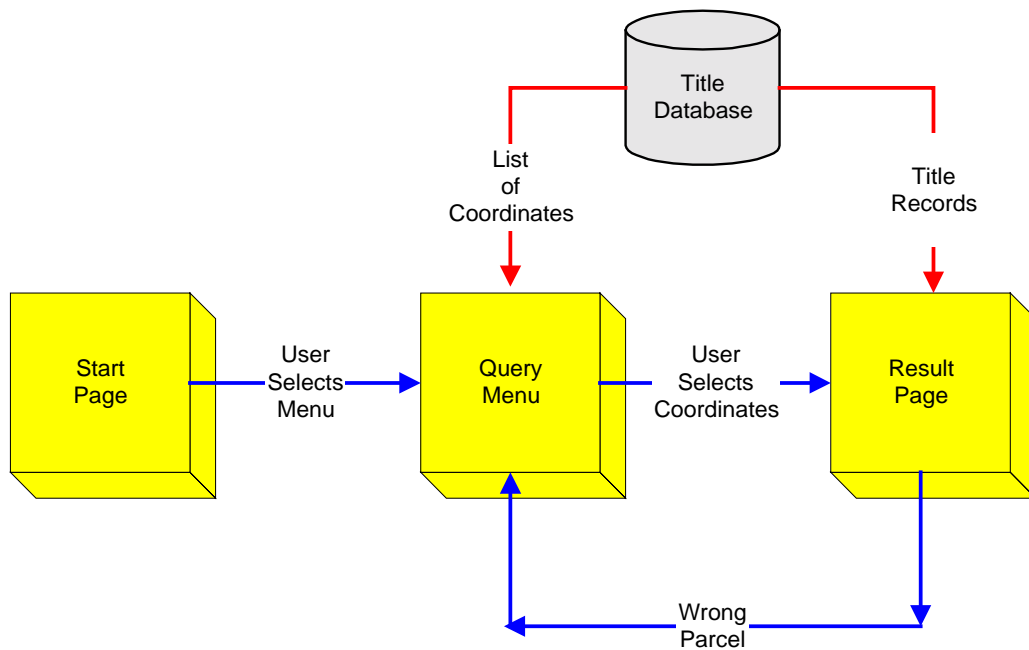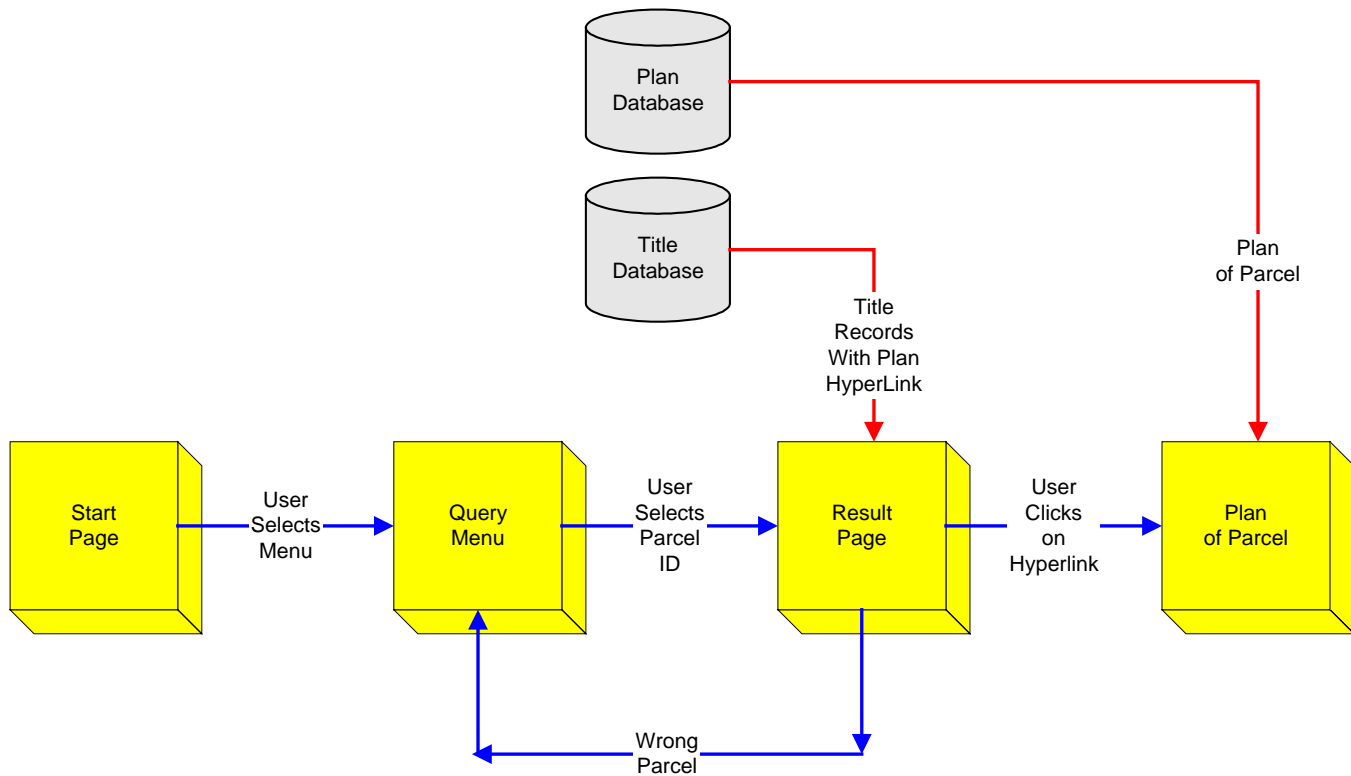

Figure 48: Diagram of Plan of Parcel application

Purpose of the application: The purpose of this application is to allow web users to locate the plan of parcel based on the coordinates of the parcel centroid. The application is easy to use; with drop-down menus that list all the parcel coordinates contained in the title register. Once chosen, the application will retrieve the relevant title information of the parcel, with the parcel identifier linked to the plan of the parcel (see Figure 48). The user has only to click on the parcel identifier to retrieve a copy of the plan of the parcel.

Relevance of the application: The application provides a simplistic method of retrieving a copy of the Certificate of Title, based on a successful search of the parcel centroidal

coordinates. It highlights the viability of linking a digital copy of the Certificate to the title registers.

Example:

> To begin the process, the user selects the parcel from the list of parcel numbers.
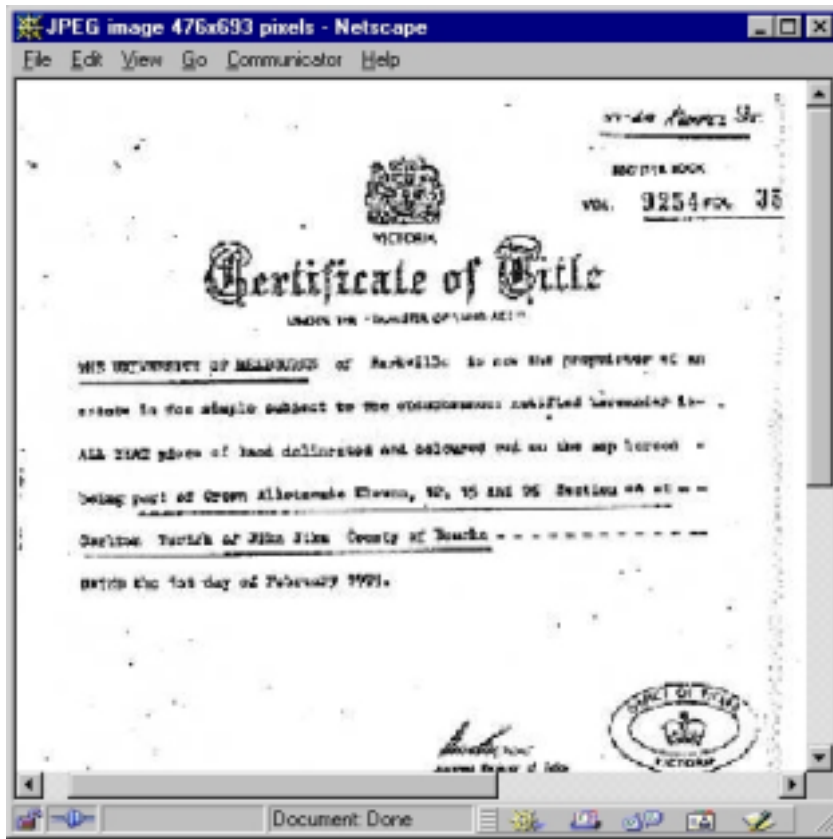
Figure 49: Plan of Parcel Screen Capture

7.7.1.3 Function: Update the Native Title details of the parcels

Update Native Title Details in VLIS

Figure 50: Diagram of Native Title application

Purpose of the application: The purpose of this application is to allow registered users to update the Native Title information of the parcel based on the centroidal coordinates of the parcels. The application resides behind a security login facility, with access validated with pre-registered names and passwords. The application is easy to use; with drop-down menus that list all the parcel coordinates contained in the title register. Once chosen, the application will retrieve the relevant title and Native Title attribute, that the user may change to match the Native Title attributes of the parcel (see Figure 50).

Relevance of the application: This application provides a simplistic approach in viewing the Native Title claim status of land parcels on the cadastral layers. If the registered user

wishes to change this claim status (based on pre-researched findings or documentation), it is possible to do so by editing the claim status attribute of the parcels.

