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## **Cadastral Systems on the World Wide Web: A Multi-Purpose Vision**

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### **ABSTRACT**

The World Wide Web (WWW) is now a reliable and efficient source of information worldwide. With this in mind, traditional cadastral systems are looking to the WWW as a tool that will better serve the users of land information. As such, this paper will outline the developments of modern cadastral systems and in particular, online cadastral systems and the increasing use of the WWW for access.

The paper will then demonstrate how a modern cadastral system can benefit by being online on the WWW. It will also review Australian and international developments on bringing cadastral systems online and assisting in managing complex land tenure systems.

The paper will discuss the realisation of a Multi-Purpose Cadastre concept through the use of the WWW, distributed databases and Map Servers. Resulting issues such as data, spatial processing, data delivery and client will be addressed.

**KEYWORDS:** WWW, Multi-Purpose Cadastre, Cadastre 2014, Map Servers, Web Servers, land title systems

### **INTRODUCTION**

Computers and Information Technology (IT) have revolutionised conventional cadastral surveying, mapping and land registration processes and are increasingly becoming significant components of any organisation where automation plays a part in improving production. Computer networks and Geographic Information Systems (GIS) also complement automation through the WWW. GIS software allows spatial queries, image manipulations and the creation of scenarios for estimating and producing results. However, what GIS software cannot do is distribute the results to multiple users using current inter-operable WWW infrastructure and protocols.

For the purpose of this paper, the authors will use the term WWW to denote 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 WWW is loosely referred to as the Internet, the Internet is actually a "network of networks" that links computers around the world. Despite differing systems, these computers all use a set of rules called the Transmission Control Protocol/Internet Protocol (TCP/IP) to exchange information (University of Georgia Center for Continuing Education, 1999).

A Map Server is a new breed of software that extends GIS functionality across the WWW. With a Map Server, live maps based on user queries can be created. A Map Server allows developers to produce geographic information by gathering data from several sources simultaneously, thus behaving as a server to the users across the WWW.

A recently published strategy by the International Federation of Surveyors (FIG), "Cadastral 2014" emphasises the importance of a vision for a modern cadastre (Kaufman and Steudler, 1998). The modern cadastre which is a realisation towards the concept of a Multi-Purpose Cadastre, 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 these systems.

This paper will attempt to discuss the Multi-Purpose Cadastre concept envisaged in Cadastre 2014 through a review of international and Australian online systems. This paper will also introduce a prototype of a Multi-Purpose Cadastre based on the trends and features of the reviewed systems, Cadastre 2014 and the use of the WWW.

## **MULTI-PURPOSE CADASTRE AND THE WORLD WIDE WEB**

A modern cadastre by definition is a parcel based land information system containing records of interests in land and is closely aligned with the operation of land markets (FIG, 1999). The modern cadastre is an integral component in establishing the fiscal and legal management of land and land use for the purpose of sustainable development. In contrast with the past, cadastral reform has concentrated on certainty and security of land tenure (Williamson, 1997).

Kaufman and Steudler (1998) defined a Multi-Purpose Cadastre as "methodically arranged public inventory of data concerning all legal land objects in a certain country or district, based on a survey of their boundaries". The Multi-Purpose Cadastre is an extension of the modern cadastre to include other land information registers. These registers might include databases with planning, valuation and other information. By including these registers, a Multi-Purpose Cadastre is expected to serve more than its original purpose of primarily serving the land market.

"Cadastral 2014" has also made six key statements about the development of cadastres towards the Multi-Purpose Cadastre concept (Kaufman and Steudler, 1998). 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.

In recent times, the cadastre has gone through improvements such as digitisation, automation, database integration and many more technological changes in order to better serve the public. One of the more significant improvements in the last few years was the adaptation of the WWW as the medium of integration and presentation of the cadastre.