Example:

To begin the process, the user selects the parcel number and if the selection is valid, the application will return the parcel details that could be changed by the user. *The NT row value of 1 represents an affected title, while 0 represents an unaffected title*. Once the new details are entered, the user clicks on the *Update Current Record* button to continue.

RESULTS

If the changes are valid, the application will return the updated Native Title details.

Figure 51: Native Title application Screen Capture

7.7.1.4   **Function: Retrieve the value of the parcel based on the parcel number**

Locate Valuation Price of Parcels in VLIS
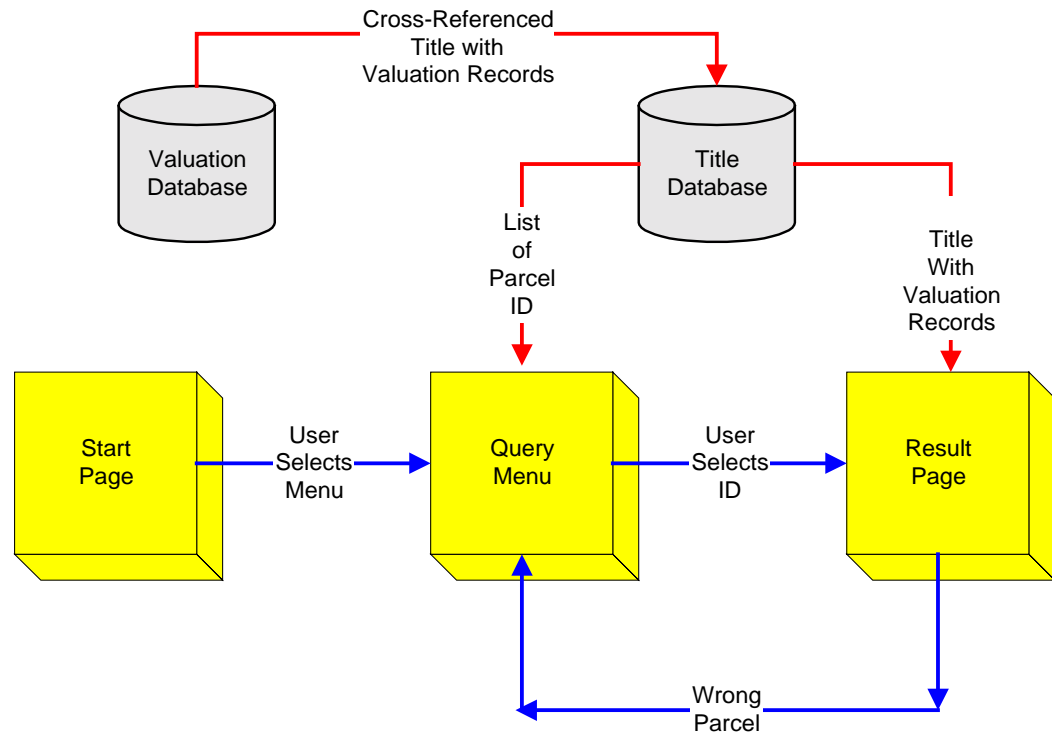
Figure 52: Diagram of Valuation Price Search application

Purpose of the application: The purpose of this application is to allow users to retrieve the valuation details of the parcel on the cadastral layer based on the centroidal coordinates of the land parcels. The application is easy to use; with drop-down menus that list all the parcel coordinates contained in the title register. Once chosen, the application will retrieve the relevant Valuation information from the Valuation database (see Figure 52).

Relevance of the application: This application eliminates the tasks of retrieving valuation information from the valuation agencies by providing the information that is linked to the parcel identifier. The user has to know the parcel identifier and the application retrieves the

corresponding valuation details from another database (conceptually stored in a valuation agency).

Example:

Figure 53: Valuation Price Search application Screen Capture

7.7.1.5   Function: Update the Title Records application
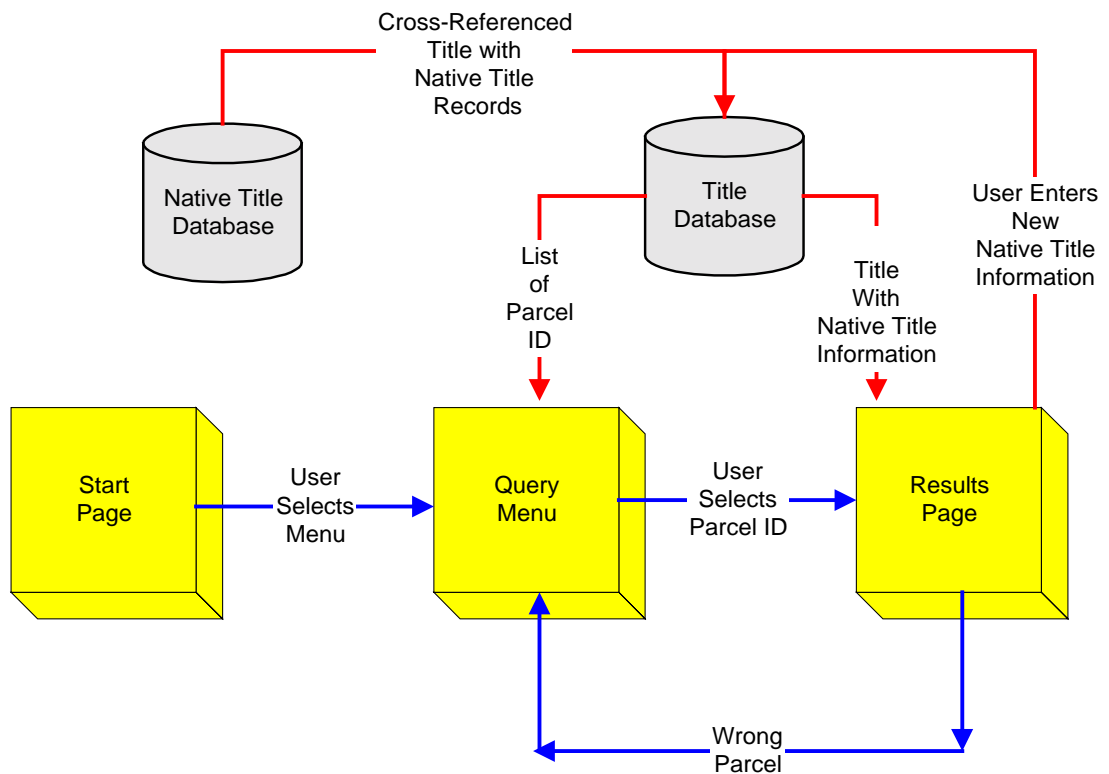
Update Title Records in VLIS
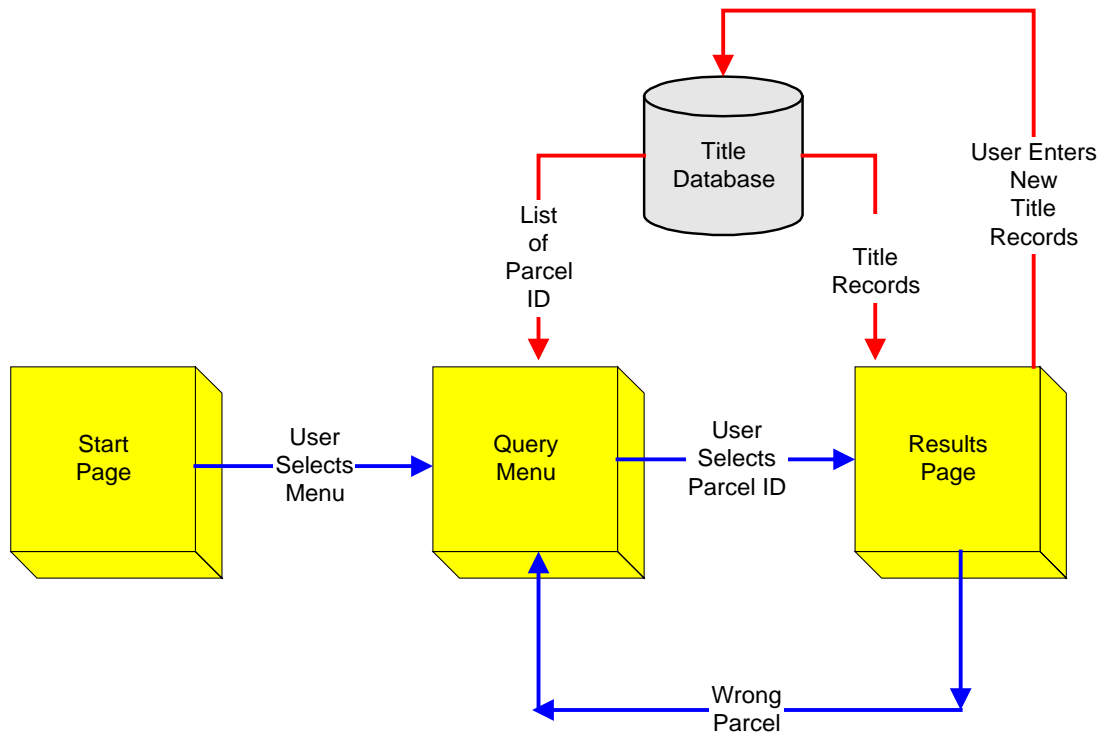
Figure 54: Diagram of Title Record Update application

Purpose of the application: The purpose of this application is to allow registered users to update the Title records of the parcel based on the parcel identifier. The application resides behind a security login facility with access available using pre-registered names and passwords. The application is easy to use; with drop-down menus that list all the parcel coordinates contained in the title register. Once chosen, the application will retrieve the relevant Title information, that the user may change to reflect the latest transaction (see Figure 54).