## **REVIEW OF CADASTRAL SYSTEMS ON THE WORLD WIDE WEB**

An investigation into the awareness of the Multi-Purpose Cadastre concept was undertaken in the first half of 1999. The objective was to understand trends in modern cadastral systems in relation to the Cadastre 2014 vision. The investigation methodology involved exploring several innovative online cadastral systems in Australia, Europe and North America. Consequently, a set of criteria was developed for selecting the appropriate online systems for this review.

The criteria for inclusion in the investigation are listed as follows:

1. The system must be fully implemented on the WWW.
2. The system must be relevant to the concept of a Multi-Purpose Cadastre. This involves the integration of the cadastre and other relevant datasets relating to the cadastre
3. Access to the system must be available to the public through the WWW (although some access charges may be required).

*Table 1: List of WWW-based Cadastral Systems (Note: These URLs were current at 22/06/99)*

<u>System</u>	<u>Jurisdiction</u>	<u>Uniform Resource Locator (URL)</u>
<b>Australia</b>		
(1) Landata	<b>Victoria</b>	<a href="http://www.landata.com.au/">http://www.landata.com.au/</a>
(2) VicMap Digital	<b>Victoria</b>	<a href="http://www.giconnections.vic.gov.au">http://www.giconnections.vic.gov.au</a>
(3) Land Information System Tasmania	<b>Tasmania</b>	<a href="http://www.thelist.tas.gov.au/">http://www.thelist.tas.gov.au/</a>
(4) ACTMapOnline	<b>ACT</b>	<a href="http://polaris.act.cmis.csiro.au/">http://polaris.act.cmis.csiro.au/</a>
<b>Europe</b>		
(5) Web-Matriklen	<b>Denmark</b>	<a href="http://WWW.kms.dk">http://WWW.kms.dk</a>
(6) Mapsite	<b>Finland</b>	<a href="http://www.nls.fi/jako/norm/index_eng.html">http://www.nls.fi/jako/norm/index_eng.html</a>
(7) JakoWWW	<b>Finland</b>	<a href="http://www.kartta.nls.fi/karttapaikka/eng/home.html">http://www.kartta.nls.fi/karttapaikka/eng/home.html</a>
<b>North America</b>		
(8) New Brunswick Internet Service	<b>New Brunswick, Canada</b>	<a href="http://caris0.universal.ca/NBGIC">http://caris0.universal.ca/NBGIC</a>
(9) Greene Internet Server	<b>Ohio, USA</b>	<a href="http://www.co.greene.oh.us/gismapservr.htm">http://www.co.greene.oh.us/gismapservr.htm</a>
(10) Mecklenburg Internet System	<b>North Carolina, USA</b>	<a href="http://ntgis_netvs.co.mecklenburg.nc.us/taxgis/">http://ntgis_netvs.co.mecklenburg.nc.us/taxgis/</a>
(11) Nashville and Davidson Property Online	<b>Tennessee, USA</b>	<a href="http://www.nashville.org/Multi-PurposeCadastre/maps/index.html">http://www.nashville.org/Multi-PurposeCadastre/maps/index.html</a>

Table 1 lists eleven International and Australian online systems that were accessed and reviewed for this paper. These are grouped into regions of interest with further discussion on these systems later in the paper.

In Australia, only four online systems were reviewed. These include Landata and Vicmap Digital in Victoria, the Land Information System Tasmania in Tasmania and ACTMapOnline in the Australian Capital Territory. Landata in **Victoria** is an extensive system for querying, tracking and retrieving titles and dealings. It provides a meticulous search on parcel creation with details relating to the creation and the status of a land parcel and those dealings affecting the parcel. Vicmap Digital is the WWW gateway to the State Digital Map Base in Victoria. Vicmap Digital returns live maps with parcel identifiers based on address queries. Landata and Vicmap Digital are presented as integrated land information delivered on the WWW through the Victorian Land Channel homepage (<http://www.land.vic.gov.au>). Land Information System Tasmania (LIST) is an initiative by the Department of Environment and Land Management, **Tasmania**. LIST allows the overlaying of spatial data themes including contours and water boundaries. One of its strengths lies in the successful integration between the survey, land titling and valuation authorities despite the apparent jurisdiction and physical separation between them. ACTMapOnline is the joint-venture between the **Australian Capital Territory** Land Information Centre and CSIRO. It is an effort to deliver land information system data in an Internet ready environment. ACTMapOnline is the only system reviewed in Australia that includes building footprints and feature

names on its cadastral map. Additionally it has a graphical functionality interface system with the ability to provide live maps through WWW queries.