Relevance of the application: The application allows registered users to update the parcel ownership information in real-time through VLIS. This service is currently not available

from the Victorian Title Registrar Office. In theory, this application will promote the use of the web to transfer land ownership between the buyer and the seller.

Example:

USER QUERY INTERFACE

APN = 11001305

Apply Filter   Reset   DropDown ?

To begin the process, the user is requested to select the parcel number from the menu.

RESULTS

Filter   Reset Filter   Update

OWNER	MAILADDRES	MAILLINE2
Clare	North Melbourne	Nm

If the selection is valid, the application returns the parcel information, where the user is able to change by clicking on the *Update* button.

Figure 55: Title Record Update application Screen Capture

7.7.1.6 Function: Update the valuation details of the parcels

Update Valuation Price of Parcels in VLIS
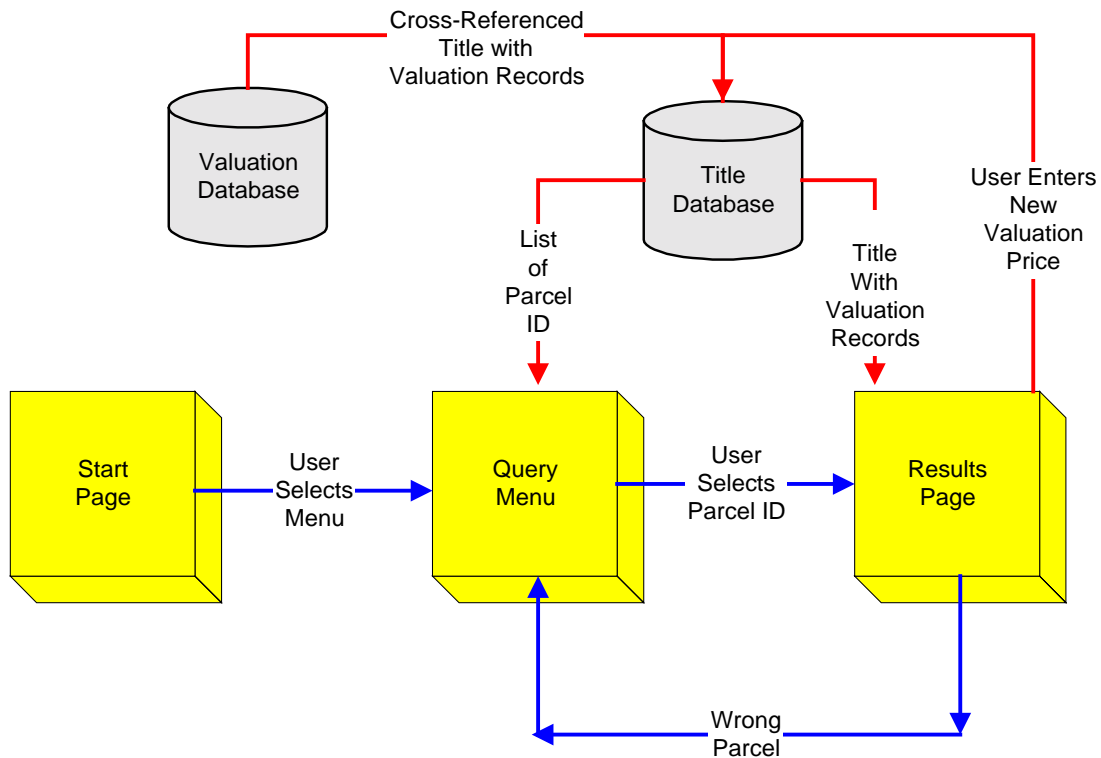
Figure 56: Diagram of Valuation Price Update application

Purpose of the application: The purpose of this application is to allow registered web users to update the Valuation information of the parcel on the cadastral layer based on the centroidal coordinates of the land parcels. The application resides behind a security firewall, managed using a pre-registered name and password for successful entry to the application. The application is easy to use; with drop-down menus that list all the parcel coordinates contained in the title register. Once chosen, the application will retrieve the relevant title and Valuation attribute, that the user may change to reflect the current valuation value (see Figure 56).

Relevance of the application: The application provides a textual search on parcels without using the graphical-based applications as mentioned in Chapter 7.8. The application does not utilise heavy bandwidth use as it uses only textual query and textual results. The return result of the query is a set of Valuation attributes that can be updated by the registered user.

Example:

Figure 57: Valuation Price Update Screen Capture

7.7.1.7   Function: Purchase maps and other tradable goods

A shopping cart program developed using ASP was used to manage the trading of maps and other tradable geo-spatial goods. The program simulates an Electronic Commerce (E-Commerce) environment where the tradable products are sold through VLIS as the merchant, with the web-users as the buyers. The shopping card program uses an Access database for records of goods such as the quantity and price of the tradable goods. The option of including photos or images of the goods is also available, with links to the appropriate records in the database. The shopping cart program delivers a series of documents to the users to simplify the following tasks:

1. Displays the general categories of items.

2. When selected, the tradable goods are displayed together with the price and the option of quantity to purchase.

3. All item/s selected by the user are recorded in the database and kept in the *virtual shopping cart*.

4. Once completed, the user is presented with a *check-out counter* that lists the items, the quantity and the total price of the item chosen.

5. Prior to completion, the program presents a *User Information* form, where the user fills out the personal details *e.g.* credit card details, address and name.

Electronic Commerce Facility in VLIS
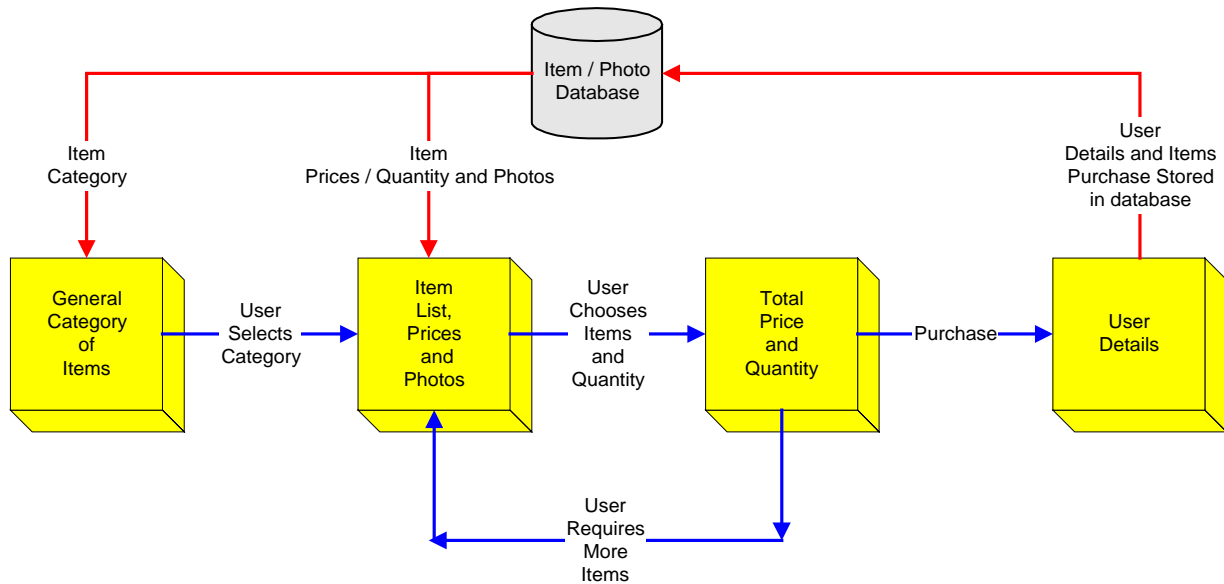
Figure 58: Electronic Commerce Facility

7.7.2 HTTP-connection tracking

Purpose of the application: The purpose of this application is to allow web users and the VLIS developers/maintainers to view the origins of the users to VLIS. The application breaks down the information into detailed data such as the frequency of the day of the visits, the operating systems used by the users, the web-browser used by the users and the IP address of the users. The application is hosted by a third-party free service that displays banners on the application icon in return for their service. The application also provides a guestbook facility for users to enter comments or feedback to the developers/maintainers (see Figure 59).

Relevance of the application: The application allows the developers/maintainers of VLIS to gauge the frequency of use of the system, which in turn influences any performance and fine-tuning of the system. The results from the application (visit frequency and browser

type) are crucial in generating tuning mechanisms that will sustain VLIS for the users. Amongst the remedies that may be generated include:

• Setting up additional middlewares that could better service simultaneous web-request

• Upgrading the database from Access to SQL Server or an equivalent database package that better targets multiple database sessions and concurrent database transactions.