In Europe, the systems reviewed include the Web-Matriklen in Denmark and JakoWWW and MapSite, both in Finland. Web-Matriklen is a product of the government of **Denmark**. Presented in Danish, the system offers in-depth title information. Online maps are made of vectors with associated attributes such as boundary names and survey benchmark numbers. The digital base map includes survey benchmark identification details while the textual components include forests and water body information. The government of **Finland** is also delivering land information through JakoWWW and MapSite. MapSite acts as a live map server, capable of bringing up maps of various scales through customisable interfaces. MapSite also provides facilities for purchasing maps by utilising electronic commerce technologies. JakoWWW on the other hand, provides title and cadastral map information of Finland. JakoWWW however was not explored as the system is only available from within Finland but its existence complements MapSite and land information delivery in Finland.

In North America, the reviewed online cadastral systems are more likely to be classified as Land Information Systems (LIS) because of their legal status and jurisdiction. Most of these systems are the responsibilities of county authorities. The **Greene, Mecklenburg, Nashville and Davidson** counties deliver information ranging from census to housing assessments through the WWW browser. The **New Brunswick** Internet Services, which is one of the pioneers in the delivery of cadastral information through the WWW, is also seen as the front-runner of the Multi-Purpose Cadastre concept. The New Brunswick system requires minimal Internet browser modules (such as Java and ActiveX) for it to work. The system also provides WWW queries through name and parcel search.

## COMPARISON OF REVIEWED SYSTEMS

Each of these systems is unique with features that distinguish one system from another. Several of these features are further explained in this paper and include government guarantees on the information, access, integration of the cadastre, breadth of information and GIS functionality, i.e., by placing one layer of information on top of another. Although there are clearly several other aspects (technical and institutional) of each systems that are comparable, the few features listed below are sufficient in presenting an overview of the differences between the systems.

### Government Guarantee

The reviewed systems were a mixture of title and deeds based systems. In North America, the reviewed systems are based on deeds whereas systems in Australia, Denmark and Finland are based on registered title. The major difference between a deed and title-based systems lies in the government guarantee on registered title.

### Access

Acquiring access to the systems is largely dependent on the current data delivery policies and commercial considerations. Some governments may have policies that heavily subsidise costs of producing spatial data to provide access and data retrieval at no charge. Interestingly, the public and the private sectors are producing datasets, interfaces and delivering data to users with a particular emphasis on quality and user-pays policies. An example is the cooperation between DATAflow Ltd. and a government subsidiary in maintaining the Digital Cadastral Database (DCDB) for Victoria.

### Integration of the cadastre

The most significant feature in all of these systems is the seamless integration of the cadastral map and the title register. In reality, databases containing the cadastral map and title registry are usually separate databases not necessarily within the same institution. The use of computer networks and the Internet simulates the opposite, giving the impression of a centralised repository consisting of maps and land information.

### Breadth of information

Another notable feature of these systems is the impression of a one-stop shop for all related land information. Apart from the cadastral map and title register, other datasets that are regularly found in these systems include contour details, zoning or land use, and land-value assessment data. Table 2 lists land related datasets such as land value and building information that complements the cadastre in these systems. Again, these separate databases are not necessarily within the same institution.

Table 2: Dataset features of WWW-based Cadastral Systems

	<u>System</u>	<u>Title/Deed Search</u>	<u>Survey Records</u>	<u>Land Value Assessment</u>	<u>Building Information</u>
<b>Australia</b>					
(1)	Landata	YES	NO	NO	NO
(2)	VicMap	NO	LIMITED	NO	NO
(3)	Land Information System Tasmania (LIST)	YES	NO	YES	YES
(4)	ACTMapOnline	YES	NO	NO	LIMITED
<b>Europe</b>					
(5)	Web-Matriklen	YES	LIMITED	NO	NO
(6)	Mapsite	NO	NO	NO	NO
(7)	JakoWWW	YES	YES	YES	NO
<b>North America</b>					
(8)	New Brunswick Internet Service	YES	LIMITED	YES	NO
(9)	Greene Internet Server	YES	YES	YES	NO
(10)	Mecklenburg Internet System	YES	YES	YES	YES
(11)	Nashville and Davidson Property Online	YES	NO	YES	YES

### GIS Functionality

Online cadastral systems are usually a collection of large databases with spatial manipulation software that treats each of the datasets listed in Table 2 separately. Each system provides interfaces to allow Internet users to include the data separately onto the cadastral map or as tabular information linked to a register. This is usually done by choosing the datasets required for use. This seamless integration of these datasets with the cadastre and other registers depicts the foundation of GIS functionality.

### THE REALISATION OF A MULTI-PURPOSE CADASTRE

The comparison of the eleven online cadastral systems has led to the conclusion that aspects of the Multi-Purpose Cadastre are evolving in these systems. Certainly each of the systems is unique but the obvious trend is that these features are pointing towards the Cadastre 2014 vision. This is further outlined in Table 3 where similarities between key features of Cadastre 2014 and those of the reviewed online cadastral systems are highlighted. This also gives rise to the proposal of a prototype for visualising the Multi-Purpose Cadastre concept with particular emphasis in understanding its associated issues.

Table 3: Similarities between the vision of Cadastre 2014 and trends of reviewed systems.

#### Cadastre 2014 Key Statements

The Multi-Purpose Cadastre will show the complete legal situation of land, including its right, restrictions and responsibility.

The separation between the maps and the registers will be abolished.

The paper and pencil cadastre will have gone.

Cadastre 2014 will be based cost recovery.

#### Features of Systems

Coming together of databases and overlaying of data themes facilitate the complete view and understanding of the situation of the land.

Map and web servers allow distributed databases to be connected and presented seamlessly to Internet users.

Digital recording of coordinates in field-work and directly feeding into computer databases for spatial processing contributes to development of the cadastre.

Electronic-Commerce technology is being used to generate revenue for maintenance of online systems and datasets.

## DEVELOPING A MULTI-PURPOSE CADASTRE

Separations between the cadastre and other land information restricts the flow of data between the government agencies and other users. This is particularly apparent when a land subdivision is to be contracted but requires investigation into several government agencies for a complete understanding of the legal and physical situation. As such, the Multi-Purpose Cadastre concept stresses the importance of removing such separations to facilitate an efficient cadastral system that shows the complete legal situation of land, including the rights, restrictions and responsibilities (Kaufman and Steudler, 1998).

With that in mind, a prototype was developed to understand the Cadastre 2014 concept. It is envisaged that the prototype will also investigate the proposal by Jones, Rowe and Kentish (1999) who 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 land information. A future cadastral system will need to satisfy this demand.*

It is important to understand the process of building an integrated land information database for the public. A land subdivision process is done by land surveyor who is given a unique parcel identifier for land registration 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 land information components.

The identifier will also be the basis for linking the databases in the prototype. The prototype as illustrated in Figure 1, will be founded on the notion that databases in separate government agencies will be mirrored and scaled using personal computers residing on a Local Area Network (LAN). For the prototype, the sample data will be provided by from planning, title, cadastral and valuation agencies.

Each of these datasets will be hosted by one of five personal computers (each simulating a government database) running popular operating systems with a Map Server to handle requests from users. A sixth computer, the host, will be equipped with a WWW Server but will act as the front-end to the WWW. The host is the entry to the system and is identified by a Uniform Resource Locator (URL) address. The host will also keep track of the unique URL addresses of the other database servers. Firewalls (a collection of software and hardware packages for maintaining security within the Internet) will also be installed in the host computer to prevent unauthorised access.