• Upgrading the web-server to include multiple web-servers that represent the same address but facilitate load balancing features as described in Chapter 8.8.5

Technologies Used: The application (hosted on a third-party free website) utilises server-side scripts that monitors the VLIS entry page for user requests. As a user downloads the entry page, an icon that is connected to the application is retrieved alongside this page. This action will trigger the third-party application to retrieve all relevant information about the user from the location, nature and behaviour of the user browser.

Figure 59: HTTP Connection Tracking Screen Capture

7.8   **Chapter Summary**

This chapter represents the contribution of this research thesis towards the advancement of geo-spatial data dissemination to the public.

The development of VLIS was conceived as a prototype to show the viability and understanding of the issues involved in the dissemination of geo-spatial data, that is integrated from distributed resources across government agencies. The chapter steps through the development of the components within VLIS, emphasising the development language, technologies, purpose and relevance of each component built.

Throughout the development period, some issues were encountered. These issues, ranging from data storage to geo-spatial processing, are acknowledged to have influenced the development of VLIS, and probably the creation of any online geo-spatial systems. These are described in the following chapter.

In summary, this chapter illustrates the development process, development and security issues that have shaped VLIS.
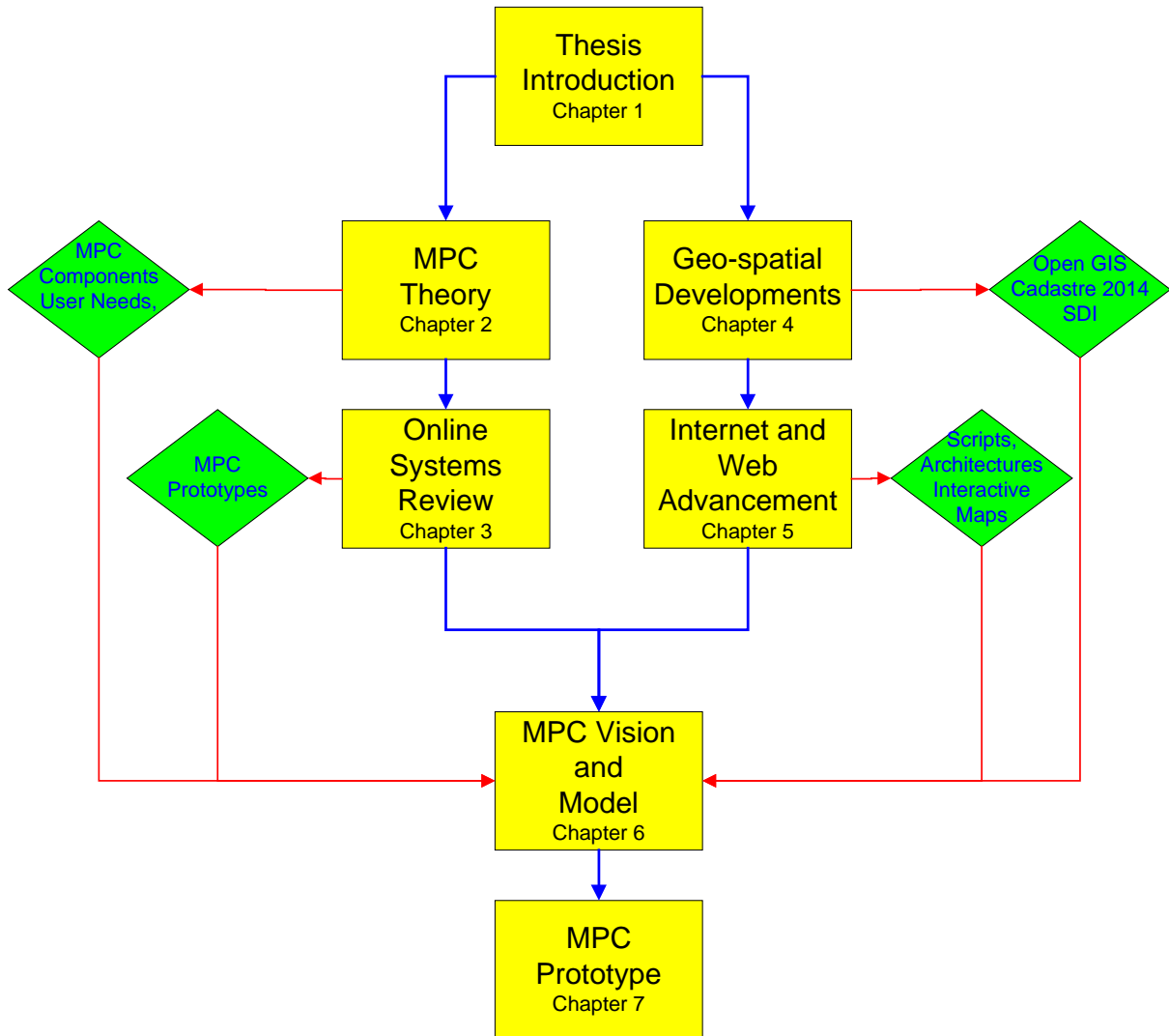
Figure 60: Development of the MPC prototype

Chapter 8

Prototype Evaluation

The MPC prototype developed was tested against a set of evaluation principles that compares the prototype to the current Victorian online geo-spatial information environment. The evaluation principles were developed from the understanding of encapsulated knowledge in this thesis.

From the evaluation, the problems and limitations of the prototype were discovered and documented. Of most interest are the security issues, which are discussed with possible solutions, and the measures to optimise the MPC prototype to cater for future needs.

Chapter 8: **PROTOTYPE EVALUATION**

8.1   **Introduction**

Chapter 7 details the development of the three-tiered processing architecture of VLIS. VLIS was not developed as a real-world solution to the limitations of online geo-spatial systems in Victoria. The products and services of VLIS are not perfect and the results returned from VLIS are certainly not to be used as a definitive reference.

VLIS is all about proof of concept. VLIS was set up to demonstrate the viability of developing a prototype that would harness the web, link distributed geo-spatial databases together and combine the relevant data through the use of common identifiers and finally deliver the results, as requested by the users through the web. VLIS does possess problems and limitations that are addressed through the evaluation process detailed in this chapter.

8.2   Development Issues

The three distinctive components within the VLIS portal resemble closely the three-tier COM model adopted by the Open GIS and the AWWWM Consortiums (Open GIS Consortium, 2000). Consequently, VLIS inherits issues that affect the performance of the three components. Through the development of VLIS, it was noted that the issues are component specific and are listed as follows:

- Issues such as data storage and format that influences the back-end component.

- Spatial processing, retrieval and delivery are examples of issues that affect the performance of the middleware.

- The data delivery and client issues affect the front-end component.

8.2.1   Data Storage and Format

Organisations are heavily investing in secure data storage software such as Oracle and InfoMix that promise increased productivity, security and integrity of the data (Oracle, 2000a). However, the problem lies in the conformity of the databases to standards that the Internet and the World Wide Web world recognise. Fortunately, standards such as ODBC (Open Database Connectivity) and JDBC (Java Database Connectivity), that utilise the Application Programming Interfaces (APIs), ensure that communication to databases are compatible in order to be used in the Internet.

The data format issues relate to the current industry situation where various formats are being used for handling geo-spatial information. With the market for geo-spatial data booming, the flooding of software packages for spatial data is astonishing. In addition, new formats are being introduced that promises better reliability and suitability for a particular use. The challenge now lies in joining geo- spatial information of different formats together. With each format having particular strengths and weaknesses, it is difficult to negotiate a common format for all geo-spatial information producers and users to adopt. Fortunately, software developers are producing software that include translators or

converters that conveniently convert data from one format to another. Nevertheless, a drawback of such a process lies in the preservative and integrity of data. The new format may even distort the original data. Ideally, the process of converting one format to another preserves the shape, accuracy and content of the data. Thus, solving data format issues is imperative in building a future MPC.

8.2.2   Spatial Retrieval and Processing

The data retrieval issue relates to the need to have mechanisms to easily store and retrieve data from the disparate databases. Currently, most databases use the Structure Query Language (SQL) engines to retrieve data. A SQL engine permits the use of structured commands to intelligently sort through, manage and retrieve data. SQL also permits retrieval of data in distributed databases across organisations and networks.

To extend spatial databases to other users, SQL is being used in conjunction with specialised retrieval and management software such as Spatial Data Engines (SDE) (ESRI, 1998). SDE are increasingly being used in large organisations to handle databases of various spatial data formats. SQL and SDE work hand in hand in a Local Area Network and the Internet environment to allow the integration of spatial and non-spatial databases. Hence, a key to a successful MPC lies in the use of SQL, SDE and distributed databases. The spatial processing issue refers to the use of tools in analysing geo-spatial information.

Herein, lies various geo-spatial data software packages introduced to better manage, manipulate and bring out added potential of spatial data. With geo- spatial information being the heart of corporate and governmental GIS organisations, powerful multiple-processor or Symmetric Multiprocessor Computers (SMP) are often used to function as powerful GIS servers for organisational-wide GIS implementation. To complement, desktop GIS users are being equipped with the latest computers for better geo-spatial information usage and manipulation. Together with SQL and SDE, the GIS desktop and server environment are seen as the heart of a future MPC.

8.3 **Evaluation of prototype**

The MPC prototype developed for this research was tested against a range of research principles that were established from the understanding of the MPC concept and developments (Chapters 2 and 3), and the developments of online systems and the current Internet technologies (Chapters 4 and 5). The justification for this evaluation is twofold. Primarily, this evaluation will be the basis for assessing the prototype, to ascertain and document its strengths and weaknesses against the set of principles. The secondary justification involves documenting the evaluation, and identifying the problems and limitations gathered from the understanding of the primary objectives.

8.3.1 **Evaluation Principles**

The set of principles developed for the evaluation is divided into two categories. These categories coincide with the two fundamental categories of knowledge used in this thesis *i.e.* the MPC concept developments (Chapters 3 and 4) and the Information Technology trends (Chapters 5 and 6). The first category is based on geo-spatial information principles that involve the comparison of the prototype to geo-spatial information needs of the MPC and current Victorian geo-spatial information policy. The second category involves the comparison of the prototype to the Information Technology trends and needs, as detailed in Chapters 4 and 5 of this thesis. These two principles are further explained in the subsections below.

8.3.2 **Geo-Spatial Information Principles**

The geo-spatial information comparison principles were developed from the understanding of the critical needs of a MPC system, its concepts and developments (detailed from Chapter 2 and 3). From Chapter 2, the fundamental components of a MPC include the five components *i.e.* the geodetic framework, cadastral layer, base maps, Land Information Centre and existing government agencies (Williamson, 1985). Additional components that are equally important from the current Victorian online perspective include the title, valuation and planning data. In line with many of the online systems reviewed in Chapter 3, GIS capabilities should be included in the prototype while the facilitation of data update should not be left behind. The use of metadata within the data stored and the ability to

search and retrieve the metadata was also included, as much of the Australian geo-spatial information scene has concentrated on this feature, in particular the Australian Spatial Data Infrastructure (ANZLIC, 1999).

Therefore, the geo-spatial information evaluation principles include:

- inclusion of the fundamental themes *i.e.* geodetic, cadastral and base maps;
- incorporation of title and valuation data;
- facilitation of mapping functions and features;
- updating of information over the web; and
- use of metadata.

8.3.3 Information Technology Principles

The second category of evaluation principles involves the comparison of the prototype to several principles of the Information Technology trends that were detailed in Chapters 4 and 5 of this thesis. The first principle is the implementation of the system on the web. This is particularly important if the system is to fulfill the notion of delivering geo-spatial information to worldwide users across an operational web. The second principle is the use of plug-ins and web-based scripts to overcome the limitations of the current HTML syntax to deliver effective geo-spatial information across the web. The third principle is the use of interactive maps to effectively generate geo-spatial information, especially maps and images. The fourth principle involves the use of a distributed processing architecture on the prototype. Other principles that are included in the evaluation are the incorporation of firewalls and security measures to ensure protection from attacks and access by unauthorised persons, and the incorporation of an Electronic Commerce environment to facilitate the trading of geo-spatial goods.

Therefore, the Information Technology evaluation principles include:

- presence of the prototype on the web;
- use of plug-ins and web-based scripts to overcome limitations of the HTML syntax;
- use of interactive maps to effectively deliver geo-spatial information;

- use of distributed processing architecture to solve the problem of database and web connections;

- inclusion of user and systems security features; and

- The incorporation of an Electronic Commerce environment.

8.4 Evaluation Process

The prototype is evaluated against the set of principles detailed in the previous section. Each aspect of the developed prototype is compared to the research principles and the current Victorian online geo-spatial information scene, and the results documented in the following table.

8.4.1 Geo-spatial Information Evaluation

Table 7: Geo-spatial Information Evaluation

Principles	Victorian Scene	Results
The inclusion of the fundamental themes *i.e.* geodetic, cadastral and base maps.	Landata and VicMap Display do not include the geodetic framework in their products but include the cadastral layer.	The prototype did not include any geodetic framework as the area of study was constrained to an area with an allotment of 100 parcels. However, the cadastral layer was used in all the themes and constituted the base maps for the prototype.
The incorporation of title and valuation data.	Landata delivers detailed title information online. However, PRISM does disseminate valuation data online. Both services are isolated.	The prototype includes a sample title and valuation database in Access databases. The databases are small, with 100 records of parcel owners, addresses, with further title and valuation information in each database.
The facilitation of mapping functions and features.	VicMap Display provides mapping functions such as Pan, Zoom and navigation but does not allow users to selectively include map layers.	The prototype does include basic mapping functionality such as Pan and Zoom, and navigational directions across the map layer. Other functions include the ability to selectively include different map layers from the same or different map servers.
Updating of information over the web.	No systems in Victoria provides updating of data over the web	The prototype allows the user to update the title, valuation and Native Title information over the web.
The use of metadata.	No systems in Victoria provide the use, display, *etc.* of metadata.	The prototype does not use metadata as it was time consuming to create metadata entries for the databases.

8.4.2 Information Technology Evaluation

Table 8: Information Technology Evaluation

Principles	Victorian Scene	Results
The presence of the prototype on the web.	Landata and VicMap Display are available online but the valuation system, PRISM in not online. It is available via the local network only.	The prototype is available online, with the IP address permanent registered to the web-server running the prototype. Worldwide users can access the prototype at http://128.250.171.204
The use of plug-ins and web-based scripts to overcome limitations of the HTML syntax.	Landata is a text-based system, while VicMap Display requires the use of browsers that could interpret Java.	The prototype uses JavaScript to deliver the functionality of zooming, panning *etc.* between the browser and the server. It uses a combination of thick / thin client technology.
The use of interactive maps to effectively deliver geo-spatial information.	Landata is a text-based system, while uses dynamic maps to display the geo-spatial map.	The prototype generates interactive maps based on user queries and map overlaying.
The use of distributed processing architecture to solve the problem of database and web connections	Landata and VicMap Display were developed on different types of processing architectures.	The prototype was developed on a distributed processing architecture, with the middleware managed by the web server and the database and maps servers residing in the back-end component.
The inclusion of user and systems security features.	Landata includes a security login procedure. Access to VicMap is open to all. Both systems are secured behind corporate firewall systems.	The prototype was built behind the firewall and proxy of the University of Melbourne. It does not have a dedicated firewall facility but does include security logins to certain parts of the prototype.
The incorporation of an Electronic Commerce environment.	Landata includes a form of E-Commerce facility while VicMap Digital is free to all.	The prototype incorporates a stand-alone E-Commerce facility to facilitate basic buying and selling of geo-spatial goods.

8.5   **Prototype Problems**

The problems of VLIS include:

- The back-end databases of VLIS are managed in Microsoft Access. Microsoft Access is a desktop relational database management package that is adequate for managing records of less than 32656. Furthermore, Microsoft Access is also capable of providing adequate database security. However, when demand increases, the databases will be subjected to thousands of requests per day. The question of security breach and the possibility of concurrent transactions when more than one user is amending the same records will potentially pose problems to the system. Clearly, the data housed within Microsoft Access will need to be migrated to larger and more powerful database management packages such as SQL Server or Oracle.

- VLIS does not support concurrent transactions. Concurrent transactions occur when the same database record is being updated at the same time, thus a capable database management package will intelligently managed the transactions based on the time and priority assigned.

- The web server within the middleware of VLIS is not capable of supporting 50 users simultaneously. Industrial strength web servers are needed to provide satisfactory response to web requests.

- Other problems that are inherent in any system developments such as data harmonisation, partnership between data providers and stakeholders, legal and institutional issues would also be apparent in this prototype. However, because this research thesis concentrates on technical development issues, institutional issues and partnership initiatives are beyond the scope of this research. Issues concerning data integration and harmonisation have been negligible because of the prototype assumptions stated in Chapter 7.4 of this thesis.

8.6   **Prototype Limitations**

The prototype evaluation permitted the understanding of the limitations of the prototype. The limitations are not critical in the general operations of the VLIS as a prototype but should be rectified if VLIS is to be made a working application in the real world.

The geo-spatial information stored in the sample databases is incomplete and fictitious. This was deliberately done to protect the privacy of the landowners, the financial institutions and the persons involved in the transactions, development or management of the land parcels involved. However, the prototype does retrieve the necessary information to show the possibility of linking the information together.

The maps generated by the prototype do not contain annotations. This was purposely performed to reduce the complexity of the original data and the generated maps. The maps generated by the prototype are dependent on the quality of the original map themes. The popular expression of *Garbage In / Garbage Out* holds true in many of computer software and decision making systems.

The Electronic Commerce facility provided does not support the actual delivery and purchase of the products. The facility is merely to present the viability of promoting and purchase of geo-spatial goods and services over the web.

8.7   Solving some security issues

The front-end component of the MPC is the focus of the users. Additionally, since the front-end component is located on the web, access to the system is anticipated to be in the order of thousands of users. This factor greatly opens up the system to malicious attacks, hackers and unauthorized entries. Therefore, this section is aimed at describing the possible methods of securing the MPC on the web.

8.7.1   Packet Filtering

Packet filtering is a technique offered by many high-end routers. It denies access from outside the network by examining the protocols involved in a given access attempt. It can also restrict access from or to a given IP address. However, packet filtering simply would not offer the same high degree of security as do firewall applications.

Packet filtering passes packets from anywhere on the Internet or the MPC system. If these machines have security bugs, hackers and criminals can easily exploit the errors via the Internet. Firewalls prevent such attacks by providing an application-level server or proxy that filters out potentially dangerous instructions.