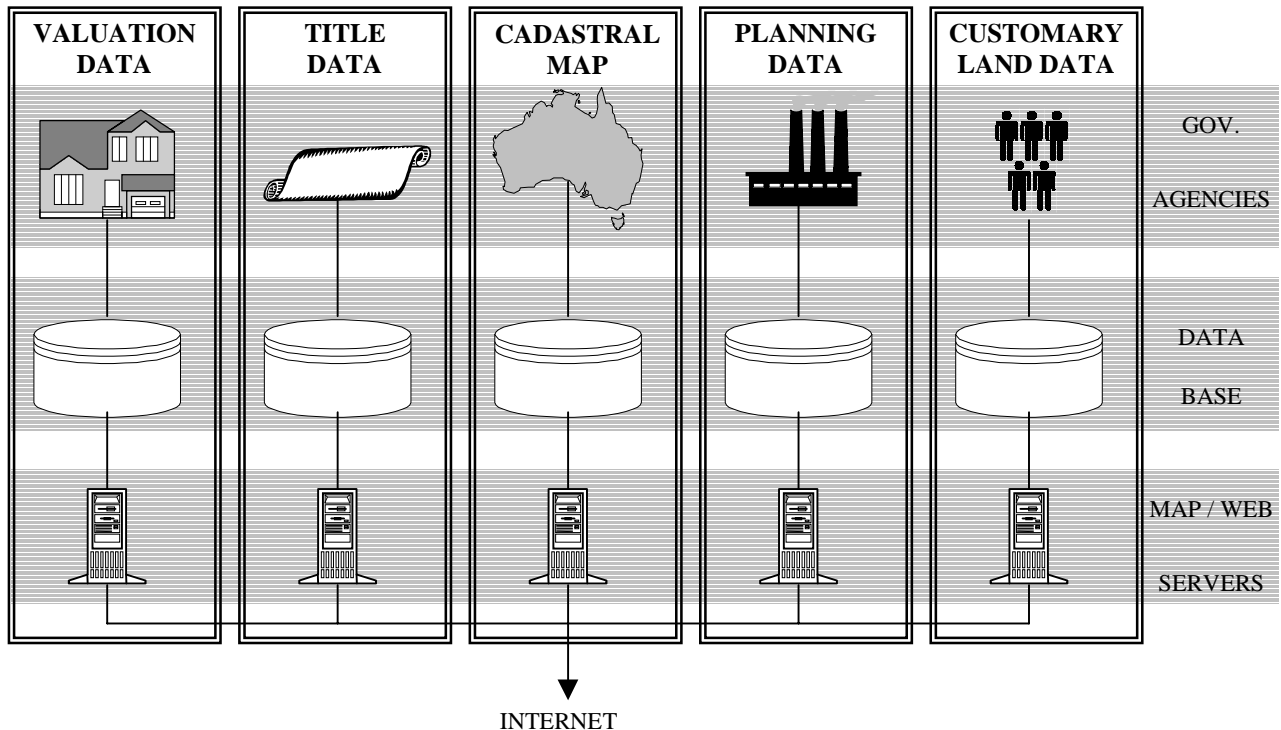


Figure 1: Conceptual model for an integrated land information database

The host computer will manage access and information requests through simultaneous data retrieval techniques to the databases. Through this method, several key factors can be addressed in the creation of an efficient Multi-Purpose Cadastre. These include:

1. Users can receive the latest datasets as the databases reside with the responsible government agencies. As a result, government agencies are able to update their database easily without interrupting the overall scheme of the system. The respective agencies retain control and ownership of the datasets while the host computer replicates the database to cater for WWW-based queries.
2. Database access is only by way of duplicating the datasets. Firewalls will ensure that the users will not be able to directly manipulate the datasets beyond the databases replicated within the host computer.
3. The host computer acts as a shop-front for the responsible agencies on the WWW. Users are able to access information from the one-stop shop but only responsible agencies are accountable for data maintenance. This creates a predictable situation where these agencies can easily monitor the behaviour, access and usage-preference of the users.
4. The shop-front will portray the seamless integration of cadastre, title and other land information. As a one-stop shop, there will be documentation, instructions and features to ensure that users understand the expectations of the system and the products it delivers.
5. Incorporating "user-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 host, utilising an E-Commerce system, such as the popular SET (Secure Electronic Transaction) will produce a revenue generation system.

Additional features may be incorporated into the prototype to better serve the public. Options such as including metadata and metadata search engines to the system will allow users to browse the datasets before using the system (Phillips, Williamson and Ezigbalike, 1998). The metadata or data dictionary will be available for all the databases while the metadata search engine will reside on the host computer as the entry point. The need for metadata will be critical as the volume of datasets increases.

In the future there will be an increasing demand for users to also be data providers. The prototype must be adaptable to future uses, which in this situation means, uploading datasets for inclusion into the databases. This option is particularly useful for rural data providers that see the system as a two-way gateway to government data. A prototype by Polley (1999) conceptualises the notion of uploading data through the WWW using Computer Gateway Interface (CGI) and the Java language.

## **ISSUES**

The proposed prototype will mimic the operational flow of data from the databases to the users. Users on the other hand would expect the data to be operational and of a certain accuracy and standard with some form of metadata precursors to delineate inconsistency. Through the prototype, several issues are addressed for the creation a successful Multi-Purpose Cadastre. Figure 2 illustrates these issues with further explanations below.

### **Data issues**

Data issues are data format and accuracy variations. Agencies working on spatial data rarely use a single generic format for their data. Depending on the requirements of each agency, one might find ARC/INFO coverage files to be of more use while other agencies utilise MicroStation and AutoCAD design files. Also, spatial data is usually created to the accuracy relevant to their use. For example, geodetic control networks are generally of higher precision than land use coverage. Therefore, for data to be used in a Multi-Purpose Cadastre, there is a need for an organisational understanding in delivering data accuracy and formats for the uniform linking of datasets.

### **Spatial processing issues**

Spatial processing issues relate to the use of spatial tools in analysing data. Due to the large market for spatial tools, agencies prefer to use a designated software package for spatial analysis with another software for spatial storage. To be able to include datasets from several agencies, custom interfaces are needed to communicate between software across multiple operating systems, networks and architectures.