Packet filtering deals solely with incoming traffic and does not have encryption capabilities. Most commercial firewalls, on the other hand allows *virtual private networks (VPN)* to be set up. VPN are in reality simply the encryption of traffic between designated entities such as firewalls and specific users on the network. Such encrypted traffic does not depend on specific transmission paths. This traffic instead represents conversation between defined entities, regardless of the physical transmission paths.

8.7.2   Firewall

A firewall must prevent hackers and other intruders from accessing confidential information via the web. At the same time, a firewall would also be little use if it interfered with internal or external user's ability to perform work such as browsing web pages, transfer files and sending electronic mail. A good firewall must overcome security issues

associated with the aforementioned works. In doing so, firewalls usually rely on proxies, application gateways and DMZ networks.

8.7.3 Proxy

A proxy, as the name suggests, acts on behalf of another computer when it is making a connection to the web. For example, if a user tries to connect to an external computer, a firewall that employs proxies would itself make the connection. To the machine being accessed, the firewall would appear to be the remote user.

Proxies most frequently point outward. That is, they protect an internal network from external attacks. In an attempt to avoid the security issues, most firewalls include intelligent proxies that understand the origin of the suspected connection and stop the connection passing through.

8.7.4 Application Gateways

By using a type of software known as application gateways, a firewall can completely shield a network from a specific protocol, whether the protocol is entering or leaving the network.

8.8   **Optimising Prototype Performance**

Throughout the development of VLIS, bottlenecks within the web server were acknowledged to influence the overall performance of VLIS. Web server bottlenecks are factors that reduce response time by the web server to respond and reply to user requests. There are a number of ways to look at this problem. One way is to look at all the functions the web server is performing, because these functions usually follow one another and the effects of a delay are cumulative. These functions include the connection systems, communication process, HTTP requests and CPU and RAM bottlenecks.

8.8.1   **Connection systems**

Connection systems relate to the physical connections between the web server, the back-end and the front-end components. To ensure that the web server delivers its contents at the desired performance, the connection system between the back-end component and the middleware has to be at least 10 MBit in the form of LAN connections, ISDN lines, leased-line digital services or other capable connections.
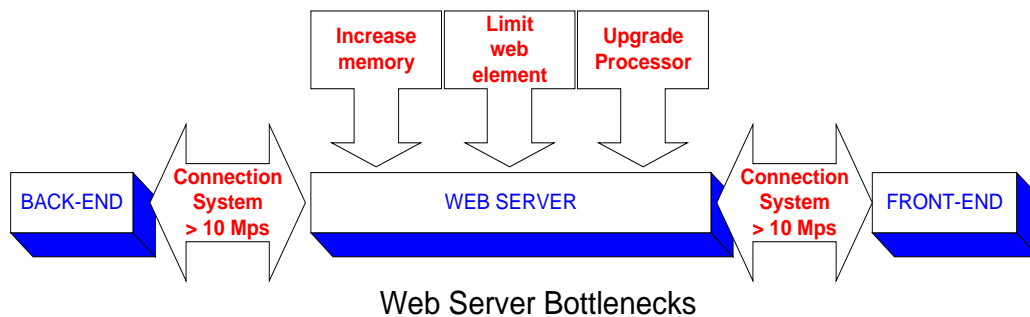

Figure 61: Web Server Bottlenecks

The connection system between the front-end component and the middleware, however, is dependent on a large number of variables such as the amount of memory, the processor speed and the type of network, network bandwidth and server architecture (see Figure 61).

8.8.2 Communication Process

Communication process relates to the overhead involved in managing a TCP (Transmission Control Protocol) session. Since TCP for communicating between the components of VLIS, often the process can result in a long wait. To reduce this wait, extra memory is added to increase the overhead. This, in turn, enlarges the TCB (Transaction-Control Block) of the system. TCB is a system memory dedicated to a TCP session. TCB usually stay dedicated to a particular session for several minutes after the session closes. Another method is by regulating the server's discrimination of identical requests coming from the same browser.

8.8.3 HTTP Requests

The VLIS site contains several web pages that generate HTTP requests when retrieved by the web browser. HTTP request relates to the manner of how TCP carries requests for service coded according to the HTTP format. A single HTTP request can kick off multiple transmissions from a web server if the page uses many separate objects such as icons and embedded controls. It may be necessary for busy web servers to increase the limit on the number of simultaneous HTTP actions by increasing the system memory and limiting the elements in the web pages. This is because each object on the web page requires more HTTP and TCP actions, which raises the likelihood of delays.

8.8.4 CPU / RAM Bottlenecks

CPU and RAM bottlenecks occur because of HTTP and TCP requests. When the CPU utilisation hits the 85 to 100 percent mark, the common remedy involves upgrading to more powerful processors or reducing the complexity of web pages.

8.8.5 Load Balancing

The reviewed systems exist on the Internet because of the crucial role of web servers in handling thousands of user requests per day. Depending on the contents, a web site may be overwhelmed with requests that could cripple a web server. There is, however, a method of avoiding this problem called *load balancing*.

Load balancing, is the concept of distributing requests over multiple servers to avoid transmission congestion and bottlenecks. When applied to a web service, this principle

usually means a system with several mirrored web servers all configured with the ability to respond directly to the same requests.

The ideal solution is to have a single address for a web server that is visible to customers, *i.e www.yourcompany.com* for example. This name is actually a virtual web server that seamlessly connects users to one of the many different mirrored servers. This can actually be accomplished in a number of ways.

One of the most common ways to do this is by using the Domain Name System (DNS). DNS is an Internet service that translates domain names into Internet Protocol (IP) addresses. Domain names are alphabetic and easy for humans to remember (like www.webreview.com), but information on the Internet is delivered using IP addresses. Each time a recognized Uniform Resource Location (URL) address is passed to the DNS server, the DNS server will translate the name into an IP address. For example, www.webreview.com would be translated into 208.201.239.35.

On the system side, DNS permits multiple IP addresses for the same web server. Each time a request is made for the web server, DNS will cycle through the available IP addresses in a round-robin fashion. This is how load sharing is accomplished.

Following is an example using DNS to distribute the Hypertext Transfer Protocol (HTTP) requests over three web servers. A company with a domain of "www.yourcompany.com" has set up three web servers: www1.yourcompany.com, www2.yourcompany.com, and www3.yourcompany.com.
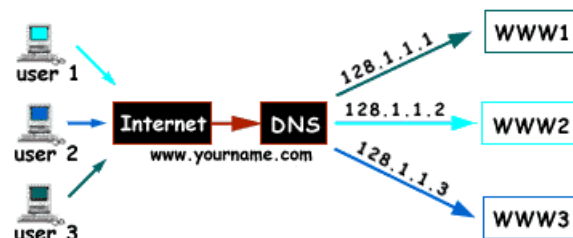
Figure 62: Using Load Balancing Techniques in Handling High Internet Demands

At the first request for www.yourcompany.com, DNS will reply with the address for www1 (128.1.1.1). The second request will be answered with www2 (128.1.1.2). The third

request will be answered with www3 and for the fourth DNS will cycle back to www1.
This is the round-robin service approach at work.

The obvious advantage of using DNS for load distribution is that it is seamless to the user
and simple to implement. There are, however, some limitations.

The main drawback with the DNS solution is that it is not foolproof. DNS cannot monitor
and detect when a web server has broken-down in the network. To solve this, a Load
Balancer is used. Load balancers are computers that are physically positioned between
users and a cluster of web servers. For large-scale public web servers this would be
between the Internet connection and the cluster. In the case of a corporate web server for
an Intranet, the load balancer would be placed between the users and the web servers.

8.9   **Chapter Summary**

This chapter is formulated to describe the imperfection of VLIS as a prototype and a working system in the real world. VLIS is a proof of concept *i.e.* the implementation of VLIS is bounded by ideal data, system, user and network conditions that help to better focus on understanding the overall working and applicability of the applications within VLIS.

The chapter describes the development issues that were documented in the development of VLIS. To understanding the problems and limitations of VLIS, it was tested against a range of evaluation principles that were gathered from the understanding of the two knowledge base encapsulated in the thesis *i.e.* the MPC concept and its development, and the impact of geo-spatial trends and IT advancement (see Figure 63).

The evaluation resulted in the comparison of VLIS against Victorian online geo-spatial systems, based on the evaluation principles created. This then contributed to the documentation of the problems and limitations of VLIS as a prototype.