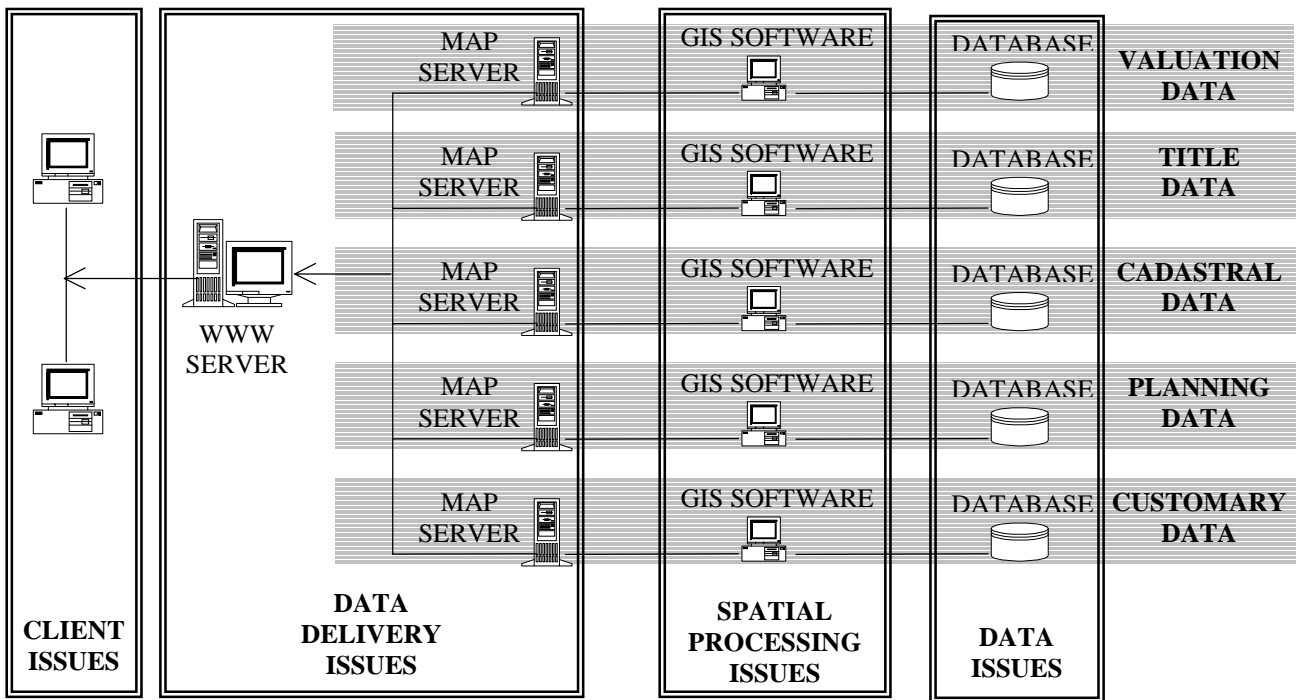


Figure 2: Construction issues in the creation of a conceptual land information data

### Data delivery issues

Data delivery issues address the use of technologies in programming languages, front-end interfaces and communication hardware for data delivery. Systems that use Java and JavaScript to deliver dynamic information often burden the WWW browser by requiring the client to use the latest WWW technology (such as server-push and client-pull). The Computer Gateway Interface (CGI) is an alternative where the user only requires the basic version of WWW browsers to use the system. Similarly, front-end interfaces such as Java Windows (Java application window on the WWW) increases bandwidths where at times they exceed the size of the data themselves.

### Client Issues

A Multi-Purpose Cadastre is expected to present users with a one-stop dynamic land information repository utilising the latest technology with extensive integration. Unfortunately user expectations could then be very high leading to misunderstanding and over-emphasis on the data. There should be mechanisms in guiding users to understand the limitations of the data and the delivery of the data to them. Also, data providers or agencies need to accommodate and target their users. For example, a specialised WWW-site might utilise state of the art technologies where its specialised audience is technology literate with specific needs and uses for the site; however the general public may be misled with the array of tools presented to them.

## CONCLUSION

The cadastral system is often seen as two separate systems comprising of cadastral maps and title registers. Only recently with the coming together of the cadastre with land related registers, the WWW and spatial tools, the Cadastre 2014 vision of a Multi-Purpose Cadastre is becoming a reality. This is highlighted by a review where features of online cadastral systems closely resemble the Multi-Purpose Cadastre concept. The Australian and international initiatives in building online cadastral systems have also indicated an evolution towards the beginning of Multi-Purpose Cadastre concept. It appears, there will be a time when access and use of a Multi-Purpose Cadastre will become a reality either as a stand-alone system or possibly through transparent integration in other business systems.

To visualise a future Multi-Purpose Cadastre, a prototype based on the features and trends of systems reviewed, Cadastre 2014 and the WWW has been conceived. Data format and transfer, spatial manipulation tools and user demands are a few of the issues that have been addressed in this paper. Through the use of Map Servers and distributed databases, the prototype will be a simplistic view of a future Multi-Purpose Cadastre.

Finally, with the speed of innovation in land information systems and recently, the convergence of spatial manipulation tools such as GIS and the WWW, it is difficult to predict what the future might hold. Currently, only the Multi-Purpose Cadastre vision can offer better services and access via the WWW to support decisions by users.



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