One of the major limitations that required some considerable understanding and focus, especially as VLIS is being live on the web, were the security and performance issues. The security issues are described, with some possible solutions such as the incorporation of firewalls and proxies, while performance issues describe the understanding of matters such as the communication processes and load balancing, which plays a major importance in most large online systems nowadays.
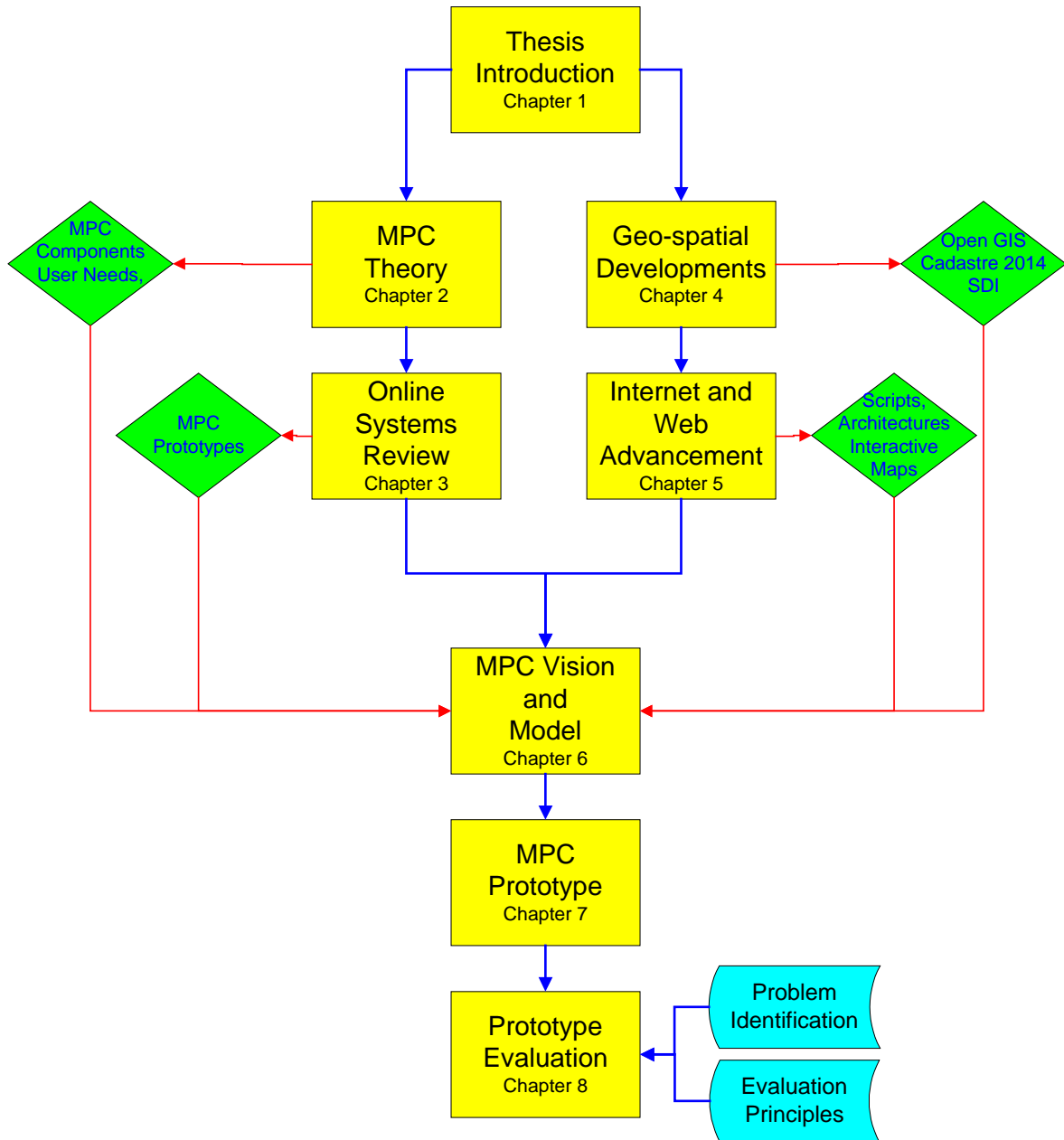
Figure 63: Evaluating the MPC prototype

Chapter 9

Conclusion

The following chapter concludes this research thesis. It highlights the future outlook, taken from a geo-spatial information perspective and includes the concluding remarks and recommendations for the future.

Chapter 9: **CONCLUSION**

9.1 **Future Outlook**

The 1990s introduced a new and different approach to geo-spatial data access. The emergence of the Internet and the World Wide Web saw the rapid surge in information publishing, from live news to encyclopedia to interactive digital maps. Web-based geo-spatial systems that were reviewed in Chapter 3 are proofs that geo-spatial information developers are making the most of the web, to provide the tools for easy and accessible geo-spatial data retrieval, searching and viewing. The MPC prototype developed for this research thesis, has ventured further by promoting the integrating of geo-spatial data, from distributed geo-spatial information resources, and allowing the updating and viewing of the data, using common entities such as the cadastral parcels.

The developments in the online geo-spatial world are seen as only the beginning. Through the development of the prototype, and the review conducted and described in Chapter 3, several technical factors have been identified as the leading impetus that will continue future geo-spatial developments on the web. It is anticipated that future geo-spatial systems will be directly and indirectly affected by these factors. These factors are highlighted in Figure 64 and described below.

Factors discussed and highlighted in Chapter 5, *i.e.*:

- Future geo-spatial systems will move away from specialised and proprietary applications, operating platforms and proprietary developments that are purposely catered for corporate or local deployment, to embody the tremendous acceptance and growth of the Internet and web.

- Future systems will provide greater user control through the use of web-based scripting and digital map delivery techniques over the web.

- Future geo-spatial information developers will enjoy the flexibility and capability of distributed processing architectures.

- An alternative data delivery language other than HTML will influence future geo-spatial systems. For example, the emerging Extensible Markup Language (XML) that promises greater data control, including geo-spatial data over the web.

- Future geo-spatial systems will be pressured to not only deliver information over the web, but also to include future standards and technologies that will enable wireless and hand-held devices such as the mobile phones, pagers and personal desktop assistants (PDAs) to view geo-spatial data as easily as desktop computers. Already, PDAs are running on cut-down versions of Microsoft and Apple operating systems, while mobile phones will also benefit from the developments of the Wireless Protocol Application (WAP) and XML that will allow users to easily view Internet contents and services (XML Resource Centre, 2000). These will dramatically open the geo-spatial market to millions of wireless device users across the world.
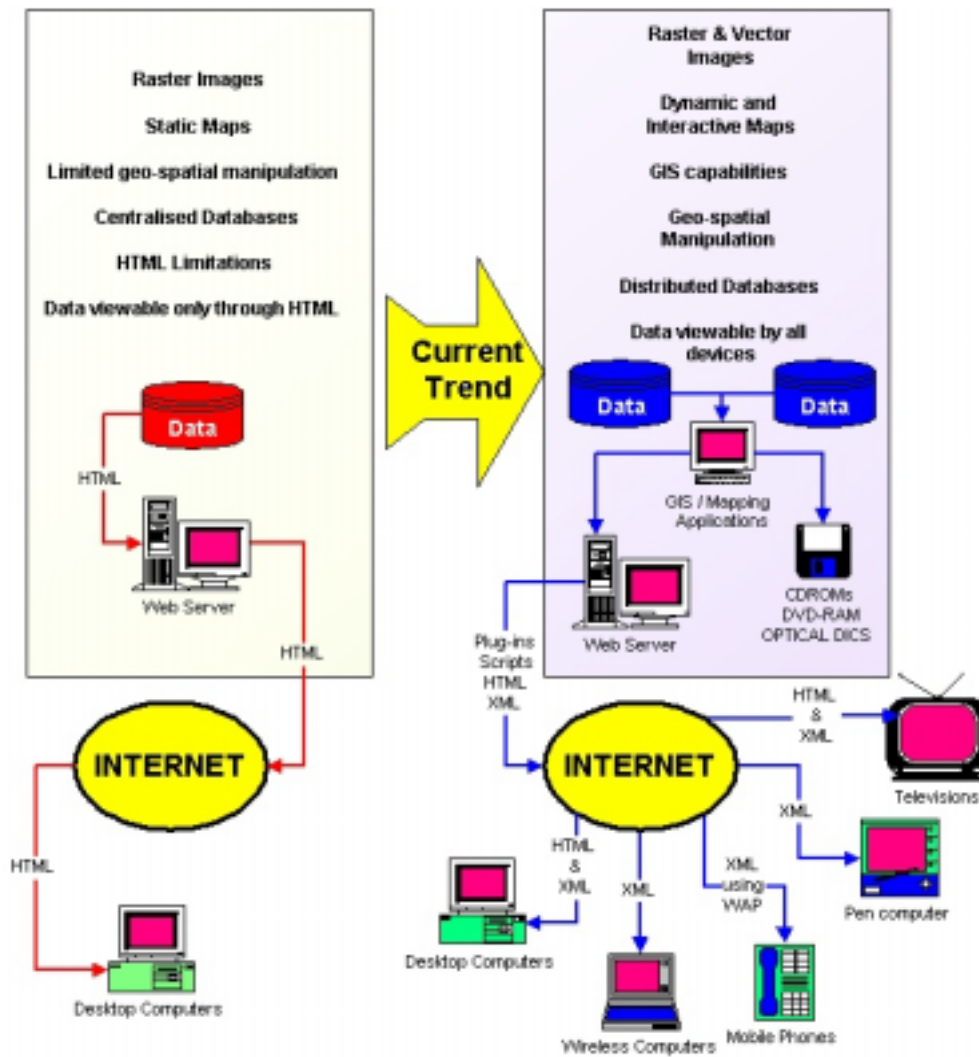
Figure 64: Future Outlook and current trends of online geo-spatial systems

- Future geo-spatial systems will completely use the thin-client technology provided by web-based scripts that will ensure the suitability of geo-spatial products to these devices. The thin-client technology allows for most of the processing to be conducted at the server-end, thus delivering just the product across the web to these devices.

- The mode of dissemination by the future geo-spatial systems will need to include cutting-edge developments such as the Asynchronous Transfer Mode (ATM) and Virtual Private Network (VPN). Currently, the ATM technology integrates voice, data and video in the same network, thus potentially allowing high-standard interactive multimedia and voice communication between users and geo-spatial

system interfaces. The Virtual Private Network (VPN) provides a secure network tunnel created for encrypted data transmission between two or more authenticated networks that will potentially allow possibilities where future geo-spatial developers could securely attach their database contents securely into an existing geo-spatial system

- The current continuing reduction in performance / price ratio of commercial and personal data storage devices and peripherals, will impact on future online geo-spatial systems. This will encourage users to turn away from the web revolution, to use peripherals such as Compact Disc-Read Only Memory (CD-ROM), as an alternative delivery medium for the geo-spatial industry. The CD-ROM technology is by now being compromised by the emerging DVD-RAM technology, which is capable of storing up to 5.2 Gigabyte per disc (2.6 Gigabytes per side compared to a CD-ROM capacity 650 Megabytes per disc) is increasingly being utilised to manage and backup large volumes of data.

- Current and future geo-spatial systems should discover and utilise the Scalable Vector Graphic (SVG) format, as it brings rich, high-resolution vector graphics on the web. Based on XML, it takes up less space than GIF and JPEG, and because it is vector, SVG displays the same high quality on wireless devices with small screens as well as large monitors. One of SVG's best features it that it allows for zooming and panning inside the graphic itself, without the need to reload and refresh, thus is suitable for geo-spatial data and images where the user can zoom in to view additional layers of information. An additional benefit of SVG is that since it is based on XML, it is entirely text-based, which allows it to be used with search engines on the web.

- Commercially, vendors are progressively incorporating software components that allow the use of geo-spatial data and maps within their products. For example, Microsoft has added applications such as Microsoft MapPoint 2001 within the popular Microsoft Office suite, that utilises geo-spatial data and incorporates maps and geo-spatial data within the Microsoft Office environment (Microsoft, 2000).

Database giant Oracle, have also released a database management system (DBMS) that totally integrates and supports the use of geo-spatial data with non-geo-spatial data in the same database structure(Oracle, 2000b).

9.2   **Conclusion**

Many scholars and practitioners have envisaged the MPC concept in the last 3 decades. The MPC concept, although idealistic in those times, are still regarded as visionary steps in addressing the inherent limitations of most modern geo-spatial systems, especially cadastral systems worldwide. This thesis recognises the importance of the MPC concept, and has described the concept as background knowledge in this research.

Interestingly, many geo-spatial systems have embarked in the utilisation of the web, to better disseminate the data contained in many of the databases and resources within them. The utilisation of the web has allowed these geo-spatial systems to be transformed into online 'virtual' systems that are accessible by most people with the proper tools of today (the computer, telephone lines and web browsers). This thesis has analysed the growing development of these online systems, and conducted a review to document the differences and similarities in these systems. Of most importance, is that these systems possess characteristics that resemble future cadastre systems of the 21st century. In this regard, a set of documents released by the International Federation of Surveyors (FIG), called Cadastre 2014, were used extensively as a guide to identifying the evolution of the modern systems into online systems that resemble features of the future systems.

The development of online systems is not the only remarkable change that is happening in the geo-spatial information world. In the last 5 years, the rapidly growing volume of geo-spatial data, attributed by rapid capturing tools such as the one-meter satellite imagery from the IKONOS satellite, Global Positioning Systems and Geographic Information Systems, are impacting on the way societies are using, storing and viewing geo-spatial data. Spatial Data Infrastructure (SDI) is also emerging as one of the fundamental components in the future of compatible, interoperable data exchange. Notwithstanding, is the emerging acceptance by many geo-spatial organisations of the importance of the web, and thus developed the Open GIS Consortium and the Australian World Wide Web Mapping Consortium that are introducing and developing prototypes, standards and concepts that are securing geo-spatial data use and application for the future.

Nor surprisingly, a significant portion of the thesis has been concerned with the Internet, the web and its related technologies. These are recognised in this thesis, as vital mechanisms that have and will ensure the development, progression and presentation of better, integrated and rich geo-spatial information to a wider audience than ever before. The web is being increasingly tested and modified to include geo-spatial data that will co-exist within the standard web environment.

The development of the prototype model and thus consequently the prototype, are the products of the amalgamation of the MPC concept, Information Technology trends and geo-spatial information revolution that are occurring around us. The prototype contributed in the quest of understanding the development issues, and the viability of delivering geo-spatial data from disparate, distributed resources across the world.

The prototype is imperfect and serves only as a proof of concept. The proper identification of the prototype problems and limitations was conceived through an evaluation process based on a set of geo-spatial and Information Technology principles gathered from the two knowledge streams of this thesis.

9.3   **Recommendation**

This thesis supports the development of online geo-spatial systems, in particular online cadastral systems, to be based on the Cadastre 2014 and the MPC concepts as championed by the International Federation of Surveyors, and the Panel on Multipurpose Cadastre. Future online systems are paramount in the effective delivery of public, and accessible geo-spatial information, and will increasingly be used transparently in future applications and systems.

This thesis also suggests that the theory and documentation of the future online geo-spatial systems are made available to the public, in a manner that will enhance the use and advancement of geo-spatial systems, information and users alike.

Finally, with the incredible speed of innovations in geo-spatial information and recently, the amalgamation of geo-spatial information manipulation tools such as GIS and the Internet, it is almost impossible to predict what the future might be. Certainly users are looking forward to better services and quicker response times through reductions in unnecessary duplication across all government jurisdictions that only a MPC can offer.
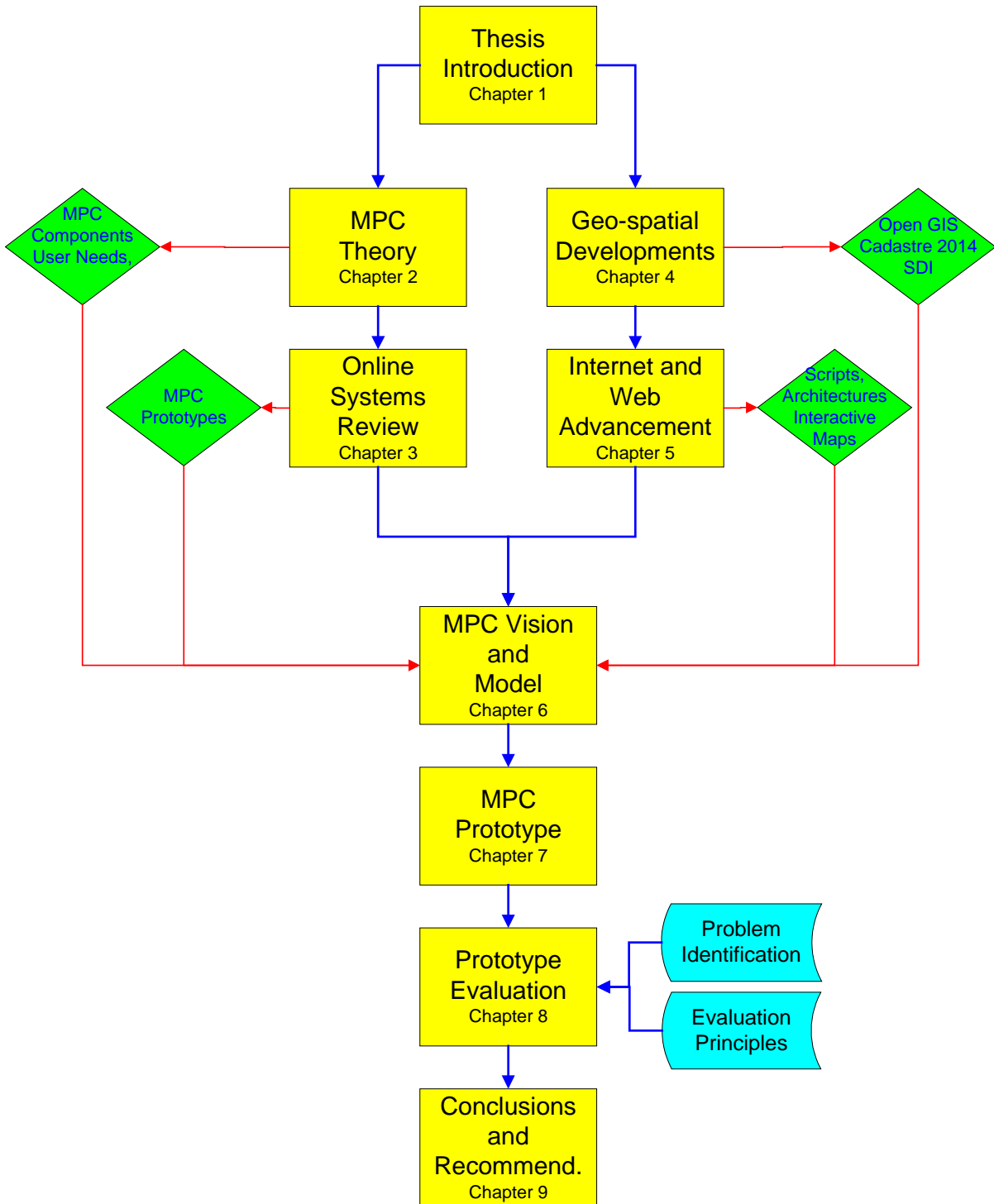
Figure 65: Concluding the thesis

Chapter 10

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List of references that were used in the development of the MPC prototype and the research thesis write-up.

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